SYLLABI
OF
PG / Ph. D. COURSES
(DEPARTMENT OF AGRICULTURAL ENGINEERING)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY
(UNDER THE MINISTRY OF EDUCATION, GOVT. OF INDIA)
DEEMED TO BE UNIVERSITY U/S 3 OF THE UGC ACT, 1956
NIRJULI - 791 109 :: ARUNACHAL PRADESH

SYLLABI
OF
PG/ Ph. D COURSES

(DEPARTMENT: AGRICULTURAL ENGINEERING)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY (NERIST)
(Deemed to be University, U/S 3 Of the UGC Act, 1956)
Nirjuli (Itanagar), Arunachal Pradesh- 791 109

Department: Agricultural Engineering

Programme: M.Tech.in Farm Machinery and Power

Year-I						
Semester-I						
S.N.	**Course code**	**Course title**	**L**	**T**	**P**	**Credits**
1.	FMP7101	Tractor System Design –I	3	1	0	4
2.	FMP7102	Design of Farm Machinery	3	1	0	4
3.	FMP7103	Soil Dynamics in Tillage and Traction	3	0	2	4
4.	FMP7104	Principles of Ergonomics	3	0	2	4
5.	FMP 70**	Elective – I	3	0	0	3
6.	FMP70**/ MA70**	Elective – II	3	0	0	3
		Total	18	2	4	22
Semester-II						
S.N.	**Course code**	**Course title**	**L**	**T**	**P**	**Credits**
1.	FMP7201	Tractor System Design –II	3	1	0	4
2.	FMP7202	Instrumentation for Agricultural Machines	2	1	2	4
3.	FMP7203	Testing and Evaluation of Tractors and Farm Equipment	3	1	0	4
4.	FMP7204	Alternative Sources of Energy	3	0	2	4
5.	FMP70**	Elective – III	3	0	0	3
6.	FMP70**/ HS70**	Elective – IV	3	0	0	3
7.	FMP7251	Seminar	0	0	3	2
		Total	17	3	7	24
Year-II						
Semester-I						
S.N.	**Course code**	**Course title**	**L**	**T**	**P**	**Credits**
1.	FMP8199	Project (Part – I)	0	0	16	8
		Total				8
Semester-II						
S.N.	**Course code**	**Course title**	**L**	**T**	**P**	**Credits**
1.	FMP8299	Project (Part – II) Total	0	0	32	16
		Total				70

Elective -I and II						
S.N.	**Course code**	**Course title**	**L**	**T**	**P**	**Credits**
1.	FMP7001	Application of Programming in Farm Machinery Design and Management	2	0	2	3
2.	FMP7002	Material Science and Engineering for Selection and Design of Farm Machines	3	0	0	3
3.	FMP7003	Principles of Mechanization and Management	3	0	0	3
4.	FMP7004	Mechanization in Tea Production	3	0	0	3
5.	FMP7005	Safety and Health in Agriculture	3	0	0	3
6.	MA70**	Statistical Methods in Agriculture	2	1	0	3
7.	HS7005	Project Management	3	0	0	3

Elective-III and IV						
S.N.	**Course code**	**Course title**	**L**	**T**	**P**	**Credits**
1.	FMP7006	Precision Agricultural Machinery	3	0	0	3
2.	FMP7007	Bio-fuel Production and Application	3	0	0	3
3.	FMP7008	Earth Moving Machinery	3	0	0	3
4.	FMP7009	Computerized Design of Agricultural Machines	1	0	4	3
5.	FMP7010	Industrial Safety	3	0	0	3
6.	HS7006	Human Resource Management	3	0	0	3
7.	HS7002	Research Methodology	3	0	0	3

FMP7101 Tractor System Design – I: 4 Credits **(3-1-0)**

Unit 1	Engine performance characteristics, selection of engine for tractors. Design principles: engine components and engine systems.	8 lectures
Unit 2	Design of tractor chassis. Tractor stability analysis: Longitudinal and lateral stability.	10 lectures
Unit 3	Design of gearbox: Sliding mesh, constant mesh and Synchromesh gearbox. Design principles of CVT, automatic and dual clutch transmission.	10 lectures
Unit 4	Design of clutch: Positive and friction clutch. Design of brake: Shoe, band and disc type. Differential and final drive.	8 lectures
Unit 5	Design and selection of wheels and tracks. Recent advances and trends of design of tractors and its systems.	6 lectures

Recommended Books:

1. Engine and Tractor Power, Carroll E. Goering and Alan C. Hansen, American Society of Agricultural Engineers. St. Joseph, Michigan,2004.
2. Tractor and its Power Units, J.B. Liljedahl, W.M. Carleton, P.K. TurnquistandH. Makoto, 4 thEd., CBS Publishers & Distributors, New Delhi, 1997.
3. The Mechanics of Tractor - Implement Performance, R. H. Macmillan, University of Melbourne, 2002, printed from: http://www.eprints.unimelb.edu.au.

FMP7102 Design of Farm Machinery: 4 Credits **(3-1-0)**

Unit 1	Recent trends in design of farm machinery. Design of primary tillage implements: mouldboard plough, disc plough, chisel plough and subsoiler.	10 lectures
Unit 2	Design of secondary tillage implements: Single acting and double acting disc harrow, cultivator, and rotavator.	10 lectures
Unit 3	Design of seed drills and planter: Metering mechanism and power train. Design of vegetable and paddy transplanter.	9 lectures
Unit 4	Design of fertilizer applicator and plant protection equipment. Design of harvesting and threshing machines for cereals, pulses and root crops.	7 lectures
Unit 5	Design of different systems of combine harvester for grain crops. Design of tools for fruit, nut and vegetable harvesting.	6 lectures

Recommended Books:

1. Engineering Principles of Agricultural Machines, A.K.Srivastava, C.E. Goering and R.P.Rohrbach, ASAB E Publication, Michigan,1993.
2. Agricultural Machines, Theory and Construction, Vol. I and II.H.Bernacki, J. Haman and C.Z. Kanafojski, Scientific Publications, Foreign Cooperation Centre of the Central Institute for Scientific, Technic al and Economic Information, Warsaw, Poland,1972.
3. Farm Machinery Design: Principles and Problems, D.N. Sharma and S.Mukesh, 3rdEd., Jain Brothers, New Delhi, 2013.

FMP7103 Soil Dynamics in Tillage and Traction: 4 Credits **(3-0-2)**

Unit 1	Mechanical properties of soil: Shear strength, adhesion, cohesion, and Mohr-Coulomb theory of soil failure. Measurement techniques for stress strain parameters and cone index of soil.	10 lectures
Unit 2	Mechanics of wheel: Traction, towed and self-propelled wheel, rigid and elastic wheel. Mechanics of track. Traction parameters: Slip, rolling resistance, tractive effort, coefficient of traction.	8 lectures
Unit 3	Pneumatic wheels: Radial and bias ply tyre, specification, construction, load bearing capacity, deflection, contact area. Comparison of single and dual tyres.	8 lectures
Unit 4	Evaluation of traction device. Effect of soil type and conditions, normal load, tyre parameters. on traction performance. Ballasting and its effects.	8 lectures
Unit 5	Mechanics of simple tillage tools. Design consideration and performance evaluation of different tillage tools. Mechanics of rigid, rotary and oscillating tillage tools.	8 lectures

Recommended Books:

1 Soil Dynamics in Tillage and Traction, W.R. Gill and G.E. Vandenberg, ARS, USDA, 1968.

2 Theory of Land Locomotion, M.G. Bekker and Ann Arbor, The University of Michigan Press, Michigan, 19 56.

3 Soil Cutting and Tillage, E. McKeyes, Elsevier, Tokyo, 1985.

4 Theory of Ground Vehicles, J.Y. Wong, John Wiley and Sons Inc., New York, 1993.

FMP7104 Principles of Ergonomics: 4 Credits **(3-0-2)**

Unit 1	Definitions and development of ergonomics. Human-machine system. Anthropometry: Workspace design principles, seat design, tractor operator workplace layout.	6 lectures
Unit 2	Physical work: Work physiology, physiological strain, physical workload, muscle physiology, physical and muscular fatigue in agricultural operation. Working posture, Work-rest schedule.	10 lectures
Unit 3	Occupational exposure to environmental factors such as thermal, dust, chemical, noise and vibration. Health effects of environmental factors and reduction of exposure to agricultural workers.	10 lectures
Unit 4	Biomechanics and human motion, manual material handling, manual material handling hazards, musculoskeletal injuries and disorders.	8 lectures
Unit 5	Quantitative and qualitative visual displays, signals and warning lights, warning signs and warning labels, vision at the workplace.	8 lectures

Recommended Books:

1 Fitting the Task to the Man, E. Grandjean, Taylor and Francis, London, 1988.
2 Human Factors in Engineering and Design, M.S. Sanders, and E.J. McCormick, McGraw Hill Inc., Singapore, 1978.
3 Hand Book of Human Vibration,M.J. Griffin, Elsevier Academic Press,London, 1996.

FMP7201 Tractor System Design – II: 4 Credits **(3-1-0)**

Unit 1	Design of single point hitch. Design of three-point hitch systems: Parameters, virtual hitch point. Effect of hitch height on tractor performance with reference to hitch design. Weight transfer analysis.	8 lectures
Unit 2	Hydraulic oil and their properties. Fluid contamination and control: Filters and coolers. Hydraulic symbols. Hydraulic reservoirs and accumulators. Seals, hoses and fittings.	5 lectures
Unit 3	Hydraulic pumps and actuators: Construction, sizing, selection, and efficiency. Hydraulic pressure, flow and direction control valve.	9 lectures
Unit 4	Design of hydraulic circuits: Single and double action hydraulic cylinder, open and close centre, synchronizing, counterbalance, sequencing and fail safe. 9 lectures	9 lectures
Unit 5	Tractor hydraulic system: Neutral, lowering and lifting mechanism. Draft, position and mixed control system. Hydraulic system maintenance, repair and reconditioning. Power steering.	11 lectures

Recommended Books:

1 Power Hydraulics, M.J.Pinches and J. Ashby, Prentice Hall International (UK) Ltd., New York,1988.
2 Fluid Power with Applications, A.Esposito, Pearson Education Inc., 2003.
3 Off-Road Vehicle Engineering Principles, Carroll E. Goering,Marvin L. Stone, David W. Smith and Paul K. Turnquist, American Society of Agricultural Engineers, Michigan, 2003.

FMP7202 Instrumentation for Agricultural Machines: 4 Credits **(3-0-2)**

Unit 1	Generalized configuration, structure and functional description of measuring instruments. Active and passive transducer, analogue and digital mode of operation, null and deflection method.	6 lectures
Unit 2	Performance characteristics of instruments including static and dynamic. Transfer function, signals and noise. Static and dynamic errors, and their statistical analysis.	8 lectures
Unit 3	Measuring devices for temperature, displacement, stress, strain, force, pressure, velocity, torque, acceleration, moisture content, noise, vibration etc.	15 lectures
Unit 4	Signal conditioning elements: Deflection bridges,amplifiers etc. Signal processing elements and software: Analogue-to-digital (A/D) conversion, and digital-to-analogue conversion (D/A).	7 lectures
Unit 5	Data acquisition, manipulating, compiling and compensating devices. Data transmission and recording. Telemetry.	6 lectures

Recommended Books:

1 Principles of Measurement Systems,J.P.Bentley, Pearson Education Limited, England,2005.

2 Measurement Systems: Application and Design, E.O. Doebelin, McGraw Hill Co., New York, 1980.

3 Mechanical Measurements, T.G. Beckwith, N.L. Buck and R.D. Marangoni, Narosa Publishing House, New Delhi, 1982.

4 Instrumentation Measurement and Analysis, B.C. Nakra and K.K. Chaudhry, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1985.

FMP7203 Testing and Evaluation of Tractors and Farm Equipment:4 Credits **(3-1-0)**

Unit 1	Importance of testing, general regulations for testing, test terminologies. Types of test: Confidential, commercial and batch. Testing facilities in India and abroad for tractor and agricultural equipment. Test codes: OECD, Nebraska, ISO and BIS.	6 lectures
Unit 2	Agricultural tractor power test: PTO performance test, test for engine, belt pulley test, and drawbar test.	10 lectures
Unit 3	Test for hydraulic power, lifting capacity and maintenance of lift load. Air cleaner oil pull-over test, assessment of power drop and wear.	7 lectures
Unit 4	Safety test: Brake performance, CG location, turning ability and provisions of safety gadgets. Condition for correct steering. Ergonomic test: Noise measurement, mechanical vibration measurement, visibility from driver's seat, smoke level.	10 lectures
Unit 5	Testing of various farm machines and their main components for functional performance, wear, strength, force, and power requirement.	9 lectures

Recommended Books:

1 BIS Test Codes IS:9253-1979, IS:5994-1979, IS:10743-1986, IS:4468-1986, IS:9545-1986, IS:9934-1986, IS:11442-1985, IS:4931-1986, IS:12062-1986, IS:10273-1986, IS:9253-1986, IS:5608-1986, IS:6460-1980, IS:6288-1971, IS:6635-1972, IS:6638-1972, IS:6813-1973, IS:8122-1981, IS:10233-1986, IS:6816-1986, IS:6284-1986.

2 RNAM Test codes and Procedures for Farm Machinery, 2 nd Ed., United Nation International Development Organization, 1995.

FMP7204 Alternative Sources of Energy: 4 Credits **(3-0-2)**

Unit 1	Renewable Energy Sources (RES): National and international scenario and different protocols. Criteria for assessing the potential of RES, classification of RES: Solar, wind, geothermal, biomass, ocean energy sources.	6 lectures
Unit 2	Design of solar thermal devices. Natural and forced convection solar drying system. Solar PV system: Power generation and economic analysis.Solar pond: Working principle and design.	10 lectures
Unit 3	Aerodynamics of wind power generation and wind resources assessment. Types of wind turbines: Working principle of horizontal and vertical axis wind turbines.Design of wind turbine blades. Performance assessment of wind turbines. Economic analysis of wind turbine generation.	9 lectures
Unit 4	Biomass and its resources: Assessment and characteristics. Biomass to thermal energy conversions – principles and technologies: Combustion, gasification and pyrolysis.Economic analysis of bio-energy conversion.	9 lectures
Unit 5	Biomass – physical and biochemical conversion processes: Biogas, biodiesel and bioethanol. Types of different conversion technologies (transesterification, biochemical and anaerobic digestion) and their economic analysis.	8 lectures

Recommended Books:

1 Non-Conventional Sources of Energy, G. D. Rai, 4 thEd., Khanna Publishers, Delhi, 1996.

2 Non-Conventional Sources of Energy, O. P. Singhal, 1 stEd., SarojPrakashan, Allahabad, 1996.

3 Solar Energy, S. P. Sukhatme, 2 ndEd., Tata McGraw Hill Publishing Co. Ltd. New Delhi, 1996.

4 Biotechnology, other Alternative Technologies for Utilization of Biomass/Agricultural Wastes, A. Chakraborty, 1 stEd., Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 1989.

FMP7001 Application of Programming in Farm Machinery Design and Management: 3 Credits (1-0-4)

Unit 1	Review of applications of computer programming in agriculture. Application of loops and decisions, structures, functions, objects and classes, arrays and strings, and pointers in computer programming.	2 lectures
Unit 2	Solving the complex problems of agricultural machines using loops, functions and matrices. Use of data structures in computer programming.	3 lectures
Unit 3	Visual basic.net: GUI design, controls, data handling, input and output operations, decision making. Microsoft excel: Data handling, analysis, and presentation using graphs and charts.	3 lectures
Unit 4	Development of computer program for farm implements design and management, performance evaluation of tractor-implement combination and ballast management.	3 lectures
Unit 5	Computer programming for performance evaluation of tractor trailer combination, implement matching.	3 lectures

Recommended Books:

1 Let Us C, YashwantP. Kanetkar, Infinity Science Press, 2008.
2 Introduction to Programming with Visual Basic .NET, Gary J. Bronson and David Rosenthal, Jones and Bartlett Publishers, Boston, 2005.
3 Microsoft Excel Functions & Formulas, B. Held, Wordware Publishing, Inc., Massachusetts,2007.

FMP7002 Material Science and Engineering for Selection and Design of Farm Machines: 3 Credits (3-0-0)

Unit 1	Classification of engineering materials. Geometry of crystal: Space lattice, Space lattice and crystal structures. Determination of Crystal structure. Metallic bonding.	7 lectures
Unit 2	Crystal imperfections and dislocations. Phase diagram and phase transformation. Fracture: Ductile and brittle fracture.	10 lectures
Unit 3	Stress and strain in materials. plastic deformation; creep and mechanism of creep; elastic, anelatsic and viscoelastic behavior; Oxidation and corrosion	11 lectures
Unit 4	Mechanical property tests for martials: Destructive and non-destructive tests, tensile and compression test, shear test, fatigue test, hardness test, impact test.	8 lectures
Unit 5	Nonmetallic materials: Polymer, fibre, composite material, and ceramic materials; their types, properties, additives, and applications. Non-ferrous metals and their alloys. Use of metallic and nonmetallic materials in construction of farm machinery.	6 lectures

Recommended Books:

1 Material Science and Engineering – A first Course, V. Raghavan, 6th Ed., PHI Learning Pvt. Ltd., Delhi, 2015.
2 Introduction to Engineering Materials, B.K. Agrawal, Tata McGraw-Hill Education, Delhi, 1988.
3 Engineering Materials and Metallurgy, R.K. Rajput, 1st Ed.,S. Chand & Co. Ltd., New Delhi, 2006.

FMP7003 Principles of Mechanization and Management: 3 Credits (3-0-0)

Unit 1	Global review of farm mechanization. Mechanization and its stages. Mechanization and its link to development.	8 lectures
Unit 2	Selection of power units, machine capacity and field machinery management for stationary and mobile farm operation.	8 lectures
Unit 3	Cost analysis of farm machinery: Valuation of machines. Identifying, monitoring and reducing machinery costs. Break-even analysis.	9 lectures
Unit 4	Financing machinery, finance schemes and selection of appropriate scheme. Alternatives to ownership, contracting, hire schemes. Maintenance management. Machinery replacement.	9 lectures
Unit 5	Analysis and organization of various operation management programmes. Inventory control of spare parts, work study, productivity, method study, use of computer in machinery management.	8 lectures

Recommended Books:

1 Farm Machinery Selection, Investment and Management, Resource Management Series, A.Landers, Farming Press,2002.
2 Farm Power and Machinery Management,D. Hunt, Iowa State University Press, Ames,2001.

FMP7004 Mechanization in Tea Production: 3 Credits (3-0-0)

Unit 1	Tea industry in India. Present status and economic importance. Cultivation of tea and equipment required for the mechanized cultivation.	6 lectures
Unit 2	Drainage of water-logged soils, irrigation practices, pest management and weed control in tea plantation.	6 lectures
Unit 3	Tea plucking: Time and motion studies on tea plucking. Chemistry of tea quality. Various manufacturing processes of black tea and green tea. Design of tea processing machines and selection of power sources.	12 lectures
Unit 4	Tasting, blending, grading and sorting, packaging of tea. Instrumentation, monitoring and process control systems for critical manufacturing stages in Tea Industry.	10 lectures
Unit 5	Transport and marketing,tea auction. Management of tea gardens and factory. Estate and worker productivity.	8 lectures

Recommended Books:

1 Tea Production and Processing, B.Banerjee, Oxford & IBH Publishing Co Pvt. Ltd., New Delhi, 2005.

FMP7005 Safety and Health issues in Agriculture: 3 Credits (3-0-0)

Unit 1	Tractor hazards such as instability, runover, power-take-off (PTO); machinery hazards; respiratory hazards in structure and environment; chemical and other hazards.	9 lectures
Unit 2	Definition and causes of accident; severity of injury; effect of season, workplace, age, working time. Agricultural injury scenario in national and international level.	9 lectures
Unit 3	Occupational safety and health principles in agriculture; Hazards and injury prevention and control: industrial safety and health approach, public health approach.	11 lectures
Unit 4	Safety engineering principles; Hierarchy hazard control; roll over protective structure (ROPS); warning sign and warning labels; machine guarding.	9 lectures
Unit 5	Provincial, national and international regulations and legislation for prevention of accidents; injury compensation.	4 lectures

Recommended Books:

1 Safety and Health for Production Agriculture, D.J.Murphy, ASAE publications, Michigan, 1992.
2 System Safety Engineering and Management, H. E. Roland and B.Moriarty, John Wiley and Sons Inc.,New York,1990.
3 Safety Engineering,James CoVan, Wiley, New York, 1995.

FMP7006 Precision Agricultural Machinery: 3 Credits (3-0-0)

Unit 1	Basics of precision agriculture, tools for implementation of precision agriculture. Information Technology. Spatial location, GPS, computer vision systems, information acquisition.	8 lectures
Unit 2	Site-specific nutrient management, data sources and decision making for site-specific nutrient management. Economic, ecological and social impacts of site-specific nutrient management. Grain quality and yield.	9 lectures
Unit 3	Site-specific weed management, weed distribution, stability of weed populations, weed monitoring and control. Site-specific herbicide application. Agro-chemicals and fertilisers, patch spraying.	9 lectures
Unit 4	Use of microprocessor based systems and computer in precision agriculture, Automation.	8 lectures
Unit 5	Crop yield monitors. Decision support systems; artificial intelligence. Remote sensing for precision agriculture. Field plot machines.	8 lectures

Recommended Books:

1 The Precision Farming Guide for Agriculturists, D. Ess, M.Morgan, and R.Reynolds, John Deere Publishing. USA,1997.
2 Precision Agriculture for Grain Production Systems, B.Whelan andJ.Taylor, Csiro Publishing, Collingwood, Australia, 2013.
3 Precision Agriculture Technology for Crop Farming, Q.Zhang, CRC Press, Boca Raton, Florida, 2016.

FMP7007 Bio-fuel Production and Application: 3 Credits **(3-0-0)**

Unit 1	Biofuel: Introduction, sources and comparison of different types of biofuel. Solid, liquid and gaseous biofuels. Economics of different biofuel sources and comparative analysis with reference to fossil fuels.	8 lectures
Unit 2	Biodiesel: Scope, sources, merits and demerits, cultivation practices of different sources of biodiesel. Physical and chemical properties of raw bio-diesel. Extraction, refining processes. Bioethanol: Sources, production process, merits and demerits	11 lectures
Unit 3	Anaerobic digestion: Design and its uses.	7 lectures
Unit 4	Biomass gasification: Pyrolysis, design theory and modelling of gasifier.	9 lectures
Unit 5	Performance of engine with different types of bio-fuels, exhaust and impact on environment.	7 lectures

Recommended Books:

1 Bio-diesel: Basics and Beyond: A comprehensive guide to production and use for Home and Farm, William H. Kemp, New Society Publishing, Canada, 2006.
2 Biodiesel Production Technologies, S.K. Mehta, Eastern Book Corporation, New Delhi, 2007.
3 Biofuels: Production, Application and Development, A.H.Scragg, CAB International, London, 2009.
4 Biomass Gasification and Pyrolysis: Practical Design and Theory, P.Basu, Elsevier Academic press, London, 2010.

FMP7008 Land Grading and Earth Moving Machinery: 3 Credits **(2-0-2)**

Unit 1	Types of earth moving machinery. Crawler tractor: Differential, brake, clutch, suspension, track-assembly, and their repair and maintenance.	8 lectures
Unit 2	Principles of operation of bulldozer, front end loader, excavator, power shovels, etc. and their applications in agricultural operations.	6 lectures
Unit 3	Principles of operation of ditchers, scrapers, leveller, roller, grader and dump truck and their applications in agricultural operations.	6 lectures
Unit 4	Boring machines and different methods of boring. Load hoisting equipment and their applications in agricultural operations.	4 lectures
Unit 5	Trouble shooting, repair and maintenance, cost of operation, and management of earth moving machines.	4 lectures

Recommended Books:

1 Land Reclamation Machinery, T. Borshchow, R. Mansurou and V. Sergeev, 1 st Ed.,MIR Publication, Moscow, 1988.
2 Manual of Tractor, J. Konrod, Asia Publishing House, London, 1968.
3 Motor Grader, E.G. Roninson, MIR Publication, Moscow, 1985.

FMP7009 Computerized Design of Agricultural Machines: 3 Credits **(1-0-4)**

Unit 1	Introduction to AutoCAD: Screen components, invoking commands, dialog boxes, saving, closing and managing workspaces.	3 lectures
Unit 2	Coordinate systems, object selection methods, setting units type and precision. Dimension: Fundamental dimensioning terms, creating linear, angular, inspection and associative dimensions.	2 lectures
Unit 3	Drawing different two dimensional objects. Hatching patterns, editing sketched objects. Creating text and tables: Annotative objects, creating and editing text, inserting table in the drawing.	3 lectures
Unit 4	Solid modelling: Creation of three dimensional machine components. Using Soildworks. Geometric dimensioning and tolerance: Characteristics and symbols used.	3 lectures
Unit 5	Digital human modelling: Use of percentile anthropometric and biomechanical data for agricultural tools and equipment design, techniques/ process of virtual ergonomics evaluation using DHMs,	3 lectures

Recommended Books/ Study materials:

1 Mastering AutoCAD 2016 and AutoCAD LT, Brian C. Benton and George Omura, Autodesk Official Press, 2016.

2 Engineering Drawing and Graphics Using AutoCAD, T. Jeyapoovan, 3rd Ed.,Vikas PublishingHouse Pvt Limited, New Delhi, 2010.
3 SolidWorks2016 Reference Guide, D.Planchard, SDC Publications, 2016.
4 Handbook of Digital Human Modelling, V.G.Duffy, CRC Press, Boca Raton, Florida, 2008.

FMP7010 Industrial Safety: 3 Credits **(3-0-0)**

Unit 1	Definition and classification of hazards. Hazardous materials: Classification, characteristics, means of exposure and health effect, disposal. Hazard information label, safety precautions.	8 lectures
Unit 2	Explosive and flammable materials: Types, classification, characteristics, safety signs, material handling. Engineering and administrative safety control.	10 lectures
Unit 3	Fire safety: Causes, safety concept, extinction methods, and fire-fighting equipment. Building safety: means of escape, evacuation strategies and procedure, fire and smoke prevention.	10 lectures
Unit 4	Electrical hazards: Causes and types of electrical injuries, general electrical safety rules, PPE. Welding: Types, health hazards of welding, reducing hazards of welding. 8	8 lectures
Unit 5	Hazard communication, medical surveillance, safety legislation, safety management.	6 lectures

Recommended Books:

1 Introduction to Fire Safety Management, A.Furness and M. Muckett, Butterworth-Heinemann, Oxford, 2010.
2 System Safety Engineering and Management, H. E. Roland and B. Moriarty, John Wiley and Sons Inc., New York, 1990.
3 Safety Engineering, James CoVan, Wiley, New York, 1995.

FMP7011 Modelling and Simulation for Agricultural Applications:3 Credits **(1-0-4)**

Unit 1	Introduction to MATLAB & data presentation: Vectors, matrices, and their operations and manipulations. Functions vs scripts. Introduction to different types of plots. Making clear and compelling plots.	3 lectures
Unit 2	Linear algebra and least Squares: Solving systems of linear equations. Least squares regression and curve fitting.	2 lectures
Unit 3	Ordinary differential equations: Numerical integration and solving 1st order, ordinary differential. System of ordinary differential equations: Converting 2nd order and higher ODEs to systems of 1st order ODEs. Solving systems of ODEs.	3 lectures
Unit 4	Introduction to dynamic systems. Modelling of mechanical and electrical systems in ordinary different equations. Transfer functions and block diagrams. Time response of dynamic systems to input commands.	3 lectures
Unit 5	Introduction to Simscape® for modelling of physical systems. Using Simscape ® for modelling different tractor subsystems like body and tire, braking system, hydraulics, suspension etc.	3 lectures

Recommended Books:

1 Numerical Methods for Engineers and Scientists: An Introduction with Applications Using MATLAB, Amos Gilat and Vish Subramiam. Wiley, 2008.
2 Klee, H. and Allen, R. Simulation of Dynamic Systems with MATLAB and Simulink, 2nd Ed., 2011, CRC Press.
3 Malab/Simulink User Guides (http://www.mathworks.com/help/techdoc/)
4 University of Michigan. Control Tutorials MATLAB, http://www.engin.umich.edu/group/ctm/

MA70 Statistical Methods in Agriculture:3 Credits** **(2-1-0)**

Unit 1	Probability, random variable, discrete and continuous random variables and their probability distribution, distribution functions and their properties	7 lectures
Unit 2	Conditional probability, independence of events, Bayes theorem, mathematical expectation, moments and moments generating function	6 lectures
Unit 3	Tests of hypothesis for small and large sample sizes	6 lectures

Unit 4	Methods of east squares, simple linear regression and correlation, multiple linear regression	6 lectures
Unit 5	Design and analysis of experiments: analysis of variance for one and two-way classified data, CRD, RBD and LSD	3 lectures

Recommended Books:

1 Fundamentals of Statistic,Vol. I and II, A.M. Groom, M.K. Gupta and B.Dasgupta, The Works Press Pvt. Ltd., Kolkata.
2 Introduction to Probability and Mathematical Statistics,V.K.Rohatgi, Wiley Eastern, New Delhi, 1976.
3 Experimental Design,W.G. Cochran and G.M. Cox, John Wiley and Sons, 1966.
4 Design and Analysis of Experiments,M.N. Das and J. Giri, Springer Verlag.

HS70 Project Management:3 Credits (3-0-0)**

Unit 1	Definition of Project, Need of Project Management, Project Development Cycle, Project Planning, Project Environment analysis, Project Report Preparation; Preliminary Screening, and Feasibility Report preparation and analysis.	8 lectures
Unit 2	Project Evaluation; Market and Demand analysis, Demand Forecasting, Technical, Financial, Socio-economic, Environmental and Entrepreneurial analyses of project, Project Selection Criteria, Project Implementation.	8 lectures
Unit 3	Resource Planning and Allocation, Estimation of Project Cost, Cost of Capital, Means of Finance, Working Capital requirement, Profitability projection, Cash Flow Analysis, Beak-even analysis.	9 lectures
Unit 4	Financial Analysis, Financial Statements, Balance Sheet, Ratio Analysis, Depreciation of Fixed Assets, Social Benefit-Cost Analysis.	9 lectures
Unit 5	Project Review Techniques, Network Technique, Programme Evaluation Review Technique (PERT), Network scheduling, CPM, Activity scheduling, Time-cost trade-offs.	8 lectures

Recommended Books:

1 Project Management,R.Panneerselvamand P. Senthilkumar, PHI, New Delhi, 2009.
2 Project Management for Business and Technology,J.M. Nicholas, Pearson Education, New Delhi, 2009.
3 Project Formulation, Implementation and Appraisal,P. Chandra, Tata McGraw-Hill, New Delhi, 2006.
4 Financial Management,P. Chandra, Tata McGraw-Hills Publishing Co. Ltd., New Delhi,
5 Project Management,H.Kerzner, CBS Publisher and Distributor, New Delhi, 2004.

HS70 Human Resources Management:3Credits (3-0-0)**

Unit 1	Theoretical foundations of HRM, HRD- an overview, Macro level manpower planning and Labour Market analysis, Organizational human resource planning (HRP).	8 lectures
Unit 2	Market, Business, Competition and Strategy, HRD strategies, design and experience, Manpower inventory, Models and techniques of manpower Demand and Supply forecasting.	8 lectures
Unit 3	Design of HR Systems for Competitive Advantage, HRD culture and climate, Behavioural factors in human resource planning-Wastage analysis, Retention, Redeployment, Exit strategies.	9 lectures
Unit 4	Career development, HRD climate and culture, QWL, Management of change. Managing Growth: People Agenda, Managing Change: People Agenda.	8 lectures
Unit 5	HRM for Corporate Globalization, HR for Mergers, Acquisitions and Joint Ventures, Emerging trends and experiences, TQM and HRD strategies, Human resource information system (HRIS), Human resource valuation and Accounting (HRA).	9 lectures

Recommended Books:

1 Strategic Human Resource Development,T.Agarwala, FMS, Delhi University, New Delhi,
2 Strategic Human Resource Development - A Guide to Action, M. Armstrong, Kogan Page Publications, New Delhi,
3 HR: Development, Planning and Deployment, A.K.Sen, Asian Books Pvt. Ltd., New Delhi.

HS70 Research Methodology:3Credits** **(3-0-0)**

Unit 1	Introduction to Research Methodology: Importance of Research in Decision Making, Defining Research Problem and Formulation of Hypothesis, Experimental Design.	9 lectures
Unit 2	Data Collection and Measurement; Methods and Techniques of Data Collection, Sampling and sampling Designs, Data Presentation and Analysis; Data Processing.	9 lectures
Unit 3	Attitude Measurement and Scales; Statistical Analysis and Interpretation of Data, Non-Parametric Tests, Multivariate analysis of Data.	8 lectures
Unit 4	Measures of Central Tendency, Dispersion, Variation, Correlation, Regression, Model building and Decision Making.	9 lectures
Unit 5	Report Writing and Presentation: Substance of Reports, formats of Reports, Presentation of Report.	7 lectures

Recommended Books:

1 Research Methodology,C.R. Kothari, New Age Publications, New Delhi,
2 Research Methodology,B. Taylor, G.Sinhaand T.Ghoshal, Prentice Hall of India, New Delhi,
3 Research Methodology,R.Panneersalvam, Prentice Hall of India, New Delhi, 2007.
4 Management Research Methodology,K.N.Krishnaswamy, A.I.Sivakumarand M.Mathirajan, Pearson Education, New Delhi, 2008.

Department: Agricultural Engineering

Programme: M.Tech. in Soil and Water Conservation Engineering

Year-I						
Semester – I						
S.N.	**Course code**	**Course title**	**L**	**T**	**P**	**Credits**
1.	SWC7101	Hydrologic Elements and Analysis	3	1	0	4
2.	SWC7102	Irrigation System Design	3	0	2	4
3.	SWC7103	Open Channel Hydraulics	3	1	0	4
4.	SWC7104	Advanced Soil Conservation Measures	3	1	0	4
5.	SWC70**	Elective I	3	0	0	3
6.	SWC/MA/HS70**	Elective II	3	0	0	3
		Total	18	3	2	**22**
Semester - II						
S.N.	**Course code**	**Course title**	**L**	**T**	**P**	**Credits**
1.	SWC7201	Groundwater Hydrology	3	1	0	4
2.	SWC7202	Design of Agricultural Drainage Systems	3	1	0	4
3.	SWC7203	Water Resources System Analysis	3	1	0	4
4.	SWC7204	Geoinformatics for Land and Water Management	2	0	4	4
5.	SWC7251	Seminar	0	0	3	2
6.	SWC70**	Elective III	3	0	0	3
7.	SWC/HS70**	Elective IV	3	0	0	3
		Total	**17**	**3**	**7**	**24**
Year – II						
Semester – III						
S.N.	**Course code**	**Course title**	**L**	**T**	**P**	**Credits**
1.	SWC8199	Project (Part I)	0	0	16	8
		Total				**8**
Semester – IV						
S.N.	**Course code**	**Course title**	**L**	**T**	**P**	**Credits**
1.	SWC8299	Project (Part II)	0	0	32	16
		Total				**16**
Grand Total						**70**
Elective – I and II						
S.N.	**Course code**	**Course title**	**L**	**T**	**P**	**Credits**
1.	SWC7001	Application of Computer Programming in Soil and Water Engineering	1	0	4	3
2.	SWC7002	Integrated Watershed Management and Modelling	3	0	0	3
3.	SWC7003	Hydrological Modelling of Small Watersheds	3	0	0	3
4.	SWC7004	Soil-Water-Plant Relationships	3	0	0	3
5.	SWC7005	Pumping Systems	3	0	0	3
6.	MA70**	Statistical Methods in Agriculture	2	1	0	3
7.	HS7005	Project Management	3	0	0	3
Elective - III and IV						
S.N.	**Course code**	**Course title**	**L**	**T**	**P**	**Credits**
1.	SWC7006	Stochastic Hydrology	3	0	0	3
2.	SWC7007	Climate Change and Water Resources	3	0	0	3
3.	SWC7008	Water Resources Planning and Management	3	0	0	3
4.	SWC7009	Flow Through Porous Media	3	0	0	3
5.	SWC7010	Advances in Crop Irrigation Management	3	0	0	3
6.	HS7006	Human Resource Management	3	0	0	3
7.	HS7002	Research Methodology	3	0	0	3

SWC7101 Hydrologic Elements and Analysis: 4 Credits **(3-1-0)**

Unit 1	Hydrologic processes and systems; Hydrologic characteristics of watersheds; Water balance: components, development of equations for different catchment conditions	8 lectures
Unit 2	Measurement, estimation, analysis and modelling of hydrologic components: precipitation, infiltration, evapotranspiration, runoff	10 lectures
Unit 3	Hydrograph analysis: Unit hydrograph, Instantaneous unit hydrograph, Synthetic unit hydrograph	10 lectures
Unit 4	Estimation of peak flood; flood routing (reservoir and channel routing)	8 lectures
Unit 5	Definition and concept of different types of hydrologic models for simulation of hydrologic problems	6 lectures

Recommended Books:

1 Applied Hydrology,V.T. Chow,D.MaidmentandL.W.Mays,McGraw-Hill,1988.
2 Hydrology and Soil Conservation Engineering, G.Das,PHI Learning India Pvt. Ltd., New Delhi, 2000.
3 Watershed Management,E.M.Tideman, Omega Scientific Publication, 1996.
4 Elementary Hydrology, V.P.Singh, Prentice-Hall,1994 .

SWC7102 Irrigation Systems Design: 4 Credits **(3-0-2)**

Unit 1	Concept of irrigation; irrigation principles; losses, conveyance, distribution, application, scheduling, estimation of crop water requirement	8 lectures
Unit 2	Border irrigation: hydraulics, design and evaluation	10 lectures
Unit 3	Basin irrigation: hydraulics, design and evaluation; Furrow irrigation: hydraulics, design and evaluation	8 lectures
Unit 4	Sprinkler irrigation system: design criteria for sprinkler irrigation, hydraulics and system layout, design of lateral, sub-main and main lines; evaluation of sprinkler systems	8 lectures
Unit 5	Drip irrigation system: design criteria for drip irrigation, hydraulics and system layout, selection of emitters, design of lateral, sub-main and main lines; evaluation of drip irrigation systems	8 lectures

Recommended Books:

1 Design and Operation of Farm Irrigation System,M.E. Jensen, ASAE Publication, 1980
2 Irrigation: Theory and Practice,A.M.Michael, Vikas Publishing House, New Delhi,2012.
3 Principles of Sprinkler Irrigation Systems,M.S.Mane andB.L.Ayare, Jain Brothers, New Delhi, 2007.
4 Principles of Drip Irrigation Systems, M.S.Mane, B.L.AyareandS.S.Magar, Jain Brothers, New Delhi,200 6.
5 Micro Irrigation – Theory and Practices, R. Suresh, Standard Publishers Distributors,2010.
6 Micro irrigation for Crop Production, Developments in Agricultural Engineering Series, Vol. 13, F.R.Lamm, J.E.Ayars and F.S.Nakayama, Elsevier, Oxford, 2007.

SWC7103 Open Channel Hydraulics: 4 Credits **(3-1-0)**

Unit 1	Open channel and their properties, energy and momentum, critical flow computation and application	8 lectures
Unit 2	Uniform flow and flow resistance; Sheet flow; Concepts of boundary layer and surface roughness; Theoretical uniform flow equations; Instability of uniform flow	8 lectures
Unit 3	Gradually varied flow; Flow profile classification and computation methods; Flow profiles in natural channels; Spatially varied flow	8 lectures
Unit 4	Hydraulic jump and its use as energy descipator, flow through channel of non-linear alignment and flow through non-prismatic channel sections.	10 lectures
Unit 5	Unsteady flow, gradually varied unsteady flow and rapidly varied unsteady flow.	8 lectures

Recommended Books:

1 Open Channel Flow,M.H.Chaudhry, Prentice Hall,1993.
2 Open Channel Hydraulics,V.T.Chow, McGraw-Hill, 1959.
3 Open Channel Flow,F.M.Henderson, McMillan,1966.
4 Open Channel Hydraulics, T.Sturm, McGraw-Hill, 2009.

SWC7104 Advanced Soil Conservation Measures: 4 Credits **(3-1-0)**

Unit 1	Mechanics of soil erosion and its estimation; sediment deposition process; impact of conservation practices on environment; major conservation practices	6 lectures
Unit 2	Layout and planning of soil and water conservation measures; design principles of soil and water structures including contour bunds and terraces; gully control measures	10 lectures
Unit 3	Soil conservation structures: hydrologic, hydraulic and structural design of permanent gully control structures	12 lectures
Unit 4	Earthen dams, seepage through dams and stability analysis	8 lectures
Unit 5	Flood control and stream bank protection measures	6 lectures

Recommended Books:

1 Hydrology and Soil Conservation Engineering, G. Das, Prentice Hall, 2000.
2 Land and Water Management Engineering, V.V.N.Murthy, Kalyani Publishers, 2008.
3 Irrigation Engineering and Hydraulic Structures, SK Garg, Khanna Publishers, Delhi, 2009.
4 Soil and Water Conservation Engineering,G.O.Schwab, D.D.Fangmeier, W.J.Elliot andR.K.Frevert, John Wiley and Sons, 1993
5 Mechanics of Sediment Transport and Alluvial Stream Problems ,R.J.GardeandK.G.RangaRaju, Wiley Eastern Ltd., 1977.
6 Soil Erosion and Conservation,R.P.C.Morgan,Blackwell Publishing, 1986.
7 A Manual on Conservation of Soil and Water USDA, Oxford & IBH, 1969.

SWC7201 Ground Water Hydrology: 4 Credits **(3-1-0)**

Unit 1	Ground water development in India; Aquifers: types, properties, determination of specific yield - laboratory and field methods, evaluation of aquifer properties	8 lectures
Unit 2	Properties affecting groundwater storage and movement; groundwater balance	8 lectures
Unit 3	Well hydraulics, 2D flow, steady and unsteady state flow in confined and unconfined aquifer, steady flow in semi confined aquifer, steady flow in sloping aquifers and in partial penetrating wells	10 lectures
Unit 4	Design and construction of tube wells	8 lectures
Unit 5	Groundwater development and modelling	8 lectures

Recommended Books:

1 Ground Water Hydrology, D.K. Todd, Wiley Eastern, 1997.
2 Ground Water, H.M.Raghunath, Wiley Eastern, 1992.
3 Concept and Models in Groundwater Hydrology, P.A.Domenico, McGraw-Hill, 1972.
4 Numerical Groundwater Hydrology, A.K.Rastogi, Penram International Publishing, Mumbai, 2007.

SWC7202 Design of Agricultural Drainage System: 4 Credits **(3-1-0)**

Unit 1	Concept of drainage: importance and benefits, interrelationship of irrigation and drainage, soil properties influencing drainage; surveys and investigations: determination of aquifer characteristics, determination of hydraulic conductivity - laboratory and field methods; drainable porosity and its importance in drainage design	8 lectures
Unit 2	Theories and application of surface and subsurface drainage; steady state, unsteady state drainage equations	10 lectures
Unit 3	Surface drainage system: types, components, design - for flat and sloping lands	8 lectures
Unit 4	Subsurface drainage system: types, components; principles and application of steady state and unsteady state equations	8 lectures
Unit 5	Salt balance and leaching requirement; reclamation and management of salt affected soils; special drainage conditions	8 lectures

Recommended Books:

1 Land drainage – Principles, Methods and Applications,A.K.Bhattacharya and A.M.Michael, Konark Publication Pvt. Ltd., New Delhi, 2006.
2 Text book of Drainage Engineering,R.Kumar andJ.Singh, ICAR Publication, 2005.
3 Drainage Engineering,J.N.Luthin, Wiley Eastern, 1978.
4 Drainage Principles and Applications. H. P. Ritzema (Editor), International Institute for Land Reclamation and Improvement. The Netherlands.,1994.

SWC7203 Water Resources System Analysis: 4 Credits (3-1-0)

Unit 1	Concepts and significance of optimization in water resources, objective functions, deterministic and stochastic inputs	6 lectures
Unit 2	Mathematical programming techniques, linear programming and its extension, simplex method, revised simplex method, simplex method-duality	10 lectures
Unit 3	Transportation problem, Non-linear programming of simple cases	10 lectures
Unit 4	Dynamic programming-multi stage decision process, goal programming	10 lectures
Unit 5	Application of optimization techniques for water resources	6 lectures

Recommended Books:

1 Operations Research: Principles and Practice,A.Ravindran, D.T.Phillips andJ.J.Solberg, Wiley Publica tion, 2007.
2 Operations Research: An Introduction,H.A. Taha, Pearson, 2016.
3 Operations Research,P.K. Gupta and D. S. Hira, S. Chand &Company Ltd.,2005.
4 Water Resources Systems Planning and Management,M.C.Chaturvedi, McGraw-Hill, 1987.
5 Water Resources Systems Modelling Techniques and Analysis, S. Vedula, P. P. Mujumdar, Tata McGraw-Hill Publishing Company Limited, New Delhi,2007.

SWC7204 Geo-informatics for Land and Water Management: 4 Credits (2-0-4)

Unit 1	Remote sensing: fundamentals, physics of remote sensing, electromagnetic radiation, interaction of ENR with atmosphere, earth surface, soils, water and vegetation.	6 lectures
Unit 2	Data acquisition; photographic system and imaging systems; visible, NIR, SWIR, and TIR imagery; photogrammetry: vertical photographs, photo interpretation, visual analysis, stereoscopic analysis.	6 lectures
Unit 3	Digital image processing: image rectification, enhancement, classification and its accuracy.	6 lectures
Unit 4	Geographic Information System (GIS) approach to integration of spatial and attribute data for capturing, analysis, manipulation and portrayal of natural resources; data types/ formats; integration of GIS with remote sensing and Global Positioning System	6 lectures
Unit 5	Application of RS and GIS technologies in water resources and watershed management; case studies	4 lectures

Recommended Books:

1 Remote Sensing and Image Interpretation,T.M.Lillesand and R.W.Keifer, John Wiley and Sons Inc., New York, 2000.
2 Concept and Techniques of Geographic Information System, C.P.Lo and A.K.W.Yeung, PHI Learning Pvt. Ltd., 2002.
3 Remote Sensing in Water Resources,Ramasamy SM, Rawat Publication, 2005.
4 Fundamentals of Geographic Information System,M.N.Demers, John Willey & Sons, 2005.
5 Remote Sensing and its Applications,L.R.A.Narayan, Universities Press, 1999.

SWC7001 Application of Computer Programming in Soil and Water Engineering: 3 Credits (1-0-4)

Unit 1	Introduction to programming and problem solving; programming basics: loops and decisions; structures; functions; objects and classes; arrays and strings; pointers	3 lectures
Unit 2	Overview of different programming platform and languages: Microsoft Excel Macro, Matlab, C, C++, Python, VBA, Visual Studio, GUI design	4 lectures
Unit 3	Estimation of hydrologic elements by programming	3 lectures
Unit 4	Writing programs for simple rainfall-runoff models	2 lectures
Unit 5	Writing programs for soil conservation structure designing	2 lectures

Recommended Books:

1 Programming Microsoft Visual Basic 6.0, F.Balena, Microsoft Press, 1999.
2 Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers,R.Pratap, Oxford Univ ersity Press, 2016.
3 Matlab Programming, Y.K.Singh andB.B.Choudhuri, Prentice Hall, 2007.
4 Object-Oriented Programming in C++, R.Lafore, Sams Publishing, 2001.
5 Learn Python the Hard Way, Z.A.Shaw, Addition Wesley, Massachusetts, 2 014.

SWC7002 Integrated Watershed Management and Modelling: 3 Credits (3-0-0)

Unit 1	Concept of integrated watershed management; consequences of watershed deterioration; watershed management strategies and responses to problems	8 lectures
Unit 2	Farming system and production technology in watershed; use of agro-forestry in management of hilly watersheds	10 lectures
Unit 3	Concept of operational watershed, national land use policy, legal and social aspects	8 lectures
Unit 4	Watershed modelling: scope, classification, technology and analysis, case studies	8 lectures
Unit 5	Watershed planning processes, watershed and environment, monitoring and evaluation of watershed projects	8 lectures

Recommended Books:

1 Watershed Planning and Management,R.V.Singh, Yash Publishing House, Bikaner,2000.
2 Hydrology and Soil Conservation Engineering: Including Watershed Management,G.Das, Prentice-Hall of India Learning Pvt. Ltd., New Delhi, 2008.
3 Watershed Management,V.DhruvaNarayana, G.SastryandU.S.Patnaik, ICAR Publication, New Delhi, 1997.
4 Integrated Watershed Management: Principles and Practice,I.W.Heathcote, John Wiley & SonsInc., New Jersey, 2009.
5 Hydrology and the Management of Watersheds, K.N.Brooks, P.F.Folliott, H.M.Gregersen andL.F.DeBano, Wiley-Blackwell,1991.

SWC7003 Hydrological Modeling of Small Watershed: 3 Credits (3-0-0)

Unit 1	Hydrological modeling of small watershed: introduction, physical characteristics of watersheds, instrumentation and data collection, generation of hydrologic information	8 lectures
Unit 2	Hydrologic simulation overview: types of mathematical models, hydrologic simulation models: classification, components, steps; Optimization models in hydrology	10 lectures
Unit 3	Erosion and sediment yield: sediment yield process and modelling	8 lectures
Unit 4	Event Based Streamflow Simulation (EBSS): data needs, structure, building of EBSS models, calibration parameters, example EBSS models	8 lectures
Unit 5	Continuous Streamflow Simulation (CSS): data needs, parameter estimation, building of CSS models, example CSS models	8 lectures

Recommended Books:

1 Introduction to Physical Hydrology,M.R.Hendricks, Oxford University Press, New York,2010.
2 Hydrology of Small Watersheds,P.V.Seethapathi, D.DuttaandR.S.Kumar, TERI Press, Darbari Seth Block, New Delhi,2008.
3 Elementary Hydrology, V.P.Singh, Prentice-Hall of India Pvt. Ltd., New Delhi,1994.
4 Introduction to Hydrology,W.ViessmanandG.L.Lewis, Prentice-Hall of India Pvt. Ltd., New Delhi,2008.
5 Remote Sensing and its Applications,L.R.A.Narayan, University Press (India) Ltd., Hyderabad, 1999.
6 Remote Sensing in Water Resources,S.M.Ramasamy, Rawat Publications, Jaipur, 2005.

SWC7004 Soil-Water-Plant Relationships: 3 Credits (3-0-0)

Unit 1	Soil properties affecting irrigation: soil structures, soil wetness, soil bulk density, soil consistency, soil fertility; plant factors affecting irrigation	8 lectures
Unit 2	Energy relationship in soil and plant, measurement of soil water and water potential, water flow through saturated and unsaturated soils	8 lectures
Unit 3	Flow of water through soil-plant-atmosphere continuum, soil moisture retention and movements, soil water potential	10 lectures
Unit 4	Rooting characteristics and moisture use of crops: evaporation, transpiration and consumptive use, measurement of evapotranspiration, crop coefficient and its use	8 lectures
Unit 5	Crop growth and yield modelling	8 lectures

Recommended Books:

1 Irrigation Theory and Practice,A.M.Michael, Vikas Publishing HousePvt. Ltd., New Delhi,1990.
2 Irrigation Water Management – Principles and Practice,D.K.Majumdar, PHILearning Pvt. Ltd., New Delhi, 2013.

SWC7005 Pumping System: 3 Credits **(3-0-0)**

Unit 1	Water lifts: indigenous and modern devices	4 lectures
Unit 2	Basic design of centrifugal pumps; its operation, installation and efficiency	10 lectures
Unit 3	Principle and performance characteristics of turbine pumps, submersible pumps and axial flow pumps and their selection and design criteria	10 lectures
Unit 4	Non-conventional energy sources for pumping, wind mills, solar pumps, hydraulic ram - their selection and design criteria	8 lectures
Unit 5	Criteria for pump selection and matching of prime movers, design of pumping station, techno-economic evaluation	10 lectures

Recommended Books:

1 Water Well and Pump Engineering, A.M.Michael andS.D.Khepar, Tata McGraw-Hill Co. Ltd., New Delhi, 2003.
2 Centrifugal Pumps and Blowers,A.H.Church andJagdishLal,Metropolitan Book Co., 1973.
3 Hydraulic and Fluid Mechanics,P.N.ModiandS.M.Seth, Standard Book House,2000.

SWC7006 Stochastic Hydrology: 3 Credits **(3-0-0)**

Unit 1	Probabilistic modelling of hydrological process: data requirement, plotting position, continuous probability distribution functions, parameter estimation techniques, goodness of fit test, estimation of return period	10 lectures
Unit 2	Risk and reliability concept in hydrology: Computation of risk, discrete probability distribution functions	8 lectures
Unit 3	Time series analysis and forecasting of hydrological processes, sequential generation of hydrological data, stream flow forecasting	12 lectures
Unit 4	Regional frequency analysis, analysis of low flows	8 lectures
Unit 5	Range and storage analysis	4 lectures

Recommended Books:

1 Statistical Methods in Hydrology, C.T.Hann, East West Press, 2002.
2 Stochastic Hydrology,P.J.Reddey, Laxmi Publication Pvt. Ltd., New Delhi, 1997.
3 Introduction to Time Series and Forecasting, P.J.Brockwell and R.A.Davis, Springer, New York, 2002.
4 Time Series Analysis, Forecasting and Control,G.E.P.Box, G.M.Jenkins,G.C.Reinsel and G.M. Ljung, John Wiley and Sons Inc., New Jersey, 2015.

SWC7007 Climate Change and Water Resources: 3 Credits **(3-0-0)**

Unit 1	Basic concept of climate, climate and weather, climatic classification; drivers of climate change, overview of changing climate, analysis of climate change	8 lectures
Unit 2	Hydrologic system overview, global and national water budget, rainfall and temperature variability	8 lectures
Unit 3	An overview of climate change effects on water (runoff, ET, soil moisture, groundwater) and soil (sediment) resources; climate change and droughts and floods; atmospheric circulation	10 lectures
Unit 4	Climate forecast: GCM and RCM; overview of future climate scenarios; assessment of future water resources (surface/ groundwater/ soil moisture) status and vulnerability	8 lectures
Unit 5	Application of hydrologic models in present and future resources assessment; climate change adaptation, capacity and methods analysis	8 lectures

Recommended Books:

1 Climatology – An Atmospheric Science, J.E.Oliver andJ.J.Hidore, Pearson EducationInc., New Delhi, 2011.
2 IPCC and NIPCC Reports3Hydrology and Hydroclimatology: Principles and Applications, M.Karamouz, S.Nazif and M.Falahi, CRC Press, Florida, 2013.

SWC7008 Water Resources Planning and Management: 3 Credits (3-0-0)

Unit 1	Water resources system: concept, characteristics and system analysis techniques; challenges in water sector	6 lectures
Unit 2	Reservoir capacity and yield, flow duration curve, reservoir planning and losses	10 lectures
Unit 3	Reservoir operation: concept, critical issues, operation, reservoir sedimentation – problems, factors influencing, and life of reservoir	10 lectures
Unit 4	Cost-Benefit analysis, conjunctive water use planning, project economic s and evaluation	8 lectures
Unit 5	Integrated river basin development, inter-basin transfer, case studies of river water disputes, environmental impact assessment of water resources projects	8 lectures

Recommended Books:

1 Water Resources Systems Planning and Management,S.K.Jain andV.P.Singh, Elsevier, Amsterdam, 2003.
2 Water Resources Systems: Modelling Techniques and Analysis,S.Vedula and P.P.Mujumdar, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 2005.

SWC7009 Flow Through Porous Media: 3 Credits (3-0-0)

Unit 1	Aquifer and fluid properties, forces holding water in soils, hydrodynamics in porous media and limitations of governing laws.	8 lectures
Unit 2	Differential equations of saturated flow, initial and boundary conditions.	8 lectures
Unit 3	Dupuit and Boussinesq approximations and linearizations techniques.	10 lectures
Unit 4	Stream functions and potential functions, solutions of confined and unconfined flow problems.	8 lectures
Unit 5	Unsaturated flow theory and simulation of soil moisture dynamics; Infiltration and capillary rise flux dynamics, analysis of seepage from canals and ditches.	8 lectures

Recommended Books:

1 Dynamics of Fluid Flow in Porous Media,J.Beer, Dover Publications Inc., New York,1972.
2 Groundwater and Seepage,M.E.Harr, Dover Publications Inc., New York,1962.
3 The Flow of Homogeneous Fluids through Porous Media,M.MuskatandR.D.Wyckoff, J.W. Edwards,1946.
4 Physical and Chemical Hydrogeology,P.A.Domenico and F.W.Schwartz, John Wiley and SonsInc., New Jersey, 1998.
5 Numerical Methods in Subsurface Hydrology, I.Remson, G.M.Hornberger and F.J.Moiz, Wiley Interscience,1971.

SWC7010 Advances in Crop Irrigation Management: 3 Credits (3-0-0)

Unit 1	Agronomy of Irrigation, crop irrigation system, soil-plant atmosphere systems; water production function types and characteristics.	8 lectures
Unit 2	Absorption of water and evapotranspiration, moisture extraction pattern of crops- soil moisture stress - plant water stress - effects on crop growth, soil moisture measurement and modelling	8 lectures
Unit 3	Crop water requirement; factors affecting; critical growth stages; estimation of water requirement of different crops, irrigation schedules for field crops	8 lectures
Unit 4	Selection of Irrigation methods in relation to soil, crop and water supply, Irrigation efficiencies, methods of irrigation; suitability; advantages; limitations, Guidelines for operation and maintenance of irrigation methods	8 lectures
Unit 5	Suitability of water for irrigation; Salinity management techniques through irrigation; irrigation with poor quality water, agronomic practices for use of problem water, water quality analysis for irrigation	10 lectures

Recommended Books:

1 Irrigation Theory and Practice,A.M.Michael, Vikas Publishing HousePvt. Ltd., New Delhi, 1990.
2 Irrigation Water Management – Principles and Practice,D.K.Majumdar, PHILearning Pvt. Ltd., New Delhi , 2013.
3 Water Quality for Agriculture,FAO Report No. 29, R.S.Ayers andD.W.Westcot, Food and Agriculture Organization of the United Nations, 1985.

4 Advances in Irrigation Agronomy,M.K.V.Carr, Cambridge University Press, Cambridge, 2012.
5 Introduction to Agronomy and Principles of Crop Production,S.R.Reddy, Kalyani Publishers, New Delhi, 2011.

MA70 Statistical Methods in Agriculture: 3 Credits** **(2-1-0)**

Unit 1	Probability, random variable, discrete and continuous random variables and their probability distribution, distribution functions and their properties	7 lectures
Unit 2	Conditional probability, independence of events, Bayes theorem, mathematical expectation, moments and moments generating function	6 lectures
Unit 3	Tests of hypothesis for small and large sample sizes	6 lectures
Unit 4	Methods of list squares, simple linear regression and correlation, multiple linear regression	6 lectures
Unit 5	Design and analysis of experiments: analysis of variance for one and two-way classified data, CRD, RBD and LSD	3 lectures

Recommended Books:

1 Fundamentals of Statistic,Vol. I and II,A.M.Groom,M.K.Gupta and B.Dasgupta, The Works Press Pvt. Ltd., Kolkata.
2 Introduction to Probability and Mathematical Statistics,V.K.Rohatgi, Wiley Eastern, New Delhi, 1976.
3 Experimental Design,W.G.Cochran andG.M.Cox, John Wiley and Sons, 1966.
4 Design and Analysis of Experiments,M.N.Das andJ. Giri, Springer Verlag.

HS7005 Project Management: 3 Credits **(3-0-0)**

Unit 1	Definition of Project, Need of Project Management, Project Development Cycle, Project Planning, Project Environment analysis, Project Report Preparation; Preliminary Screening, and Feasibility Report preparation and analysis.	8 lectures
Unit 2	Project Evaluation; Market and Demand analysis, Demand Forecasting, Technical, Financial, Socio-economic, Environmental and Entrepreneurial analyses of project, Project Selection Criteria, Project Implementation.	8 lectures
Unit 3	Resource Planning and Allocation, Estimation of Project Cost, Cost of Capital, Means of Finance, Working Capital requirement, Profitability projection, Cash Flow Analysis, Beak-even analysis.	9 lectures
Unit 4	Financial Analysis, Financial Statements, Balance Sheet, Ratio Analysis, Depreciation of Fixed Assets, Social Benefit-Cost Analysis.	9 lectures
Unit 5	Project Review Techniques, Network Technique, Programme Evaluation Review Technique (PERT), Network scheduling, CPM, Activity scheduling, Time-cost trade-offs.	8 lectures

Recommended Books:

1 Project Management,R.Panneerselvam and P.Senthilkumar, PHI, New Delhi,2009.
2 Project Management for Business and Technology,J.M.Nicholas, Pearson Education, New Delhi, 2009.
3 Project Formulation, Implementation and Appraisal,P.Chandra, Tata McGraw-Hill, New Delhi, 2006.
4 Financial Management,P.Chandra, Tata McGraw-Hills Publishing Co. Ltd., New Delhi,
5 Project Management,H.Kerzner, CBS Publisher and Distributor, New Delhi,2004.

HS7006 Human Resources Management: 3 Credits **(3-0-0)**

Unit 1	Theoretical foundations of HRM, HRD- an overview, Macro level manpower planning and Labour Market analysis, Organizational human resource planning (HRP).	8 lectures
Unit 2	Market, Business, Competition and Strategy, HRD strategies, design and experience, Manpower inventory, Models and techniques of manpower Demand and Supply forecasting.	8 lectures
Unit 3	Design of HR Systems for Competitive Advantage, HRD culture and climate, Behavioural factors in human resource planning-Wastage analysis, Retention, Redeployment, Exit strategies.	9 lectures

Unit 4	Career development, HRD climate and culture, QWL, Management of change. Managing Growth: People Agenda, Managing Change: People Agenda.	8 lectures
Unit 5	HRM for Corporate Globalization, HR for Mergers, Acquisitions and Joint Ventures, Emerging trends and experiences, TQM and HRD strategies, Human resource information system (HRIS), Human resource valuation and Accounting (HRA).	9 lectures

Recommended Books:

1 Strategic Human Resource Development,T.Agarwala, FMS, Delhi University, New Delhi,
2 Strategic Human Resource Development - A Guide to Action, M.Armstrong, Kogan Page Publications, New Delhi,
3 HR: Development, Planning and Deployment,A.K.Sen, Asian Books Pvt. Ltd., New Delhi.

HS7002 Research Methodology: 3 Credits (3-0-0)

Unit 1	Introduction to Research Methodology: Importance of Research in Decision Making, Defining Research Problem and Formulation of Hypothesis, Experimental Design.	9 lectures
Unit 2	Data Collection and Measurement; Methods and Techniques of Data Collection, Sampling and sampling Designs, Data Presentation and Analysis; Data Processing.	9 lectures
Unit 3	Attitude Measurement and Scales; Statistical Analysis and Interpretation of Data, Non-Parametric Tests, Multivariate analysis of Data.	8 lectures
Unit 4	Measures of Central Tendency, Dispersion, Variation, Correlation, Regression, Model building and Decision Making.	9 lectures
Unit 5	Report Writing and Presentation: Substance of Reports, formats of Reports, Presentation of Report.	7 lectures

Recommended Books:

1 Research Methodology,C.R.Kothari, New Age Publications, New Delhi,
2 Research Methodology,B.Taylor, G.SinhaandT.Ghoshal, Prentice Hall of India, New Delhi,
3 Research Methodology,R.Panneersalvam, Prentice Hall of India, New Delhi,2007.
4 Management Research Methodology, K.N.Krishnaswamy, A.I.SivakumarandM.Mathirajan, Pearson Education, New Delhi,2008.

Courses offered to the students of other department

AE 7223 Forest Hydrology and Watershed Management: 3 Credits (2-1-0)

Unit 1	Concept of forest hydrology, hydrological cycle and its components; analysis of precipitation data, infiltration modeling, estimation of evaporation, evapotranspiration,	8 lectures
Unit 2	Runoff; estimation concept of hydrograph and its component, methods of base flow separation, unit hydrograph	4 lectures
Unit 3	Concept of watershed and objectives of watershed management, causes and consequences of watershed deterioration, delineation and coding of watershed, geo-morphological characteristics of watershed affecting runoff, Sedimentation: definition, types and methods of measurement	6 lectures
Unit 4	Soil survey: definition and its type, codification of soil survey; Land capability classification: objectives, characteristics, land capability ratings and determination of different land capability classes	5 lectures
Unit 5	Watershed inventory, prioritization and treatment of watersheds, Landslides and its control, torrents control; role of horticulture, forestry and agro-forestry in watershed management, Watershed work plan, economic evaluation of watershed management projects	5 lectures

Recommended Books:

1 Hydrology: Principles, Analysis and Design, H.M. Raghunath,3rdEd.,New Age International, New Delhi, 2006.
2 Land and Water Management, V.V.N. Murtyand M.K.Jha, 5 thEd.,Kalyani Publishers, New Delhi, 2011.
3 Watershed Planning and Management, Rajvir Singh, Yash Publishing House, Bikaner, India, 2000.
4 Hydrology, Soil Conservation and Watershed Management, G. Das, PHI, New Delhi, 2008.
5 Soil and Water Conservation Engineering, R. Suresh, 2ndEd., Standard Publishers Distributors, Delhi, 2005.

Ph.D. PROGRAMME IN AGRICULTURAL ENGINEERING

Semester-II						
S.N.	**Course code**	**Course title**	**L**	**T**	**P**	**Credits**
1.	AE9001	Computer Programming in Soil and Water Engineering	3	0	0	3
2.	AE9002	Stochastic Modelling in Hydrology	3	0	0	3
3.	AE9003	Soil and Water Systems Simulation and Modelling	3	0	0	3
4.	AE9004	Application of RS and GIS in Natural Resources Management	3	0	0	3
5.	AE9005	Water and Climate Change	3	0	0	3
6.	AE9006	Design of Pressurized Irrigation Systems	3	0	0	3
7.	AE9007	Modelling of Soil-Water-Plant Continuum	3	0	0	3
8.	AE9008	Emerging Techniques in Watershed Management	3	0	0	3
9.	AE9009	Optimization Techniques in Water Resources	3	0	0	3
10.	AE9010	Research Methodology	3	0	0	3
11.	AE9011	Computer Application in Agriculture	3	0	0	3
12.	AE9012	Industrial Safety	3	0	0	3
13.	AE9013	Material Science and Engineering	3	0	0	3
14.	AE9014	Principles of Mechanization and Management	3	0	0	3
15.	AE9015	Safety and Health in Agriculture	3	0	0	3
16.	AE9016	Precision Agricultural Machinery	3	0	0	3
17.	AE9017	Bio-Fuel Production and Application	3	0	0	3
18.	AE9018	Instrumentation for Agricultural Application	3	0	0	3

AE9001 Computer Programming in Soil and Water Engineering: 3 Credits (3-0-0)

Unit 1	Introduction to programming and problem solving; programming basics: loops and decisions; structures; functions; objects and classes; arrays and strings; pointers	8 lectures
Unit 2	Overview of different programming platform and languages: Microsoft Excel Macro, Matlab, C, C++, Python, VBA, Visual Studio, GUI design	12 lectures
Unit 3	Estimation of hydrologic elements by programming	7 lectures
Unit 4	Writing programs for simple rainfall-runoff models	8 lectures
Unit 5	Writing programs for soil conservation structure designing	7 lectures

Recommended Books:

1. Programming Microsoft Visual Basic 6.0, F. Balena, Microsoft Press, 1999.
2. Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers, R. Pratap, Oxford University Press, 2016.
3. Matlab Programming, Y.K. Singh and B.B. Choudhuri, Prentice Hall, 2007.
4. Object-Oriented Programming in C++, R. Lafore, Sams Publishing, 2001.
5. Learn Python the Hard Way, Z.A. Shaw, Addition Wesley, Massachusetts, 2014.

AE9002 Stochastic Modelling in Hydrology: 3 Credits (3-0-0)

Unit 1	Probabilistic modelling of hydrological process: data requirement, plotting position, continuous probability distribution functions, parameter estimation techniques, goodness of fit test, estimation of return period	10 lectures
Unit 2	Risk and reliability concept in hydrology: Computation of risk, discrete probability distribution functions	8 lectures
Unit 3	Time series analysis and forecasting of hydrological processes, sequential generation of hydrological data, stream flow forecasting	12 lectures
Unit 4	Regional frequency analysis, analysis of low flows	8 lectures
Unit 5	Range and storage analysis	4 lectures

Recommended Books:

1 Statistical Methods in Hydrology, C.T. Hann, East West Press, 2002.
2 Stochastic Hydrology, P.J. Reddey, Laxmi Publication Pvt. Ltd., New Delhi, 1997.
3 Introduction to Time Series and Forecasting, P.J. Brockwell and R.A. Davis, Springer, New York, 2002 .
4 Time Series Analysis, Forecasting and Control, G.E.P. Box, G.M. Jenkins, G.C. Reinsel and G.M. Ljung , John Wiley and Sons Inc., New Jersey, 2015.

AE9003 Soil and Water Systems Simulation and Modelling: 3 Credits (3-0-0)

Unit 1	Hydrological modeling of small watershed: introduction, physical characteristics of watersheds, instrumentation and data collection, generation of hydrologic information	8 lectures
Unit 2	Hydrologic simulation overview: types of mathematical models, hydrologic simulation models: classification, components, steps; Optimization models in hydrology	10 lectures
Unit 3	Erosion and sediment yield: sediment yield process and modelling	8 lectures
Unit 4	Event Based Streamflow Simulation (EBSS): data needs, structure, building of EBSS models, calibration parameters, example EBSS models	8 lectures
Unit 5	Continuous Streamflow Simulation (CSS): data needs, parameter estimation, building of CSS models, example CSS models	8 lectures

Recommended Books:

1 Introduction to Physical Hydrology, M.R. Hendricks, Oxford University Press, New York,2010.
2 Hydrology of Small Watersheds, P.V.Seethapathi, D.Duttaand R.S. Kumar, TERI Press, Darbari Seth Block, New Delhi, 2008.
3 Elementary Hydrology, V.P. Singh, Prentice-Hall of India Pvt. Ltd., New Delhi, 1994.
4 Introduction to Hydrology, W.Viessmanand G.L. Lewis, Prentice-Hall of India Pvt. Ltd., New Delhi, 2008.
5 Remote Sensing and its Applications, L.R.A. Narayan, University Press (India) Ltd., Hyderabad, 1999.
6 Remote Sensing in Water Resources, S.M.Ramasamy, Rawat Publications, Jaipur, 2005.

AE9004 Application of RS and GIS in Natural Resources Management: 3 Credits (3-0-0)

Unit 1	Remote sensing: fundamentals, physics of remote sensing, electromagnetic radiation, interaction of ENR with atmosphere, earth surface, soils, water and vegetation.	6 lectures
Unit 2	Data acquisition; photographic system and imaging systems; visible, NIR, SWIR, and TIR imagery; photogrammetry: vertical photographs, photo interpretation, visual analysis, stereoscopic analysis.	10 lectures
Unit 3	Digital image processing: image rectification, enhancement, classification and its accuracy.	10 lectures
Unit 4	Geographic Information System (GIS) approach to integration of spatial and attribute data for capturing, analysis, manipulation and portrayal of natural resources; data types/ formats; integration of GIS with remote sensing and Global Positioning System	8 lectures
Unit 5	Application of RS and GIS technologies in water resources and watershed management; case studies	8 lectures

Recommended Books:

1 Remote Sensing and Image Interpretation, T.M. Lillesand and R.W. Keifer, John Wiley and Sons Inc., New York, 2000.
2 Concept and Techniques of Geographic Information System, C.P. Lo and A.K.W. Yeung, PHI Learning Pvt. Ltd., 2002.
3 Remote Sensing in Water Resources, S.M.Ramasamy, Rawat Publication, 2005.
4 Fundamentals of Geographic Information System, M.N. Demers, John Willey & Sons, 2005.
5 Remote Sensing and its Applications, L.R.A. Narayan, Universities Press, 1999.

AE9005 Water and Climate Change: 3 Credits **(3-0-0)**

Unit 1	Basic concept of climate, climate and weather, climatic classification; drivers of climate change, overview of changing climate, analysis of climate change	8 lectures
Unit 2	Hydrologic system overview, global and national water budget, rainfall and temperature variability	8 lectures
Unit 3	An overview of climate change effects on water (runoff, ET, soil moisture, groundwater) and soil (sediment) resources; climate change and droughts and floods; atmospheric circulation	10 lectures
Unit 4	Climate forecast: GCM and RCM; overview of future climate scenarios; assessment of future water resources (surface/ groundwater/ soil moisture) status and vulnerability	8 lectures
Unit 5	Application of hydrologic models in present and future resources assessment; climate change adaptation, capacity and methods analysis	8 lectures

Recommended Books:

1 Climatology - An Atmospheric Science, J.E. Oliver and J.J. Hidore, Pearson Education Inc., New Delhi , 2011.
2 IPCC and NIPCC Reports
3 Hydrology and Hydroclimatology: Principles and Applications, M. Karamouz, S. Nazif and M. Falahi, CR C Press, Florida, 2013

AE9006 Design of Pressurized Irrigation Systems: 3 Credits **(3-0-0)**

Unit 1	Present status, scope and potential problems; inventory of resources – water source, crop and soil information, land topography; data requirement; general rules for design	8 lectures
Unit 2	Indigenous micro irrigation systems: pitcher, suction irrigation, bamboo drip irrigation system, low cost drip irrigation systems	6 lectures
Unit 3	Sprinkler irrigation: adaptability, problems and prospects, types of sprinkler irrigation systems; design of sprinkler irrigation system: layout selection, hydraulic design of lateral, sub-main and main pipe line, design steps; selection of pump and power unit for sprinkler irrigation system; performance evaluation of sprinkler irrigation system; economics	12 lectures
Unit 4	Design of drip irrigation system: general considerations, wetting patterns, irrigation requirement, emitter selection, hydraulics of drip irrigation system, design steps; necessary steps for proper operation of a drip irrigation system; performance evaluation of drip irrigation system; economics; fertigation: uses, advantages and limitations	12 lectures
Unit 5	Problems and maintenance of pressurized irrigation systems	4 lectures

Recommended Books:

1 Irrigation: Theory and Practice, A.M. Michael, Vikas Publishing House, New Delhi, 2012.
2 Principles of Sprinkler Irrigation Systems, M.S. Mane and B.L.Ayare, Jain Brothers, New Delhi, 2007.
3 Principles of Drip Irrigation Systems, M.S. Mane, B.L.Ayare and S.S.Magar, Jain Brothers, New Delhi, 2006.
4 Micro Irrigation – Theory and Practices, R. Suresh, Standard Publishers Distributors, 2010.
5 Micro irrigation for Crop Production, Developments in Agricultural Engineering Series, Vol. 13, F.R. Lamm, J.E.Ayarsand F.S. Nakayama, Elsevier, Oxford, 2007.

AE9007 Modelling of Soil-Water-Plant Continuum: 3 Credits **(3-0-0)**

Unit 1	Soil properties affecting irrigation: soil structures, soil wetness, soil bulk density, soil consistency, soil fertility; plant factors affecting irrigation	8 lectures
Unit 2	Energy relationship in soil and plant, measurement of soil water and water potential, water flow through saturated and unsaturated soils	8 lectures
Unit 3	Flow of water through soil-plant-atmosphere continuum, soil moisture retention and movements, soil water potential	10 lectures
Unit 4	Rooting characteristics and moisture use of crops: evaporation, transpiration and consumptive use, measurement of evapotranspiration, crop coefficient and its use	8 lectures
Unit 5	Crop growth and yield modeling	8 lectures

Recommended Books:

1 Irrigation Theory and Practice, A.M. Michael, Vikas Publishing HousePvt. Ltd., New Delhi, 1990.

2 Irrigation Water Management – Principles and Practice, D.K.Majumdar, PHILearning Pvt. Ltd., New Delhi, 2013.

AE9008 Emerging Techniques in Watershed Management: 3 Credits (3-0-0)

Unit 1	Concept of integrated watershed management; consequences of watershed deterioration; watershed management strategies and responses to problems	8 lectures
Unit 2	Farming system and production technology in watershed; use of agro-forestry in management of hilly watersheds	10 lectures
Unit 3	Concept of operational watershed, national land use policy, legal and social aspects	8 lectures
Unit 4	Watershed modelling: scope, classification, technology and analysis, case studies	8 lectures
Unit 5	Watershed planning processes, watershed and environment, monitoring and evaluation of watershed projects	8 lectures

Recommended Books:

1 Watershed Planning and Management, R.V. Singh, Yash Publishing House, Bikaner, 2000.

2 Hydrology and Soil Conservation Engineering: Including Watershed Management, G. Das, Prentice-Hall of India Learning Pvt. Ltd., New Delhi, 2008.

3 Watershed Management, V.DhruvaNarayana, G.Sastryand U.S.Patnaik, ICAR Publication, New Delhi, 1997 .

4 Integrated Watershed Management: Principles and Practice, I.W.Heathcote, John Wiley & SonsInc., New Jersey, 2009.

5 Hydrology and the Management of Watersheds,K.N. Brooks, P.F.Folliott, H.M.Gregersen and L.F.DeBano, Wiley-Blackwell,1991.

AE9009 Optimization Techniques in Water Resources: 3 Credits (3-0-0)

Unit 1	Concepts and significance of optimization in water resources, objective functions, deterministic and stochastic inputs	6 lectures
Unit 2	Mathematical programming techniques, linear programming and its extension, simplex method, revised simplex method, simplex method-duality	10 lectures
Unit 3	Transportation problem, Non-linear programming of simple cases	10 lectures
Unit 4	Dynamic programming-multi stage decision process, goal programming	10 lectures
Unit 5	Application of optimization techniques for water resources	6 lectures

Recommended Books:

1 Operations Research: Principles and Practice,A.Ravindran, D.T.Phillips andJ.J.Solberg, Wiley Publication, 2007.

2 Operations Research: An Introduction,H.A. Taha, Pearson, 2016.

3 Operations Research,P. K. Gupta and D. S. Hira, S. Chand & Company Ltd.,2005.

4 Water Resources Systems Planning and Management,M.C.Chaturvedi, McGraw-Hill, 1987.

5 Water Resources Systems Modelling Techniques and Analysis, S. Vedula, P. P. Mujumdar, Tata McGraw-Hill Publishing Company Limited, New Delhi,2007.

AE9010 Research Methodology: 3 Credits (3-0-0)

Unit 1	Research: meaning, objective, significance; defining research problem; problems of research in India; review of the literature	8 lectures
Unit 2	Method of data collection: historical method, case study, observation, interview, questionnaire, experimental method; null and alternate hypothesis; design of experiments; errors in measurements	10 lectures
Unit 3	Analysis and interpretation of data: regression and correlation, ANOVA, T-test, chi-square test, principle component analysis; development of models and empirical equations using analytical methods and principles of similitude	10 lectures
Unit 4	Presentation of data; report writing: substance of report, format of report, basic concept of report writing	8 lectures
Unit 5	Ethical issues in research; impact factor, citation index, H-index	6 lectures

Recommended Books:

1 Research Methodology,C.R.Kothari, New Age Publications, New Delhi, 2004.
2 Research Methodology,B.Taylor, G.Sinha and T. Ghoshal, Prentice Hall of India, New Delhi, 2006.
3 Research Methodology,R.Panneersalvam, Prentice Hall of India, New Delhi,2007.
4 Management Research Methodology,K.N.Krishnaswamy, A.I.SivakumarandM.Mathirajan, Pearson Education, New Delhi,2008.

AE9011 Computer Application in Agriculture: 3 credits (3-0-0)

Unit 1	Introduction to programming and problem solving. Programming basics: loops and decisions, structures, functions, objects and classes, arrays and strings, pointers.	6 lectures
Unit 2	Introduction to C programming, fundamentals, structure, constants, variables, data types, expressions using operators, managing input and output operations, decision making, looping.	9 lectures
Unit 3	One and two dimensional arrays and strings. Function: Pass by value and pass by reference, recursion, and pointers.	9 lectures
Unit 4	Visual basic.net: GUI design, controls, data handling, input and output operations, decision making. Microsoft excel: Data handling, analysis, and presentation using graphs and charts.	9 lectures
Unit 5	C and visual basic programming, and spread sheet for agricultural applications: Implement matching, farm machinery design and traction analysis.	9 lectures

Recommended Books:

1 Let Us C, Yashwant P. Kanetkar, Infinity Science Press, 2008.
2 Introduction to Programming with Visual Basic .NET, Gary J. Bronson and David Rosenthal, Jones and Bartlett Publishers, Boston, 2005.
3 Microsoft Excel Functions and Formulas, B. Held, Wordware Publishing Inc., Massachusetts, 2007.

AE9012 Industrial Safety: 3 credits (3-0-0)

Unit 1	Definition and classification of hazards. Hazardous materials: Classification, characteristics, means of exposure and health effect, disposal. Hazard information label, safety precautions.	8 lectures
Unit 2	Explosive and flammable materials: Types, classification, characteristics, safety signs, material handling. Engineering and administrative safety control.	10 lectures
Unit 3	Fire safety: Causes, safety concept, extinction methods, and fire-fighting equipment. Building safety: means of escape, evacuation strategies and procedure, fire and smoke prevention.	10 lectures
Unit 4	Electrical hazards: Causes and types of electrical injuries, general electrical safety rules, PPE. Welding: Types, health hazards of welding, reducing hazards of welding.	8 lectures
Unit 5	Hazard communication, medical surveillance, safety legislation, safety management.	6 lectures

Recommended Books:

1 Introduction to Fire Safety Management, A. Furness and M. Muckett, Butterworth-Heinemann, Oxford, 2010 .
2 System Safety Engineering and Management, H. E. Roland and B. Moriarty, John Wiley and Sons Inc., New York, 1990.
3 Safety Engineering, James CoVan, Wiley, New York, 1995.

AE9013 Material Science and Engineering: 3 credits (3-0-0)

Unit 1	Classification of engineering materials. Geometry of crystal: Space lattice, Space lattice and crystal structures. Determination of Crystal structure. Metallic bonding.	7 lectures
Unit 2	Crystal imperfections and dislocations. Phase diagram and phase transformation. Fracture: Ductile and brittle fracture etc.	10 lectures
Unit 3	Stress and strain in materials. plastic deformation; creep and mechanism of creep; elastic, anelatsic and viscoelastic behavior; Oxidation and corrosion	11 lectures

Unit 4	Mechanical property tests for martials: Destructive and non-destructive tests, tensile and compression test, shear test, fatigue test, hardness test, impact test etc.	8 lectures
Unit 5	Nonmetallic materials: Polymer, fibre, composite material, and ceramic materials; their types, properties, additives, and applications. Non-ferrous metals and their alloys.	6 lectures

Recommended Books:

1 Material Science and Engineering - A first Course, V. Raghavan, 6th Ed., PHI Learning Pvt. Ltd., Del hi, 2015.
2 Introduction to Engineering Materials, B.K. Agrawal, Tata McGraw-Hill Education, Delhi, 1988.
3 Engineering Materials and Metallurgy, R.K. Rajput, 1st Ed., S. Chand & Co. Ltd., New Delhi, 2006.

AE9014 Principles of Mechanization and Management: 3 credits (3-0-0)

Unit 1	Status of mechanization. Mechanization and its stages. Factor affecting mechanization.	8 lectures
Unit 2	Selection of power units, machine capacity, field machinery management, matching machines to create an efficient system.	8 lectures
Unit 3	Cost analysis of farm machinery: Valuation of machines. Identifying, monitoring and reducing machinery costs. Break-even analysis.	9 lectures
Unit 4	Financing machinery, finance schemes and selection of appropriate scheme. Alternatives to ownership, contracting, hire schemes. Maintenance management. Machinery replacement.	9 lectures
Unit 5	Analysis and organization of various operation management programmes. Inventory control of spare parts, work study, productivity, method study, use of computer in machinery management.	8 lectures

Recommended Books:

1 Farm Machinery Selection, Investment and Management, Resource Management Series, A. Landers, Farming Press, 2002.
2 Farm Power and Machinery Management, D. Hunt, Iowa State University Press, Ames, 2001.

AE9015 Safety and Health in Agriculture: 3 credits (3-0-0)

Unit 1	Tractor hazards such as instability, runover, power-take-off (PTO), etc.; machinery hazards; respiratory hazards in structure and environment; chemical and other hazards.	9 lectures
Unit 2	Definition and causes of accident; severity of injury; effect of season, workplace, age, working time etc.; agricultural injury picture.	9 lectures
Unit 3	Occupational safety and health principles in agriculture; Hazards and injury prevention and control: industrial safety and health approach, public health approach.	11 lectures
Unit 4	Safety engineering principles; Hierarchy hazard control; roll over protective structure (ROPS); warning sign and warning labels; machine guarding.	9 lectures
Unit 5	Provincial, national and international regulations and legislation for prevention of accidents; injury compensation.	4 lectures

Recommended Books:

1 Safety and Health for Production Agriculture, D.J. Murphy, ASAE publications, Michigan, 1992.
2 System Safety Engineering and Management, H. E. Roland and B. Moriarty, John Wiley and Sons Inc., New York, 1990.
3 Safety Engineering, James CoVan, Wiley, New York, 1995.

AE9016 Precision Agricultural Machinery: 3 credits (3-0-0)

Unit 1	Basics of precision agriculture, tools for implementation of precision agriculture. Information Technology. Spatial location, GPS, computer vision systems, information acquisition.	8 lectures
Unit 2	Site-specific nutrient management, data sources and decision making for site-specific nutrient management. Economic, ecological and social impacts of site-specific nutrient management. Grain quality and yield.	9 lectures
Unit 3	Site-specific weed management, weed distribution, stability of weed populations, weed monitoring and control. Site-specific herbicide application. Agro-chemicals and fertilisers, patch spraying.	9 lectures

Unit 4	Use of microprocessor based systems and computer in precision agriculture, Automation.	8 lectures
Unit 5	Crop yield monitors. Decision support systems; artificial intelligence. Remote sensing for precision agriculture. Field plot machines.	8 lectures

Recommended Books:

1 The Precision Farming Guide for Agriculturists, D. Ess, M. Morgan, and R. Reynolds, John Deere Publishing. USA, 1997.
2 Precision Agriculture for Grain Production Systems, B. Whelan and J. Taylor, Csiro Publishing, Collingwood, Australia, 2013.
3 Precision Agriculture Technology for Crop Farming, Q. Zhang, CRC Press, Boca Raton, Florida, 2016

AE9017 Bio-fuel Production and Application: 3 Credits (3-0-0)

Unit 1	Biofuel: Introduction, sources and comparison of different types of biofuel. Solid, liquid and gaseous biofuels. Economics of different biofuel sources with non-renewable sources	8 lectures
Unit 2	Biodiesel: Scope, sources, merits and demerits, cultivation practices of different sources of biodiesel. Physical and chemical properties of raw bio-diesel. Extraction, refining processes.	9 lectures
Unit 3	Bioethanol: Sources, production process, merits and demerits	9 lectures
Unit 4	Biomass gasification: Pyrolysis, design theory and modelling of gasifier.	9 lectures
Unit 5	Performance of engine with different types of bio-fuels, exhaust and impact on environment.	7 lectures

Recommended Books:

1 Bio-diesel: Basics and Beyond: A comprehensive guide to production and use for Home and Farm, William H. Kemp, New Society Publishing, Canada, 2006.
2 Biodiesel Production Technologies, S.K. Mehta, Eastern Book Corporation, New Delhi, 2007.
3 Biofuels: Production, Application and Development, A.H. Scragg, CAB International, London, 2009.
4 Biomass Gasification and Pyrolysis: Practical Design and Theory, P. Basu, Elsevier Academic press, London, 2010

AE 9018 Instrumentation for Agricultural Application: 3 Credits (3-0-0)

Unit 1	Generalized configuration, structure and functional description of measuring instruments. Active and passive transducer, analogue and digital mode of operation, null and deflection method.	6 lectures
Unit 2	Performance characteristics of instruments including static and dynamic. Transfer function, signals and noise. Static and dynamic errors, and their statistical analysis.	8 lectures
Unit 3	Measuring devices for temperature, displacement, stress, strain, force, pressure, velocity, torque, acceleration, moisture content, noise, vibration etc.	15 lectures
Unit 4	Signal conditioning elements: Deflection bridges, amplifiers etc. Signal processing elements and software: Analogue-to-digital (A/D) conversion, and digital-to-analogue conversion (D/A).	7 lectures
Unit 5	Data acquisition, manipulating, compiling and compensating devices. Data transmission and recording. Telemetry.	6 lectures

Recommended Books:

1 Principles of Measurement Systems, J.P. Bentley, Pearson Education Limited, England, 2005.
2 Measurement Systems: Application and Design, E.O. Doebelin, McGraw Hill Co., New York, 1980.
3 Mechanical Measurements, T.G. Beckwith, N.L. Buck and R.D. Marangoni, Narosa Publishing House, New Delhi, 1982.
4 Instrumentation Measurement and Analysis, B.C. Nakra and K.K. Chaudhry, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1985.

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY

SYLLABI
OF
PG / Ph. D. COURSES
(DEPARTMENT OF CIVIL ENGINEERING)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY

(UNDER THE MINISTRY OF EDUCATION, GOVT. OF INDIA)

DEEMED TO BE UNIVERSITY U/S 3 OF THE UGC ACT, 1956

NIRJULI - 791 109 :: ARUNACHAL PRADESH

SYLLABI
OF
PG/ Ph. D COURSES

(DEPARTMENT: CIVIL ENGINEERING)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY (NERIST)

(Deemed to be University, U/S 3 Of the UGC Act, 1956)
Nirjuli (Itanagar), Arunachal Pradesh- 791 109

Department of Civil Engineering

1. Name of the Programme : **M Tech in Environmental Science & Engineering**
2. Department : **Civil Engineering**
3. Nature : **Regular programme**
4. Duration : **Four semesters**
5. Admission & Scholarships : **As per the Institute norms**
6. Evaluation Scheme : **As per the Institute norms**

Programme Structure

Break-up of Semester wise load:

Semester I	(Courses)	: 20 credits
Semester II	(Courses)	: 20 credits
Semester III	(Seminar/Dissertation)	: 10 credits
Semester IV	(Dissertation)	: 16 credits
		66 credits

Course Structure:

SEMESTER I

AS 7100 Environmental Bio-Technology	3-1-0 4
ESE 7101 Physico-Chemical Treatment Processes	3-0-2 4
ESE 7102 Biological Treatment Process	3-0-2 4
MA7107 Advanced Mathematical Techniques	3-1-0 4
CY 7100 Environmental Chemistry	4-0-0 4

Total Credits 20

SEMESTER II

ESE 7201 Solid Waste Management	3-1-0 4
Four courses from the following Electives:	

Total Credits 20

LIST OF ELECTIVES:

ESE 7001 Advance Water and Wastewater Treatment	3-1-0 4
ESE 7002 Rural Water Supply and Sanitation	3-1-0 4
ESE 7003 Environmental Impact Assessments	3-1-0 4
ESE 7004 Unit Processes and Operations in Environmental Engg.	3-1-0 4
ESE 7005 Environmental Sanitation	3-1-0 4
ESE 7006 Surface Water Quality Modelling	3-1-0 4
ESE 7007 Water Distribution Networks	3-1-0 4
ESE 7008 Geo-Environmental Engineering	3-1-0 4
ESE 7009 Optimization Techniques in Water Resources	3-1-0 4
ESE 7010 Industrial Wastewater Treatment	3-1-0 4
ESE 7011 Design of Water and Wastewater Systems	3-1-0 4
IDE 7001 Energy System and Environment	3-1-0 4
IDE 7002 Hazardous Waste and Disaster Management	3-1-0 4
IDE 7003 Oil and Marine Pollution	3-1-0 4
IDE 7004 Air and Noise Pollution	3-1-0 4
IDE 7005 Waste Land Ecology	3-1-0 4
IDE 7006 Selected Topics in Environmental Engineering	3-1-0 4
IDE 7007 Environmental Systems Modelling	3-1-0 4
IDE 7008 Sustainable Technologies and Development	3-1-0 4
IDE 7009 Environmental Management	3-1-0 4

IDE 7010 Environmental Risk Assessment	3-1-0 4
IDE 7011 Future Studies	3-1-0 4
ESE 70** Any Other Relevant Subject(s)	3-1-0 4
IDE 70** Any Other Relevant Subject(s)	3-1-0 4

SEMESTER III

ESE 8100 Seminar on Selected Topics of the Specialization	0-0-4 2
ESE 8099 Project/Dissertation	0-0-16 8
	Total Credits 10

SEMESTER IV

ESE 8099 Project/Dissertation	0-0-32 16
	Total Credits 16
	Grand Total of 66 Credits

Detail Syllabi

AS 7100: Environmental Biotechnology: 4 credits (3-1-0)

Unit I	Environmentally sound biotechnology, Microbial control of environmental pollution, Removal and recovery of heavy metals from industrial waste water, mineral leaching.	12 lectures
Unit II	Detoxification and disposal of pesticides and other solid wastes employing micro-organisms, Bio pesticides for use in agricultural and health sectors, Bio fertilizers for future use.	10 lectures
Unit III	Use of biocides and other micro-organisms as biological tools for controlling various diseases, Vermicomposting and straw decomposition, Recovery of energy from solid wastes using microbes.	10 lectures
Unit IV	Microbial enhanced oil recovery in oil extraction processes, Revegetation of mining areas using tree-microbe symbiosis.	10 lectures

Recommended Books:

1. A.K. Chatterji (2007). Introduction to Environmental Biotechnology, 2nd Edition, Prentice-Hall of India Pvt. Ltd, New Delhi
2. M. H. Fulekar (2010) Environmental Biotechnology, CRC-Press New York & Science Publisher, New Hampsh ire
3. K. Allen (2015), Environmental Biotechnology, 1st Edn., CBS Publishers and Distributors, Pvt. Ltd., New Delhi
4. P. K. Mohapatra (2007) Text Book of Environmental Biotechnology ,I.K. International Publishing House Pvt. Ltd, Nw Delhi
5. D.A. John Wase and C.F. Foster (1987) Environmental Biotechnology, Willis Horwood Series Environment al Engineering, Ellis Horwood Ltd. & John Willey

ESE 7101: Physico-Chemical Treatment Processes: 4 credits (3-0-2)

Unit I	Water quality and concepts of beneficial use, Water quality criteria and drinking water standards.	10 lectures
Unit II	Physicochemical processes for water and waste water treatment: Sedimentation, Flocculation, Chemical coagulation, Filtration.	16 lectures
Unit III	Adsorption, Ion-exchange, Precipitation, Disinfection, Aeration, Gas transfer, membrane processes etc.	16 lectures

Recommended Books:

1. Environmental Engineering, H.S. Peavy, D. R. Rowe & G. Tchobanoglous, McGraw Hill International, New York.
2. Environmental Engineering, G. Kiely, Tata McGraw Hill Education Private Limited, New Delhi, 2009.
3. Environmental Engineering Vol. I: Water Supply Engineering, S.K. Garg, Khanna Publications, Delhi. 2009.
4. Water Supply Engineering (Environmental Engineering Vol. I): P. N. Modi, Standard Book House, N. Del hi.
5. Water Supply & Sanitary Engineering, G.S. Birdi and J.S. Bindie, Dhanpat Rai Publishing Co., New Del hi.
6. Process Chemistry for Water and Wastewater Treatment, Benefield, Judkins&Weand, Prentice Hall Inc., New Jersey.
7. Wastewater Treatment Plants: Planning, Design & Operation, S.R. Qasim, CBS College Publishing, New York.

ESE 7102:Biological Treatment Process: 4 credits (3-0-2)

Unit I	Characteristics of municipal waste water, Preliminary and primary treatment.	06 lectures
Unit II	Reaction kinetics, Reactor types and their analysis, Bio-kinetics parameters evaluation.	06 lectures
Unit III	Aerobic and anaerobic process design, Design of diffused and attached growth processes.	15 lectures
Unit IV	Waste stabilization pond, Oxidation ditch, and Aerated lagoons, On site treatment systems, Effluent disposal.	15 lectures

Recommended Books:

1. Wastewater Treatment Concept and Design Approach: G. L. Karia& R. A. Christian, PHI, N. Delhi.
2. Wastewater Treatment for Pollution Control and Reuse, S. J. Arceivala, Asolekar, Tata McGraw Hill, New Delhi.
3. Water and Wastewater Engineering, Desogh Principles and Practice: Mackenzie L. Davis, McGraw Hill Education (India) Private Limited, New Delhi.
4. Environmental Engineering Vol II: Sewage Disposal and Air Pollution Engineering, S.K. Garg, Khanna Publications, Delhi.
5. Sewage Treatment & Disposal and Waste Water Engineering (Environmental Engineering Vol. II): P. N. Modi, Stabdard Book House, N. Delhi.
6. Water and Wastewaters Technology: Mark J. Hammer, Mark J. Hammer Jr, PHI Learning Private Limited, New Delhi.
7. Wastewater Enineering: Treatment, Disposal & Reuse, Metcalf & Eddy, Tata McGraw Hill, New Delhi.

CY7100 Environmental Chemistry: 4 credits (4-0-0)

Unit I	Chemical Equilibrium and The Chemistry of Natural waters: Introduction to Environmental chemistry, Stoichiometry of chemical reactions, Equilibrium concept, activity and activity coefficient, Solutions to equilibrium problems – exact solutions and approximate solutions; Formation of ion-pairs and complexes in aqueous systems, Calculation of species-concentrations in solutions of complexes; Oxidation-reduction chemistry in natural waters, electron activity measurement (pE), The limits of pE in water / Water stability boundaries, pE–pH diagrams of Fe-H_2O and N_2-H_2O systems; Acid mine drainage; Acid-base chemistry in natural waters – the carbonate system; Measurement of organic compounds in water - DO, BOD and COD.	13 lectures
Unit II	Organic Pesticides and Non-Pesticide Toxic Organic Compounds: Types of synthetic organic pesticides - molecular structures and properties, Chemical stability of the pesticides, Photolytic reactions of pesticides, Non-photolytic reactions of pesticides —hydrolysis reactions, oxidation and reduction reactions, degradative reactions; Dioxins – preparation and properties, Chlorophenolic origin of dioxins, Numbering system of dioxin; Polychlorinated biphenyls(PCBs) – their properties and numbering system, Polychlorinated biphenyls contamination by Furans – their properties and numbering system; Toxicity patterns of dioxins, PCBs and Furans, Toxicity Equivalent Factor(TEQ) scale, Polyaromatic hydrocarbons (PAHs) – their properties.	13 lectures
Unit III	Atmospheric Chemistry: Importance of the Atmosphere, Major regions of the Atmosphere, Chemical and Photochemical reactions in the Atmosphere, Free radical reactions in the atmosphere, Chlorofluorocarbons (CFCs) – their properties and Du Pont numbers, Steady-state in the atmospheric reactions, Stratospheric ozone depletion, Catalytic processes of ozone depletion (mechanism-I and II); Greenhouse effect, Energy absorption by Greenhouse gases, Characteristics of Greenhouse gases – spectroscopy of the greenhouse gas molecules, Atmospheric windows; Radio-nuclides, Types of radio-nuclides, Radio-active dating, Modes of radio-nuclide decay, Measuring rate of radio-active disintegration and Health threat.	13 lectures

Unit IV	Instrumental Methods of Analysis: UV-Vis Spectrophotometer, Infra-red (IR) spectroscopy, Atomic Emission Spectrophotometer, Atomic Absorption Spectrophotometer, Flame Photometer, Fluorimeter, Gas Chromatography(GC), High Performance Liquid Chromatography(HPLC), Ion-selective electrodes, Chemiluminiscence method, Numerical problems.	13 lectures

Recommended Books :

1. Colin Baird and Michael Cann, Environmental Chemistry, 3rdEdn. (2005), W. H. Freeman and Company, New York.
2. Gary W. vanLoon and Stephen J. Duffy, Environmental Chemistry - A Global Perspective, 1st Indian Edn. 2008), Oxford University Press.
3. N. Sawyer, Perry L. McCarty and Gene F. Parkin, Chemistry for Environmental Engineering and Science, 5thEdn. (2003), Tata McGraw-Hill Publishing Company Ltd, New Delhi.
4. R. M. Harrison and S. J. de Mora, Introductory Chemistry for the Environmental Sciences, 2ndEdn. (1995), Cambridge University Press.
5. Julian E. Andrews, Peter Brimblecombe, Tim. D. Jickells, Peter S. Liss and Brian J. Reid, An Introduction to Environmental Chemistry, 2ndEdn. (2004), Blackwell Publishing.
6. Ian Pulford and Hugh Flowers, Environmental Chemistry at a Glance, (2006), Blackwell Publishing.
7. Stanley E. Manahan, Environmental Chemistry, 6thEdn. (1994) Lewis Publishers.
8. V. Subramanian, A Textbook in Environmental Science, (2002), Narosa Publishing house, NewDelhi.
9. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, Analytical Chemistry – An Introduction,Edition (2000) Saunders College Publishing Philadelphia, London.
10. Gilbert M. Masters, Introduction to Environmental Engineering and Science, (1994)Prentice-Hall of India Pvt. Ltd., New Delhi.
11. Ian Williams, Environmental Chemistry – A Molecular Approach, (2001), John Wiley & Sons, Ltd.

MA-7107 Advanced Mathematical Techniques: 4 Credits(3-1-0)

Unit- I	Ordinary differential equation of first and second order, complementary function, particular integral, variation of parameter method.	8 Lectures
Unit -II	Basic concepts, modeling, vibration string, one dimensional wave equation, separation of variable method.	6 Lectures
Unit- III	Elementary statistics, correlation, regression, random variables, probability distribution, binomial, Poisson and Normal distribution, estimation of parameters, confidence interval, hypothesis of testing, goodness of fit.	10 Lectures
Unit -IV	Linear programing, graphical solution, un-constrained and constrained non-linear optimization, Lagrange multipliers.	8 Lectures
Unit -V	Solution of algebraic equations by iteration method, finite differences, interpolation, numerical integration and differentiation, numerical method for ODE and PDE.	10 Lectures

Recommended Books:

1. Ordinary and partial differential Equation, M. D. Raishighania, S. Chand publication.
2. Fundamentals of Statistics, S. C. Gupta and V.K Kapoor,Sultan Chand & Sons .
3. Introductory methods of numerical analysis, S. S. Sastry, PHI.

References:

1. Partial Differential Equation, Sneddon, I. N., McGraw-Hill.
2. Theory of Ordinary Differential Equations, Earl CoddingtonMcGraw-Hill.
3. Advanced Engineering mathematics by E Keyszig.
5. Linear Programming by R.K.Gupta.

ESE 7001: Advanced Water and Waste Water Treatment: 4 credits (3-1-0)

Unit I	Extension of principles and applications to experimental determination of design parameters and operation criteria for various physical, chemical and biological unit operations involved in water treatment.	10 lectures
Unit II	Air pollution and solid waste management techniques.	08 lectures

Unit III	Unit operations and unit processes like Sedimentation, Coagulation and Flocculation, Filtration, Disinfection, Adsorption, Ion exchange, Stream simulation, Activated sludge process.	12 lectures
Unit IV	Anaerobic digestion, waste treatment in stabilization pond, Testing for some air pollutants, Testing/Examination of some air pollutants and soil wastes parameters.	12 lectures

Recommended Books:

1. Environmental Engineering, H.S. Peavy, D. R. Rowe & G. Tchobanoglous, McGraw Hill International, New York.
2. Environmental Engineering, G. Kiely, Tata McGraw Hill Education Private Limited, New Delhi, 2009.
3. Process Chemistry for Water and Wastewater Treatment, Benefield, Judkins&Weand, Prentice Hall Inc., New Jersey.
4. Wastewater Treatment Plants: Planning, Design & Operation, S.R. Qasim, CBS College Publishing, New York.
5. Wastewater Treatment Concept and Design Approach: G. L. Karia& R. A. Christian, PHI, N. Delhi.
6. Wastewater Treatment for Pollution Control and Reuse, S. J. Arceivala, Asolekar, Tata McGraw Hill, N ew Delhi.
7. Water and Wastewaters Technology: Mark J. Hammer, Mark J. Hammer Jr, PHI Learning Private Limited, N ew Delhi.
8. Wastewater Enineering: Treatment, Disposal & Reuse, Metcalf & Eddy, Tata McGraw Hill, New Delhi.

ESE 7002: Rural Water Supply and Sanitation: 4 credits (3-1-0)

Unit I	Objective of rural water supply, Sources, Selection of sources, Quality aspects.	10 lectures
Unit II	Construction and development of wells, Water Supply Distribution.	10 lectures
Unit III	Rural excreta disposal, Solid waste disposal.	10 lectures
Unit IV	Use of appropriate technology, Bio-gas generation, Current practices.	12 lectures

Recommended Books

1. Environmental Engineering Vol. I: Water Supply Engineering, S.K. Garg, Khanna Publications, Delhi.
2. Environmental Engineering Vol II: Sewage Disposal and Air Pollution Engineering, S.K. Garg, Khanna Publications, Delhi.
3. Water Supply Engineering (Environmental Engineering Vol. I): P. N. Modi, Standard Book House, N. Del hi.
4. Sewage Treatment & Disposal and Waste Water Engineering (Environmental Engineering Vol. II): P. N. M odi, Stabdard Book House, N. Delhi.
5. Water Supply & Sanitary Engineering, G.S. Birdi and J.S. Bindie, Dhanpat Rai Publishing Co., New Del hi, 1998.
6. Rural Water Supply And Sanitation, Sanjay Gupta, Vayu Education of India - New Delhi.
7. Rural Water Supply; A Practical Handbook on the Supply of Water & Construction of Waterworks, Allan Greenwell.
8. Rural Water Supply and Sanitation, Forest B. Wright, McGraw-Hill.
9. Problems of Rural Water Supply, GebrerufaelGirmayGebrekidan, VdmVerlag.

ESE 7003: Environmental Impact Assessment: 4 credits (3-1-0)

Unit I	Planning and Management of Environmental Impact Studies	6 lectures
Unit II	Impact indentation methodologies: base line studies, screening, scoping, checklist, networks, overlays	10 lectures
Unit III	Prediction and assessment of impacts on the socioeconomic environment, Environmental cost benefit analysis, Decision methods for evaluation of alternatives	10 lectures
Unit IV	Case Studies, Environmental impact assessment at project level, regional level, sectoral level, and policy level	8 lectures
Unit V	Sustainable development, Environmental policy in planned, mixed and market economies. Preventive environmental management.	8 lectures

Recommended Books:

1. Environmental Impact Assessment, Canter, L. W., Mcgraw Hill Education (India) 2014.
2. Introduction to Environmental Impact Assessment: Guide to Principles and Practice, Noble, B. 2000.

ESE 7004: Unit Processes and Operations in Environmental Engineering: 4 credits (3-1-0)

Unit I	Principles and application to experimental determination of design parameters and operational criteria for various physical, chemical and biological unit operation and processes used in water and waste water treatment.	26 lectures
Unit II	Process dynamics and analysis of various unit operations & processes.	16 lectures

Recommended Books:

1. Environmental Engineering, H.S. Peavy, D. R. Rowe & G. Tchobanoglous, McGraw Hill International, New York.
2. Environmental Engineering, G. Kiely, Tata McGraw Hill Education Private Limited, New Delhi, 2009.
3. Process Chemistry for Water and Wastewater Treatment, Benefield, Judkins&Weand, Prentice Hall Inc., New Jersey.
4. Wastewater Treatment Plants: Planning, Design & Operation, S.R. Qasim, CBS College Publishing, New York.
5. Wastewater Treatment Concept and Design Approach: G. L. Karia& R. A. Christian, PHI, N. Delhi.
6. Wastewater Treatment for Pollution Control and Reuse, S. J. Arceivala, Asolekar, Tata McGraw Hill, N ew Delh
7. Water and Wastewater Engineering, Desogh Principles and Practice: Mackenzie L. Davis, McGraw Hill Education (India) Private Limited, New Delhi.
8. Water and Wastewaters Technology: Mark J. Hammer, Mark J. Hammer Jr, PHI Learning Private Limited, N ew Delhi.

ESE 7005: Environmental Sanitation: 4 credits (3-1-0)

Unit I	Communicable Diseases: General definitions, Method of communication, Control of communicable diseases, Control source, Mode of transmission and susceptibilities, Respiratory, water and food borne, insect and rodent borne, and miscellaneous diseases.	12 lectures
Unit II	Sanitation of Public Bathing Places: Bathing water and health, Bathing place standards, Bathing load pool design, Operation and maintenance of bathing branches.	12 lectures
Unit III	Food Sanitation: Milk and food sanitation. Insecticides and Rodent control, Disinfectants and insecticides. Residential sanitation, Industrial sanitation, Miscellaneous methods of sanitation.	12 lectures
Unit IV	Brief introduction to principles of Epidiology and Paracitology.	06 lectures

Recommended Books

1. Control of Communicable Diseases Manual, 19th Edition, Edited by David L. Heymann Washington, DC: American Public Health Association, 2008.
2. Hygienic Production of Milk, S B Barbuddhe and B K Swain, Animal Sciences Section, Indian Council of Agricultural Research.
3. Principles of Epidemiology in Public Health Practice, An Introduction to Applied Epidemiology and Biostatistics, U.S. Department of Health And Human Services, Atlanta, GA 30333, 2012
4. Principles of Epidemiology, A Self-Teaching Guide, Lewis H. Roht Beatrice J. Selwyn Alfonso H. Holgu in, Academic Press, 1982.

ESE 7006 Surface Water Quality Modeling: 4 credits (3-1-0)

Unit I	River hydrology and derivation of the stream equation	6 lectures
Unit II	Derivation of the estuary equation, Distribution of water quality in rivers and estuaries	8 lectures
Unit III	Physical and hydrological characteristics of lakes, Finite difference steady state river, estuary and lake models	8 lectures
Unit IV	Dissolved oxygen models in rivers, estuaries and lakes	6 lectures
Unit V	Fate of indicator bacteria, pathogens and viruses in water; Basic mechanisms of eutrophication, Lake phytoplanckton models, River eutrophication analysis, finite segment models	8 lectures
Unit V	Elements of toxic substance analysis.	6 lectures

Recommended Books :

1. Principles of Surface Water Quality Modelling, R. V. Thomann and J. A. Mueller, Harper & Row, Publis hers, New York, 1987.
2. Surface Water Quality, S. C. Chapra, McGraw-Hill, New York, N.Y., 1997.

ESE 7007 Water Distribution Networks: 4 credits (3-1-0)

Unit I	Types of water supply systems, water distribution networks, basic principles of design of water distribution networks.	3 lectures
Unit II	Frictional loss in pipes, Moody diagram, minor head loss, simple pipe flow problems, equivalent pipes, reservoirs, pumps and valves.	7 lectures
Unit III	Network parameters, type of analysis, rules for solving pipe networks.	5 lectures
Unit IV	Formulation of equation of networks with known and unknown pipe resistance, pumps and check valves.	5 lectures
Unit V	Different methods of pipe network analysis, Hardy Cross Method, Newton Raphson method, Linear theory method and Gradient method	12 lectures

Recommended Books:

1. Fair, G. M., Geyer, J. C. and Okun, D. A. (1971). "Elements of Water Supply and Wastewater Disposal" , John Wiley and Sons, New York.
2. Mays, L. W. (2000). "Water Distribution Systems Handbook", McGraw Hill, New York.
3. Bhave, P. R. and Gupta, R. (2006). "Analyis of Water Distribution Networks", Narosa Publishing House Pvt. Ltd. New Delhi.

ESE 7008: Geo-Environmental Engineering: 4 credits (3-1-0)

Unit I	Source, Production and classification of wastes; Soil pollution processes; Physico-chemical and biological interactions in soil.	10 lectures
Unit II	Effects on geotechnical properties and case studies; Waste disposal facilities such as landfills and impoundments, Slurry walls, etc.	10 lectures
Unit III	Barrier systems- basic concepts, design and construction, Stability, compatibility and performance; Transport in subsurface; Reuse of waste materials; Remediation of contaminated sites.	12 lectures
Unit IV	Vibration problems and control, Rain induced land slides, bearing aspects of waste management.	10 lectures

Recommended Books:

As mentioned in GTE 7006 (Geo-Environmental Engineering)

ESE 7009: Optimization Techniques in Water Resources: 4 credits (3-1-0)

Unit I	Optimization techniques	6 lectures
Unit II	Linear programming, non-linear programming, geometric programming, dynamic programming	15 lectures
Unit III	Network flow algorithm and Goal programming	8 lectures
Unit IV	Introduction to modern heuristic methods like generic algorithm and simulated annealing	10 lectures

Recommended Books :

1. Operations Research, Principles and Practice, Ravindran, Phillips, D. T. and Solberg, J. J., John Wi ley & Sons, New York, 2000.
2. Optimization for Engineering Design, Algorithms and Examples, K Deb, Prentice Hall, New Delhi, 1995.

ESE 7010: Industrial Waste Water Treatment: 4 credits (3-1-0)

Unit I	Industrial waste water characteristics, Flow management and sampling techniques.	08 lectures
Unit II	General principles of industrial waste water treatment.	12 lectures
Unit III	Material recovery and water reuse.	08 lectures
Unit IV	Pollution abatement techniques applicable to paper and pulp, textile, tanning sugar and distillery, Fertilizers, Food processing and chemical industries.	14 lectures

Recommended Books:

1. Industrial Water Pollution Control: W. Wesley Eckenfelder, McGraw Hill Education (India) Private Lim ited (3rd Edition), 2000.
2. Environmental Engineering: G. N. Pandey, G. C. Carney, Tata McGraw Hill Publishing Company Limited, 1995.
3. Environmental Management: G. N. Pandey, Vikas Publishing House Pvt. Ltd. New Delhi, 1997.

ESE 7011: Design of Water and Waste Water Systems: 4 credits **(3-1-0)**

Unit I	Water Treatment Systems: Design of hydraulic and mechanical rapid mixing devices and flocculators, Design of sedimentation tanks, Filters.	08 lectures
Unit II	Water Collection, Conveyors and Distribution Systems: Design criteria of intake structures, Design of transmission lines (rising mains), Pumping systems, Design and analysis of distribution systems, Capacity determination of service reservoirs.	12 lectures
Unit III	Design of Sewerage and Drainage Systems.	08 lectures
Unit IV	Waste Water Treatment Systems: Design of screens, Grit chamber, Activated sludge process, Trickling filters, Extended aeration systems, Stabilization ponds, Lagoons, Sludge digesters, Design criteria of anaerobic biological reactors including anaerobic filter, UASBR.	14 lectures

Recommended Books :

1. Peavy H.S, Rowe D.R. and TchobanoglousG ,"Environmental Engineering" Tata McGraw Hills, New Delhi.
2. Metcalf and Eddy Inc., Wastewater Engineering – Treatment and Reuse, Tata McGraw Hill India.
3. Kawamura, S., Integrated Design and Operation of Water Treatment Facilities, John Wiley & Sons.
4. Sincero, A. P. and Sincero, G. A., Environmental Engineering: A Design Approach, PrenticeHall India.
5. Montgomery, J. M., Water Treatment: Principles and Design, John Wiley & Sons.
6. Mark J.Hammer,Mark J. Hammer Jr., Water and Waste Water Technology, PHI Learning Pvt.Limited.

ESE 7201: Solid Waste Management: 4 credits **(3-1-0)**

Unit I	Introduction; source, types, quantity, characteristics of solid wastes. Health & environmental implication of solid waste handling. Sampling & analyses of solid wastes.	10 lectures
Unit II	Municipal solid waste management: storage, collection, transfer, and transportation.	10 lectures
Unit III	Treatment & disposal of solid wastes: sanitary land filling, composting, incineration.	10 lectures
Unit IV	Typical design of all elements of MSW management. Resource conservation & recovery. Legal aspects.	12 lectures

Recommended Books :

1. Integrated Solid Waste Management, Engineering Principles and Management Issues, George Tchobanoglou s, Hilary Theisen and Samuel Vigil. McGraw-Hill Edition (India) Private Limited, New York. 2015.
2. Hazardous Waste Management: Charles A. Wentz, McGraw Hill.
3. Management of Organic Waste: S. Kumar & A. Bharti, INTECH.
4. Environmental Engineering, H.S. Peaviy, D.R. Rowe & G. Tchobanoglous, McGraw Hill International, New York.
5. Environmental Engineering, G. Kiely, Tata McGraw Hill Education Private Limited, New Delhi, 2009.
6. Hazardous Waste Management, La Grega, McGraw Hill International, New York.
7. Wastewater Engineering: Treatment, Disposal & Reuse, Metcalf & Eddy, McGraw Hill, New Delhi.

IDE 7001: Energy System and Environment: 4 credits **(3-1-0)**

Unit I	Mineral resources, metal and Non metals , Wood.	12 lectures
Unit II	Energy Resources: Coal, Petroleum and Natural Gas, Nuclear Fission and Fusion, Solar Energy, Wind Energy, Geothermal, Tidal, Hydroelectricity etc.	15 lectures
Unit III	Environmental impact management of energy production consumption and conservation renewable resources of energy.	15 lectures

Recommended Books

1. Annual Report (2017-18), Ministry of Mines, Government of India
2. Indian Minerals Yearbook 2017 Vol. II- Reviews on Metals and Alloys, Indian Bureau of Mines, Nagpur.
3. Indian Minerals Yearbook 2017 Vol. III- Mineral Reviews, Indian Bureau of Mines, Nagpur.
4. Renewable Energy Resources, John Twidell and Tony Weir, Taylor & Francis, New York.

IDE 7002: Hazardous Waste and Disaster Management: 4 credits (3-1-0)

Unit I	Sources and types of radio active waters, Uranium, Milling, Conversion and enrichment facilities, reactor fuel fabrication,	10 lectures
Unit II	Nuclear power reactors, Nuclear Reactor Fuel Reprocessing, Radio nuclides used for medical and industrial applications, High level radioactive waste treatment methods, Non high level radioactive waste and disposal of some radioactive elements.	12 lectures
Unit III	Hazard and operability analysis for chemical and other hazardous plants, Fault free analysis, Risk analysis and management,	10 lectures
Unit IV	Case studies, Disaster Management Planning, Insurance tariffs in hazardous industries, Design for safety.	10 lectures

Recommended Books

1. Hazardous Waste Management: Charles A. Wentz, McGraw Hill.
2. Hazardous Waste Management, La Grega, McGraw Hill International, New York.
3. Management of Organic Waste: S. Kumar & A. Bharti, INTECH.
4. Integrated Solid Waste Management, Engineering Principles and Management Issues, George Tchobanoglous, Hilary Theisen and Samuel Vigil. McGraw-Hill Edition (India) Private Limited, New York. 2015

IDE 7003: Oil and Marine Pollution: 4 credits (3-1-0)

Unit I	Introduction, Types of oil sources, Significance of oil pollution, Effect on plant and animal life.	10 lectures
Unit II	Prevention of oil pollution, Method of control, Legal aspects of oil pollution.	10 lectures
Unit III	Sources of marine wastes, Disposal of Marine wastes,	10 lectures
Unit IV	Physical, chemical, and biological parameters of marine waste, Limitations of indicator organisms.	12 lectures

Recommended Books

1. Oil Pollution and Marine Ecology, Nelson-Smith, Anthony, Springer.
2. Environmental Hazards: Marine Pollution, Martha Gorman, Santa Barbara, Calif.
3. Manual on Oil Pollution: Combating oil spills, International Maritime Organization, IMO Publishing.

IDE 7004: Air and Noise Pollution: 4 credits (3-1-0)

Unit I	Introduction, Air pollution: Ambient air qualities, Standards and air quality monitoring, Fluid resistance to particle motion,	10 lectures
Unit II	Emission Sources: Effects of pollutants on man, material and plants; Meteorology with reference to air pollution;	10 lectures
Unit III	Transport and dispersion of pollutants in air; Air pollution control measures.	08 lectures
Unit IV	Noise pollution: Sound and noise, Environmental and industrial noise, Effect of noise pollution, Measures for prevention and control of noise, Noise control legislations.	14 lectures

Recommended Books

1. Handbook of Environmental Engineering Volume 1, Air Pollution Control Engineering, Lawrence K. Wang, Norman C. Pereira and Yung-Tse Hung, Humana Press, New Jersey. 2004.
2. Enviromental Engineering (Vol. II) Sewage Waste Disposal and Air Pollution Engineering, Santosh Kumar Garg, Khanna Publishers, New Delhi.
3. Environmental Noise Pollution, Noise Mapping, Public Health, and Policy, Enda Murphy Eoin King, Elsevier, 2014.

IDE 7005: Waste Land Ecology: 4 credits **(3-1-0)**

Unit I	Introduction, scope, Deforestation, Present status of waste land, Ecological characteristics of waste land, Causes of formation, Physical and biological causes.	12 lectures
Unit II	Physical causes: Earth quake, Land slides, Floods, Drought, Salinity, Water logging and Fire.	08 lectures
Unit III	Biological causes: Deforestation, Grazing, shifting cultivation and faulty agricultural practices.	08 lectures
Unit IV	Reclamation of waste land, Scientific land use practices, A-forestation, Agro forestry, Soil conservation practices, importance of water catchment areas, Development of recreational and amenity areas.	14 lectures

Recommended Books

1. A Source Book for Ecological Restoration, Foundation for Ecological Security, Anand, Gujarat, India. http://iasc2011.fes.org.in/ 2008
2. Do's& Don'ts for Common Disasters, National Institute of Disaster Management, Ministry of Home Affairs, Govt. of India.
3. Hydro-Meteorological Disasters, National Institute of Disaster Management, Ministry of Home Affairs, Govt. of India.
4. Land Tenure And Deforestation, Interactions and Environmental Implications, Peter Dorner and William C. Thiesenhusen, United Nations Research Institute For Social Development, Switzerland.
5. Running Pure: The importance of forest protected areas to drinking water, Nigel Dudley and Sue Stolton, Research report for the World Bank / WWF Alliance for Forest Conservation and Sustainable Use, HMD, UK.

IDE 7006: Selected Topics in Environmental Engineering: 4 credits **(3-1-0)**

Unit I	Environment: Physical environment, pollution density, Temperature, Noise, Illumination, Psychological environment (culture).	08 lectures
Unit II	Behaviour: Mental activities (thinking, feeling and imagination), Emotional activities.	08 lectures
Unit III	Bio-electromagnetic: Introduction of electromagnetic pollution, Causes, Bio-electromagnetic, Pollution due to transmitters, Radar, Cellular telephones etc., current induced inhuman body, Dosimetry, WHO hazard limit, Effect on vegetation, FDTD (finite difference time domain) method,	12 lectures
Unit IV	Introduction and application to pollution study: Human risk factor and environmental requirement near high power transmitter installations and cellular and microcellular environment, SAR calculation, Introduction to EMI & EMC, Application of laser, Numerical technique and safety measures.	14 lectures

Recommended Books

1. Social Emotional Teaching Strategies, TheCenter on the Social and Emotional Foundations for Early Learning, Gail E. Joseph, Phil Strain, Tweety Yates, & Mary Louise Hemmeter.
2. Human Behavior: The Complete Pocket Guide, Bryn Farnsworth, https://imotions.com/blog/human-behavior/, 2018.
3. Wireless Radiation & EMF Studies, Joel M. Moskowitz, School of Public Health, University of California, Berkeley, file:///C:/Users/dell/Documents/Downloads/Moskowitz_recent_EMF_papers_2018.pdf, 2018

IDE 7007: Environmental System Modelling: 4 credits **(3-1-0)**

Unit I	Models and its development: model and model building processes, testing the performance of a model, application of model to environmental problems, decay kinetics, continuous flow stirred tank reaction model, plug flow reaction model.	9 lectures
Unit II	Pollution in rivers and streams: contaminant transport process, Longitudinal dispersion, dissolve oxygen models in rivers, introduction to waste load allocation model, introduction to water quality in lakes and reservoirs.	10 lectures
Unit III	Groundwater quality modeling: groundwater flow equation, hydrodynamic dispersion, advection-dispersion equations, point and non point source problems.	7 lectures

Unit IV	Introduction to optimization techniques, basic components of the optimization problems, application of optimization techniques to engineering problems,	10 lectures
Unit V	Linear programming, solution by graphical technique and simplex method. Application of environmental modelling softwares to real life problems	5 lectures

Recommended Books :

1. Environmental Systems Optimization, D. A. Haith, John Wiley & Sons, 1982.
2. Environmental Engineering, G. Kiely, McGraw Hill Singapore, 1998.
3. Water Quality Engineering in Natural Systems, D. A. Chin, John Wiley & Sons, 2006.
4. Introduction to Environmental Modelling, Smith, J and Smith, P, Oxford Press, 2007.
5. Environmental Systems Modeling, R. K. Prasad,Standard Publishers, Distributors, New Delhi 2019

IDE 7008: Sustainable Technologies and Development: 4 credits (3-1-0)

Unit I	Environment, Economy and performance, Technology for development, Methods for eco-compatible production processes.	12 lectures
Unit II	Role of NGO's UNDP in environmental protection.	08 lectures
Unit III	Environmental technology and industrial development in India.	08 lectures
Unit IV	Biotechnology applications in environmental perspective, Renewable resources, Future strategies.	14 lectures

Recommended Books

1. Evaluation of the Role And Contribution of UNDP in Environment and Energy, United Nations Development Programme, NY.
2. The Role of The United Nations In Environmental Protection And Sustainable Development, H. French, Worldwatch Institute, Washington DC, USA.
3. The Role of Technology and Innovation in Inclusive and Sustainable Industrial Development, Industrial Development Report, UNIDO, 2016

IDE 7009: Environmental Management: 4 credits (3-1-0)

Unit I	Environmental Economics (EE) Definition and scope : Valuation methods- EOP, PE and RC, HCA, HM, TCM, and CVM, Reliability and choice valuation methods, Case studies-EE of deforestation, Biodiversity conservation and watershed projects.	12 lectures
Unit II	Environmental Auditing (EA), Theory and applications: Guide line for EA, Establishing and conducting an effective environmental audit, EA in some leading MNCS.	12 lectures
Unit III	Environmental Administration (EAd) : Economic development and environmental linkage, The concept of sustainable development, Definition, scope and issues in environmental management in Indian context, Institutional capacities in India, ENVIS and Environmental Laboratories, EPA 1996, Air Act, Water Act and Pesticides Act, Environmental standards for air , water, land and noise, Preparation of Environmental management plan, Recent trends, strategies, programme and plans in the field of environment management. International: the work of UNEP, UNESCO (IBP to IGBP) IUCN and Ramsar convention, UNCD 1992, National: The work of MEF, Environmental Action Plan, Conservation strategies.	18 lectures

Recommended Books

1. Environmental Management: G. N. Pandey, Vikas Publishing House Pvt. Ltd. New Delhi, 1997.
2. Canter, L. W., Environmental Impact Assessment, McGraw-Hill, 2nd Ed., 1997.
3. Agarwal, N. P., Environmental Reporting and Auditing, Raj Pub., 2002.
4. Judith, P. and Eduljee, G., Environmental Impact Assessment for Waste Treatment and Disposal Facilities, John Wiley & Sons, 1994.
5. G. Burke, B. R. Singh and L. Theodore., Handbook of Environmental Management and Technology, 2nd Ed. , John Wiley & Sons, 2000.
6. C. H. Eccleston, Environment Impact Statements: A Comprehensive Guide to Project and Strategic Planning, John Wiley & Sons, 2000.
7. J. G. Rau and D. C. Wooten, Environmental Impact Analysis Handbook, McGraw-Hill, 1980.
8. R. F. Fuggle and M. A. Rabie, Environmental Management in South Africa, Juta & Co. Ltd., 1991.

9. R. M. Harrison, Pollution, Causes, Effects and Control, 2nd Ed., Whitstable Lithop Ltd., 1990.
10. K. Whitelaw and Butterworth, ISO 14001 : Environmental System Handbook, 1997.

IDE 7010: Environmental Risk Assessment: 4 credits **(3-1-0)**

Unit I	Basic concepts of environmental risk and definitions	6 lectures
Unit II	Hazard identification procedures; Environmental Risk Zonation; Consequence analysis and modeling (discharge models, dispersion models, fire and explosion models, effect models etc).	12 lectures
Unit III	Estimation of incident frequencies from historical data, frequency modeling techniques e.g., Fault Tree Analysis (FTA) and Event Tree analysis (ETA)	10 lectures
Unit IV	Case studies. Human factors in risk analysis	8 lectures
Unit V	Calculation and presentation of risk (individual risk, societal risk); Risk management. Rules, regulations and conventions.	8 lectures

Recommended Books :

1. Computer Simulation and Modelling, F. Neelamkavil, John Wiley, 1987.
2. Reliability Engineering, Govil, A.K.

IDE 7011: Future Studies: 4 credits **(3-1-0)**

Unit I	Introduction, Methodology in future studies, Perspective, Planning, system modelling, Anticipatory techniques, Technological forecasting, Technology assessment, Global and sectorial perspectives. Scenario building, Quantitative and qualitative studies.	10 lectures
Unit II	Energy future: Energy-economy environment relationships, forecast with reference to conventional and non-conventional energy sources, Global development, principles of energy accounting and auditing, practice of energy management.	10 lectures
Unit III	Urban future : Population trends and forecast, Human mobility and migration , housing in the future, services in the city of future , basic needs, prospects of the third world, preferred scenario and planning.	10 lectures
Unit IV	Environmental future: Technological civilization and its implications on environment. Ecological balance, Deforestation, Disposal of individual waste, river and ocean pollution, automobile emission, Noise Pollution, Planning and legislation, Case studies.	12 lectures

Recommended Books

1. Future Studies, Foresight and Scenarios as basis for betterstrategic decisions, A. Rialland, K.E. Wold, NTNU
2. Foresight Methodologies, Training Module 2, United Nations Industrial Development Organization, Austria.
3. Environment and Development Challenges: The Imperative to Act.
4. How Technology Could Contribute to a Sustainable World, Philip J. Vergragt, Orion Kriegman and Paul Raskin, Tellus Institute, Boston.

1. Name of the Programme : **MTech in Geotechnical Engg**
2. Department : **Civil Engineering**
3. Nature : **Regular programme**
4. Duration : **Four semesters**
5. Admission & Scholarships : **As per the Institute norms**
6. Evaluation Scheme : **As per the Institute norms**
7. Version : **As approved in the meeting of The BoS held on Sept 15, 2017**

Programme Structure

a) Break-up of Semester wise load :

Semester I	(courses)	: 22 credits
Semester II	(courses)	: 20 credits
Semester III	(Seminar/Dissertation)	: 8 credits
Semester IV	(Dissertation)	:16 credits
		66 credits

b) Structure :

SEMESTER I

Code	Title	Credits
1. MA 7107	Advanced Mathematical Techniques	3-1-0 4
2. GTE 7101	Applied Geotechnical Engineering	3-1-0 4
3. GTE 7102	Design of Shallow Foundation	3-1-0 4
4. GTE 7103	Theory of Vibration	3-1-0 4
5. GTE 7151	Geotechnical Exploration, Sampling & Testing	0-0-3 2
6. GTE 70**	Elective I	3-1-0 4
		22

SEMESTER II

1. GTE 7201	Deep Foundations	3-1-0 4
2. GTE 7202	Numerical Methods in Geotechnical Engg	3-1-0 4
3. GTE 70**	Elective II	3-1-0 4
4. GTE 70**	Elective III	3-1-0 4
5. GTE 70**	Elective IV	3-1-0 4
		20

SEMESTER III

1. GTE 8110	Seminar on Selected Topics (Audit)	0-0-04 2
2. GTE 8099	Project/Dissertation	0-0-16 8
		8

SEMESTER IV

1. GTE 8099	Project/Dissertation	0-0-32 16
		16

LIST OF ELECTIVES

1. GTE 7001 Rock Mechanics
2. GTE 7002 Critical State Soil Mechanics
3. GTE 7003 Ground Improvement Techniques
4. GTE 7004 Earthquake Geotechnical Engineering

5. GTE 7005 Optimization Techniques in Geotechnical Engineering
6. GTE 7006 Geo-environmental Engineering
7. GTE 7007 Pavement Design
8. GTE 7008 Ground Water Hydrology
9. GTE 7009 Finite Element Analysis
10. GTE 7010 Soil Dynamics
11. GTE 7011 Machine Foundations

Course Details

GTE 7101 Applied Geotechnical Engineering 4Cr (3-1-0)

Unit I	Earth pressure: Rankine, Coulomb and Graphical Methods.	10 lectures
Unit II	Retaining walls: Gravity, cantilever and counterfort retaining walls: Stability checks and design; Sheet Pile Structures: Cantilever sheet piling, Anchored sheet piling: Free and fixed earth support methods of analysis, anchorages for bulkheads; Br aced excavations, heave at bottom of cohesion -less and cohesive soils; Arching in soils.	14 lectures
Unit III	Stability analysis of slope s Stability of infinite slopes; Stability of finite slopes; Effective and total stress approach; Shape of slip surface; Methods of slices - Swedish, Bishop, Morgenstern and Price methods; Location of critical slip circle	10 lectures
Unit IV	Earth and rock -fill dams: Types of Earth and Rockfill dams, Stability analysis of Earth and Rock -fill dams, Introduction to Reinfo rced earth structures.	8 lectures

Recommended Books

1. Saran, S, Analysis and Design of Substructures: Limit State Design, 2nd Ed, Oxford and IBH, New Delhi, 2015,
2. Murthy, V N S,Geotechnical Engineering: Principles and Practices of Soil Mechanics and Foundation Engineering, CRC Press, Taylor and Francis, 2002.
3. Coduto, Donald P,Geotechnical Engineering: Principles and Practices, 2nd Ed, Pearson Education, New Delhi, 2017.
4. Budhu, Mun,iSoil Mechanics and Foundations, 2nd Ed, Wiley India, New Delhi, 2007.
5. RanjanGopal, and Rao, A S R,Basic and Applied Soil Mechanics, New Age International Pvt Ltd, 2006.

GTE 7102 Design of Shallow Foundations 4Cr (3-1-0)

Unit I	Bearing capacity of shallow foundations; Estimation of Bearing Capacity from Building Codes/Analytical Methods/Lab and Field Tests, Different analytical methods, Limit analysis of bearing capacity, Effect of water table, Eccentric Loads, Footings on or near slopes.	12 lectures
Unit II	Settlement of shallow foundations, Elastic and consolidation settlements; Settlement estimates from penetration tests, Settlement tolerance. Allowable bearing pressure.	8 lectures
Unit III	Foundations on problematic soils. Remedial measures.	4 lectures
Unit IV	Principles of foundation design. Contact Pressure Distribution. Yield line analysis of footings subjected to uniform and non-uniform contact pressure distribution.	8 lectures
Unit V	Structural Design of spread, combined, strap, ring footings, and rafts.	10 lectures

Recommended Books :

1. Saran, S,Analysis and Design of Substructures, Limit State Design, Oxford and IBH Publishing Co Private Limited, New Delhi, 1998.
2. Murthy, V N S,Advanced Foundation Engineering, CBS Publishers and Distributors, New Delhi, 2007.
3. Budhu, M,Soil Mechanics and Foundations, 2nd Edition, Wiley India Private Limited, New Delhi, 2007.
4. Bowles,J E,Foundation Analysis and Design, 5th Edition, McGraw Hill International Edition, Singapore,1997.
5. McCarthy, D F,Essentials of Soil Mechanics and Foundations, 7 th Edition, Pearson Prentice Hall, New Jersey, 2007.
6. Terzaghi, K,Peck, R B,and Mesri, G,Soil Mechanics in Engineering Practice, 3 rd Edition, John Wiley and Sons, New York, 1996.
7. Varghese, P C,Foundation Engineering, Prentice Hall of India, New Delhi, 2005.
8. Brahma, S P,Foundation Engineering, Tata McGraw Hill Publishing Co Limited, New Delhi, 1991.
9. Recent Literature.

GTE 7103 Theory of Vibration 4cr (3-1-0)

Unit I	Single degree of freedom systems - free vibration: introduction to dynamics of structures and their modelling, springs in series and parallel; Eq uation of motion and response, free vibration , damping, amplitude, natural frequency and logarithmic decrement.	6 lectures
Unit II	Single degree of freedom system - forced vibration under harmonic loading; Undamped and damped harmonic excitation; resonance; Half power band method for damping; transmissibilty, vibration isolation, Seismic Instruments; Introduction to Duhamel's Integral, response to unit impulse, step force, rectangular pulse force, linearly increasing force concept of response spectrun; Response to Seismic excitation.	12 lectures
Unit III	Multi degree of freedom system: Equation of motion, two degrees of freedom system, natural vibration, frequency and modes, orthogonally and normalisation of modes .	7 lectures
Unit IV	Solution of equation of motion: eigenvalue problem, estimating fundamental frequency by Rayleigh's method .	5 lectures
Unit V	Modal analysis: modal equation, modal expansion of displacement, modal displacement super position, response, element forces.	6 lectures
Unit VI	Continuous systems: undamped equation of motion, natural vibration frequencies and modes of uniform simply supported and cantilever beams .	6 lectures

Recommended Books :

1. Paz, M,Structural Dynamics: Theory & Computations, CBS, New Delhi, 1985
2. Chopra, A K,Dynamics of Structures, Theory and Applications to Earthquake Engineering, Prentice Hall of India, New Delhi, 2000.
3. Claugh and Penzien, Dynamics of Structures, McGraw Hill International, New York, 1993.
4. Craig Jr, Structural Dynamics, John Wiley and Sons, New York, 1981.

GTE 7151 Geotechnical Exploration Sampling and Testing 2Cr (0-0-3)

Problems and phases of foundation investigations, Sample requirements, sampling methods and equipment, Handling, preservation and transportation of samples, Sample preparation, laboratory tests, analysis of results and interpretation, importance of in situ testing. Precautions and interpretation, Site evaluation and reporting.

GTE 7201 Deep Foundations 4Cr (3-1-0)

Unit I	Introduction of deep foundation, different types of deep foundation, requirement for deep foundation	8 lectures
Unit II	Pile foundation, classification of piles, estimation of load carrying capacity of single and pile group under various loading conditions Pile load testing (static, dynamic meth ods and data interpretation), negative skin friction, settlement of pile foundation, Laterally loaded piles, Code provision, D esign of pile and pile cap .	14 lectures
Unit III	Well foundation, types, components, construction methods, design methods.	10 lectures
Unit IV	Structural design consideration, code provision, Design of piles and pile cap, Design methods for well foundation.	10 lectures

Recommended Books:

1. Murthy,VNS,Advanced Foundations Engineering, CBS Publishers & Distributors Pvt. Ltd., 2011.
2. Saran, S,Analysis and Design of Substructures- Limit State Design, Oxford & IBH Publishing Co. Pvt. Ltd., 2013.
3. Krishna Raju, N,Design of Reinforced Concrete Structures, CBS Publishers & Distributors Pvt. Ltd., 2014.
4. Prakash S, and Sharma,H D,Pile Foundations in Engineering Practice, Wiley India Pvt. Ltd., 2013.

GTE 7202 Numerical Methods in Geotechnical Engineering 4Cr (3-1-0)

Unit I	Introduction to numerical modelling in Geote chnical Engineering, Review of basic concepts: – Stress at a point, Invariants of stre ss and strain, Equilibrium and Compatibility, Constitutive behaviour and its idealization, Methods of analysis.	6 lectures
Unit II	Constitutive modelling of soil - Elastic constitutive models: linear isotropic elasticity, linear anisotropic elasticity, no nlinear elasticity:K-G model, hyperbolic model; E lastic-plastic models: Essential ingredients of elastic -plastic models; Simple elastic -plastic constitutive models: Tresca model, Von Mises model, Mohr - Coulomb model, Drucker -Prager model; Development of Cri tical state models.	8 lectures
Unit III	Introduction to FEM - historical development, advantages, general procedure of finite element analysis, displacement approach, concept of nodes, elements and boundary conditions; FE equation by direct approach for b ar and truss elements.	12 lectures
Unit IV	Principle of stationary potential energy: Potential energy of an elastic body, Rayleigh -Ritz Method, Galerkin's method, Co -ordinate systems : global, local and natural co -ordinates, Shape functions for different types of elements.	6 lectures
Unit V	Finite element form of Rayleigh -Ritz method - Formulation of strain - displacement matrix and stiffness matrix; Isoparametric formulation: bar element, triangular elements (CST), consist ent element nodal load vector; Numerical integration by Gauss quadrature.	10 lectures

Recommended Books :

1. Atkinson J H and Brandsby P L, Introduction to Critical State Soil Mechanics, McGraw Hill.
2. Wood, D M, Soil behaviour and Critical State Soil Mechanics, Cambridge University Press, New York
3. Potts D M and Zdravkovic L, Finite Element Analysis in Geotechnical Engineering. Thomas Telford.
4. Desai C S and Abel, J F, Introduction to the Finite Element Method: A Numerical Method for Engineer ing Analysis, 10th Reprint, Van Nostrand Reinhold Co., New York, 1972.
5. Reddy J N, An Introduction to FEM, 3rd Ed, McGraw Hill series in Mechanical Engineering, 2006.

MA 7107 Advanced Mathematical Techniques 4Cr (3-1-0)

Unit I	Ordinary Differential Equations: Ordinary differential equation of first and second order, complementary function, particular integral, variation of parameter method.	8 lectures
Unit II	Partial Differential Equations: Basic concepts, modelling, vibration string, one dimensional wave equation, separation of variable method.	6 lectures
Unit III	Statistics: Elementary statistics, correlation, regression, random variables, probability distribution, binomial, Poisson and Normal distribution, estimation of parameters, confidence interval, hypothesis of testing, goodness of fit.	10 lectures
Unit IV	Optimization: Linear programing, graphical solution, un-constrained and constrained non-linear optimization, Lagrange multipliers.	8 lectures
Unit V	Numerical Analysis: Solution of algebraic equations by iteration method, finite differences, interpolation, numerical integration and differentiation, numerical method for ODE and PDE.	10 lectures

Recommended Books :

1. Raishighania, M D,Ordinary and Partial Differential Equations, S. Chand Publications, ND, 2005.
2. Gupta,S C and Kapoor, VK ,Fundamentals of Mathematical Statistics, Sultan Chand & Sons, ND, 2014.
3. Sastry, S S,Introductory Methods of Numerical Analysis, PHI, ND, 2005.
4. Sneddon, I N, Partial Differential Equation, Dover Edition, (First published by McGraw-Hill in 1957), 2006.
   Coddington, E and Levinson, N, Theory of Ordinary Differential Equations,Indian Reprint, McGraw

Electives

GTE 7001 Rock Mechanics 4Cr (3-1-0)

Unit I	Geological formation of rocks, Structural Geology, Classification of rocks, Physico-mechanical Properties of rocks.	10 lectures
Unit II	Laboratory and Field Tests, Stress-strain behaviour, Failur e Criteria for intact rocks and rock masses, Fracture mechanism.	10 lectures
Unit III	Analysis and design of underground openings, Instrumentation in tunnels.	10 lectures
Unit IV	Rock Support and reinforcement, Foundations on rocks, Stability of rock slopes.	12 lectures

Recommended Books :

1. Mukerjee, P K, A Text Book of Geology, World Press, 1995.
2. Brady, B H G, and Brown, E T, Rock Mechanics for Underground Mining, Chapman and Hall, London, 1993.
3. Goodman, R E, Introduction to Rock Mechanics, John Wiley and Sons, NY, 1989.
4. Bieniawski, Z T, Engineering Rock Mechanics Classification, John Wiley and Sons, NY, 1989.
5. Wyllie, D C, Foundations on Rock, 2nd Ed, E & FN Spon, London, 1992.

GTE 7002 Critical State Soil Mechanics 4Cr (3-1-0)

Unit I	Effective stresses, Volume change behaviour of soils, Stress-strain invariants, Isotropic/Anisotropic moduli, Modelling of drained and undrained behaviour, Role of elasticity in soil mechanics, Small strain elasticity theories.	8 lectures
Unit II	Plasticity theory, Yielding of me tals, Combined loading and yield loci, Yield in sands and clays, Volume change and plastic hardening, Friction block model, Plastic potential, Normality and stability.	8 lectures
Unit III	Introduction to elasto-plastic modelling of soil, Critical state concept, Behaviour of normally/over-consolidated clays, and loose/dense sands, Critical state and constant volume, Stress-dilatancy.	8 lectures

Unit IV	Mohr Coulomb failure, Critical state line and drained/un-drained strength, Peak and residual strengths, Stress Path and Laboratory tests.	8 lectures
Unit V	Introduction to Cam Clay model, Development of Cam Clay model from tri-axial test data, Application of model and critical state soil mechanics.	10 lectures

Recommended Books:

1. Atkinson JH and Brandsby PL, Introduction to Critical State Soil Mechanics, McGraw Hill.
2. Wood, DM, Soil behaviour and Critical State Soil Mechanics, Cambridge University Press, New York
3. Schofield, A and Wroth, P, Critical State Soil Mechanics, Cambridge University, *www-civ.eng.cam.ac.uk/geotech_new/publications/schofield_wroth_1968.pdf*
4. Mitchell, R J, Fundamentals of Soil Behaviour, 3rd Ed, Wiley, NY, 2005.
5. Bolton, M, A Guide to Soil Mechanics, McMillan Education, NY, 1987.

GTE 7003 Ground Improvement Techniques 4Cr (3-1-0)

Unit I	Introduction, necessity and methods of Ground Improvement, Analysis and design of Dewatering Systems, Methods of Grouting, properties, Grouting types, Methods of Rock Reinforcement.	8 lectures
Unit II	Introduction and methods of Compaction, Factors affecting Compaction, engineering properties of Compacted Soil, Field Compaction and its control.	8 lectures
Unit III	Introduction of Soil stabilisation, Soil stabilisation using admixtures, Cement stabilisation, Lime stabilisation, Bituminous stabilisation and other chemical stabilisers, Geotechnical application.	8 lectures
Unit IV	Problematic soils- Problems, remedies and construction in problematic soils, Application of Micro pile and Sand compaction pile, Introduction of Stone column, Principle, design and method of installation of Stone column.	12 lectures
Unit V	Concept of Reinforced earth, Materials, Application and design of Reinforced earth, Principles and applications of Geotextiles in construction work.	6 lectures

Recommended Books:

1. Purushothama Raj,P,Ground Improvement Technique, Laxmi Publications (P) Ltd,2014.
2. Arora, K R,Soil Mechanics and Foundation Engineering, Standard Publishers Distributors, 2011.
3. Ranjan,Gopal and Rao, A S R,Basic and Applied Soil Mechanics, New Age International (P) Ltd., 2006.
4. Saran, S,Reinforced Soil and its Engineering Applications, I. K. International Publishing House Pvt. Ltd., 2013.
5. SivakumarBabu, G L,An Introduction to Soil Reinforcement &Geosynthetics, University Press, Hyderabad, 2006.

GTE 7004 Earthquake Geotechnical Engineering 4Cr (3-1-0)

Unit I	Introduction to Geotechnical Earthquake Engineering and Seismic Hazards, Earthquakes: Causes; Introduction to Plate Tectonics, Earthquake Magnitudes, Intensity, Types of Earthquake Waves .	6 lectures
Unit II	Ground Motion: Definition and Strong motion measurement; Ground Motion Parameters.	6 lectures
Unit III	Wave Propagation in Elastic rods, Elastic media and Halfspace; P, S and R waves- Characteristics and engineering significance.	6 lectures
Unit IV	Dynamic Soil Properties and measurement, Dynamic Bearing Capacity.	8 lectures
Unit V	Seismic Site Response Analysis; Introduction to computer codes.	8 lectures
Unit VI	Introduction to Seismic Earth Pressure, and Seismic Soil- Structure Interaction.	8 lectures

Recommended Books:

1. Kramer, S L,Geotechnical Earthquake Engineering, 2/e, Pearson Education Inc, New Delhi, 1996.
2. Towohata, I, Geotechnical Earthquake Engineering, Springer Verlag, 2008, (e-book link: http://link.springer.com/book/10.1007%2F978-3-540-35783-4)
3. Saran,S, Analysis and Design of Foundations and Retaining Structures Subjected to Seismic Loads, I.K. International, New Delhi, 2012.

GTE 7005 Optimization Techniques in Geotechnical Engineering 4Cr (3-1-0)

Unit I	Introduction to Optimization, Linear and Non-Linear Programming Problems, Formulation, Graphical solutions of LP Problems.	6 lectures
Unit II	Solution of LP problems by SIMPLEX, Slack, Surplus and Artificial Variables, Two Phase SIMPLEX, Artificial Cost Function and Big M Method.	8 lectures
Unit III	Integer Programming Problems, Branch and Bound Method, Duality of LP problems.	6 lectures
Unit IV	Non-Linear Programming, Unconstrained optimization of single- and multi-variables functions, Conditions for optimality, Gradient Vector, Hessian Matrix, Quadratic form of a function, Tests on matrix of the quadratic form.	8 lectures
Unit V	Non-Linear Constrained optimization, Lagrange's Function, K-K-T conditions of optimality.	6 lectures
Unit VI	Numerical Methods of optimization, Direct Search Methods, Gradient Based Methods, Nature Inspired Methods, Example from field of Geotechnical Engineering.	8 lectures

Recommended Books :

1. Arora, J S,Introduction to Optimum Design, McGraw hill Inc, New York
2. Mittal,K V and Mohan, C,Optimization Methods, New Age International Publishers, New Delhi
3. Ramamurthy, P,Operation Research, New Age International Publishers, New Delhi
4. Iyengar N G R,and Gupta, Structural Design Optimization, EWP, New Delhi
5. Belegundu and Chandrapatla, Optimization Concept and Applications, Pearson Education, New Delhi
6. Recent Literature

GTE7006Geo-environmental Engineering 4Cr (3-1-0)

Unit I	Introduction, Sources & Impact of Contamination and Soil-Waste Interaction, Concepts of Integrated SWM & Geo-environmental Engineering.	6 lectures
Unit II	Soil composition and mineralogy; types and characteristics of contaminants; theory of water seepage in soil and hydraulic conductivity; theory of reactive contaminant transport in soil including molecular diffusion, mechanical dispersion and advective flow.	8 lectures
Unit III	Principles and Planning of Landfills, Liners for Landfills, Landfill Covers, Generation and Control of Leachate and Gas from Landfills,Use of Geosynthetics and geomembranes.	10 lectures
Unit IV	Stability of Slopes and Settlement of Landfills, Costs, Construction Aspects and Site Selection of Landfills.	8 lectures
Unit V	Slurry Deposited Waste and their Geotechnical Properties, Planning & Design, Incremental Raisings and Failures of Slurry Ponds, Environmental Control Measures at Slurry Ponds, Geotechnical Reuse of Waste, and Remediationof contaminated sites.	10 lectures

Recommended Books :

1. Daniel, DE, Geotechnical practice for waste disposal, Chapman and Hall, 1993.
2. Datta, M, Waste disposal in Engineered landfills, Narosa Publishers, 1998.
3. Qian, X, Koerner, R, and Gray, DH,Geotechnical aspects of landfill design and construction, Prentice Hall, 2002.

4. Vick, SG, Planning, analysis and design of tailings dams, John Wiley & Sons, 1990.
5. Gulhati, SK and Datta M, Geotechnical Engineering, McGraw Hill,2005.
6. Sharma, HD, and Reddy, KR, Geoenvironmental Engineering: Site Remediation, Waste Containment and Emerging Waste Management Technologies, John Wiley & Sons, Inc. Hoboken, New Jersey, 2004 (ISBN:0-471-21599-6).

GTE 7007 Pavement Design 4Cr (3-1-0)

Unit I	Pavement structures, flexible, rigid and semi-rigid pavements, components, evaluation of properties of pavement and sub-grade materials.	8 lectures
Unit II	Stress in flexible pavement, homogenous and layered system, effect of total load and tyre pressure, equivalent wheel and axle loads.	8 lectures
Unit III	Design of flexible pavements, different methods, IRC specifications.	12 lectures
Unit IV	Stress in rigid pavement, relative stiffness of slabs, stresses due to bending, warping, expansion and contraction, combined stresses, IRC recommendation and design method of reinforced slabs.	8 lectures
Unit V	Joints, loads transfer at transverse joints by dowel bars, maintenance of joints, pavement distress, maintenance and strengthening of pavements.	6 lectures

Recommended Books :

1. Yoder,ET, and Hitczak, MW, Principles of Pavement Design, John Wiley and Sons Inc, NY, 1975.
2. Khanna, S K,Justo,C E G,and Veeraraghavan,A,Highway Engineering, Nem Chand & Brothers, Roorkee, Indi a, 2015.
3. Huang, Yang H. Pavement Analysis and Design, 2nd Edition, Prentice Hall, 2003.
4. Srinivasa Kumar, R,Pavement Design, Universities Press, Hyderabad India, 2013.
5. Singh,Alam,and Chowdhuri, G R,Soil Engineering in Theory and Practice Vol 1: Fundamentals and General Principles, CBS, ND, 1994.
6. IRC: 37-2012, Guidelines for the design of Flexible Pavement (Third revision). Indian Roads Congress.
7. IRC: 58-2015, Guidelines for the design of plain jointed rigid pavements for highways (fourth revision). Indian Roads Congress.

GTE 7008 Ground Water Hydrology 4Cr (3-1-0)

Unit I	Occurrence of ground water, ground water movement, saturated and unsaturated flow. ground water geophysics: electrical resistivity and seismic refraction method.	10 lectures
Unit II	Groundwater flow: differential equations governing groundwater flow, radial flow to wells.	8 lectures
Unit III	Evaluation of aquifer properties: Theis method, Jacob method, Chow's method.	8 lectures
Unit IV	Groundwater modeling techniques, Analog models, Mathematical models.	8 lectures
Unit V	Groundwater recharge, discharge and balance; management of groundwater: concept of basin management, conjunctive use.	8 lectures

Recommended Books :

1. Todd, D K, Groundwater Hydrology, John Wiley & Sons, Singapore, 1995.
2. Freeze, R A and J A Cherry,Groundwater, Prentice Hall. Inc., NJ, 1979.
3. Raghunath, H M, Groundwater, New Age International, New Delhi,1982.
4. Karanath,Groundwater Assessment Development & Management, Tata McGraw Hill, New Delhi, 1987.
5. Bear, J, Hydraulics of Groundwater, McGraw Hill, New York, 1979.

GTE 7009 Finite Element Analysis 4Cr (3-1-0)

Unit I	Approximate Solution of Boundary Value Problems: Approximate solution using Rayleigh_Ritz Method and Galerkin method, Boundary conditions and general comments.	5 lectures
Unit II	Basic Finite Element Concepts:Basic ideas in a finite element solution, General finite element solution procedure, Concept of nodes, elements and degree of freedom. Coordinate and shape functions. Treatment of Boundary conditions. Finite element equations using Rayleigh-Ritz method. Application to axial deformation of bars and axial spring element, Treatment of multi-freedom constraints.	10 lectures
Unit III	Analysis of Trusses: Coordinate transformation, Derivation of element stiffness matrix, calculation of internal stresses, stresses due to temperature changes.	5 lectures
Unit IV	Isoparametric Elements: Isoparametric triangular elements-Natural (or Area) coordinates for triangles, Shape functions for triangular elements, Natural coordinate mapping for triangles, Six node triangular element for general 2D BVP Isoparametric quadrilateral elements-Shape functions for rectangular elements, Isoparametric mapping for quadrilateral elements, Numerical integration for quadrilateral elements, Four node quadrilateral element for 2D BVP, Eight node serendipity element for 2D BVP.	6 lectures
Unit V	Two Dimensional Elasticity: Governing differential equations, Constant strain triangular element, Four node quadrilateral element, Eight node isoparametric element. Application of CST for analysis of plane stress problems.	8 lectures
Unit VI	Axisymmetric Elasticity Problems: Governing equations for axisymmetric elasticity, Axisymmetric linear triangular element, Axisymmetric four node isoparametric element.	8 lectures

Recommnded Books :

1. Reddy, J N,An Introduction to the Finite Element Method, 3rd Edition, McGraw-Hill Science/Engineering/Math, 2005.
2. Chandrupatla T R, and Belegundu, A D, Introduction to Finite Elements in Engineering, Prentice Hall, 2003.
3. Bathe, K-J, Finite Element Procedures, Prentice Hall, 1996.
4. Zienkiewicz, O C, Taylor, R L, Zhu, J Z, The Finite Element Method: Its Basis and Fundamentals, Else vier, 2005.
5. Cook, R D, Malkus, D S, Plesha, M E, and Witt, RJ, Concepts and Applications of Finite Element Analysis, 4th Edition, Wiley-India, 2007.
6. Hughes, T J R, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Dover Publications, 2000.
7. Potts D M and Zdravkovic L Finite Element Analysis in Geotechnical Engineering. Thomas Telford.
8. Desai CS, and Abel, JF, Introduction to the Finite Element Method: A Numerical Method for Engineering Analysis, Tenth Reprint.Van Nostrand Reinhold Co., New York, 1972.

GTE 7010 Soil Dynamics 4Cr **(3-1-0)**

Unit I	Wave Propagation: Longitudinal and torsional waves in infinitely long rod; Solution for one-dimensional and three-dimensional equations of motion; Waves in semi-infinite media; Earthquake waves – P-wave, S-wave, Rayleigh wave and Love wave; Locating earthquake's epicenter. Attenuation of stress waves – material and radiation damping; Waves in layered medium, Dispersion.	10 lectures
Unit II	Stresses in soil element; Determination of dynamic soil properties; Field tests; Laboratory tests; Model tests; Stress-strain behavior of cyclically loaded soils; Estimation of shear modulus; Effect of strain level on the dynamic soil properties; Modulus reduction curve; Damping ratio; Linear, equivalent-linear and non-linear models; Ranges and applications of dynamic soil tests; Cyclic plate load test; Block Vibration Test; Measurement of seismic response of soil at low and high strain, using laboratory tests; SASW/MASW tests, cross bore hole test	14 lectures
Unit III	Liquefaction analysis: Introduction, pore pressure, liquefaction related phenomena-flow liquefaction and cyclic mobility, factors affecting liquefaction, liquefaction of cohesion-less soils and sensitive clays, liquefaction susceptibility, State criteria -CVR line, SSL, FLS, Evaluation of liquefaction potential, Characterization of earth quake loading and liquefaction resistance, cyclic stress ratio, effects of liquefaction; Cyclic triaxial and direct shear test, Vibration Table studies, Basic concept of soil improvement due to dynamic loading; Various methods; Mitigation of liquefaction.	10 lectures
Unit IV	Dynamic earth pressures; Force and displacement based analysis; Pseudo-static and Pseudo-dynamic analysis; Earth Pressure: Active and passive earth pressures; Terzaghi's passive wedge theory, numerical methods, earth pressure measurements.; Seismic design of retaining walls: types, modes of failures, static pressure, seismic response, seismic displacement, design considerations.Guidelines of various design codes.	8 lectures

Recommended Books :

1. Prakash, S, Soil Dynamics, McGraw-Hill Book Company.
2. Das, B M,Principles of Soil Dynamics, PWS-KENT Publishing Company.
3. Kramer, S L,Geotechnical Earthquake Engineering, Prentice Hall Inc.
4. Barkan, D D,Dynamics of Bases and Foundations, McGraw-Hill Book Company.
5. Richart,E E,et al., Vibrations of Soils and Foundations, Prentice Hall Inc.

GTE 7011 Machine Foundations 4Cr **(3-1-0)**

Unit I	Overview of Soil Dynamics, Introduction to Machine Foundations, Types, Design Criteria, Methods of Analysis.	4 lectures
Unit II	Method of Dynamic Subgrade Modulus (Barkan's Method); Definition of Soil Stiffness and Dynamic Elastic Constants; Block Vibration Test; Relevant IS codal recommendations for Reciprocating, Impact and Turbo Generator Foundations.	10 lectures
Unit III	Elastic Halfspace Theory; Analogs in various modes of vibration.	6 lectures
Unit IV	Impedance Functions: Definition, characteristics; Computational Methods; Rigorous and Simplified models.	4 lectures
Unit V	Introduction to Cone Model; Translational and Rocking cones; their static and dynamic stiffnesses; Effect of Contact Pressure distribution.	8 lectures
Unit VI	Design examples.	10 lectures

Recommended Books :

1. Baishya, S, Dynamic Response of Embedded Block Foundations in Layered Media, PhD Thesis, IIT Roorkee, (Chapter 2),2002.
2. Barkan, DD, Dynamics of Bases and Foundations, McGraw Hills, 1962.
3. Richart, Hall and Woods, Vibrations of Soil and Foundations, Prentice Hall, NY, 1970.
4. Saran, S, Soil Dynamics and Machine Foundations, Galgotia Publications, New Delhi,1999.
5. Wolf, J P, Foundation Vibration Analysis using Simple Physical Models, Prentice HallInc, NY,1994.
6. Wolf, J.P. and Deeks, A, Foundation Vibration Analysis: A Strength-of-Materials Approach, Elsevier.2 004.

List of Course Work Subjects for Ph. D.

Sl No.	Course Code	Course Title	L	-	T	-	P	:	Cr
1.	CE 9001	Scaled Boundary Finite Element Method	3	-	1	-	0	:	4
2.	CE 9002	Water Resources Systems	3	-	1	-	0	:	4
3.	CE 9003	Hydraulics of Open Channels	3	-	1	-	0	:	4
4.	CE 9004	Stochastic Hydrology	3	-	1	-	0	:	4
5.	CE 9005	Groundwater Flow and Contaminant Transport Modelling	3	-	1	-	0	:	4
6.	CE 9006	Sediment Transportation	3	-	1	-	0	:	4
7.	CE 9007	Geographical Information Systems (GIS)	3	-	1	-	0	:	4
8.	CE 9008	Non Linear Finite Element Method	3	-	1	-	0	:	4
9.	CE 9009	Advance Mechanics of Solids	3	-	1	-	0	:	4
10.	CE 9010	Bridge Engineering	3	-	1	-	0	:	4
11.	CE 9011	Prestressed Concrete	3	-	1	-	0	:	4
12.	CE 9012	Advanced RCC Design and Construction Techniques	3	-	1	-	0	:	4
13.	CE 9013	Traffic Engineering	3	-	1	-	0	:	4
14.	CE 9014	Traffic Flow Modeling and Simulation	3	-	1	-	0	:	4
15.	CE 9015	Urban Transportation Systems Planning	3	-	1	-	0	:	4
16.	CE 9016	Geopolymer Concrete	3	-	1	-	0	:	4
17.	CE 9017	Durability of Concrete	3	-	1	-	0	:	4
18.	CE 9051	Applications of Finite Elements	1	-	0	-	6	:	4

Course Code: CE 9001
Course Title: Scaled Boundary Finite Element Method **LTP: 3-1-0=4 Cr.**

Course Content:

Units	Topic	Lectures/Practice Sessions
Unit-I	Introduction, Concept of Scaled Boundary (SB) Transformation, Scaled Boundary Finite Element Method: Advantages over other methods: Finite Element and Boundary Element Methods, Major Application Areas	6
Unit II	SB Transformation based De rivation: SB Transformation, Governing equations in Scaled Boundary Coordinates, Method of Weighted Residual, SBFE equations in Displacement and Stiffness Dynamic Stiffness Matrix,	12
Unit -III	Solution Procedures for SBFE equation: Illustration with Sing le line Element, Solutions in Statics, Mass of Bounded Medium, High frequency Asymptotic expansion of Dynamic Sti ffness of Unbounded medium, Numerical solution.	12
Unit-IV	Solution in Time Domain: Continued Fraction Technique for Bounded and Unbounded Domain	12

Recommended Books :

1. Wolf, J. P. and Song, C. (1996). *Finite-Element Modelling of Unbounded Media.* John Wiley & Sons Ltd, England.
2. Wolf, J. P. (2003). *The Scaled Boundary Finite Element Method.* John Wiley & Sons Ltd, England.
3. *Lehmann, L. (2007).* Wave Propagation in Infinite Domains. With Applications to Structure Interaction. *(https://link.springer.com/content/pdf/10.1007%2F3-540-71109-0.pdf)*
4. *Mohasseb, S. (2015) The Scaled Boundary Finite Element Method – Introduction*
5. *(https://www.ethz.ch/content/dam/ethz/special-interest/baug/ibk/structural-mechanics-dam/education/femII SBFEM1.pdf)*
6. *Mohasseb, S. (2015) The Scaled Boundary Finite Element Method – Theory*
7. *(https://www.ethz.ch/content/dam/ethz/special-interest/baug/ibk/structural-mechanics-dam/education/femII/SBFEM2.pdf)*

Course Code: CE 9002
Course Title: Water Resources Systems **LTP: 3-1-0=4 Cr.**

Course Content:

Units	Topic	Lectures
Unit I	Systems concepts and system analysis, System techniques in water resources	6 lectures
Unit II	Economic consideration in water resources systems	5 lectures
Unit III	Application of system analysis in irrigation, flood control, hydropower generation, water supply and drainage, Storage-yield analysis, Rule curves, Reservoir sizing,	14 lectures
Unit IV	Multi reservoir systems, Real time operation, Systems reliability	10 lectures
Unit V	Recent modelling tools and Case studies	8 lectures

Recommended Books:

1. Water Resources Systems: Modelling Techniques and Analysis, S. Vedula and P. P. Majumdar, McGraw Hil l Publishing Company, New Delhi, 2005.
2. Water Resources Systems:Planning and Analysis, D. P. Loucks, J. R. Stedinger, D. A. Haith, Prentice Hall Inc., NJ, 1981.
3. Water Resources Systems Engineering, Hall, K., A and Draoup, J.A., Tata McGraw Hill, 1970.
4. Water Resources Planning, Neil, G.S., McGraw Hill, 1985.
5. National Water Policy, Ministry of Water Resources, Government of India, 1987.

Course Code: CE 9003
Course Title: Hydraulics of Open Channels **LTP: 3-1-0=4 Cr.**
Course Content:

Units	Topic	Lecture
Unit I	Open channel flow and its classification: Description and types. Energy and momentum equation for prismatic and non-prismatic open channel sections, Critical flow, its computation and application, and depth in channels	7 lectures
Unit II	Uniform flow: Its computation and application, other uniform flow for mulae, conveyance of a channel section, section factor and hydraulic exponent.	7 lectures
Unit III	Gradually varied flow (GVF): Basic assumptions, dynamic equation of gradually varied flow, flow profiles, method of singular point and transitional depth. Computation, analytical and graphical methods. Channel transitions in sub-critical and super-critical flow.	7 lectures
Unit IV	Spatially varied flow (SVF) : Basic principles and assumption, dynamic equation for spatially varied flow, analysis of flow profile, methods of numerical integration and the isoclinal method	7 lectures
Unit V	Rapidly varied flow (RVF): Characteristics of the flow, hydraulic jump and jump as an energy dissipater, flow in channels of non-linear alignment, discharge measurement techniques in open channels.	7 lectures
Unit VI	River mechanics, river erosion, river training works; dam engineering and related environmental issues; concept of hydraulic models.	7 lectures

Recommended Books:

1. Open Channel Hydraulics, V. T. Chow, McGraw Hill Book Co., Inc., New York
2. Open Channel Flow, F. M, Henderson, The MacMillan Co. Inc., New York.
3. Open Channel Flow, Chaudhry, M. H., Prentice Hall of India, 1998.
4. Flow through Open Channel, Ranga Raju, K.G., Tata McGraw Hill, New Delhi,1996.

Course Code: CE 9004
Course Title: Stochastic Hydrology **LTP: 3-1-0=4 Cr.**
Course Content:

Units	Topic	Lecture
Unit I	Probability concepts and advance distribution, Stochastic processes	8 lectures
Unit II	Regression and correlation, Autoregressive and moving average processes	10 lectures
Unit III	Sequential generation of data, Generation of stochastic fields, Markovian process, Dis-aggregation, Intervention analysis	10 lectures
Unit IV	Time series analysis and modelling	8 lectures
Unit V	Stochastic models, Spatial and temporal modelling of hydrological variables, Risk analysis in hydrology.	8 lectures

Recommended Books:

1. Stochastic Subsurface Hydrology, L. W. Gelhar, Prentice Hall, N. J., 1993.
2. Stochastic Hydrology, Reddy, P. J., Laxmi Publication, New Delhi, 1997.
3. Water Resources Engineering, Mays, L.W., John Willey and Sons, US, 2001.
4. Statistical Methods in Hydrology, Haan, C. T., Iowa State University Press, 1977.
5. Handbook of Hydrology, Maidment, D. R., McGraw Hill, 1993.

Course Code: CE 9005
Course Title: Groundwater Flow and Contaminant Transport Modelling **LTP: 3-1-0=4 Cr**
Course Content:

Units	Topic	Lecture
Unit I	Groundwater contamination, Sources and causes of groundwater contamination	5 lecture
Unit II	Contaminant transport process, advection and hydrodynamics dispersion, advection-dispersion equation, Biodegradation, Radioactive decay, Reactive processes, Multiphase contamination, NAPLs, VOCs, Site specific groundwater quality problems in Indian context	8 lectures
Unit III	Numerical models, Finite difference method (FDM), Finite element method (FEM) Numerical modeling of steady and transient flows in saturated and unsaturated domain, Contaminant transport modeling	8 lectures
Unit IV	Application of FEM and FDM in groundwater modeling, Regional aquifer simulation, Contaminated groundwater systems and their remediation	10 lectures
Unit V	Development and optimization based management of aquifer systems, Stochastic models, Random field concepts in groundwater models	7 lectures
Unit VI	Groundwater remediation, pump and treat. Bioremediation, phytoremediation processes.	8 lectures

Recommended Books :

1. Numerical Groundwater Modelling, A, K. Rastogi, Penram International Publishing, Mumbai, 2007.
2. Introduction to Groundwater Modelling, H. F. Wang and M. P. Anderson, W. H. Freeman and Company, New Yor, 1982.
3. Ground Water Contamination: Transport and Remediation, P. B. Bedient, H. S. Rifai and C. J. Newell, Prentice Hall, NJ, 1999.
4. Contaminants in the Subsurface: Source Zone Assessment and Remediation, Committee on Source Removal of Contaminants in the Subsurface, National Academy Press, 2004.
5. Contaminant Hydrogeology, Fetter, C.W., Prentice Hall, 1999.
6. Modeling Groundwater Flow and Pollution, Bear, J. and Verruijt, A., Reidel Publishing Company, 199 0.

Course Code: CE 9006
Course Title: Sediment Transportation **LTP: 3-1-0=4 Cr**
Course Content:

Units	Topic	Lecture
Unit I	Properties of sediments, Sediment yield, Models of sediment transport, regimes of flow, forms of bed roughness, Resistance to flow	8 lectures
Unit II	Bed load transport and related equations, theory of sediment suspension, sediment distribution along vertical, total load equations, sediment distribution in a stream section, sediment distribution with time, fine sediments and bed materials discharge, bed load and suspended load samples.	13 lectures
Unit III	Design of alluvial channels, Principles of stream power and minimum energy. meandering and braiding of streams, reservoir sedimentation, density currents, coastal sediment problems, sediment transport through pipelines, sediment sampling and measuring devices.	17 lectures

Recommended Books:

1. Fluvial Process in River Engineering, Howard Chang, John Wiley & Sons, New York, 1988.
2 Mechanics of Sediment Transport and Alluvial Stream Problems, Gadre, R. J. and Ranga Raju, K. G. New Age, New Delhi, 2000.
3. Soils in our Environment, R.W Miller & R.L Donahue, Prentice Hall, 2001.
4. Scientific methods in Analysis of Sediments, J.C. Griffiths, McGraw Hill, 2002 .
5. Sediment Transport-Theory and Practice, Yang, C. T., McGraw Hill Companies, Inc., New Delhi, 1996.
6. Fluvial Forms and Processes, Knighton, D., Edward Arnold, Baltimore, MD., 1984.
7. Rivers Form and Process in Alluvial Channels, Richards, K., Methuen, NY, 1982.
8. River Mechanics, Vol. I and II, Shen, H.W., Water Resources Publication, Fort Collins, CO., 1971.

Course Code: CE 9007
Course Title: Geographical Information Systems (GIS) **LTP: 3-1-0=4 Cr**
Course Content:

Units	Topic	Lecture
Unit I	Introduction to Geographical Information Systems (GIS), Databases and database management systems, Spatial databases, Coordinate systems and geo referencing, Interpolation methods: Deterministic and Statistical	10 lectures
Unit II	Digital elevation models and their applications, Strategies for development, Implementation and Management of GIS, Case studies on use of GIS selected from various areas such as water and Land resources, Environment, transportation, etc.,	12 lectures
Unit III	Projects involving creation of small GIS modules related to water resources problems and other generic areas.	10 lectures
Unit IV	Stereoscopic viewing, application to water resources mapping, area assessment and watershed management – satellite data – geo-coding – GPS and GIS utilities – classification using imageries – applications in water resources and watershed management – case studies.	10 lectures

Recommended Books:

1. Principles of Geographical Information Systems, Burrough, Peter A. and McDonnell, Rachael A., Oxford University Press, 1998
2. Introduction to Geographical Information Systems, Chang, K. T, Tata McGraw Hill, New Delhi, 2002.
3. Remote Sensing Image Analysis: Including the Spatial Domain, De -Jong, S.M., Vander, Meer, F.D., 200 4. Springer, 2014.
4. Remote Sensing and Image Interpretation, Lillesand, K., John Wiley & Sons, 1979.

Course Code: CE 9008
Course Title: Non Linear Finite Element Method **LTP: 3-1-0=4 Cr.**
Course Content:

Units	Topic	Lectures
Unit-I	Overview, A Tour of Nonlinear Analysis. Residual Force Equations, One -Parameter Residual Equations. Critical Points and Related Properties. Conservative Systems.	6 lectures
Unit II	Review of Continuum Mechanics: Kinematics, Review of Continuum Mechanics: Field Equations. TL Bar and Related Elements: Formulation. TL Bar Elements: Truss Analysis. The TL Plane Beam Element: Formulation. The TL Plane Beam Element: Implementation	8 lectures
Unit -III	CR Formulation Overview I. CR Formulation Overview II. Unified Kinematic Description: Space Bar. The CR Formulation: BE Plane Beam	8 lectures
Unit-IV	Overview of Solution Methods. Purely Incremental Methods: Load Control. Purely Incremental Methods: General Control. Purely Incremental Methods: Implementation. Purely Incremental Methods: Benchmark Examples. Conventional Newton Methods. Newton Methods: General Control and Variants. Corrective Methods: Implementation.	10 lectures
Unit-V	Structural Stability: Basic Concepts. Linearized Prebuckling: Formulation. Linearized Prebuckling: Implementation. Linearized Prebuckling: Examples and Limitations. Qualitative Analysis of Critical Points. Nonlinear Bifurcation Analysis. Imperfections. Nonconservative Loading: Overview. Aero - and Hydrodynamic Loading. Dynamic Stability: Formulation. Dynamic Stability: Examples.	10 lectures

Recommended Books :

1. Introduction to Nonlinear Finite Element Analysis" by N. H. Kim . Springer, 2014, ISBN-10: 1441917454
2. Computational Inelasticity", by J.C. Simo and T.J.R. Hughes, Springer, NY
3. Nonlinear Finite Elements for Continua and Structures", by T. Belytschko, W. K. Liu, and B. Moran, W iley, NY
4. An Introduction to Nonlinear Finite Element Analysis by J. N. Reddy, Oxford University Press, 2004, ISBN 019852529X
5. The Finite Element Method: Linear Static and Dynamic Finite Element Analysis by T. J. R. Hughes, Dover Publications, 2000

Course Code: CE 9009
Course Title: Advanced Mechanics of Solids **LTP: 3-1-0=4 Cr.**
Course Content:

Units	Topic	Lecture
Unit I	Analysis of Stress-Stress Vector, State of Stress at a Point, Rectangular Stress Components, Stress on an Arbitrary Plane, Transformation of axes; Principal Stress and Plane, Stress Invariants	8 lectures
Unit II	Mohr's Circle, Octahedral Stresses, Lame's Ellipsoid, Equations of Equilibrium in Cartesian and Cylindrical Coordinates; Axisymmetric and Plane Stress case	8 lectures
Unit III	Analysis of Strain-Deformations, definition of Strain, State of Strain at a Point, Finite and Infinitesimal Strains, Geometrical Meaning of Shearing Strains, Principal Strain, Dilatation, Strain Invariants, Compatibility Conditions	8 lectures
Unit IV	Stress Strain Relationship-Generalised Hooks Law, Stress- Strain Relations for Isotropic Materials; Displacement Equations of Equilibrium; Theories of Failure-Mohr's Theory of Failure, Yield Locus, Tresca and Von Mises Theories, Saint - Venant's Equations, Introduction to Hamilton's principles; Rayleigh -Ritz and Weighted residual methods; Stability Theory	10 lectures
Unit V	Bending of Curved Beams; Unsymmetrical Bending; Shear Centre and Flexure Centre; Torsion-Torsion of Thin Walled Tubes, Torsion of Noncircular Sections, Membrane Analogy, Torsion of Multicellular Axisymmetric Problems - Thick Walled Cylinders, Shrink Fit of Composite Tubes, Rotating Disks and Cylinders. Sections;	8 lectures

Recommended Books:

1. S. Timoshenko and J.N. Goodier, Theory of Elasticity, McGraw Hill Book Company, Internati onal Ed, 1970
2. Advanced Mechanics of Solids, 3rd Edition, L.S. Srinath, Tata McGraw Hill, New Delhi, 2009.
3. Advanced Mechanics of Materials, 6th Edition, Aurther P Boresi and Richard J Schmidt, John Wiley and Sons, Inc, New York, 2003.
4. Advanced Strength and Applied Stress Analysis, 2nd Edition, Richard G Budynas, McGraw Hill International, New York, 1999.
5. Engineering Solid Mechanics Fundamentals and Applications, Abdel-Rahman Ragab and Saleh Eldain Bayoumi, CRC Press, Boca Raton, Florida, 1999.
6. Strength of Material, G.H. Ryder, MacMillan India ltd, New Delhi, 2001 reprint.
7. Engineering Mechanics of Solids, Egor P Popov, Prentice Hall of India, New Delhi, 1990.
8. Introduction to Solid Mechanics, 2nd Edition, Irving H Shames, Prentice Hall of India, New Delhi, 1990.
9. Fundamentals of Structural Mechanics, 2nd Edition, Keith D Hjelmstad, Springer (India) Private Ltd, New Delhi, 2005.
10. Mechanics of Materials, Vol I & II, E J Hearn, Butterworth-Hrinemann (Elsevier), Reed Elsevier (India) Private Ltd, New Delhi, 2008.
11. Advanced Mechanics of Solids, Otto T Bruhns, Springer-Verlog, Springer (India) Private Ltd, New Delh i, 2008.
12. M.H.Sadd, "Elasticity: Theory, Applications and Numerics", Academic Press, 2006.

Course Code: CE 9010
Course Title: Bridge Engineering **LTP: 3-1-0=4 Cr.**
Course Content:

Units	Topic	Lecture
Unit I	Types o f bridges; structural configurations; bridge loading standards in India and other countries (IRC, IRS and AASHTO guidelines); Impact effect; Standard specifications for road and railway bridges; analysis of bridge deck.	8 lectures
Unit II	Reinforced co ncrete bridges -- design of deck slab; T -beam bridge; balanced cantilever type; design and details of articulation.	8 lectures
Unit III	Prestressed concrete bridges -- Pretensioned and post tensioned concrete bridges; analysis of section for flexure, shea r and bond; losses in prestress, deflection of girder; partial prestressing; analysis and design of anchorage block; box girder bridge.	8 lectures
Unit IV	Steel bridges -- steel-concrete composite constructions, shear connectors and the ir design; types of bearings and layout.	8 lectures
Unit V	Abutment and piers -- scour at abutment and piers; types of foundations; analysis for stresses and design; introduction to soil -structure interaction. Numerical modeling and analysis; intr oduction to earthquake resistant design of bridges.	10 lectures

Recommended **Books:**

1. D. J. Victor, *Essentials of Bridge Engineering*, Oxford IBH, 1980.
2. V. K. Raina, *Concrete Bridge Practice Analysis Design and Economics*, Tata McGraw Hill, 2nd Ed, 1994.
3. N. Rajagopalan, *Bridge Superstructure*, Narosa Publishing House, 2006.
4. W. F. Chen and L. Duan, Bridge Engineering Handbook, CRC press, 2003.
5. B. Bakht and L.G. Jaeger, *Bridge Analysis Simplified*, McGraw Hill, 1987.
6. 4. E. J. O'Brien, and D. L. Keogh, *Bridge Deck Analysis*, Taylor and Francis, 1999.
7. H. Eggert and W. Kauschke, *Structural Bearings*, Ernst & Sohn, 2002.
8. T. Y. Lin and N. H. Burns, *Design of Prestressed Concrete Structures*, John Wiley and Sons, 1981. L. Fryba, *Dynamics of Ra*

Course Code: CE 9011

Design of Pre-Stressed Concrete Structures: 4 Credits (3-1-0)

Course Content:

Units	Topic	Lecture
Unit I	Introduction to pre-stressed concrete: concept of pre-stressing, advantages and disadvantages, materials and hard wares, pre-stressing systems, pre-tensioning and post tensioning of members.	7 lectures
Unit II	Losses in pre-stress and analysis: different types of losses, analysis of pre-stress and bending stresses, pressure line concept, load balancing; Cracking moment.	7 lectures
Unit III	Shear torsion and deflection: shear and principal stresses; ultimate shear resistance, design for shear and torsion; deflection of pre-stresses members and its influence; short and long term deflections ; Codal values of deflection.	7 lectures
Unit IV	Transmission and anchorage zone: transmission length in pre-tensioned members; Bond stresses; Transverse tensile stresses; End zone reinforcements; Anchorage zone stresses in post tensioned members; Stress distribution in end block ; Anchorage zone reinforcement, Codal provisions.	7 lectures
Unit V	Composite pre-stressed beam: types of composite construction, shrinkage stresses, deflection and flexural strength at different stages.	7 lectures
Unit VI	Tension and compression members: simple pre-stressed tension members; Pre-stressing for hoop tension; Pre-stressed columns; Poles; Piles and sleepers.	7 lectures

Recommended Books:

1. Fundamentals of Prestressed Concrete, N.C. Sinha and S.K. Roy, S.Chand& Co, New Delhi, 1994.
2. P Prestressed Concrete Structures, T Y Lin and Burn, John Wiley & Sons, New York, 1982.
3. Prestressed Concrete Design, M K Hurst, Chapman & Hall, London, 1988.
4. Modern Prestressed Concrete, J R Libby, CBS, New Delhi, 1986restessed Concrete, N Krishna Raju, Tata McGraw Hill, New Delhi, 1995.
5. Prestressed Concrete, P. Dayaratnam, Oxford & IBH, New Delhi, 1985.

Course Code: CE 9012

Course Title: Advanced Design and Construction Techniques LTP: 3-1-0=4 Cr.

Course Content

Units	Topic	Lecture
Unit I	Review of Limit State Design Method applicable to RCC and Steel Structures; Yield Line Theory;	6 lectures
Unit II	P-M, M-phi relationships; strut-and-tie method; design of deep beam and corbel; design of shear walls; compression field theory for shear design; design against torsion; Indian and ACI Standards; Eurocode	8 lectures
Unit III	Design of Flat and Waffle slabs; Design of Water tanks;Design of Silos and Bunkers; Design of Shear Walls in Multistoreyed Buildings;	8 lectures
Unit IV	Steel structures -- stability design; torsional buckling (pure, flexural and lateral); design of beam-columns; fatigue resistant design; Indian and AISC Standards; Eurocode	10 lectures
Unit V	Different Construction Techniques; Term Project	10 lectures

Recommended Books:

1. S. U. Pillai and D. Menon, *Reinforced Concrete Design*, Tata McGraw-Hill 3rd edition, 2009.
2. P.C. Varghese, *Limit State Design of Reinforced Concrete*, Prentice Hall India, 2008.
3. N. Subramaniam, Design of Steel Structures, Oxford University Press, 2008

4. C.G. Salmon, J.E. Johnson and F.A. Malhas, Steel Structures Design and Behavior Emphasizing Load and Resistance Factor Design, Pearson Education, 5th Ed, 2009.
5. IS 800: 2007 – General Construction in Steel - Code of Practice, Bureau of Indian Standards, 2007
6. S.N. Sinha, *Reinforced Concrete Design*, Tata McGraw-Hill, 2nd Edition, 2002.
7. M.L. Gambhir, *Fundamentals of Reinforced Concrete Design*, Prentice Hall India, 2006.
8. A. K. Jain, *Reinforced concrete: Limit state design*, Nem Chand and Bros. 1999.
9. J. Macgregor and J. K. Wight, *Reinforced Concrete: Mechanics and Design*, Prentice Hall, 5th edition, 2008.
10. R. Park and T. Paulay, *Reinforced Concrete Structures*, John Wiley and Sons, 1975.
11. Specification for Structural Steel Buildings, American Institute of Steel Construction, 2005.
12. Eurocode 2 Part 1-1, BS EN 1992-1-1 Common Rules for Buildings and Civil Engineering Structures, The Institution of Structural Engineers, 2004.
13. Eurocode 3 Part 1-1, BS EN 1993-1-1 Design of Steel Structures General Rules and Rules for Buildings, The Institution of Structural Engineers, 2004

Course Code: CE 9013
Course Title: Traffic Engineering **LTP: 3-1-0=4 Cr.**
Course Content

Units	Topic	Lecture
Unit I	Driver behavior, traffic information and control systems, traffic studies- volume, speed and delay studies,	10 lectures
Unit II	Elements of traffic flow theory, characteristics of uninterrupted traffic, capacity and LOS of Uninterrupted facilities, characteristics of interrupted traffic.	10 lectures
Unit III	Traffic Analysis and Management: Capacity and Level of Service concepts, Queuing models and applications, Basics of traffic management. Traffic intersection control: Principles of Traffic Control and Traffic Signs, Road Markings and Channelization, Uncontrolled Intersection: Gap acceptance and capacity concepts, Uncontrolled Intersection: Capacity and LOS analysis, Traffic Rotaries and Grade Separated Intersection.	12 lectures
Unit IV	Design of parking, lighting and terminal facilities, simulation of traffic systems, statistics and probability in traffic engineering, trends in traffic engineering.	10 lectures

Recommended Books:

1. Roger P. Roess, William R. McShane & Elena S. Prassas, Traffic Engineering, Prentice-Hall, 1990.
2. Pignataro L. J., Traffic Engineering – Theory and Practice, Prentice Hall, 1973.
3. P. Chakroborty and A. Das, Principles of Transportation Engineering, Prentice Hall of India Pvt. Ltd ., 2003.
4. C. J. Khisty and B. K. Lall, Transportation Engineering: An Introduction, Prentice- Hall India, 2003 .
5. Wohl M. and Martin B. V., Traffic System Analysis, McGraw-Hill Book Company, 1967.
6. L. R. Kadiyali, Traffic Engineering, Khanna Publishers, 2000.
7. A. D. May, Traffic Flow Fundamentals, Prentice–Hall, 1990.
8. C.S. Papacostas, Transportation Engineering and Planning, Prentice-Hall India, 2001.
9. Highway Capacity Manual (HCM), Transportation Research Board, USA, 2010.

Course Code: CE 9014
Course Title: Traffic Flow Modeling and Simulation **LTP: 3-1-0=4 Cr.**
Course Content

Units	Topic	Lecture
Unit I	Traffic flow characteristics; deterministic and stochastic models of stream flows;	10 lectures
Unit II	Microscopic traffic flow modeling: Car Following Models: Linear models, Car Following Models: Non-linear models, Lane Changing Models, Microscopic Traffic Simulation (Vehicle generation, model frame work, calibration and validations, statistical error analysis, applications). Macroscopic models: First order models, analysis of shock waves, Numerical implementation of first order models, Cell transmission models.	14 lectures
Unit III	Cellular automata models: Discrete Simulation, Traffic Progression and Platoon dispersion.	08 lectures
Unit IV	Probability concepts. Fundamentals of traffic simulation modeling; simulation methodologies and model design; simulation languages; application of macro and micro simulation packages.	10 lectures

Recommended Books:

1. A. D. May, Traffic Flow Fundamentals, Prentice–Hall, 1990
2. Wohl M. and Martin B. V., Traffic System Analysis, McGraw-Hill Book Company, 1967.
3. Drew D. R., Traffic Flow Theory and Control, McGraw-Hill, 1968.
4. P. Chakroborty and A. Das, Principles of Transportation Engineering, Prentice Hall of India Pvt. Ltd ., 2003.
5. Pignataro L. J., Traffic Engineering – Theory and Practice, Prentice Hall, 1973.
6. Krishna Rao K. V. and Tom V. M., Lecture Notes on Recent Developments in Urban Transportation Systems Planning, IIT Bombay, 2003.

Course Code: CE 9015

Course Title: Urban Transportation Systems Planning **LTP: 3-1-0=4 Cr.**

Course Content

Units	Topic	Lecture
Unit I	Introduction to transportation planning; Urban Travel and Transportation Systems Characteristics, systems approach to transportation planning; types of models;	12 lectures
Unit II	Concept of travel demand and supply; socio-economic, land use, network, and transport system characteristics affecting transportation planning; study area definition, zoning principles, cordon and screen lines, data collection through primary and secondary sources, sampling techniques;	06 lectures
Unit III	Transport Behavior of Individuals and Households, land use-transport models.	10 lectures
Unit IV	Travel Demands Forecasting; four-stage sequential modeling approach; trip generation; trip distribution; modal split; trip assignment;	14 lectures

Recommended Books:

1. J. de D. Ortuzar and L.G. Willumsen, Modelling Transport, John Wiley and Sons, 2001.
2. C.J. Khisty and B.K. Lall, Transportation Engineering – An Introduction, Prentice Hall of India Pvt. Ltd., 2002.
3. C. S. Papacostas and P. D. Prevedouros, Transportation Engineering and Planning, Prentice Hall of In dia Pvt. Ltd., 2001.
4. P. Chakroborty and A. Das, Principles of Transportation Engineering, Prentice Hall of India Pvt. Ltd ., 2003.
5. B.G. Hutchinson, Principles of Urban Transport Systems Planning, McGraw- Hill Book Co., New York, 19 74.
6. L.R. Kadiyali, Traffic Engineering and Transport Planning, Khanna Publishers, New Delhi, 2000.
7. G. E. Gray and L. A. Hoel, Public Transportation, Prentice Hall, New Jersey, 1992.

Course Code: CE 9016

Course Title: Geopolymer Concrete **LTP: 3-1-0=4 Cr.**

Course Content:

Units	Contents	Lectures
Unit I	Geopolymer Concrete: Inorganic polymeric new materials, basics of geopolymer concrete and impact on global warming, types of geopolymer concrete.	8 lectures
Unit II	Making materials : Aggregates, Fly ash, Sodium silicate, Sodium hydroxide	6 lectures
Unit III	Mix proportioning, production process, effects of curing temperature, properties with aging and testing methods.	12 lectures
Unit IV	Uses of geopolymer concrete and its composites: Fire resistant wood panels , Insulated panels and walls, Decorative stone artifacts, Foamed (expanded) panels for thermal insulation, Low-tech building materials, Low energy ceramic tiles, Refractory items, Thermal shock refractory, Aluminum foundry application, Geopolymer concrete composites, Fire resistant and fire proof composite for infrastructures repair and strengthening,.	8 lectures
Unit V	Special application of geopolymer for repair and rehabilitation of concrete structures, Fireproof high-tech applications in aircraft interior, automobile, High-tech resin systems, Ultra high temperature resistant members, Safe disposal of toxic metals, nuclear and uranium waste.	8 lectures

Recommended Books:

1. Davidovits, J. Geopolymer chemistry and application, Geopolymers Institute, ISBN 2-651-4820-1-9, 2008.
2. Davidovits, J. Geopolymers-Inorganic polymeric new materials, Journal of Thermal Analysis, Vol. 37, pp. 1633-1656, 1991.
3. Davidovits, J. Global Warming Impact on the Cement and Aggregates Industries, World Resource Review, Vol. 6, No. 2, pp. 263-278, 1994. 2
4. Hardjito, D. and Rangan, B.V. Development and properties of Low-Calcium Fly Ash-based, Geopolymer Co ncrete, Research Report GC-I, Faculty of Engineering, Curtin University of Technology, 2005.
5. Hardjito, D., Wallah, S.E. and Rangan, B.V. Study on Engineering Properties of Fly Ash-Based Geopoly mer Concrete, Journal of the Australasian Ceramic Society, Vol. 38, No. 1, pp. 44-47, 2002.

6. Hardjito, D., Wallah, S.E., Sumajouw, D.M.J. and Rangan, B.V. On the Development of Fly Ash Based Ge opolymer Concrete ACI Materials Journal, Vol. 101, No. 1, 2004.
7. Anuradha, R., Sreevidya, V., Venkatasubramani, R. and Rangan, B.V. Modified guidelines for geopolyme r concrete mix design using Indian standard, Asian Journal of Civil Engineering (Building and Housing) Vol. 13, No. 3, pp. 353-3 64, 2012. 8.
8. Buchwald, A. and Schulz, M. Alkali-activated binders by use of industrial by - products, Cement Conc rete Research, Vol. 35, pp. 968--973, 2005.

Course Code: CE 9017
Course Title: Durability of Concrete **LTP: 3-1-0=4 Cr.**
Course Content:

Units	Contents	Lectures
Unit I	Introduction to durability, Microstructure of cement based systems, Bonding, Pore system, Distribution capillary voids, Permeability, Aggregate-hydrated cement paste interface, Microstructure, Transition zone.	8 lectures
Unit II	Mix proportioning of high-volume fly ash and slag concrete; their life time performance.	8 lectures
Unit III	Deterioration of concrete, Causes, Transport mechanism, Controlling concrete degradation; Corrosion of reinforcement system: Understanding, Investigation and Repair etc.	8 lectures
Unit IV	Admixtures interface in concrete; effects of superplasticisers, air entraining, corrosion inhibitor, expansion producing, mineral and other admixtures on durability of concrete.	8 lectures
Unit V	Durability of special concrete: High strength, Self compacting, Pervious, Lightweight, Fibre reinforced, High density, Roller compacted, High performance and Mass concrete in different exposure conditions.	8 lectures

Recommended Books:

1. P.K.Mehta and Paulo J.M.Monteiro, "Concrete: microstructure, properties and materials", The McGrawHi ll Companies
2. AM Neville, Properties of concrete, Pearson
3. M L Gambhir, Concrete Technology, Tata McGraw Hill Companies
4. AR Santakumar, Concrete Technology, Oxford University Press.
5. Non-destructive test methods by Nicholas J. Carino (http://fire.nist.gov/bfrlpubs/build98/PDF/b98019.pdf).
6. V.M. Malhotra, Nicholas J. Carin; Handbook on Nondestructive Testing of Concrete Second Edition
7. GUIDELINES ON NON-DESTRUCTIVE TESTING OF BRIDGES BS – 103,
8. (http://www.rdso.indianrailways.gov.in/uploads/files/1296882621315-bs_103.pdf).
9. Practical Non-Destructive Testing, By Baldev Raj, Tammana Jayakumar, M

Course Code: CE 9051
Course Title: Applications of Finite Elements: **LTP: 1-0-6=4 Cr.**
Course Content:

Units	Topic	Lectures	Practice Sessions (3 hours each)
Unit-I	Programming Finite Element Method: Overall Program Structure of FE Frame-works, Object Oriented Frameworks	3	4
Unit-II	Element Stiffness Matrices for common 1-D, 2-D and 3D elements, Plane-strain, Plane-stress, Axisymmetric and Isoparametric Elements	3	6
Unit-III	Methods of Handling Material/Geometric/Contact Nonlinearity, Solution Techniques, Common Convergence issues related to meshing and solution methods.	4	6
Unit-IV	Civil Engineering Applications of FE Codes like ABAQUS, ANSYS, OpenSees, Code-Aster/Salome-Meca etc. Structural, Geotechnical/ Fluid-Mechanics and other Problems. (Any one/combination thereof)	4	12

Recommended Books:

1. Kwon, Y. W. and Bang, H. (2011), The Finite Element Method using MATLAB, CRC Press
2. ANSYS tutorials (https://sites.ualberta.ca/~wmoussa/AnsysTutorial/)
3. ABAQUS tutorials (http://www.abaquspython.com/videos.html)
4. Wiki pages for OpenSees (https://opensees.berekeley.edu)
5. OpenSees Example Manual (http://opensees.berkeley.edu/wiki/index.php/Examples)

6. Aubry, J. P. (2013), Beginning with Code-Aster, A Practical Introduction to FEM using Code-Aster, Gm sh and Salome, Frama Book.
7. (https://framabook.org/docs/Code_Aster/beginning_with_Code_Aster_JPAubry_20131206.pdf)
8. Relevant You-Tube and other online Resources

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY

SYLLABI
OF
PG / Ph. D. COURSES
(DEPARTMENT : COMPUTER SCIENCE & ENGINEERING)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY
(UNDER THE MINISTRY OF EDUCATION, GOVT. OF INDIA)
DEEMED TO BE UNIVERSITY U/S 3 OF THE UGC ACT, 1956
NIRJULI - 791 109 :: ARUNACHAL PRADESH

SYLLABI
OF
PG/ Ph. D COURSES

(DEPARTMENT : COMPUTER SCIENCE & ENGINEERING)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY (NERIST)

(Deemed to be University, U/S 3 Of the UGC Act, 1956)
Nirjuli (Itanagar), Arunachal Pradesh- 791 109

M. Tech in Computer Science and Engineering

Course Structure:

Year I
Semester I

			L	T	P	C
CS	7101	Algorithm Design and Analysis	3	0	2	4
CS	7102	High Performance Computer Architecture	3	1	0	4
CS	70xx	Elective I	3/3	1/0	0/2	4
CS	70xx	Elective II	3/3	1/0	0/2	4
CS/HS	70xx	Elective III	3	1	0	4
CS	7151	Seminar	0	0	4	2
						22

Elective I, II and III {any three of the following courses}:

(i) CS 7001 Intelligent Systems.
(ii) CS 7002 Ubiquitous Computing
(iii) CS 7003 Computational Complexity
(iv) CS 7004 Bioinformatics
(v) CS 7005 Artificial Intelligence
(vi) CS 7006 Fault Tolerant Systems
(vii) CS 7007 Computer Graphics
(viii) CS 7008 Advanced Compiler Construction
(ix) CS 7009 VLSI Design
(x) CS 7010 Object Oriented Systems
(xi) CS 7011 Advanced Software Engineering
(xii) CS 7012 Game theory
(xiii) CS 7013 Systems Biology
(xiv) HS 7001 Organizational Behavior

Year I
Semester II

			L	T	P	C
CS	7201	Computer Communication Networks	3	0	2	4
CS	7202	Advanced Operating Systems	3	0	2	4
CS	70xx	Elective IV	3/3	1/0	0/2	4
CS	70xx	Elective V	3/3	1/0	0/2	4
CS/HS	70xx	Elective VI	3/3	1/0	0/2	4
CS	7251	Computing Laboratory	0	0	8	4
						24

Elective IV, V and VI {any three of the following courses}:

(i) CS 7014 Distributed Systems
(ii) CS 7015 Advances in Database Management Systems
(iii) CS 7016 Advanced Image Processing
(iv) CS 7017 Advanced Graph Theory
(v) CS 7018 Real Time Systems
(vi) CS 7019 Embedded Systems
(vii) CS 7020 Cryptography
(viii) CS 7021 Data Warehousing and Data Mining
(ix) CS 7022 Information and system security
(x) CS 7023 Machine learning
(xi) CS 7024 Computational Geometry
(xii) CS 7025 Simulation and Modelling
(xiii) CS 7026 Cognitive Radio Networks
(xiv) HS 7004 Marketing Management

Year II
Semester I

		L	T	P	C
CS 8197	Project Seminar I	0	0	4	2
CS 8198	Project Viva Voce I	0	0	4	2
CS 8199	Project Part Report	0	0	8	4
					8

Year II
Semester II

		L	T	P	C
CS 8297	Project Seminar II	0	0	8	4
CS 8298	Project Viva Voce II	0	0	8	4
CS 8299	Project Thesis	0	0	16	8
					16

A total of 70 credits have to be completed to get the M.Tech. degree. At least one humanities course (HS 70xx) has to be taken as elective in either semester I or II.

(Note: Maximum of two humanities courses can be taken).

Detailed Syllabus

CS 7101 Algorithm Design and Analysis : 4 credits (3-0-2)

Units	Topics	Lectures
Unit I	Revisiting divide and conquer, recursion, dynamic programming, greedy, branch and bound, etc., Amortized Analysis, Graph Algorithms and related theorems: shortest paths, topological sort, bipartite graphs, matching, ma ximum flow and cut sets, planar graphs. Correctness of Algorithms.	10
Unit II	NP-complete problems and Reducibility: satisfiability, clique, vertex cover, independent set, Hamiltonian cycle, TSP, knapsack, set cover, bin packing.	8
Unit III	Approximati on Algorithms for set cover, tsp, bin packing.	5
Unit IV	Randomized Algorithms, Numerical algorithms: integer, matrix and polynomial multiplication, FFT, extended Euclid's algorithm, modular exponentiation, primality testing, cryptographic computations.	10
Unit V	Advanced Data Structures: 2 -3-4 tree, Red -black tree, Skip Lists; Computational Geometry: range searching, convex hulls, segment intersections, closest pairs;	9

Recommended Books:

1. Introduction to Algorithms, T. H. Cormen, C. L. Leiserson, R. L. Rivest, and C. Stein, MIT Press.
2. Algorithm Design Manual, S Skiena, Springer.

Reference Books

1. Approximation Algorithms, V. V. Vajirani, Springer.
   Randomized Algorithms, Rajeev Motwani and Prabhakar Raghavan, Cambridge University Press.

CS 7102 High Performance Computer Architecture : 4 credits (3-1-0)

Unit	Topics	Lectures
Unit I	Introduction: review of basic computer architecture, quantitative techniques in computer design, measuring and reporting performance. CISC and RISC processors. Pipelining: Basic concepts, instruction and arithmetic pipeline, data hazards, control hazards, and structural hazards, techniques for handling hazards. Exception handling. Pipeline optimization techniques. Compiler techniques for improving performance	10
Unit II	Hierarchical memor y technology: Inclusion, Coherence and locality properties; Cache memory organizations, Techniques for reducing cache misses; Virtual memory organization, mapping and management techniques, memory replacement policies.	7
Unit III	Instruction -level parall elism: basic concepts, techniques for increasing ILP, superscalar, super pipelined and VLIW processor architectures. Array and vector processors.	8
Unit IV	Instruction -level parallelism: basic concepts, techniques for increasing ILP, superscalar, super pi pelined and VLIW processor architectures, Array and Vector processors	7
Unit V	Taxonomy of parallel architectures. Centralized shared -memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared -memory, architect ure, Cluster computers, data flow computers, reduction computer archit ectures, systolic architectures, GPU,GPGPU,Basics of parallel programming.	10

Recommened Books:

1. John L. Hennessy and David A. Patterson "Computer Architecture: A Quantitative Approach" Morgan Kaufmann.
2. Kai Hwang "Advanced Computer Architecture: Parallelism, Scalability, Programmability" McGraw Hill.

Reference Books :

1. John Paul Shen and Mikko H. Lipasti,"Modern Processor Design: Fundamentals of Superscalar Processors" Waveland Press.
2. M. J. Flynn, Computer Architecture: Pipelined and Parallel Processor Design, Narosa Publishing House.

CS 7201 Computer Communication Network : 4 credits (3-0-2)

Units	Topics	Lectures
Unit I	Computer Communication Networks - overview and introduction, The ISO referen ce Model, Network Topologies, Connectivity and Delay Analysis, Backbone Design and Digital Communication Concepts.	**8**
Unit II	The Physical Layer, Data Link Layer Protocol with Case Studies, Point to Point Networks, Routing and Flow Control, Packet Commun ication Technology, Packet Broadcasting, Terrestrial Networks, Local Area Networks, Mixed Media and Large Scale Integrated Networks.	**8**
Unit III	Transport and Session Layers, Presentation Layer Protocols and Data Link Layer Concepts of Distributed Systems, Computer Networks and a Distributed System Fibre Optic Network, Examples and Case Studies. Optical Communications, SONET, WDM: R W A problem; Software defined networks(SDN)	**8**
Unit IV	Virtual topology design: various algorithms for virtual topology design ; Optical burst switching; GMPLS.	**8**
Unit V	RSVP – Goals & Characteristics, Data Flow, RSVP operations, Protocol Mechanisms -Multiprotocol Label Switching – Operations, Label Stacking, Protocol details – RTP –Protocol Architecture, Data Transfer Protocol, RTCP	**10**

Recommended Books

1. William Stallings, "HIGH SPEED NETWORKS AND INTERNET", Pearson Education, Second Edition, 2002.
2. Warland, Pravin Varaiya, "High performance communication networks", Second Edition , Jean Harcourt Asia Pvt. Ltd., , 2001.

Reference Books

1. Irvan Pepelnjk, Jim Guichard, Jeff Apcar, "MPLS and VPN architecture", Cisco Press, Volume 1 and 2, 2003.
2. Abhijit S. Pandya, Ercan Sea, "ATM Technology for Broad Band Telecommunication Networks", CRC Press, New York, 2004.
3. James F. Kurose, Keith W. Ross, "Computer Networking, A Top-Down Approach", Pearson Education, 6th Edition

CS 7202 Advanced Operating Systems : 4 credits (3-0-2)

Units	Topics	Lectures
Unit I	Overview – Synchronization Mechanisms – Processes and Threads - Process Sched uling – Deadlocks: Detection, Prevention and Recovery – Models of Resources – Memory Management Techniques.	8hr
Unit II	Issues in Distributed Operating System – Architecture – Communication Primitives – Lamport's Logical clocks – Causal Ordering of Messa ges – Distributed Mutual Exclusion Algorithms – Centralized and Distributed Deadlock Detection Algorithms – Agreement Protocols.	9hr

Unit III	Distributed File Systems – Design Issues - Distributed Shared Memory – Algorithms for Implementing Distributed Sh ared memory –Issues in Load Distributing – Scheduling Algorithms – Synchronous and Asynchronous Check Pointing and Recovery – Fault Tolerance – Two -Phase Commit Protocol – Nonblocking Commit Protocol – Security and Protection.	8hr
Unit IV	Basic Model of Re al Time Systems - Characteristics - Applications of Real Time Systems – Real Time Task Scheduling - Handling Resource Sharing - Mobile Operating Systems –Micro Kernel Design - Client Server Resource Access – Processes and Threads - Memory Management - File system.	8hr
Unit V	Linux System: Design Principles - Kernel Modules - Process Management Scheduling - Memory Management - Input -Output Management - File System - Interprocess Communication. iOS and Android: Architecture and SDK Framework - Media Layer - Services Layer - Core OS Layer - File System.	9hr

Recommended Books

1. Mukesh Singhal and Niranjan G. Shivaratri, "Advanced Concepts in Operating Systems – Distributed, Database, and Multiprocessor Operating Systems", Tata McGraw-Hill, 2001.
2. Abraham Silberschatz; Peter Baer Galvin; Greg Gagne, "Operating System Concepts", Seventh Edition, John Wiley & Sons, 2004.

Reference Books

1. Daniel P Bovet and Marco Cesati, "Understanding the Linux kernel", 3rd edition, O'Reilly, 2005.
2. Rajib Mall, "Real-Time Systems: Theory and Practice", Pearson Education India, 2006.
3. Neil Smyth, "iPhone iOS 4 Development Essentials – Xcode", Fourth Edition, Payload media, 2011.

CS 7251 Computing Laboratory: 4 credits (0-0-8)

Unit	Topics	Lectures
Unit I	MATLAB: Branching and Looping, matrix o perations and file processing, linear and non -near programming, optimization problem solving toolbox, Neural Network toolbox.	10
Unit II	MATLAB: distributions, feature extraction, classification, and clustering.	10
Unit III	Programming in R and R packa ges for data mining, graph theory and social networks, biological networks.	8
Unit IV	Python: Looping, branching, List operations and multidimensional lists, file processing, object oriented features.	10
Unit V	Python packages: Requests , SciPy , Sympy.	4

Text Books:

Recommended Books:

1. Matlab: A Practical Introduction to Programming and Problem Solving, Stormy Attaway, Butterworth-Heinemann Limited.
2. MATLAB for Engineers, Holly Moore, Pearson.
3. Fundamentals of Python, K. A. Lambert, Cengage Learning.
   The Art of R Programming: A Tour of Statistical Software Design, Norman Matloff

Elective I, II and III

CS 7001 Intelligent Systems : 4 credits (3-1-0)

Units	Topics	Lectures
Unit I	Data, information and knowledge. Model of an intelligent system. Models of knowledge representations: Representation and reasoning in logic. Semantic representations: semantic networks, frames; Frame/ script systems; Conceptual dependency and conceptual graphs.	8hr
Unit II	Ontologies. Knowledge based systems: Software architecture of a knowledge -based system, Rule -based programming and production systems, Rule chaining and inference control.	8hr
Unit III	Inference: reasoning about knowledge, Tempor al reasoning, Inference under uncertainty: Bayesian techniques, Fuzzy reasoning, Case -based reasoning.	8hr
Unit IV	Intelligent agents, the agent metaphor and attributes of agent - hood, Agent theory and languages, Inter -agent communication, Ontological iss ues. Alternatives to the symbolic approach: Foundations of connectionist networks; their history. Applications of AI: Example application domains , e.g. Configuration, Diagnosis.	10hr
Unit V	Planning, intelligent interfaces, user -modelling, Practical implications of choosing and applying AI solutions. Knowledge representation and the Web, Semantic Web.	8hr

Recommended Books

1. Russel, S., Norvig, P.: Artificial Intelligence, a Modern Approach, Pearson Education
2. Mitchel, T.: Machine Learning. McGraw Hill

Reference Books

1. G. Weiss, *Multiagent Systems*, MIT Press, 1999.
2. M. Wooldridge, *An Introduction to MultiAgent Systems*, J. Wiley & Sons

CS 7002 Ubiquitous Computing : 4 credits (3-0-2)

Units	Topics	Lectures
Unit I	Overview of wireless technologies, Sig nal propagation, Multiplexing, Modulation, and Spread spectrum techniques.	8hr
Unit II	Media access control: FDMA, TDMA, CDMA. Cellular systems: AMPS, GSM, DECT, UMTS, IMT -2000. CDMA - based cellular systems. Satellite systems: basic routing, localization , and handoff issues.	8hr
Unit III	Wireless Networks: packet radio network, Wireless LAN :IEEE 802.11 b, Blue -tooth, Wireless ATM. Wireless Application Protocol (W AP) and WML.	8hr
Unit IV	Mobile Networking: Mobile IP, Ad -Hoc Networks: AODV, DSR, DSDV ro uting. Wireless TCP: indirect TCP, Snooping TCP, Mobile TCP	8hr

Unit V	Information Management, Location - Independent and Location - dependent computing models, Mobile applications and services, Security. Introduction to cloud computing	**10hr**

Recommended Books

1. Forouzen, "Data Communication and Networking", TMH
2. A.S. Tanenbaum, Computer Networks, Pearson Education

Reference Books

1. W. Stallings, Data and Computer Communication, Macmillan Press
2. Charles Perkins, Ad hoc Networks, Addison Wesley.

CS 7003 Computational Complexity : 4 credits (3-1-0)

Units	Topics	Lectures
Unit I	Models of Computation, resources (time and space), algorithms, computability, complexity. Amortized analysis	8hr
Unit II	Complexity classes, P/NP/PSP ACE, reductions, hardness, comple teness, hierarchy, relationships between complexity classes.	8hr
Unit III	Randomized computation and complexity; Logical characterizations, incompleteness; Approximability.	8hr
Unit IV	Circuit complexity, lower bounds; Parallel computation' and complexit y; Counting problems; Interactive proofs.	10hr
Unit V	Probabilistically checkable proofs; Communication complexity; Quantum computation.	8hr

Recommended Books :

1. Christos H. Papadimitriou., Combinatorial Optimization: Algorithms and Complexity , Prentice-Hall
2. Sanjeev Arora and Boaz Barak , Complexity Theory: A Modern Approach, Cambridge University Press

Reference Books :

1. Steven Homer , Alan L. Selman , Computability and Complexity Theory , Springer

CS 7004 Bioinformatics : 4 credits (3-0-2)

Unit	Topics	Lectures
Unit I	**Basic Biology :** The unity and the diversity of living things. Prokaryotes and Eukaryotes, Yeast and People, Evolutionary time and relatedness, Tissuess, cells, compartments and organelles, Central dogma of molecular biology, Concept of DNA, RNA, Protein and metabolic pathway. Concept of Bioinformatics, Recent challenges in Bioinformatics.	8
Unit II	**Biological databases :** Their needs and challenges. Example of different biological databases - sequence, structure, function, micro-array, pathways. **Walk through the genome :** Prediction of regulatory motifs, Operon, Gene, splices site.	6
Unit III	**Sequence Analysis :** Theory and Tools : - Pairwise alignment - Different local and global search alignent, Heuristic searches (like BLAST) applicable to search against database,Multiple alignment algorithms, Whole genome comparison. **Hidden Markov models** - The evaluation, decoding and estimation problem and the algorithms. Application in sequence analysis.	10
Unit IV	**Molecular phylogeny :** Maximum Parsimony, distance Matrix and maximum likelihood methods. Concepts of adaptive evolution, **Phylogenetic trees :** Probabilistic approaches, Grammar-based approaches.	8
Unit V	**Application of graph theory in Biology :** Biochemical Pathway, Protein-protein interaction network, Regulatory network and their analysis.	10

Recommended Books

1. Neil C. Jones and Pavel A. Pevzner. An Introduction to Bioinformatics Algorithms, MIT Press
2. Bruce R. Donald. Algorithms in Structural Molecular Biology.

Reference Books

1. Durbin, Eddy, Krogh, Mitchison., Biological Sequece Analyis, Cambridge press.
2. David W. mount, Bioinfomatics, Cold Spring Harbo Laboratory Press

CS 7005 Artificial Intelligence : 4 credits (3-1-0)

Unit	Topics	Lectures
Unit I	Problem solving by search : state space, problem reduction, game playing, constraint satisfaction; Automated Reasoning: proposition and first order logic.	8hr
Unit II	Inference and deduction, resolution - refutation, answer extraction, knowledge based systems, logic programming and constrained logic programming.	8hr
Unit III	Non-monotonic reasoning; Planning; state-space, plan space and partial order planning, planning algorithms.	8hr
Unit IV	Reasoning under Uncertainty: probabilistic reasoning, belief networks; Learning: inductive learning, decision trees, logical approaches, computational learning theory.	10hr
Unit V	Neural networks, reinforcement learning; Intelligent Agents; Natural Language Understanding; Applications.	8hr

Recommended Books :

1. "Artificial Intelligence"- By Elaine Rich And Kevin Knight (2nd Edition) Tata McGraw Hill.
2. Artificial Intelligence: A Modern Approach, Stuart Russel, Peter Norving, PHI.

Reference Books :

1. Introduction to Prolog Programming By Car Townsend.
2. KM Fu, " Neural Networks in Coputer Intelligence", McGraw Hill.

CS 7006 Fault Tolerant Systems : 4 credits (3-1-0)

Unit	Topics	Lectures
Unit I	Fundamental concepts in the theory of reliable computer systems design. Reliability Engineering concepts, Introduction to redundancy theory, limit theorems; decision theory in redundant systems.	10hr
Unit II	Hardware fault tolerance, redundancy techniques, detection of faults, replication and compression techniques, self-repairing techniques, concentrated and distributed voters, models of fault tolerant computing systems.	8hr
Unit III	Case studies. Software fault tolerance: fault tolerance versus fault intolerance, errors and their management strategies. Implementation techniques: software defense, protective redundancy, architectural support. Petri nets.	8hr
Unit IV	Fault recovery techniques. Coding theory: application to fault tolerant system design.	8hr
Unit V	Fault-tolerance and reliability of multi-computer networks (direct and indirect): falt-tolerant routing & sparing techniques. Yield and reliability enhancement for VLSI/WSI array processors.	8hr

Recommended Books :

1. Israel Koren and C.M.Krishna, "Faul Tolerant Systems", Morgan Kaufman, 1st Edition, 2007.
2. Pradhan, D.K., Fault-Tolerant Computing -- Theory and Techniques, (2 Volumes), Prentice-Hall, 1986

Reference Books :

1. Johnson, B.W., Design and Analysis of Fault-Tolerant Systems, Addison Wesely, 1989.

CS 7007 Computer Graphics : 4 credits (3-0-2)

Unit	Topics	Lectures
Unit -I	Introduction: Display of entities, Geometric computation and representation, Graphics Environments; Working Principles of display devices; refreshing raster scan devices, vector devices, Cathode Ray Tube Terminals, Plotters, LCD, LED displays; Display of colors; Look Up Tables, display of gray shades, Half toning; Display and drawing of graphics primitives: point, line polygon, circle, curves and text;	8
Unit -II	Coordinate Conventions: world coordinates, devices coordinates, normalized device coordinates, view-port and window, zooming and panning by changing coordinate reference frames; Computations on polygons: point inclusion problem, polygon intersection, clipping, polygonization of a point set, convex hull computation, triangulation of polygons;	10
Unit -III	Transformations in 2D and 3D: translation, rotation, scaling, reflection, Projection: perspective and parallel projections, isometric projection, Transformation matrices;	8
Unit -IV	Volume and Surface Representation; polygonal meshes, parametric curves and surfaces, Cubic and Bicubic Splines, Voxel, Octree and Medial Axis representation, Sweep Representation, Surfaces and Volumes by rotation of curves and surfaces, fractal modeling;	8
Unit -V	Hidden surface and line elimination: Elimination of back surfaces, painters' algorithms, Binary Space Partitioning Tree; Rendering and Visualization: Shading model, Constant, Goraud an d Phong Shading, Ray tracing algorithm, Radiosity Computation; Computer Animation: fundamental concepts.	8

Recommended Books:

1. Principles of Interactive Computer Graphics, 2nd Edition, Newman & Sproull: McGraw Hill International., New York, 2001.
2. Computer Graphics, 2nd Ed., Hearn and Baker, Prentice Hall of India, New Delhi, 2001.

Reference Books

1. Computer Graphics: Principles and Practice (in C), 2nd Ed., J.D. Foley, A. VanDam, SK Feiner, & J.F. Hughes, AWL Publication, New York, 2000.

CS 7008 Advanced Compiler Construction : 4 credits (3-0-2)

Units	Topics	Lectures
Unit I	Introduction: Language Processors - The Structure of a Compiler – The Evolution of Programming Languages - The Science of Building a Compiler – Applications of Compiler Technology Programming Language Basics - The Lexical Analyzer Generator -Parser Generator - Overview of Basic Blocks and Flow Graphs - Optimization of Basic Blocks - Principle Sources of Optimization.	9hr
Unit II	Instruction-Level Parallelism: Processor Architectures – Code-Scheduling Constraints – Basic-Block Scheduling –Global Code Scheduling – Software Pipelining.	9hr

Unit III	Optimizing For Parallelism And Locality -Theory: Basic Concepts – Matrix-Multiply: An Example - Iteration Spaces - Affine Array Indexes – Data Reuse A rray data dependence Analysis	8hr
Unit IV	Optimizing For Parallelism And Locality -Application: Finding Synchronization - Free Parallelism – Synchronization Between Parallel Loops – Pipelining – Locality Optimizations – Other Uses of Affine Transforms.	8hr
Unit V	Inter-procedural Analysis: Basic Concepts – Need for Interprocedural Analysis – A Logical Representation of Data Flow – A Simple Pointer -Analysis Algorithm – Context Insensitive Interprocedural Analysis – Context Sensitive Pointer-Analysis - Datalog Implementation by Binary Decision Diagrams.	8hr

Recommended Books :

1. Alfred V.Aho, Monica S.Lam, Ravi Sethi, Jeffrey D.Ullman, "Compilers:Principles, Techniques and Too ls", Second Edition, Pearson Education,2008.
2. Randy Allen, Ken Kennedy, "Optimizing Compilers for Modern Architectures: A Dependence-based Approach", Morgan Kaufmann Publishers, 2002.

Reference Books :

1. Steven S. Muchnick, "Advanced Compiler Design and Implementation", Morgan Kaufmann Publishers - Elsevier Science, India, Indian Reprint 2003.

CS 7009 VLSI Design : 4 credits (3-0-2)

Unit	Topics	Lectures
Unit-I	Introduction to VLSI Design, Different types of VLSI design styles: Full custom, standard cell based, gate array based, programmable logic, field programmable gate arrays etc.	8hr
Unit-II	VLSI Design flow. CMOS logic: PMOS, NMOS and CMOS, Electrical characteristics, operation of MOS transistors as a switch and an amplifier, MOS inverter	8hr
Unit-III	stick diagram, design rules and layout, delay analysis, different type of MO S circuits: Dynamic logic, BiCMOS, pass transistors etc.	8hr
Unit-IV	CMOS process, Combinational logic cells, Sequential logic cells, Datapath logic cells, I/O cells. ASIC Library Design: Transistors as Resistors and parasitic Capacitance, Logical effort, g ate array, standard cell and datapath cell design.	8hr
Unit-V	Introduction to hardware description language (HDL) Verilog/Vi -IDL. A logic synthesis example. Floor -planning and Placement: I/O and power planning, clock planning. Routing: global and detailed. Example design technique: mapping of architecture to silicon.	10hr

Recommended Books :

1 Basic VLSI Design, 3rd Ed., D.A. Pucknell, K. Eshraghian, Prentice Hall of India, New Delhi, 2001. VLSI Technology, 2nd Ed., S.M. Sze, Mc. Graw Hill International, New York,1998.

2 Principles of CMOS VLSI Design, AWL Publishing, 2000.

Reference Books

1. Computational Aspects of VLSI, J.D.Ullman, Computers Science Press.

CS 7010 Object Oriented Systems : 4 credits (3-0-2)

Units	Topics	Lectures
Unit I	Review of programming practices and c ode-reuse; Object model and object-oriented concepts; Object -oriented programming languages and implementation	**10hr**
Unit II	Object-oriented analyses and design using UML structural, behavioral and architectural modeling;	**8hr**
Unit III	Unified development process, Software reuse design patterns, components and framework	**8hr**
Unit IV	Distributed object computing, interoperability and middleware standards COM/DCOM and CORBA;	**8hr**
Unit V	Object oriented database system data model, object definition and query language, object -relational system.	**8hr**

Recommended Books:

1. Object-Oriented Modeling and Design with UML (2nd Edition) 2nd Edition by Michael R. Blaha , James R Rumbaugh

2. Object-Oriented Systems Analysis and Design Using UML by Simon Bennett ,Publisher : McGraw-Hill Education 2010-04-01

CS 7011 Advanced Software Engineering : 4 credits (3-0-2)

Units	Topics	Lectures
Unit I	Soft ware process models, process iteration, process activities, rational unified process, computer aided software engineering. Management activities, project planning, project scheduling, risk management.	8hr
Unit II	Functional and Non – functional requireme nts, user requirements, system requirements, interface specifications, software requirements document, Requirements engineering processes, feasibility studies, elicitation and analysis, validations, management, System Models; Architectural Design – Distrib uted Systems Architectures – Application Architectures, Object Oriented Design, Real time Software Design.	12hr
Unit III	Software testing fundamentals – Test Case Design – White Box - Basis Path Testing – Control Structure Testing – Black Box – Testing for Specialized environments, Architectures and Applications Software Testing Strategies	7hr
Unit IV	Software Quality Concepts – Quality Assurance – Software Technical Reviews – Formal Approach To Software Quality Assurance; Reliability, Quality Standards, Software Quality Assurance Plan.	7hr
Unit V	Software Maintenance, Software Configuration Management, configuration item, process, objects in the software configuration, version control, change control, configuration audit, status reporting, SCM Standards , Case study : Martha Stockton Greengage (MSG) foundations	8hr

Recommended Books :

1. Software Engineering, A practitioner's Approach by Roger S. Pressman, McGrawHill International Edition, 6th Edition
2. Software Engineering by Sommerville, Pearson Education, 7th edition
3. Software Engineering by K.K. Aggarwal & Yogesh Singh, New Age International Publishers

Reference Books

1. Software Engineering, An Engineering Approach by James F. Peters, Witold Pedrycz, John Wiley
2. Software Engineering principles and practice by Waman S Jawadekar, The McGraw-Hill Companies

Lab: Java and associated techniques, case tools, configuration managements.

CS 7012 Game Theory : 4 credits (3-1-0)

Unit	Topics	Lectures
Unit I	Introduction, Utilities, Rationality, Intelligence, Commo n Knowledge, Classification of Games.	4 Lectures
Unit II	Non-Cooperative Games: Strategic Form Games with Illustrative Examples, Dominant Strategy Equilibria, Pure Strategy Nash Equilibrium with Illustrative Examples and Key Results, Mixed Strategy Nash E quilibrium with Illustrative Examples and Key Results such as the Nash Theorem.	9 Lectures
Unit III	Non-Cooperative Games: Computation of Nash Equilibria and introduction to algorithmic theory, Matrix Games: Saddle Points, Minimax Theorem, Bayesian Games , Bayesian Nash Equilibrium, Evolutionary Game Theory (ESS Strategies), Repeated Game.	9 Lectures
Unit IV	Cooperative Games: Correlated Strategies and Correlated Equilibrium, The Nash Bargaining Problem, Coalitional Games (Transferable Utility Games) ,The Core, The Shapley Value, Other Solution Concepts: Kernel, Nucleolus	10 Lectures
Unit V	Mechanism Design: Social Choice Functions with Illustrative Examples, Implementation of Social Choice Functions, Incentive Compatibility and Revelation Theorem, Gibb ard-Satterthwaite and Arrow Impossibility Theorem, Vickrey -Clarke -Groves (VCG) Mechanisms, Bayesian Mechanisms (dAGVA), Revenue Equivalence Theorem, Myerson Optimal Auction.	10 Lectures

Recommended Books:

1. Computer Science and Game Theory: A Brief Survey, Joseph Y. Halpern.
2. Martin J. Osborne. An Introduction to Game Theory. Oxford University Press. Indian Edition, 2003.

Reference Books

1. Roger B. Myerson. Game Theory: Analysis of Conflict. Harvard University Press, 1991.
2. Y. Narahari, Dinesh Garg, Ramasuri Narayanam, Hastagiri Prakash. Game Theoretic Problems in Network Economics and Mechanism Design Solutions. Springer, London, 2009.

CS 7013 Systems Biology : 4 credits (3-0-2)

Unit I	Systems Biology – Fundamentals: Overview of Gene Control –Working of Genetic Sw itches – Introductory Systems Biology The biochemical paradigm, genetic paradigm and the systems paradigm.	6 Lectures

Unit II	Kinetics: Equilibrium Binding and Co -operativity -Michaelis -Menten Kinetics –identical and independent binding sites – Identical and interacting binding sites, non -interacting binding sites; Genetic switch in Lambda Phage -Noise -based Switches and Amplifiers for Gene Expression; Synthetic genetic switches –Ecoli chemotaxis –biological oscillators - genetic oscillators -The Origin an d Consequences of Noise in Biochemical Systems.	10 Lectures
Unit III	Developmental Systems Biology Building an Organism Starting From a Single Cell -Quorum Sensing – Programmed Population Control by Cell -Cell Communication and Regulated Killing - Drosophi la Development. Establishment of Developmental Precision and Proportions in the Early Drosophila embryo.	9 Lectures
Unit IV	Gene expression networks: Gene regulation at a single cell level - Transcription Networks -basic concepts -coherent Feed Forward L oop (FFL) and delay gate -The incoherent FFL -Temporal order, Signaling networks and neuron circuits -Aspects of multi -stability in gene networks.	10 Lectures
Unit V	Network analysis: Gene Set Enrichment and Network Analyses, Deep Sequencing Data Processi ng and Analysis, Data Processing and Identifying Differentially Expressed Genes.	7 Lectures

Recommended Books:

1. An Introduction to Systems Biology: Design Principles of Biological Circuits, Uri Alon, Chapman & Hall/ CRC Press
2. A First Course in Systems Biology, Eberhard O. Voit, Garland Science.

Reference Books

1. Algorithms in Structural Molecular Biology, Bruce R. Donald

Elective IV, V and VI
CS 7014 Distributed Systems : 4 credits (3-1-0)

Unit	Topics	Lectures
Unit-I	Basic concepts. Models of computation: shared memory and message passing systems, synchronous and asynchronous systems. Inherent limitations of a Distributed System; Absence of global clock; Absence of shared memory; Lamport's logical clocks; A limitation of Lamport's clocks; Vector clocks; Causal ordering of messages; Global state; Chandy -Lamport's Global state record ing algorithm; Termination detection;	8
Unit-II	Distributed Mutual Exclusion algorithms: Classification of Distributed Mutual Exclusion. algorithms; Requirements of mutual exclusion algorithms; Performance measure; Non - Token based algorithms; Lamport's a lgorithm; The Ricart - Agrawala algorithm; Token based algorithms; Suzuki Kasami broadcast algorithm; Raymond's Tree based algorithm; Comparative performance analysis	8
Unit-III	Distributed Deadlock Detection: Deadlock handling strategies in distributed sys tems; Resource versus communication deadlocks; Centralized control; Distributed control; Hierarchical control; Centralized deadlock detection algorithms: The completely centralized algorithm; The Ho - Ramamurthy algorithm; Distributed deadlock detection algorithm: An Edge -chasing algorithm; A global state detection based algorithm	8
Unit-IV	Agreement Protocols: Model of process failures; Authenticated and non-authenticated messages; Classification of agreement problems; The Byzantine agreement problem; the c onsensus problem; the interactive consistency problem; Lamport - Shostak-Pease algorithm.	10
Unit-V	Distributed fault tolerance, Replication, Redundancy, Roll Back Recovery, Fusion Based Technique, Multiple Faults Handling, Multiple Failure Detector	8

Recommended Books:

1. Distributed System: Concept and Design, 2nd Ed. , Georage Colounis, J. Dollimore, Tim Kindberg, AWT Publication, New York 200
2. Concurent Systems, 2nd Ed., Sape Mullender, AWL Publications, New York, 2000

Reference Books :

1. Advanced Operating Systems by Mukesh Singhal and Nirajan Shivaratri

CS 7015 Advances in Database Management Systems : 4 credits (3-1-0)

Units	Topics	Lectures
Unit I	Basic concepts of Relational Databases: Transaction processing, concurrency control, recovery, etc. Deductive databa ses: Datalog and Recursion, Evaluation of Datalog program, Recursive queries with negation. Introduction to Temporal Databases.	10

Unit II	Object Oriented and Object Relational Databases: Modeling Complex data semantics, Specialization, Generalization and Aggregation. Objects, Objects Identity, Object reference. Assignments/Implementation in Object -oriented Database Systems.	8
Unit III	Distributed Databases: Distributed data storage: Fragmentation and replication, Location and fragment transparency, dist ributed query processing. Distributed transaction and concurrency control, commit protocols: 2PC, 3PC.	8
Unit IV	Parallel Databases: Parallel Database Architectures, Parallel Query Evaluation. Advanced Transaction Processing: Nested and Multilevel Transa ctions.	6
Unit V	Multimedia Databases: Modeling and Storage of multimedia data. Data Structures: R -Tree, k -d tree, Quadtrees, Content -based retrieval. Big Data, Non -SQL databases	10

Recommended Books:

1. Ramakrishnan R. and J. Gehrke. Database Management Systems, 3rd ed., McGraw - Hill.

Reference Book

1. Garcia-Molina, H., J. Ullman et al. Database Systems: The Complete Book, Prentice Hall.
2. Gray, P., K.G. Kulkarni, and N.W. Paton. Object-Oriented Databases: A Semantic Data Model Approach. Prentice-Hall, Hertfordshire.
3. Blaha, M., Premerlani, W., Object-Oriented Modeling and Design for Database Applications, Prentice-Hall.

CS 7016 Advanced Image Processing : 4 credits (3-0-2)

Units	Topics	Lectures
Unit I	Sensor and Imaging: Imaging Optics, Radiometry of Ima ging, Illumination sources and techniques, Camera Principles, Color Imaging, Single Sensor Color Imaging and Color Demosaicing, Range Images, 3D Imaging.	**8hr**
Unit II	Signal Representation: Vector Space and Unitary Trasnsforms, Multi-Resolutional Signal R epresentation, Wavelet Decomposition, Scale space and diffusion, Representation of color, Retinex Processing, Markov Random Field Modellings of Images.	**8hr**
Unit III	Non-linear Image Processing: Median and Order Statistics Filters, Rank -Ordered -Mean Filter s and Signal Dependent Rank-Ordered -Mean Filters, Two Dimensional Teager Filters, Applications of non -linear filters in image enhancement, edge detection's, noise removal etc.	**8hr**
Unit IV	Feature Estimation: Morphological Operations, Edge Detection, Edges in multichannel images, Texture Analysis, Optical flow based motion estimation, Reflectance based shape recovery, Depth from focus, Stereo matching and depth estimation.	**8hr**
Unit V	Image and Video Compression Standards: Lossy and lossless compression sch emes: Transform Based, Sub -l}and Decomposition, Entropy Encoding, JPEG, JPEG2000, MPEG -l, MPEG-4, and MPEG - 7. Object Analysis, Classification: Bayesian Classification, Fuzzy Classification, Neural Network Classifiers, Shape Reconstruction from volumetric data, Knowledge -based interpretation of Images.	**10hr**

Recommended Books

1. Digital Image Processing 2nd Edition, Rafael C. Gonzalvez and Richard E. Woods. Published by: Pearson Education.
2. Digital Image Processing and Computer Vision, R.J. Schalkoff. Published by: John Wiley and Sons, NY.

Reference Books

1. Fundamentals of Digital Image Processing, A.K. Jain. Published by Prentice Hall, Upper Saddle River, NJ.
2. Sonka, Digital Image Processing and Computer Vision, Cengage Learning.
3. Gonzalez and Woods, Digital Image Processing, Addison Wesley.

CS 7017 Advanced Graph Theory : 4 credits (3-1-0)

Unit	Topics	Lectures
Unit -I	Basic Concepts: Graphs and digraphs, incidence and adjacency matrices, isomorphism, the automorphism group; Trees: Equivalent definitions of trees and forests, Cayley's formula, the Matrix - Tree theorem, minimum spanning trees; Connectivity: Cut vertices, cut edges, bonds, the cycle space and the bond space, blocks, Menger's theorem;	8
Unit -II	Paths and Cycles: Euler tours, Hamilton paths and cycles, theorems of Dirac, Ore, Bondy and Chvatal, girth, circumference, the Chinese Postman Problem, the Traveling Salesman problem, diameter and maximum degree, shortest paths;	8
Unit -III	Matchings: Berge's Theorem, perfect matchings, Hall's theorem, Tutt e's theorem, Konig's theorem, Petersen's theorem, algorithms for matching and weighted matching (in both bipartitie and general graph_), factors of graphs (decompositions of the complete graph), Tutte's f-factor theorem;	8
Unit -IV	Extremal problems: Indep endent sets and covering numbers, Turan's theorem, Ramsey theorems; Colorings: Brooks theorem, the greedy algorithm, Welsh -Powell bound, critical graphs, chromatic polynomials, girth and chromatic number, Vizing's theorem; Graphs on surfaces: Planar graphs, duality, Euler's formula, Kuratowski's theorem, toroidal graphs, 2 cell embeddings, graphs on other surfaces;	10
Unit -V	Directed graphs: Tournaments, directed paths and cycles, connectivity and strongly connected digraphs, branchings; Networks and flo ws: Flow cuts, Max flow min cut theorems, perfect square; Selected topics: Dominating sets, the reconstruction problem, intersection graphs, perfect graphs, random graphs.	8

Recommended Books:

1. "Introduction to Graph Theory" by Douglas B. West
2. "Graph Theory with Applications to Engineering and Computer Science" by Narsingh Deo

Reference Books

1. "Network Flows: Theory, Algorithms, and Applications" by R. Ahuja, T. Magnanti, and J. Orlin
2. "Handbook of Graph Theory (Discrete Mathematics and Its Applications)" by Jonathan L. Gross, Jay Yellen

CS 7018 Real Time Systems (3-1-0)

Unit	Topics	Lectures
Unit I	Introduction to real time system, embedded systems and reactive systems; Hard and Soft Real Time Systems, Real time Scheduling: Clock driven, Priority driven, issues with R ate Monotonic Algorithm (RMA).	7
Unit II	Resource and resource access control: Priority inheritance protocol, Priority ceiling protocol, Preemption -ceiling protocol(PCP);priority inversion under PCP, issues of Resource sharing protocol.	8
Unit III	Scheduling real time tasks in Multiprocessor and Distributed systems, Fault tolerant scheduling tasks, and Clock issues in distributed systems.	10
Unit IV	Commercial real time systems, Real Time Communication: Types of Network, QoS, real time communication i n LAN	10
Unit V	Real Time databases: Design issues, characteristics of temporal data, concurrency control and protocols	7

Recommended Books:

1. Jane W. S. Liu, Real-Time Systems, PHI.
2. Seppo J. Ovaska Phillip A. Laplante, Real-Time Systems Design and Analysis: Tools for the Practition er, Wiley.

Reference Books:

3. Rajib Mall, Real-Time Systems: Theory and Practice, Pearson

CS 7019 Embedded Systems : 4 credits (3-0-2)

Units	Topic	Lectures
Unit-I	Introduction to Embedded Systems - definitions and constraints; hardware, firmware and processor requirements; special purpose processors; bare -board and RTOS based programming, embedded C/C++ compilers and debuggers	10
Unit-II	Input-output design and I/O communication protocols; sample systems based on ARM, MIPS and Motorola architectures, embedded system emulators	8
Unit-III	Introduction to some microcontroller based boards; desi gn space exploration for constraint satisfaction; co -design approach; example system design	8
Unit-IV	Formal approach to specification; specification languages; specification refinement and design; design validation	8
Unit-V	Real Time operating system is sues with respect to embedded system applications; time constraints and performance analysis.	8

Recommended Books:

1. Embedded Systems - Raj Kamal, TMH.
2. Embedded System Design - Frank Vahid, Tony Givargis, John Wiley.

Reference Books

1. Andrew N Sloss, Dominic Symes, Chris Wright, “ARM System Developer’s Guide - Designing and Optimizing System Software”, 2006, Elsevier
2. Design with PIC Microcontrollers, John B. Peatman, Pearson Education Asia, 2002

CS 7020 Cryptography : 4 credits (3-0-2)

Unit	Topics	Lectures
Unit-I	Introduction: Basic objectives of cryptography, secret -key and public-key cryptography, one way and trapdoor one -way functions, cryptanalysis, attack models, classical cryptography.	8
Unit-II	Block ciphers: Modes of operation, DES and its variants, RCS, IDEA, SAFER, FEAL, BlowFish, AES, linear and differential cryptanalysis. Stream ciphers: Stream ciphers based on linear feedback shift registers, SEAL, unconditional security.	8
Unit-III	Message digest: Properties of hash functions, MD2, MD5 and SHA-l, keyed hash functions, attacks on hash functions. Public-key parameters: Modular arithmetic, gcd, primality testing, Chinese remainder theorem, modular square roots, finite fields.	8
Unit-IV	Intractable problems: Integer factorization problem, RSA problem, modular square root problem, discrete logarithm problem, Diffie-Hellman problem, known algorithms for solving the intractable problems. Public -key encryption: RSA, Rabin and EIGamal schemes, side channel attacks. Key exchange: Diffie-Hellman and MQV algorithms.	10
Unit-V	Digital signatures: RSA, DAS and NR signature schemes, blind and undeniable signatures. Entity authentication: Passwords, challenge-response algorithms, zero-knowledge protocols. Standards: IEEE, RSA and ISO standards. Network issues: Certification, public-key infrastructure (PKI), secured socket layer (SSL), Kerberos. Advanced topics: Elliptic and hyper-elliptic curve cryptography, number field sieve, lattices and their applications in cryptography, hidden monomial cryptosystems, cryptographically secure random number generators.	8

Recommended Books:

1. Cryptography Theory and Practice Douglas R. Stinson CRC Press
2. Handbook of Applied Cryptography by Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone

Reference Books

1. Cryptanalysis: A Study of Ciphers and Their Solution by Helen F. Gaines

CS 7021 Data Warehousing and Data Mining (3-0-2)

Unit	Topics	Lectures
Unit I	**Data Warehousing:** Integration of a Data Mining System with a Database or Data Warehouse System, Major Issues in Data Mining, Why Pre-process the Data?, Data Warehouse Architecture, Data Warehouse Implementation, Development of Data Cube and OLAP Technology.	8
Unit II	**Classification** : Decision tree induction, information gain, gain ratio, gini index as split measures, Naïve Bayes classification, Bayesian Belief Networks, Support Vector Machines, Lazy learners, Prediction: Linear, Non -linear and logistic regression, Accuracy and Error Measures, Ensemble Methods —Increasing the Accuracy: Bagging, Boosting .	12

Unit III	**Association R ule Mining** : Mining categorical Association Rules i.e. Apriori, FP -growth, Mining Multilevel Association Rules, Mining Multi -dimensional Association Rules, Mining Quantitative Association Rules.	8
Unit IV	**Clustering** : Types of Data in Cluster Analysis, K-means, K-medoids, Agglomerative versus divisive hierarchical clustering (i.e. AGNES vs DIANA), ROCK: A Hierarchical Clustering Algorithm for Categorical Attributes, DBSCAN, STING: STatistical INformation Grid, Outlier analysis.	7
Unit V	Mining Time -Series Data , Methods for Mining Frequent Subgraphs, Graph mining applications: Graph Indexing, Similarity Search, Classification, and Clustering, Basics of NN, GA and Fuzzy Logic and their use in data mining.	7

Recommended Books:

1. Kamber and Han, Data Mining Concepts and Techniques, Hartcourt India P. Ltd.
2. I. H Witten, E. Frank, Data Mining: Practical Machine Learning Tools and Techniques, Morgan-Kaufman Publisher.

Reference Books:

1. Charu C. Aggarwal , Data Mining: The Textbook, Springer.

CS 7022 Information and System Security : 4 credits (3-0-2)

Unit	Topics	Lectures
Unit-I	Types of Information and need for information security. Authentication Applications: Kerberos, X.509 authentication service.	8
Unit-II	E-mail Security. S/MIME, spam filtering , Phishing, Hac king.	9
Unit-III	IP Security overview, VPN tunneling, architecture; authentication header and security payload encapsulation.	8
Unit-IV	Web Security. Intrusion detection systems. Expert systems, neural network, data mining and game theoretic approaches. Misuse detection and anomaly detection.	8
Unit-V	Denial of service, DDOS (Distributed Denial of Service), Buffer overflow, SQL injection, reverse telnet. User to root and remote to local attacks. Virus and other malicious software. Firewalls_1 Secure mult i-party computation applications. Security in wireless networks. Biometric authentication.	9

Recommended Books:

1. The Code Book: The Science of Secrecy from Ancient Egypt to Quantum Cryptography by Simon Singh
2. Software Security Engineering by Julia H. Allen, Sean Barnum, Robert J. Ellison, Gary McGraw, and Nancy R

Reference Books

1. The Web Application Hacker's Handbook: Discovering and Exploiting Security Flaws by Dafydd Stuttard and Dafydd Stuttard

CS 7023 Machine Learning: 4 credits (3-0-2)

Unit I	The concept l earning task. General -to-specific ordering of hypotheses. Version spaces. Inductive bias. Decision Tree Learning. Rule Learning: Propositional and First -Order, Over -fitting, Cross - Validation.	8 Lectures
Unit II	Experimental Evaluation of Learning Algorit hms Instance -Based Learning: k -Nearest neighbor algorithm, Radial basis functions. Case-based learning. Computational Learning Theory: probably approximately correct (PAC) learning. Sample complexity. Computational complexity of training.	8 Lectures
Unit III	Vapnik -Chervonenkis dimension. Artificial Neural Networks: Linear threshold units, Perceptrons, Multilayer networks and back - propagation, recurrent networks. Probabilistic Machine Learning, Maximum Likelihood Estimation, MAP.	8 Lectures
Unit IV	Bayes Classifiers Naive Bayes. Bayes optimal classifiers, Minimum description length principle. Bayesian Networks, Inference in Bayesian Networks, Bayes Net Structure Learning Unlabelled data: EM, preventing overfitting, Gaussian Mixture Models.	10 Lectures
Unit V	Unsupervised Learning: K -means K -medoid, automated clustering, Hierarchical Clustering; Hidden Markov Models, Reinforcement, Learning Support Vector Machines, Ensemble learning: boosting, bagging..	8 Lectures

Recommended Books:

1. Machine Learning, Tom Mitchell, McGraw.
2. Machine Learning: An Algorithmic Perspective, Stephen Marsland, CRC Press.

Reference Books

1. The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Trevor Hastie, Robert Tibshirani and Jerome Friedman, Springer.
   Pattern Recognition and Machine Learning, Christopher Bishop, Springer.

CS 7024 Computational Geometry : 4 credits (3-0-2)

Unit	Topics	Lectures
Unit -I	Convex hulls: construction in 2d and 3d, lower bounds; Triangulations: polygon triangulations, representations, point - set triangulations, planar graphs;	8
Unit -II	Voronoi diagrams: construction and 'applications, variants; Delayney triangulations: divide -and-conquer, flip and incremental algorithms, duality of Voronoi diagrams, min -max angle properties	8
Unit -III	Geomet ric searching: point location, fractional cascading, linear programming with prune and search, finger trees, concatenable queues, segment trees, interval trees;	8
Unit -IV	Visibility: algorithms for weak and strong visibility, visibility with reflections, art-gallery problems; Arrangements of lines: arrangements of hyperplanes, zone theorems, many -faces complexity and algorithms; Combinatorial geometry: Ham - sandwich cuts, Helly's theorems, k -sets, polytopes and hierarchies, polytopes	8

Unit -V	linear proga rmming in d -dimensions, complexity of the union of convex sets, simply connected sets and visible regions; Sweep techniques: plane sweep for segment intersections, Fortune's sweep, for Voronoi diagrams, topological sweep for line arrangements; Randomizatio n in computational geometry: algorithms, techniques for counting; Robust geometric computing; Applications of computational geometry	10

Recommended Books:

1. Franco P. Preparata and Michael Ian Shamos (1985). Computational Geometry - An Introduction. Springer-Verlag.

Reference Books

1 Algorithms in Combinatorial Geometry by Herbert Edelsbrunner Publisher Springer

2 Computational Geometry in C by Joseph O'Rourke Cambridge University Press

CS 7025 Simulation and Modelling : 4 credits (3-0-2)

Unit I	System models and role of simulation. Entities, Attributes, States and Activities. Types of systems: Deterministic, Stochastic, Continuous and Discrete systems. Steps in simulation studies.	7
Unit II	Statistical tools and techniques: generation of pseudorandom numbers, random variate generation for uniform, Poisson and normal distributions, sampling and estimation, maximum likelihood estimation, confidence intervals and hypothesis testing, stochastic processes and Markov models.	10
Unit III	Discrete event simulation langua ges. Simulation of inventory and queuing systems: single and multi -server queues, network of queues. Modeling and performance evaluation of computers and computer communication networks.	10
Unit IV	Workload characterization. Continuous system simulation l anguages, growth and decay models, system dynamics diagrams. Biological and Sociological system simulation.	8
Unit V	Verification and validation of simulation models: input/output validation, sensitivity analysis, performance measures and their estimation. Case studies.	7

Recommended Books:

1. Modeling and Simulation, ? Hans-Joachim Bungartz, Stefan Zimmer, Martin Buchholz, Dirk Pflüger, Springer.
   Modeling and Simulation: The Computer Science of Illusion, Stanislaw Raczynski,

CS 7026 Cognitive Radio Networks : 4 credits (3-0-2)

Unit I	Cognitive radio: goals, benefits, definitions, a rchitectures, relations with other radios, issues, enabling technologies, policies, interoperability/coexistence, etc. Spectrum: Licensed, unlicensed, shared unlicensed, opportunistic unlicensed, Current spectral usage and issues, Regulations, regulation c hanges. Applications of CRN.	8 lectures

Unit II	The Cognitive Radio Cycle: Spectrum Sensing, Spectrum Decision, Spectrum Sharing and Spectrum Mobility. Various Energy Detection techniques used in CRN. Various Dynamic Spectrum Access (DSA) algorithms, F ountain Codes and Game -theory approach. PHY, MAC, Network, source/channel joint coding, joint routing and link adaptation, routing/power adaptation, Efficiency measures and metrics, network and system aspects, etc. , Femto cells and relation to cognitive ra dio , 2.5G/3G/4G cognitive features (case study WIMAX & LTE): Multi-carrier system adaptation (OFDM(A) adaptive features), Adaptive CP, adaptive number of carriers, sub -band adaptive modulation, pre -compensation, adaptive PAPR reduction, link adaptation, etc.	12 lectures
Unit III	IEEE 802.22: Introduction, Overview of the IEEE 802.22 standard, PHY and MAC -layers in IEEE 802.22, Spectrum Sensing.	6 lectures
Unit IV	Cognitive Radio Network security: Various security issues in CRN, SSDF attack, PUEA at tack, attacks specific to various layers, security vulnerabilities in IEEE 802.22, security threats to the radio software.	8 lectures
Unit V	Introduction t o Software -Defined Radios (SDR): Hardware limitations, A/D, filters, antennas, AGC, etc. Processin g, programmability (flexibility) vs power consumption, Digital signal processing role in SDR, and some examples, FPGA/DSP and mixed programming platforms CRN test -beds based on SDRs. Introduction to GNU Radio : Analog Receiver, Digital Transmitter and Recei ver, Cognitive Transmitter.	8 lectures

Recommended Books:

1. "Cognitive Radio Communications and Networks: Principles and Practice", Alexander M. Wyglinski, Maziar Nekovee and Thomas Hou Professor, Academic Press, 2010
2. "Cognitive Radio Networks: From Theory to Practice", Ahmed Khattab, Dmitri Perkins and Magdy Bayoumi, Springer, 2013

Reference Books

1. "Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems", HüseyinArslan, Springer, 2007
2 "Cognitive Radio Networks: Medium Access Control for Coexistence of Wireless Systems", Kaigui Bian, Jung-Min Park and Bo Gao, Springer, 2014
3 "Essentials of Cognitive Radio", Linda E. Doyle, Cambridge University Press, 2009

DEPARTMENT OF COMPUTER SCIENCE & ENGINNERING
M.TECH IN INFORMATION TECHNOLOGY

Course Structure:

Year I

SEMESTER I		**L T P C**
IT 7100	ADVANCED COMPUTER ARCHITECTURE	3-1-0- 4
IT 7101	SOFTWARE ENGINEERING METHODOLOGIES	3-0-2- 4
IT 7102	ADVANCED DATA STRUCTURES	3-0-2- 4
IT 7151	SEMINAR	0-0-4- 2
IT/CS-xxxx	ELECTIVE I	(3-0-2/3-1-0)- 4
IT/CS-xxxx	ELECTIVE II	(3-0-2/3-1-0)- 4

Elective I and II [Any two of the following courses]

i) IT 7001 NEURAL NETWORKS AND APPLICATIONS
ii) IT 7002 MODELLING AND STIMULATION
iii) IT 7006 ADVANCED SPEECH PROCESSING
iv) IT 7007 INFORMATION THEORY AND CODING
v) IT 7008 MULTIMEDIA SYSTEMS
vi) CS 7002 UBIQUITOUS COMPUTING
vii) CS 7004 BIOINFORMATICS
viii) CS 7005 ARTIFICIAL INTELLIGENCE
ix) CS 7006 FAULT TOLERANT SYSTEMS
x) CS 7007 COMPUTER GRAPHICS

Year I

SEMESTER II

IT 7200	ADVANCED DATABASE MANAGEMENT SYSTEMS	3-1-0-4
IT 7201	ADVANCED COMPUTER NETWORKS	3-0-2-4
IT 7202	ADVANCED OPERATING SYSTEM	3-0-2-4
IT/CS/MA/HSxxxx	Elective III	(3-0-2/3-1-0)-4
IT xxxx	Elective IV	(3-0-2/3-1-0)-4

Elective III and IV [Any two of the following courses with the condition that a maximum of one elective can be chosen from outside the IT and CS courses)

i) IT 7003 PATTERN RECOGNITION AND APPLICATIONS
ii) IT 7004 OPTIMIZATION TECHNIQUES
iii) IT 7005 MANAGEMENT INFORMATION SYSTEM
iv)IT 7009 RELIABILITY ENGINEERING
v) IT 7010 CAD for VLSI DESIGN
vi) CS 7014 DISTRIBUTED SYSTEMS
vii) CS 7016 ADVANCED IMAGE PROCESSING
viii) CS 7017 ADVANCED GRAPH THEORY
ix) CS 7019 EMBEDDED SYSTEMS
x) CS 7020 CRYPTOGRAPHY
xi) CS 7021 DATA WAREHOUSING AND DATA MINING
xii) CS 7022 INFORMATION AND SYSTEM SECURITY
xiii) HS 7003 HUMAN RESOURCES MANAGEMENT
xiv) HS 7004 MARKETING MANAGEMENT
xv) MA 7001 ADVANCED DISCRETE MATHEMATICS

Year II

SEMESTER I

IT 8197	PROJECT SEMINAR-I	0-0-4-2
IT 8198	PROJECT VIVA VOCE I	0-0-4-2
IT 8199	PROJECT PART I	0-0-8-4

Year II

SEMESTER II

IT 8297	PROJECT SEMINAR II	0-0-8-4
IT 8298	PROJECT VIVA VOCE II	0-0-8-4
IT 8299	PROJECT THESIS	0-0-16-8
		Total = 66 Credits

DETAILED SYLLABUS:

IT-7100: Advanced Computer Architecture **3-1-0-4**

Units	Topics	Lectures
Unit I	Introduction: review of basic computer architecture, quantitative techniques in computer design, measuring and reporting performance. CISC and RISC processors.	6hr
Unit II	Hierarchical memory technology: Inclusion, Coherence and locality properties; Cache memory organizations, Techniques for reducing cache misses; Virtual memory organization, mapping and management techniques, memory replacement policies.	8hr
Unit III	Pipelining : Basic concepts, instruction and arithmetic pipeline, data hazards, control hazards, and structural hazards, techniques for handling hazards. Exception handling, Pipeline optimization techniques, Compiler techniques for improving performance.	10hr
Unit IV	Instruction-level parallelism: basic concepts, techniques for increasing ILP, superscalar, super pipelined and VLIW processor architectures, Array and Vector processors, Multiprocessor architecture.	8hr
Unit V	Taxonomy of parallel architectures. Centralized shared-memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared-memory, architecture, Cluster computers. Non Von Neumann architectures: data flow computers, reduction computer architectures, systolic architectures.	10hr

Recommended Books :

1. Kai Hwang "Advanced Computer Architecture: Parallelism, Scalability, Programmability" McGraw Hill.
2. M. J. Flynn, "Computer Architecture: Pipelined and Parallel Processor Design" Jones & Bartlett Learn ing.
3. John Paul Shen and Mikko H. Lipasti,"Modern Processor Design: Fundamentals of Superscalar Processors " Waveland Press.
4. John L. Hennessy and David A. Patterson "Computer Architecture: A Quantitative Approach" Morgan Kauf mann.

IT – 7101: Software Engineering Methodologies **3-0-2-4**

Units	Topics	Lectures
Unit I	Software process models, process iteration, process activities, rational unified process, computer aided software engineering. Management activities, project planning, project scheduling, risk management.	8hr
Unit II	Functional and Non – functional requirements, user requirements, system requirements, interface specifications, software requirements document, Requirements engineering processes, feasibility studies, elicitation and analysis, validations, management, System Models; Architectural Design – Distributed Systems Architectures – Application Architectures, Object Oriented Design, Real time Software Design.	12hr
Unit III	Software testing fundamentals – Test Case Design – White Box - Basis Path Testing – Control Structur e Testing – Black Box – Testing for Specialized environments, Architectures and Applications Software Testing Strategies	7hr
Unit IV	Software Quality Concepts – Quality Assurance – Software Technical Reviews – Formal Approach To Software Quality Assurance; Reliability, Quality Standards, Software Quality Assurance Plan.	7hr
Unit V	Software Maintenance, Software Configuration Management, configuration item, process, objects in the software configuration, version control, change control, configuration audit, status reportin g, SCM Standards, Case study : Martha Stockton Greengage (MSG) foundations	8hr

Recommended Books :

1. Software Engineering, A practitioner's Approach by Roger S. Pressman, McGrawHill International Editi on, 6th Edition
2. Software Engineering by Sommerville, Pearson Education, 7th edition
3. Software Engineering by K.K. Aggarwal & Yogesh Singh, New Age International Publishers
4. Software Engineering, An Engineering Approach by James F. Peters, WitoldPedrycz, John Wiley
5. Software Engineering principles and practice by Waman S Jawadekar, The McGraw-Hill Companies

IT-7102 Advanced Data Structures **3-0-2-4**

Units	Topics	Lectures
Unit I	Introduction of basic concepts of Object Oriented Programming, data types, branching & looping, Pointers, pass by value, pass by pointer, pass by reference, Dynamic memory using new/delete, Introduction to STL, Streams, string and vector, ADT, List (Singly and Doubly Linked List) implementation	8hr
Unit II	Object based programming concrete classes, Constructors, Assignment, descriptor, runtime polymorphism, operator, overloading, explicit and implicit type conversion, friend functions, namespaces, dependent name lookup, Object oriented programming, derived classes, single inheritance: Public, private, protected, Virtual functions, protocol classes, Class hierarchies., Stacks and Queues- Applications and Implementations.	8hr
Unit III	Compile-time polymorphism, function Templates & overloading, template classes, partial and complete specializations, introduction to template policies/traits,Trees – General– Binary – Binary Search – Expression Search – AVL – Introduction to Red Black trees and Splay tree – B Trees – Implementations – Tree Traversals	10hr
Unit IV	Set – Implementation – Basic Operations on Set – Priority Queue – Implementation – Graphs – Directed Graphs – Shortest Path Problem – Undirected Graph – Spanning Trees – Graph Traversals:hash table representation: hash functions: collision resolution:separate chaining: open addressing:linear probing: quadratic probing: double hashing: rehashing	8hr
Unit V	Searching Techniques – Sorting – Internal Sorting – Bubble Sort – Insertion Sort – Quick Sort – Heap Sort – Bin Sort – Radix Sort – External Sorting – Merge Sort – Multiway Merge Sort – Polyphase Sorting – Design Techniques – Divide and Conquer – Dynamic Programming – Greedy Algorithm – Backtracking – Local Search Algorithms	8hr

Recommended Books :

1. Mark Allen Weiss, ¯Data Structures and Algorithm Analysis in C++ , Pearson Education, 2002.
2. Aho Hopcroft Ullman, ¯Data Structures and Algorithms , Pearson Education, 2002.
3. Horowitz Sahni, Rajasekaran, ¯Computer Algorithms , Galgotia, 2000.
4. Tanenbaum A.S, Langram Y, Augestien M.J., Data Structures using C & C++ , Prentice Hall of India, 2 002.
5. Data structures, Algorithms and Applications in C++, S.Sahni, University Press (India) Pvt.Ltd, 2nd edition, Universities Press Orient Longman Pvt. Ltd.

IT-7200 Advanced Database Management Systems **3-1-0- 4**

Units	Topics	Lectures
Unit I	Fundamental concepts of Relational Databases: ER diagram, Normalization, Transactions, etc. Deductive databases: Datalog and Recursion, Evaluation of Datalog program, Recursive queries with negation.	10 hr
Unit II	Object Oriented and Object Relational Databases: Modeling Complex data semantics, Specialization, Generalization and Aggregation. Objects, Objects Identity, Object reference.	8hr
Unit III	Distributed Databases: Distributed data storage: Fragmentation and replication, Location and fragment transparency, distributed query processing. Distributed transaction and concurrency control, distributed deadlocks, commit protocols: 2PC, 3PC.	10hr
Unit IV	Parallel Databases: Parallel Database Architectures, Parallel Query Evaluation. Advanced Transaction Processing: Nested and Multilevel Transactions.	6hr
Unit V	Real Time Databases: Temporal Constraints, Soft and Hard Contraints.Multimedia Databases: Modeling and Storage of multimedia data. Data Structures: R-Tree, k-d tree, Quadtrees, Content-based retrieval. XML Databases.	8hr

Recommended Books :

1. Ramakrishna R. and J. Gehrke. Database Management Systems, 3rd ed., Mc Graw Hill.
2. Garcia-Molina, H., J. Ullman et al. Database : The Complete Book, Prentice Hall.
3. Gray, P., K. G. Kulkarni, and N.W. Paton. Object-Oriented Databases : A Semantic Data Model Appro ach. Prentice-Hall, Hertfordshire.
4. Blaha, M., Premerlani W., Object-Oriented Modeling and Design for Database Applications, Prentice -Hall.

IT-7201 Advanced Computer Networks **3-0-2- 4**

Units	Topics	Lectures
Unit I	Fundamental Computer Networking Concepts: ISO/OSI Reference Model, TCP/IP protocol suite – TCP Congestion Control - Performance Metrics - Queuing Models – QoS	6 hr
Unit II	Inside Routers-Switching Fabric,Advanced Routing Protocols: RIP, OSPF, BGP, Multicast Routing Protocol –RPB, TRPB - IPv6 - P2P systems	8hr
Unit III	Advanced MAC protocols: 802.11 MAC, DFWAC-CSMA/CA, Frame Structure,Wireless Networking Concepts. Overlay Networks: 6Bone, MBone, RON, VOIP, SIP, Cloud Computing, 3G, 4G, WiMAX ,	8 hr
Unit IV	Integrated Services Architecture – Approach, Components, Services- QueuingDiscipline, FQ, PS, BRFQ, GPS, WFQ – Random Early Detection, DifferentiatedServices	10 hr
Unit V	RSVP – Goals & Characteristics, Data Flow, RSVP operations, Protocol Mechanisms -Multiprotocol Label Switching – Operations, Label Stacking, Protocol details – RTP –Protocol Architecture, Data Transfer Protocol, RTCP.	10 hr

Books/References:

1. William Stallings, "HIGH SPEED NETWORKS AND INTERNET", PearsonEducation, Second Edition, 2002.
2. Warland, PravinVaraiya, "High performance communication networks", SecondEdition , Jean Harcourt Asi a Pvt. Ltd., 2001.
3. IrvanPepelnjk, Jim Guichard, Jeff Apcar, "MPLS and VPN architecture", CiscoPress, Volume 1 and 2, 20 03.
4. Abhijit S. Pandya, Ercan Sea, "ATM Technology for Broad Band TelecommunicationNetworks", CRC Press, New York, 2004.
5. James F. Kurose, Keith W. Ross, "Computer Networking, A Top-Down Approach", Pearson Education, 6 th Edition

IT-7202 Advanced Operating System **3-0-2- 4**

Units	Topics	Lectures
Unit I	Distributed Operating Systems: Design and Implementation. File Systems, Mode of Computation, Load Balancing, Event Ordering	6 hr
Unit II	Synchronization, Distributed Mutual Exclusion, Deadlocks in Distributed Systems. Process Synchronization in multiprocessing / multiprogramming systems. Inter process communication techniques.	10 hr
Unit III	Interprocess communication and co-ordination in large distributed systems. Distributed resource management, Real time Operating Systems	8 hr
Unit IV	Information Maganement in distributed systems: security, integrity and concurrency problems.	8 hr
Unit V	Fault tolerance. Operation System issues related to the internet, intranet, pervasive computing, embedded systems, mobile systems. Features of UNIX.	10 hr

Recommended Books :

1. William Stallings,Operating Systems: Internals and Design Principles (5th ed.),Prentice-Hall of Indi a 2006.
2. Maurice J. Bach,Design of the UNIX Operating System , Prentice Hall, 1986
3. D.M. Dhamdhere, Operating Systems: A Concept Based Approach (2nd ed.), Tata McGraw-Hill, 2007

Electives (Electives with course codes CS-xxxx and HS-xxxx are from the MTech(CSE) syllabus which is already approved by the AC)

IT-7001 Neural Networks and Applications **3-1-0-4**

Units	Topics	Lectures
Unit I	Fundamental of Artificial neural networks, Model of an artificial neuron, NN Architectures.	6 hr
Unit II	Single & Multilayer network Perceptrons, perception learning algorithm, Back propagation, variation of standard back propagation algorithm, applications, counter propagation	10 hr
Unit III	Network structure, training the Cohen layer, Grossberg layer, applications	6 hr
Unit IV	Associative memory: Auto correlators, Kosko's discrete BAM, exponential BAM, Adaptive resonance theory: ART1, ART2, Applications	10 hr
Unit V	Statistical methods, Boltzman training, Cauchy training application to optimization problems. Hopfield nets, Statistical Hopfield nets, Self-organization Map, various applications of ANN.	10 hr

Recommended Books :

1. S. Haykin, Neural Networks: A Comprehensive Foundation (2nd ed.), Prentice Hall,1999
2. R.Rojas and J. Feldman,Neural Networks: A Systematic Introduction (1st ed.),Springer, 1996.
3. B. Yegnanarayana,Artificial Neural Networks ,Prentice-Hall of India, 2006

IT-7002 Modelling and Simulation **3-1-0-4**

Units	Topics	Lectures
Unit I	Systems: Models types, Principles used in modeling, system studies, interacting subsystems and example, simulation definitions, examples, steps in computer simulations, advantages and disadvantages of simulation, simulation study, classification of simulation languages.	10 hr
Unit II	System Simulation: Techniques of simulation, Monte Carlo method, comparisons of simulation and analytical methods, numerical computation techniques for continuous and discrete models, cobweb models	6 hr
Unit III	Continuous system simulation: Models, Differential equation, analog computer, analog methods, digital analog simulators, CSSLS, CSMPIII language, System Dynamics: exponential, growth and decay models, logistic curves and generalization of growth models	6 hr
Unit IV	Probability concepts in simulation: Stochastic variables, discrete and continuous probability function, continuous uniform distributed and computer generation of random numbers, uniform random number generator, rejection method	10 hr
Unit V	Object oriented approach in simulation, simulation in C++, Introduction to GPSS, action times, choice of paths, numerical attributes functions, GPSS model applied to any application etc.	10 hr

Recommended Books :

1. G. Gordan, "System Simulation", 2 nd Edition PHI
2. T.A. Payer, "Introduction to Simulation", McGraw Hill
3. W.A. Spriet, " Computer Oriented Modeling and Simulation"
4. NarsinghDeo, "System Simulation with Digital Computers", PHI.
5. V. Rajaraman, "Analog Simulation", PHI.
6. Law and Kelton, "Simulation Modeling and Analysis", 3 rd Edition, McGraw Hill

IT – 7003 Pattern Recognition and Applications **3-1-0-4**

Units	Topics	Lectures
Unit I	Pattern Recognition: Different approaches to pattern recognition. Feature Extraction and classification stages, Bayes Decision Rules for two Class problem, Pattern classification using Statistical classifiers - Bayes' classifier - Classification performance measures - Risk and error probabilities. Bayes maximum likelihood rule, minimum distance classifier, error probabilities for classifier, Mahalanobis distance, Bound for error probabilities, Estimation of parameters, Learning. Single layer perceptron,.	10 hr
Unit II	Clustering, - Clustering transformation and feature ordering - Clustering in feature selection Minimum within cluster distance criterion, k-mean algorithm single linkage, complete linkage and average linkage algorithms, Isodata algorithm.	8 hr
Unit III	Feature Selection algorithms for feature selection such as Branch and Bound, Sequential forward and backward selections, GSFS and GSBS, (L, R) algorithm.*Criterion function:* Probabilistic Separability criterion, error probability based criterion, entropy based criterion, minimum within class distance based criterion, probabilistic independence. Principal Component Analysis	8 hr
Unit IV	*Fuzzy Set-theoretic Pattern Recognition* Usual Fuzzy set theoretic operations –union, intersection etc. Multitvalued Logic: Zade Compositional Rule of inference Fuzzy *C-means* algorithm. Supervised Classification: Multitvalued Recognition System Fuzzy set theoretic based feature selection criteria , Applications with appropriating classification errors such as comission and Omission.	10 hr
Unit V	Application of Pattern Recognition: Speech recognition, Character recognition and Scene Analysis.	6 hr

Recommended Books :

1. *P. A.* Devijver and J. Kittler, Pattern Recognition: A Statistical Approach *(*Prentice-HallInternational, Englewood Cliffs, NJ, 1980).
2. *R. O.* Dudaand P. E. Hart*,* Pattern Classification and Scene Analysis *(*Wiley-Interscience, New York, 1973).
3. *K.* Fukunaga, *Introduction to Statistical Pattern Recognition, 2nd Ed. (* Academic Press, New York, 1990.
4. *D. J.* Hand, *Discrimination and Classification (*John Wiley and Sons, Chichester, UK, 1981*).*

IT-7004 Optimization Techniques **3-1-0-4**

Units	Topics	Lectures
Unit I	Linear Programming: Graphical method, Simplex method, Revised simplex method, Duality in Linear Programming (LP), Sensitivity analysis, other algorithms for solving problems, Transportation, assignment and other applications.	10 hr
Unit II	Non Linear Programming: Unconstrained optimization techniques, Direct search methods, Descent methods, constrained optimization.	6 hr
Unit III	Formulation of Integer Programming problems, Gomory's cutting plane methods, Branch and Bound Techniques.	6 hr
Unit IV	Characteristics of Dynamic Programming, Bellman's principle of optimality, Concepts of dynamic programming, tabular method of solution, Calculus method of solution.	10 hr
Unit V	Network Construction-computation of earliest start time, latest start time, Total, free and independent float time-Crashing-Computation of optimistic, most likely Pessimistic and expected time-Resource analysis in Network scheduling.	10 hr

Recommended Books :

1. L.R.Foulds, "Optimization Techniques: An Introduction", Springer Verlag.
2. Chander Mohan and Kusum Deep, "Optimization Techniques", New Age Science Publishers.
3. Kalyanmoy Deb, "Optimization for Engineering Design: Algorithms and Examples", PHI.

IT-7005 Management Information System **3-1-0-4**

Units	Topics	Lectures
Unit I	Matching the Information System Plan to the Organizational Strategic Plan, Identifying Key Organizational Objectives and Processes, Developing an Information System Development, User's role in Systems Development Process, Maintainability and Recoverability in System Design.	8 hr
Unit II	Models for Representing Systems: Mathematical, Graphical and Hierarchical (Organization Chart, Tree Diagram), Information Flow, Process Flow, Methods and Heuristics, Decomposition and Aggregation, Information Architecture, Application of System Representation to Case Studies.	9 hr
Unit III	Information Theory, Information Content and Redundancy, Classification and Compression, Summarizing and Filtering, Inferences and Uncertainty, Identifying Information needed to Support Decision Making, Human Factors, Problem characteristics and Information System Capabilities in Decision Making.	9 hr
Unit IV	Transaction Processing Applications, Basic Accounting Application, Budgeting and Planning Applications. Centralized versus Decentralized Allocation Mechanism.	8 hr
Unit V	Systems analysis and design, System development life cycle, Limitation, End User Development, Managing End Users, Off-the Shelf Software Packages, Outsourcing, Comparison of Different Methodologies.	8 hr

Books/References:

1. Management Information System, Oz Thomson Learning 5th edition
2. Management Information System, W.S.Jawadekar, 3rd edition, TMH
3. Management Information System, James O'Brien, 7th edition, TMH
4. Information Systems the foundation of E-Business, Steven Alter, 4 th Edition Person education
5. Information Technology for management, Turban, McLean, Wetherbe, 4th edition, Wiley

IT- 7006 Advanced Speech Processing **3-0-2-4**

Units	Topics	Lectures
Unit I	Anatomy & Physiology of Speech Organs, The process of Speech Production, The Acoustic Theory of Speech Production, Digital models for speech, Classification of Speech, phonemes and Case studies on American/UK English Phonemes.	8 hr
Unit II	Fundamentals of signals and systems, Sampling theorem, Fourier Analysis, Filter Bank Analysis, Digital processing of Speech Signal, Short Time Analysis of Speech Signal and Time Domain Parameters of Speech.	8 hr
Unit III	Linear Predictive Coding, Autocorrelation method, Covariance method, LPC Coefficients, Spectral Analysis, Formant Frequency, Fundamental Frequency, Cepstral Analysis of Speech and Cepstral Coefficients Estimation.	8 hr
Unit IV	Automatic Speech Recognition, Basic Pattern Recognition Approaches, Parametric Representation of Speech, Similarity Evaluations of Speech Patterns, Clustering Techniques, Vector Quantization, Artificial Neural Networks, Isolated Word and Continuous Speech Recognition Systems, Gaussian Mixer model, Hidden Markov model, Adaptability to Variability in Speech and Language models.	10 hr
Unit V	Speaker Recognition and Speech Synthesis issues, Text to Speech Conversion, Performance and Characteristics of Text to Speech conversion, Voice processing hardware and software architectures.Case Studies: Speech Processor Design, SVM, GMM-UBM and GMM-SVM models.	8 hr

Books/References:

1. Speech and Language Processing - Daniel Jurafsky, James H. Martian.
2. Digital Processing of Speech Signals - Lawrence R. Rabiner, Ronald W. Schafer, Pearson Education.
3. Fundamentals of Speech Recognition - Lawrence R. Rabiner, Biing-Hwang Juang, Pearson Education.
4. Speech Communications: Human & Machine - Douglas O'Shaughnessy, IEEE Press.

IT-7007 Information Theory and Coding **3-1-0-4**

Units	Topics	Lectures
Unit I	Information theory: information and entropy, properties of entropy of a binary memory less source, extension of a binary memory less source	8 hr
Unit II	Source coding theorem: Shannon fano coding, Huffman coding, Lempel ziv coding; discrete memoryless source;	8 hr
Unit III	Binary symmetric channel; mutual information properties; channel capacity; channel coding theorem;	8 hr
Unit IV	Introduction to algebra: groups, fields, binary field arithmetic, construction of Galois field basic properties, computations, BCH code, Reed Solomon code;	9 hr
Unit V	Linear block codes, generator matrices, parity check matrices , encoder, syndrome and error correction minimum distance, error detection capabilities; Cyclic codes; Convolution codes: encoder generator matrix, state diagram, distance properties, maximum likelihood decoding; Viterbi decoding; Turbo coding; Trellis coding; Unidirectional Error Correcting Codes; Applications of error correcting codes.	9 hr

Recommended Books :

1. Simon Haykin: An Introduction to Analog and Digital Communications, Wiley India Private Limited (21 August 2006)
2. Ranjan Bose: Information Theory, Coding And Cryptography, McGraw Hill Education (India) Private Limi ted; 2 edition (25 April 2008)

IT-7008 : Multimedia Systems **3-0-2-4**

Units	Topics	Lectures
Unit I	Definition of Multimedia, Source characteristics, Source encoding/decoding algorithm: up to MPEG4.	8 hr
Unit II	ITU standards of Multimedia up to H.324 Multimedia Modems: up to V. 34,	8 hr
Unit III	Definitions of NB, WB & BB, Evolution of Broad band networks, ISDN & BISDN network architectures, techniques and theories, Examples of some networks.	8 hr
Unit IV	Economic vs. Technical aspects of BISDN, BISDN services, Conversational service, Messaging service, Retrieval service, Distribution service etc., BISDN protocol.	8 hr
Unit V	Reference model, ATM cell switching in BISDN, AAL types, VBR, CBR, ABR services, Performance Analysis, Traffic Management, Multimedia System Examples: Video Conferencing, Tele-education, Tele-medicine.	10 hr

Recommended Books :

1. John F. Koegel Buford: Multimedia Systems, Publisher: Dorling Kindersley (Rs); First Edition (1994)
2. AndleighPrabhat K., Thakrar Kiran: Multimedia Systems Design, Publisher: Prentice-Hall (2002) Rafael C. Gonzalez, Richard E. Woods: Digital Image Processing: International Edition , Publisher: Pearson; 2 edition (1 August 2001).

IT-7009 Reliability engineering **3-1-0-4**

Units	Topics	Lectures
Unit I	History, Reliability: A Birth to Death problems of Developing Countries, Education and research, predication and Analysis, problems, future direction/prospects.	8 hr
Unit II	Reliability function, MTTF, Hazard Models, Failure Data Analysis, Plots, Distribution and Estimation of failure data, Data Management system modeling, Assumptions	10 hr
Unit III	Two state modeling, Three state modeling, Cut set approach, Tie set and cut set approach, Reliabilit y Evaluation of flow Networks, System performance measurement	8 hr
Unit IV	State space approach for single unit, two unit, k-out-of-m: G system, Approaches types and applications, Markov models.	8 hr
Unit V	Important Definitions, Important measures of events, extended to multistage systems, Modularization, somatic synthesis, computer codes for various type of analysis.	8 hr

Recommended Books :

1. R.Billinton and R.N.Allan, "Reliability Evaluation of Engineering Systems: Conncepts and Techniques" , Springer International Edition, 2nd Edition, Indian Reprint 2007.
2. Martin .L.Shooman, "Probabilistic Reliability: An Engineering Approach", 2 nd Edition Melbourne,FL,1990.

IT – 7010 CAD for VLSI Design **3-0-2-4**

Units	Topics	Lectures
Unit I	Introduction to VSLI system, the top down approach for location, partitioning, floor planning, placement etc.	8 hr
Unit II	The top down approach for routing: fundamentals, global routing, detailed routing, Routing in field programmable Gate-arrays etc.	8 hr
Unit III	Performance issues in circuit layout, Single layer routing and applications: cell generation and programmable structures.	8 hr
Unit IV	Programmable logic arrays, Transistor chaining, Gate matrix, layout and Weinberger Array, other CMOS cell layout styles Compaction: 1D compaction, 2D compaction.	8 hr
Unit V	Software usage – HDL introduction, HDL synthesis methodologies, Different proprietary packages for CAD – VLSI.	10 hr

Recommended Books :

1. Seetharaman Ramachandran: Digital VLSI Systems Design: A Design Manual for Implementation of Project s on FPGAs and ASICs Using Verilog , Publisher: Springer; 2007 edition (4 June 2007)
2. MD Liakot Ali, DrIshakAris, RoslinaSidek: Verilog Hdl, Publisher: VDM Verlag (18 June 2010)
3. Joseph Cavanagh: Digital Design and Verilog HDL Fundamentals, Publisher: Taylorandfrancis (2008)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY

SYLLABI
OF
PG / Ph. D. COURSES
(DEPARTMENT OF ELECTRICAL ENGINEERING)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY
(UNDER THE MINISTRY OF EDUCATION, GOVT. OF INDIA)
DEEMED TO BE UNIVERSITY U/S 3 OF THE UGC ACT, 1956
NIRJULI - 791 109 :: ARUNACHAL PRADESH

SYLLABI
OF
PG/ Ph. D COURSES

(DEPARTMENT : ELECTRICAL ENGINEERING)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY (NERIST)
(Deemed to be University, U/S 3 Of the UGC Act, 1956)
Nirjuli (Itanagar), Arunachal Pradesh- 791 109

Department: Electrical Engineering
Programme: M. Tech in Power System Engineering

Year: First Semester: First

Sl. No.	Course Code	Course Title	L	T	P	Cr
1.	EE 7101	AC Power Transmission System	3	1	0	4
2.	EE 7102	Renewable Power Generation Technologies	3	0	0	3
3.	EE 7103	Power System Modeling and Control	3	1	2	5
4.	EE 7104	HVDC Transmission System	3	1	0	4
5.	EE 7105	Advanced Switchgear and Protection	3	1	0	4
6.	EE 7106	Smart Grid Technologies	3	1	0	4

Total: 24

Year: First Semester: Second

Sl. No.	Course Code	Course Title	L	T	P	Cr
1.	EE 7201	Soft Computing Techniques in Power System	3	0	2	4
2.	EE 7202	Power System Instrumentation	3	0	2	4
3.	EE 7203	Economic Operation of Power System	3	1	0	4
4.	EE 70**	Elective-I	3	0/1	2/0	4
5.	EE 70**	Elective-II	3	0	0	3

Total: 19

Year: Second Semester: First

Sl. No.	Course Code	Course Title	L	T	P	C
1.	EE 8090	Minor Project/Seminar	0	0	16	8
2.	EE 8199	Pre-Submission and Defence of Dissertation (Dissertation to continue)	0	0	4	2

Total: 10

Year: Second Semester: Second

Sl. No.	Course Code	Course Title	L	T	P	C
1.	EE 8299	Dissertation (to be completed) Post submission and Defence of Dissertation	0	0	28	14

Total: 14

Elective-I

Sl. No.	Course Code	Course Title	L	T	P	Cr
1.	EE 7001	Instrumentation and Control	3	1	0	4
2.	EE 7002	Optimal Control Systems	3	1	0	4
3.	EE 7003	Reliability Engineering	3	1	0	4
4.	EE 7004	High Voltage and Insulation Engineering	3	0	2	4
5.	EE 7005	Power System Reliability	3	0	2	4
6.	EE 7006	Artificial Intelligence Application in Power System	3	0	2	4
7.	EE 7007	Advanced Microprocessor and Applications	3	0	2	4
8.	EE 7008	Microcontrollers and their Applications	3	0	2	4

Elective-II

Sl. No.	Course Code	Course Title	L	T	P	Cr
1.	EE 7011	Modeling and Analysis of Electrical Machines	3	0	0	3
2.	EE 7012	Power Quality	3	0	0	3
3.	EE 7013	Condition Monitoring of High Voltage Equipment	3	0	0	3
4.	EE 7014	High Voltage Equipment	3	0	0	3
5.	EE 7015	Power System Protection	3	0	0	3
6.	EE 7016	Power Electronic Drives	3	0	0	3
7.	EE 7017	System Theory	3	0	0	3
8.	EE 7018	Digital Instrumentation in Power System	3	0	0	3

N. B.: The Ph. D students may opt from the PG Courses either Core or Elective to complete the Course work.

EE 7101 AC Power Transmission System (3-1-0: 4)

Unit-I	Theory of AC electric power transmission networks: challenges related to reactive power and voltage control as well as steady-state and transients stability.	**9 Lectures**
Unit-II	Reactive power compensation (shunt reactors and capacitors): series compensation and SVC, STATCOM and other Flexible AC Transmission Systems (FACTS) devices.	**10 Lectures**
Unit-III	Dynamic voltage control and stability, some case studies.	**9 Lectures**
Unit-IV	Design considerations of EHV and UHV power transmission systems: audible noise, radio interference, environmental aspects of transmission lines.	**12 Lectures**
Unit-V	Coordination of system over-voltages with external insulation strengths leading to economic insulation structures based on quantitative evaluation of reliability; General comparison of A.C. and D.C. transmission with HVDC systems.	**2 Lectures**

Total **42** lectures

Recomened Books:

1. Power System Engineering – D. P. Kothari, I. J. Nagrath ,Tata McGraw Hill.
2. Understanding FACTS: concepts and technology of flexible AC transmission systems - Narain G. Hingorani, Laszlo Gyugyi, IEEE Press
3. HVDC Power Transmission Systems – K.R. Padiyar (New Age International P(Ltd.) Publishers.
4. EHV-AC, HVDC Transmission & Distribution Engineering – S. Rao, Khanna Publishers.

EE 7102 Renewable Power Generation Technologies (3-0-0: 3)

Unit-I	Sun and Earth-Basic Characteristics of solar radiation: Angle of sunrays on solar collector, Photovoltaic cell, characteristics, equivalent circuit, Photovoltaic modules and arrays.	**8 Lectures**
Unit-II	PV Systems: Design of PV systems, Standalone system with DC and AC loads with and without battery storage, Grid connected PV systems, Maximum Power Point Tracking.	**8 Lectures**
Unit-III	Wind energy : energy in the wind, aerodynamics, rotor types, forces developed by blades, Aerodynamic models, braking systems, tower, control and monitoring system, design considerations-power curve, power speed characteristics, choice of electrical generators.	**9 Lectures**
Unit-IV	Wind turbine generator systems: fixed speed induction generator, performance analysis, semi variable speed induction generator, variable speed induction generators with full and partial rated power converter topologies, isolated systems, self excited induction generator permanent magnet alternator, performance analysis.	**9 Lectures**
Unit-V	Hybrid energy systems : wind-diesel system, wind-PV system, micro hydro-PV system, biomass-PV-diesel system, geothermal-tidal and OTEC systems.	**8 Lectures**

Total **42** lectures

Recomended Books:

1. Chetan Singh Solanki, 'Solar Photovoltaics-Fundamentals, Technologies and Applications', PHI Learning Pvt. Ltd., New Delhi, 2011
2. Van Overstraeton and Mertens R.P., 'Physics, Technology and use of Photovoltaics', Adam Hilger, Bristol,1996.
3. John F. Walker & Jenkins. N, 'Wind energy Technology', John Wiley and sons, Chichester, UK, 1997.
4. Freries L. L, 'Wind Energy Conversion Systems', Prentice Hall, U.K., 1990

EE 7103 Power System Modeling and Control (3-1-2: 5)

Unit-I	Sequence impedance of power system components and their representation, Bus impedance matrix formation, Matrix method of solving three-phase circuits under LG, LL, 2LG and 3 phases short-circuit conditions using symmetrical components.	**5 Lectures**

Unit-II	Stability : swing equation, synchronous machine models for stability studies, steady-state stability, transient stability, equal area criterion, numerical solution of nonlinear swing equation, Multi-machine systems	**8 Lectures**
Unit-III	Load frequency control: Need for frequency and voltage control, basic generator control loops, generator model, load model, turbine model, static and dynamic analysis of single area LFC, static and dynamic analysis of two area LFC, secondary control, tie-line transfer function and bias control, state-pace model of single and two area system.	**11 Lectures**
Unit-IV	Reactive power and voltage control: Amplifier model, exciter model, generator model and sensor model, static and dynamic performance of AVR loop, stability compensations, Modern control application: pole-placement design, optimal control design.	**10 Lectures**
Unit-V	Methods of voltage control: Shunt reactors, shunt capacitors, series capacitors, synchronous condensers, power system stabilizer, tap-changing transformers	**8 Lectures**

Recomended Books: Total **42** lectures

1. Electric Energy Systems Theory- An introduction by Olle I. Elgerd, Tata McGraw Hill Publishing Compa ny Ltd, New Delhi, Second Edition, 2003.
2. Power System Stability and Control by P. Kundur, McGraw Hill Publications, USA, 1994
3. Electric Power Systems: Theory & Practice – M. N. Bandyopadhyay, PHI.
4. Operation and Control in Power systems by P S R Murty, B S Publications, Hyderabad, 2008.
5. Computer Analysis Methods for Power System by Heydt, Macmillan.

EE 7104 HVDC Transmission System (3-1-0: 4)

Unit-I	Introduction to HVDC Transmission system: Comparison of AC and DC Transmission, application, Types of DCLinks, Main components of HVDC transmission system, Modern Trends in HVDC Technology, Telecommunication requirements in HVDC system.	**9 Lectures**
Unit-II	Analysis of HVDC converters: Graetz's bridge converter, characteristics and detailed analysis of LCC and VSC, Converter and HVDC system control, Higher level controllers, control of VSC, Converter faults, protection against over-currents and over-voltages in a converter station.	**8 Lectures**
Unit-III	Smoothing reactors and Filters: Smoothing reactor, DC line, transient over-voltages in DC line, Protection of DC line, DC breakers, Mono-polar operation, Harmonics and filters, design of AC filters, DC filters, active filters.	**10 Lectures**
Unit-IV	Introduction to MTDC systems: Types of MTDC system, Control and protection of MTDC system, Study of MTDC systems, Multi-infeed DC system, MTDC system using VSC, Operation aspects of EHV transmission systems, design features of transmission lines.	**10 Lectures**
Unit-V	Power flow analysis with VSC based HVDC system, Torsional interaction with HVDC system. Field visits.	**5 Lectures**

Recomended Books: Total **42** lectures

1. HVDC Power Transmission System Technology & System Interaction – K.R.Padiyar
2. Arrillaga, J., "High Voltage Direct Current Transmission", Peter Pregrinus, London, 1983.
3. Power System Engineering: Nagraj and Kothari, TMH
4. Electrical Power System Design –WillamD.Stevension

EE 7105 Advanced Switchgear and Protection (3-1-0: 4)

Unit-I	Over current protection: concepts and philosophy, Equipment protection: transformers, generators, motors and bus bars. Distance and Carrier Protection of Transmission lines: types of distance relays and	**10 Lectures**
Unit-II	their characteristics, stepped distance schemes, zone-1 extension schemes, pilot aided distance schemes, numerical protection.	**10 Lectures**

Unit-III	Surge response of transformers, Overvoltage mitigation, Surge Arresters, Insulation co-ordination.	**6 Lectures**
Unit-IV	Computation of power system transients.	**8 Lectures**
Unit-V	Overview of computer relaying, hardware organization, Algorithm development, Applications, Integration to substation function	**8 Lectures**

Total **42** lectures

Recomended Books:

1. Electric Power Systems: Theory & Practice – M. N. Bandyopadhyay, Prentice Hall of India Publishers.
2. Transients in Power System- Lou van der Sluis, John Wiley & Sons Ltd.
3. Notes given in the class.
4. Switchgear Protection & Power Systems – Sunil S. Rao, Khanna Publishers.
5. Power System Switchgear & Protection – M. Chander, B. Ravindranath , New Age International Publishers.

EE 7106 **Smart Grid Technologies** **(3-1-0: 4)**

Unit I	Introduction to Smart Grid: Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Concept of Resilient & Self-healing Grid, Present development & International policies in Smart Grid, Diverse perspectives from experts and global Smart Grid initiatives.	**8 Lectures**
Unit II	Smart Grid Technologies: Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).	**9 Lectures**
Unit III	Smart Meters And Advanced Metering Infrastructure: Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU), Intelligent Electronic Devices(IED) & their application for monitoring & protection.	**9 Lectures**
Unit IV	Power Quality Management in Smart Grid: Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.	**8 Lectures**
Unit V	High Performance Computing For Smart Grid Applications: Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.	**8 Lectures**

Total **42** lectures

Recomended Books:

1. Vehbi C. Güngör, DilanSahin, TaskinKocak, SalihErgüt, ConcettinaBuccella, Carlo Cecati, and Gerhard P. Hancke, Smart Grid Technologies: Communication Technologies and Standards IEEE Transactions On Industrial Informatics, Vol. 7, No. 4, November 2011.
2. Xi Fang, SatyajayantMisra, GuoliangXue, and Dejun Yang "Smart Grid – The New and Improved Power Grid: A Survey" , IEEE Transaction on Smart Grids,
3. Stuart Borlase "Smart Grid :Infrastructure, Technology and Solutions",CRC Press 2012.
4. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley.

EE 7201 **Soft Computing Techniques in Power System** **(3-0-2: 4)**

Unit-I	ANN: Introduction, Artificial Neuron, Structures of Neural Network, Training Algorithm, and Activation Function, Applications in Power System.	**8 Lectures**
Unit-II	Fuzzy: Introduction, Classification of Fuzzy Theory, Fuzzy Sets, Membership Function, Fuzzy Rule Base, Defuzzification, Adaptive Fuzzy Systems, Neuro Fuzzy Systems, Fuzzy Controller, Applications in Power system.	**8 Lectures**
Unit-III	Optimization Techniques: Introduction, Classical Optimisation Techniques, Objective function, Fitness function, convergence, population, co-evolution, problem formulation, GA, Simulated Annealing, Applications in Power System.	**10 Lectures**
Unit-IV	Wavelets: Introduction, Mathematical Background, Continuous Wavelet and Discrete Wavelet Transform, Mother Wavelet, Advantages over Fourier Transform, Applications, WNN, Applications in power system.	**9 Lectures**
Unit-V	Support Vector Machine: Introduction, Mathematical Background, Classification rules, Applications in power system.	**7 Lectures**

Total **42** lectures

Recimended Books:

1. An Introduction to Neural Networks – James A. Anderson, Prentice-Hall India.
2. Neuro-Fuzzy Control Systems – Kaimal, Dasgupta, Harisankar, NarosaPublishinHouse.
3. Fuzzy Logic with Engineering Appications – T. J. Ross, McGraw Hill Publishers.
4. Ten lectures on Wavelets – I. Daubachieus, IEEE Publications.
5. A Wavelet tour of signal processing – S. Mallat, Elsevier Publications.Wavelets forsensing technologies – A. K. Chan, C. Peng, Artech House Publishers.
6. Principles of Soft Computing, 2nd edition - S.N. Sivanandam, S.N. Deepa, Wiley Publications

EE 7202 **Power System Instrumentation** **(3-0-2: 4)**

Unit-I	General scope of instrumentation in power systems: Electrical instruments and meters. Telemetry, elements of telemetry system, subsystems of telemetry system, types of signal transmission medium, classification of telemetry system, modulation in telemetry	**10 Lectures**
Unit-II	Communication in power systems: Data transmission channels-pilots, inductive coordination, voice communication, PLCC, Microwave links. Interference effect, coaxial and optical fibre systems, two-way mobile radio systems. WAN-based network, distributed processing	**11 Lectures**
Unit-III	SCADA and operating systems: configuration of SCADA systems, master terminal units, data display system. Remote control instrumentation. Area and Central Control station instrumentation.	**10 Lectures**
Unit-IV	Data loggers: disturbance recorders, Frontiers of future power system instrumentation including microprocessor based systems.	**6 Lectures**
Unit-V	Application of digital computers for data processing and on-line system control, Automatic meter reading and billing.	**5 Lectures**

Total **42** lectures

Recomended Books:

1. Fundamental of Industrial Instrumentation and Process Control by Disnn, MGH
2. Switchgear Protection & Power Systems – Sunil S. Rao, Khanna Publishers.
3. Electric Power Systems: Theory & Practice – M. N. Bandyopadhyay, PHI.
4. Advanced Power System Analysis and Dynamics by L. P. Singh ,WEL.
5. Power System Analysis by Arthur R. Berger & Vijay Vittal, Pearson.
6. Power System Analysis by HadiSaadat, TMH.
7. Power System Operation by R. H. Miller and J. H. Malinowski, MGH.

EE 7203 Economic Operation of Power System **(3-1-0: 4)**

Unit-I	Modelling of Synchronous Machine and Its Components: Two axis model, real and reactive power transfer equations of cylindrical rotor and salient pole synchronous machine, equivalent circuit and general phasor diagram at different load conditions, dynamic modelling of cylindrical rotor and salient pole synchronous machine for transient, subtransient and steady state conditions, Sub-synchronous Resonance (SSR).	**9 Lectures**
Unit-II	Modelling of Power System Components and Automatic Generation Control (AGC): Physical characteristics and modelling of power system components like excitation system, generator, prime movers, governors, load and transmission line. Automatic voltage regulator (AVR), load frequency control (LFC), tie-line bias control, automatic generation control for single, double and multi control areas. Alert and emergency system operation and control.	**9 Lectures**
Unit-III	Steady State, Dynamic and Transient stability: State space formulation of single machine and multi-machine models with control equipments. Application of numerical techniques to multi-machine dynamic and transient stability studies. Transient and dynamic stability study of integrated power system using Runge-Kutta and trapezoidal rule techniques, model reduction, Case studies.	**8 Lectures**
Unit-IV	Economic Operation of Power System: Economic performance analysis of power System, economic load dispatch of generators with and without generator limits, and with and without considering line loss. Cost of generations.	**8 Lectures**
Unit-V	Control of Reactive Power Flow: Damping effects of flexible AC transmission system (FACTS) devices, On load tap changer (OLTC) transformers, Flexible AC transmission system (FACTS), Static VAR compensators(SVC), system loss minimization.	**10 Lectures**

Total **42** lectures

Recomended Books:

1. Electrical Power System Analysis by John J. Grainger & W. D. Stevension, TMH.
2. Power System Analysis by HadiSaadat, TMH.
3. Power System Operation by R. H. Miller and J. H. Malinowski, MGH
4. Power System Analysis by Arthur R. Berger & Vijay Vittal, Pearson.
5. Advanced Power System Analysis and Dynamics by L. P. Singh, WEL.
6. Economic Operation of Power Systems by Kirchmayer L.K. John Wiley & Sons

EE 7001 Instrumentation and Control **(3-1-0: 4)**

Unit I	Introduction to mechanical sensor and their structure and function, Performance, Characteristics, Static and Dynamic.	**8 Lectures**
Unit II	Fundamentals of signals acquisition, conditioning and processing, Measurement of temperature, pressure, flow, position, velocity, acceleration, force, torque etc.	**10 Lectures**
Unit III	Introduction to control systems, mathematical model of physical systems in transfer function and state space forms, response of dynamic systems, concept of pole & zero of a system, realization of transfer functions, stability analysis.	**9 Lectures**
Unit IV	Introduction of discrete time system, Controllers: P, PI, PD and PID, Feed forward etc. tuning of controller parameters, implementation of controllers using digital computer.	**9 Lectures**
Unit V	Introduction to various types of Actuator (ac and dc servomotors, valve), tacho-generator, servo amplifier etc.	**6 Lectures**

Total **42** lectures

Recomended Books:

1. Industrial Instrumentation and Control by S. K. Singh TMH
2. Principle of Industrial Instrumentation by Patranabis, TMH.
3. Process Control by K. Krishnaswamy New Age.

EE 7002 Optimal Control Systems **(3-1-0: 4)**

Unit-I	Introduction Classical and modern control, Optimization, Optimal control.	**4 Lectures**
Unit-II	Calculus of Variations and Optimal Control basic concepts, optimum of a function and a functional, Variational problem, Extrema functions and functionals with conditions Linear Quadratic Optimal Control Systems.	**8 Lectures**
Unit-III	Problem formulation, Finite-time LQR, Infinite-time LQR, Linear Quadratic tracking system, LQT system, LQR with specified degree of stability.	**10 Lectures**
Unit-IV	Discrete-Time Optimal Control Systems, Variational calculus for discrete-time systems, discrete-time optimal control systems, discrete-time. LQR, Riccati equation, discrete-time LQT system.	**10 Lectures**
Unit-V	Pontryagin Minimum Principle. Constrained system, Pontryagin minimum principle, Dynamic programming, Hamilton-Jacobi-Bellman equation, Constrained Optimal Control Systems. Fuel-optimal systems Minimum fuel system, Energy optimal systems.	**10 Lectures**

Total **42** lectures

Recomended Books:

1. Kirk, D. E., Optimal Control Theory: An Introduction, Dover Publications, 2004.
2. Sage A. P. and White C. C., Optimum System Control, Prentice Hall PTR, Englewood Cliffs, NJ, 1977.
3. Bryson A. W. and Ho. Y., Applied Optimal Control: Optimization, Estimation and Control, Hemisphere Publishing Corporation, New York, NJ, 1975
4. Naidu, D. S., Optimal Control Systems, CRC Press, Boca Raton, FL 33431, 2003.

EE 7003 Reliability Engineering **(3-1-0: 4)**

Unit-I	Reliability Function and Reliability Indices: Introduction to reliability, reliability function, Relationship among hazard rate, failure density function and reliability. Elementary analysis and Estimation techniques for reliability. Different Hazard functions, Bath tub curve, reliability indices as MTTF, MTBF, MTTR, MTTFF. Relationship among MTBF, hazard rate, failure rate and reliability.	**8 Lectures**
Unit-II	Reliability Modelling of Independent-components Systems: Reliability evaluation for series, parallel and mixed systems. Different techniques for reliability evaluation of complex systems. Reliability evaluation of redundant system and multi-states system.	**10 Lectures**
Unit-III	Systems with Reparable Components: Repairable and non-repairable system, Maintainability, mean up and mean down time, Steady state availability and Point availability, Renewal theory, Marcovian models. Markov method for evaluation of availability, reliability and MTTF for single unit system, two similar, standby and dissimilar units system with joint servicing, without joint servicing and single repairman facility. Impact of surroundings on system's reliability and availability.	**10 Lectures**
Unit-IV	Power System Reliability: Definition, system adequacy and security, outages and interruptions, forced outage rate, reliability evaluation of generating system, capacity outage probability table, loss of load Probability(LOLP), loss of load expected(LOLE), interconnected systems and composite generation systems.	**8 Lectures**
Unit-V	Reliability evaluation of transmission and distribution systems: reliability indices for Transmission and distribution system, System Average Interruption duration Index (SAIDI), Customers Average Interruption duration Index (CAIDI), etc. for both parallel and meshed networks. Substation and Switching station reliability calculation. Analysis of plant and station availability. Evaluation of reliability worth.	**6 Lectures**

Total **42** lectures

Recomended Books:

1. Reliability Evaluation of Engineering Systems by Roy Billington and Ronald Allan, Springer
2. Reliability Analysis and Prediction – A Methodological Oriented Treatment by K. B. Mishra, Elsevier Science Publication, Amsterdan.
3. Electric Power Distribution Reliability" Second Edition, by Richard E. Brown, CRC Press Taylor & Francis Group, 2009
4. Optimal Reliability Modeling- Principles and Applications" by Way Kuo and Ming J. Zuo,, Springer 2003
5. Probabilistic Reliability- An Engineering Approach by Martin L. Shooman, MGH
6. Reliability Engineering by E. Balagurusami, TMH
7. System Reliability (Evaluation & Prediction in Engineering) by A. Pages and M. Gondran, Northern Oxford Academy.

EE 7004 High Voltage and Insulation Engineering (3-0-2: 4)

Unit-I	Electrostatic Field and its measurement using latest computational methods: FDM (Finite Difference Method), FEM (Finite Element Method), CSM (Charge Simulation Method), Boundary Element Method.	**9 Lectures**
Unit-II	Generation of High Voltage: DC – voltage doubler circuit, Cock-croft Walton voltage multiplier circuit, van-de graff generator; AC- Cascading of transformer, series resonant ckt; Impulse – multistage, marx circuit; Impulse current generation, Measurement of High AC, DC and Impulse Voltage and Current.	**10 Lectures**
Unit-III	Dielectric Losses: Measurement of Dielectric Constant, loss factor and resistivity, large capacitance, Break down Mechanism in Gas, Liquid and Solid Dielectric, Partial discharge, RSG.	**8 Lectures**
Unit-IV	Transients in power system, traveling waves on transmission line, lightning phenomenon, Insulation Co-ordination and Over-voltage Protection due to lightning and switching surge.	**8 Lectures**
Unit-V	High Voltage Insulators and Bushings, voltage gradings, Corona Phenomenon and Loss. Radio-Interference and its measurement.	**7 Lectures**

Total **42** lectures

Recomended Books:

1. High Voltage Engineering: Fundamentals by Kuffel, Zaengl, Kuffel- Newnes Publishers.
2. High Voltage Engineering by Naidu, Kamaraju- Tata McGraw Hill Publishers.
3. High Voltage Engineering by Naidu &Kamaraju - Tata McGraw Hill Publishers.
4. High Voltage Engineering by C.L. Wadhwa- New Age International, New Delhi.
5. High Voltage Test Techniques by Dieter, Kurt - Newnes Publishers.
6 Advances in High Voltage Engineering by Haddad & Warne (Editors) - IEE Publications.

EE 7005 Power System Reliability (3-0-2: 4)

Unit-I	Basic Probability Theory: Review of probability concepts, Probability distribution, Probability distribution in reliability evaluation, Network modeling and evaluation of simple and complex systems, System reliability evaluation using probability distribution, Frequency and duration techniques.	**12 Lectures**
Unit-II	Power system quality assessment/enhancement: Generation System Reliability Evaluation, Concepts of LOLP, LOPE, EIR and EENS, Evaluation of these indices for isolated operation of Generation system, Reliability analysis using frequency and duration techniques, Static reserve, Operating reserve.	**10 Lectures**
Unit-III	Transmission System Reliability Evaluation: Evaluation of the LOLP and EENS indices for an isolated transmission system.	**7 Lectures**
Unit-IV	Distribution System Reliability Evaluation: Reliability analysis of radial systems with perfect and imperfect switching.	**5 Lectures**
Unit-V	Customer reliability indices and risk prediction: Interconnected Power System Reliability Evaluation, Contingency planning and risk control management.	**8 Lectures**

Total **42** lectures

Recomended Books:

1. Reliability Evaluation of Engineering Systems by Roy Billington and Ronald Allan, Springer
2. Reliability Analysis and Prediction – A Methodological Oriented Treatment by K. B. Mishra , Elsevier Science Publication, Amsterdan.
3. Electric Power Distribution Reliability" Second Edition, by Richard E. Brown, CRC Press Taylor & Francis Group, 2009
4. Optimal Reliability Modeling- Principles and Applications" by Way Kuo and Ming J. Zuo,, Springer2003

EE 7006 Artificial Intelligence Application in Power System (3-0-2: 4)

Unit-I	Introduction AI, Use of expert systems to power system monitoring operation and control, Expert systems in fault diagnosis.	**5 Lectures**
Unit-II	Application of Neural Network based power system estimator and controllers, Error correction learning, Hebbian learning, Competitive learning, Boltzman learning, Supervised learning ,Unsupervised learning, Reinforcement learning.	**7 Lectures**
Unit-III	Fuzzy sets and crisp sets: Intersections of Fuzzy sets, Union of Fuzzy sets, the complement of Fuzzy sets, Fuzzy reasoning : Linguistic variables, Fuzzy propositions, Fuzzy compositional rules of inference : Methods of decompositions, de-fuzzification, methodology of fuzzy design : Direct & Indirect methods with single and multiple experts, Adaptive fuzzy control, Rule base design using dynamic response.	**7 Lectures**
Unit-IV	Applications of imaging and pattern recognition for system identification and control, Database management and computer graphics aided decision making process.	**8 Lectures**
Unit-V	Applications of AI Techniques, Load forecasting Load flow studies, Economic load dispatch, Load frequency control, Single area system and two area system , Small Signal Stability (Dynamic stability) Reactive power control, speed control of DC and AC Motors, Alarm analysis and decision making process, optimization techniques	**15 Lectures**

Total **42** lectures

Recomended Books:

1. Artificial Intelligence by Rich and Knight, TMH.
2. Artificial Intelligence and Instrument systems by Padhy, Oxford.
3. Artificial Intelligence by N. J. Nilson, Elsvier.
4. Artificial Intelligence and Expert System by Patterson, PHI.
5. S.Rajasekaran and G.A.V.Pai Neural Networks, Fuzzy Logic & Genetic Algorithms, PHI, New Delhi, 2003.
6. Electrical Power Applications with Fuzzy systems, El Hawaray, IEEE Press.

EE 7007 Advanced Microprocessor and Applications (3-0-2: 4)

Unit-I	16-bit microprocessor: 8086 Processor, architecture, bus interface unit and execution unit, segmentation of memory, instruction set, assembly language programming, Interrupt-software and hardware, priority of the interrupts, Standard peripherals and its interfacing.	**14 Lectures**
Unit-II	Coprocessor: Architecture, its handshaking signals for main processor, data formats, stack registers, coprocessor instruction set.	**6 Lectures**
Unit-III	Bus interface: Industry Standard Architect (ISA) bus, the extended ISA, Micro Channel Architecture (MCA), Video Electronics Standard Association(VESA) local bus, Peripheral Component Interconnect (PCI) bus, Small Computer Systems Interface (SCSI), Parallel Printer Interface (LPT), Universal Serial Bus (USB), Accelerated Graphics Port (AGP). Asynchronous and synchronous data format and data transfer, modems and interfacing.	**10 Lectures**
Unit-IV	Microprocessor Applications: Temperature, pressure, flow, speed measurement and control, Case studies of some industrial applications.	**5 Lectures**

Unit-V	32-bit Processors and Pentium Processor: 32-bit processor architecture, memory management unit, real address mode and virtual address mode, protected mode of operation, flags, privilege levels, paging mode of operation, Pentium processor: architecture, memory bank, data bus and its interfacing with 32-bit memory, new instructions, System timing, burst cycle method of memory read, Intel chipset for Pentium processors.	**7 Lectures**

Recomended Books: Total **42** lectures

1. Microprocessor and Interfacing by Doglas V. Hall,TMH.
2. Advanced Microprocessors and Interfacing by B. Ram , TMG.
3. The 8086/8088 Family by John Uffenback , PHI.
4. The Intel Microprocessors by B. B. Brey , PHI.
5. The 80X86 Family by John Uffenback, Pearson.
6. Microprocessors and Applications: Intel and Motorola by M. Raffiquzzaman, PHI.
7. The 8086 and 80486, Pentium by W. A. Triebel and Avtar Singh, PHI .

EE 7008 Microcontrollers and their Applications **(3-0-2: 4)**

Unit-I	Introduction to microprocessor, computer and its organization, programming system, address bus, data bus and control bus, tristate bus, clock generation, connecting microprocessor to I/O devices, data transfer schemes, architectural advancements of microprocessors.	**5 Lectures**
Unit-II	Introduction, generation of I/O ports, PPI-8255, various modes of operation and interfacing to microprocessor. Interfacing Keyboard, display, stepper motor interfacing, D/A and A/D converter; memory interfacing to microprocessor, interrupt structure of microprocessor, vector interrupt table, interrupt service routine; introduction to DOS and BIOS interrupts, interfacing interrupt controller 8259, DMA controller 8257; serial communication standards, serial data transfer schemes; 8251 USART architecture and interfacing; RS-232; IEEE-488, prototyping and troubleshooting, introduce through case studies and the system design principles.	**15 Lectures**
Unit-III	Coprocessor configuration, closely coupled configuration, loosely coupled configuration, 8087 numeric data processor , data types, architecture of 8089 I/O processor, communication between CPU and IOP.	**5 Lectures**
Unit-IV	Introduction to 8051 microcontroller, architecture, memory organization, special function registers, I/O port operation, I/O interfacing, memory interfacing, counters and timers, serial data I/O, interrupts, description of instructions. assembly directives; programming assembly software with algorithms, interfacing with keyboards, LEDs, 7 segment LEDs, LCDs, interfacing with ADCs; interfacing with DACs, etc., overview of the architecture of 8096 16-bit microcontroller.	**10 Lectures**
Unit-V	Introduction to system design using microprocessors; case studies – traffic light control, washing machine control, RTC interfacing using I2C standard- motor control-relay, PWM, dc and stepper motor.	**7 Lectures**

Total **42** lectures

Recomended Books:

1. Microprocessors and Microcontrollers, Architecture, programming and system design using 8085, 8086, 8051 and 8096 by Krishna Kant, PHI 2007.
2. Microprocessors and Interfacing, Programming and Hardware by Douglas V. Hall, TMH, 2006.
3. The 8051 Microcontroller and Embedded Systems by Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinley, Pearson Education 2008, Second Edition.
4. The 8086 Microprocessor: Programming and Interfacing the PC by Kenneth J. Ayala, Delmar Publishers, 2007.
5. Advanced Microprocessors and Peripherals by A K Ray, K M Bhurchandi, TMH, 2007.

EE 7011 Modeling and Analysis of Electrical Machines **(3-0-0: 3)**

Unit-I	Basic concepts of Rotating Machines : Calculation of air gap mmf and per phase machine inductance using physical machine data, Voltage and torque equation of dc machine.	**9 Lectures**
Unit-II	Three phase symmetrical induction machine : Application of reference frame theory to three phase symmetrical induction, dynamic direct and quadrature axis model in arbitrarily rotating reference frames.	**6 Lectures**
Unit-III	Three phase symmetrical salient pole synchronous machines : Application of reference frame theory to three phase synchronous machines, dynamic direct and quadrature axis model in arbitrarily rotating reference frames.	**6 Lectures**
Unit-IV	Determination of Synchronous Machine Dynamic Equivalent Circuit Parameters, Analysis and dynamic modeling of two phase asymmetrical induction machine and single phase induction machine.	**12 Lectures**
Unit-V	Special Machines : Permanent magnet synchronous machine: Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines, Construction and operating principle, dynamic modeling and self-controlled operation, Analysis of Switch Reluctance Motors.	**9 Lectures**

Recomended Books: Total **42** lectures

1. Charles Kingsley, Jr., A.E. Fitzgerald, Stephen D.Umans, 'Electric Machinery', Tata Mcgraw Hill, 5th Edition, 1992.
2. R. Krishnan, 'Electric Motor & Drives: Modeling, Analysis and Control', Prentice Hall of India, 2nd Edition, 2001.
3. Miller, T.J.E., 'Brushless Permanent Magnet and Reluctance Motor Drives', Clarendon Press, 1st Edition, 1989.
4. P. C. Kraus, "Analysis of Electric Machinery and Drive Systems", Second Edition, IEEE Press Power Engineering Series, Willey Interscience, New York.
5. Chee-MunOng, "Dynamic Simulation of Electric Machinery using Matlab/Simulink", Prentice Hall PTR, 1998.

EE 7012 Power Quality **(3-0-0: 3)**

Unit-I	Electric power quality phenomena : IEC and IEEE definitions , power quality disturbances , voltage fluctuations, transients, unbalance, waveform distortion, power frequency variations.	**8 Lectures**
Unit-II	Voltage variations : Voltage sags and short interruptions , flicker, longer duration variations , sources , range and impacton sensitive circuits-standards , solutions and mitigations , equipment and techniques.	**8 Lectures**
Unit-III	Transients : origin and classifications , capacitor switching transient , lightning, load switching , impact on users , protection , mitigation.	**9 Lectures**
Unit-IV	Harmonics : sources , definitions & standards , impacts , calculation and simulation, harmonic power flow , mitigation and control techniques , filtering , passive and active.	**8 Lectures**
Unit-V	Power Quality conditioners : shunt and series compensators , STATCOM , D-Statcom , Dynamic voltage restorer , unified power quality conditioners , case studies.	**9 Lectures**

Total **42** lectures

Recomended Books:

1. Heydt, G.T., 'Electric Power Quality', Stars in a Circle Publications, Indiana,2nd edition 1996.
2. Bollen, M.H.J., 'Understanding Power Quality Problems: Voltage sags and interruptions', IEEE Press, New York, 2000.
3. Arrillaga, J, Watson, N.R., Chen, S., 'Power System Quality Assessment', Wiley, New York, 2000.
4. Narain G. Hingorani, Laszlo Gyugyi, "Understanding FACTS: concepts and technology of flexible AC transmission systems", IEEE Press, New York, 2000.

EE 7013 Condition Monitoring of High Voltage Equipment **(3-0-0: 3)**

Unit-I	Preventive Maintenance: How Preventive Maintenance Helps, Purpose of Diagnostic Testing, Why Condition Monitoring, Causes of Insulation Degradation, Oil-Paper composite Insulation System.	**7** Lectures
Unit-II	Traditional Condition Assessment Techniques for Oil-Paper Composite Insulation: Dissolved Gas Analysis, Furan Analysis, Degree of Polymerization. Moisture in Oil-Paper Composite Insulation: Moisture Distribution, Moisture Dynamics, Effects of Moisture, Moisture Detection – Crackle Test, Karl Fischer Titration, Equilibrium Curves, Comparision of Equilibrium Curves, ABB and Serena's Equations, Moisture content in Paper, Moisture Management, Oil Reclamation.	**9** Lectures
Unit-III	Dielectric Response Measurement: Polarization Mechanisms in Dielectrics, Dielectric Response in Time-Domain. Polarization and Depolarization Current (PDC) Measurement, PDC Measurement – Test Set Up and Typical Results.	**9** Lectures
Unit-IV	Recovery Voltage Measurement (RVM). RVM fundamentals, Polarization Spectrum, Typical RVM Results. Frequency Domain Spectroscopy (FDS), FDS equipment and analysis.	**8** Lectures
Unit-V	Dielectric Response Function and Insulation Model: Mathematical Models of Dielectric Response, Oil conductivity, Paper Conductivity, Relating Oil and Paper. Conductivities with Insulation condition, Modelling of Recovery Voltage, Dielectric Response in Frequency Domain, Dissipation Factor, Identification of Equivalent Model parameters, Calculating RV from Equivalent Model, Calculating Dissipation Factor from Equivalent Model, Calculating Complex Capacitance from Equivalent Model.	**9** Lectures

Total **42** lectures

Recomended Books:

1. Condition monitoring and assessment of power transformers using computational intelligence. W.H. Tan g. Q.H. Wu. Springer, London , 2011.
2. Condition Assessment of High Voltage Insulation in Power system Equivalent by Author(s): R.E. James and Q. Su, 2008 IET Publication.
3. Recent trends in the condition Monitoring of Transformers by Chakravati, Dey and Chetterjee , Springer, 2013.
4. IEEE and ELSEVIER JOURNAL PAPERS.
5. Standards of IEEE, IEC, CIGRE and BIS.

EE 7014 High Voltage Equipment **(3-0-0: 3)**

Unit-I	High Voltage Power Transformer: Transformer insulation requirements. Dielectric Strength and voltage conditions, winding arrangements, surge behaviour, behaviour of liquid dielectric, electrode surface phenomena, gas evolution, processing techniques, construction of EHV transformer, short circuit behaviour.	**8** Lectures
Unit-II	Loading and Life of Transformer: Life of Transformer, aging of insulation, Significance of weighted value of ambient temperature, relationship between Weighted ambient, winding temperature rise and hot spot temperature, relationship between weighted ambient and load, transformer loading guide, selection and use of transformer. Testing of transformer: Testing of power transformer, impulse testing and partial discharge testing.	**10** Lectures
Unit-III	High Voltage Bushings: Types, non-condenser bushing, condenser bushing, bushing application for different equipments like, alternator, transformer, switchgear, wall bushing, design of bushing and testing procedures.	**8** Lectures
Unit-IV	High Voltage Circuit Breakers: Air break, SF6 and Vacuum circuit breakers.	**8** Lectures
Unit-V	Gas Insulated Substation (GIS): Advantages of GIS, comparison of GIS and air insulated substations, design and layout of GIS, description of various components of GIS.	**8** Lectures

Total **42** lectures

Recomended Books:

1. The J & P Transformer Book, 12thEdn, M J Heathcote, Newnes, 1998.
2. Transformer, Bharat Heavy Electricals Limited, Tata McGraw Hill, 2001. IEEE and ELSEVIER JOURNAL PAP ERS.

3. Blume, L.F., and BoyaJian, Transformer Engineering, John Wiley and sons, 1951.
4. Garzon, R.D., HV Circuit breakers – Design and applications, Marcel and Dekker NY, 1996.
5. Flurscheim, C.H., Power Circuit Breaker: Theory and Design, Peter Peregrinus Ltd., 1975
6. Ryan, H.M., and Jones G.R., SF6 circuit Breaker, Peter Peregrinus Ltd., 1969
7. GIS by Hermann Koch, Wiley Publications.

EE 7015 Power System Protection (3-0-0: 3)

Unit-I	Two and Multi-input protection relaying: Generalised theory, characteristics derived by 2-input and multi-input phase and amplitude comparators. Duality concept, multi-input comparator circuitry. Instantaneous amplitude comparators.	**8** Lectures
Unit-II	Distance relays: Principles of operation, zone discrimination, basic measuring elements, different characteristics used - their development through comparators, distance measurement problems, distance relay settings, requirement characteristics for different zones, performance characteristics, VA burden and relay accuracy, conic pick up and quadrilateral characteristic by multi input phase and amplitude comparators.	**10** Lectures
Unit-III	Polyphase distance relay: Basic idea, different phase comparison schemes. Wire pilot relaying: Introduction; summation devices and sequence networks, problems in pilot relaying, pilot wire protection characteristic, pilot supervision, characteristic of pilot circuits, practical design considerations, typical protection schemes.	**10** Lectures
Unit-IV	Carrier pilot Relaying: Mode of communication, coupling equipment, signalling equipment, mode of signal transmission, carrier aided distance protection, carrier phase comparison protection	**8** Lectures
Unit-V	Numerical relaying: Introduction, protection philosophy, basic hardware and protection schemes, protection algorithms, microprocessor application to protective relays.	**6** Lectures

Total **42** lectures

Recomended Books:

1. Warrington, A.R., and Von, C., Protective Relaying: Theory and Practical, Vol. II, Chapman and Hall, 1970
2. IEEE Tutorial Course on Microprocessor Relays and Protection system, Power Systems Research Group, University of Saskatchewan, 1979 and 1987.
3. Phadke, A.G., and Thorp, J., computer relaying for Power Systems, John Wiley, Inc. 1988.
4. IEEE Tutorial Course on Advancement in Microprocessor Based Protection and communication, 1997.
5. Technical papers from IEEE transaction, CIGRE, IEEE journals.
6. P.M. Anderson, power System Protection, Wiley, 1998.

EE 7016 Power Electronics Drives (3-0-0: 3)

Unit-I	Basic power electronic drive system : components, Different types of loads, shaft-load coupling systems, Stability of power electronic drive.	**6** Lectures
Unit-II	Conventional methods of DC motor speed control : single phase and three phase converter fed D.C motor drive, Power factor improvement techniques, four quadrant operation.	**10** Lectures
Unit-III	Chopper fed drives, input filter design, Step-up chopper for photovoltaic systems, Braking and speed reversal of DC motor drives using choppers, multiphase choppers.	**10** Lectures
Unit-IV	Conventional methods of induction motor speed control : Solid state controllers for Stator voltage control, soft starting of induction motors, Rotor side speed control of wound rotor induction motors, Voltage source and Current source inverter fed induction motor drives.	**10** Lectures
Unit-V	Speed control of synchronous motors: field oriented control, load commutated inverter drives, switched reluctance motors and permanent magnet motor drives.	**6** Lectures

Total **42** lectures

Recomended Books:

1. P.C Sen, Thyristor DC Drives, John wiely and sons, New York, 1981.
2. R.Krishnan, Electric Motor Drives – Modeling, Analysis and Control, Prentice-Hall of India Pvt Ltd., NewDelhi, 2003.
3. BimalK.Bose, Modern Power Electronics and AC Drives, Pearson Education (Singapore) Pte. Ltd., New Delhi, 2003.

EE 7017 System Theory **(3-0-0: 3)**

Unit-I	Introduction to state space modeling : modeling of physical systems, Solution to vector differential equations and state transition matrix.	**8** Lectures
Unit-II	Controllability and Observability : definitions and Kalman rank conditions, Detectability and Stabilizability, Kalman decomposition.	**8** Lectures
Unit-III	Introduction to nonlinear systems : Phase plane analysis of nonlinear system using linear approximation, Limit cycle and periodic solutions, Singular points (equilibrium points) and qualitative behavior near singular points.	**6** Lectures
Unit-IV	Stability of nonlinear systems : Lyapunov direct and indirect methods, Input to state stability, Various methods to check the stability of nonlinear systems.	**10** Lectures
Unit-V	State feedback controller design using pole placement: Observer design using Kalman filter algorithm, LQR and LQG controller design.	**10** Lectures

Total lecture **42**

Recomended Books:

1. Ogata, K., "Modern Control Engineering" , Prentice Hall of India, 1981.
2. C.T. Chen, 'Linear Systems Theory and Design" Oxford University Press, 3rd Edition, 1999.
3. M. Vidyasagar, "Nonlinear Systems Analysis", 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey 07632.
4. Hassan K. Khalil, Nonlinear Systems (3rd Edition), Pearson Educational International
5. Inc. Upper Saddle River, New Jersey 07458

EE 7018 Digital Instrumentation in Power System **(3-0-0: 3)**

Unit-I	Overview of A/D converter: types and characteristics, sampling, errors: building blocks of automation systems, counters, modes of operation- frequency, period, time interval measurements, pre-scaler, heterodyne converter for frequency measurement, single and multi-channel data acquisition systems.	**8** Lectures
Unit-II	Data transmission systems, 8086 microprocessor based system design, peripheral interfaces, time division multiplexing (TDM), digital modulation, pulse modulation, pulse code format, interface systems and standards, communications.	**9** Lectures
Unit-III	Instrumentation bus, modem standards, basic requirements of instrument bus standards, bus communication, interrupt and data handshaking, interoperability, interchangeability for RS- 232, USB, RS-422, RS-485.	**8** Lectures
Unit-IV	Virtual instrumentation: block diagram and architecture, data flow techniques, graphical programming using GUI, real time embedded system, intelligent controller, software and hardware simulation of I/O communication blocks, peripheral interface, ADC/DAC, digital I/O, counter, timer.	**8** Lectures
Unit-V	PC based DAS, SCADA, Data loggers, PC based industrial process measurements like flow, temperature, pressure and level development system, CRT interface and controller with monochrome and colour video display.	**9** Lectures

Total lecture **42**

Recomended Books:

1. Ogata, K. "Modern Control Engineering" , Prentice Hall of India, 1981.
1. A. J. Bouwens, "Digital Instrumentation", TATA McGraw-Hill Edition, 1998.
2. N. Mathivanan, "Microprocessors, PC Hardware and Interfacing", Prentice-Hall India, 2005.
3. H. S. Kalsi, "Electronic Instrumentation", Second Edition, Tata McGraw-Hill,2006.
4. Joseph J. Carr, "Elements of Electronic Instrumentation and Measurement", Third Edition, Pearson Education, 2003.
5. Buchanan, "Computer busses", Arnold, London, 2000.
6. Jonathan W. Valvano, "Embedded Microcomputer systems", Asia Pvt. Ltd., Brooks/Cole, Thomson, 2001.

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY

SYLLABI
OF
PG / Ph. D. COURSES
(DEPARTMENT: ELECTRONICS & COMMUNICATION ENGINEERING)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY
(UNDER THE MINISTRY OF EDUCATION, GOVT. OF INDIA)
DEEMED TO BE UNIVERSITY U/S 3 OF THE UGC ACT, 1956
NIRJULI - 791 109 :: ARUNACHAL PRADESH

SYLLABI
OF
PG/ Ph. D COURSES

(DEPARTMENT: ELECTRONICS & COMMUNICATION ENGINEERING)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY (NERIST)

(Deemed to be University, U/S 3 Of the UGC Act, 1956)
Nirjuli (Itanagar), Arunachal Pradesh- 791 109

NERIST, Nirjuli, Arunachal Pradesh

MTECH ECE (with Specialization in VLSI and Communication) SYLLABUS

SEMESTER I

Course Code	Names of Subjects	L	T	P	C
MA-7102	LINEAR ALGEBRA	3	1	0	4
EC-7100	MODERN DIGITAL COMMUNICATION TECHNIQUES	3	1	0	4
EC-7101	SEMICONDUCTOR DEVICE MODELLING	3	1	0	4
EC-70xx	1st Elective-A **(FOR COMM. STUDENTS)** 1st Elective-B **(FOR VLSI STUDENTS)**	3	0	0	3
EC-70xx	2nd Elective-A **(FOR COMM. STUDENTS)** 2nd Elective-B **(FOR VLSI STUDENTS)**	3	0	0	3
EC-7155	COMMUNICATION ENGINEERING LABORATORY **(FOR COMM. STUDENTS)**	0	0	6	3
EC-7156	Analog and Digital Circuit Simulation Lab **(FOR VLSI STUDENTS)**	0	0	6	3
				TOTAL	**21**

SEMESTER II

Course Code	Names of Subjects	L	T	P	C
EC-7200	WIRELESS COMMUNICATION	3	1	0	4
EC-7201	CMOS MIXED SIGNAL CIRCUITS	3	1	0	4
EC-70xx	3rd Elective-A **(FOR COMM. STUDENTS)** 3rd Elective-B **(FOR VLSI STUDENTS)**	3	0	0	3
EC-70xx	4th Elective-A **(FOR COMM. STUDENTS)** 5th Elective-B **(FOR VLSI STUDENTS)**	3	0	0	3
EC-70xx	Elective-C	3	0	0	3
EC-7255	RF LABORATORY **(FOR COMM. STUDENTS)**	0	0	6	3
EC-7256	Circuit Simulation and FPGA Lab **(FOR VLSI STUDENTS)**	0	0	6	3
EC-7299	Seminar	0	0	6	3
				TOTAL	**23**

SEMESTER III

Course Code	Names of Subjects	L	T	P	C
EC-8199	Project Part I	0	0	16	8
				TOTAL	**8**

SEMESTER IV

Course Code	Names of Subjects	L	T	P	C
EC-8299	Project Part II	0	0	32	16
				TOTAL	**16**
				TOTAL CERDITS	**68**

LIST OF ELECTIVES

ELECTIVES A (FOR COMM. STUDENTS)

No.	Names of Subjects	L	T	P	C
EC 7001	DIGITAL AUDIO AND VIDEO COMMUNICATION	3	0	0	3
EC 7002	TELECOMMUNICATION SWITCHING AND NETWORKS	3	0	0	3
EC 7003	MOBILE COMMUNICATION	3	0	0	3
EC 7004	RF INTEGRATED CIRCUITS	3	0	0	3
EC 7005	MICROWAVE DEVICES AND CIRCUITS	3	0	0	3
EC 7006	INFORMATION THEORY AND CODING TECHNIQUES	3	0	0	3
EC 7007	COMPUTER COMMUNICATION NETWORKS	3	0	0	3
EC 7008	OPTICAL COMMUNICATION	3	0	0	3
EC 7009	SATELLITE COMMUNICATION SYSTEM	3	0	0	3
EC 7010	RF COMPONENT AND CIRCUIT DESIGN	3	0	0	3
EC 7011	RADAR SIGNAL PROCESSING	3	0	0	3
EC 7012	ANTENNAS AND PROPAGATION FOR WIRELESS COMMUNICATION	3	0	0	3
EC 7013	ADVANCED NETWORKS TECHNOLOGIES	3	0	0	3
EC 7014	ERROR CONTROL TECHNIQUE	3	0	0	3
EC 7015	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	3	0	0	3
EC 7016	CHANNEL MODELLING FOR WIRELESS COMMUNICATION	3	0	0	3
EC 7017	HIGH SPEED COMMUNICATION TECHNIQUES	3	0	0	3
EC 7018	SIGNAL PROCESSING FOR COMMUNICATION	3	0	0	3
EC 7019	ADVANCED DIGITAL SIGNAL PROCESSING	3	0	0	3

ELECTIVES B (FOR VLSI STUDENTS)

No.	Names of Subjects	L	T	P	C
EC 7030	VLSI TECHNOLOGY	3	0	0	3
EC 7031	CMOS ANALOG IC DESIGN	3	0	0	3
EC 7032	LOW POWER VLSI DESIGN	3	0	0	3
EC 7034	DIGITAL IC DESIGN	3	0	0	3
EC 7035	CAD FOR VLSI	3	0	0	3
EC 7036	DESIGN OF SEMICONDUCTOR MEMORIES	3	0	0	3
EC 7037	MEMS AND MICROSYSTEMS TECHNOLOGY	3	0	0	3
EC 7038	ADVANCED COMPUTER ARCHITECTURE	3	0	0	3
EC 7039	ANALOG FILTER DESIGN	3	0	0	3
EC 7040	VLSI SIGNAL PROCESSING	3	0	0	3
EC 7041	VLSI DATA CONVERSION CIRCUIT	3	0	0	3
EC 7042	TESTING AND VERIFICATION OF VLSI CIRCUITS	3	0	0	3
EC 7043	DIGITAL SYSTEM DESIGN USING FPGA	3	0	0	3
EC 7044	PHOTONICS INTEGRATED CIRCUITS	3	0	0	3

ELECTIVES C (Common Electives)

No.	Names of Subjects	L	T	P	C
EC 7060	NANOELECTRONICS	3	0	0	3
EC 7061	NEURAL NETWORKS, ARCHI TECTURE AND ITS APPLICATIONS	3	0	0	3
EC 7062	ADAPTIVE SIGNAL PROCESSING	3	0	0	3
EC 7063	SOFT COMPUTING	3	0	0	3
EC 7064	STATISTICAL SIGNAL PROCESSING AND MODELLING	3	0	0	3
EC 7065	INTELLIGENT INSTRUMENTATION	3	0	0	3
EC 7066	DIGITAL IMAGE PROCESSI NG	3	0	0	3
EC 7067	SPEECH PROCESSING	3	0	0	3
EC 7068	MODERN CONTROL ENGG	3	0	0	3
EC 7069	BIOMEDICAL SIGNAL PROCESSING	3	0	0	3
EC 7070	EMBEDDED SYSTEM DESIGN	3	0	0	3
EC 7071	BIO-SENSORS AND BIO MEMS	3	0	0	3
EC 7072	CONVEX OPTIMIZATION	3	0	0	3

MA-7102	LINEAR ALGEBRA	3-1-0	4
Unit I	Review of Vector spaces, bases & dimension, dual space, quotient space.	7	Hrs
Unit II	Linear Transformations: Linear transformations, representation of Linear transformations by matrices, Eigen values and eigen vectors, invariant subspaces, annihilating polynomials, triangulation and diagonalization.	9	Hrs
Unit III	The Primary Decomposition theorem, rational and Jordan Canonical forms. inner product spaces, orthonormal bases, Gram-Schmidt orthogonalization process.	14	Hrs
Unit IV	Linear functionals, adjoint, self adjoint, normal and unitary operators, spectral theorem for normal operators, Bilinear forms, Quadratic forms	10	Hrs

Recommended Books :

1. K. Hoffman and R. Kunze, Linear Algebra, PHI, 1996.
2. G.C. Cullen, Linear Algebra with Applications, Addison Wesley 1997.
3. S. Axler, Linear Algebra Done Right, UTM, Springer 1997.
4. G. Williams, Linear Algebra with Applications, Jones and Burlet Publishers,2001.
5. P. R. Halmos, Finite dimensional vector spaces, Springer Verlag, New York, 1987.

EC-7100	MODERN DIGITAL COMMUNICATION TECHNIQUES	3-1-0	4
Unit I	Analog-to-Digital Conversion: Sampling theorem, Pulse-Amplitude Modulation, Channel bandwidth for PAM signal, Natural sampling, Flat top sampling, Quantization of signals, Quantization error, Pulse-code modulation (PCM), Electrical representation of binary digits, The PCM system, Companding, Multiplexing PCM signals, Differential PCM, Delta modulation, Adaptive delta modulation, Vocoders, Channel Vocoder, Linear Predictive coder.	8	Hrs
Unit II	Digital Modulation Techniques: Binary Phase-Shift Keying (BPSK), Differential Phase-Shift Keying, Differentially-Encoded PSK (DEPSK), Quadrature Phase-Shift Keying (QPSK), Quadrature Amplitude Shift Keying (QASK), Binary Frequency-Shift Keying (BFSK), Similarity of BPSK and BFSK, M-ary FSK, Minimum Shift Keying (MSK).	12	Hrs
Unit III	Data Transmission: A base band signal receiver, Probability of error, The Optimum Filter, Matched Filter, Probability of error in Matched filter, Coherent reception, Coherent reception of PSK and FSK, Non-Coherent reception of FSK, PSK and QPSK, Calculation of error probability of BPSK and BFSK, Error probability for QPSK] Bit-by-bit encoding versus Symbol-by-Symbol encoding, Relationship between Bit error rate and Symbol Error rate and comparison of modulation systems.	12	Hrs
Unit IV	Information Theory and Coding: Discrete messages, The concept of amount of information, Entropy, Information rate, Coding to increase average information per bit, Shannon's theorem, Capacity of a Gaussian channel, Bandwidth-S/N tradeoff, use of orthogonal signals to attain Shannon's limit, Efficiency of orthogonal signal transmission, Coding: Parity check bit coding for error detection, Coding for error detection and error correction, Block codes (coding and decoding), Convolution codes (coding and decoding), Comparison of error rates in coded and uncoded transmission.	10	Hrs

Recommended Books:

1. Wayne Tomasi, "Electronic communications systems" 5th edition Pearson Educaion Asia, 2006
2. Taub and Schilling, "Principles of Communication Systems", TMH, IInd Edition, 2006
3. S. Haykin, "Digital Communication", Wiley, 2006.
4. S. Haykin, "Analog and Digital Communication", Wiley.

EC-7101	SEMICONDUCTOR DEVICE MODELLING	3-1-0	4
Unit I	Concentration and motion of carriers in Semiconductor bulk - Equilibrium concentration in intrinsic and extrinsic semiconductors, Excess carriers, Drift and Diffusion transport, continuity equation. Concentration and motion of carriers at the interface-Surface recombination, surface mobility etc	7	Hrs
Unit II	Device Modeling-Basic equations for device analysis, approximation to these equations for deriving analytical expressions	9	Hrs
Unit III	PN Homojunction- ideal static I-V characteristics and deviations including breakdown, ac small signal equivalent circuit, switching characteristics. MIS Junction/capacitor-ideal C-V characteristics and deviations due to interface states/charges and work function differences, threshold voltage.	14	Hrs
Unit IV	BJT-Transistor action, Static Characteristics, ac small signal equivalent circuit, switching characteristics. FETs-Field effect, types of transistors (JFET, MESFET, MISFET, MOSFET), Static characteristics of MISFET and MOSFET, small signal equivalent circuit, difference between BJT and FETS.	10	Hrs

Recommended Books :

1. Physics of Semiconductor Devices, Simon M. Sze and Kwok K. Ng,2006
2. E.S. Yang, Microelectronic Devices, McGraw Hill, Singapore, 1988.
3. B.G. Streetman, Solid State Electronic Devices, Prentice Hall of India, New Delhi,
4. Semiconductor Device Modeling, Giuseppe Massobrio and Paolo Antognetti

EC-7200	WIRELESS COMMUNICATION	3-1-0	4
Unit I	Introduction to Wireless Communication System s – evolution of mobile radio communications, mobile radio systems around the world, radio communication systems – paging systems, cordless telephone systems, cellular telephone systems; comparison of common wireless communications, trends in cellular radio and personal communication, second generation (2G) cellular networks, third generation (3G) wireless networks, Introduction to 4G, introduction to radio wave propagation, free space propagation model.	10	Hrs
Unit II	Basics of mobile communication– Limitations of conventional mobile system, mobile cellular communication – introduction, concept of frequency reuse, cluster size, cellular system architecture – mobile station, base stati on, MSC, channel assignment strategies, call handover strategies, interference and system capacity, improving capacity in cellular systems – cell splitting, sectoring, repeaters, microcell, zone concept.	10	Hrs
Unit III	Global sy stem for mobile communication, GSM services and features, system architecture, GSM radio subsystem, GSM channel types, location updating and call setup, introduction to CDMA digital cellular standard, comparison between GSM and CDMA	12	Hrs
Unit IV	Wireless networking – wireless local area network standards, technology – RF and IR wireless IT – LAN, diffuse, quasi -diffuse and point-to-point IR wireless LAN, advantages and applications of Wireless LAN, introduction to WI -FI, Bluetooth	10	Hrs

Recommended Books:

1. Wireless communication principles and practice, 2nd Ed, Theodore S Rapaport, Pearson Education.
2. Wireless communication, 1st Edition, Andrea Goldsmith, Cambridge
3. Fundamentals of Wireless Communication, 1st Edition by David Tse, Cambridge

EC-7201	CMOS MIXED SIGNAL CIRCUITS	3-1-0	4
Unit I	Analog and discrete -time signal processing, Analog integrated continuous -time and discrete -time (switched -capacitor) filters	9	Hrs
Unit II	Basics of Digital to analog converters (DAC). DACs. Voltage, current, and charge scaling DACs, Cyclic DAC, Pipeline DAC.	7	Hrs
Unit III	Basics of Analog to digital converters (ADC). Successive approximation ADCs. Dual slope ADCs. High -speed ADCs (e.g. flash ADC, pipeline ADC and related architectures).High -resolution ADCs (e.g. delta -sigma converters)	14	Hrs
Unit IV	Mixed-Signal layout. Interconnects. Phase locked loops, Delay locked loops and their applications.	10	Hrs

Recommended Books:

1. CMOS mixed-signal circuit design by R. Jacob Baker Wiley India, IEEE press, reprint 2008.
2. CMOS circuit design, layout and simulation by R. Jacob Baker Revised second edition, IEEE press, 2008.
3. Design of analog CMOS integrated circuits by Behad Razavi McGraw-Hill, 2003.

ELECTIVES A (FOR COMM. STUDENTS)

EC 7001	DIGITAL AUDIO AND VIDEO COMMUNICATION	3-0-0	3
Unit I	Introduction, Speech production model, speech coding, Quantizers for speech signal, mew-law and optimum Quantizer, Adaptive quantizer, Differential quantization, LDM and ADM, DPCM and Adaptive prediction, linear prediction of speech	6	Hrs
Unit II	CCITT recommendations for speech digitization, HDTV, Low resolution TV and videoconferencing requirements	8	Hrs
Unit III	Frequency domain waveform coding of speech-LTC, ATC; Parameter coding of speech channel, format and LPC vecoders	10	Hrs
Unit IV	Coding of monochrome and colour video signals-Transform and Adaptive transform coding; Sub band coding; Vector quantization; Inter -frame and Hybrid coding; Delayed decision and run length coding	8	Hrs
Unit V	Effects of transmission errors; Audio and Video conference; Video telephone	10	Hrs

Recommended Books:

1. Digital processing of speech signals by Rabiner L.R., Prentice Hall
2. Principles of Computer Speech by I.H. Witten
3. Digital speech : Coding for Low Bit Rate Communication System by A.M.Kondoz, Willey, 2nd ed.
4. Voice and Data Communication handbook by R.J.Bates, McGrow Hill
5. A practical handbook of Speech Coder by R.Goldberg and L.Rick, CRC Pr

EC 7002	TELECOMMUNICATION SWITCHING AND NETWORKS	3-0-0 3
Unit I	Multiplexing: Transmission Systems, FDM Multiplexing and modulation, Time Division Multiplexing, Digital Transmission and Multiplexing: Pulse Transmission, Line Coding, Binary N – Zero Substitution, Digital Biphase, Differential Encoding, Time Division Multiplexing, Time Division Multiplex Loops and Rings	6 Hrs
Unit II	SONET/SDH: SONET Multiplexing Overview, SONET Frame Formats SONET Operations, Administration and Maintenance, Payload Framing and Frequency Justification, Virtual Tributaries, DS3 Payload Mapping, E4 Payload Mapping, SONET Optical Standards, SONET Networks. SONET Rings: Unidirectional Path-Switching Ring, Bidirectional Line-Switched Ring	8 Hrs
Unit III	Digital Switching: Switching Functions, Space Division Switching, Time Division Switching, two-dimensional switching: STS Switching, TST Switching, No.4 ESS Toll Switch, Digital Gross-Connect Systems, and Digital Switching in an Analog Environment. Elements of SSNO7 Signaling	10 Hrs
Unit IV	Network Synchronization Control and Management Timing: Timing Recovery: Phase-Locked Loop, Clock Instability, Jitter Measurements, Systematic Jitter. Timing Inaccuracies: Slips, Asynchronous Multiplexing, Network Synchronization, U.S. Network Synchronization, Network Control, Network Management	8 Hrs
Unit V	Digital Subscriber Access and traffic analysis, ISDN: ISDN Basic Rate Access Architecture, ISDN U Interface, ISDN D Channel Protocol. High-Data-Rate Digital Subscriber Loops: Asymmetric Digital Subscriber Line, VDSL. Digital Loop Carrier Systems: Universal Digital Loop Carrier Systems, Integrated Digital Loop Carrier Systems, Next-Generation Digital Loop Carrier, Fiber in the Loop, Hybrid Fiber Coax Systems, and Voice band Modems: PCM Modems, Local microwave Distribution Service, Digital Satellite Services. Traffic Characterization: Arrival Distributions, Holding Time Distributions, Loss Systems, And Network Blocking Probabilities: End-to-End Blocking Probabilities, Overflow Traffic, And Delay Systems: Exponential Service Times, Constant Service Times, Finite Queues.	10 Hrs

Recommended Books:

1. Bellamy John, "Digital Telephony", John Wily & Sons, Inc. 3rd ed. 2000
2. Viswanathan. T., "Telecommunication Switching System and Networks", PHI 1994
3. Robert G. Winch, "Telecommunication transmission systems", 2nd ed. TMH 2004
4. Marion Cole, "Intro. to Telecommunications" 2nd ed. Pearson education 2008.
5. Tom Sheldon, "Encyclopedia of Networking and telecom." TMH seventh reprint 2006

EC 7003	MOBILE COMMUNICATION	3-0-0 3
Unit I	Introduction to Cellular Mobile Systems: A basic cellular system, performance criteria, uniqueness of mobile radio environment, operation of cellular systems, planning a cellular system, overview of generations of cellular systems. Elements of Cellular Radio Systems Design and interference: General description of the problem, concept of frequency reuse channels, co-channel interference reduction factor, desired C/I from a normal case in an omni directional antenna system, cell splitting, consideration of the components of cellular systems. Introduction to co-channel interference, co-channel measurement design of antenna system, antenna parameter and their effects	10 Hrs

Unit II	Cell Coverage for Signal & antenna structures: General introduction, obtaining the mobile point to point mode, propagation over water or flat open area, foliage loss, propagation near in distance, long distance propagation, point to point prediction model- characteristics, cell site, antenna heights and signal coverage cells, mobile to mobile propagation. Characteristics of basic antenna structures, antenna at cell site, mobile antennas. Frequency Management & Channel Assignment, Hand Off & Dropped Calls: Frequency management, fixed channel assignment, non-fixed channel assignment, traffic & channel assignment. Why hand off, types of handoff and their characteristics, dropped call rates & their evaluation.	10 Hrs
Unit III	Modulation methods and coding for error detection and correction: Introduction to Digital modulation techniques, modulation methods in cellular wireless systems, OFDM. Block coding, convolution coding and Turbo coding. Multiple access techniques: FDMA, TDMA, CDMA; Time-division multiple access (TDMA), code division multiple access (CDMA), CDMA capacity, probability of bit error considerations, CDMA compared with TDMA	12 Hrs
Unit IV	Second generation, digital, wireless systems, GSM, IS_136 (D-AMPS), IS-95, mobile management, voice signal processing and coding.	10 Hrs

Recommended Books:

1. Mobile Cellular Telecommunications; 2nd ed.; William, C Y Lee McGraw Hill
2. Mobile wireless communications; Mischa Schwartz, Cambridge University press, UK, 2005
3. Mobile Communication Hand Book; 2nd Ed.; IEEE Press
4. Wireless communication principles and practice, 2nd Ed, Theodore S rappaport, Pearson Education.
5. 3G wireless Demystified; Lawrence Harte, Mc. Graw Hill pub.

EC 7004 RF INTEGRATED CIRCUITS 3-0-0 3

Unit I	RF Filter design: Basic resonator and filter configurations-special filter realization-filter implementation-coupled filter	10 Hrs
Unit II	Active RF Components: RF diodes-bipolar junction transistor –RF field effect transistor-high electron mobility transistors-diode models-transistor models-measurement of active devices-scattering parameter device characterization.	8 Hrs
Unit III	Matching and biasing networks: Impedance matching using discrete components-micro strip line matching networks-amplifier classes of operation and biasing networks	14 Hrs
Unit IV	RF Transistor amplifier design: Characteristics of amplifier-amplifier power relations-stability consideration-constant gain-broadband, high power, and multistage amplifiers, Oscillators and mixers: Basic oscillator model-high frequency oscillator configuration-basic characteristics of mixer	10 Hrs

Recommended Books:

1. Reinhold Ludwig, "RF circuit design, theory and applications" Pavel Bretchko, "Pearson Asia Education", edition 2001
2. D.Pozar, "Microwave Engineering", John Wiley & Sons, New York, 1998
3. Bahil and P. Bhartia, "Microwave Solid State Circuit Design, John Willey & Sons, New York,

EC 7005	MICROWAVE DEVICES AND CIRCUITS	3-0-0 3
Unit I	Microwave frequencies, Interactions between electrons and fields, Electromagnetic plane waves, Electric and magnetic wave equations, Poynting theorem, Uniform plane waves and reflection, Plane wave propagation in free space and lossless dielectric, Plane wave propagation in lossy media, Plane wave propagation in metallic film coating on plastic substrate	10 Hrs
Unit II	Transmission line equations and solutions, Reflection coefficient and transmission coefficient, Standing wave and standing wave ratio, Line impedance and admittance, Smith chart, Microwave waveguides and components, Rectangular waveguides, Microwave cavities, Directional couplers, Circulators and isolators, Microwave transistors and tunnel diodes, Microwave bipolar transistors, Heterojunction transistors, Microwave tunnel diodes, Microwave field effect transistors, Junction field effect transistors, Metal semiconductor field effect transistors	10 Hrs
Unit III	Transferred electron devices, Gunn – effect diodes – GaAs diode, Ridley-watkins-Hilsum (RWH) theory, Modes of operation, LSA diodes, InP diodes, Avalanche transit time devices, Read diode, IMPATT diode, TRAPATT diodes, BARITT diodes, Microwave linear beam tubes (O Type), Conventional vacuum triodes, , Tetrodes and pentodes, klystrons, Multicavity klystron amplifiers, Reflex klystrons, Helix traveling wave tubes (TWT), Coupled cavity traveling wave tubes, Microwave crossed filed tubes (M Type), Magnetron oscillators, Forward wave crossed field amplifier (FWCFA OR CFA)	12 Hrs
Unit IV	Strip lines, Microstrip lines, Parallel strip lines, Coplanar strip lines, Shielded strip lines, Monolithic microwave integrated circuits, Materials, Monolithic microwave integrated circuit growth, MOSFET fabrication.	10 Hrs

Recommended Books:

1. Samuel Y.Liao, " Microwave Devices and Circuits" Third edition,PHI
2. SK Roy, M Mitra, "Microwave semiconductor devices", PHI 2003
3. David M. Pozar, "Microwave Engineering" Wiley

EC 7006	INFORMATION THEORY AND CODING TECHNIQUES	3-0-0 3
Unit I	Definitions, Uniquely Decodable Codes, Instantaneous Codes, Krafts Inequality, McMillan's Inequality, Optimal Codes, Binary Huffman Codes, r-ary Huffman codes, Information and Entropy, Properties of Entropy Function, Entropy and Average Word -Length, Shannon-Fano Coding, Shannon's First Theorem, Information Channels, Binary Symmetric Channel, System Entropies, System Entropies for Binary Symmetric Channel, Extension of Shannon's First Theorem to Information Channels, Mutual Information, Mutual Information for the Binary SymmetricChannel,HammingDistance,Shannon'sSecond (Fundamental) Theorem, Converse of Shannon's Theorems.	10 Hrs
Unit II	Review: Algebra, Krawtchouk Polynomials, Combinatorial Theory, Probability Theory. Linear Codes: Block Codes, Linear Codes, Hamming Codes, Majority Logic Coding, Weight Enumerators, The Lee Metric, Hadamard Codes, Golay Codes (Binary and Ternary), Reed Muller Codes, And Kerdock Codes.Bounds on Codes: Gilbert Bound, Upper Bound, Linear Programming Bounds, Hamming's Sphere –Packing Bound, Gilbert Varshamov Bound, Hadamard Matrices and Codes	10 Hrs
Unit III	Cyclic Codes: Generator Matrix, Check polynomial, Zeros of Cyclic	12 Hrs

Gilbert Varshamov Bound, Hadamard Matrices and Codes

Unit III	Cyclic Codes: Generator Matrix, Check polynomial, Zeros of Cyclic Codes, BCH Codes, Reed-Solomon Codes, Quadratic Residue Codes, Generalized Reed-Muller Codes. Perfect Codes and Uniformly Packed Codes: Lloyd's Theorem, Characteristic Polynomial of a Code, Uniformly Packed Codes, Nonexistence Theorems	12 Hrs
Unit IV	Quaternary Codes, Binary Codes Derived from codes over Z4, Galois Rings over Z4, Cyclic Codes over Z4. Goppa Codes. Algebraic Curves, Divisors, Differentials on a Curve, Riemann – Roch Theorem, Codes from Algebraic Curves. Arithmetic Codes: AN Codes, Mandelbaum – Barrows Codes, Convolutional Codes	10 Hrs

Recommended Books:

1. G.A. Jones and J. M. Jones, "Information and Coding Theory", Springer, 2000.
2. J. H. van Lint, "Introduction to Coding Theory", Springer, 1999.
3. Cover Thomas, "Elements of Information Theory", and Wiley 2006.
4. R. W. Hamming, "Coding and Information Theory", Prentice Hall, 1986.
5. T. M. Cover and J. A. Thomas, "Elements of Information Theory", Wiley, 1991.
6. R. E. Blahut, "Principles and Practice of Information Theory," AWL, 1987.

EC 7007	COMPUTER COMMUNICATION NETWORKS	3-0-0 3
Unit I	Concept of CCN/DCN, characteristics of data – Users' sub-network, topological design etc. Accessing techniques, Data Modeling – M/M/1 analysis, Circuit switching, message switching,	10 Hrs
Unit II	Packet switching, and ATM cell swi tching, Protocols, ISO, OSI, Networking objectives, classification of networks – LAN, MAN, WAN, ISDN	8 Hrs
Unit III	Techniques and theories of CSMA/CD Bus, Token Ring, Token passing bus- throughput analysis, Modeling (Stalling Models, IEEE Model etc.)	14 Hrs
Unit IV	Introduction to wireless networks, GSM, TDMA & CDMA -design and analysis, PCS concepts, Network operation and maintenance, Network Delay analysis, Routing, Flow Control, Congestion Control	10 Hrs

Recommended Books :

1. Behrouz A. Forouzan, "TCP/IP Protocol Suit", TMH, 2000
2. Wayne Tomasi, "Introduction to Data communications and Networking", Pearson Ed. 2007
3. Tananbaum A. S., "Computer Networks", 3rd Ed., PHI, 1999
4. Black U, "Computer Networks-Protocols, Standards and Interfaces", PHI, 1996
5. Stallings W., "Data and Computer Communications", 6th Ed., PHI, 2002.
6. Stallings W., "SNMP, SNMPv2, SNMPv3, RMON 1 & 2", 3rd Ed., Addison Wesley, 1999
7. Laurra Chappell (Ed), "Introduction to Cisco Router Configuration", Techmedia

EC 7008	OPTICAL COMMUNICATION	3-0-0 3
Unit I	Introduction: concepts of information, general communication systems, evolution of optical fiber communication systems, advantages, disadvantage of optical fiber, communication systems. Wave propagation in dielectric waveguide: snell's law, internal reflec tion, dielectric slab wave guide, numerical aperture, propagation of model & rays. Step-index fibers, graded index fibers.	8 Hrs
Unit II	Attenuation in optics fibers: Fiber attenuation, connectors &splices, bending loses, Absorption, scattering, very low loss materials, plastic & polymer-clad-silica fibers. Wave propagation in fibers: wave propagation in step index & graded index fiber, fiber dispersion, single mode fibers, multimode fibers, dispersion shifted fiber, dispersion flattened fiber, polarization	10 Hrs

polarization

Unit III	Optical sources & detectors: principles of light emitting diodes (LED's) , design of LED's for optical fiber communications, semiconductor LASER for optical fiber communication system ,principles of semiconductor photodiode detectors, PIN photodiode, Avalanche photodiode detectors. Optical fiber communication system: telecommunication, local distribution series, computer networks local data transmission & telemetry, digital optical fiber communication system, first & second generation system, future system.	14 Hrs
Unit IV	Advanced multiplexing strategies: Optical TDM, subscriber multiplexing (SCM), WDM. Optical networking: data communication networks, network topologies, MAC protocols, Network Architecture-SONET/TDH, optical transport network, optical access network, optical premise network.	10 Hrs

Recommended Books:

1. Senior J., optical fiber communications, principles & practice, PHI.
2. Keiser G., optical fiber communications, McGraw-hill.
3. Gowar J., optical communication systems, PHI.
4. William B. Jones jr., Introduction to optical fiber communication systems, Holt, Rinehart and Winston, Inc

EC 7009 SATELLITE COMMUNICATION SYSTEM 3-0-0 3

Unit I	Introduction: Origin and brief history of satellite communications, an overview of satellite system engineering, satellite frequency bands for communication. Orbital theory:Orbital mechanics, locating the satellite in the orbit w.r.t. earth look angle determination. Azimuth & elevation calculations.	10 Hrs
Unit II	Spacecraft systems: Attitude and orbit control system, telemetry, tracking and command (TT&C), communications subsystems, transponders, spacecraft antennas. Satellite link design: Basic transmission theory, noise figure and noise temperature, C/N ratio, satellite down link design, satellite uplink design	10 Hrs
Unit III	Modulation, Multiplexing, Multiple access Techniques: Analog telephone transmission, Fm theory, FM Detector theory, analog TV transmission, S/N ratio Calculation for satellite TV linking, Digital transmission, base band and band pass transmission of digital data, BPSK, QPSK , FDM, TDM, Access techniques: FDMA, TDMA, CDMA	14 Hrs
Unit IV	Encoding & FEC for Digital satellite links: Channel capacity, error detection coding, linear block, binary cyclic codes, and convolution codes. Satellite Systems: Satellite Earth station Technology, satellite mobile communication, VSAT technology, Direct Broadcast by satellite (DBS)	8 Hrs

Recommended Books:

1. Timothy Pratt, Charles W. Bostian, "Satellite communication", John Wiley &sons , Publication, 2003
2. J.J. Spilker, "Digital Communication by satellite, PHI Publication, 1997
3. J. Martin, "Communication satellite systems", PHI publication, 2001

EC 7010	RF COMPONENT AND CIRCUIT DESIGN	3-0-0	3
Unit I	Transmission lines, Broadband Matching, Scattering Parameters, microwave transistors	10	Hrs
Unit II	Passive Components: Inductors, Inductor Model, Analytical model, Printed Inductors, Inductors on Si substrate and GaAs substrate. Thick film inductors,Thin film inductors, LTCC inductors. Wire Inductors. Capacitors, Monolithic capacitors, interdigital capacitors. Resistors, chip resistor ,MCM resistor, Monolithic resistors, Microwave Resonators and Narrowband Filters, Broadband Filters Microwave Amplifier Design: Two-Port Power Gains, Amplifier Stability Low Noise Amplifier Design,Broadband Amplifier Design	8	Hrs
Unit III	Microwave Amplifier Design: Two -Port Power Gains, Amplifier Stability Low Noise Amplifier Design,Broadband Amplifier Design	14	Hrs
Unit IV	Microwave Oscillators: One Port negative resistance oscillators, Two Port negative resistance oscillators, Oscillator configurations	10	Hrs

Recommended Books :

1. Lumped Elements for RF and Microwave Circuits " I. J. Bahl ,Artech House
2. Microwave Transistor Amplifier: Analysis and Design, Gonzalez G. Prentice Hall 1984.
3. Microwave Semiconductor Circuit Design, Davis W. Alan, Van NostrandReinhold, 1984.
4. Microwave Circuit Analysis and Amplifier Design, Samuel Y. Liao, Prentice Hall 1987.
5. High Frequency Amplifier, Ralph S. Carson, Wiley Interscience, 1982

EC 7011	RADAR SIGNAL PROCESSING	3-0-0	3
Unit I	Introduction: Classification of Radars based on functions, principles of operation etc., performance me asures and interplay between Radar parameters, Target parameters and Environment parameters. Classical Detection and Estimation Theory, Binary Hypotheses Testing, Likelyhood Ratio Test, Neymon square,MAP, Maximum Likelihood Estimation of parameters, Cramer-Rao Bounds,Chemoof Bounds	10	Hrs
Unit II	Representation of Signals, K-L expansion, Equivalent Low-pass representation of Band pass signals and noise. Detection of Slowly Fluctuating point Targets in white noise and coloured noise. Swerling Target models. Optimum receivers. Correlator and Band pass M atohed Filter Receivers. PD – PF performance;Coherent and non-coherent Integration sub-optimum Reception. Radar Power –Aperture product.	10	Hrs
Unit III	Range and Doppler Resolution: Ambiguity function and its properties. Local and Global Accuracy. Signal Design. LFM. Polyphase coded signals Detection of a Doppler shifted slowly fluctuating point target return in a discrete scatterer environment. Dobly dispersive Fading Target and Clutter models-Scattering function description. Land clutter -pulse length limited and Beam width limited clutter. Sea clutter.	14	Hrs
Unit IV	Optimum / Sub optimum reception of Range Spread / Dop pler Spread / Doubly spread targets in the presence of noise and clutter. Introduction to	8	Hrs

Recommended Books:

1. Di Franco. JV and Rubin, WL., "Radar Detection",Artech House, 1980.
2. Gaspare Galati (Ed), "Advanced Radar Techniques and Systems", Peter Perigrinus Ltd., 1993.
3. Ramon Nitzberg, "Radar Signal Processing and Adaptive Systems",Artech House, 1999.
4. W Rihaczek, "Principles of High Resolution Radar",Artech House,1996.

EC 7012 ANTENNAS AND PROPAGATION FOR WIRELESS COMMUNICATION

3-0-0 3

Unit I	Radiation fields of wire antennas: Concept of vector potential. Modification for time varying retarded case. Fields associated with Hertzian dipole. Radiation resistance of elementary dipole with linear current distribution. Radiation from half-wave dipole and quarter – wave monopole. Use of capacity hat and loading coil for short antennas	6 Hrs
Unit II	Antenna Fundamentals and Antenna Arrays: Definitions: Radiation intensity, Directives gain, Directivity, Power gain, Beam Width, Band Width, Gain and radiation resistance of current element. Half-wave dipole and folded dipole. Reciprocity principle, Effective length and Effective area. Relation between gain effective length and radiation resistance.	12 Hrs
Unit III	Loop Antennas: Radiation from small loop and its radiation resistance. Antenna Arrays: Expression for electric field from two and three element arrays. Uniform linear array. Method of pattern multiplication. Binomial array. Use of method of images for antennas above ground	8 Hrs
Unit IV	Traveling wave (wideband) antennas: Radiation from a traveling wave on a wire. Analysis and design of Rhombic antenna. Coupled Antennas: Self and mutual impedance of antennas. Two and Three element Yagi antennas, Log periodic antenna. Aperture and Lens Antennas: Radiation from an elemental area of a plane wave (Huygen's Source). Radiation from the open end of a coaxial line. Radiation from a rectangular aperture treated as an array of Huygen's sources. Relation between dipole and slot impedances. Method of feeding slot antennas. Thin slot in an infinite cylinder. Field on the axis of an e-plane sectoral horn. Radiation form circular aperture. Beam width and effective area. Reflector type of antennas (dish antennas). Dielectric lens and metal plane lens antennas. Lumeberg lens. Spherical waves and biconical Antenna	8 Hrs
Unit V	Propagation: Ground wave, space wave and sky wave propagation. Sky wave propagation: Structure of the ionosphere. Effective dielectric constant of ionized region. Mechanism of refraction. Refractive index. Critical frequency. Skip distance. Effect of earth's magnetic field. Energy loss in the ionosphere due to collisions. Maximum usable frequency. Fading and Diversity reception. Space wave propagation: Reflection from ground for vertically and horizontally polarized waves. Ground wave propagation: Attenuation characteristics for ground wave propagation. Calculation of field strength at a distance.	8 Hrs

Recommended Books:

1. E.C. Jordan and Balmain, "Electro Magnetic Waves and Radiating Systems", PHI, 1968, Reprint 2003
2. John D. Kraus and Ronalatory Markefka, "Antennas", Tata McGraw-Hill Book Company, 2002
3. R.E. Collins, "antennas and Radio Propagation", McGraw-Hill, 1987
4. Ballany, "Antenna Theory", John Wiley & Sons, Second Edition, 2003

EC 7013	ADVANCED NETWORKS TECHNOLOGIES	3-0-0	3
Unit I	Internet working model, application & upper layers, Physical & data link layers network layer & path determination, router basics: Types, configuration & operation	8	Hrs
Unit II	TCP/IP, IP Addressing, IP routing configuration, Multi protocol routing , IP Subnets, IP routing protocols: OSPF, RIP, BGP, IP forwarding, classless inter domain routing, traffic management with access lists.	10	Hrs
Unit III	Transport protocols: TCP, basic behavior, versions of TCP, UDP, and link layer technologies: ARP, RARP, Ethernet, HDLC, and LAP -B. Modems, CSU/DSU, B.35 and G.7.3 interfaces, ISDN, Fire walling, IPSEC basics, L2TP, New services over internet	14	Hrs
Unit IV	Introduction to WAN connection, configuration of X.25, configuration of frame-relay, new services over the Internet: VOIP, Fax over IP, VOATM, VOFR, RTP/RTCP, SIP, H.323. Virtual private network, IP -multicast,	10	Hrs

Recommended Books:

1. W R Stevens, " TCP/IP Illustrated- Volume 1- The Protocols, Pearson Edition Asis Education,
2. Duglas Comer, "Internetworking with TCP/IP Volume 1 – Principles, protocols and architecture, entice Hall, 4th Edition 2000
3. Internetworking Technologies handbook, 2nd edition, 1999, Cisco Press
4. Introduction to CISCO router configuration; 1998, Cisco Press

EC 7014	ERROR CONTROL TECHNIQUE	3-0-0	3
Unit I	Basic Digital Communication, Signal Detection, Memoryless Channels, Hamming Codes, Overview of Information Theory (Random variables, Entropy, Conditional Entropy, Relative Entropy, Mutual Entropy, Channel Capacity, Channel Coding Theorem (without proof) and its implication). Groups (Definition and properties, Subgroups, Cyclic groups and order, Cosets, Lagrange's theorem, Isomorphism, Homomorphism), Linear Algebra (Vector Spaces, Independence, Basis, dimension, inner product, dual space, orthogonality), Rings (Definition, Polynomials, Quotient Rings, Ideals); Number Theory and Algebra (Divisibility, Euclidean Algorithm, Sugiyama Algorithm, Congruences, f function, Chinese Remainder Theorem, Fields over R and C, Galois Fields, Galois Field Arithmetic, Irreducible and Primitive Polynomials, Krawtchouk Polynomials).	8	Hrs
Unit II	Linear Block Codes (Generator Matrix, Parity Check Matrix, Dual Codes, Weight Distribution, Hamming Codes and their Dual, Erasure Decoding); Cyclic Codes (Cyclic Encoding, Syndrome Decoding, Binary CRC Codes); BCH, Reed Solomon Codes, Goppa Codes, Peterson's Algorithm, Belekamp – Massey Algorithm, Forney's Algorithm	10	Hrs
Unit III	Welch – Berlekamp Key Equation, Guruswami –Sudan Decoding Algorithm and Soft RS decoding, Hadamard Matrices and Codes, Reed Muller Codes, Quadratic Residue Codes, Golay Codes; Gilbert – Varshamov Bound, Plotkin Bound, Griesmer Bound, Linear Programming and Related Bounds, McEliece – Rodemich – Rumsey – Welch Bound; Bursty Channels, Interleavers and Concatenation; Soft Decision Decoding Algorithms;	14	Hrs
Unit IV	Convolutional Codes, Viterbi Algorithm, Error Analysis, Puncturing,	10	Hrs

Unit IV	Convolutional Codes, Viterbi Algorithm, Error Analysis, Puncturing, Suboptimal decoding algorithm for Convolutional codes, convolutional codes as block codes, Trellis representation of Block and Cyclic Codes, Trellis Coded Modulation. Turbo Codes – Encoding parallel concatenated codes, decoding algorithms, Error Floor and Weight Distribution. Low Density Parity Check Codes – Construction, Tanner graphs, Decodin g. Space Time Coding – Fading Channels, Rayleigh Fading, MIMO Channel, Space Time Block Codes, Space – Time Trellis Codes.	10 Hrs

Recommended Books:

1. T. K. Moon, "Error Correction Coding: Mathematical Methods and Algorithms", Wiley, 2006
2. W. C. Huffman and V. Pless, "Fundamentals of Error – Correcting Codes", CUP, 2003.
3. S. Lin and D. J. Costello, "Error Control Coding: Fundamentals and Application", 1983.
4. R. H. Morelos-Zaragoza, "The Art of Error Correcting Codes", Wiley, 2002.

EC 7015	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	3-0-0 3
Unit I	Introduction to Electromagnetic Compatibility (EMC), EMC Requirements for Electronic Systems,Radiated Emissions,Conducted Emissions ,Spectra of Digital Waveforms,The Spectrum of Trapezoidal (Clock) Waveforms,pectral Bounds for Trapezoidal Waveforms, Effect of Rise/Falltime on Spectral Content,Bandwidth of Digital Waveforms, Effect of Repetition Rate and Duty Cycle,Effect of Ringing (Undershoot/Overshoot)	6 Hrs
Unit II	Transmission Lines and Signal Integrity:The Transmission-Line Equations,Printed Circuit Board (PCB) Structures,High-Speed Digital Interconnects and Signal IntegritySinusoidal Excitation of the Line and the Phasor Solution	6 Hrs
Unit III	Conducted Emissions and Susceptibility: Measurement of Conducted Emissions,1 The Line Impedance Stabilization Network (LISN),Common- and Differential-Mode Currents Again, Power Supply Filters,Basic Properties of Filters, A Generic Power Supply Filter Topology,Effect of Filter Elements on Common	8 Hrs
Unit IV	Differential-Mode Currents,Separation of Conducted Emissions into Common and Differential-Mode Components for Diagnostic Purposes,Power Supplies,Linear Power Supplies,Switched-Mode Power Supplies (SMPS), Effect of Power Supply Components on ConductedEmissions, Power Supply and Filter Placement,Conducted Susceptibility	6 Hrs
Unit V	Crosstalk: Three-Conductor Transmission Lines and Crosstalk,The Transmission-Line Equations for Lossless Lines,The Per-Unit-Length Parameters,Homogeneous versus Inhomogeneous Media, Wide-Separation Approximations for Wires, Numerical Methods for Other Structures,Wires with Dielectric Insulations(Ribbon Cables),Rectangular Cross-Section Conductors(PCB Lands),The Inductive –Capacitive Coupling Approximate Model, Frequency-Domain Inductive-Capacitive Coupling Model, Inclusion of Losses: Common-Impedance Coupling,Time-Domain Inductive – Capacitive Coupling Model\	8 Hrs
Unit VI	Shielding Effectiveness: Far-Field Sources, Exact Solution, Approximate Solution, Shielding Effectiveness: Near-Field Sources, Near Field versus Far Field,Electric Sources,Magnetic Sources, Low-Frequency, Magnetic Field Shielding, Effect of Apertures, System Design for EMC.	8 Hrs

Recommended Books :

1. Clayton R Paul: Introduction to Electromagnetic Compatibility Wiley 2nd Edition
2. V.P. Kodali, "Engineering Electromagnetic Compatibility",S. Chand & Co. Ltd., New Delhi, 2000.
3. "Electromagnetic Interference and Compatibility", IMPACT series, IIT-Delhi, Modules1-9.
4. Keiser, "Principles of Electromagnetic Compatibility", 3rd ed., ,Artech House
5. Henry W.Ott.,"Noise Reduction Techniques in Electronic Systems", AWiley Inter Science Publications, John Wiley and Sons, Newyork, 1988

EC 7016	CHANNEL MODELLING FOR WIRELESS COMMUNICATION	3-0-0	3
Unit I	Propagation Mechanisms - Free space propagation, reflection and transmission, diffraction, scattering on rough surfaces, wave guiding	6	Hrs
Unit II	Statistical Description of Wireless Channels - The time-invariant two-path model, time-variant two-path model, small-scale fading without line-of-sight, small-scale fading with line-of-sight, Doppler spectra, level crossing rate and random FM, large-scale fading	6	Hrs
Unit III	Wideband Channel Characterization - Narrowband vs. wideband systems, system-theoretic description of propagation channels, the WSSUS model, description methods for time dispersion, description methods for angular dispersion	8	Hrs
Unit IV	Channel Models - Narrowband models, wideband models, spatial models, deterministic models, models for ultra wideband channels	6	Hrs
Unit V	Channel Sounding - Time-domain methods, frequency-domain methods, generalizations, spatially resolved methods	8	Hrs
Unit VI	Antenna aspects in wireless systems - Requirements for antennas in mobile radio, antennas for mobile stations, antennas for base stations, aspects of multiple antenna systems	8	Hrs

Recommended Books:

1. Wireless Communications, 2nd Edition, by Andreas F. Molisch, Wiley
2. Wireless Communications, 2nd Edition, by Andrea Goldsmith, Cambridge University Press
3. Wireless Communication: Principles and Practice, 2nd Edition, by Theodore Rappaport, Prentice Hall

EC 7017	HIGH SPEED COMMUNICATION TECHNIQUES	3-0-0	3
Unit I	High Speed Networks: Frame Relay Networks – Asynchronous transfer mode – ATM Protocol Architecture, ATM logical Connection, ATM Cell – ATM Service Categories – AAL. High Speed LAN's: Fast Ethernet, Gigabit Ethernet, Fiber Channel – Wireless LAN's: applications, requirements – Architecture of 802.11	10	Hrs
Unit II	Congestion and Traffic Management: Queuing Analysis – queuing Models – Single Server Queues – Effects of Congestion – Congestion Control – Traffic Management – Congestion Control in Packet Switching Networks – Frame Relay Congestion Control	8	Hrs
Unit III	TCP and ATM Congestion Control: TCP Flow Control – TCP Congestion Control – Retransmission – Timer Management – Exponential RTO back off – KARN's Algorithm – Window Management – Performance of TCP over ATM Traffic and Congestion control in ATM – Requirements – Attributes – Traffic Management Frame work, Traffic control – ABR traffic Management - ABR rate control, RM cell formats ABR Capacity allocations – GFR traffic management	14	Hrs
Unit IV	Integrated and Differentiated Services: Integrated Services Architecture –	10	Hrs

allocations – GFR traffic management

Unit IV	Integrated and Differentiated Services: Integrated Services Architecture – Approach, Components, Services – Queuing Discipline, FQ, PS, BRFQ, GPS, WFQ – Random Early Detection, Differentiated Services. Protocols for QOS Support: RSVP – Goals & Characteristics, Data Flow, RSVP operations, Protocol Mechanisms – Multiprotocol Label. Switching – Operations, Label Stacking, Protocol details – RTP – Protocol Architecture, Data Transfer Protocol, RTCP	10 Hrs

Recommended Books :

1. High Speed Networks and Internet", Communication networks, Edition, 2001, By William Stallings, ean Harcourt Asia Pvt. Ltd
2. MPLS and VPN architecture, Volume 1 and 2, 2003, by Irvan Pepelnjk, Jim Guichard and Jeff Apcar, Cisco Press.
3. Encyclopedia of Networking and telecommunications, 2001, By Tom Sheldon, TMH.

EC 7018 SIGNAL PROCESSING FOR COMMUNICATION 3-0-0 3

Unit I	History and philosophy. Descret time signals. Definitions: Descrete time abstraction, Basic signals, deigital frequency, Elementary operator, reproducing formula, energy and power. Classes of Descret time signals	6 Hrs
Unit II	Signal space and Hilbert spaces: Euclidean Geometry, Vector spaces to Hilbert spaces.Subspace, base and projections. Finite length signals, Periodic signals and Infinite sequences. Fourier analysis: DFT, DFS, DTFT, Relationship between transforms, FT Properties, Time and Frequency Analysis	8 Hrs
Unit III	Stochastic Signal Processing: Random Variables, Random Vectors, Random Processes. Spectral representation of Stataionary Random Processes: Power Spectral Density, PSD of a Stationary Process, White Noise. Stochastic Signal Processing	10 Hrs
Unit IV	Interpolation and Sampling: Continuous Time Signals. Interpolation: Local Interpolation, Polynomial interpolation, Sinc interpolation. Sampling Theorem. Anliasing: Intuition and proof. Non-Bandlimitted Signals. Descrete Time processing of analog Signals: Digital differentiator, Fractional Delays	8 Hrs
Unit V	Data Comvertors and Multirate Signal Processing: Quantixzation, Uniform Scalar Quantization, Advanced Quantizer, ADC and DAC. Multirate Signal processing: Downsampling: Downsampling OperatorProperties, Frequency Domain Representation. Upsampling and Interpolation. Oversampled ADC and DAC.	10 Hrs

Recommended Books :

1. Paolo Prandoni, Martin Vetterli, "Signal Processing for Communications" EPEL Press.
2. Fredric J. Harris, "Multirate Signal Processing for Communication Systems" Pearson.
3. Martin Vetterli, Jelena Kovacevic, Vivek K Goyal, "Foundations of Signal Processing".
4. Ananthram Swami, Qing Zhao, Yao-Win Hong, Lang Tong, "Wireless Sensor Networks: Signal Processing and Communications Perspectives" Wiley.

EC 7019	ADVANCED DIGITAL SIGNAL PROCESSING	3-0-0	3
Unit I	Parametric methods for power spectrum estimation: Relationship between the auto correlation and the model parameters – The Yule – Walker method for the AR Model Parameters – The Burg Method for the AR Model parameters – unconstrained least-squares method for the AR Model parameters – sequential estimation methods for the AR Model parameters – selection of AR Model order	6	Hrs
Unit II	Adaptive signal processing :FIR adaptive filters – steepest descent adaptive filter – LMS algorithm – convergence of LMS algorithms – Application: noise cancellation – channel equalization – adaptive recursive filters – recursive least squares.	8	Hrs
Unit III	Multirate signal processing :Decimation by a factor D – Interpolation by a factor I – Filter Design and implementation for sampling rate conversion: Direct form FIR filter structures – Polyphase filter structure.	10	Hrs
Unit IV	Linear prediction and optimum linear filters: Innovations Representation of a Stationary Random Process, Forward and Backward Linear Prediction, Solution of the Normal Equations, Levinson-Durbin Algorithm, Schiir Algorithm, Properties of the Linear Prediction-Error Filters, Wiener Filters for Filtering and Prediction	8	Hrs
Unit V	Wavelet transforms :Fourier Transform : Its power and Limitations – Short Time Fourier Transform – The Gabor Transform - Discrete Time Fourier Transform and filter banks – Continuous Wavelet Transform – Wavelet Transform Ideal Case – Perfect Reconstruction Filter Banks and wavelets – Recursive multi-resolution decomposition – Haar Wavelet – Daubechies Wavelet.	10	Hrs

Recommended Books:

1. John G.Proakis, Dimitris G.Manobakis, Digital Signal Processing, Principles,Algorithms and Applications, Third edition, (2000) PHI.
2. Monson H.Hayes – Statistical Digital Signal Processing and Modeling, Wiley, 2002.
3. L.R.Rabiner and R.W.Schaber, Digital Processing of Speech Signals, Pearson Education(1979).
4. Roberto Crist, Modern Digital Signal Processing, Thomson Brooks/Cole (2004)
5. Raghuveer. M. Rao, Ajit S.Bopardikar, Wavelet Transforms, Introduction to Theory and applications, Pearson Education, Asia, 2000

EC 7030	VLSI TECHNOLOGY	3-0-0	3
Unit I	Environment for VLSI Technology: Clean room and safety requirements. Wafer cleaning processes and wet chemical etching techniques. Solid State diffusion modelling and technology; Ion Implantation modeling, technology and damage annealing	7	Hrs
Unit II	Oxidation and Lithography: Kinetics of Silicon dioxide growth both for thick, thin and ultrathin films. Oxidation technologies in VLSI and ULSI;Photolithography, E -beam lithography and newer lithography techniques for VLSI/ULSI; Mask generation	9	Hrs
Unit III	Chemical Vapor Deposition techniques : CVD techniques for deposition of polysilicon, silicon dioxide, silicon nitride and metal films; Epitaxial growth of silicon; modelling and technology.Metal film deposition : Evaporati on and sputtering techniques. Failure mechanisms in metal interconnects; Multi -level metallization schemes	14	Hrs
Unit IV	Plasma and Rapid Thermal Processing: PECVD, Plasma etching and RIE techniques; RTP techniques for annealing, growth and d eposition of various films for use in ULSI.Process integration for NMOS, CMOS and Bipolar circuits; Advanced MOS technologies.	10	Hrs

Recommended Books:

1. C.Y. Chang and S.M.Sze (Ed), ULSI Technology, McGraw Hill Companies Inc, 1996.
2. S.K. Ghandhi, VLSI Fabrication Principles, John Wiley Inc., New York, 1983.
3. S.M. Sze (Ed), VLSI Technology, 2nd Edition, McGraw Hill, 1988.

EC 7031	CMOS ANALOG IC DESIGN	3-0-0	3
Unit I	A Review of MOS equations in weak (sub-threshold) and strong inversion regions, MOS controlled switch; MOS diode; MOS capacitor; MOS active resistor, single-stage common source, common gate and common drain amplifiers.	5	Hrs
Unit II	MOS current mirrors (simple, cascode and low-voltage wide swing types), supply and temperature independent biasing method. Multiple current source and sink design	6	Hrs
Unit III	Stability analysis of closed loop amplifier, loop-gain, frequency and time domain behavior, open-loop gain and gain bandwidth product, gain and phase cross-over frequencies, multiple poles and zeros of closed loop amplifier, pre-dominant and non-dominant poles, gain margin and phase margin optimization for stable system design, various frequency-compensation techniques (Miller's and feed-forward path)	6	Hrs
Unit IV	Op-amp at the block level, ideal and real behaviors of op-amp, multi-stage op-amp and its frequency compensation, Two-stage current mirror op-amp, telescopic and folded cascode op-amp design equations, non-ideal behavior such as slew rate, DC off-set, Ibias offset and device mismatch effects.	6	Hrs
Unit V	Voltage gain, limit of input common mode range (ICMR), significance of CMRR and PSRR, inverting and non-inverting amplifiers, op-amp-mismatch and noise effects, single-ended and fully differential op-amps, common-mode feedback circuit for FD-Op-amp, MOS thermal and flicker noise equations, O noise and Inoise spectral densities, noise corner frequency	7	Hrs
Unit VI	Operational transconductance amplifier (OTA), transconductance gain equations in weak and strong inversion regions, two-stage OTA design (telescopic, cascode and folded-cacode types), single ended and fully-differential OTAs, frequency compensation techniques to increase phase margin for stable OTA structures.	4	Hrs
Unit VII	Voltage and current reference, band-gap reference; beta multiplier, active RC bi-quadratic filters using integrators loop, switched capacitor (SC) filter, OTA-C bi-quadratic filters	6	Hrs

Recommended Books:

1. Analog Circuit Design: Art, Science and Personalities (EDN Series for Design Engineers) (Paperback), Jim Williams, Newnes; Reprint edition, 1991.
2. Analog Integrated Circuit Design, David Johns and Ken Martin, John Wiley & Sons, 1997.
3. Mixed Analog Digital VLSI Devices and Technology (An introduction), Y. Tsividis, World Scientific, N ew Jersey, 2002.
4. Analysis and design of Analog Integrated Circuits, Gray, Hurst, Lewis, and Meyer, 4th Edition, John Wiley and Sons.
5. Design of Analog Integrated Circuits and Systems, K. R. Laker and W.M.C. Sansen, McGraw-Hill, January 1994.
6. Design of Analog CMOS Integrated Circuits, Behzad Razavi, McGraw Hill Education.
7. Design of CMOS Operational Amplifiers, By Rasoul Dehghani, Artech House publication, 2013.

EC 7032	LOW POWER VLSI DESIGN	3-0-0	3
Unit I	Introduction: Power dissipation analysis, Physics of Power Dissipation in CMOS FET Devices, Dynamic power, Static power	9	Hrs
Unit II	Low-power circuit techniques –Voltage scaling and thre shold-voltage hurdle in low-power design, Low power design Using Energy Recovery Technique	7	Hrs
Unit III	Advanced Techniques - Low Power CMOS VLSI Design, Low-power circuit level and device level approach	10	Hrs
Unit IV	Low-power Analog and digital design issues in weak inversion and strong inversion regions of operation	6	Hrs
Unit V	Power Estimation - Synthesis for Low Power - Design and Test of Low Voltages - CMOS Circuits.	8	Hrs

Recommended Books:

1. Gary Yeap " Practical Low Power Digital VLSI Design",1997.
2. Kaushik Roy, Sharat Prasad, "Low Power CMOS VLSI Circuit Design", 2000.

EC 7034	DIGITAL IC DESIGN	3-0-0	3
Unit I	Introduction; Metrics; Switch Logic; Process; Gates; MOS Transistor; Inverter VTC,MOS Capacitor; Inverter Delay; Power Buffer Sizing; Wires; CMOS Logic; Logical Effort; Process variation Effects, Introduction to VLSI fabrication.	9	Hrs
Unit II	Memory; Decoders; Pass Transitor; Dynamic and Static Logic; Domino Logic; Scaling; Adders; Multipiers; Latches; Timing; Clock; SRAM; Design for Performance; Power Performance Tradeoff.	7	Hrs
Unit III	Analysis and Design of Digital Integrated Circuits. Circuit analysis of piecewise linear single energy storage element networks. Rules for determining states of diodes and transistors. Bipolar junction and field effect transistors as switches.	14	Hrs
Unit IV	Basic digital logic gates. Integrated circuit logic and building blocks (TTL, MOS, CMOS, ECL, Integrated Injection Logic). Sweep circuits (constant current, Miller, bootstrap), Monostable, Astable, and Bistable (Schmitt Trigger) switching circuits, Applications (pulse width modulator, triangle wave generator, FM function generator design).	10	Hrs

Recommended Books:

1. Ivan Sutherlnd, Robert F Sroull, David Harris, Logical Effort: Designing Fast CMOS Circuits
2. N. Weste and K. Eshranghian, Principles of CMOS VLSI Design, Addison Wesley. 1985
3. L. Glaser and D. Dobberpuhl, The Design and Analysis of VLSI Circuits, Addison Wesley, 1985
4. C. Mead and L. Conway, Introduction to VLSI Systems, Addison Wesley, 1979.
5. J. Rabaey, al Integrated Circuits: A Design Perspective, Prentice Hall India, 1997.

EC 7035	CAD FOR VLSI	3-0-0	3
Unit I	VLSI Physical Design Automation: VLSI Design Cycle, New Trends in VLSI Design Cycle, Physical Design Cycle, New Trends in Physical Design Cycle, Design Styles, System Packaging Styles	9	Hrs
Unit II	Partitioning, Floor Planning, Pin Assignment and Placement: Partitioning – Problem formulation, Classification of Partitioning algorithms, Kernighan-Lin Algorithm, Simulated Annealing, Floor Planning – Problem formulation, Classification of floor planning algorithms, constraint based floor planning, Rectangular Dualization, Pin Assignment – Problem formulation, Classification	7	Hrs

	of pin assignment algorithms, General and channel Pin assignments, Placement – Problem formulation, Classification of placement algorithms, Partitioning based placement algorithms	
Unit III	Global Routing and Detailed Routing: Global Routing – Problem formulation, Classification of global routing algorithms, Maze routing algorithms, Detailed Routing – Problem formulation, Classification of routing algorithms, Single layer routing algorithms.	10 Hrs
Unit IV	Physical Design Automation of FPGAs: FPGA Technologies, Physical Design cycle for FPGAs, Partitioning, Routing – Routing Algorithm for the Non - Segmented model, Routing Algorithms for the Segmented Model; Physical Design Automation of MCMs: Introduction to MCM Technologies, MCM Physical Design Cycle	6 Hrs
Unit V	Chip Input and Output Circuits: ESD Protection, Input Circuits, Output Circuits and noise, On-chip clock Generation and Distribution, Latch-up and its prevention	8 Hrs

Recommended Books:

1. N.A. Sherwani, "Algorithms for VLSI Physical Design Automation ", 1999.
2. S.H.Gerez, "Algorithms for VLSI Design Automation ", 1998.

EC 7036	**DESIGN OF SEMICONDUCTOR MEMORIES**	**3-0-0 3**
Unit I	RANDOM ACCESS MEMORY TECHNOLOGIES Static Random Access Memories (SRAMs): SRAM Cell Structures-MOS SRAM Architecture-MOS SRAM Cell and Peripheral Circuit Operation-Bipolar SRAM Technologies-Silicon On Insulator (SOl) Technology-Advanced SRAM Architectures and Technologies- Application Specific SRAMs. Dynamic Random Access Memories (DRAMs): DRAM Technology Development-CMOS DRAMs-DRAMs Cell Theory and Advanced Cell Strucutures-BiCMOS DRAMs-Soft Error Failures in DRAMs-Advanced DRAM Designs and Architecture-Application Specific DRAMs	9 Hrs
Unit II	NONVOLATILE MEMORIES Masked Read-Only Memories (ROMs)-High Density ROMs-Programmable Read-Only Memories (PROMs)-Bipolar PROMs-CMOS PROMs-Erasable (UV) - Programmable Road-Only Memories(EPROMs)-Floating-GateEPROMCell-One-Time Programmable (OTP) Eproms-Electrically Erasable PROMs (EEPROMs)-EEPROM Technology And Arcitecture -Nonvolatile SRAM-Flash Memories (EPROMs or EEPROM)-Advanced Flash Memory Architecture	7 Hrs
Unit III	MEMORY FAULT MODELIN G, TESTING, AND MEMORY DESIGN FORTESTABILITY AND FAULT TOLERANCE RAM Fault Modeling, Electrical Testing, Peusdo Random Testing -Megabit DRAM Testing-Nonvolatile Memory Modeling and Testing-IDDQ Fault Modeling and Testing-Application Specific Memory Testing.	10 Hrs
Unit IV	SEMICONDUCTOR MEMORY RELIABILITY AND RADIATION EFFECTS General Reliability Issues-RAM Failure Modes and Mechanism-Nonvolatile Memory Reliability-Reliability Modeling and Failure Rate Prediction-Design for Reliability-Reliability Test Structures-Reliability Screening and Qualification. Radiation Effects-Single Event Phenomenon (SEP)-Radiation Hardening Techniques-Radiation Hardening Process and Design Issues-Radiation Hardened Memory Characteristics-Radiation Hardness Assurance and Testing - Radiation Dosimetry-Water Level Radiation Testing and Test Structures	6 Hrs

Level Radiation Testing and Test Structures

Unit V	ADVANCED MEMORY TECHNOLOGIES AND HIGH -DENSITY MEMORYPACK AGING TECHNOLOGIES Ferroelectric Random Access Memories (FRAMs)-Gallium Arsenide (GaAs) FRAMs-Analog Memories-Magnetoresistive Random Access Memories (MRAMs)-Experimental Memory Devices. Memory Hybrids and MCMs (2D)-Memory Stacks and MCMs (3D)-Memory MCM Testing and Reliability Issues-Memory Cards-High Density Memory Packaging Future Directions	8 Hrs

Recommended Books:

1. Ashok K.Sharma, " Semiconductor Memories Technology, Testing and Reliability ", Prentice-Hall of India Private Limited, New Delhi, 1997.
2. R. Jacob Baker, "DRAM"

EC 7037 MEMS AND MICROSYSTEMS TECHNOLOGY 3_0_0 3

Unit I	Historical Background: Silicon Pressure sensors, Micromachining, MicroElectroMechanical Systems	5 Hrs
Unit II	Microfabrication and Micromachining : Integrated Circuit Processes, Bulk Micromachining : Isotropic Etching and Anisotropic Etching, Wafer Bonding, High Aspect-Ratio Processes (LIGA)	6 Hrs
Unit III	Physical Microsensors : Classification of physical sensors, Integrated, Intelligent, or Smart sensors, Sensor Principles and Examples : Thermal sensors, Electrical Sensors, Mechanical Sensors, Chemical and Biosensors	6 Hrs
Unit IV	Microactuators : Electromagnetic and Thermal microactuation, Mechanical design of microactuators, Microactuator examples, microvalves, micropumps, micromotors-Microactuator systems : Success Stories, Ink-Jet printer heads, Micro-mirror TV Projector	6 Hrs
Unit V	Surface Micromachining: One or two sacrificial layer processes, Surface micromachining requirements, Polysilicon surface micromachining, Other compatible materials, Silicon Dioxide, Silicon Nitride, Piezoelectric materials, Surface Micromachined Systems : Success Stories, Micromotors, Gear trains, Mechanisms	7 Hrs
Unit VI	Application Areas: All-mechanical miniature devices, 3-D electromagnetic actuators and sensors, RF/Electronics devices, Optical/Photonic devices, Medical devices e.g. DNA-chip, micro-arrays	4 Hrs
Unit VII	RF/Electronics device/system, Optical/Photonic device/system, Medical device e.g. DNA-chip, micro-arrays	6 Hrs

Recommended Books:

1. Stephen D. Senturia, "Microsystem Design" by, Kluwer Academic Publishers, 2001.
2. Marc Madou, "Fundamentals of Microfabrication" by, CRC Press, 1997.Gregory Kovacs, "Micromachined Transducers Sourcebook" WCB . McGraw-Hill, Boston, 1998.
3. M.-H. Bao, "Micromechanical Transducers: Pressure sensors, accelrometers, and gyroscopes" by Elsevier, New York, 2000.

EC 7038	ADVANCED COMPUTER ARCHITECTURE	3_0_0	3
Unit I	Introduction: review of basic computer architecture, quantitative techniques in computer design, measuring and reporting performance. CISC and RISC processors	9	Hrs
Unit II	Pipelining : Basic concepts, instruction and arithmetic pipeline, data hazards, control hazards, and structural hazards, techniques for handling hazards. Exception handling, Pipeline optimization techniques, Compiler techniques for improving performance	7	Hrs
Unit III	Hierarchical memory technology: Inclusion, Coherence and locality properties; Cache memory organizations, Techniques for reducing cache misses; Virtual memory organization, mapping and management techniques, memory replacement policies	10	Hrs
Unit IV	Instruction-level parallelism: basic concepts, techniques for increasing ILP, superscalar, super pipelined and VLIW processor architectures, Array and Vector processors	6	Hrs
Unit V	Multiprocessor architecture: taxonomy of parallel architectures. Centralized shared-memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared-memory, architecture, Cluster computers, Non Von Neumann architectures: data flow computers, reduction computer architectures, systolic architectures	8	Hrs

Recommended Books:

1. Kai Hwang, "Advanced Computer Architecture ", McGraw Hill International, 1993.
2. William Stallings, "Computer Organization and Architecture ", Macmillan Publishing Company, 1990.
3. M.J. Quinn, "Designing Efficient Algorithms for Parallel Computers ", McGraw Hill International, 1994.

EC 7039	ANALOG FILTER DESIGN	3-0-0	3
Unit I	Introduction: transfer function, pass bands and attenuation band of ideal and realizable filters, comparison between passive and active filters, Design of second order filters (all types i.e. low pass, high pass, band pass, band reject, all pass) with unity and variable gain. Design of second order state variable filters, switched capacitor circuits, switched capacitor integrators (inverting and non-inverting type), universal SC filters, frequency limitation of SC filters, multiple order cascade filters, sensitivity of passive and active filters	9	Hrs
Unit II	Introduction to operational transconductance amplifier, bipolar and MOS OTA, OTA characteristic, OTA biasing tech niques, OTA based tunable filters, active only Biquadratic filters, high frequency OTA RF filters, two integrators loop g_m-C universal Biquadratic filters, OTA based LC filters, Voltage mode vs current mode filters, Adjoint and transpose conversion methods.	7	Hrs
Unit III	Introduction to Current mode Filters: Current conveyors, all generation of current conveyors and their transfer matrix, Bi-polar and CMOS CC cells, detailed analysis of second generation current conveyors (CC-II), Filter design methods using CC-I and CC-II, CCC-II	14	Hrs
Unit IV	Introduction to Current Feedback operational Amplifier: CC-II and buffer based CFOA CMOS Cell, merits of CFOA over op-amp, CFOA based oscillator, CFOA based active universal filters	10	Hrs

Recommended Books:

1. Design with Operational Amplifier and Analog Integrated Circuits, Third Edition by Sergio Franco, Ta ta Mc Graw-Hill.
2. Linear Integrated Circuits, by S Salivahannn, V S Kanchana Bhaaskaran, The Mc Graw-Hill Companies.
3. A Text book of Operational Transconductance Amplifier and Analog Integrated Circuits, by Tahira Parv een, Reprint 2010, I.K. International Publishing House Pvt. Ltd. New Delhi & Bangalore, ISBN: 978-93-80026-55-8.
4. Low Voltage Low Power CMOS Current Conveyors by Giuseppe Ferri and Nicola C. Guerrini, Kluwer Academic Publisher Boston/ Dordrecht/ London, 2003.ISBN: 1-4020-7486-7.

EC 7040	**VLSI SIGNAL PROCESSING**	**3-0-0 3**
Unit I	Introduction to DSP systems - Iteration Bound - Pipelined and parallel processing	9 Hrs
Unit II	Retiming - Unfolding - Algorithmic strength reduction in filters and transforms.	7 Hrs
Unit III	Systolic architecture design - fast convolution - Pipelined and parallel recursive and adaptive filters.	10 Hrs
Unit IV	Scaling and round off noise - Digital lattice filter structures - Bit level arithmetic architecture - Redundant arithmetic	6 Hrs
Unit V	Numerical strength reduction - Synchronous, wave and asynchronous pipe lines - low power design - programmable digital signal processors	8 Hrs

Recommended Books:

1. Keshab K.Parthi, " VLSI Digital Signal Processing systems, Design and implementation ", Wiley, Inter Science, 1999.
2. Mohammed Isamail and Terri Fiez, " Analog VLSI Signal and Information Processing ", Mc Graw-Hill, 1994.
3. S.Y. Kung, H.J. White House, T. Kailath, " VLSI and Modern Signal Processing ", Prentice Hall, 1985.
4. Jose E. France, Yannis Tsividis, " Design of Analog - Digital VLSI Circuits for Telecommunication an d Signal Processing ", Prentice Hall, 1994.

EC 7041	**VLSI DATA CONVERSION CIRCUIT**	**3-0-0 3**
Unit I	Sampling, Spectral properties of sampled signals, Oversampling and its implications on anti -alias filter design, Time Interleaved Sampling, Analysis of a Ping -Pong Sampling system, Analysis of Offset and Gain Errors in Time -Interleaved Sample and Holds.	5 Hrs
Unit II	Bottom Plate Sampling, Gate Bootstrapped Switch, the Nakagome Charge-Pump, Characterizing a Sample -and-Hold, Correct choice of input frequency, Discrete Fourier Series Refres her, FFT Leakage and the Rectangular Window, Spectral Windows, the Hann Window, the Blackman Window	6 Hrs
Unit III	Switch Capacitor Circuits, Parasitic Insensitive SC Amplifiers, Nonidealities in SC Amplifiers: Finite Opamp Gain and DC O ffset., Finite Opamp Gain -Bandwidth Product, Introduction to Fully Differential Operation	6 Hrs
Unit IV	Integral Nonlinearity (INL), Dynamic Characterization of ADCs, SQNR, Quantization Noise Spectrum, SFDR, Flash A/D Converter Basics, the Regenerative Latch, Preamp Offset Correction (Auto - zeroing)	6 Hrs

zeroing)

Unit V	Coupling Capacitor Considerations in an Auto -zeroed Preamp, Transistor Level Preamp Design, Timing issues in a flash ADC. Bubble Correction Logic in a Flash ADC, Comparator Meta -stability, D/A Converter Basics, INL/DNL, DAC Spectra and Pulse Shapes.	7 Hrs
Unit VI	NRZ vs RZ DACs, DAC Architectures, Binary Weighted versus Thermometer DACs, Binary vs Thermometer DACs, Current Steering DACs	4 Hrs
Unit VII	Oversampled Approaches to Data Conversion, Benefits of Oversampling. Oversampling with Noise Shaping, Signal and Noise Transfer Functions, First and Second Order Delta -Sigma Converters, Introduction to Continuous -time Delta Sigma Modulators (CTDSM)	6 Hrs

Recommended Books:

1. Understanding Delta - Sigma Data Converters: R. Schreier, Wiley
2. Understanding Delta-Sigma Data Converters : R.Schreier and G.Temes
3. John Wiley CMOS Data Converters for Communications: N.Tan, Springer.

EC 7042 TESTING AND VERIFICATION OF VLSI CIRCUITS 3-0-0 3

Unit I	Scope of testing and verification in VLSI design process. Issues in test and verification of complex chips, embedded cores and SOCs	9 Hrs
Unit II	Fundamentals of VLSI testing. Fault models. Automatic test pattern generation. Design for testability	7 Hrs
Unit III	Scan design. Test interface and boundary scan. System testing and test for SOCs. Iddq testing. Delay fault testing. BIST for testing of logic and memories. Test automation	14 Hrs
Unit IV	Design verification techniques based on simulation, analytical and formal approaches. Functional verification. Timing verification. Formal verification. Basics of equivalence checking and model checking. Hardware emulation	10 Hrs

Recommended Books:

1. Wakerly, J.F., Digital Design: Principles and Practices, Prentice Hall.
2. Kevin Skahil, VHDL For Programmable Logic, Addison Wesley.
3. FPGA Data sheets, Application Notes.
4. Current literature from relevant journals and conference proceedings.

EC 7043 DIGITAL SYSTEM DESIGN USING FPGA 3-0-0=3

Unit I	Introduction to Digital design, hierarchical design, controller (FSM),case study	9 Hrs
Unit II	FSM issues, timing issues, pipelining, resource sharing, metastability, synchronization	7 Hrs
Unit III	MTBF Analysis, setup/hold time of various types of flip-flops, synchronization between multiple clock domains, reset recovery, proper resets	10Hrs
Unit IV	VHDL: different models, simulation cycles, process, concurrent and sequential statements, loops, delay models, library, packages, functions, procedures, coding for synthesis, test bench	6Hrs
Unit V	FPGA: logic block and routing architecture, design methodology, special resources, Virtex-II, Stratix architectures, programming FPGA, constraints, STA, timing closure, case study.	8Hrs

Recommended Books:

1. Wakerly, J.F., Digital Design: Principles and Practices, Prentice Hall.
2. Kevin Skahil, VHDL For Programmable Logic, Addison Wesley.
3. FPGA Data sheets, Application Notes. Current literature from relevant journals and conference proceedings.

EC 7044	PHOTONICS INTEGRATED CIRCUIT S	3-0-0	3
Unit I	Principles: Introduction to photonics, optical waveguide theory, numerical techniques and simulation tools, photonic waveguide components – couplers, tapers, bends, gratings. Electro -optic, acousto-optic, magneto-optic and non-linear optic effects. Modulators, switches, polarizers, filters, resonators, optoelectronics integrated circuits. Amplifiers, mux/demux, transmit receive modules	16	Hrs
Unit II	Technology: materials – glass, lithium niobate, silicon, compound semiconductors, polymers. Fabrication – lithography, ion-exchange, deposition, diffusion. Process and device characterization. Packaging and environmental issues	14	Hrs
Unit III	Applications: photonic switch matrices. Planar lightwave circuits, delay line circuits for antenna arrays, circuits for smart optical sensors. Optical signal processing and computing. Micro-opto-electro-mechanical systems.	7	Hrs
Unit IV	Photonic bandgap structures. VLSI photonics	3	Hrs

Recommended Books:

1. Pollock, C.R., and Lip Son, M., Integrated Photonics, Kluwer Pub., 2003.
2. Tamir, T.(ed.), Guided-wave optoelectronics,Second Edn,Springer Verlag, 1990.
3. Nishihara, H., Haruna, M., and Suhara, T., Optical Integrated Circuits, McGraw Hill, 1988.
4. Murphy, E.J. (ed.), Integrated Optical Circuits and Components: Design and Applications, Marcel and Dekker, 1999.
5. Current literature: Special issues of journals and review articles.

ELECTIVES C (Common Electives)

EC 7060	NANOELECTRONICS	3-0-0	3
Unit I	INTRODUCTION TO NANOTECHNOLOGY: Background to nanotechnology: Types of nanotechnology and nanomachines Molecular Nanotechnology: Electron microscopenanodots; nanolithography. Nanomaterials: preparation – plasma arcing – chemical vapor deposition – sol-gels – electrodeposition – ball milling – applications	6	Hrs
Unit II	FUNDAMENTALS OF NANOELECTRONICS: Fundamentals of logic devices:- Requirements – dynamic properties – threshold gates; physical limits to computations; concepts of logic devices:- classifications – spintronics – quantum cellular automata – quantum computing – DNA computer; performance of information processing systems;- of biological neurons – performance estimation for the human brain. Ultimate computation:- power dissipation limit – dissipation in reversible computation – the ultimate computer	8	Hrs
Unit III	SILICON MOSFETs & QUANTUM TRANSPORT DEVICES: Silicon MOSFETS - Novel materials and alternate concepts:- scaling rules – advanced MOSFET concepts. Quantum transport devices based on resonant tunneling:- Electron tunneling; Single electron devices for logic applications:- Single electron devices – applications of single electron devices to logic circuits	10	Hrs
Unit IV	CARBON NANOTUBES: Carbon Nanotube: Fullerenes - types – assemblies – purification of carbon nanotubes – electronic propertics – synthesis of carbon nanotubes – carbon nanotube interconnects – carbon nanotube FETs – Nanotube for memory applications – prospects of an all carbon nanotube nanoelectronics	8 10	Hrs Hrs

Unit V	MOLECULAR ELECTRONICS: Electrodes & contacts – functions – molecular electronic devices – first test systems – simulation and circuit design – fabrication; Future applications: MEMS – robots – random access memory – mass storage devices	10 Hrs

Recommended Books:

1. Michael Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons and Burkhard Raguse, Nanotechnology: Basic Science and Emerging Technologies, Chapman & Hall / CRC, 2002
2. T. Pradeep, NANO: The Essentials – Understanding Nanoscience and Nanotechnology, TMH'07
3. Rainer Waser (Ed.), Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices, Wiley-VCH, 2003
4. George W. Hanson,"Fundamentals of Nanoelectronics", Prentice Hall, 2007.
5. Karl Goser et.al, "Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum devices", Springer, 2005.
6. Mark. A. Reed and Takhee, "Molecular Electronics", American Scientific Publishers, 2003.
7. Michael C. Petty, "Molecular Electronics: From Principles to Practice", John Wiley & Sons, Ltd, 2007.

EC 7061 NEURAL NETWORKS, ARCHITECTURE AND ITS APPLICATIONS 3-0-0 3

Unit I	Network architecture, Artificial intelligence and neural networks, Learning processes, Learning with or without a teacher, Memory adoption, and statistical nature of learning process	6 Hrs
Unit II	Single layer perception, Adaptive filtering problem, LMS Algorithm, Learning curve, Perception convergence	8 Hrs
Unit III	Multi-layer perception: Back propagation, algorithm, output presentation and decision rule, supervised learning as optimization problem, Generalized radial basics, Function network	10 Hrs
Unit IV	Temporal processing using feed forward network, Network Architectures, Distributed time lagged feed forward network, Temporal back propagation algorithm	8 Hrs
Unit V	Dynamically driven recurrent networks, Sate space model, Learning algorithms, Real time recurrent learning, Kalman Filter, De-coupled extended kalman filters	10 Hrs

Recommended Books :

1. Neural network- A Comprehensive foundation, 2nd Ed, Simon Haykin, Addison Wiseley Longman, New York, 2001.
2. Neural Network- Algorithms, Applications and progggramming, J A Freeman and D M Skapura, AWL, NY, 2000.
3. An introduction to Neural Network, James A Anderson, Prentice Hall of India, New Delhi.

EC 7062	ADAPTIVE SIGNAL PROCESSING	3-0-0	3
Unit I	Introduction to vectors spaces, Review of notion of random variable, stochastic process, moments, ergodicity, LSI filtering of WSS processes, power density spectrum	8	Hrs
Unit II	Stochastic processes: Cross-correlation, filtering of WSS processes introduction to Wiener filtering. bandlimited processes, harmonic processes, the general linear process, and autoregressive processes stochastic models, autoregressive models, AR process, stochastic processes, MA and ARMA processes.	6	Hrs
Unit III	Simulation of AR processes and Wiener filtering. Comparison of time averages and ensemble averages. IIR Wiener filter for general linear process.	10	Hrs
Unit IV	Introduction to eignenvalue and eigenvector analysis of correlation matrix. Wiener filter using eigenvector basis, finished Wiener filter slides	8	Hrs
Unit V	Linear Prediction: FIR and IIR MMSE linear prediction. Introduction to "Backward Linear Prediction". Backward linear prediction, Gram Schmidt orthogonalization, Levinson algorithm. Prediction error filters, the lattice structure, joint-process estimation	10	Hrs

Recommended Books:

1. S. Haykin, Adaptive Filter Theory, fifth edition, Prentice Hall, 2013.
2. A. Sayed, Adaptive Filters, Wiley-IEEE Press, 2008. Available as ebook through University of Ottawa library.

EC 7063	SOFT COMPUTING	3-0-0	3
Unit I	Fuzzy Logic: Crisp set and Fuzzy set, Basic concepts of fuzzy sets, membership functions. Basic operations on fuzzy sets, Properties of fuzzy sets, Fuzzy relations	6	Hrs
Unit II	Propositional logic and Predicate logic, fuzzy If – Then rules, fuzzy mapping rules and fuzzy implication functions, Applications	10	Hrs
Unit III	Neural Networks: Basic concepts of neural networks, Neural network architectures, Learning methods, Architecture of a back propagation network, Applications	8	Hrs
Unit IV	Genetic Algorithms: Basic concepts of genetic algorithms, encoding, genetic modeling	8	Hrs
Unit V	Hybrid Systems: Integration of neural networks, fuzzy logic and genetic algorithms.	10	Hrs

Recommended Books:

1. S. Rajasekaran and G.A. Vijaylakshmi Pai.. Neural Networks Fuzzy Logic, and Genetic Algorithms, Prentice Hall of India.
2. K.H.Lee.. First Course on Fuzzy Theory and Applications, Springer-Verlag.
3. J. Yen and R. Langari.. Fuzzy Logic, Intelligence, Control and Information, Pearson Education

EC 7064	STATISTICAL SIGNAL PROCESSING AND MODELLING	3-0-0 3
Unit I	Review of random variables: Distribution and density functions, moments, independent, uncorrelated and orthogonal random variables; Vector-space representation of Random variables, Schwarz Inequality Orthogonalit principle in estimation, Central Limit theorem, Random processes, wide-sense stationary processes, autocorrelation and autocovariance functions, Spectral representation of random signals, Wiener Khinchin theorem Properties of power spectral density, Gaussian Process and White noise process, Linear System with random input, Spectral factorization theorem and its importance, innovation process and whitening filter, .Random signal modelling: MA(q), AR(p) , ARMA(p,q) models	6 Hrs
Unit II	Parameter Estimation Theory: Principle of estimation and applications, Properties of estimates, unbiased and consistent estimators, Minimum Variance Unbiased Estimates (MVUE), Cramer Rao bound, Efficient estimators; Criteria of estimation: the methods of maximum likelihood and its properties ; Baysean estimation : Mean square error and MMSE, Mean Absolute error, Hit and Miss cost function and MAP estimation	6 Hrs
Unit III	Estimation of signal in presence of white Gaussian Noise: Linear Minimum Mean-Square Error (LMMSE) Filtering: Wiener Hoff Equation, FIR Wiener filter, Causal IIR Wiener filter , Noncausal IIR Wiener filter, Linear Prediction of Signals, Forward and Backward Predictions, Levinson Durbin Algorithm, Lattice filter realization of prediction error filters	8 Hrs
Unit IV	Adaptive Filtering: Principle and Application, Steepest Descent Algorithm Convergence characteristics; LMS algorithm, convergence, excess mean square error, Leaky LMS algorithm;Application of Adaptive filters ;RLS algorithm, derivation, Matrix inversion Lemma, Intialization, tracking of nonstationarity	6 Hrs
Unit V	Kalman filtering: State-space model and the optimal state estimation problem, discrete Kalman filter, continuous-time Kalman filter, extended Kalman filter	8 Hrs
Unit VI	Spectral analysis: Estimated autocorrelation function, periodogram, Averaging the periodogram (Bartlett Method), Welch modification, Blackman and Tukey method of smoothing periodogram, Prametric method, AR(p) spectral estimation and detection of Harmonic signals, MUSIC algorithm	8 Hrs

Recommended Books:

1. M. Hays: Statistical Digital Signal Processing and Modelling, John Willey and Sons, 1996.
2. M.D. Srinath, P.K. Rajasekaran and R. Viswanathan: Statistical Signal Processing with Applications, PHI, 1996.
3. Simon Haykin: Adaptive Filter Theory, Prentice Hall, 1996.
4. D.G. Manolakis, V.K. Ingle and S.M. Kogon: Statistical and Adaptive Signal Processing, McGraw Hill, 2000.
5. S. M. Kay: Modern Spectral Estimation, Prentice Hall, 1987.

EC 7065 INTELLIGENT INSTRUMENTATION 3-0-0 3

Unit I	Introduction: Introduction to intelligent instrumentation, Historical Perspective, Current status, software based instruments	6	Hrs
Unit II	Virtual Instrumentation, Introduction to graphical programming, data flow & graphical programming techniques, advantage of VI techniques, VIs and sub VIs loops and charts, arrays, clusters and graphs, case and sequence structure, formula nodes, string and file I/O, Code Interface Nodes and DLL links	8	Hrs
Unit III	Data Acquisition Methods : Analog and Digital IO, Counters, Timers, Basic ADC designs, interfacing methods of DAQ hardware, software structure, use of simple and intermediate Vis. Use of Data Sockets for Networked communication and controls	10	Hrs
Unit IV	PC Hardware Review and Instrumentation Buses Structure, timing, interrupts, DMA, operating system, ISA, PCI, USB, PCMCIA Buses. IEEE488.1 & 488.2 serial Interfacing-RS 232C,RS422, RS423, RS485, USB, VXI, SCXI, PXI	8	Hrs
Unit V	Sensors: Examples and definition, Capacitive sensors: fundamentals, application and examples, Accelerometers, Pizoelectric sensors, Pressure sensors, Thermometers and flow sensors, Radiation sensors, Inductive and Magnetic sensors, Macro machine sensors: design and fabrication	10	Hrs

Recommended Books:

1. G.C. Barney / Intelligent Instrumentation / Prentice Hall, 1995ce:
2. Lisa,K.Wells &Jeffery Travis / Lab VIEW For every one Prentice Hall,1997
3. A.S. Morris / Principles of measurement and Instrumentation / Prentice Hall, 1993.
4. S. Gupta / P.C Interfacing for data Acquisition & Process Control 2nd Edition / Instrument Society o f America, 1994.
5. Gray Johnson / Lab VIEW Graphical Programming 2nd Edition / Tata Mc Graw Hill, 1997.
6. Bitter, Mohiuddin, Nawrocki / Advanced Cal VIEW Programming Techniques.

EC 7066	DIGITAL IMAGE PROCESSING	3-0-0	3
Unit I	Fundamental concepts of digital geometry, Digital image representation, Fundamental steps in image processing, Elements of digital image Processing systems, Image acquisitions, Storage, Processing, Communication, Display digital image fundamentals. Elements of visual perception, Simple image model, Sampling and quantization, Basic relationships between pixels, neighbour of pixels, Connectivities, Relation, Equivalence and transitive clause, Distance measures , Arithmetic/logic operations	6	Hrs
Unit II	Imaging Geometry: basic transformations, perspective transformations, Camera models; Photographic films- Film structure and exposure, film Characteristics diaphragm and shutter setting. Introduction to Fourier Transform, the discrete Fourier Transform, some properties of two dimensional Fourier Transform, separability, translation periodicity and conjugate symmetry, rotation, distributivity, and scaling, average value, Laplacian, convolution, and Correlation sampling, Fast Fourier Transforms, FFT algorithm, Inverse FFT , Implementation	8	Hrs
Unit III	Image enhancement: Spatial domain methods, Frequency domain method, Enhancement by point processing , Simple intensity transforms, Histogram processing, Image subtraction, Image averaging, Spatial filtering, Smoothing filters Image restoration : Degradation model, Degradation model for continuous Functions, algebra approach to restoration, Un-constrained restoration, constrained restoration, Removal of blur caused by uniform linear motion, Blind image, Deconvolution, Some algorithms	10	Hrs
Unit IV	Image coding- Redundancy, Interpixel redundancy, Measuring information, Information channel, Fundamental coding theorem, Image Segmentation , Line detection, Edge detection, Thresholding , Region splitting and merging	8	Hrs
Unit V	Image compression, Image compression models: The source encoder and decoder, Channel encoder and decoder, Error free compression, Variable length coding, Lossless predictive coding, Lossy compression: Lossy predictive coding, Transformed coding, Synthesis and analysis of image, Recognition, interpretation	10	Hrs

Recommended Books:

1. Digital Image Processing (3rd Edition) by Rafael C. Gonzalez and Richard E. Woods
2. Digital Image Processing Using Java, Efford, AWL, NY, 2000.
3. The Computer Image, A Watt and F.Policarpo AWL, NY, 1999
4. Fundamentals of Image Processing by A.K.Jain, PHI

EC 7067	SPEECH PROCESSING	3-0-0	3
Unit I	The Speech Production mechanism: Physiological and Mathematical Model.Relating the physiological and mathematical model. Categorization of Speech Sounds based on the source-system and the articulatory model	6	Hrs
Unit II	Speech Signal Processing Concepts: Discrete time speech signals, relevant properties of the fast Fourier transform and Z-transform for speech recognition, convolution, linear and non linear filter banks. Spectral estimation of speech using the Discrete Fourier transform. Pole-zero modeling of speech and linear prediction (LP) analysis of speech. Homomorphic speech signal de convolution, real and complex cepstrum, application of cepstral analysis to speech signals	8	Hrs
Unit III	The Speech Recognition Front End: Feature extraction for speech recognition, Static and dynamic features for speech recognition, robustness issues, discrimination in the feature space, feature selection. Mel frequency cepstral co-efficients (MFCC), Linear prediction cepstral coefficients (LPCC), Perceptual LPCC	10	Hrs
Unit IV	Distance measures for comparing speech patterns : Log spectral distance, cepstral distances, weighted cepstral distances, distances for linear and warped scales. Dynamic Time Warping for Isolated Word Recognition	8	Hrs
Unit V	Statistical models for speech recognition: Vector quantization models and applications in speaker recognition. Gaussian mixture modeling for speaker and speech recognition. Discrete and Continuous Hidden Markov modeling for isolated word and continuous speech recognition.Using the HTK toolkit for building a simple speech recognition system	10	Hrs

Recommended Books:

1. Digital Processing of Speech Signals, LR Rabiner and RW Schafer, Pearson Education.
2. Discrete-Time Speech Signal Processing: Principles and Practice, Thomas F. Quatieri, Cloth, 816 pp. ISBN: 013242942X Published: OCT 29, 2001.
3. Fundamentals of Speech Recognition, L. Rabiner and B. Juang, Prentice-Hall SignalProcessing Series, Pages: 507, Year of Publication: 1993, ISBN:0-13-015157-2.
4. Speech and Audio Signal Processing: Processing and perception of speech and music B. Gold and N. Morgan, Wiley 2000, ISBN: 0-471-35154-7.
5. Corpus-Based Methods in Language and Speech Processing, Steve Young et. al editors, 234 pages, Kluwer, ISBN 0-7923-4463-4.
6. Discrete Time Processing of Speech Signals, JR Deller, JG Proakis, JH
7. Hidden Markov Models for Speech Recognition, XD Huang, YAriki, MAJack, Edinburgh University Press.

EC 7068	MODERN CONTROL ENGG	3-0-0	3
Unit I	Discrete Time Systems: Introduction to discret time systems, the Z transformation:, Solving differential equations by z-transformation methods, the inverse z-transformation, Pulse transfer function, Theorems of the z-transformation, zero order hold, response between sampling instants	6	Hrs
Unit II	Stability Analysis: Introduction, Relation between s-plane z-plane, Stability analysis using JHRY criterion, Stability analysis using bilinear transformation	8	Hrs

Unit III	Time domain analysis of S.D. System: Introduction, Time response of S.D System, Root Loci for digital control systems, Steady state effort analysis of S.D Systems. Frequency domain analysis of S.D Systems,the loci for digital control systems	10Hrs
Unit IV	The Bode Diagram C.M and P.M, State Space analysis of control systems: Introduction, state space representation of continuous and discrete time systems, Solutions of time invariant and time varying state equation. State transition metric; Relation between state equation and transfer function	8Hrs
Unit V	Characteristic equation, Eigen values and Eigen vectors. State model form T.F., Controllability: Introduction, Definitions, Theorems on controllability, Observability: Introduction, Definition, Theorems on observability, Control system design: Design of digital control systems with deadbeat response, pole placement design by state feedback, state observer, Design of full and reduced order observer. Introduction to nonlinear control systems: describing function techniques, Phase plane techniques	10Hrs

Recommended Books:

1. Digital Control System, Kuo, International Edition, Saunders College Publishing, New York.
2. Digital Control System Analysis and Design, Philips and H T Nagle, PHI
3. Digital Control of Dynamic Systems, Franklin, Addision Wesley, Tokyo

EC 7069 BIOMEDICAL SIGNAL PROCESSING **3-0-0 3**

Unit I	Introduction: General measurement and diagnostic system, classification of signals, introduction to biomedical signals, Biomedical signal acquisition and processing, Difficulties in signal acquisition. ECG: ECG signal origin, ECG parameters-QRS detection different techniques, ST segment analysis, Arrhythmia, Arrhythmia analysis, Arrhythmia monitoring system	6 Hrs
Unit II	ECG Data Reduction: Direct data compression Techniques: Turning Point, AZTEC, Cortes, FAN, Transformation Compression Techniques: Karhunen - Loeve Transform, Other data compression Techniques: DPCM, Huffman coding, Data compression Techniques comparison. Signal averaging: Basics of signal averaging, Signal averaging as a digital filter, A typical averager, Software and limitations of signal averaging	8 Hrs
Unit III	Frequency Domain Analysis: Introduction, Spectral analysis, linear filtering, cepstral analysis and homomorphic filtering. Removal of high frequency noise (power line interference), motion artifacts (low frequency) and power line interference in ECG, Time Series Analysis: Introduction, AR models, Estimation of AR parameters by method o f least squares and Durbin's algorithm, ARMA models. Spectral modeling and analysis of PCG signals	10 Hrs
Unit IV	Spectral Estimation: Introduction, Blackman- tukey method, The periodogram, Pisarenko's Harmonic decomposition, Prony' method, Evaluation of prosthetic heart valves using PSD techniques. Comparison of the PSD estimation methods. Event Detection and waveform analysis: Need for event detection, Detection of events & waves, Correlation analysis of EEG signals, The matched filter, Detection of the P wave , Identification of heart sounds, Morphological analysis of ECG waves, analysis of activity	8 Hrs
Unit V	Adaptive Filtering: Introduction, General structure of adaptive filters, LMS adaptive filter, adaptive noise cancellation, Cancellation of 60 Hz interference in ECG, cancellation of ECG from EMG signal, Cancellation of maternal ECG in fetal ECG. EEG: EEG signal characteristics, Sleep EEG classification and epilepsy	10 Hrs

Recommended Books:

1. "Biomedical Signal Analysis" A case study approach, Rangaraj M Rangayyan, John Wiley publications.
2. "Biomedical Signal Processing Time and Frequency Domains Analysis (Volume I)", Arnon Cohen, CRC press.
3. "Biomedical Signal Processing Principles and Techniques" D.C.Reddy, Tata Mc Graw-Hill
4. "Biomedical Digital Signal Processing", Willis J. Tompkins, PHI.

EC 7070	EMBEDDED SYSTEM DESIGN	3-0-0	3
Unit I	Introduction to Microcontrollers and Microprocessors: Basic Architectures of Microcontrollers, Processor Types and Memory Structures, Organization of Data Memory; Instruction Set, Addressing Modes and Port Structure, External Memory Access, Timers, Interrupts, Program Branching Instructions, and Serial Communication	6	Hrs
Unit II	Introduction to Real Time Embedded Systems: Embedded Systems Components, Memory, Digital Signal Processors, General Purpose Processors, Embedded Processors and Memory-Interfacing	8	Hrs
Unit III	Embedded Systems I/O: Interfacing bus, Protocols, Timers, Interrupts, DMA,USB and IrDA, AD and DA Converters, Analog Interfacing	10	Hrs
Unit IV	Design of Embedded Processors: Field Programmable Gate Arrays and Applications, Introduction to Hardware Description Languages, Embedded Communications: Serial, Parallel, Network, Wireless Communication	8	Hrs
Unit V	Embedded System Software and Software Engineering issues: Introduction to Real-Time Systems, Real-Time Task Scheduling, Concepts in Real-Time Operating Systems, Commercial Real-Time Operating Systems, Introduction to Software Engineering, Requirements Analysis and Specification, Modeling Timing Constraints, Software Design	10	Hrs

Recommended Boooks:

1. David E Simon, "An embedded software primer ", Pearson education Asia, 2001.
2. John B Peat man " Design with Microcontroller ", Pearson education Asia, 1998.
3. Jonartthan W. Valvano Brooks/cole " Embedded Micro computer Systems. Real time Interfacing ", Thomson learning 2001.
4. Burns, Alan and Wellings, Andy, " Real-Time Systems and Programming Languages ", Second Edition. Harlow: Addison-Wesley-Longman, 1997.
5. Raymond J.A. Bhur and Donald L.Bialey, "An Introduction to real time systems: Design to networking with C/C++ ", Prentice Hall Inc. New Jersey, 1999.
6. Grehan Moore, and Cyliax, " Real time Programming: A guide to 32 Bit Embedded Development. Reading "Addison-Wesley-Longman, 1998.
7. Heath, Steve, " Embedded Systems Design ", Newnes 1997.

EC 7071	BIO-SENSORS AND BIO MEMS	3-0-0	3
Unit I	Approaches to designing electronic systems Sensor classification & sensing principles Introduction to biosensors & bioMS	8	Hrs
Unit II	Semiconductor sensors for physical measurands Physicochemical sensors integrable on silicon.	10	Hrs
Unit III	Biosensors: Structures & device analysis Catalytic biosensors Affinity biosensors	14	Hrs
Unit IV	BioMS: Architectures & analytic models	10	Hrs

Recommended Books:

1. SM Sze John Wiley, Semiconductor Devices: Physics & Technology' by, India, 2002.
2. RS Muller, RT Howe, SD Senturia, RL Smith and RM White, 'Microsensors', IEEE Press, New York, 1991.
3. Mohamed Gad-el-Hak (R), MEMS handbook' CRC Press, Boca Raton, 2002.
4. Anthony P.F.Turner, Isao Karube and George S. Wilson, 'Biosensors :fundamentals and applications' , Oxford University Press, Oxford, 1987.
5. S Middelhoek & SAAudet , 'Silicon sensors', Academic Press Limited,London,1989.
6. A Sandana. 'Engineering biosensors: kinetics and design applications', Academic Press, San Diego, 2002.
7. D Voet & JG Voet , 'Biochemistry', J Wiley & Sons, New York, 1990.

EC 7072	CONVEX OPTIMIZATION	3-0-0	3
Unit I	Convex sets, functions, and optimization problems. Basics of convex analysis. Least-squares, linear and quadratic programs, semidefinite programming, minimax, extremal volume, and other problems	10	Hrs
Unit II	Optimality conditions, duality theory, theorems of alternative, and applications. Interiorpoint methods. Subgradient, cutting-plane, and ellipsoid methods. Decentralized convex optimization via primal and dual decomposition	8	Hrs
Unit III	Alternating projections. Exploiting problem structure in implementation. Convex relaxations of hard problems, and global optimization via branch & bound. Robust optimization.	14	Hrs
Unit IV	Applications to signal processing, control, digital and analog circuit design, computational geometry, statistics, and mechanical engineering	10	Hrs

Recommended Books:

1. Boyd, Stephen, and Lieven Vanderberghe. Convex Optimization. Cambridge, UK: Cambridge University Press, 2004.
2. Bertsekas, Dimitri. Convex Optimization Theory. Nashua, NH: Athena Scientific, 2009.
3. Ben-Tal, Aharon, and Arkadi Nemirovski. Lectures on Modern Convex Optimization: Analysis, Algorithms , and Engineering Applications (MPS-SIAM Series on Optimization).

Ph. D. in Electronics and Communication Engineering (PT/FT)

Course	Names of Subjects	L	T	P	C
EC 9051	ENGINEERING RESEARCH METHODOLOGY	4	0	0	4
EC 90XX	3 COURSES	3	0	0	3

No.	Names of Subjects	L	T	P	C
EC 9001	TELECOMMUNICATION SWITCHING AND NETWORKS	3	0	0	3
EC 9002	MOBILE COMMUNICATION	3	0	0	3
EC 9003	RF INTEGRATED CIRCUITS	3	0	0	3
EC 9004	MICROWAVE DEVICES AND CIRCUITS	3	0	0	3
EC 9005	INFORMATION THEORY AND CODING TECHNIQUES	3	0	0	3
EC 9006	COMPUTER COMMUNICATION NETWORKS	3	0	0	3
EC 9007	OPTICAL COMMUNICATION	3	0	0	3
EC 9008	SATELLITE COMMUNICATION SYSTEM	3	0	0	3
EC 9009	RF COMPONENT AND CIRCUIT DESIGN	3	0	0	3
EC 9010	RADAR SIGNAL PROCESSING	3	0	0	3
EC 9011	ANTENNAS AND PROPAGATION FOR WIRELESS COMMUNICATION	3	0	0	3
EC 9012	ADVANCED NETWORKS TECHNOLOGIES	3	0	0	3
EC 9013	ERROR CONTROL TECHNIQUE	3	0	0	3
EC 9014	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	3	0	0	3
EC 9015	CHANNEL MODELLING FOR WIRELESS COMMUNICATION	3	0	0	3
EC 9016	HIGH SPEED COMMUNICATION TECHNIQUES	3	0	0	3
EC 9017	SIGNAL PROCESSING FOR COMMUNICATION	3	0	0	3
EC 9018	ADVANCED DIGITAL SIGNAL PROCESSING	3	0	0	3
EC 9019	VLSI TECHNOLOGY	3	0	0	3
EC 9020	CMOS ANALOG IC DESIGN	3	0	0	3
EC 9021	LOW POWER VLSI DESIGN	3	0	0	3
EC 9022	DIGITAL IC DESIGN	3	0	0	3
EC 9023	CAD FOR VLSI	3	0	0	3
EC 9024	DIGITAL AUDIO AND VIDEO COMMUNICATION	3	0	0	3
EC 9025	DESIGN OF SEMICONDUCTOR MEMORIES	3	0	0	3
EC 9026	MEMS AND MICROSYSTEMS TECHNOLOGY	3	0	0	3
EC 9027	ADVANCED COMPUTER ARCHITECTURE	3	0	0	3
EC 9028	ANALOG FILTER DESIGN	3	0	0	3
EC 9029	VLSI SIGNAL PROCESSING	3	0	0	3
EC 9030	VLSI DATA CONVERSION CIRCUIT	3	0	0	3
EC 9031	TESTING AND VERIFICATION OF VLSI CIRCUITS	3	0	0	3
EC 9032	DIGITAL SYSTEM DESIGN USING FPGA	3	0	0	3
EC 9033	PHOTONICS INTEGRATED CIRCUITS	3	0	0	3
EC 9034	NANOELECTRONICS	3	0	0	3
EC 9035	NEURAL NETWORKS, ARCHITECTURE AND ITS APPLICATIONS	3	0	0	3
EC 9036	ADAPTIVE SIGNAL PROCESSING	3	0	0	3
EC 9037	SOFT COMPUTING	3	0	0	3
EC 9038	STATISTICAL SIGNAL PROCESSING AND MODELLING	3	0	0	3
EC 9039	INTELLIGENT INSTRUMENTATION	3	0	0	3
EC 9040	DIGITAL IMAGE PROCESSING	3	0	0	3
EC 9041	SPEECH PROCESSING	3	0	0	3
EC 9042	MODERN CONTROL ENGG	3	0	0	3

No.	Names of Subjects	L	T	P	C
EC 9043	BIOMEDICAL SIGNAL PROCESSING	3	0	0	3
EC 9044	EMBEDDED SYSTEM DESIGN	3	0	0	3
EC 9045	BIO-SENSORS AND BIO MEMS	3	0	0	3
EC 9046	CONVEX OPTIMIZATION	3	0	0	3
EC 9047	MODERN DIGITAL COMMUNICATION TECHNIQUES	3	0	0	3
EC 9048	SEMICONDUCTOR DEVICE MODELLING	3	0	0	3
EC 9049	WIRELESS COMMUNICATION	3	0	0	3
EC 9050	CMOS MIXED SIGNAL CIRCUITS	3	0	0	3
EC 9051	ENGINEERING RESEARCH METHODOLOGY	3	0	0	3
EC 9052	TERM PAPER	3	0	0	3

EC 9001 TELECOMMUNICATION SWITCHING AND NETWORKS 3-0-0-3

Units	Topics	Lectures
Unit I	Multiplexing: Transmission Systems, FDM Multiplexing and modulation, Time Division Multiplexing, Digital Transmission and Multiplexing: Pulse Transmission, Line Coding, Binary N – Zero Substitution, Digital Biphase, Differential Encoding, Time Division Multiplexing, Time Division Multiplex Loops and Rings	6 hr
Unit II	SONET/SDH: SONET Multiplexing Overview, SONET Frame Formats SONET Operations, Administration and Maintenance, Payload Framing and Frequency Justification, Virtual Tributaries, DS3 Payload Mapping, E4 Payload Mapping, SONET Optical Standards, SONET Networks. SONET Rings: Unidirectional Path-Switching Ring, Bidirectional Line-Switched Ring	8 hr
Unit III	Digital Switching: Switching Functions, Space Division Switching, Time Division Switching, two-dimensional switching: STS Switching, TST Switching, No.4 ESS Toll Switch, Digital Gross-Connect Systems, and Digital Switching in an Analog Environment. Elements of SSNO7 Signaling	10 hr
Unit IV	Network Synchronization Control and Management Timing: Timing Recovery: Phase-Locked Loop, Clock Instability, Jitter Measurements, Systematic Jitter. Timing Inaccuracies: Slips, Asynchronous Multiplexing, Network Synchronization, U.S. Network Synchronization, Network Control, Network Management.	8 hr
Unit V	Digital Subscriber Access and traffic analysis, ISDN: ISDN Basic Rate Access Architecture, ISDN U Interface, ISDN D Channel Protocol. High-Data-Rate Digital Subscriber Loops: Asymmetric Digital Subscriber Line, VDSL. Digital Loop Carrier Systems: Universal Digital Loop Carrier Systems, Integrated Digital Loop Carrier Systems, Next-Generation Digital Loop Carrier, Fiber in the Loop, Hybrid Fiber Coax Systems, and Voice band Modems: PCM Modems, Local microwave Distribution Service, Digital Satellite Services. Traffic Characterization: Arrival Distributions, Holding Time Distributions, Loss Systems, And Network Blocking Probabilities: End-to-End Blocking Probabilities, Overflow Traffic, And Delay Systems: Exponential Service Times, Constant Service Times, Finite Queues.	10 hr

Books/References:

1. Bellamy John, "Digital Telephony", John Wily & Sons, Inc. 3rd ed. 2000
2. Viswanathan. T., "Telecommunication Switching System and Networks", PHI 1994
3. Robert G. Winch, "Telecommunication transmission systems", 2nd ed. TMH 2004
4. Marion Cole, "Intro. to Telecommunications" 2nd ed. Pearson education 2008.
5. Tom Sheldon, "Encyclopedia of Networking and telecom." TMH seventh reprint 2006

EC 9002 MOBILE COMMUNICATION 3-0-0 3

Units	Topics	Lectures
Unit I	Introduction to Cellular Mobile Systems: A basic cellular system, performance criteria, uniqueness of mobile radio environment, operation of cellular systems, planning a cellular system, overview of generations of cellular systems. Elements of Cellular Radio Systems Design and interference: General description of the problem, concept of frequency reuse channels, co-channel interference reduction factor, desired C/I from a normal case in an omni directional antenna system, cell splitting, consideration of the components of cellular systems. Introduction to co-channel interference, co-channel measurement design of antenna system, antenna parameter and their effects.	10 hr
Unit II	Cell Coverage for Signal & antenna structures: General introduction, obtaining the mobile point to point mode, propagation over water or flat open area, foliage loss, propagation near in distance, long distance propagation, point to point prediction model- characteristics, cell site, antenna heig hts and signal coverage cells, mobile to mobile propagation. Characteristics of basic antenna structures , antenna at cell site, mobile antennas. Frequency Management & Channel Assignment, Hand Off & Dropped Calls: Frequency management, fixed channel assignment, non-fixed channel assignment, traffic & channel assignment. Why hand off, types of handoff and their characteristics, dropped call rates & their evaluation.	10 hr
Unit III	Modulation methods and coding for error detection and correction: Introduction to Digital modulation techniques, modulation methods in cellular wireless systems, OFDM. Block coding, convolution coding and Turbo coding. Multiple access techniques: FDMA, TDMA, CDMA; Time-division multiple access (TDMA), code division multiple access (CDMA), CDMA capacity, probability of bit error considerations, CDMA compared with TDMA	12 hr
Unit IV	Second generation, digital, wireless systems, GSM, IS_136 (D-AMPS), IS-95, mobile management, voice signal processing and coding.	10 hr

Books/References:

1. Mobile Cellular Telecommunications; 2nd ed.; William, C Y Lee McGraw Hill
2. Mobile wireless communications; Mischa Schwartz, Cambridge University press, UK, 2005
3. Mobile Communication Hand Book; 2nd Ed.; IEEE Press
4. Wireless communication principles and practice, 2nd Ed, Theodore S rappaport, Pearson Education.
5. 3G wireless Demystified; Lawrence Harte, Mc. Graw Hill pub.

EC 9003 RF INTEGRATED CIRCUITS 3-0-0 3

Units	Topics	Lectures
Unit I	RF Filter design: Basic resonator and filter configurations-special filter realization-filter implementation-coupled filter	10 hr
Unit II	Active RF Components: RF diodes-bipolar junction transistor –RF field effect transistor-high electron mobility transistors-diode models-transistor models-measurement of active devices-scattering parameter device characterization.	8 hr
Unit III	Matching and biasing networks: Impedance matching using discrete components- micro strip line matching networks-amplifier classes of operation and biasing networks	14 hr
Unit IV	RF Transistor amplifier design: Characteristics of amplifier-amplifier power relations-stability consideration-constant gain-broadband, high power, and multistage amplifiers, Oscillators and mixers: Basic oscillator model-high frequency oscillator configuration-basic characteristics of mi xer	10 hr

Books/References:

1. Reinhold Ludwig, “RF circuit design, theory and applications” Pavel Bretchko, “Pearson Asia Educatio n”, edition 2001
2. D.Pozar, “Microwave Engineering”, John Wiley & Sons, New York, 1998
3. Bahil and P. Bhartia, “Microwave Solid State Circuit Design, John Willey & Sons, New York.

EC 9004 MICROWAVE DEVICES AND CIRCUITS 3-0-0 3

Units	Topics	Lectures
Unit I	Microwave frequencies, Interactions between electrons and fields, Electromagnetic plane waves, Electric and magnetic wave equations, Poynting theorem, Uniform plane waves and reflection, Plane wave propagation in free space and lossless dielectric, Plane wave propagation in lossy media, Plane wave propagation in metallic film coating on plastic substrate	10 hr
Unit II	Transmission line equations and solutions, Reflection coefficient and transmission coefficient , Standing wave and standing wave ratio, Line impedance and admittance, Smith chart, Microwave waveguides and components, Rectangular waveguides, Microwave cavities, Directional couplers, Circulators and isolators, Microwave transistors and tunnel diodes, Microwave bipolar transistors, Heterojunction transistors, Microwave tunnel diodes, Microwave field effect transistors, Junction field effect transistors, Metal semiconductor field effect transistors	10 hr
Unit III	Transferred electron devices, Gunn – effect diodes – GaAs diode, Ridley- watkins-Hilsum (RWH) theory, Modes of operation, LSA diodes, InP diodes, Avalanche transit time devices, Read diode, IMPATT diode, TRAPATT diodes, BARITT diodes, Microwave linear beam tubes (O Type), Conventional vacuum triodes, , Tetrodes and pentodes, klystrons, Multicavity klystron amplifiers, Reflex klystrons, Helix traveling wave tubes (TWT), Coupled cavity traveling wave tubes, Microwave crossed filed tubes (M Type), Magnetron oscillators, Forward wave crossed field amplifier (FWCFA OR CFA)	12 hr
Unit IV	Strip lines, Microstrip lines, Parallel strip lines, Coplanar strip lines, Shielded strip lines, Monolithic microwave integrated circuits, Materials, Monolithic microwave integrated circuit growth, MOSFET fabrication	10 hr

Books/References:

1. Samuel Y.Liao, " Microwave Devices and Circuits" Third edition,PHI
2. SK Roy, M Mitra, "Microwave semiconductor devices", PHI 2003
3. David M. Pozar, "Microwave Engineering" Wiley

EC 9005 INFORMATION THEORY AND CODING TECHNIQUES 3-0-0 3

Units	Topics	Lectures
Unit I	Definitions, Uniquely Decodable Codes, Instantaneous Codes, Krafts Inequality, McMillan's Inequality, Optimal Codes, Binary Huffman Codes, r-ary Huffman codes, Information and Entropy, Properties of Entropy Function, Entropy and Average Word-Length, Shannon-Fano Coding, Shannon's First Theorem, Information Channels, Binary Symmetric Channel, System Entropies, System Entropies for Binary Symmetric Channel, Extension of Shannon's First Theorem to Information Channels, Mutual Information, Mutual Information for the Binary Symmetric Channel, Hamming Distance, Shan.	10 hr
Unit II	Review: Algebra, Krawtchouk Polynomials, Combinatorial Theory, Probability Theory. Linear Codes: Block Codes, Linear Codes, Hamming Codes, Majority Logic Coding, Weight Enumerators, The Lee Metric, Hadamard Codes, Golay Codes (Binary and Ternary), Reed Muller Codes, And Kerdock Codes.Bounds on Codes: Gilbert Bound, Upper Bound, Linear Programming Bounds, Hamming's Sphere –Packing Bound, Gilbert Varshamov Bound, Hadamard Matrices and Codes	10 hr
Unit III	Cyclic Codes: Generator Matrix, Check polynomial, Zeros of Cyclic Codes, BCH Codes, Reed-Solomon Codes, Quadratic Residue Codes, Generalized Reed- Muller Codes. Perfect Codes and Uniformly Packed Codes: Lloyd's Theorem, Characteristic Polynomial of a Code, Uniformly Packed Codes, Nonexistence Theorems	12 hr
Unit IV	Quaternary Codes, Binary Codes Derived from codes over Z4, Galois Rings over Z4, Cyclic Codes over Z4. Goppa Codes. Algebraic Curves, Divisors, Differentials on a Curve, Riemann – Roch Theorem, Codes from Algebraic Curves. Arithmetic Codes: AN Codes, Mandelbaum – Barrows Codes, Convolutional Codes.	10 hr

Books/References:

1. G. A. Jones and J. M. Jones, "Information and Coding Theory", Springer, 2000.
2. J. H. van Lint, "Introduction to Coding Theory", Springer, 1999.
3. Cover Thomas, "Elements of Information Theory", and Wiley 2006.
4. R. W. Hamming, "Coding and Information Theory", Prentice Hall, 1986.
5. T. M. Cover and J. A. Thomas, "Elements of Information Theory", Wiley, 1991.
6. R. E. Blahut, "Principles and Practice of Information Theory," AWL, 1987.

EC 9006 COMPUTER COMMUNICATION NETWORKS 3-0-0 3

Units	Topics	Lectures
Unit I	Concept of CCN/DCN, characteristics of data – Users' sub-network, topological design etc. Accessing techniques, Data Modeling – M/M/1 analysis, Circuit switching, message switching,	10 hr
Unit II	Packet switching, and ATM cell switching, Protocols, ISO, OSI, Networking objectives, classification of networks – LAN, MAN, WAN, ISDN	8 hr
Unit III	Techniques and theories of CSMA/CD Bus, Token Ring, Token passing bus throughput analysis, Modeling (Stalling Models, IEEE Model etc.)	14 hr
Unit IV	Introduction to wireless networks, GSM, TDMA & CDMA-design and analysis, PCS concepts, Network operation and maintenance, Network Delay analysis, Routing, Flow Control, Congestion Control	10 hr

Books/References:

1. Behrouz A. Forouzan, "TCP/IP Protocol Suit", TMH, 2000
2. Wayne Tomasi, "Introduction to Data communications and Networking", Pearson Ed. 2007
3. Tananbaum A. S., "Computer Networks", 3rd Ed., PHI, 1999
4. Black U, "Computer Networks-Protocols, Standards and Interfaces", PHI, 1996
5. Stallings W., "Data and Computer Communications", 6th Ed., PHI, 2002.
6. Stallings W., "SNMP, SNMPv2, SNMPv3, RMON 1 & 2", 3rd Ed., Addison Wesley, 1999
7. Laurra Chappell (Ed), "Introduction to Cisco Router Configuration", Techmedia

EC 9007 OPTICAL COMMUNICATIONS 3-0-0 3

Units	Topics	Lectures
Unit I	Introduction: concepts of information, general communication systems, evolution of optical fiber communication systems, advantages, disadvantage of optical fiber, communication systems. Wave propagation in dielectric waveguide: snell's law, internal reflection, dielectric slab wave guide, numerical aperture, propagation of model & rays. Step-index fibers, graded index fibers.	8 hr
Unit II	Attenuation in optics fibers: Fiber attenuation, connectors &splices, bending loses, Absorption, scattering, very low loss materials, plastic & polymer-clad- silica fibers. Wave propagation in fibers: wave propagation in step index & graded index fiber, fiber dispersion, single mode fibers, multimode fibers, dispersion shifted fiber, dispersion flattened fiber, polarization.	10 hr
Unit III	Optical sources & detectors: principles of light emitting diodes (LED's) , design of LED's for optical fiber communications, semiconductor LASER for optical fiber communication system ,principles of semiconductor photodiode detectors, PIN photodiode, Avalanche photodiode detectors. Optical fiber communication system: telecommunication, local distribution series, computer networks local data transmission & telemetry, digital optical fiber communication system, first & second generation system, future system.	14 hr
Unit IV	Advanced multiplexing strategies: Optical TDM, subscriber multiplexing (SCM), WDM. Optical networking: data communication networks, network topologies, MAC protocols, Network Architecture- SONET/TDH, optical transport network, optical access network, optical premise network.	10 hr

Books/References:

1. Senior J., optical fiber communications, principles & practice, PHI.
2. Keiser G., optical fiber communications, McGraw-hill.
3. Gowar J., optical communication systems, PHI.
4. William B. Jones jr., Introduction to optical fiber communication systems, Holt, Rinehart and Winsto n, Inc.

EC 9008 SATELLITE COMMUNICATION SYSTEM 3-0-0 3

Units	Topics	Lectures
Unit I	Introduction: Origin and brief history of satellite communications, an overview of satellite system engineering, satellite frequency bands for communication. Orbital theory:Orbital mechanics, locating the satellite in the orbit w.r.t. earth look angle determination. Azimuth & elevation calculations.	10 hr 8 hr
Unit II	Spacecraft systems: Attitude and orbit control system, telemetry, tracking and command (TT&C), communications subsystems, transponders, spacecraft antennas. Satellite link design: Basic transmission theory, noise figure and noise temperature, C/N ratio, satellite down link design, satellite uplink design	14 hr
Unit III	Modulation, Multiplexing, Multiple access Techniques: Analog telephone transmission, Fm theory, FM Detector theory, analog TV transmission, S/N ratio Calculation for satellite TV linking, Digital transmission, base band and band pass transmission of digital data, BPSK, QPSK , FDM, TDM, Access techniques: FDMA, TDMA, CDMA	10 hr
Unit IV	Encoding & FEC for Digital satellite links: Channel capacity, error detection coding, linear block, binary cyclic codes, and convolution codes. Satellite Systems: Satellite Earth station Technology, satellite mobile communication, VSAT technology, Direct Broadcast by satellite (DBS).	

Books/References:

1. Timothy Pratt, Charles W. Bostian, "Satellite communication", John Wiley &sons , Publication, 2003
2. J.J. Spilker, "Digital Communication by satellite, PHI Publication, 1997
3. J. Martin, "Communication satellite systems", PHI publication, 2001

EC 9009 RF COMPONENT AND CIRCUIT DESIGN 3-0-0 3

Units	Topics	Lectures
Unit I	Transmission lines ,Broadband Mactching, Scattering Parameters, microwave transistors	10 hr
Unit II	Passive Components: Inductors, Inductor Model, Analytical model, Printed Inductors, Inductors on Si substrate and GaAs substrate. Thick film inductors,Thin film inductors, LTCC inductors. Wire Inductors. Capacitors, Monolithic capacitors, interdigital capacitors. Resistors, chip resistor , MCM resistor, Monolithic resistors, Microwave Resonators and Narrowband Filters, Broadband Filters Microwave Amplifier Design: Two-Port Power Gains, Amplifier Stability Low Noise Amplifier Design, Broadband Amplifier Design	8 hr 14 hr
Unit III	Microwave Amplifier Design: Two-Port Power Gains, Amplifier Stability Low Noise Amplifier Design,Broadband Amplifier Design	10 hr
Unit IV	Microwave Oscillators: One Port negative resistance oscillators, Two Port negative resistance oscillators, Oscillator configurations	

Books/References:

1. Lumped Elements for RF and Microwave Circuits " I. J. Bahl ,Artech House.
2. Microwave Transistor Amplifier: Analysis and Design, Gonzalez G. Prentice Hall 1984.
3. Microwave Semiconductor Circuit Design, Davis W. Alan, Van NostrandReinhold, 1984.
4. Microwave Circuit Analysis and Amplifier Design, Samuel Y. Liao, Prentice Hall 1987
5. High Frequency Amplifier, Ralph S. Carson, Wiley Interscience, 1982 .

EC 9010 RADAR SIGNAL PROCESSING 3-0-0 3

Units	Topics	Lectures
Unit I	Introduction: Classification of Radars based on functions, principles of operation etc., performance measures and interplay between Radar parameters, Target parameters and Environment parameters. Classical Detection and Estimation Theory, Binary Hypotheses Testing, Likelyhood Ratio Test, Neymon square,MAP, Maximum Likelihood Estimation of parameters, Cramer-Rao Bounds,Chemoof Bounds	10 hr
Unit II	Representation of Signals, K-L expansion, Equivalent Low-pass representation of Band pass signals and noise. Detection of Slowly Fluctuating point Targets in white noise and coloured noise. Swerling Target models. Optimum receivers. Correlator and Band pass M atohed Filter Receivers. PD – PF performance; Coherent and non-coherent Integration sub-optimum Reception. Radar Power –Aperture product.	10 hr
Unit III	Range and Doppler Resolution: Ambiguity function and its properties. Local and Global Accuracy. Signal Design. LFM. Polyphase coded signals Detection of a Doppler shifted slowly fluctuating point target return in a discrete scatterer environment. Dobly dispersive Fading Target and Clutter models-Scattering function description. Land clutter-pulse length limited and Beam width limited clutter. Sea clutter.	14 hr
Unit IV	Optimum / Sub optimum reception of Range Spread / Doppler Spread / Doubly spread targets in the presence of noise and clutter. Introduction to Adaptive Detection and CFAR Techniques.	8 hr

Books/References:

1. Di Franco. JV and Rubin, WL., "Radar Detection", Artech House, 1980.
2. Gaspare Galati (Ed), "Advanced Radar Techniques and Systems", Peter Perigrinus Ltd., 1993.
3. Ramon Nitzberg, "Radar Signal Processing and Adaptive Systems", Artech House, 1999.
4. W Rihaczek, "Principles of High Resolution Radar", Artech House,1996.

EC 9011 ANTENNAS AND PROPAGATION FOR WIRELESS COMMUNICATION 3-0-0 3

Units	Topics	Lectures
Unit - I	Radiation fields of wire antennas: Concept of vector potential. Modification for time varying retarded case. Fields associated with Hertzian dipole. Radiation resistance of elementary dipole with linear current distribution. Radiation from half-wave dipole and quarter – wave monopole. Use of capacity hat and loading coil for short antennas	6 hr
Unit - II	Antenna Fundamentals and Antenna Arrays: Definitions: Radiation intensity, Directives gain, Directivity, Power gain, Beam Width, Band Width, Gain and radiation resistance of current element. Half-wave dipole and folded dipole. Reciprocity principle, Effective length and Effective area. Relation between gain effective length and radiation resistance.	12 hr
Unit - III	Loop Antennas: Radiation from small loop and its radiation resistance. Antenna Arrays: Expression for electric field from two and three element arrays. Uniform linear array. Method of pattern multiplication. Binomial array. Use of method of images for antennas above ground.	8 hr
Unit - IV	Traveling wave (wideband) antennas: Radiation from a traveling wave on a wire. Analysis and design of Rhombic antenna. Coupled Antennas: Self and mutual impedance of antennas. Two and Three element Yagi antennas, Log periodic antenna. Aperture and Lens Antennas: Radiation from an elemental area of a plane wave (Huygen's Source). Radiation from the open end of a coaxial line. Radiation from a rectangular aperture treated as an array of Huygen's sources. Relation between dipole and slot impedances. Method of feeding slot antennas. Thin slot in an infinite cylinder. Field on the axis of an e- plane sectoral horn. Radiation form circular aperture. Beam width and effective area. Reflector type of antennas (dish antennas). Dielectric lens and metal plane lens antennas. Lumeberg lens. Spherical waves and biconical Antenna.	8 hr
Unit - V	Propagation: Ground wave, space wave and sky wave propagation. Sky wave propagation: Structure of the ionosphere. Effective dielectric constant of ionized region. Mechanism of refraction. Refractive index. Critical frequency. Skip distance. Effect of earth's magnetic field. Energy loss i n the ionosphere due to collisions. Maximum usable frequency. Fading and Diversity reception. Space wave propagation: Reflection from ground for vertically and horizontally polarized waves. Ground wave propagation: Attenuation characteristics for ground wave propagation. Calculation of field strength at a distance.	8 hr

Books/References:

1. E.C. Jordan and Balmain, "Electro Magnetic Waves and Radiating Systems", PHI, 1968, Reprint 2003
2. John D. Kraus and Ronalatory Markefka, "Antennas", Tata McGraw-Hill Book Company, 2002
3. R.E. Collins, "antennas and Radio Propagation", McGraw-Hill, 1987.
4. Ballany, "Antenna Theory", John Wiley & Sons, Second Edition, 2003.

EC 9012 ADVANCED NETWORKS TECHNOLOGIES 3-0-0 3

Units	Topics	Lectures
Unit I	Internetworking model, application & upper layers, physical & data link layers network layer & path determination, router basics: Types, configuration & operation	10 hr
Unit II	TCP/IP, IP Addressing, IP routing configuration, Multi protocol routing, IP Subnets, IP routing protocols: OSPF, RIP, BGP, IP forwarding, classless inter domain routing, traffic management with access lists.	8 hr
Unit III	Transport protocols: TCP, basic behavior, versions of TCP, UDP, and link layer technologies: ARP, RARP, Ethernet, HDLC, and LAP-B. Modems, CSU/DSU, B.35 and G.7.3 interfaces, ISDN, Fire walling, IPSEC basics, L2TP, New services over internet	14 hr
Unit IV	Introduction to WAN connection, configuration of X.25, configuration of frame-relay, new services over the Internet: VOIP, Fax over IP, VOATM, VOFR, RTP/RTCP, SIP, H.323. Virtual private network, IP-multicast, QOS architectures in the Internet, IntServ, DiffServ, Core Stateless fare Queing., Int ernet access technologies- security, directory enabled networking, network caching technologies	10 hr

Books/References:

1. W R Stevens, " TCP/IP Illustrated- Volume 1- The Protocols, Pearson Edition Asis Education,
2. Duglas Comer, "Internetworking withTCP/IP Volume 1 – Principles, protocols and architecture, Prentic e Hall, 4th Edition 2000
3. Internetworking Technologies handbook, 2nd edition, 1999, Cisco Press
4. Introduction to CISCO router configuration; 1998, Cisco Press.

EC 9013 ERROR CONTROL TECHNIQUE 3-0-0 3

Units	Topics	Lectures
Unit I	Basic Digital Communication, Signal Detection, Memoryless Channels, Hamming Codes, Overview of Information Theory (Random variables, Entropy, Conditional Entropy, Relative Entropy, Mutual Entropy, Channel Capacity, Channel Coding Theorem (without proof) and its implication). Groups (Definition and properties, Subgroups, Cyclic groups and order, Cosets, Lagrange's theorem, Isomorphism, Homomorphism), Linear Algebra (Vector Spaces, Independence, Basis, dimension, inner product, dual space, orthogonality), Rings (Definition, Polynomials, Quotient Rings, Ideals); Number Theory and Algebra (Divisibility, Euclidean Algorithm, Sugiyama Algorithm, Congruences, f function, Chinese Remainder Theorem, Fields over R and C, Galois Fields, Galois Field Arithmetic, Irreducible and Primitive Polynomials, Krawtchouk Polynomials).	8 hr
Unit II	Linear Block Codes (Generator Matrix, Parity Check Matrix, Dual Codes, Weight Distribution, Hamming Codes and their Dual, Erasure Decoding); Cyclic Codes (Cyclic Encoding, Syndrome Decoding, Binary CRC Codes); BCH, Reed Solomon Codes, Goppa Codes, Peterson's Algorithm, Belekamp – Massey Algorithm, Forney's Algorithm	10 hr
Unit III	Welch – Berlekamp Key Equation, Guruswami –Sudan Decoding Algorithm and Soft RS decoding, Hadamard Matrices and Codes, Reed Muller Codes, Quadratic Residue Codes, Golay Codes; Gilbert – Varshamov Bound, Plotkin Bound, Griesmer Bound, Linear Programming and Related Bounds, McEliece – Rodemich – Rumsey – Welch Bound; Bursty Channels, Interleavers and Concatenation; Soft Decision Decoding Algorithms;	14 hr
Unit IV	Convolutional Codes, Viterbi Algorithm, Error Analysis, Puncturing, Suboptimal decoding algorithm for Convolutional codes, convolutional codes as block codes, Trellis representation of Block and Cyclic Codes, Trellis Coded Modulation. Turbo Codes – Encoding parallel concatenated codes, decoding algorithms, Error Floor and Weight Distribution. Low Density Parity Check Codes – Construction, Tanner graphs, Decoding. Space Time Coding – Fading Channels, Rayleigh Fading, MIMO Channel, Space Time Block Codes, Space – Time Trellis Codes.	10 hr

Books/References:

1. T. K. Moon, "Error Correction Coding: Mathematical Methods and Algorithms", Wiley, 2006
2. W. C. Huffman and V. Pless, "Fundamentals of Error – Correcting Codes", CUP, 2003.
3. S. Lin and D. J. Costello, "Error Control Coding: Fundamentals and Application", 1983.
4. R. H. Morelos-Zaragoza, "The Art of Error Correcting Codes", Wiley, 2002.

EC 9014 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY 3-0-0 3

Units	Topics	Lectures
Unit I	Introduction to Electromagnetic Compatibility (EMC), EMC Requirements for Electronic Systems,Radiated Emissions,Conducted Emissions ,Spectra of Digital Waveforms,The Spectrum of Trapezoidal (Clock) Waveforms,pectral Bounds for Trapezoidal Waveforms, Effect of Rise/Falltime on Spectral Content,Bandwidth of Digital Waveforms, Effect of Repetition Rate and Duty Cycle,Effect of Ringing (Undershoot/Overshoot)	6 hr
Unit II	Transmission Lines and Signal Integrity : The Transmission-Line Equations, Printed Circuit Board (PCB) Structures,High-Speed Digital Interconnects and Signal IntegritySinusoidal Excitation of the Line and the Phasor Solution	
Unit III	Conducted Emissions and Susceptibility: Measurement of Conducted Emissions,1 The Line Impedance Stabilization Network (LISN),Common- and Differential-Mode Currents Again, Power Supply Filters,Basic Properties of Filters, A Generic Power Supply Filter Topology,Effect of Filter Elements on Common	6 hr
Unit IV	Differential-Mode Currents,Separation of Conducted Emissions into Common and Differential-Mode Components for Diagnostic Purposes,Power Supplies,Linear Power Supplies,Switched-Mode Power Supplies (SMPS), Effect of Power Supply Components on ConductedEmissions, Power Supply and Filter Placement,Conducted Susceptibility	8 hr
Unit V	Crosstalk: Three-Conductor Transmission Lines and Crosstalk,The Transmission-Line Equati ons for Lossless Lines,The Per-Unit-Length Parameters,Homogeneous versus Inhomogeneous Media, Wide-Separation Approximations for Wires, Numerical Methods for Other Structures, Wires with Dielectric Insulations(Ribbon Cables),Rectangular Cross-Section Conductors(PCB Lands), The Inductive –Capacitive Coupling Approximate Model, Frequency-Domain Inductive-Capacitive Coupling Model, Inclusion of Losses: Common-Impedance Coupling,Time-Domain Inductive – Capacitive Coupling Model	6 hr
Unit VI	Shielding Effectiveness: Far-Field Sources, Exact Solution, Approximate Solution, Shielding Effectiveness: Near-Field Sources, Near Field versus Far Field,Electric Sources,Magnetic Sources, Low-Frequency, Magnetic Field Shielding, Effect of Apertures, System Design for EMC.	8 hr

Books/References:

1. Clayton R Paul: Introduction to Electromagnetic Compatibility Wiley 2nd Edition
2. V.P. Kodali, "Engineering Electromagnetic Compatibility",S. Chand & Co. Ltd., New Delhi, 2000.
3. "Electromagnetic Interference and Compatibility", IMPACT series, IIT-Delhi, Modules1-9.
4. Keiser, "Principles of Electromagnetic Compatibility", 3rd ed., , Artech House

EC 9015 CHANNEL MODELLING FOR WIRELESS COMMUNICATION 3-0-0 3

Units	Topics	Lectures
Unit I	Propagation Mechanisms - Free space propagation, reflection and transmission, diffraction, scattering on rough surfaces, wave guiding	6 hr
Unit II	Statistical Description of Wireless Channels - The time-invariant two-path model, time-variant two-path model, small-scale fading without line-of-sight, small-scale fading with line-of-sight, Doppler spectra, level crossing rate and random FM, large-scale fading	6 hr
Unit III	Wideband Channel Characterization - Narrowband vs. wideband systems, system-theoretic description of propagation channels, the WSSUS model, description methods for time dispersion, description methods for angular dispersion	8 hr
Unit IV	Channel Models - Narrowband models, wideband models, spatial models, deterministic models, models for ultra wideband channels	6 hr
Unit V	Channel Sounding - Time-domain methods, frequency-domain methods, generalizations, spatially resolved methods	8 hr
Unit VI	Antenna aspects in wireless systems - Requirements for antennas in mobile radio, antennas for mobile stations, antennas for base stations, aspects of multiple antenna systems.	8 hr

Books/References:

1. Wireless Communications, 2nd Edition, by Andreas F. Molisch, Wiley
2. Wireless Communications, 2nd Edition, by Andrea Goldsmith, Cambridge University Press
3. Wireless Communication: Principles and Practice, 2nd Edition, by Theodore Rappaport, Prentice Hall

EC 9016 HIGH SPEED COMMUNICATION TECHNIQUES 3-0-0 3

Units	Topics	Lectures
Unit I	High Speed Networks: Frame Relay Networks – Asynchronous transfer mode - ATM Protocol Architecture, ATM logical Connection, ATM Cell – ATM Service Categories – AAL. High Speed LAN's: Fast Ethernet, Gigabit Ethernet, Fiber Channel – Wireless LAN's: applications, requirements – Architecture of 802.11	10 hr
Unit II	Congestion and Traffic Management: Queuing Analysis – queuing Models – Single Server Queues – Effects of Congestion – Congestion Control – Traffic Management – Congestion Control in Packet Switching Networks – Frame Relay Congestion Control	8 hr
Unit III	TCP and ATM Congestion Control: TCP Flow Control – TCP Congestion Control – Retransmission – Timer Management – Exponential RTO back off – KARN's Algorithm – Window Management – Performance of TCP over ATM Traffic and Congestion control in ATM – Requirements – Attributes – Traffic Management Frame work, Traffic control – ABR traffic Management - ABR rate control, RM cell formats ABR Capacity allocations – GFR traffic management	14 hr
Unit IV	Integrated and Differentiated Services: Integrated Services Architecture - Approach, Component s, Services – Queuing Discipline, FQ, PS, BRFQ, GPS, WFQ – Random Early Detection, Differentiated Services. Protocols for QOS Support: RSVP – Goals & Characteristics, Data Flow, RSVP operations, Protocol Mechanisms – Multiprotocol Label. Switching – Operations, Label Stacking, Protocol details – RTP – Protocol Architecture, Data Transfer Protocol, RTCP	10 hr

Books/References:

1. High Speed Networks and Internet", Communication networks, Edition, 2001, By William Stallings, ean Harcourt Asia Pvt. Ltd
2. MPLS and VPN architecture, Volume 1 and 2, 2003, by Irvan Pepelnjk, Jim Guichard and Jeff Apcar, Cis co Press.
3. Encyclopedia of Networking and telecommunications, 2001, By Tom Sheldon, TMH.

EC 9017 SIGNAL PROCESSING FOR COMMUNICATION 3-0-0 3

Units	Topics	Lectures
Unit I	History and philosophy. Descret time signals. Definitions: Descrete time abstraction, Basic signals, deigital frequency, Elementary operator, reproducing formula, energy and power. Classes of Descret time signals	6 hr
Unit II	Signal space and Hilbert spaces: Euclidean Geometry, Vector spaces to Hilbert spaces.Subspace, base and projections. Finite length signals, Periodic signals and Infinite sequences. Fourier analysis: DFT, DFS, DTFT, Relationship between transforms, FT Properties, Time and Frequency Analysis	8 hr
Unit III	Stochastic Signal Processing: Random Variables, Random Vectors, Random Processes. Spectral representation of Stataionary Random Processes: Power Spectral Density, PSD of a Stationary Process, White Noise. Stochastic Signal Processing	10 hr
Unit IV	Interpolation and Sampling: Continuous Time Signals. Interpolation: Local Interpolation, Polynomial interpolation, Sinc interpolation. Sampling Theorem. Anliasing: Intuition and proof. Non-Bandlimitted Signals. Descrete Time processing of analog Signals: Digital differentiator, Fractional Delays.	8 hr
Unit V	Data Comvertors and Multirate Signal Processing: Quantixzation, Uniform Scalar Quantization, Advanced Quantizer, ADC and DAC. Multirate Signal processing: Downsampling: Downsampling OperatorProperties, Frequency Domain Representation. Upsampling and Interpolation. Oversampled ADC and DAC.	10 hr

Books/References:

1. Paolo Prandoni, Martin Vetterli, "Signal Processing for Communications" EPEL Press.
2. Fredric J. Harris, "Multirate Signal Processing for Communication Systems" Pearson.
3. Martin Vetterli, Jelena Kovacevic, Vivek K Goyal, "Foundations of Signal Processing".
4. Ananthram Swami, Qing Zhao, Yao-Win Hong, Lang Tong, "Wireless Sensor Networks: Signal Processing an d Communications Perspectives" Wiley.

EC 9018 ADVANCED DIGITAL SIGNAL PROCESSING 3-0-0 3

Units	Topics	Lectures
Unit I	Parametric methods for power spectrum estimation: Relationship between the auto correlation and the model parameters – The Yule – Walker method for the AR Model Parameters – The Burg Method for the AR Model parameters – unconstrained least-squares method for the AR Model parameters – sequential estimation methods for the AR Model parameters – selection of AR Model order.	6 hr
Unit II	Adaptive signal processing :FIR adaptive filters – steepest descent adaptive filter – LMS algorithm – convergence of LMS algorithms – Application: noise cancellation – channel equalization – adaptive recursive filters – recursive least squares.	8 hr
Unit III	Multirate signal processing :Decimation by a factor D – Interpolation by a factor I – Filter Design and implementation for sampling rate conversion: Direct form FIR filter structures – Polyphase filte r structure.	10 hr
Unit IV	Linear prediction and optimum linear filters: Innovations Representation of a Stationary Random Process, Forward and Backward Linear Prediction, Solution of the Normal Equations, Levinson-Durbin Algorithm, Schiir Algorithm, Properties of the Linear Prediction-Error Filters, Wiener Filters for Filtering and Prediction .	8 hr
Unit V	Wavelet transforms :Fourier Transform : Its power and Limitations – Short Time Fourier Transform – The Gabor Transform - Discrete Time Fourier Transform and filter banks – Continuous Wavelet Transfor m – Wavelet Transform Ideal Case – Perfect Reconstruction Filter Banks and wavelets – Recursive multi-resolution decomposition – Haar Wavelet – Daubechies Wavelet .	10 hr

Books/References:

1. John G.Proakis, Dimitris G.Manobakis, Digital Signal Processing, Principles, Algorithms and Applications, Third edition, (2000) PHI.
2. Monson H.Hayes – Statistical Digital Signal Processing and Modeling, Wiley, 2002.
3. L.R.Rabiner and R.W.Schaber, Digital Processing of Speech Signals, Pearson Education(1979).
4. Roberto Crist, Modern Digital Signal Processing, Thomson Brooks/Cole (2004).
5. Raghuveer. M. Rao, Ajit S.Bopardikar, Wavelet Transforms, Introduction to Theory and applications, P earson Education, Asia, 2000.

EC 9019 VLSI TECHNOLOGY 3-0-0 3

Units	Topics	Lectures
Unit I	Environment for VLSI Technology: Clean room and safety requirements. Wafer cleaning processes and wet chemical etching techniques. Solid State diffusion modelling and technology; Ion Implantation modeling, technology and damage annealing	7 hr
Unit II	Oxidation and Lithography: Kinetics of Silicon dioxide growth both for thick, thin and ultrathin films. Oxidation technologies in VLSI and ULSI; Photolithography, E-beam lithography and newer lithography techniques for VLSI/ULSI; Mask generation	9hr
Unit III	Chemical Vapor Deposition techniques : CVD techniques for deposition of polysilicon, silicon dioxide , silicon nitride and metal films; Epitaxial growth of silicon; modelling and technology.Metal film deposition : Evaporation and sputtering techniques. Failure mechanisms in metal interconnects ; Multi-level metallization schemes	14 hr 12 hr
Unit IV	Plasma and Rapid Thermal Processing: PECVD, Plasma etching and RIE techniques; RTP techniques for annealing, growth and deposition of various films for use in ULSI.Process integration for NMOS, CMOS and Bipolar circuits; Advanced MOS technologies.	

Books/References:

1. C.Y. Chang and S.M.Sze (Ed), ULSI Technology, McGraw Hill Companies Inc, 1996.
2. S.K. Ghandhi, VLSI Fabrication Principles, John Wiley Inc., New York, 1983.
3. S.M. Sze (Ed), VLSI Technology, 2nd Edition, McGraw Hill, 1988.

EC 9020 CMOS ANALOG IC DESIGN 3-0-0 3

Units	Topics	Lectures
Unit I	A Review of MOS equations in weak (sub-threshold) and strong inversion regions, MOS controlled switch; MOS diode; MOS capacitor; MOS active resistor, single-stage common source, common gate and common drain amplifiers.	5 hr
Unit II	MOS current mirrors (simple, cascode and low-voltage wide swing types), supply and temperature independent biasing method. Multiple current source and sink design.	6hr
Unit III	Stability analysis of closed loop amplifier, loop-gain, frequency and time domain behavior, open-loop gain and gain bandwidth product, gain and phase cross-over frequencies, multiple poles and zeros of closed loop amplifier, pre-dominant and non-dominant poles, gain margin and phase margin optimization for stable system design, various frequency-compensation techniques (Miller's and feed-forward path).	6 hr
Unit IV	Op-amp at the block level, ideal and real behaviors of op-amp, multi-stage op-amp and its frequency compensation, Two-stage current mirror op-amp, telescopic and folded cascode op-amp design equations, non-ideal behavior such as slew rate, DC off-set, Ibias offset and device mismatch effect s.	6 hr
Unit V	Voltage gain, limit of input common mode range (ICMR), significance of CMRR and PSRR, inverting and non-inverting amplifiers, op-amp-mismatch and noise effects, single-ended and fully differential op-amps, common- mode feedback circuit for FD-Op-amp, MOS thermal and flicker noise equations, O noise and Inoise spectral densities, noise corner frequency.	7 hr
Unit VI	Operational transconductance amplifier (OTA), transconductance gain equations in weak and strong inversion regions, two-stage OTA design (telescopic, cascode and folded-cacode types), single ended and fully- differential OTAs, frequency compensation techniques to increase phase margin for stable OTA structures.	4 hr
Unit VII	Voltage and current reference, band-gap reference; beta multiplier, active RC bi-quadratic filters using integrators loop, switched capacitor (SC) filter, OTA-C bi-quadratic filters	6 hr

Books/References:

1. Analog Circuit Design: Art, Science and Personalities (EDN Series for Design Engineers) (Paperback), Jim Williams, Newnes; Reprint edition, 1991.
2. Analog Integrated Circuit Design, David Johns and Ken Martin, John Wiley & Sons, 1997.
3. Mixed Analog Digital VLSI Devices and Technology (An introduction), Y. Tsividis, World Scientific, N ew Jersey, 2002.
4. Analysis and design of Analog Integrated Circuits, Gray, Hurst, Lewis, and Meyer, 4th Edition, John Wiley and Sons.

EC 9021 LOW POWER VLSI DESIGN 3-0-0 3

Units	Topics	Lectures
Unit I	Introduction: Power dissipation analysis, Physics of Power Dissipation in CMOS FET Devices, Dynamic power, Static power	9 hr
Unit II	Low-power circuit techniques –Voltage scaling and threshold-voltage hurdle in low-power design, Low power design Using Energy Recovery Technique	7 hr
Unit III	Advanced Techniques - Low Power CMOS VLSI Design, Low-power circuit level and device level approach	10 hr
Unit IV	Low-power Analog and digital design issues in weak inversion and strong inversion regions of operation	6 hr
Unit V	Power Estimation - Synthesis for Low Power - Design and Test of Low Voltages - CMOS Circuits.	8 hr

Books/References:

1. Gary Yeap " Practical Low Power Digital VLSI Design",1997.
2. Kaushik Roy, Sharat Prasad, "Low Power CMOS VLSI Circuit Design", 2000.

EC 9022 DIGITAL IC DESIGN 3-0-0 3

Units	Topics	Lectures
Unit I	Introduction; Metrics; Switch Logic; Process; Gates; MOS Transistor; Inverter VTC,MOS Capacit or; Inverter Delay; Power Buffer Sizing; Wires; CMOS Logic; Logical Effort; Process variation Effects, Introduction to VLSI fabrication.	9 hr
Unit II	Memory; Decoders; Pass Transitor; Dynamic and Static Logic; Domino Logic; Scaling; Adders; Multipiers; Latches; Timing; Clock; SRAM; Design for Performance; Power Performance Tradeoff.	7 hr
Unit III	Analysis and Design of Digital Integrated Circuits. Circuit analysis of piecewise linear single energy storage element networks. Rules for determining states of diodes and transistors. Bipolar junction and field effect transistors as switches.	14 hr
Unit IV	Basic digital logic gates. Integrated circuit logic and building blocks (TTL, MOS, CMOS, ECL, Integrated Injection Logic). Sweep circuits (constant current, Miller, bootstrap), Monostable, Astable, and Bistable (Schmitt Trigger) switching circuits, Applications (pulse width modulator, triangle wave generator, FM function generator design).	10 hr

Books/References:

1. Ivan Sutherlnd, Robert F Sroull, David Harris, Logical Effort: Designing Fast CMOS Circuits
2. N. Weste and K. Eshranghian, Principles of CMOS VLSI Design, Addison Wesley. 1985
3. L. Glaser and D. Dobberpuhl, The Design and Analysis of VLSI Circuits, Addison Wesley, 1985
4. C. Mead and L. Conway, Introduction to VLSI Systems, Addison Wesley, 1979.
5. J. Rabaey, Digital Integrated Circuits: A Design Perspective, Prentice Hall India, 1997.

EC 9023 CAD FOR VLSI 3-0-0 3

Units	Topics	Lectures
Unit I	VLSI Physical Design Automation: VLSI Design Cycle, New Trends in VLSI Design Cycle, Physical Design Cycle, New Trends in Physical Design Cycle, Design Styles, System Packaging Styles.	9 hr
Unit II	Partitioning, Floor Planning, Pin Assignment and Placement: Partitioning – Problem formulation, Classification of Partitioning algorithms, Kernighan- Lin Algorithm, Simulated Annealing, Floor Planning – Problem formulation, Classification of floor planning algorithms, constraint based floor planning, Rectangular Dualization, Pin Assignment – Problem formulation, Classification of pin assignment algorithms, General and channel Pin assignments, Placement – Problem formulation, Classification of placement algorithms, Partitioning based placement algorithms.	7 hr
Unit III	Global Routing and Detailed Routing: Global Routing – Problem formulation, Classification of global routing algorithms, Maze routing algorithms, Detailed Routing – Problem formulation, Classification of routing algorithms, Single layer routing algorithms.	10 hr
Unit IV	Physical Design Automation of FPGAs: FPGA Technologies, Physical Design cycle for FPGAs, Partitioning, Routing – Routing Algorithm for the Non - Segmented model, Routing Algorithms for the Segmented Model; Physical Design Automation of MCMs: Introduction to MCM Technologies, MCM Physical Design Cycle.	6 hr
Unit V	Chip Input and Output Circuits: ESD Protection, Input Circuits, Output Circuits and noise, On-chip clock Generation and Distribution, Latch-up and its prevention	8 hr

Books/References:

1. N.A. Sherwani, "Algorithms for VLSI Physical Design Automation ", 1999.
2. S.H.Gerez, "Algorithms for VLSI Design Automation ", 1998.

EC 9024 DIGITAL AUDIO AND VIDEO COMMUNICATION 3-0-0 3

Units	Topics	Lectures
Unit I	Introduction, Speech production model, speech coding, Quantizers for speech signal, mew-law and optimum Quantizer, Adaptive quantizer, Differential quantization, LDM and ADM, DPCM and Adaptive prediction, linear prediction of speech	6 hr
Unit II	CCITT recommendations for speech digitization, HDTV, Low resolution TV and videoconferencing requirements	8 hr
Unit III	Frequency domain waveform coding of speech-LTC, ATC; Parameter coding of speech channel, format and LPC vecoders	10 hr
Unit IV	Coding of monochrome and colour video signals-Transform and Adaptive transform coding; Sub band coding; Vector quantization; Inter-frame and Hybrid coding; Delayed decision and run length coding	8 hr
Unit V	Effects of transmission errors; Audio and Video conference; Video telephone.	10 hr

Books/References:

1. Digital processing of speech signals by Rabiner L.R., Prentice Hall.
2. Principles of Computer Speech by I.H.Witten.
3. Digital speech : Coding for Low Bit Rate Communication System by A.M.Kondoz, Willey, 2nd ed.
4. Voice and Data Communication handbook by R.J.Bates, McGrow Hill.
5. A practical handbook of Speech Coder by R.Goldberg and L.Rick, CRC Pr.

EC 9025 DESIGN OF SEMICONDUCTOR MEMORIES **3-0-0 3**

11Units	Topics	Lectures
Unit I	RANDOM ACCESS MEMORY TECHNOLOGIES Static Random Access Memories (SRAMs): SRAM Cell Structures-MOS SRAM Architecture-MOS SRAM Cell and Peripheral Circuit Operation-Bipolar SRAM Technologies-Silicon On Insulator (SOl) Technology-Advanced SRAM Architectures and Technologies- Application Specific SRAMs. Dynamic Random Access Memories (DRAMs): DRAM Technology Development-CMOS DRAMs-DRAMs Cell Theory and Advanced Cell Strucutures-BiCMOS DRAMs-Soft Error Failures in DRAMs-Advanced DRAM Designs and Architecture-Application Specific DRAMs.	9 hr
Unit II	NONVOLATILE MEMORIES Masked Read-Only Memories (ROMs)-High Density ROMs-Programmable Read-Only Memories (PROMs)- Bipolar PROMs-CMOS PROMs-Erasable (UV) - Programmable Road-Only Memories (EPROMs)-Floating- Gate EPROM Cell-One-Time Programmable (OTP) Eproms-Electrically Erasable PROMs (EEPROMs)- EEPROM Technology And Arcitecture-Nonvolatile SRAM-Flash Memories (EPROMs or EEPROM)-Advanced Flash Memory Architecture.	7 hr
Unit III	MEMORY FAULT MODELING, TESTING, AND MEMORY DESIGN FORTESTABILITY AND FAULT TOLERANCE RAM Fault Modeling, Electrical Testing, Peusdo Random Testing-Megabit DRAM Testing- Nonvolatile Memory Modeling and Testing-IDDQ Fault Modeling and Testing-Application Specific Memory Testing.	10 hr
Unit IV	SEMICONDUCTOR MEMORY RELIABILITY AND RADIATION EFFECTS General Reliability Issues-RAM Failure Modes and Mechanism-Nonvolatile Memory Reliability-Reliability Modeling and Failure Rate Prediction-Design for Reliability-Reliability Test Structures- Reliability Screening a nd Qualification. Radiation Effects-Single Event Phenomenon (SEP)-Radiation Hardening Techniques-Radiation Hardening Process and Design Issues-Radiation Hardened Memory Characteristics-Radiation Hardness Assurance and Testing - Radiation Dosimetry-Water Level Radiation Testing and Test Structures.	6 hr
Unit V	ADVANCED MEMORY TECHNOLOGIES AND HIGH-DENSITY MEMORYPACKAGING TECHNOLOGIES Ferroelectric Random Access Memories (FRAMs)-Gallium Arsenide (GaAs) FRAMs-Analog Memories-Magnetoresistive Random Access Memories (MRAMs)-Experimental Memory Devices. Memory Hybrids and MCMs (2D)-Memory Stacks and MCMs (3D)-Memory MCM Testing and Reliability Issues-Memory Cards-High Density Memory Packaging Future Directions	8 hr

Books/References:

1. Ashok K.Sharma, " Semiconductor Memories Technology, Testing and Reliability ", Prentice-Hall of Ind ia Private Limited, New Delhi, 1997.
2. R. Jacob Baker, "DRAM"

EC 9026 MEMS AND MICROSYSTEMS TECHNOLOGY **3-0-0 3**

Units	Topics	Lectures
Unit I	Historical Background: Silicon Pressure sensors, Micromachining, MicroElectroMechanical Systems.	7 hr
Unit II	Microfabrication and Micromachining : Integrated Circuit Processes, Bulk Micromachining : Isotropi c Etching and Anisotropic Etching, Wafer Bonding, High Aspect-Ratio Processes (LIGA)	8 hr
Unit III	Physical Microsensors: Classification of physical sensors, Integrated, Intelligent, or Smart s ensors, Sensor Principles and Examples : Thermal sensors, Electrical Sensors, Mechanical Sensors, Chemical and Biosensors	9 hr
Unit IV	Microactuators : Electromagnetic and Thermal microactuation, Mechanical design of microactuators, Microactuator examples, microvalves, micropumps, micromotors-Microactuator systems: Success Stories, Ink-Jet printer heads, Micro-mirror TV Projector	9 hr
Unit V	Surface Micromachining: One or two sacrificial layer processes, Surface micromachining requirements, Polysilicon surface micromachining, Other compatible materials, Silicon Dioxide, Silicon Nitride, Piezoelectric materials, Surface Micromachined Systems: Success Stories, Micromotors, Gear trains, Mechanisms,RF/Electronics device/systemand Applications.	9 hr

Books/References:

1. Stephen D. Senturia, "Microsystem Design" by, Kluwer Academic Publishers, 2001.
2. Marc Madou, "Fundamentals of Microfabrication" by, CRC Press, 1997.Gregory Kovacs, "Micromachined Tr ansducers Sourcebook" WCB McGraw-Hill, Boston, 1998.
3. M.-H. Bao, "Micromechanical Transducers: Pressure sensors, accelrometers, and gyroscopes" by Elsevie r, New York, 2000.

EC 9027 ADVANCED COMPUTER ARCHITECTURE **3-0-0 3**

Units	Topics	Lectures
Unit I	Introduction: review of basic computer architecture, quantitative techniques in computer design, measuring and reporting performance. CISC and RISC processors.	9 hr
Unit II	Pipelining : Basic concepts, instruction and arithmetic pipeline, data hazards, control hazards, and structural hazards, techniques for handling hazards. Exception handling, Pipeline optimization techniques, Compiler techniques for improving performance.	7 hr
Unit III	Hierarchical memory technology: Inclusion, Coherence and locality properties; Cache memory organizations, Techniques for reducing cache misses; Virtual memory organization, mapping and management techniques, memory replacement policies.	10 hr
Unit IV	Instruction-level parallelism: basic concepts, techniques for increasing ILP, superscalar, super pipelined and VLIW processor architectures, Array and Vector processors	6 hr
Unit V	Multiprocessor architecture: taxonomy of parallel architectures. Centralized shared-memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared-memory, architecture, Cluster computers, Non Von Neumann architectures: data flow computers, reduction computer architectures, systolic architectures	8 hr

Books/References:

1. Kai Hwang, "Advanced Computer Architecture ", McGraw Hill International, 1993.
2. William Stallings, "Computer Organization and Architecture ", Macmillan Publishing Company, 1990.
3. M.J. Quinn, "Designing Efficient Algorithms for Parallel Computers ", McGraw Hill International, 199 4.

EC 9028 ANALOG FILTER DESIGN 3-0-0 3

Units	Topics	Lectures
Unit I	Introduction: transfer function, pass bands and attenuation band of ideal and realizable filters, comparison between passive and active filters, Design of second order filters (all types i.e. low pass, high pass, band pass, band reject, all pass) with unity and variable gain. Design of second order state variable filters, switched capacitor circuits, switched capacitor integrators (inverting and non-inverting type), universal SC filters, frequency limitation of SC filters, multiple order ca scade filters, sensitivity of passive and active filters.	9 hr
Unit II	Introduction to operational transconductance amplifier, bipolar and MOS OTA, OTA characteristic, OTA biasing techniques, OTA based tunable filters, active only Biquadratic filters, high frequency OTA RF filters, two integrators loop g_m-C universal Biquadratic filters, OTA based LC filters, Voltage mode vs current mode filters, Adjoint and transpose conversion methods.	7 hr
Unit III	Introduction to Current mode Filters: Current conveyors, all generation of current conveyors and their transfer matrix, Bi-polar and CMOS CC cells, detailed analysis of second generation current conveyors (CC-II), Filter design methods using CC-I and CC-II, CCC-II	14 hr
Unit IV	Introduction to Current Feedback operational Amplifier: CC-II and buffer based CFOA CMOS Cell, merits of CFOA over op-amp, CFOA based oscillator, CFOA based active universal filters.	10 hr

Books/References:

1. Design with Operational Amplifier and Analog Integrated Circuits, Third Edition by Sergio Franco, Ta ta Mc Graw-Hill.
2. Linear Integrated Circuits, by S Salivahannn, V S Kanchana Bhaaskaran, The Mc Graw-Hill Companies.
3. A Text book of Operational Transconductance Amplifier and Analog Integrated Circuits, by Tahira Parv een, Reprint 2010, I.K. International Publishing HousePvt. Ltd. New Delhi & Bangalore, ISBN: 978-93-80026-55-8.
4. Low Voltage Low Power CMOS Current Conveyorsby Giuseppe Ferri and Nicola C. Guerrini, Kluwer Academi c Publisher Boston/ Dordrecht/ London, 2003.ISBN: 1-4020-7486-7.

EC 9029 VLSI SIGNAL PROCESSING 3-0-0 3

Units	Topics	Lectures
Unit I	Introduction to DSP systems - Iteration Bound - Pipelined and parallel processing	9 hr
Unit II	Retiming - Unfolding - Algorithmic strength reduction in filters and transforms.	7 hr
Unit III	Systolic architecture design - fast convolution - Pipelined and parallel recursive and adaptive filt ers.	10 hr
Unit IV	Scaling and round off noise - Digital lattice filter structures - Bit level arithmetic architecture - Redundant arithmetic	6 hr
Unit V	Numerical strength reduction - Synchronous, wave and asynchronous pipe lines - low power design - programmable digital signal processors	8 hr

Books/References:

1. Keshab K.Parthi, " VLSI Digital Signal Processing systems, Design and implementation ", Wiley, Inter Science, 1999.
2. Mohammed Isamail and Terri Fiez, " Analog VLSI Signal and Information Processing ", Mc Graw-Hill, 19 94.
3. S.Y. Kung, H.J. White House, T. Kailath, " VLSI and Modern Signal Processing ", Prentice Hall, 1985.
4. Jose E. France, Yannis Tsividis, " Design of Analog - Digital VLSI Circuits for Telecommunication an d Signal Processing", Prentice Hall, 1994.

EC 9030 VLSI DATA CONVERSION CIRCUIT 3-0-0 3

Units	Topics	Lectures
Unit I	Sampling, Spectral properties of sampled signals, Oversampling and its implications on anti-alias filter design, Time Interleaved Sampling, Analysis of a Ping-Pong Sampling system, Analysis of Offset and Gain Errors in Time-Interleaved Sample and Holds.	7 hr
Unit II	Bottom Plate Sampling, Gate Bootstrapped Switch, the Nakagome Charge- Pump, Characterizing a Sample-and-Hold, Correct choice of input frequency, Discrete Fourier Series Refresher, FFT Leakage and the ectangular Window, Spectral Windows, the Hann Window, the Blackman Window.	8 hr
Unit III	Switch Capacitor Circuits, Parasitic Insensitive SC Amplifiers, Nonidealities in SC Amplifiers: Finite Opamp Gain and DC Offset., Finite Opamp Gain-Bandwidth Product, Introduction to Fully Differential Operation.	8 hr
Unit IV	Integral Nonlinearity (INL), Dynamic Characterization of ADCs, SQNR, Quantization Noise Spectrum, SFDR, Flash A/D Converter Basics, the Regenerative Latch, Preamp Offset Correction (Auto-zeroing).	9 hr
Unit V	Coupling Capacitor Considerations in an Auto-zeroed Preamp, Transistor Level Preamp Design, Timing issues in a flash ADC. Bubble Correction Logic in a Flash ADC, Comparator Meta-stability, D/A Converter Basics, INL/DNL, DAC Spectra and Pulse Shapes.NRZ vs RZ DACs and Oversampled Approaches to Data Conversion.	10 hr

Books/References:

1. Understanding Delta - Sigma Data Converters: R. Schreier, Wiley.
2. Understanding Delta-Sigma Data Converters : R.Schreier and G.Temes.
3. John Wiley CMOS Data Converters for Communications: N.Tan, Springer

EC 9031 TESTING AND VERIFICATION OF VLSI CIRCUITS 3-0-0 3

Units	Topics	Lectures
Unit I	Scope of testing and verification in VLSI design process. Issues in test and verification of complex chips, embedded cores and SOCs	9 hr
Unit II	Fundamentals of VLSI testing. Fault models. Automatic test pattern generation. Design for testability	7 hr
Unit III	Scan design. Test interface and boundary scan. System testing and test for SOCs. Iddq testing. Delay fault testing. BIST for testing of logic and memories. Test automation	14 hr
Unit IV	Design verification techniques based on simulation, analytical and formal approaches. Functional verification. Timing verification. Formal verification. Basics of equivalence checking and model checking. Hardware emulation.	10 hr

Books/References:

1. M. Bushnell and V. D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers, 2000.
2. M. Abramovici, M. A. Breuer and A. D. Friedman, "Digital Systems Testing and Testable Design", IEEE Press, 1990.
3. T.Kropf, "Introduction to Formal Hardware Verification", Springer Verlag, 2000.
4. P. Rashinkar, Paterson and L. Singh, "System-on-a-Chip Verification-Methodology and Techniques", Kluwer Academic Publishers, 2001.

EC 9032 DIGITAL SYSTEM DESIGN USING FPGA 3-0-0 3

Units	Topics	Lectures
Unit I	Introduction to Digital design, hierarchical design, controller (FSM), case study	9 hr
Unit II	FSM issues, timing issues, pipelining, resource sharing, metastability, synchronization	7 hr
Unit III	MTBF Analysis, setup/hold time of various types of flip-flops, synchronization between multiple clock domains, reset recovery, proper resets	10 hr
Unit IV	VHDL: different models, simulation cycles, process, concurrent and sequential statements, loops, delay models, library, packages, functions, procedures, coding for synthesis, test bench	6 hr
Unit V	FPGA: logic block and routing architecture, design methodology, special resources, Virtex-II, Strati x architectures, programming FPGA, constraints, STA, timing closure, case study.	8 hr

Books/References:

1. Wakerly, J.F., Digital Design: Principles and Practices, Prentice Hall.
2. Kevin Skahil, VHDL For Programmable Logic, Addison Wesley.
3. FPGA Data sheets, Application Notes.
4. Current literature from relevant journals and conference proceedings.

EC 9033 PHOTONICS INTEGRATED CIRCUITS 3-0-0 3

Units	Topics	Lectures
Unit I	Principles: Introduction to photonics, optical waveguide theory, numerical techniques and simulation tools, photonic waveguide components – couplers, tapers, bends, gratings. Electro-optic, acousto-optic, magneto-optic and non-linear optic effects. Modulators, switches, polarizer s, filters, resonators, optoelectronics integrated circuits. Amplifiers, mux/demux, transmit receive modules	16 hr
Unit II	Technology: materials – glass, lithium niobate, silicon, compound semiconductors, polymers. Fabrication – lithography, ion-exchange, deposition, diffusion. Process and device characterization. Packaging and environmental issues	14 hr
Unit III	Applications: photonic switch matrices. Planar lightwave circuits, delay line circuits for antenna arrays, circuits for smart optical sensors. Optical signal processing and computing. Micro-opto-electro-mechanical systems.	8 hr
Unit IV	Photonic bandgap structures. VLSI photonics.	4 hr

Books/References:

1. Pollock, C.R., and Lip Son, M., Integrated Photonics, Kluwer Pub., 2003.
2. Tamir, T. (ed.), Guided-wave optoelectronics, Second Edn, Springer Verlag, 1990.
3. Nishihara, H., Haruna, M., and Suhara, T., Optical Integrated Circuits, McGraw Hill, 1988.
4. Murphy, E.J. (ed.), Integrated Optical Circuits and Components: Design and Applications, Marcel and Dekker, 1999.
5. Current literature: Special issues of journals and review articles.

EC 9034 NANOELECTRONICS 3-0-0 3

Units	Topics	Lectures
Unit I	INTRODUCTION TO NANOTECHNOLOGY: Background to nanotechnology: Types of nanotechnology and nanomachines Molecular Nanotechnology: Electron microscope nanodots; nanolithography. Nanomaterials: preparation – plasma arcing – chemical vapor deposition – sol- gels – electrodeposition – ball milling – applications.	6 hr
Unit II	FUNDAMENTALS OF NANOELECTRONICS: Fundamentals of logic devices:- Requirements – dynamic properties – threshold gates; physical limits to computations; concepts of logic devices:- classifications –spintronics – quantum cellular automata – quantum computing – DNA computer; performance of information processing systems;- of biological neurons – performance estimation for the human brain. Ultimate computation:- power dissipation limit – dissipation in reversible computation – the ultimate computer.	8 hr
Unit III	SILICON MOSFETs & QUANTUM TRANSPORT DEVICES: Silicon MOSFETS - Novel materials and alternate concepts:- scaling rules –advanced MOSFET concepts. Quantum transport devices based on resonant tunneling:- Electron tunneling; Single electron devices for logic applications:- Single electron devices – applications of single electron devices to logic circuits.	10 hr
Unit IV	CARBON NANOTUBES: Carbon Nanotube: Fullerenes - types – assemblies – purification of carbon nanotubes – electronic propertics – synthesis of carbon nanotubes – carbon nanotube interconnects – carbon nanotube FETs – Nanotube for memory applications – prospects of an all carbon nanotube nanoelectronics.	8 hr
Unit V	MOLECULAR ELECTRONICS: Electrodes & contacts – functions – molecular electronic devices – first test systems – simulation and circuit design – fabrication; Future applications: MEMS – robots – random access memory – mass storage devices	10 hr

Books/References:

1. Michael Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons and Burkhard Raguse, Nanotechnology: Basic Science and Emerging Technologies, Chapman & Hall / CRC, 2002
2. T. Pradeep, NANO: The Essentials – Understanding Nanoscience and Nanotechnology, TMH'07
3. Rainer Waser (Ed.), Nanoelectronics and Information Technology: Advanced Electronic Materials and No vel Devices, Wiley-VCH, 2003
4. George W. Hanson,"Fundamentals of Nanoelectronics", Prentice Hall, 2007.
5. Karl Goser et.al, "Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum device s", Springer, 2005.
6. Mark. A. Reed and Takhee, "Molecular Electronics", American Scientific Publishers, 2003.
7. Michael C. Petty, "Molecular Electronics: From Principles to Practice", John Wiley & Sons, Ltd, 2007 .

EC 9035 NEURAL NETWORKS, ARCHITECTURE AND ITS APPLICATIONS 3-0-0 3

Units	Topics	Lectures
Unit I	Network architecture, Artificial intelligence and neural networks, Learning processes, Learning with or without a teacher, Memory adoption, and statistical nature of learning process	6 hr
Unit II	Single layer perception, Adaptive filtering problem, LMS Algorithm, Learning curve, Perception convergence	8 hr
Unit III	Multi-layer perception: Back propagation, algorithm, output presentation and decision rule, supervised learning as optimization problem, Generalized radial basics, Function network	10 hr
Unit IV	Temporal processing using feed forward network, Network Architectures, Distributed time lagged feed forward network, Temporal back propagation algorithm	8 hr
Unit V	Dynamically driven recurrent networks, Sate space model, Learning algorithms, Real time recurrent learning, Kalman Filter, De-coupled extended kalman filters.	10 hr

Books/References:

1. Neural network- A Comprehensive foundation, 2nd Ed, Simon Haykin, Addison Wiseley Longman, New York, 2001.
2. Neural Network- Algorithms, Applications and progggramming, J A Freeman and D M Skapura, AWL, NY, 20 00.
3. An introduction to Neural Network, James A Anderson, Prentice Hall of India, New Delhi

EC 9036 ADAPTIVE SIGNAL PROCESSING 3-0-0 3

Units	Topics	Lectures
Unit I	Introduction to vectors spaces, Review of notion of random variable, stochastic process, moments, ergodicity, LSI filtering of WSS processes, power density spectrum	6 hr
Unit II	Stochastic processes: Cross-correlation, filtering of WSS processes introduction to Wiener filtering. bandlimited processes, harmonic processes, the general linear process, and autoregressive processes stochastic models, autoregressive models, AR process, stochastic processes, MA and ARMA processes.	8 hr 10 hr
Unit III	Simulation of AR processes and Wiener filtering. Comparison of time averages and ensemble averages. IIR Wiener filter for general linear process.	8 hr
Unit IV	Introduction to eignenvalue and eigenvector analysis of correlation matrix. Wiener filter using eigenvector basis, finished Wiener filter slides.	10 hr
Unit V	Linear Prediction: FIR and IIR MMSE linear prediction. Introduction to "Backward Linear Prediction". Backward linear prediction, Gram Schmidt orthogonalization, Levinson algorithm. Prediction error filters, the lattice structure, joint-process estimation	

Books/References:

1. S. Haykin, Adaptive Filter Theory, fifth edition, Prentice Hall, 2013.
2. A. Sayed, Adaptive Filters, Wiley-IEEE Press, 2008. Available as ebook through University of Ottawa library.

EC 9037 SOFT COMPUTING 3-0-0 3

Units	Topics	Lectures
Unit I	Fuzzy Logic: Crisp set and Fuzzy set, Basic concepts of fuzzy sets, membership functions. Basic operations on fuzzy sets, Properties of fuzzy sets, Fuzzy relations	6 hr
Unit II	Propositional logic and Predicate logic, fuzzy If – Then rules, fuzzy mapping rules and fuzzy implication functions, Applications	10 hr
Unit III	Neural Networks: Basic concepts of neural networks, Neural network architectures, Learning methods, Architecture of a back propagation network, Applications	8 hr
Unit IV	Genetic Algorithms: Basic concepts of genetic algorithms, encoding, genetic modeling	8 hr
Unit V	Hybrid Systems: Integration of neural networks, fuzzy logic and genetic algorithms.	10 hr

Books/References:

1. S. Rajasekaran and G.A.Vijaylakshmi Pai.. Neural Networks Fuzzy Logic, and Genetic Algorithms, Prent ice Hall of India.
2. K.H.Lee.. First Course on Fuzzy Theory and Applications, Springer-Verlag.
3. J. Yen and R. Langari.. Fuzzy Logic, Intelligence, Control and Information, Pearson Education

EC 9038 STATISTICAL SIGNAL PROCESSING AND MODELLING 3-0-0 3

Units	Topics	Lectures
Unit I	Review of random variables: Distribution and density functions, moments, independent, uncorrelated and orthogonal random variables; Vector-space representation of Random variables, Schwarz Inequality Orthogonalit principle in estimation, Central Limit theorem, Random processes, wide-sense stationary processes, autocorrelation and autocovariance functions, Spectral representation of random signals, Wiener Khinchin theorem Properties of power spectral density, Gaussian Process and White noise process, Linear System with random input, Spectral factorization theorem and its importance, innovation process and whitening filter, .Random signal modelling: MA(q), AR(p) , ARMA(p,q) models.	6 hr
Unit II	Parameter Estimation Theory: Principle of estimation and applications, Properties of estimate s, unbiased and consistent estimators, Minimum Variance Unbiased Estimates (MVUE), Cramer Rao bound, Efficient estimators; Criteria of estimation: the methods of maximum likelihood and its properties ; Baysean estimation : Mean square error and MMSE, Mean Absolute error, Hit and Miss cost function and MAP estimation	6 hr
Unit III	Estimation of signal in presence of white Gaussian Noise: Linear Minimum Mean-Square Error (LMMSE) Filtering: Wiener Hoff Equation, FIR Wiener filter, Causal IIR Wiener filter, Noncausal IIR Wiener filter, Linear Prediction of Signals, Forward and Backward Predictions, Levinson Durbin Algorithm, Lattice filter realization of prediction error filters.	8 hr
Unit IV	Adaptive Filtering: Principle and Application, Steepest Descent Algorithm Convergence characteristics; LMS algorithm, convergence, excess mean square error, Leaky LMS algorithm;Application of Adaptive filters ; RLS algorithm, derivation, Matrix inversion Lemma, Intialization, tracking of nonstationarity	6 hr
Unit V	Kalman filtering: State-space model and the optimal state estimation problem, discrete Kalman filter, continuous-time Kalman filter, extended Kalman filter.	8 hr
Unit VI	Spectral analysis: Estimated autocorrelation function, periodogram, Averaging the periodogram (Bartlett Method), Welch modification, Blackman and Tukey method of smoothing periodogram, Prametric method, AR(p) spectral estimation and detection of Harmonic signals, MUSIC algorithm	8 hr

Books/References:

1. M. Hays: Statistical Digital Signal Processing and Modelling, John Willey and Sons, 1996.
2. M.D. Srinath, P.K. Rajasekaran and R. Viswanathan: Statistical Signal Processing with Applications, PHI, 1996.
3. Simon Haykin: Adaptive Filter Theory, Prentice Hall, 1996.
4. D.G. Manolakis, V.K. Ingle and S.M. Kogon: Statistical and Adaptive Signal Processing, McGraw Hill, 2000.
5. S. M. Kay: Modern Spectral Estimation, Prentice Hall, 1987.

EC 9039 INTELLIGENT INSTRUMENTATION 3-0-0 3

Units	Topics	Lectures
Unit I	Introduction: Introduction to intelligent instrumentation, Historical Perspective, Current status, software based instruments.	6 hr
Unit II	Virtual Instrumentation, Introduction to graphical programming, data flow & graphical programming techniques, advantage of VI techniques, VIs and sub VIs loops and charts, arrays, clusters and graphs, case and sequence structure, formula nodes, string and file I/O, Code Interface Nodes and DLL links.	8 hr
Unit III	Data Acquisition Methods : Analog and Digital IO, Counters, Timers, Basic ADC designs, interfacing methods of DAQ hardware, software structure, use of simple and intermediate Vis. Use of Data Sockets for Networked communication and controls	10 hr
Unit IV	PC Hardware Review and Instrumentation Buses Structure, timing, interrupts, DMA, operating system, ISA, PCI, USB, PCMCIA Buses. IEEE488.1 & 488.2 serial Interfacing-RS 232C,RS422, RS423, RS485, USB, VXI, SCXI, PXI	8 hr
Unit V	Sensors: Examples and definition, Capacitive sensors: fundamentals, application and examples, Accelerometers, Pizoelectric sensors, Pressure sensors, Thermometers and flow sensors, Radiation sensors, Inductive and Magnetic sensors, Macro machine sensors: design and fabrication.	10 hr

Books/References:

1. G.C. Barney / Intelligent Instrumentation / Prentice Hall, 1995ce.
2. Lisa,K.Wells &Jeffery Travis / Lab VIEW For every one Prentice Hall,1997.
3. A.S. Morris / Principles of measurement and Instrumentation / Prentice Hall, 1993.
4. S. Gupta / P.C Interfacing for data Acquisition & Process Control 2nd Edition / Instrument Society o f America, 1994.
5. Gray Johnson / Lab VIEW Graphical Programming 2nd Edition / Tata Mc Graw Hill, 1997.
6. Bitter, Mohiuddin, Nawrocki / Advanced Cal VIEW Programming Techniques.

EC 9040 DIGITAL IMAGE PROCESSING 3-0-0 3

Units	Topics	Lectures
Unit I	Fundamental concepts of digital geometry, Digital image representation, Fundamental steps in image processing, Elements of digital image Processing systems, Image acquisitions, Storage, Processing, Communication, Display digital image fundamentals. Elements of visual perception, Simple image model, Sampling and quantization, Basic relationships between pixels, neighbour of pixels, Connectivities, Relation, Equivalence and transitive clause, Distance measures , Arithmetic/logic operations.	6 hr
Unit II	Imaging Geometry: basic transformations, perspective transformations, Camera models; Photographic films- Film structure and exposure, film Characteristics diaphragm and shutter setting. Introduction to Fourier Transform, the discrete Fourier Transform, some properties of two dimensional Fourier Transform, separability, translation periodicity and conjugate symmetry, rotation, distributivity, and scaling, average value, Laplacian, convolution, and Correlation sam pling, Fast Fourier Transforms, FFT algorithm, Inverse FFT, Implementation.	8 hr
Unit III	Image enhancement: Spatial domain methods, Frequency domain method, Enhancement by point processing , Simple intensity transforms, Histogram processing, Image subtraction, Image averaging, Spatial filtering, Smoothing filters Image restoration : Degradation model, Degradation model for continuous Functions, algebra approach to restoration, Un-constrained restoration, constrained restoration, Removal of blur caused by uniform linear motion, Blind image, Deconvolution, Some algorithms.	10 hr
Unit IV	Image coding- Redundancy, Interpixel redundancy, Measuring information, Information channel, Fundamental coding theorem, Image Segmentation , Line detection, Edge detection, Thresholding, Region splitting and merging..	8 hr

Units	Topics	Lectures
Unit V	Image compression, Image compression models: The source encoder and decoder, Channel encoder and decoder, Error free compression, Variable length coding, Lossless predictive coding, Lossy compression: Lossy predictive coding, Transformed coding, Synthesis and analysis of image, Recognition, interpretation ensors, Radiation sensors, Inductive and Magnetic sensors, Macro machine sensors: design and fabrication.	10 hr

Books/References:

1. Digital Image Processing (3rd Edition) by Rafael C. Gonzalez and Richard E. Woods.
2. Digital Image Processing Using Java, Efford, AWL, NY, 2000.
3. The Computer Image, A Watt and F.Policarpo AWL,NY, 1999.
4. Fundamentals of Image Processing by A.K.Jain, PHI.

EC 9041 SPEECH PROCESSING 3-0-0 3

Units	Topics	Lectures
Unit I	The Speech Production mechanism: Physiological and Mathematical Model. Relating the physiological and mathematical model. Categorization of Speech Sounds based on the source-system and the articulatory model.	6 hr
Unit II	Speech Signal Processing Concepts: Discrete time speech signals, relevant properties of the fast Fourier transform and Z-transform for speech recognition, convolution, linear and non linear filter banks. Spectral estimation of speech using the Discrete Fourier transform. Pole-zero modeling of speech and linear prediction (LP) analysis of speech. Homomorphic speech signal de convolution, real and complex cepstrum, application of cepstral analysis to speech signals	8 hr
Unit III	The Speech Recognition Front End: Feature extraction for speech recognition, Static and dynamic features for speech recognition, robustness issues, discrimination in the feature space, featur e selection. Mel frequency cepstral co-efficients (MFCC), Linear prediction cepstral coefficients (LPCC), Perceptual LPCC.	10 hr
Unit IV	Distance measures for comparing speech patterns : Log spectral distance, cepstral distances, weighted cepstral distances, distances for linear and warped scales. Dynamic Time Warping for Isolated Word Recognition.	8 hr
Unit V	Statistical models for speech recognition: Vector quantization models and applications in speaker recognition. Gaussian mixture modeling for speaker and speech recognition. Discrete and Continuous Hidden Markov modeling for isolated word and continuous speech recognition.Using the HTK toolkit for building a simple speech recognition system.	10 hr

Books/References:

1. Digital Processing of Speech Signals, LR Rabiner and RW Schafer, Pearson Education.
2. Discrete-Time Speech Signal Processing: Principles and Practice, Thomas F. Quatieri, Cloth, 816 pp . ISBN: 013242942X Published: OCT 29, 2001.
3. Fundamentals of Speech Recognition, L. Rabiner and B. Juang, Prentice-Hall SignalProcessing Series, Pages: 507, Year of Publication: 1993, ISBN:0-13-015157- 2.
4. Speech and Audio Signal Processing: Processing and perception of speech and music B. Gold and N. Morgan, Wiley 2000, ISBN: 0-471-35154-7.
5. Corpus-Based Methods in Language and Speech Processing, Steve Young et. al editors, 234 pages, Kluwe r, ISBN 0-7923-4463-4.
6. Discrete Time Processing of Speech Signals, JR Deller, JG Proakis, JH Hansen, Year of Publication: 1 993, ISBN:0023283017.
7. Hidden Markov Models for Speech Recognition, XD Huang, Y Ariki, MA Jack, Edinburgh University Press.

EC 9042 MODERN CONTROL ENGG 3-0-0 3

Units	Topics	Lectures
Unit I	Discrete Time Systems: Introduction to discret time systems, the Z transformation:, Solving differential equations by z-transformation methods, the inverse z-transformation, Pulse transfer function, Theorems of the z- transformation, zero order hold, response between sampling instants.	6 hr
Unit II	Stability Analysis: Introduction, Relation between s-plane z-plane, Stability analysis using JHRY criterion, Stability analysis using bilinear transformation.	8 hr
Unit III	Time domain analysis of S.D. System: Introduction, Time response of S.D System, Root Loci for digital control systems, Steady state effort analysis of S.D Systems. Frequency domain analysis of S.D Systems, the loci for digital control systems.	10 hr
Unit IV	The Bode Diagram C.M and P.M, State Space analysis of control systems: Introduction, state space representation of continuous and discrete time systems, Solutions of time invariant and time varying state equation. State transition metric; Relation between state equation and transfer function .	8 hr
Unit V	Characteristic equation, Eigen values and Eigen vectors. State model form T.F., Controllability: Introduction, Definitions, Theorems on controllability, Observability: Introduction, Definition, Theorems on observability, Control system design: Design of digital control systems with deadbeat response, pole placement design by state feedback, state observer, Design of full and reduced order observer. Introduction to nonlinear control systems: describing function techniques, Phase plane techniques.	10 hr

Books/References:

1. Digital Control System, Kuo, International Edition, Saunders College Publishing, New York.
2. Digital Control System Analysis and Design, Philips and H T Nagle, PHI.
3. Digital Control of Dynamic Systems, Franklin, Addision Wesley, Tokyo.

EC 9043 BIOMEDICAL SIGNAL PROCESSING 3-0-0 3

Units	Topics	Lectures
Unit I	Introduction: General measurement and diagnostic system, classification of signals, introduction to biomedical signals, Biomedical signal acquisition and processing, Difficulties in signal acquisition. ECG: ECG signal origin, ECG parameters-QRS detection different techniques, ST segment analysis , Arrhythmia, Arrhythmia analysis, Arrhythmia monitoring system.	6 hr
Unit II	ECG Data Reduction: Direct data compression Techniques: Turning Point, AZTEC, Cortes, FAN, Transformation Compression Techniques: Karhunen - Loeve Transform, Other data compression Techniques: DPCM, Huffman coding, Data compression Techniques comparison. Signal averaging: Basics of signal averaging, Signal averaging as a digital filter, A typical averager, Software and limitations of signal averaging.	8 hr
Unit III	Frequency Domain Analysis: Introduction, Spectral analysis, linear filtering, cepstral analysis and homomorphic filtering. Removal of high frequency noise (power line interference), motion artifacts (low frequency) and power line interference in ECG, Time Series Analysis: Introduction, AR models, Estimation of AR parameters by method of least squares and Durbin's algorithm, ARMA models. Spectral modeling and analysis of PCG signals.	10 hr
Unit IV	Spectral Estimation: Introduction, Blackman- tukey method, The periodogram, Pisarenko's Harmonic decomposition, Prony' method, Evaluation of prosthetic heart valves using PSD techniques. Comparison of the PSD estimation methods. Event Detection and waveform analysis: Need for event detection, Detection of events & waves, Correlation analysis of EEG signals, The matched filter, Detection of the P wave , Identification of heart sounds, Morphological analysis of ECG wave s, analysis of activity.	8 hr
Unit V	Adaptive Filtering: Introduction, General structure of adaptive filters, LMS adaptive filter, adapti ve noise cancellation, Cancellation of 60 Hz interference in ECG, cancellation of ECG from EMG signal, Cancellation of maternal ECG in fetal ECG. EEG: EEG signal characteristics, Sleep EEG classification and epilepsy.	10 hr

Books/References:

1. "Biomedical Signal Analysis" A case study approach, Rangaraj M Rangayyan, John Wiley publications.
2. "Biomedical Signal Processing Time and Frequency Domains Analysis (Volume I)", Arnon Cohen, CRC pres s.
3. "Biomedical Signal Processing Principles and Techniques" D.C.Reddy, Tata Mc Graw-Hill.
4. "Biomedical Digital Signal Processing", Willis J. Tompkins, PHI.

EC 9044 EMBEDDED SYSTEM DESIGN 3-0-0 3

Units	Topics	Lectures
Unit I	Introduction to Microcontrollers and Microprocessors: Basic Architectures of Microcontrollers, Processor Types and Memory Structures, Organization of Data Memory; Instruction Set, Addressing Modes and Port Structure, External Memory Access, Timers, Interrupts, Program Branching Instructions, and Serial Communication.	6 hr
Unit II	Introduction to Real Time Embedded Systems: Embedded Systems Components, Memory, Digital Signal Processors, General Purpose Processors, Embedded Processors and Memory-Interfacing.	8 hr
Unit III	Embedded Systems I/O: Interfacing bus, Protocols, Timers, Interrupts, DMA,USB and IrDA, AD and DA Converters, Analog Interfacing.	10 hr
Unit IV	Design of Embedded Processors: Field Programmable Gate Arrays and Applications, Introduction to Hardware Description Languages, Embedded Communications: Serial, Parallel, Network, Wireless Communication.	8 hr
Unit V	Embedded System Software and Software Engineering issues: Introduction to Real-Time Systems, Real-Time Task Scheduling, Concepts in Real-Time Operating Systems, Commercial Real-Time Operating Systems, Introduction to Software Engineering, Requirements Analysis and Specification, Modeling Timing Constraints, Software Design.	10 hr

Books/References:

1. David E Simon, " An embedded software primer ", Pearson education Asia, 2001.
2. John B Peat man " Design with Microcontroller ", Pearson education Asia, 1998.
3. Jonartthan W. Valvano Brooks/cole " Embedded Micro computer Systems. Real time Interfacing ", Thomso n learning 2001.
4. Burns, Alan and Wellings, Andy, " Real-Time Systems and Programming Languages ", Second Edition. Har low: Addison-Wesley-Longman, 1997.
5. Raymond J.A. Bhur and Donald L.Bialey, " An Introduction to real time systems: Design to networking with C/C++", Prentice Hall Inc. New Jersey, 1999.
6. Grehan Moore, and Cyliax, " Real time Programming: A guide to 32 Bit Embedded Development. Reading " Addison-Wesley-Longman, 1998.
7. Heath, Steve, " Embedded Systems Design ", Newnes 1997.

EC 9045 BIO-SENSORS AND BIO MEMS 3-0-0 3

Units	Topics	Lectures
Unit I	Approaches to designing electronic systems Sensor classification & sensing principles Introduction to biosensors & bio MEMS.	8 hr
Unit II	Semiconductor sensors for physical measurands Physicochemical sensors integrable on silicon.	10 hr
Unit III	Biosensors: Structures & device analysis Catalytic biosensors Affinity biosensors.	14 hr
Unit IV	BioMS: Architectures & analytic models.	10 hr

Books/References:

1. SM Sze John Wiley, Semiconductor Devices: Physics & Technology' by, India, 2002.
2. RS Muller, RT Howe, SD Senturia, RL Smith and RM White, 'Microsensors', IEEE Press, New York, 1991.
3. Mohamed Gad-el-Hak (R), MEMS handbook' CRC Press, Boca Raton, 2002.
4. Anthony P.F.Turner, Isao Karube and George S. Wilson, 'Biosensors :fundamentals and applications' , Oxford University Press, Oxford, 1987.
5. S Middelhoek & SA Audet , 'Silicon sensors', Academic Press Limited,London,1989.
6. A Sandana. 'Engineering biosensors: kinetics and design applications', Academic Press, San Diego, 20 02.
7. D Voet & JG Voet , 'Biochemistry', J Wiley & Sons, New York, 1990.

EC 9046 CONVEX OPTIMIZATION 3-0-0 3

Units	Topics	Lectures
Unit I	Convex sets, functions, and optimization problems. Basics of convex analysis. Least-squares, linear and quadratic programs, semidefinite programming, minimax, extremal volume, and other problems.	8 hr
Unit II	Optimality conditions, duality theory, theorems of alternative, and applications. Interiorpoint methods. Subgradient, cutting-plane, and ellipsoid methods. Decentralized convex optimization via primal and dual decomposition.	10 hr
Unit III	Alternating projections. Exploiting problem structure in implementation. Convex relaxations of hard problems, and global optimization via branch & bound. Robust optimization.	14 hr
Unit IV	Applications to signal processing, control, digital and analog circuit design, computational geometry, statistics, and mechanical engineering.	10 hr

Books/References:

1. Boyd, Stephen, and Lieven Vanderberghe. Convex Optimization. Cambridge, UK: Cambridge University Pre ss, 2004.
2. Bertsekas, Dimitri. Convex Optimization Theory. Nashua, NH: Athena Scientific, 2009.
3. Ben-Tal, Aharon, and Arkadi Nemirovski. Lectures on Modern Convex Optimization: Analysis, Algorithms , and Engineering Applications (MPS-SIAM Series on Optimization).

EC-9047 MODERN DIGITAL COMMUNICATION TECHNIQUES 3-0-0 3

Units	Topics	Lectures
Unit I	Analog-to-Digital Conversion: Sampling theorem, Pulse-Amplitude Modulation, Channel bandwidth for PAM signal, Natural sampling, Flat top sampling, Quantization of signals, Quantization error, Pulse-code modulation (PCM), Electrical representation of binary digits, The PCM system, Companding, Multiplexing PCM signals, Differential PCM, Delta modulation, Adaptive delta modulation, Vocoders, Channel Vocoder, Linear Predictive coder.	8 hr
Unit II	Digital Modulation Techniques: Binary Phase-Shift Keying (BPSK), Differential Phase-Shift Ke ying, Differentially-Encoded PSK (DEPSK), Quadrature Phase-Shift Keying (QPSK), Quadrature Amplitude Shift Keying (QASK), Binary Frequency-Shift Keying (BFSK), Similarity of BPSK and BFSK, M-ary FSK, Minimum Shift Keying (MSK).	10 hr
Unit III	Data Transmission: A base band signal receiver, Probability of error, The Optimum Filter, Matched Filter, Probability of error in Matched filter, Coherent reception, Coherent reception of PSK and FSK, Non-Coherent reception of FSK, PSK and QPSK, Calculation of error probability of BPSK and BFSK, Error probability for QPSK] Bit-by-bit encoding versus Symbol- by-Symbol encoding, Relationship between Bit error rate and Symbol Error rate and comparison of modulation systems.	14 hr
Unit IV	Information Theory and Coding: Discrete messages, The concept of amount of information, Entropy, Information rate, Coding to increase average information per bit, Shannon's theorem, Capacity of a Gaussian channel, Bandwidth -S/N tradeoff, use of orthogonal signals to attain Shannon's limit, Efficiency of orthogonal signal transmission, Coding: Parity check bit coding for error detec tion, Coding for error detection and error correction, Block codes (coding and decoding), Convolution codes (coding and decoding), Comparison of error rates in coded and uncoded transmission.	10 hr

Books/References:

1. Wayne Tomasi, "Electronic communications systems" 5th edition Pearson Educaion Asia, 2006
2. Taub and Schilling, "Principles of Communication Systems", TMH, IInd Edition, 2006
3. S. Haykin, "Digital Communication", Wiley, 2006.
4. S. Haykin, "Analog and Digital Communication", Wiley.

EC-9048 SEMICONDUCTOR DEVICE MODELLING 3-0-0 3

Units	Topics	Lectures
Unit I	Concentration and motion of carriers in Semiconductor bulk Equilibrium concentration in intrinsic and extrinsic semiconductors, Excess carriers, Drift and Diffusion transport, continuity equation. Concentration and motion of carriers at the interfaceSurface recombination, surface mobility etc.	7 hr
Unit II	Device ModelingBasic equations for device analysis, approximation to these equations for deriving analytical expressions.	9 hr
Unit III	PN Homojunctionideal static IV characteristics and deviations including breakdown, ac small signal equivalent circuit, switching characteristics. MIS Junction/capacitorideal CV characteristics and deviations due to interface states/charges and work function differences, threshold voltage.	14 hr
Unit IV	BJTTransistor action, Static Characteristics, ac small signal equivalent circuit, switching characteristics. FETsField effect, types of transistors (JFET, MESFET, MISFET, MOSFET), Stat ic characteristics of MISFET and MOSFET, small signal equivalent circuit, difference between BJT and FETS.	10 hr

Books/References:

1. Physics of Semiconductor Devices, Simon M. Sze and Kwok K. Ng,2006.
2. E.S. Yang, Microelectronic Devices, McGraw Hill, Singapore, 1988.
3. B.G. Streetman, Solid State Electronic Devices, Prentice Hall of India, New Delhi.
4. Semiconductor Device Modeling,Giuseppe Massobrio and Paolo Antognetti.

EC-9049 WIRELESS COMMUNICATION 3-0-0 3

Units	Topics	Lectures
Unit I	Introduction to Wireless Communication Systems – evolution of mobile radio communications, mobile radio systems around the world, radio communication systems – paging systems, cordless telephone systems, cellular telephone systems; comparison of common wireless communications, trends in cellular radio and personal communication, second generation (2G) cellular networks, third generation (3G) wireless networks, Introduction to 4G, introduction to radio wave propagation, free space propagation model.	10 hr
Unit II	Basics of mobile communication – Limitations of conventional mobile system, mobile cellular communication – introduction, concept of frequency reuse, cluster size, cellular system architecture – mobile station, base station, MSC, channel assignment strategies, call handover strategies, interference and system capacity, improving capacity in cellular systems – cell splitting, sectorin g, repeaters, microcell, zone concept.	10 hr
Unit III	Global system for mobile communication, GSM services and features, system architecture, GSM radio subsystem, GSM channel types, location updating and call setup, introduction to CDMA digital cellular standard, comparison between GSM and CDMA.	12 hr
Unit IV	Wireless networking – wireless local area network standards, technology – RF and IR wireless IT – LAN, diffuse, quasi-diffuse and point-to-point IR wireless LAN, advantages and applications of Wireless LAN, introduction to WI-FI, Bluetooth.	10 hr

Books/References:

1. Wireless communication principles and practice, 2nd Ed, Theodore S Rapaport, Pearson Education.
2. Wireless communication, 1st Edition, Andrea Goldsmith, Cambridge.
3. Fundamentals of Wireless Communication, 1st Edition by David Tse, Cambridge.

EC-9050 CMOS MIXED SIGNAL CIRCUITS 3-0-0 3

Units	Topics	Lectures
Unit I	Analog and discrete-time signal processing, Analog integrated continuous-time and discrete-time (switched-capacitor) filters.	9 hr
Unit II	Basics of Digital to analog converters (DAC). DACs. Voltage, current, and charge scaling DACs, Cycli c DAC, Pipeline DAC.	7 hr
Unit III	Basics of Analog to digital converters (ADC). Successive approximation ADCs. Dual slope ADCs. High-speed ADCs (e.g. flash ADC, pipeline ADC and related architectures).High-resolution ADCs (e.g. delta-sigma converters).	14 hr
Unit IV	Mixed-Signal layout. Interconnects. Phase locked loops, Delay locked loops and their applications.	10 hr

Books/References:

1. CMOS mixed-signal circuit design by R. Jacob Baker Wiley India, IEEE press, reprint 2008.
2. CMOS circuit design, layout and simulation by R. Jacob Baker Revised second edition, IEEE press.
3. Design of analog CMOS integrated circuits by Behad Razavi McGraw-Hill, 2003.

EC 9051 ENGINEERING RESEARCH METHODOLOGY 3-0-0 3

Units	Topics	Lectures
Unit I	Research Preparation and Planning: Objectives of research – research and its goals. Critical thinkin g. Techniques for generating research topics. Topic selection and justification. Development of a research proposal – Theoretical and Experimental Processes.	8 hr
Unit II	Research Resources: Sources of information. Literature search. World Wide Web, Online data bases – search tools. Citation indices - Principles underlying impact factor – literature review – Case studies, review articles and Meta-analysis – record of research review - Role of the librarian. Ethi cal and Moral Issues in Research, Plagiarism, tools to avoid plagiarism – Intellectual Property Rights – Copy right laws – Patent rights.	10 hr
Unit III	Academic Writing and Presentation: Proposal submission for funding agencies, Elements of Style. Organization of proposals, Basic knowledge of funding agencies, Research report writing, Communication skills, Tailoring the presentation to the target audience – Oral presentations, Poster preparations, Submission of research articles for Publication to Reputed journals, Thesis writi ng, and Research report writing. Elements of excellent presentation: Preparation, Visual and Delivery. Oral Communication skills and Oral defense.	12 hr
Unit IV	Data Collection, Analysis and Inference: Basic Statistical Distributions and their applications - Binomial, Poisson, Normal, Exponential, Weibull and Geometric Distributions. Sample size determination & sampling Techniques-Random sampling, stratified sampling, systematic sampling and cluster sampling. Large Sample Tests and Small Sample Tests-Student–t-test, F-test and ÷ 2 test and their applications in research studies. Correlation and Regression Analysis-Time series Analysis- Forecasting methods. Factor analysis, Cluster Analysis and Discriminant Analysis. Principl es of Experimentation, Basic Experimental Designs: Completely Randomized Design Randomized Block Design and Latin Square Design. Factorial Designs: 22 , 23 and 24 – Accuracy, Precision and error analysis.	12 hr
Unit V	Mathematical Modelling: Basic concepts of modeling of Engineering systems – static and dynamic model – Model for prediction and its limitations. System simulation — validation. Use of optimization techniques – Genetic Algorithm, Simulated Annealing, Particle Swarm Optimization.	14 hr

Books/References:

1. Research Methodology for Engineers, Ganesan R, MJP Publishers, Chennai.
2. Probability & Statistics for Engineers and Scientists,Walpole R.A., Myers R.H., Myers S.L. and Ye, K ing: Pearson Prentice Hall, Pearson Education.
3. Thesis and assignment writing, Anderson B.H., Dursaton, and Poole M., Wiley Eastern.
4. How to write and illustrate scientific papers?, Bijorn Gustavii, Cambridge University Press.
5. Research Design and Methods, Bordens K.S. and Abbott, B.b.: Mc Graw Hill.

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY

SYLLABI
OF
PG / Ph. D. COURSES
(DEPARTMENT OF MECHANICAL ENGINEERING)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY

(UNDER THE MINISTRY OF EDUCATION, GOVT. OF INDIA)

DEEMED TO BE UNIVERSITY U/S 3 OF THE UGC ACT, 1956

NIRJULI - 791 109 :: ARUNACHAL PRADESH

SYLLABI
OF
PG/ Ph. D COURSES

(DEPARTMENT OF MECHANICAL ENGINEERING)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY (NERIST)
(Deemed to be University, U/S 3 Of the UGC Act, 1956)
Nirjuli (Itanagar), Arunachal Pradesh- 791 109

DEPARTMENT OF MECHANICAL ENGINNERING

Course Structure (Regular)

M. Tech. In Mechanical Engg. (Computer Integrated Manufacturing)

Semester I						
Sl. No	Course Code	Title	L	T	P	Credits
1	ME-7101	Advanced Operations Research	3	0	0	3
2	ME-7102	Finite Element Methods	3	0	0	3
3	ME-7103	Computer Aided Design	4	0	0	4
4	ME-7104	Computer Aided Manufacturing	4	0	0	4
5	ME-7105	Automation in Manufacturing System	4	0	0	4
6	ME-7151	Sessionals-I	0	0	6	3
		Total Credits				21
Semester II						
Sl. No	Course Code	Title	L	T	P	Credits
1	ME-7201	Advanced Manufacturing Process	3	0	0	3
2	ME-7202	Advanced Manufacturing Management	3	0	0	3
3	ME-7203	Modeling of Manufacturing Systems	4	0	0	4
4	ME-70*	Elective -I	4	0	0	4
5	ME-70*	Elective -II	4	0	0	4
6	ME-7251	Sessionals-II	0	0	6	3
		Total Credits				21
Semester III						
Sl. No	Course Code	Title	L	T	P	Credits
1	ME-8098	Seminar	-	-	-	2
2	ME-8199	Project – Phase I	-	-	-	8
		Total Credits				10
Semester IV						
Sl. No	Course Code	Title	L	T	P	Credits
1	ME-8299	Project-Phase II, Thesis Evaluation	0	0	0	10
		Seminar and viva voce	0	0	0	6
		Total Credits				16

List of Electives for Specialization in Computer Integrated Manufacturing

Sl. No	Course Code	Title	L	T	P	Credits
1.	ME 7021	Flexible Manufacturing Systems	4	0	0	4
2.	ME 7022	Intelligent Manufacturing Systems	4	0	0	4
3.	ME 7023	Advanced Materials Technology	4	0	0	4
4.	ME 7024	Machine Tool Engineering	4	0	0	4
5.	ME 7025	Robotics	4	0	0	4
6.	ME 7026	Theory of Machining	4	0	0	4
7.	ME 7027	Advanced Tribology	4	0	0	4
8.	ME 7028	Computer Aided Product Development	4	0	0	4
9.	ME 7029	Design for Manufacture and Assembly	4	0	0	4
10.	ME 7030	Composite Materials	4	0	0	4
11.	ME 7031	Statistical Optimization Techniques	4	0	0	4
12.	ME 7032	Applications of Soft Computing Techniques	4	0	0	4
13.	ME 7033	Advanced Welding Technology	4	0	0	4

SYLLABUS (Computer Integrated Manufacturing)

ME-7101: Advanced Operations Research **3 credits (3-0-0)**

Unit I	Advanced topics in Linear Programming: Revised Simplex Algorithm, Simplex Method for Bounded Variables, One Dimensional Cutting Stock Problem, Primal Dual Algorithm, Goal Programming and Solution.	7 lectures
Unit II	Integer Programming: Solving Zero-One Problems, Branch and Bond Algorithm for Integer Programming, Cutting Plane Algorithm, All Integer Dual Algorithm.	6 lectures
Unit III	Network Modeling: Network Model, Shortest Path Problem, Successive Shortest Path Problem, Maximum Cost Flow Problem.	5 lectures
Unit IV	Travelling Salesman Problem (TSP) and extensions: Branch and Bound Algorithm, for TSP, Heuristics for TSP, Chinese Postman Problem, Vehicle Routeing Problem.	6 lectures
Unit V	Game Theory: Introduction, Two-person zero-sum games, Maxmin-Minimax principle, Games without saddle points, mixed strategies, $2 \times n$ and m2 Games, Dominance property, Algebraic solutions to rectangular games, Graphical Solution.	6 lectures
Unit VI	Non-linear Programming-Single Variable Optimization: Introduction, Kuhn-Tucker conditions, Quadratic programming, Separable programming.	6 lectures
Unit VII	Special Topics:Analytic Hierarchy Process for Decision Making, Extreme Difference Method, Introduction to GA.	6 lectures

Recommended books :

1. Operations Research- An Introduction 8th Edition, H. A., Taha, McMillam Press, 2014
2. Operations Research, J. K. Sharma, Macmillan, 1997.
3. Operations Research Methods and Practice , C.K. Mustaffi , New Edge International , 4 th Edition, 2009.
4. Engineering Optimization Methods and Applications, G. V. Reklaitis, A. Ravindran and K. M. Ragsdell, Wiley, 1983

ME-7102: Finite Element Methods **3 credits (3-0-0)**

Unit I	Introduction: Basic concept of Finite Element Method, Historical background, FEM Applications, General Description of FEM, Direct FEM, Commercial FEM software packages. Spring element-stiffness matrix, boundary conditions, solving equations. Variational formulation approach-Rayleigh-Ritz method, principle of minimum potential energy, weighted residual methods.	8 lectures
Unit II	Linear static analysis: Bar and Beam Problems, local and global coordinate system, transformation of coordinate systems, element stress. Analysis of truss. Natural coordinate system, Interpolation polynomial, isoparametric elements and Numerical integration, Gaussian quadrature approach, simple problems in 1-D.	10 lectures
Unit III	Finite element analysis of two dimensional problems: Review of the basic theory in 2-D elasticity, plane stress, 2-D problems using Constant Strain Triangles (CST), isoparametric representation, element matrices and stress calculations. Finite element modeling and simulation techniques-symmetry, nature of FE solutions, error, convergence, adaptivity, substructures (super elements) in FEA.	10 lectures
Unit IV	Thermal analysis: Review of basic equations of heat transfer, steady state one dimensional heat conduction, governing equations, boundary conditions, element characteristics, problems in 1-D.	6 lectures
Unit V	Structural vibration and dynamic analysis:Dynamic considerations of structures, Consistent mass matrix, eigen values, eigen vector, natural frequencies, mode shapes, free vibration (normal mode) analysis, Newmark's time integration, introduction to transient response analysis.	8 lectures

Recommended books :

1. Finite Element Methods for Engineers, U.S. Dixit, Cengage Publications, 2009.
2. An introduction to the Finite Element Method, J.N. Reddy, McGraw Hill, 3 rd Ed., 2006.
3. Concepts and Applications of Finite Element Analysis, R.D. Cook,D.L. Malkus, M.E. Plesha, R.J. Witt, Willy India Ed.,
4. The Finite Element Method in Engineering, S.S. Rao, Pregamon Press, 1989.
5. The Finite Element Method in Engg. Science, O.C. Zienkiewicz, R.L. Taylor, J.Z. Zhu, McGraw-Hill, 6 th Ed., 2005.

ME-7103: Computer Aided Design **4 credits (4-0-0)**

Unit I	Principles of computer graphics: Introduction, graphic primitives, point plotting, lines, Bresenham's circle algorithm, ellipse, transformation in graphics, coordinate systems, view port, 2D and 3D transformation, hidden surface removal, reflection, shading and generation of characters.	8 lectures
Unit II	CAD tools: Definition of CAD tools, types of system, CAD/CAM system evaluation criteria, input and output devices, Graphics standard, functional areas of CAD, modeling and viewing.	10 lectures
Unit III	Curve design: Curve interpolation, curve fitting, representation of curve, differential geometry of curve, Ferguson's or Hermite cubic segment, three tangent theorem, Barycentric coordinate and affine transformation, Bezier Segment, and Composite Bezier Segment.	10 lectures
Unit IV	Surface design: Polynomial splines, B-Splines, design features of B-spline curves, non-uniform rational B-Splines (NURBS), parametric representation of surfaces, different surfaces, tensor product surface patch, boundary interpolation surfaces, composite surfaces, B-spline surface patch, rational B-Spline surface patch (NURBS)	10 lectures
Unit V	Solid modeling: Solids, topology of surfaces, invariant of surfaces, surface as manifolds, representation of Solids, wireframe model, boundary representation scheme, constructive solid geometry (CSG),	8 lectures
Unit VI	Computations for Geometric Design:Proximity of a point and line, Intersection between lines, relation between point and polygon, proximity between a point and a plane, membership classification, Subdivision of space, Boolean operations on polygon and intersection between freeform curves.	10 lectures

Recommended books :

1. Computer Aided Engineering Design, A. Saxena, B. Sahay, Springer Netherlands, 2005.
2. Computer Aided Design and Manufacturing, M.M. Sarcar, K. Mallikarjuna Rao, K. Lalit narayan, PHI lea rning, 2008.
3. CAD/CAM Theory & Practice, Ibrahim Zeid, Tate McGraw Hill, 2 nd Ed., 2009.
4. CAD/CAM Computer aided Design and Manufacture, M. P Groover and E W Zimmers, PHI, 1984.

ME 7104: Computer Aided Manufacturing **4 credits (4-0-0)**

Unit I	Introduction: Fundamentals of numerical control, advantages and limitations of NC systems, classification of NC systems. Features of NC machine tools: Design consideration of NC machine tools, increasing productivity with NC machines, machining centre, tooling for CNC machine.	10 lectures
Unit II	System Device: Feedback devices, counting devices, digital analog converters. Interpolations: DDA integrators, simple and symmetrical DD reference word, CNC interpolators.	10 lectures
Unit III	NC part programming: Punched, tape, format, manual part programming, computer aided programming, ATP programming. Control loops for NC systems: Control loops for point and counting systems. Computerized numerical control: CNC concepts- advantage of CNC, references pulse techniques, sampled data techniques, micro computers in CNC.	12 lectures
Unit IV	Adaptive control systems: Adaptive control with optimization, Adaptive control with constraints variable gain AC systems, online search strategies.	10 lectures
Unit V	Process planning, manufacturing support systems, CAPP, advanced manufacturing, lean production & agile manufacturing. Production systems (operation level): Computer generated time standards machinability data systems, cutting conditions optimization, production planning, capacity planning, shop floor control, computer integrated manufacturing systems, system components and applications.	14 lectures

Recommended books :

1. Computer Control of Manufacturing Systems, Y Koren, McGraw Hill, 2005
2. Numerical Control and Computer AidedManufacturing, T.K. Kundra, P.N. Rao and N.L.K.Tiwari, Tata McGr aw-Hill, 2006.
3. Automation, Production systems & Computer Integrated Manufacturing , M.P.Groover, Pearson Eucation A sia, 2008.
4. Computer numerical control machines and computer aided manufacture, P. Radhakrishnan, New Age Intern ational, 2012
5. CNC Machines, M.Aditan, B.S. Pabla, New Age International, 2009.

ME 7105: Automation in Manufacturing Systems **4 credits (4-0-0)**

Unit I	Fundamentals of Manufacturing: Production system facilities, Manufacturing support systems. Automation in production systems, automation principles and strategies, manufacturing operations, production relationship.	10 lectures
Unit II	Mathematical concepts & models: Production concepts and mathematical models, costs of manufacturing operations.	10 lectures
Unit III	Construction elements for automation, automated workpiece handling, working principles and techniques for feeding arrangement, transfer mechanism, assembly automation, automated packaging, automated inspection and computer vision.	11 lectures
Unit IV	Industrial Control: industrial control systems, sensors, actuators and other control systems, discrete controls using PLC & FLC. Power hydraulics and pneumatics: concepts, features and parameters governing the section of various components necessary for building the elements, circuit design and analysis, industrial application of fluid power and pneumatic systems, electro-hydraulic servo system, fluid logic control, MPL, fluid logic control.	14 lectures
Unit V	PLC: Introduction, micro PLC, programming of PLC, logic functions, input & output modules, PLC processors, PLC instructors, documenting PLC systems, timer and counter instructions, sequencing instructions, mask data representation, PLC programming, exercises for industrial applications, ladder logic diagram.	11 lectures

Recommended books :

1. Automated Production system and CIM, by Michael P. Grover, 2 nd Ed. Pearson Education Ltd., 2001.
2. CAD/CAM-computer integrated design and manufacturing, M P Grover and Emory W Zimmers, Pearson Educat ion Ltd., 2003.
3. Industrial automation and robotics, A K Gupta and S.K. Arora, Laxmi Publications, 2008.
4. Mechatronics, Ganesh S Hegde, Laxmi Publications, 2011.

ME.7151 Sessional -I (0-0-6)

Sessional courses will be combination of laboratory work and practice classes in laboratories /works hops as per the requirements of the courses. These courses will be evaluated in terms of seminar/reports/practice te st/viva voce.

ME 7201: Advanced Manufacturing Processes **(3-0-0)**

Unit I	Characteristics of arc and mode of metal transfer in arc welding, weldability, determination of preheat temperature, use of Schaeffler's diagram, weldability tests, heat flow in welding — significance, theory of heat flow, cooling rate determination, selection of welding parameters based on heat flow analysis, residual stress and distortion.	10 lectures
Unit II	Force analysis in forming and rolling operations, calculation of roll pressure, force analysis in extrusion operation, friction and frictionless drawing, extrusion and tube drawing.	10 lectures
Unit III	Forgeability, theory of forging, mixed friction in forging and die design for forging.	12 lectures
Unit IV	Special machining processes: Working principle and applications of EDM, ECM, AJM, USM, LBM, EBM and water jet machining	10 lectures

Recommended books :

1. Manufacturing Science, A. Ghosh and A.K. Mallik, East West Press, 2nd Ed., 2010.
2. Welding and Welding Processes, R.S. Parmar, Khanna publishers, 2010.
3. Mechanical Metallurgy, G. Deiter, Mc Graw Hill International, 1986.
4. Advanced Machining Processes, V.K. Jain, Allied publishers, 2007.
5. Modern Machining Processes, P.C. Pandey and H.S. Shan, Tata McGraw Hill, 1981.

ME-7202: Advanced Manufacturing Management **(3-0-0)**

Unit I	Production system theory, concepts and system simulation as applied to manufacturing. Flexible production system and continuous flow production.	8 lectures
Unit II	Productivity in manufacturing systems, principles of productivity, different techniques for improvement of productivity, CAD, CAM, CIM, Robotics, group technology, costs of manufacturing.	10 lectures
Unit III	Material requirement Planning, JIT, Kanban & Kaizen System, management by objectives, quality circles, PQ team approach, flex time, job rotation, ergonomics.	8 lectures

Unit IV	Total quality management, zero defect theory, Statistical process control.	8 lectures
Unit V	Concepts of value engg., value analysis, zero base budgeting. Introduction to logistics management, terrotechnology and life cycle costing.	8 lectures

Recommended books :

1. Production Systems Management, M.P. Poonia, Upendra Pandel, B. L. Salvi, Standard Publishers distrib uters, 2006.
2. Productivity Engineering and Management, David J Sumanth, Tata McGaw Hill, 1990.
3. Production planning and control, S.K. Mukherjee, Eastern Economy, 2 nd Ed., 2010.
4. Production and Operation Management, S.N Chary, Tata McGraw Hill publishing Co.1995.
5. The Toyota way, 14 management principles, Jeffery K Liker, Tata McGraw Hill publishing house, 2004.
6. Value Engineering, S.S. Iyer, New Age International publisher, 1996.

ME-7203: Modeling of Manufacturing Systems **4 Credits (4-0-0)**

Unit I	Introduction to systems and modeling: discrete and continuous system, limitations of simulation, linear programming, single and multivariable optimization techniques for solving the problem in the area of manufacturing systems.	12 lectures
Unit II	Random number generation and their techniques: random variable generation, tests for random numbers, monte-carlo simulation, analysis of simulation data, input modeling, verification and validation of simulation models of output analysis for a single model.	12 lectures
Unit III	Modeling of automated manufacturing systems, performance modeling tools, automatic storage and retrieval system, Markov chain models, quenching models, probabilistic models and stochastic models.	10 lectures
Unit IV	Queueing I: single-server queues, Queueing II: queuing networks, material requirements, planning, multi-stage control and scheduling, simulations of inventory problems.	10 lectures
Unit V	Toyota production system, Tata production system, Suzuki production system, problems solving the real situation in industries, development of the programming skills for solving the problem related to the manufacturing systems.	12 lectures

Recommended books :

1. Operation Research, H. Taha, Tata McGraw Hill, 2000.
2. Optimization: Practice and Problems, S.S. Rao, New age Publshers, 2 nd Ed., 2000.
3. Computer Simulation and Modelling, F. Neelamkvit, John Wiley and Sons, 2005.

ME-7251: Sessional-II (0-0-6)

Sessional courses will be combination of laboratory work and practice classes in laboratories /works hops as per the requirements of the courses. These courses will be evaluated in terms of seminar/reports/practice te st/viva voce.

ME -7021: Flexible Manufacturing Systems **4 Credits (4-0-0)**

Unit I	FMS: an overview, definition of an FMS, types & configurations, concepts,types of flexibility & performance measures. Function of FMS host computer, FMS host and area controller function and distribution. Development & implementation of FMS: Planning phase, integration, system configuration. FMS layouts, host system development, planning, hardware & software development.	8 lectures
Unit II	Automated materials handling. & storage, functions, types/analysis of material handling equipment, design of conveyor & AGV systems and its problems. Automated storages: system performance , AS/RS, Carousel storage system, WIP storage system, interfacing, handling storage with manufacturing.	10 lectures
Unit III	Modeling and Analysis of FMS, analytical, heuristics, application of simulation, FMS model, simulation softwares-SLAM II. Concepts of distributed numerical control, DNC system , communication between DNC computer & machine control unit, hierarchical processing of date in DNC system, features of DNC system, inspection in FMS.	12 lectures
Unit IV	Planning, scheduling and control of FMS: Introduction , scheduling of single product, N –product and single batch. Modeling of problems 'n' operations on 'm' machines, scheduling rules, loading problems ,tool management & related issues, material handling system schedule, heuristic algorithms. Illustrated examples. Database in FMS.	10 lectures
Unit V	Group technology in FMS: Coding and classification, OPTIZ coding, machine cell grouping approaches, roc, mathematical programming, cell layout design: Hollier method, knowledge base system for GT	8 lectures
Unit VI	FMS Relational: Economic and technological justification of FMS, GT, JIT and its operation and evaluation, typical case studies.	8 lectures

Recommended books :

1. Handbook of Flexible Manufacturing Systems, N. K.Jha, Academic Press Inc.,1991
2. Flexible Manufacturing System, H. K. Shivanand, New Age International,2006
3. Flexible manufacturing, Parrish D J, Butter Worth — Heinemann, Ltd Oxford,1993
4. Automation, Production system & Computer Integrated Manufacturing System - M.P.Groover, Pearson Euca tion Asia, 2008.
5. Intelligent Manufacturing Systems, A.Kusiak, Prentice Hall, Englewood Cliffs, New Jersey Prentice Ha ll,1990.

ME-7022: Intelligent Manufacturing Systems **4 Credits (4-0-0)**

Unit I	Basic concepts of Artificial intelligence and expert systems, system components, system architecture and data flow, system operations	12 lectures
Unit II	Knowledge based systems, knowledge representation, knowledge acquisition and optimization, knowledge based approaches to design of mechanical parts, mechanisms and automated assembly, knowledge based system for material selection, intelligent process planning system.	16 lectures
Unit III	Intelligent system for equipment selection, intelligent system for project management & factory monitoring.	8 lectures
Unit IV	Scheduling in manufacturing, scheduling the shop floor, Diagnosis & trouble shooting.	8 lectures
Unit V	The role of Artificial Intelligence in the factory of future, intelligent systems.	12 lectures

Recommended books :

1. Intelligent Manufacturing System, A. Kussiak, Prentice Hall, 1990.
2. Introducing Artificial Intelligence, G.L. Simons, NCC Pub., 1990.
3. Artificial Intelligence, E. Rich, 3rd Ed., Tata Mcgraw Hill, 2009.
4. Automation, Production System and Computer Integrated Manufacturing Systems, M P Groover, Pearson Education, 2008.

ME-7023: Advanced Materials Technology **4 Credits (4-0-0)**

Unit I	Development of newer materials: properties of materials, structural property relationship, newer materials, ceramics and composite materials. Ceramics: Fine ceramics, types of ceramics, structure of ceramics, properties of ceramics, applications.	9 lectures
Unit II	Composite materials, types of metal matrix composites (MMC), ceramic matrix composites (CMC), polymer composite structure, properties and applications of different composite materials.	9 lectures
Unit III	Powder Metallurgy: Introduction, Production of powder, characterization & testing of powders, powder conditioning, powder compaction, sintering, finishing operations, application of PM components.	12 lectures
Unit IV	Processing of composites: Processing of MMC, CMC, vacuum infiltration, squeeze casting, pressure die casting, rheocasting, compocasting, super plastic forming, processing of PMC, hand lay up, bag molding process, autoclave moulding, compression moulding, pultrution, filament winding, resin transfer moulding and injection moulding.	12 lectures
Unit V	Surface treatment: Surface engineering, surface quality, and integrity, concepts, mechanical treatment, thermal & thermo-chemical treatment, thermal spraying processes and applications, vapour deposition processes & application, ion treatment and laser treatment.	14 lectures

Recommended books :

1. Materials and Processing in Manufacturing, E. Paul Degarmo, J.T. Black, Ronald A Kohser, MGH, 9 th Edi., 2003.
2. Fiber Reinforced Composites, P. K. Mallik, CRC Press, 3 rd Edi., 1993.
3. Metal Matrix Composites, Minoru Taye, Richard J. Arsenault, 1989.
4. Composite Material Handbook, M.M. Schwartz, Mc Graw Hills, 1983.

ME 7024 Machine Tool Engineering **4 Credits (4-0-0)**

Unit I	Introduction to metal cutting, machine tools & transmission of motion in machine tools	8 lectures
Unit II	Mechanical drives for providing rotational movements in machine tools.	12 lectures
Unit III	Strength and rigidity of machine tool structures. Analysis of spindle bearings slides and guides.	14 lectures
Unit IV	Vibration of machine tools & dynamic rigidity	10 lectures
Unit V	Automatic drives for machine tools. NC & CNC systems for machine tools.	12 lectures

Recommended books :

1. Principles of Machine Tool, G. C. Sen and A. Bhattacharya, New Central Book Agency, 2013.
2. Design of Machine Tool, N.K. Mehta, TMH, 3 rd Edi., 2012.
3. Fundamentals of Machining and Machine Tools, G. Boothroyd and W. Knight, CRC Taylor & Francis, 3 rd Ed.,2006.
4. Manufacturing Science, A Ghosh and A K Mallik, East-West, 2 nd Ed., 1992.

ME: 7025 Robotics **4 Credits (4-0-0)**

Unit I	Introduction: A sense of history, manipulators and manipulations, robot configuration, robot analysis and control in a nutshell.	6 lectures
Unit II	Kinematics I: Robot geometry preliminary, position and orientation of a rigid body, co-ordinate transformation, Euler angle, homogeneous transformations. kinematics modeling of manipulator arms, open kinematic chains, the Denavit-Hartenberg (D-H) notation, kinematics equations. Inverse kinematics: introduction, solving the kinematic equation for the 5 R/P manipulators, solvability.	10 lectures
Unit III	Kinematics II: Differential motion kinematic modeling of instantaneous motions, differential relations, infinitesimal relations, computation of the manipulators, Jacobian, inverse instantaneous kinematics: Resolved motion rate, redundancy, optimal solutions.	10 lectures
Unit IV	Static's: Force and moment anylysis, equivalent joint torques, duality, transformations of force and moments, stiffness, introduction, endpoint compliance analysis, the principal transformation of compliance matrices.	7 lectures
Unit V	Dynamics: Newton-Euler formulation of equation of motion, basic dynamic equation, closed form dynamic equations, physical interpretation of the dynamic equation. Lagrangian formulation of the manipulator dynamics, Lagrange dynamics, the manipulators inertia tensor, deriving Lagrange motion equation, transformations of generalized co-ordinates. Inverse dynamics; introduction, recursive computation, moving co-ordinates.	8 lectures
Unit VI	Trajectory planning & control: Feedback and closed-loop control, transfer functions, control of second-order systems, non-linear & time varying systems, adaptive control, trajectory interpolators, basic structure of trajectory interpolators, cubic joint trajectories, general design consideration on trajectories: 4-3-4 & 3-5-3 trajectories, admissible motion trajectories	9 lectures
Unit VII	Sensors in robotics: Machine vision, force & torque sensors, robot programming: simulators and languages, tele-robotics and virtual interfaces for task specification and programming, economics of robotics, social issues & future of robotics.	6 lectures

Recommended books :

1. Robotics and Control, R.K.Mittal and I.J. Nagrath, Tata McGraw Hill, 1 st Ed., 2003.
2 Robotics, control vision and intelligence, K.S. Fu, R.C. Gonzalez, and C.S.G. Lee., Tata McGraw Hill , 2008.
3 Introduction to Robotics: Mechanics and Control, John J. Craig, Addison-Wesley, 1989.

ME 7026: Theory of Machining **4 Credits (4-0-0)**

Unit I	Machining, definition and objectives, geometry of cutting tools, turning, milling and drilling in different reference system and work reference systems, tool and work reference system. Sharpening and resharpening of cutting tools.	8 lectures
Unit II	Mechanism of chip formation by single point tools, drills and milling cutters, types of chips and their characteristics, effective rake.	8 lectures
Unit III	Mechanics of machining, theoretical estimation and experimental determination of cutting forces, power consumption. Dynamometers: types, design, construction and use. Cutting tools, methods of failure, mechanics of tool wear, essential properties, assessment of tool life and cutting tool mate rials	12 lectures
Unit IV	Thermodynamics of machining, sources of heat generation, cutting temperature modeling, measurement of cutting temperature. Cutting fluids: Purpose, essential characteristics, selection and methods of application.	10 lectures
Unit V	Economics of machining: Principal objectives, main parameters and their role on cutting forces, cutting temperatures, tool life and surface quality, selection of optimum combination of parameters.	10 lectures
Unit VI	Introduction to low temperature machining: Cryogenic machining, minimum quality lubrication (MQL) machining.	8 lectures

Recommended books :

1. Fundamentals of Metal Cutting and machine tools, G. Boothoyd, McGraw Hill International, 2005.
2. Production Technology - HMT, Tata McGraw Hill, 2001.
3. Fundamentals of Metal Cutting and Machine Tools, B.L. Juneja, G.S. Sekhon and Nitin Seth, New Age In ternational, 2nd Ed., 2003.

ME 7027: Advanced Tribology **4 Credits (4-0-0)**

Unit I	Introduction to tribology, friction, wear and lubrication. Regime of lubrication. Classifications of contacts and applications.	16 lectures
Unit II	Properties of lubricants. boundary, hydrodynamic, hydrostatic and elasto-hydrodynamic lubrication theories.	20 lectures
Unit III	Selection of bearing type: Sliding and rolling. Generalized Reynolds equation: Application to hydrodynamic thrust and journal bearings. Gas film lubrication.	20 lectures

Recommended books :

1. Modern Tribology Handbook, Bharat Bhushan, CRC Press, 2000
2. Introduction to Tribology of Bearings, B C Majumdar, S Chand, 2008
3. Engineering Tribology, Gwidon Stachowiak and Andrew Batchelor, Butterworth-Heinemann, 4th Ed, 2013

ME 7028: Computer Aided Product Development **4 Credits (4-0-0)**

Unit I	Product development processes and organization, stages of product development and important definitions	8 lectures
Unit II	Early design, requirements, definition, conceptual design methods, software design and requirement issues	12 lectures
Unit III	Tradeoff analysis, optimization analysis using cost and utility metrics, design for life cycle, desi gn for warranties and design for producibility.	12 lectures
Unit IV	Detailed design, detailed design with software, prototypes, modeling and simulation, FEM, software tools for detailed design.	12 lectures
Unit V	Test and evaluation, strategies, software test and evaluation, introduction to SAP, production & field testing and software tools, supply chain and logistics.	12 lectures

Recommended books :

1. Product Development and Design for Manufacturing - A Collaborative Approach to Producibility and Rel iability, John W Priest and Jose M Sanchez, CRC Press, 2001.
2. Product Door and Corporate Strategy, R Blaich and J. Blaich; McGraw Hill Inc., 1993.

ME 7029: Design for Manufacture and Assembly **4 Credits (4-0-0)**

Unit I	Introduction to DFMA, traditional design and manufacture and concurrent engineering, DFMA as the tool for concurrent engineering.	8 lectures
Unit II	Three DFMA criteria for retaining components for redesign of a product, design for manual assembly, design for automatic assembly.	12 lectures
Unit III	Computer-aided design for assembly, design for manufacture (design for machining).	12 lectures
Unit IV	Design for producibility, best practices, producibility software tools, Boothroyd and Dewhurst design for assembly and disassembly.	12 lectures
Unit V	Geometric tolerancing for manufacture, design for test and inspection, best practices for testability, design for effective and efficient tests.	12 lectures

Recommended books :

1. Product Design for Manufacture and Assembly, G. Boothroyd, P. Dewhurst& W. Knight, CRC Press, 2010.
2. Design for Manufacturing: A Structured Approach, C. Poli, Butterworth Heinemann, 2001.

ME 7030: Composite Materials **4 Credits (4-0-0)**

Unit I	Introduction to composites: Fundamentals of composites and structures, need for composites, classification of composites, classical lamination theory, matrix materials, reinforcement materials, applications of various types of composites, fibre production techniques for glass, carbon and ceramic fibre, introduction to nano- composites.	10 lectures
Unit II	Processing of composites: Characteristics of MMC, limitations of MMC, rule of mixtures, processing of MMC, powder metallurgy processes, diffusion bonding, stir casting, squeeze casting, in-situ reactions, interface, applications of MMC in aerospace and automotive industries. Natural composites.	12 lectures

Unit III	Characterisation of composites: ceramic matrix composites, toughening mechanism, processing, sintering, hot pressing, cold isostatic pressing (CIP), hot isostatic pressing (HIP), applications of cmc in aerospace and automotive industries, carbon composites, advantages of carbon matrix, limitations of carbon matrix and carbon fibre, chemical vapour deposition of carbon on carbon fibre preform, sol-gel technique.	10 lectures
Unit IV	Interface & Failure analysis: Interphase, mechanisms of bonding, measurements of interface bonding strength, yielding, particle/fibre fracture, interface de-cohesion/de-bonding, elastic stress analysis of composite material, fatigue strength improvement techniques, stress concentration around cut outs in composite laminates, stability of composite laminate plates and shells, hybrid materials and applications.	10 lectures
Unit V	Machining of composites: Machining of MMC, surface integrity in machining, machinability aspects, traditional machining processes of MMC; Grinding of MMC, dry cutting of SiCp reinforced MMC, modeling, computational methods and optimization in machining of MMC.	14 lectures

Recommended books :

1. Composite Materials, S. C. Sharma, Narosa Publishing House, 2000.
2. Composite Material: Science and Engineering, K. K. Chawla, Springer, 2nd Edi., 1998.
3. An Introduction to Metal Matrix Composites, T. W. Clyne & P. J. Withers, Cambridge University Press, 1993.
4. Engineering Mechanics of Composite Materials, I. Daniel & O. Ishai, Oxford University Press, 2006.
5. Manufacturing of Polymer Composites, B. T. Astrom, Chapman & Hall, 1997.

ME 7031: Statistical Optimization Techniques **4 Credits (4-0-0)**

Unit I	Introduction to statistical approach: Types of statistical techniques, Error minimization, Hypothesis testing, Limitations, Analysis of variance (ANOVA), F-test, Simple design of ANOVA, Completely randomized design.	10 lectures
Unit II	Experimental Designs: Design of experiments, Full and fractional factorial design of experiments with 2 & 3 factor; Distinction between random factor & fixed factor, Expected mean square rules, Nested Design, Mixed Design, Nested factor and factorial factor, Confounded design, Fractional factorial design, Split-split plot design, Strip-split plot design., correlation analysis.	12 lectures
Unit III	Regression analysis: Linear and Multiple, Matrix method. Response Surface Methodology: Concept, CCD design, Taguchi design, Analysis of response surface, Experimental design, orthogonal array: Design, Column effect method, Taguchis' S/N ratio approach, ANOM optimization Multivariate analysis of variance (MANOVA), One way MANOVA, Factorial MANOVA with 2 factors	12 lectures
Unit IV	Optimization Techniques: Formulation of an optimization problem, objective functions and constraints, golden section search method, successive quadratic estimation method, simplex search method, steepest descent method, Kuhn-Tucker conditions, sensitivity analysis, integer programming, dynamic programming, linear programming.	12 lectures
Unit V	Non-traditional optimization algorithms: Introduction to genetic Algorithms; Binary coded genetic algorithms, Real coded genetic algorithms; Particle swarm optimization, Firefly algorithm and Ant colony optimization; Its application to manufacturing optimization problems.	10 lectures

Recommended books :

1. Taguchi Techniques for Quality Engineering, P.J. Ross, McGraw Hill Co, 2008.
2. Applied Design of Experiments & Taguchi Methods, K. Krishnaiah and P. Shahabudeen, PHI, 2012.
3. Advanced Modeling and Optimization of Manufacturing Processes, P.V. Rao, Springer, 2005.
4. Design and Analysis of Experiments: with applications to Engineering & Science, R. L. Mason, R.F. Gunst and J.L. Hess, Wiley Series on Probability and Statistics, Wiley, 2003.
5. Modeling of Metal Forming and Machining Processes-by Finite Element and Soft Computing Methods, P.M. Dixit and U.S. Dixit, Springer, 2008.
6. Design & Analysis of Experiments, R. Panneerselvan, PHI, 2012.

ME 7032: Application of Soft Computing Techniques **4 Credits (4-0-0)**

Unit I	Introduction: Introduction to different manufacturing processes; Environmental aspects of machining process; Nano-finishing process; Need for modeling and optimization of machining process; Problem solving methods and tools, problem space and state space; some important modeling and optimization techniques: Conventional Vs soft computing method of optimization. Multiple regression, Taguchi robust design, factorial design method, response surface methodology, etc.	14 lectures
Unit II	Artificial Neural Networks: Concept of biological neuron, Nerve structure and synapse, Artificial Neuron and its model, Neural Network architecture, single layer and multilayer feed forward networks, recurrent networks, Back propagation algorithm, factors affecting back propagation training, applications of soft computing to Mechanical engineering/ Production engineering problems.	14 lectures
Unit III	Fuzzy Logic: Fuzzy Set, Mathematical definition of fuzzy set, Membership functions, Fuzzy relations, Fuzzy arithmetic, Fuzzy logic, Fuzzy rule base, Fuzzy inference, Fuzzy modeling of manufacturing process, ANFIS modeling.	14 lectures
Unit IV	Soft computing based optimization: Introduction to genetic Algorithms; binary coded genetic algorithms, real coded genetic algorithms; Particle swarm optimization, Firefly algorithm and Ant colony optimization; Its application to manufacturing optimization problems.	14 lectures

Recommended books :

1. Soft Computing Integrating Evolutionary, Neural and Fuzzy Systems, T. Andrea, Tomassini and Macro, Springer, 2001.
2. Multi-objective Optimization using Evolutionary Algorithms, Kalyanmoy Deb, John Wiley and Sons, 2001.
3. Modeling of Metal Forming and Machining Processes by Finite Element and Soft Computing Methods, P.M. Dixit and U.S. Dixit, Springer, 2008.
4. Artificial Intelligence, E. Rich, McGraw Hill, 1990.

ME 7033: Advanced Welding Technology **4 Credits (4-0-0)**

Unit I	Evolution of welding, classification of welding process, working principle, forces involved in joining and weldability of metals. Overview of fusion and solid state welding process. Gas tungsten arc welding (GTAW), Gas metal arc welding (GMAW), Submerged arc welding (SAW), Plasma arc welding (PAW): working principles, applications, advantages and disadvantages. Modelling of weld parameters.	14 lectures
Unit II	Physics of welding arc, energy source in welding processes, voltage distribution along the arc, arc efficiency, welding power sources, constructional features, electrode polarity, static and dynamic characteristics, duty cycle, special welding power source.	10 lectures
Unit III	Heat flow in welding, welding parameters and its effects, weld thermal simulator, residual stresses: its distribution in weld and its influences; fatigue, solidification of weld metal, heat affected zone (HAZ), and factors affecting HAZ, fusion zone, etc.,	12 lectures
Unit IV	Overview of friction stir welding (FSW) process, working principles, applications, materials used, FSW Tools, and tool geometry; Diffusion welding, resistance welding, spot and seam welding processes; Modeling and optimization of weld parameters.	10 lectures
Unit V	Radiant energy welding processes: electron beam welding (EBW) and laser beam welding (LBW); working principle, welding set-up and applications. Testing of welds: tensile, bend, hardness. impact, notch and fatigue tests, liquid penetration test, magnetic particle examination. ultrasonic testing.	10 lectures

Recommended books :

1. Joining of Materials and Structures, Robert W. Messler, Jr., Elsevier Butterworth– Heinemann. 2004.
2. Welding and Welding Technology, R.L. Little, Tata McGraw Hill, 1980.
3. Production Technology, R. K. Jain, Khanna Publications. 1995.
4. Welding Processes and Technology, R.S Parmer, Khanna Publications. 1995.
5. Friction Stir Welding and Processing, Science and Engineering, Rajiv Sharan Mishra, ParthaSarathi De, Nilesh Kumar, Springer International Publishing, Switzerland, 2014.
6. Welding Metallurgy, Sindo Kou, John Wiley & Sons, INC, 2002.

Course Structure (Regular)

M. Tech. in Mechanical Engineering Thermal and Fluid Engineering

Semester I						
Sl. No	Course Code	Title	L	T	P	Credits
1	MA-71**	Advanced Mathematics	3	0	0	3
2	ME-7100	Numerical techniques for Engineering Applications	3	0	0	3
3	ME-7111	Advanced Fluid Mechanics	4	0	0	4
4	ME-7112	Advanced Thermodynamics and Heat Transfer	4	0	0	4
5	ME-7113	Mechanical Systems Design	4	0	0	4
6	ME-7152	Practice - I	0	0	6	3
		Total Credits				21
Semester II						
Sl. No	Course Code	Title	L	T	P	Credits
1	ME-7211	Computational Fluid Dynamics and Heat Transfer	3	0	0	3
2	ME-7212	Measurements and control in Fluids & Thermal Engg	3	0	0	3
3	ME-70**	Elective I	4	0	0	4
4	ME-70**	Elective II	4	0	0	4
5	ME-70**	Elective III	4	0	0	4
6	ME-7252	Practice - II	0	0	6	3
		Total Credits				21
Semester III						
Sl. No	Course Code	Title	L	T	P	Credits
1	ME-8098	Seminar	-	-	-	2
2	ME-8199	Project – Phase I	-	-	-	8
		Total Credits				10
Semester IV						
Sl. No	Course Code	Title	L	T	P	Credits
1	ME-8299	Project - Phase II	-	-	-	-
		Thesis Evaluation	0	0	0	10
		Seminar and Viva Voce	0	0	0	06
		Total Credits				16

List of Electives for Specialization in Thermal and Fluid Engineering

ME-7001	Viscous Flow Theory
ME-7002	Theory of Compressible Flow
ME-7003	Dynamics and Thermodynamics of Turbomachines
ME-7004	Cryogenic Engineering
ME-7005	Combustion Engineering
ME-7006	Convection & Multiphase flow
ME-7007	Conduction and Radiation
ME-7008	Gas Turbines and Jet Propulsion
ME-7009	Design of Heat Exchangers
ME-7010	Refrigeration Machinery and Components
ME-7011	Absorption Refrigeration and Heating Systems
ME-7012	Design of IC Engine Components and Sub-Systems
ME-7013	Alternative Fuels for Transportation

SYLLABUS (Thermal and Fluid Engineering)

MA-71: Advanced Mathematics** **3 credit (3-0-0)**

Unit I	Variational algebra; calculus of variation.	7 lectures
Unit II	Linear and non-linear regression; multiple linear regression, statistical methods-data presentation; modeling and analysis, tests and hypothesis.	7 lectures
Unit III	Algebraic transformations; Fourier analysis and its applications	12 lectures
Unit IV	Mathematical functions like Bessel's functions etc.	6 lectures
Unit V	Metrics and Jacobians; Coordinate transformations (Curvilinear to rectangular coordinates); inverse transformations	10 lectures

Recommended books :

1. Advanced Engineering Mathematics, E. Kreyzig, New Age International, 1996.
2. Numerical Methods for Scientific and Engineering Computation, M. K. Jain, S. R. K. Iyengar, and R . K. Jain, New Age International, 3rd Ed., 1993
3. Continuum Mechanics, D.S. Chandrashekaraiah and L. Debnath, Academic Press, 1994.
4. Advanced Engineering Mathematics, P.V. O'Neil, Cengage Learning, 2007
5 Mathematical Methods for Physicists, G. B. Arfken and H. J. Weber Academic Press, 5 th Ed., 2012.

ME-7100: Numerical Techniques for Engineering Application **3 credit (3-0-0)**

Unit I	Classification and characteristics of PDEs.	6 lectures
Unit II	Finite differences applied to PDEs, consistency and stability; initial value and boundary value problems.	8 lectures
Unit III	Iterative methods; methods of solving simultaneous equations.	12 lectures
Unit IV	ADI and ADE techniques.	8 lectures
Unit V	Tridiagonal and pentadiagonal system of equations; Thomas algorithm.	8 lectures

Recommended books :

1. Numerical methods in FORTRAN, McCormick & Salvadori PHI,1992
2. Numerical Method, Problems and Solutions, M.K. Jain, S.R.K.Iyengar, R.K. Jain, New Age International , 1996.
3. Numerical Methods for Engineering Applications, Joel H. Ferziger, Wiley, 2 nd Edi, 1998.
4. A First Course in Numerical Methods, Uri M. Ascher and Chen Greif, PHI Learning, 7th Edi., 2013.

ME-7111: Advanced Fluid Mechanics **4 Credits (4-0-0)**

Unit I	Derivation of general Navier-Stokes equation; simplification of N-S equation.	8 lectures
Unit II	Energy equation and its applications, Potential flows.	10 lectures
Unit III	Velocity and thermal boundary layers	14 lectures
Unit IV	Exact and approximate solutions of boundary layer equations.	12 lectures
Unit V	Normal and Oblique shocks; Prandtl-Meyer expansion; Fanno and Rayleigh flows.	12 lectures

Recommended books :

1. Advanced Fluid Mechanics, William Graebel, Academic Press, 1st Ed., 2007.
2. Fluid Mechanics for Engineers: A Graduate Textbook, Meinhard T. Schobeiri, Springer, 2010.
3. Fluid Mechanics: Fundamentals and Applications, John M. Cimbala and Yunus A. Cengel, McGraw Hill, 3rd Ed., 2006.
4. Fluid Mechanics, F. M. White, Tata McGraw-Hill, 7 th Ed.,, 2011.
5. Fundamentals of Fluid Mechanics, B. R. Munson, D. F. Young and T. H. Okhiishi, John Wiley, 2002.

ME-7112: Advanced Thermodynamics and Heat Transfer **4 Credits(4-0-0)**

Unit I	Review of engineering thermodynamics; Thermodynamic laws and their corollaries, properties of mixtures, work transfer- direct & indirect converters, statistical approach to thermodynamics.	12 lectures
Unit II	Three dimensional transient and steady conduction.	11 lectures
Unit III	Natural and forced convection, radiation heat transfer	12 lectures
Unit IV	Combined conduction, convection & radiation. Heat transfer in two phase flows.	10 lectures
Unit V	Mass diffusion, combined heat and mass transfer.	11 lectures

Recommended books :

1. Advanced Thermodynamics Engineering, Kalyan Annamalai, Ishwar K. Puri, Milind A. Jog, CRC Press, 2nd Edi., 2011.
2. Thermodynamics and Heat Power, Irving Granet, Maurice Bluestein, CRC Press,8th Edi., 2014.
3. Advanced Engineering Thermodynamics, Adrian Bejan, Wiley Interscience, 2nd Edi., 1997.
4. *Thermodynamics:* An Engineering Approach, Y. A. *Çengel* and M. A. *Boles,* McGraw-Hill, 5thEdi., 2006.

ME-7113: Mechanical Systems Design **4 Credits (4-0-0)**

Unit I	Properties of engineering materials, static & dynamic stresses in machine elements; stress concentration & stress intensity in machine members.	10 lectures
Unit II	System analysis & synthesis; human ergonomics; internationally accepted standards & data, foolproof designing tools and design improvement- fishbone or ishikawa diagram.	10 lectures
Unit III	FMEA, why-why analysis, ethical issues in system design, design & control of dynamic mechanical systems.	10 lectures
Unit IV	Design of prime movers, non-prime movers & power transmission systems (pressure vessels/ pumps/turbines/gear boxes/conveyer systems/belt and pulley drives.	18 lectures
Unit V	Introduction to MEMS & NEMS (Micro & Nano- Electro Mechanical Systems) design.	8 lectures

Recommended books :

1. Engineering by Design, Gerard Voland, Prentice Hall,2nd Ed, 2003.

ME-7152 Practice-I (0-0-6)

Practice courses will be combination of laboratory work and practice classes in laboratories/ worksh ops as per the requirements of the courses taken by the concerned students. These courses will be evaluated in term s of seminar/ reports/viva voce.

ME-7211: Computational Fluid Dynamics and Heat Transfer **3 Credits (3-0-0)**

Unit I	Governing equations in conservation and non-conservation forms; difference methods applied to governing equations and their characteristics.	6 lectures
Unit II	Consistency and stability of different schemes; computational methods of solving basic fluid dynamics and heat transfer problems.	8 lectures
Unit III	Transformation of equations between physical plane and computational pane grid generation techniques, graphics principles.	12 lectures
Unit IV	CFD application to some physical problems like flow in pipes, flow through nozzles and flow over aerofoils. Solution of N-S equations.	16 lectures

Recommended books :

1. Computational Fluid Dynamics, J. D. Anderson Jr., Tata McGraw-Hill International 1st Edi., 2012.
2. Computational Fluid Mechanics & Heat Transfer, D.A. Anderson, J.C. Tannehill & R.H. Pletcher, Taylor & Francis, 2nd edi., 1997.
3. Numerical Heat Transfer and Fluid Flow, S.V. Patankar, Hemisphere, 1980.
4. Fundamentals of Computational Fluid Dynamics, P. J. Roache, Hermosa Pub, 2003.
5. Computational Fluid Dynamics, T. J. Chung Cambridge University Press, 2010.

ME-7212 Measurements and control in Fluid & Thermal Engineering **3 Credits (3-0-0)**

Unit I	Introduction to measurements for scientific and engineering applications, need and goal, broad category of methods for measuring field and derived quantities.	9 lectures
Unit II	Principles of measurement, parameter estimation, regression analysis, correlations, error estimation and data presentation, analysis of data.	9 lectures
Unit III	Measurement of field quantities, thermometry,heat flux measurement, measurement of force, pressure, flow rate, velocity, humidity, noise, vibration measurement of the above by probe and non-intrusive techniques.	12 lectures
Unit IV	Measurement of derived quantities: torque, power, thermophysical properties, radiation and surface properties, analytical methods and pollution monitoring, mass spectrometry, chromatography and spectroscopy.	12 lectures

Recommended books :

1. Fundamentals of Temperature, Pressure and Flow Measurement, R.P. Benedict, John Wiley, 1984.
2. Measurement Systems , Application and Design, E. O. Doebelin, McGraw Hill, 3rd Edition, 2003.
3. Measurements in Heat Transfer, E. R. G. Eckert and R. J. Goldstein, McGraw Hill, 2 nd Edi., 1976.

ME-7252 Practice-II (0-0-6)

Practice courses will be combination of laboratory work and practice classes in laboratories/ worksh ops as per the requirements of the courses taken by the concerned students. These courses will be evaluated in term s of seminar/ reports/viva voce.

ME-7001: Viscous Flow Theory **4 Credits (4-0-0)**

Unit I	Comparison of theoretical, experimental & numerical studies; Similarity principles; Navier-Stokes equations.	6 lectures
Unit II	Boundary layer equation; non dimensionalisation, approximation of B.L equation, B.L. separation and control, vortex formation.	12 lectures
Unit III	Some exact solutions of B.L. Equation.	12 lectures
Unit IV	Approximate solutions of N-S equation.	12 lectures
Unit V	Integral methods, turbulent boundary layer, turbulence models and flow equations, steady and unsteady turbulent boundary layers, numerical methods.	14 lectures

Recommended books :

1. Viscos Fluid Flow, 3rd Edition, Frank M. White, MGH, 2005.
2. Boundary Layer Theory, Hermann Schlichting and Klaus Gersten, Springer, 2017.
3. Mechanics of fluids,William Jolly Duncan, Alexander Thom, A Young, Hodder Arnold, 1970.

ME-7002: Theory of Compressible Flow **4 Credits (4-0-0)**

Unit I	Introductory concepts: Energy equation, critical & stagnation state properties; 1-D flow with area change.	8 lectures
Unit II	Normal and oblique shock analysis; isentropic turn of supersonic flow, Prandtl-Meyer expansion.	12 lectures
Unit III	Compressible flow with friction; compressible flow with heat transfer, combined effect of friction and heat transfer; multidimensional compressible flow.	14 lectures
Unit IV	Compressible flow measurements: supersonic wind tunnel, flight speed measurement, Schlieren technique and interferometer.	10 lectures
Unit V	Computational techniques for compressible flow equations.	12 lectures

Recommended books :

1. Fundamental of Gas Dynamics, R.D. Zucker & O. Biblarz, John Wiley & Sons, 2002.
2. Gas Dynamics, Vol I & II, M. J. Zucrow & J. D. Hoffmann, John Wiley International, 1976 & 1977.
3. Dynamics & Thermodynamics of Compressible, A.H. Shapiro, John Wiley & Sons, 1977.
4. Gas dynamics, E. Rathakrishnan, PHI, 5th Edi., 2014.
5. Modern Compressible Flow: With Historical Perspective, J. D. Anderson, Jr, McGraw Hill, 2003.

ME-7003: Dynamics and Thermodynamics of Turbomachines **4 Credits (4-0-0)**

Unit I	Dimensional analysis: Similitude; Basic thermodynamics, Fluid Mechanics; definitions of efficiency.	8 lectures
Unit II	Two dimensional cascade analysis, two dimensional analysis of axial flow machines, turbines, compressors & fans.	12 lectures
Unit III	Centrifugal pumps, fans & compressors.	12 lectures
Unit IV	Three dimensional flow in axial turbomachines; radial flow machines.	12 lectures
Unit V	Hydraulic turbines & wind turbines.	12 lectures

Recommended books :

1. Fluid Mechanics and Thermodynamics of Turbomachinery, S. L. Dixon and C. A. Hall, Butterworth-Heinem ann and Elsevier, 7th Ed.,, 2014.
2. Theory of Turbo machines, by G. T. Csanady, McGraw-Hill,1964.
3. *Turbines, Compressors* and *Fans,*S.M. Yahya, McGraw-Hill, 4th Edi., 2010
4. *Impeller pumps,* S £azarkiewicz, ATadeusz , *Pergamon Press* , 1965.

ME-7004 Cryogenic Engineering **4 Credits (4-0-0)**

Unit I	Methods of producing cold, thermodynamic basis, first and second law analysis.	10 lectures
Unit II	Vapour compression systems: Ideal and actual cycles; single Stage, multistage and cascaded systems, environmental aspects and alternate refrigerants.	12 lectures
Unit III	Vapour absorption systems: Refrigerant - absorbent combinations, single stage, multistage and open cycle systems.	16 lectures
Unit IV	Non convective flat systems: Vapour jet, air-cycle, thermo - electric refrigeration cryogenic liquefaction and refrigeration systems low temperature insulations, typical applications of refrigeration and cryogenics.	18 lectures

Recommended books :

1. Refrigeration and Air Conditioning, W. F. Stoecker and J. W. Jones, McGraw Hill, 2 nd Ed., 1983.
2. Principles of Refrigeration, W. B. Gosney, Cambridge University Press, 1982.
3. Thermal Environmental Engineering, J. L. Threlkeld, Prentice Hall, 1970.
4. Cryogenic Systems, R. F. Barron, Oxford University Press, 1985.

ME-7005 Combustion Engineering **4 Credits (4-0-0)**

Unit I	Characteristic of free and confined turbulent and swirling gas jets and their combustion Stabilization of burning gas jets, characteristics design consideration of gas burners.	14 lectures
Unit II	Combustion of liquid fuels, fuel atomization, types of injectors and spray characteristics, burning droplet in its ballistic trajectory, characteristics of spray combustion, characteristics and design consideration of oil burners.	14 lectures
Unit III	Coal combustion. combustion of pulverized coal, combustion of coal on a bed, in a fluidised bed and in a cyclone furnace, stabilization of pulverized coal combustion, design considerations of coal burners	14 lectures
Unit IV	Boilers and Furnaces: types used in industries, thermodynamics, fluid flow and heat transfer aspects of boilers and furnaces combustion in internal combustion engines, combustion generated pollution.	14 lectures

Recommended books :

1. The *Science of Flames and Furnaces*, M W Thring, Chapman and Hall, 2nd Ed., 1962
2. *Fuels and combustion*, S.P. Sharma, Chander Mohan, New Delhi, India: Tata McGraw-Hill,1987
3. Combustion Engineering, Kenneth W. Ragland , Kenneth M. Bryden, CRC Press, 2 nd Ed., 2011.
4. *Industrial Furnaces,* W. Trinks, M. H. Mawhinney, R. A. Shannon, R. J. Reedand J. R. GarveyJohn Wiley & Sons, *6th Ed.,* 2004

ME-7006 Convection & Multiphase flow **4 Credits (4-0-0)**

Unit I	Introduction to single and two phase flows, conservation laws, Navier Stokes equation, differential and integral forms.	10 lectures
Unit II	External laminar flows over flat plate, wedge flows, flow over cylinders, separation , internal laminar flow , circular pipe, non-circular ducts.	12 lectures
Unit III	Free convection, vertical plate cylinders, mixed convection, natural convection in porous media, enclosures.	16 lectures
Unit IV	Turbulent flows: Theory, models and correlations, condensation, boiling and two phase flows, film and dropwise condensation, nusselt theory, pool and film boiling, pressure drop and heat transfer in two phase flows, numerical solution to convection problems.	18 lectures

Recommended books :

1. Convective Heat and Mass Transfer, M. Kays and M. E. Crawford, McGraw hill, 4 th Ed., 2005.
2. Convective Heat Transfer, I. Pop and Derek B. Ingham, Elsevier Science & Technology Books, 2001.
3. Convection Heat Transfer, Adrian Bejan, Wiley — Interscience Publication, 1984.
4. Heat Transfer in Condensation and Boiling, K. Stephan, Springer Verlag, 1992.
5. Boiling Heat Transfer and Two Phase Flow, L. S. Tong and Y. S. Tang, Taylor and Francis, 1998.
6. Hand Book of Phase Change: Boiling and Condensation, S G. Kandlikar, M Shoji, V K. Dhir, Taylor and Francis, 1999.

ME- 7007: Conduction and Radiation **4 Credits (4-0-0)**

Unit I	Conduction heat transfer – heat equation in Cartesian, cylindrical and spherical coordinates, boundary conditions, extended surface heat transfer.	12 lectures
Unit II	Transient conduction: conduction with phase change, integral methods, integral transforms and numerical methods	14 lectures
Unit III	Radiation heat transfer: Fundamentals laws of thermal radiation, surface properties, radiative heat exchange among diffuse, gray and non-gray surfaces separated by non-participating media.	14 lectures
Unit IV	Gas radiation and radiation transfer in enclosures containing absorbing and emitting media, interaction of radiation with conduction and convection.	16 lectures

Recommended books :

1. Analytical Methods in Conduction Heat Transfer, G. E. Myers, McGraw Hill, 1971.
2. Heat Transfer, A J. Chapman, MacMillan, 3 rd Ed., 1974.
3. Radiation Heat Transfer, E. M. Sparrow and R. D. Cess, Brooks / Cole, 1970.
4. Thermal Radiation, J. R. Howell, M. P. Menguc and R. Siegel, CRC Press; 5 th Ed., 2010.

ME-7008 Gas Turbines & Jet Propulsion **4 Credits (4-0-0)**

Unit I	Axial flow turbines, two-dimensional and experimental flow in turbines - design charts, correlations and applications to stage performance, off-design performance estimation.	10 lectures
Unit II	Three dimensional flow, Viscous flows, losses and efficiencies turbines of low shape parameter, partial admission turbines, Stenning's analysis Supersonic and transonic turbine stages nozzle and rotor blade passage calculations.	12 lectures
Unit Ill	Cooled turbines: Single spool compressor and turbine matching, general methods and simplified methods of equilibrium operation turbine cooling methods.	14 lectures
Unit lV	Theory of propellers, Reaction principle, essential features of propulsive devices, momentum theory applied to propulsive devices, performance of turboprop, turbojet and turbofan engines	10 lectures
Unit V	Combustion in jet engines, augmentation of thrust, noise suppression, factors influencing performance and design of ramjet engines, supersonic inlets and starting problem.	10 lectures

Recommended books :

1. *Axial Flow Turbines, J.H. Horlock, Krieger* Publishing Company, 1973.
2. *Turbines*, *Compressors* and *Fans*, 4th Edition, S.M. Yahya, McGraw-Hill, 2010.
3. Turbine design and application volumes I, II, and III, Glassman, Arthur J. NASA Lewis Research Center, Cleveland, OH., United States,1994.
4. *Gas Turbines, V. Ganesan,* McGraw-Hill, 2010.
5. Mechanics and Thermodynamics of Propulsion, P. G. Hill, and C. R. Peterson, Pearson, 1992.
6. Gas Turbine Theory, H. I. H. Saravanamuttoo, G.F.C. Rogers, and H. Cohen, Pearson, 2001.
7. Fundamentals of Jet Propulsion with Applications, R. D. Flack, Cambridge University Press, 2005.
8. Aircraft Propulsion, S. Farokhi, Wiley, 2014.

ME-7009 Design of Heat Exchanger **4 Credits (4-0-0)**

Unit I	Classification of heat exchangers, basic design method for heat exchangers, design of shell and tube heat exchangers TEMA Code.	12 lectures
Unit II	Plate heat exchangers, Power plant heat exchangers, Heat exchangers for heat recovery at low, medium and high temperatures.	16 lectures
Unit Ill	Computerised methods for design and analysis of heat exchangers, compact heat exchangers, regenerative heat exchangers.	14 lectures
Unit IV	Principles of boiler design codes for mechanical design of heat exchangers, performance enhancement of heat exchangers, fouling of heat exchangers, testing, evaluation and maintenance of heat exchangers.	14 lectures

Recommended books :

1. Process Heat Transfer, Donald Q. Kern, McGraw Hill, 1950.
2. Process Heat Transfer, G. F. Hewitt, G. L. Shires and T. R. Bott, CRC Press, 1994.
3. Compact Heat Exchangers, W. M. Kays and A. L. London, McGraw Hill, 1998.
4. Heat Exchanger Selection: Rating and Thermal Design, Sadik Kakac and Hongtan Liu, CRC press, 2012.
5. Heat Exchangers, Holger Martin, Hemisphere Publishing Corporation, 1992.

ME-7010 Refrigeration Machinery and Components **4 Credits (4-0-0)**

Unit I	Design of reciprocating compressor components frames, crank case, stuffing boxes, seals, valves, pistons, piston rings, cranks, connecting roads etc. design of rotary vane, rotary piston and screw compressors.	12 lectures
Unit II	Analysis of centrifugal compressor capacity regulation of compressors, testing of refrigeration compressors.	12 lectures
Unit Ill	Various types of condensers and evaporators: Thermal design and construction of condensers and evaporators, types of expansion devices capillary. tube, thermostatic gap expansion valves, automatic expansion valves and float valves. Design and selection of expansion devices,design of refrigerant piping.	16 lectures
Unit IV	Refrigeration system, controls and safety devices; Solenoid valves, suction and evaporator pressure regulator, filters, driers, oil separators, relief valves, safety valves high and low press ure cut outs, thermostats, water regulator. Motors for refrigeration compressors, dehydrating charging and testing of refrigeration systems, application of microprocessors in refrigeration system.	16 lectures

Recommended books :

1. *Ashrae Handbook—Fundamentals,2013*
2. *Ashrae Hand Book. Refrigeration, 2010*
3. *Handbook of Air Conditioning & Refrigeration by Shan K. Wang,* McGraw-Hill, New York 2000
4. Heat Exchanger Design Handbook, Second Edition, by Kuppan Thulukkanam, CRC Press, 2013

ME-7011 Absorption Refrigeration and Heating Systems **4 Credits (4-0-0)**

Unit I	Classification of sorption systems: Absorption and adsorption, dry and wet types absorption, refrigeration systems, heat pumps, heat transformers.	12 lectures
Unit II	Wet absorption systems: Solution thermodynamics, refrigerant absorbent combinations, vapour pressure,concentration, temperature, enthalpy relations and charts.	12 lectures
Unit III	Single stage, multistage, resorption and hybrid systems: Types and design considerations for components such as absorbers, generators, rectifiers. Pumpless absorption systems.	16 lectures
Unit IV	Dry absorption / adsorption systems: Refrigerant, sorbent combinations and their properties, system analysis, metal hydride based systems heat and mass transfer in sorption beds and reactors.	16 lectures

Recommended books :

1. Principles of Refrigeration, W. B. Gosney, Cambridge University Press, 1982.
2. Absorption Chillers and Heat Pumps, K. E. Herold, R. Radermacher and S. A. Klein, CRC Press, 1996.
3. Heat Conversion Systems, G. Alefeld and R. Radermacher, CRC press, 1993.

ME 7013: Design of IC Engine Components and Sub-Systems **4 Credits (4-0-0)**

Unit I	Introduction to different types of I.C. engine systems, Engine design and operating parameters.	8 lectures
Unit II	Fuels for engines and their characteristics, aviation turbine fuels, fuel-air mixing, different types of carburettors, gas exchange, combustion characteristics and calculation of calorific values, fuel injection systems, ignition and combustion.	12 lectures
Unit III	Combustion chamber designs for spark ignition and compression-ignition engines, engine cooling and cooling system design, air cooling and water cooling system, engine lubrication systems, wet sump lubrication and charged lubrication systems.	13 lectures
Unit IV	Emission control and types of emission systems, ignition systems, battery ignition system, magneto"ignition system, scavenging parameters, Indian and European standard on emission norms.	12 lectures
Unit V	Design of supercharged engines, turbo engines, Jet engines, testing and performance of I.C. engines.	11 lectures

Recommended books :

1. Internal Combustion Engine, by John B. Heywood,TMH, 1988
2. A Text book of Internal Combustion Engines, by R.K. Rajput, Laxmi Publication, 2005
3. I.C. Engines Applied Thermo Sciences, by Colin R. Ferguson & Allan T. Kirkpatrick, WILLEY 2nd Edition, 2011
4. I.C. Engines: Combustion & Emissions by B.P. Pundir, Alpha Science, 2010

ME 7014 Alternative Fuels for Transportation 4 Credits (4-0-0)

Unit I	An introduction to hydrocarbon fuels, their availability and effects on environment, gasoline and diesel, self-ignition characteristics of the fuel, Octane number, Cetane number.	8 lectures
Unit II	Alternative fuels: liquid and gaseous fuels, Physico-chemical characteristics, alternative liquid fuels, alcohol fuels - ethanol & methanol, fuel composition, fuel induction techniques, fumigation, emission of oxygenates, applications to engines and automotive conversions, liquid hydrogen as fuel.	12 lectures
Unit III	Biodiesel formulation techniques, transesterification, application in diesel engines, DME (Dimethyl ether) properties, fuel injection consideration, general introduction to LPG and LNG, compressed natural gas components, mixtures and kits, fuel supply system, emission studies and control.	14 lectures
Unit IV	Hydrogen combustion characteristics, flashback control techniques, safety aspects and system development, NOx emission control.	10 lectures
Unit V	Biogas, producer gas and their characteristics, system development for engine applications.	12 lectures

Recommended books :

1. Alternative Transportation Fuels, M.K. Gajendra Babu, K.A,Subramanian, CRC Press, Taylor & Francis G roup, 2013
2. Renewable Energy, M.K. Ghosh Roy, Scientific International Pvt.Ltd, 1 st Ed., 2015
3. Biofuels for Road Transport, ,Lucas Reijinders,Mark A.K. Huijbregts, Springer,2009
4. Biofuels: Production and Future Perspectives, Ramsarup Singh, Ashok Pandey, CRC, Press,2016
5. Advances in Biodiesel Production Process and Technology, Rafael Luque and Juan A.Melero ,Woodhead Publications, 2011.

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY

SYLLABI
OF
PG / Ph. D. COURSES
(DEPARTMENT OF MATHEMATICS)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY

(UNDER THE MINISTRY OF EDUCATION, GOVT. OF INDIA)

DEEMED TO BE UNIVERSITY U/S 3 OF THE UGC ACT, 1956

NIRJULI - 791 109 :: ARUNACHAL PRADESH

SYLLABI
OF
PG/ Ph. D COURSES

(DEPARTMENT OF MATHEMATICS)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY (NERIST)
(Deemed to be University, U/S 3 Of the UGC Act, 1956)
Nirjuli (Itanagar), Arunachal Pradesh- 791 109

Department : Mathematics

Programme M. Tech

MA-7100 ADVANCED DISCRETE MATHEMATICS **(3-1-0: 4 Credits)**

Units	Topics	Lectures
Unit I	Sets, equivalence relation, partial order relation.	6 hr
Unit-II	Lattice and Boolean algebra, propositional calculus.	6 hr
Unit-III	Algebraic structure, monoid, group, permutation group,codes and group codes.	10 hr
Unit-IV	Ring, integral domain, polynomial ring and cyclic codes, field and finite fields. combinatorics, recurrence relation, generating functions.	10 hr
Unit-V	Graph Theory: Planar graphs, trees, binary trees, cut sets, finite state machines, digital networks, switching circuits, automata, discrete probability theories.	10 hr

Recomended Books:

1. Discrete Mathematics with Applications, T. Koshy, Academic Press Inc., 2004.
2. Discrete Mathematical Structures with Applications to Computer Science, J.P. Tremblay and R. Manoha r, McGraw Hill, 2001.
3. Discrete Mathematics and Its Applications, K.H. Rosen, 7th Edition, McGraw Hill, 2011.

References:

1. Elements of Discrete Mathematics, C. Liu and D. Mohapatra, 4th Edition, Tata McGraw Hill, 2012.
2. Discrete and Combinatorial Mathematics, R.P. Grimaldi, Pearson Education, 2011.
3. Discrete Mathematics for Computer Scientists and Mathematicians, J.L. Mott, A. Kandel and T.P. Baker , 2nd Edition, Pearson Education, 2015.

MA-7102 LINEAR ALGEBRA (EC) **(3-1-0: 4 Credits)**

Units	Topics	Lectures
Unit I	Review of vector spaces, bases & dimension, dual space, quotient space .	8 hr
Unit -II	Linear transformations, representation of linear transformations by matrices, eigen values and eigen vectors, invariant subspaces, annihilating polynomials, triangulation and diagonalization.	9 hr
Unit- III	Primary decomposition theorem, rational and Jordan form, inner product spaces, orthonormal bases, Gram-Schmidt orthogonalization process.	9 hr
Unit -IV	Linear functionals, adjoint, self adjoint, normal and unitary operators, spectral theorem for normal operators.	8 hr
Unit -V	Bilinear forms, positive forms, quadratic forms.	8 hr

Recomended Books:

1. Linear Algebra, K. Hoffman and R. Kunze, PHI, 1996.
2. Linear Algebra , S. Axler, Done Right, UTM, Springer 1997.

References:

1. Linear Algebra with Applications, G.C. Cullen, Addison Wesley 1997.
2. Finite dimensional vector spaces, P. R. Halmos, SpringerVerlag, New York, 1987.

MA-7107 ADVANCED MATHEMATICAL TECHNIQUES **(3-1-0: 4 Credits)**

Units	Topics	Lectures
Unit I	Ordinary differential equation of first and second order, complementary function, particular integr al, variation of parameter method.	8 hr
Unit -II	Basic concepts, modeling, vibration string, one dimensional wave equation, separation of variable method.	6 hr
Unit- III	Elementary statistics, correlation, regression, random variables, probability distribution, binomial , Poisson and Normal distribution, estimation of parameters, confidence interval, hypothesis of testing, goodness of fit.	10 hr
Unit -IV	Linear programing, graphical solution, un-constrained and constrained non-linear optimization, Lagrange multipliers.	8 hr
Unit -V	Solution of algebraic equations by iteration method, finite differences, interpolation, numerical integration and differentiation, numerical method for ODE and PDE.	10 hr

Recomended Books:

1. Odinary and partial differential Equation, M. D. Raishighania, S. Chand publication.
2. Fundamentals of Statistics, S. C. Gupta and V.K Kapoor ,Sultan chand & Sons .
3. Introductory methods of numerical analysis, S. S. Sastry, PHI.

References:

1. Partial Differential Equation, Sneddon, I. N., McGraw-Hill.
2. Theory of Ordinary Differential Equations, Earl Coddington McGraw-Hill.

MA-7108 STATISTICAL METHODS IN AGRICULTURE (3-0-0:3 Credits)

Units	Topics	Lectures
Unit I	Probability, random variable, discrete and continuous random variables and their probability distributions, distribution functions and their properties.	9 hr
Unit- II	Conditional probability, independence of events, Bayes theorem, mathematical expectation, moments and moment generating function.	8 hr
Unit -III	Tests of hypothesis for small and large sample sizes.	8 hr
Unit- IV	Method of least squares, simple linear regression and correlation, multiple linear regression.	8 hr
Unit- V	Design and analysis of experiments, analysis of variance for one and two-way classified data, CRD, RBD and LSD.	9 hr

Recomended Books:

1. Fundamentals of Statistics, Vol. I & II, A.M. Groom, M.K. Gupta and B. Dasgupta, The World Press Pvt . Ltd., Calcutta, 1994.
2. Introduction to Probability and Mathematical Statistics, V.K. Rohatgi, Wiley Eastern, New Delhi, 19 76.

References:

1. Experimental Design, Cochran W.G. and Cox G.M. (1957) : John Wiley and Sons.
2. Design and Analysis of Experiments, Das, M.N. and Giri J. (1986) : Springer Verlag

MA-7109 BIOSTATISTICS (3-0-0:3 Credits)

Units	Topics	Lectures
Unit I	Important variables of forestry sector. probability and probability distributions, review of probability theory, concept of random variable and expectation, probability distributions (Binomial, Poisson, Normal, exponential).	9 hr
Unit-II	Correlation and regression, simple, rank, partial, multiple, intra-class correlations, Furnivall, index and coefficient of determination, linear and nonlinear regressions, parabolic, exponential, power and logarithmic functions.	9 hr
Unit -III	Estimation and testing of hypothesis, concept of point and interval estimation, estimators and estimates, properties of good estimators- unbiasedness and minimum variance, tests of significance based on t, F, z and F^2.	8 hr
Unit -IV	Analysis of variance (ANOVA), one way and two way classification with single and more than one cell frequency, design of experiments principles of experimental designs, Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD).	8 hr
Unit-V	Sampling – Theory and applications, sample survey versus complete enumeration simple random sampling (with and without replacement), stratified random sampling, systematic and cluster sampling.	9 hr

Recomended Books:

1. Statistical Methods for Agricultural Workers. Pase UG & Sukhatme MU. 1978. ICAR.
2. Fundamentals of Statistics, Vol. I & II, A.M. Groom, M.K. Gupta and B. Dasgupta , The World Press P vt. Ltd., Calcutta, 1994.

References:

1. Statistical Tools for Agro-Forestry Research – Bivariate Analysis for Intercropping Experiments. Dea r KBG, Mead R & Relay J. 1987. ICRAF, Nairobi.
2. Principles of Database Management, Matin J. 1976, Prentice Hall.

MA-7110 ADVANCED MATHEMATICS **(3-0-0: 3Credits)**

Units	Topics	Lectures
Unit- I	Variational algebra , calculus of variation .	8 hr
Unit -II	Linear and non-linear regression' multiple linear regressions statistical methods-data presentation, modeling and analysis, test and hypotheses.	9 hr
Unit -III	Algebraic transformations, Fourier analysis and its application.	8 hr
Unit -IV	Mathematical functions, Bessel's functions, Legendre's functions.	9 hr
Unit -V	Metricesand Jacobians, coordinate transformations (Curvilinear to rectangular coordinates) , inverse transformations.	8 hr

Recomended Books:

1. Fundamentals of Mathematical Statistics, S. C. Gupta and V.K Kapoor ,Sultan chand & Sons .
2. Advanced differential Equation, M. D. Raishighania, S. Chand publication.
3. Calculus of variations with applications, A.S Gupta, PHI Learning Pvt. Ltd.

References:

1. Fundamentals of Statistics, Michael Sullivan, Second Edition, Prentice Hall.
2. An Introduction to the Calculus of Variations, Charles W. Fox.

DEPARTMENT : MATHEMATICS

Programme M. Sc

COURSE CARRICULUM

MA/MSc MATHEMATICS

I SEMESTER			
Course Code	**Course Title**	**L T P**	**C R**
MA 7101	Abstract Algebra	3-1-0	4
MA 7102	Linear Algebra	3-1-0	4
MA 7103	Real Analysis	3-1-0	4
MA 7104	Ordinary Differential Equations	3-1-0	4
MA 7105	Programming Languages	3-1-0	4
MA 7151	Programming Languages Lab(C/C++)	0-0-4	2
		Total Credit	22

II SEMESTER			
Course Code	**Course Title**	**L T P**	**C R**
MA 7201	Complex Analysis	3-1-0	4
MA 7202	Topology	3-1-0	4
MA 7203	Partial Differential Equations	3-1-0	4
MA 7204	Mathematical Methods	3-1-0	4
MA 7205	Numerical Analysis	3-1-0	4
MA 7251	Numerical Analysis Lab	0-0-4	2
		Total Credit :	22

III SEMESTER			
Course Code	**Course Title**	**L T P**	**C R**
MA 8101	Functional Analysis	3-1-0	4
MA 8102	Probability & Statistics	3-1-0	4
MA 8103	Analytical Mechanics	3-1-0	4
MA 80**	Elective I	3-1-0	4
MA 80**	Elective II	3-1-0	4
		Total Credit:	20

IV SEMESTER			
Course Code	**Course Title**	**L T P**	**C R**
MA 8201	Mathematical Programming	3-1-0	4
MA 8202	Discrete Mathematics	3-1-0	4
MA 80**	Elective III	3-1-0	4
MA 80**	Elective IV	3-1-0	4
MA 8205	Project		8
		Total Credit:	24

LIST OF ELECTIVES

Electives I & II

(Every student is required to choose any two of the following.)

MA-8001	Advanced Real Analysis	(3-1-0: 4 Credits)
MA-8002	Number Theory	(3-1-0: 4 Credits)
MA-8003	Computational Linear Algebra	(3-0-2: 4 Credits)
MA-8004	Special Functions and Integral Transforms	(3-1-0: 4 Credits)
MA-8005	Optimization Techniques	(3-1-0: 4 Credits)
MA-8006	Sampling Techniques	(3-1-0: 4 Credits)
MA-8007	Fractional Differential Equations	(3-1-0: 4 Credits)
MA-8008	Design and Analysis of Algorithm	(3-1-0: 4 Credits)
MA-8009	Numerical Solutions of ODE	(3-0-2: 4 Credits)
MA-8010	Stochastic Processes	(3-1-0: 4 Credits)
MA-8011	Mathematical Modelling	(3-1-0: 4 Credits)
MA-8012	Wavelets	(3-1-0: 4 Credits)
MA-8013	Ring Theory	(3-1-0: 4 Credits)

Electives III & IV

(Every student is required to choose any two of the following.)

MA-8014	Operator Theory	(3-1-0: 4 Credits)
MA-8015	Graph Theory	(3-1-0: 4 Credits)
MA-8016	Numerical Solutions of PDE	(3-0-2: 4 Credits)
MA-8017	Operation Research	(3-1-0: 4 Credits)
MA-8018	Commutative Algebra	(3-1-0: 4 Credits)
MA-8019	Differential Geometry	(3-1-0: 4 Credits)
MA-8020	Fuzzy Sets and Fuzzy Logic	(3-1-0: 4 Credits)
MA-8021	Fluid Dynamics	(3-1-0: 4 Credits)
MA-8022	Measure Theory	(3-1-0: 4 Credits)
MA-8023	Finite Element Methods	(3-1-0: 4 Credits)
MA-8024	Control Theory	(3-1-0: 4 Credits)
MA-8025	Advanced Algebra	(3-1-0: 4 Credits)

MA-7101 ABSTRACT ALGEBRA **(3-1-0: 4 Credits)**

Units	Topics	Lectures
Unit- I	Review of groups, subgroups, cosets, Lagrange's theorem, normal subgroups, quotient group, homomorphism and isomorphism	8
Unit II	Automorphism groups, permutation groups, Cayley's theorem, structure of cyclic groups, conjugate and normalizer of an element, direct product of groups, finite Abelian groups, Cauchy's theorems and Sylow's theorems.	9
Unit III	Ring, zero divisor, integral domain, ideals, quotient ring, isomorphism theorems.	8
Unit IV	Polynomial ring, prime, irreducible elements and their properties, unique factorization domain, principal ideal domain and Euclidean domain.	9
Unit V	Field, finite fields, field extensions, Galois theory.	8

Recomended Books:

1. I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd.
2. J.B. Fraleigh, A first course in Abstract Algebra

References:

1. S. Lang, Algebra, Addison Wesley.
2. C. Musili, Introduction of Rings and Modules, Narosa Publishing House
3. M. Artin, Algebra, PHI.

MA-7102 LINEAR ALGEBRA **(3-1-0: 4 Credits)**

Units	Topics	Lectures
Unit- I	Review of Vector spaces, bases & dimension, dual space, quotient space.	8
Unit II	Linear transformations, representation of linear transformations by matrices, eigen values and eigen vectors, invariant subspaces, annihilating polynomials, triangulation and diagonalization.	9
Unit III	Primary decomposition theorem, rational and Jordan form, inner product spaces, orthonormal bases, Gram-Schmidt orthogonalization process.	9
Unit IV	Linear functionals, adjoint, self adjoint, normal and unitary operators, spectral theorem for normal operators.	8
Unit V	Bilinear forms, positive forms, quadratic forms.	8

Recomended Books:

1. K. Hoffman and R. Kunze, Linear Algebra, PHI, 1996.
2. S. Axler, Linear Algebra Done Right, UTM, Springer 1997.

References:

1. G.C. Cullen, Linear Algebra with Applications, Addison Wesley 1997.
2. P. R. Halmos, Finite dimensional vector spaces, Springer Verlag, New York, 1987.

MA-7103 REAL ANALYSIS **(3-1-0: 4 Credits)**

Units	Topics	Lectures
Unit- I	Real number system and its structure as a complete ordered field, Archimedean property, sequences and series of real numbers, subsequences, monotone sequences, limit inferior, limit superior, convergence of sequences and series, Cauchy's criterion, root and ratio tests for the convergence of series, power series, product of series, absolute and conditional convergence.	9
UNIT II	Metric spaces, continuity, uniform continuity, completeness, compactness, connectedness, nested interval theorem, Heine-Borel theorem, intermediate value theorem, Bolzano-Weierstrass theorem, Baire category theorem.	8
UNIT III	Monotonic functions, functions of bounded variation, Riemann-Stieltjes integrals and their properties, differentiation and its properties, mean value theorems, Taylor's theorem, fundamental theorem of calculus.	8
UNIT IV	Sequences and series of functions, pointwise convergence, uniform convergence and its relations to continuity, differentiation and integration, equicontinuity, Arzela-Ascoli's theorem, Weierstrass approximation theorem.	9
UNIT V	Lebesgue measure and Lebesgue integral.	8

Recomended Books:

1. W. Rudin, Principles of Mathematical Analysis, McGraw Hill.
2. T.M. Apostol, Mathematical Analysis, Narosa Publishing House.
3. R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley & Sons Inc.
4. G. de Barra, Measure Theory and Integration, New Age Int. Pvt. Ltd.
5. C.D. Aliprantis and O. Burkinshaw, Principles of Real Analysis, Academic Press.

References:

1. R.R. Goldberg, Methods of Real Analysis, John Wiley & Sons Inc.
2. P.R. Halmos, Measure Theory, Springer.
3. N.L. Carothers, Real Analysis, Cambridge University Press

MA-7104 ORDINARY DIFFERENTIAL EQUATIONS (3-1-0: 4 Credits)

Units	Topics	Lectures
Unit- I	Linear ordinary differential equations of higher order with constant coefficients, homogenous and nonhomogeneous linear ordinary differential equations, Wronskian, variation of parameters method, reduction of order of equations.	8
Unit II	Power series method of ODE, introduction to initial value problem, existence and uniqueness of solution to initial value problem.	9
Unit III	Picard's and Peano's existence theorems, continuation of solutions and maximum interval of existence, continuous dependence.	8
Unit IV	Boundary value problems for second order equations, Green's function, Strum comparison theorems and oscillations, eigen value problems.	9
Unit V	Two dimensional autonomous systems and phase space analysis, critical points, proper and improper nodes, spiral point and saddle points, asymptotic behavior, stability.	8

Recomended Books:

1. L. Perko, Differential Equations and Dynamical Systems, Springer Verlag, New York.
2. G.F. Simmons, Differential Equations, Tata McGraw Hill, 1993.
3. E.A. Coddington, An Introduction to Ordinary Differential Equations, PHI, 1974.

References:

1. S.J. Farlow, An Introduction to An Introduction to Ordinary Differential Equations,PHI, 1974.
2. Boyce and DiPrima, Ordinary Differential Equations and Boundary Value Problems, John Willey and Sons , 2000.

MA- 7105 PROGRAMMING LANGUAGE (3-1-0: 4 Credits)

Units	Topics	Lectures
Unit- I	Computer fundamentals: Major hardware and software components of a digital computer, concepts of machine language, assembly language and high level language. Number systems: binary, octal, hexadecimal; algebraic operations and conversions, algorithms and flow charts.	9
Unit II	Fundamentals of C: Introduction to C; comments in C; data types in C, variables in C, input output statements, constant declaration, arithmetic operators in C, arithmetic expressions, assignment statements, arithmetic assignment operators, increment and decrement operators, type conversions, boolean expressions, operator precedence.	9
Unit III	Loops and decisions: While loop, do while loop, if statement, if else statement, switch statement, conditional operators. The break statement, the continue statement, the goto statement. Arrays and pointers: Arrays, declaration of one dimensional arrays, two dimensional arrays, pointers.	8
Unit IV	Structures: User defined data types, structures, array of structures, enumerated data type. Function in C: Simple functions, passing arguments to functions with return value, call by value, call by reference, overloaded functions, inline functions, default arguments.	8
Unit V	Object and classes: Class, types of accesses, difference between structure and classes, accessing members of a class, constructors, destructors. Searching and sorting: Bubble sort, selection sort, insertion sort, linear search and binary search.	8

Recomended Books:

1. V. Rajaraman, Fundamentals of computers, PHI, 2002.
2. E. Balaguruswamy,Programming in ANSI C, Tata McGraw-Hill, 2004.

References:

1. Y. P. Kanetkar, Let us C, BPB Publication, 2001.
2. M. G. Venkateshmurthy, Programming Techniques through C, Pearson Education, 2002.

MA- 7151 PROGRAMMING LANGUAGES LAB (C/ C++) **(0-0-4: 2 Credits)**

Units	Topics	Lectures
Unit- I	Determine whether a particular year is a leap year or not, to find the factorial value of any positi ve integer. Generating all prime numbers from 1 to 300.	4
Unit II	Obtaining the prime factors of a positive integer, obtaining the transpose of a 4 x 4 matrix.	5
Unit III	Multiplying two 3 x 3 matrices, obtaining the determinant of a 5 x 5 matrix. Finding the roots of a quadratic equation $ax^2 + bx + c = 0$.	6
Unit IV	Given two points (x,y) and (u,v) in the plane ; to add, subtract, multiply and divide two complex numbers $x + iy$ and $u + iv$. Evaluating the series $\sin x \quad x \quad \frac{x^3}{3!} \quad \frac{x^5}{5!} \quad \frac{x^7}{7!}$ ... (up to 10 terms).	6
Unit V	Finding the area of a triangle if lengths of its three sides are given. Obtaining the distance between two points in plane . Problems on selection sort, bubble sort and insertion sort.	7

References:

1. Y. P. kanetkar, Let us C, Fifth edition, BPB publication, 2016.
2. E. Balagurusamy, Programming in ANSI C, Tata Mcgraw Hill Education , 2004.

MA- 7201 COMPLEX ANALYSIS (3-1-0: 4 Credits)

Units	Topics	Lectures
Unit- I	Topology of the complex plane, sequence and series of functions, analytic functions, harmonic functions, formation of analytic functions.	8
Unit II	Bilinear transformations, **c**onformal mappings, and related problems.	9
Unit III	Complex integration, Cauchy's integral theorem, Morera's theorem, Cauchy's integral formula, maximum-modulus principle, Schwarz' lemma and Liouville theorem	8
Unit IV	Power series, Taylor's theorem and analytic continuation, zeros of analytic functions, classificatio n of singularities, Laurent's theorem, Casorati- Weierstrass theorem, argument principle, Rouche theorem, Hurwitz theorem.	9
Unit V	Residue theorem and its applications to evaluate real integrals.	8

Recomended Books:

1. S. Ponnusamy, Foundations of Complex Analysis, 2 nd edition, Narosa, 2011.
2. J.W. Brown and R.V. Churchill, Complex Variables and Applications, Mc-Graw Hill Higher Education, 20 09.
3. J. H. Mathews and R. W. Howell, Complex Analysis for Mathematics and Engineering, 3rd edition, Naros a, 1998.

References:

1. L.V. Ahlfors, Complex Analysis, Third Edition, McGraw-Hill Publishing Company, 1979.
2. J.B. Conway, Functions of Complex Variable, 2 nd Edition, Narosa Publishing House, India, 1994.

MA- 7202 TOPOLOGY **(3-1-0: 4 Credits)**

Units	Topics	Lectures
Unit- I	Topological spaces, bases and sub-bases, subspaces, closure, interior and boundary, continuity, open functions, homeomorphisms and embeddings.	9
Unit II	Strong and weak topologies, metric topology, product topology and quotient topology.	8
Unit III	Countability axioms, separability, Lindelof's spaces, separation axioms (T_0, T_1, T_2, T_3, T_4), regularity, complete regularity, normality.	9
Unit IV	Compactness, local compactness, Uryshon's lemma, Uryshon's metrization theorem, Tychonoff's theorem, compactification.	8
Unit V	Connectedness, local and path connectedness components, products of connected spaces.	8

Recomended Books:

1. J.R. Munkres, Topology: A First Course (2/e), Prentice- Hall, 2000.
2. G. F. Simmons, Introduction to Topology and Modern Analysis, Robert E. Krieger Publishing Company, Inc, 1983.

References:

1. K.D. Joshi, Topology,Wiley-Eastern, 1988.
2. J. L. Kelley, General Topology, Springer, 1991.

MA-7203 PARTIAL DIFFERENTIAL EQUATIONS **(3-1-0: 4 Credits)**

Units	Topics	Lectures
Unit- I	Origin of first order partial differential equations, classification, Lagrange's method for solving of first order quasi-linear partial differential equations of the form Pp + Qq = R, integral surfa ces passing through a given curve, surfaces orthogonal to a given system of surfaces, Cauchy's method for first order partial differential equations.	9
Unit II	Non-linear partial differential equations, compatible system of first order equations, Charpit's and Jacobi's methods, Cauchy's method of characteristics, and general solution of higher order linear homogenous and non-homogenous partial differential equations with constant coefficients.	8
Unit III	Genesis of second order partial differential equations, classification, reduction to canonical forms and characteristics.	8
Unit IV	Solutions of boundary value problems by the method of separation of variables, method of separation of variable for wave equation, D'Alembert's solution, vibration of infinite string, vibra tion of a semi-infinite string, vibration of finite string.	9
Unit V	Method of separation of variables for heat equation, heat conduction problem for an infinite rod, heat conduction in a finite rod, method of separation of variables for Laplace's equation, Dirichlet and Neumann's problem, theory of Green's function for Laplace's equation, method of integral transform.	8

Recomended Books:

1. I. N. Sneddon, Partial Differential Equations, McGraw-Hill, 1957.
2. R. Haberman, Elementary Applied Partial Differential equations, Prentice-Hall, New Jersey, 1987.
3. W. E. Willams, Partial Differential Equations, Oxford, 1980.
4. Lawrence C. Evans, Differential Equations, AMS-GTM, Vol.19, Indian edition, 2010.

References:

1. F. John, Partial Differential Equations, 3 rd edition, Narosa, 1979.
2. E. Zauderer, Partial Differential Equations of Applied Mathematrics, third edition, Wiley, 2011.

MA-7204 MATHEMATICAL METHODS **(3-1-0: 4 Credits)**

Units	Topics	Lectures
Unit- I	Linear functionals, minimal functional theorem, general variation of a functional, Euler-Lagrange equation, variational problems with fixed boundaries, sufficient conditions for extremum.	9
Unit II	Linear integral equations of the first and second kind of Fredholm and Volterra type, solution by successive substitutions and successive approximations, solution of equations with separable kernels, Fredholm alternative.	8

Unit III	General solution of Bessel equation, recurrence relations, orthogonal sets of Bessel functions, modified Bessel functions, general solution of Legendre equation, Legendre polynomials, Associated Legendre polynomials, Rodrigues formula, orthogonality of Legendre polynomials.	8
Unit IV	Concept and calculation of Green's function, approximate Green's function, Green's function method for solving differential equations.	8
Unit V	Fourier series, generalized Fourier series, Fourier cosine series, Fourier sine series, Fourier integrals. Fourier transform, Laplace transform, solution of differential equation by Laplace and Fourier transform methods.	9

Recomended Books:

1. G. N. Watson, A Treatise on the Theory of Bessel Functions, Cambridge Univeristy Press, 1944.
2. G. F. Roach, Green's Functions, Cambridge University Press, 1995.

References:

1. A. D. Poularikas, The Transforms and Applications – Handbook, CRC Press, 1996.
2. J. W. Brown and R. Churchill, Fourier Series and Boundary Value Problems, McGraw Hill, 1993

MA- 7205 NUMERICAL ANALYSIS (3-1-0: 4Credits)

Units	Topics	Lectures
Unit- I	Definition and sources of errors, propagation of errors, backward error analysis, sensitivity and conditioning, stability and accuracy, floating-point arithmetic and rounding errors.	9
Unit II	Solution of algebraic and transcendental equations by iteration , Newton Rahpson method, Regula Falsi method, numerical solution of simultaneous equations by Gauss-Jacobi, Gauss-Siedel and SOR method.	8
Unit III	Interpolation, extrapolation and inverse interpolation, divided difference, approximations of functions, Hermite interpolation, spline interpolation, B-splines, cubic splines and curve fitting by least squares and group average methods.	8
Unit IV	Numerical integration, Newton's-Cotes formula, Trapezodial and Simpson's rules, Weddle's rule, Romberg's Method.	8
Unit V	Solution of ordinary differential equations, Taylor's series method, Euler's and modified Euler's method, Runge-Kutta methods, multistep methods, Milne's Predictor-Corrector method, accuracy and stability.	9

Recomended Books:

1. W. Cheney and D. Kincaid, Numerical Mathematics and Computing, Cengage Learning, 2013.
2. M. K. Jain, S. R. K. Iyengar, R. K. Jain, Numerical methods, Problems and solutions, New Age International (P) Ltd., 1996.

References:

1. K. E. Atkinson, Introduction to Numerical Analysis, 2nd Edition, John Wiley, 1989.
2. R.L. Burden and J. D.Faires, Numerical Analysis, Cengage Learning, 2005 .

MA- 7251 NUMERICAL ANALYSIS LAB (0-0-4: 2 Credits)

Units	Topics	Lectures
Unit- I	Algebraic and transcendental equations by simple iteration method, method of false position, Newton-Raphson method.	9
Unit II	Simultaneous linear algebraic equations by Gauss elimination method, Jacobi's method, Gauss Seidel iteration method.	8
Unit III	To find the numerically largest eigen value of a square matrix.	8
Unit IV	Interpolate by using Gauss's Forward/ Backward interpolation formula and Lagrange's interpolation formula from a set of given data.	8
Unit V	Ordinary differential equation by Euler's and Runge-Kutta's Methods.	9

Recomended Books:

1. T Veerarajan and T Ramachandran, Numerical Methods, Tata Mcgraw-Hill, New Delhi.
2. R M Somasundaram, R M Chandrasekaran, Numerical methods with C++ Programming, PHI, 2005.

MA- 8101 FUNCTIONAL ANALYSIS (3-1-0: 4 Credits)

Units	Topics	Lectures
Unit- I	Normed linear spaces,equivalent norms, bounded linear operators and functionals, Hanh-Banach theorem, Banach spaces.	9
Unit II	Uniform boundedness theorem, open mapping theorem, closed graph theorem, duals and transposes, compact operators and their spectra.	8
Unit III	Hilbert spaces, polarization identity and parallelogram law, orthogonality, Reisz representation theorem, orthonormal systems, Bessel's inequality, Parsevals identity.	9
Unit IV	Adjoint operators, normal and self adjoint operators, unitary operators, isometry, orthogonal projection.	8
Unit V	Spectrum of an operator and it's non emptiness, spectral theorem for compact self -adjoint operators.	8

Recomended Books:

1. Erwin Kreyszig, Introductory functional analysis with applications, John Wiley and Sons, New York, 1978.
2. Walter Rudin, Functional Analysis, McGraw Hill, 2000.
3. G. F. Simmons, Introduction to Topology and Modern Analysis, Robert E. Krieger Publishing Company, Inc, 1983.
4. G. Bachman and L. Narici, Functional Analysis, Dover publication, 2003.

References:

1. Balmohan V. Limaye, Functional Analysis, 2 nd edition, Wiley Eastern Limited, 1996.
2. P. R. Halmos, Linear Algebra Problem Book, The Mathematical Association of America, USA, 1995.

MA-8102 PROBABILITY & STATISTICS (3-1-0: 4 Credits)

Units	Topics	Lectures
Unit- I	Sample spaces, events, probability – classical and statistical definitions, conditional probability, independence of events, Bayes theorem.	9
Unit II	Random variables - discrete and continuous random variables, probability mass and density function, distribution function and their properties, mathematical expectation, moments and moment generating function.	8
Unit III	Important discrete distributions: Bernoulli, binomial, negative binomial, Poisson, hypergeometric. continuous distributions - uniform, normal, student's t, F, Chi-square and exponential distribution.	9
Unit IV	Law of large numbers, central limit theorem, method of least squares, Scatter diagram, linear correlation coefficient, linear regression, multiple correlations and multiple regression.	8
Unit V	Sampling distribution, method of estimation, properties of good estimator, confidence intervals, tests of hypothesis based on Normal, X^2, and t.	8

Recomended Books:

1. A.M. Groom, M.K. Gupta and B. Dasgupta, Fundamentals of Statistics, Vol. I & II, The World Press Pvt. Ltd., Calcutta, 1994.
2. V.K. Rohatgi, Introduction to Probability and Mathematical Statistics, Wiley Eastern, New Delhi, 197 6.

References:

1. R.V. Hogg and A.T. Craig (1978) : Introduction of Mathematical Statistics, Fourth Edition, Collier Macmillon Publishers
2. Emuel Parzen, Stochastic Process, Holden-Day, San Francisco California.

MA- 8103 ANALYTICAL MECHANICS (3-1-0: 4 Credits)

Units	Topics	Lectures
Unit- I	Review of elementary principles, Lagranges equation of first kind, D' Alembert's principle, generalized coordinates and degrees of freedom, equation of motion in generalized coordinates for holonomic system, Lagrange's equation of motion for conservative holonomic dynamical system, velocity dependent potential, kinetic energy in terms of generalized coordinates, derivation of Newton's equation of motion from Lagrange's equation.	8
Unit II	Hamilton's canonical equations. Hamilton's variables, Hamiltonian as constant of motion cyclic coordinates, Poisson brackets, fundamental Poisson brackets, deduction's Jacobi-Poisson theorem, calculus of variations, fundamental lemma of calculus of variations, variation of functional, Euler's equation of one dependent variable.	9

Unit III	Hamilton's variational principles, Lagrange's equation for holonomic conservative system from Hamilton's principle, extension of Hamilton's principle to non-conservative system, Lagrange's equation from Hamiltons principle for non-holonomic system, Hamilton's canonical equation using Hamilton's principle, Newton's equation from Hamilton's principle.	9
Unit IV	Canonical transformation, conditions of canonical transformation, generating functions, properties of canonical transformations, verifications of canonical transformation.	8
Unit V	Hamilton-Jacobi Equation for Hamilton's principal functions, Jacobi's theorem (first form), Hamilton's theorem (first form), Hamilton-Jacobi equation for Hamilton's characteristic function, Jacobi's theorem (second form), separation of variables, Lagrange brackets and its properties. invariance of Lagrange brackets.	8

Recomended Books :

1. R N Tiwari and B. S. Thakur, Classical Mechanics, PHI, 2007.
2. Rajput and Gupta, Mathematical Physics, Pragati Prakashan.

References:

1. Goldstein, Classical Mechanics

MA- 8201 MATHEMATICAL PROGRAMMING (3-1-0: 4 Credits)

Units	Topics	Lectures
Unit- I	Linear programming problem, hyper planes, convex set, convex combination, convex hull, convex polyhedron, basic solution, feasible solution optimal solution, solution of linear programming problem by simplex method, two phase simplex method, the big M-method.	8
Unit II	Duality in linear programming, comparison of solution of primal and its dual, advantage of duality, duality theorem, unboundedness theorem, complementary slackness theorem, dual simplex method, revised simplex method.	9
Unit III	Transportation problems, mathematical method of transportation problem, the transportation algorithm, method for finding initial solution, north west corner method, least cost method, Vogel's approximation method, close – loop in transportation table and its problems, modi (or u – u) method for optimal solution, variation in transportation problem, unbalanced supply and demand, degeneracy and its resolution, alternative optimum solutions, prohibited transportation routes.	9
Unit IV	Integer programming problems. Gomory's all IPP technique, construction of Gomory's constraint, computational method, branch-and-bound algorithm and computation procedure, transportation problem and its solution.	8
Unit V	Game theory: two-person zero-sum games, maximum criterion, dominance rules, mixed strategies, mini-max theorem, solutions of 2x2 and 2xm games.	8

Recomended Books :

1. H. A. Taha, Operations Research: an Introduction, Macmillan, 1982.
2. Kanti Swarup, P. K. Gupta and M. M. Singh, Operations Research, Sultan Chand and Sons, 1985.

References:

1. L. C. Thomas, *Games:* Theory and Applications, John Wiley, 1984.
2. M. Shabik, Game Theory in the Social Sciences, MIT Press, 1982.
3. J.K.Sharma, Operations research: Theory and Applications, Macmillan Publishers India limited.

MA-8202 DISCRETE MATHEMATICS (3-1-0: 4 Credits)

Units	Topics	Lectures
Unit- I	Counting principles, principle of mathematical induction, partitions and allocations, pigeonhole principle, principle of inclusion and exclusion, arrangements, derangements.	8
Unit II	Generating function, recurrence relations.	9
Unit III	Posets, chain, well ordered sets, lattices, Boolean algebra, axiom of choice, cardinal and ordinal numbers.	9
Unit IV	Propositional calculus: Well-formed formulas, truth tables, tautologies, equivalence, duality, norma l forms.	8
Unit V	Predicate calculus: propositional logic, propositional equivalence, predicates and quantifiers, rule s of inference.	8

Recomended Books:

1. J.P. Tremblay and R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, McGraw Hill.
2. K.H. Rosen, Discrete Mathematics and Its Applications, McGraw Hill.

References:

1. C.L. Liu, Elements of Discrete Mathematics, Tata McGraw Hill.
2. R.P. Grimaldi, Discrete and Combinatorial Mathematics, Pearson.

Electives I & II

MA- 8001 ADVANCED REAL ANALYSIS **(3-1-0: 4 Credits)**

Units	Topics	Lectures
Unit- I	Functions of several variables, continuity, differentiability, total derivative, directional derivative, partial derivative, Jacobian, chain rule, mean value theorems.	8
Unit II	Higher derivatives for functions of several variables, interchange of the order of differentiation, Taylor's theorem, inverse mapping theorem, implicit function theorem.	9
Unit III	Extremum problems, extremum problems with constraints, Lagrange's multiplier method.	9
Unit IV	Multiple integrals, properties of integrals, existence of integrals, iterated integrals, Change of variables.	8
Unit V	Curl, Gradient, Divergence, Laplacian in cylindrical and spherical coordinates, Line integrals, Surface integrals, theorems of Green, Gauss and Stokes.	8

Recomended Books:

1. T.M. Apostol, Mathematical Analysis, Narosa Publishing House.
2. T.M. Apostol, Calculus. Vol. II: Multi-variable Calculus and Linear Algebra, with applications to Differential Equations and Probability, John Wiley & Sons Inc.

References:

1. S. Lang, Calculus of Several Variables, Springer.
2. M. Moskowitz and F. Paliogiannis, Functions of Several Real Variables, World Scientific.
3. Spiegel, Murray R., Schaum's Outline of Vector Analysis, Schaum's Outline Series.
4. W. Fleming, Functions of Several Variables, Springer.

MA- 8002 NUMBER THEORY **(3-1-0: 4 Credits)**

Units	Topics	Lectures
Unit- I	Divisibility, greatest common divisor, least common multiple, prime numbers, factorisation in prime numbers, fundamental theorem of arithmetic, the Euclidean algorithm, Perfect numbers, Mersenne numbers, Fermat theoram.	8
Unit II	Concept of congruences and its elementary properties, congruences in one unknown, complete residue system, reduced residue system, Gauss function, Mobius function, Euler function.	9
Unit III	Diophantine equations, linear Diophantine equations, pythagoras equation, sum of two squares.	9
Unit IV	Quadratic residues and congruences of second degree in one unknown, Legendre symbol, Jacobi symbol, congruences of second degree with prime modulus and with composite modulus.	8
Unit V	Primitive roots and indices, order, necessary and sufficient condition for the existence of primitive roots, construction of reduced residue system.	8

Recomended Books:

1. Niven and H. Zuckerman, An Introduction to the Theory of Numbers, 5th edition, Wiley Eastern, 2000.
2. M. Burton, Elementary Number Theory, 2nd edition, Universal Book Stall, New Delhi, 1994.

References:

1. Y. Hsiung, Elementary Theory of Numbers, World Scientific, 1992; First Indian Reprint, Allied Publishers Limited, 1995.
2. G. E. Andrews, Number Theory, Hindustan Publishing Corporation, New Delhi, 1992.
3. S. G. Telang, Number Theory, Tata McGraw Hill Publishing Company Limited, New Delhi, 1996.

MA- 8003 COMPUTIONAL LINEAR ALGEBRA (3-0-2: 4 Credits)

Units	Topics	Lectures
Unit- I	Linear systems, LU decompositions, Gaussian elimination with partial pivoting, banded systems, positive definite systems, Cholesky decomposition.	8
Unit II	Vector and matrix norms, perturbation theory of linear systems, condition numbers, estimating condition numbers, floating point arithmetic, analysis of roundoff errors.	9
Unit III	Gram-Schmidt orthonormal process, orthogonal matrices, householder transformation, givens rotations, QR factorization, roundoff error analysis of orthogonal matrices, stability of QR factorization.	9
Unit IV	Solution of linear least squares problems, normal equations, singular value decomposition(SVD), polar decomposition, Moore-Penrose inverse, rank deficient least squares problems, sensitivity analysis of least-squares problems.	8
Unit V	Reduction to Hessenberg and tridiagonal forms, power and inverse power methods, Rayleigh quotient iteration, explicit and implicit QR algorithms for symmetric and non-symmetric matrices, implementation of implicit QR algorithm, computing the SVD, sensitivity analysis of singular values and singular vectors, the Arnoldi and the Lanczos iterations.	8

Recomended Books:

1. L. N. Trefethen and David Bau, Numerical Linear Algebra, SIAM, 1997.
2. D. S. Watkins, Fundamentals of Matrix Computation, Wiley, 1991.

References:

1. G. H. Golub and C.F.Van Loan, Matrix Computation, John Hopkins U. Press, Baltimore, 1996.
2. G. W. Stewart, Introduction to Matrix Computations, Academic Press, 1973.
3. J.W. Demmel, Applied numerical linear algebra, SIAM, Philadelphia, 1997.

MA-8004 SPECIAL FUNCTION AND INTEGRAL TRANSFORMS (3-1-0:4 Credits)

Units	Topics	Lectures
Unit- I	Hypergeometric functions: Definitions of hypergeometric series and function,properties of hypergeometric functions, integral formula for hypergemetric series, linear transformations, contiguous function relations, linear relation between the solutions of hypergeometric differential equations, Kumar's confluent's hypergeometric function, elementary properties of genarlisedhypergeometric function.	9
Unit II	Hermite polynomials, Laguerre and associated Laguerre polynomials.	8
Unit III	Jacobi polynomials: definition and special case, Bat man's generating function, Rodrigue formula, orthogonality, recurrence relations, expansion in series of polynomials.	8
Unit IV	Chebyshev polynomials: solution of Chebyshev's equation, expansions, generating functions, recurrence relations, orthogonality.	8
Unit V	Hankel Transform: Definition and elementary properties: inversion theorem, Hankel transforms of derivatives, Parseval's theorem, application to the solution of boundary value problems, application to the solution of partial differential equations.	9

Recomended Books:

1. Rainville E.D., Special function, Macmillan, New York.
2. I.N. Sneddon, The use of integral transform, Tata McGraw Hill.

References:

1. M.R. Spigel, Theory and problems of Laplace transform.
2. Sharma and Vasistha, Integral transforms, Krishna Prakashan, Meerut.

MA-8005 OPTIMIZATION TECHNIQUES **(3-1-0: 4 Credits)**

Units	Topics	Lectures
Unit- I	Ellipsoid method, Karmarkar's method, duality and sensitivity.	8
Unit II	Transportation and assignment problems, unconstrained optimization of functions of several variables.	9
Unit III	Classical techniques, numerical methods for unconstrained optimization, constrained optimization of functions of several variables, Lagrange multiplier.	8
Unit IV	Kuhn- Tucker theory, numerical methods for constrained optimization, convex optimization, quadratic optimization.	9
Unit V	Dynamic programming.	8

Recomended Books:

1.G.C.Onwubolu and B.V.Babu, New Optimization Techniques in Engineering, Springer,2004.

2. David G. Luemberger,Optimization by Vector Space Method,Willey IEEE,1969.

References:

1. J. Nocedal and Stephen J. Wright, Numerical Optimization, Springer,1999.

2. M. Asghar Bhatti, Practical Optimization Methods with Mathematical Applications, Springer, 2000.

MA-8006 SAMPLING TECHNIQUES **(3-1-0: 4 Credits)**

Units	Topics	Lectures
Unit- I	Concept of population and sample, need for sampling, complete enumeration versus sampling, basic concepts in sampling, sampling and non-sampling errors.	8
Unit II	Simple random sampling with and without replacement, estimation of population mean, population proportions and their standard errors.	9
Unit III	Idea of heterogeneous population, stratified random sampling, proportional, Neuman and optimum allocations, comparison with simple random sampling for fixed sample size .	9
Unit IV	Ratio, product and regression methods of estimation, estimation of population mean, evaluation of bias and variance to the first order of approximation, comparison with simple random sampling.	8
Unit V	Systematic sampling (when population size (N) is an integer multiple of sampling size (n)), elementary idea of cluster sampling.	8

Recomended Books:

1. W.G. Cochran, Sampling Technique, Wiley Eastern, New Delhi, 1977.
2. P. Mukhopadhyay, Theory and Methods of Survey Sampling, Prentice-Hall of India Pvt. Ltd, New Delhi, 1998.
3. P.V. Sukhatme, B.V. Sukhatme, S. Sukhatme and C. Ashok, Sampling Theory of Survey with Applications, Iowa State University Press, Ames, Iowa, 1984.
4. Des Raj and Promod Chandhok, Sample Survey Theory, Narosa Publishing House, New Delhi, 1998.

References:

1. M.N. Murthy, Sampling Theory & Methods, 2nd edition, Stat. Pub. Soc., Calcutta, 1977.
2. R.J. Jensen, Statistical Survey Techniques, Wiley, N.Y., 1978.

MA- 8007 FRACTIONAL DIFFERENTIAL EQUATIONS **(3-1-0: 4 Credits)**

Units	Topics	Lectures
Unit- I	Spaces of integrable, absolutely continuous and continuous function spaces, classical Mittag-Leffler functions, generalized Mittag-Leffler functions, Wright functions, fixed point theorem.	8
Unit II	Riemann-Liouville fractional integrals and fractional derivatives, caputo fractional derivatives, Grunwald-Letnikov fractional derivatives.	9
Unit III	Ordinary fractional differential equations, existence and uniqueness theorems, equivalence of the Cauchy type problem and the Volterra integral equations, the weighted Cauchy type problem and Cauchy type problem for linear equations.	9

Unit IV	Equations with the Riemann-Liouville fractional derivatives in the space of continuous functions, global solutions, equations with the Caputo fractional derivatives in the space of continuously differentiable functions.	8
Unit V	Laplace transform method for solving ordinary differential equations with Riemann-Liouville fractional derivatives and Caputo fractional derivatives, partial fractional differential equations, solution of Cauchy problem for fractional evolution equations.	8

Recomended Books:

1. A.A. Kilbas, H.M. Srivastava and J.J. Trujillo, Theory and Applications of Fractional Differential e quations, Elsevier, 2006.

References:

1. I. Podlubny , Fractional differential Equations, San Diego Academic Press, san Diego, 1999.
2. Y. Zhou, Basic Theory of Fractional Differential Equations, World Scientific, 2015.

MA- 8008 DESIGN AND ANALYSIS OF ALGORITHMS (3-1-0: 4Credits)

Units	Topics	Lectures
Unit- I	Introduction to design and analysis of algorithms, growth of functions, recurrences, application to analysis of heap sort, priority queues and Rabin Karp string matching algorithms.	8
Unit II	Algorithm design and analysis Techniques (i) divide and conquer & randomization (Examples : quick sort, Miller – Rabin primality test), lower bound for sorting.	9
Unit III	Algorithm design and analysis techniques, dynamic programming (examples matrix chain multiplication, travelling salesman problem), greedy methods programming(examples activity – selection problem, job sequencing with deadlines), backtracking (Example : 8-queens problem & subset sun problem).	9
Unit IV	Graph algorithms, data structure for disjoint sets, minimum spanning tree (algorithm of Kruskal and Prim), single source shortest paths (Dijkstra's algorithms), all pairs shortest paths (Floyd – Warshall algorithm).	8
Unit V	NP:Completeness and approximation algorithms, polynomial time verification, NP Completeness and Reducibility, NP completeness proofs, NP Complete problems (Hamiltonian – cycle problem, Traveling Salesman problem), approximation algorithm for traveling salesman problem.	8

Recomended Books:

T. Coremen, C.E. Leiserson and R.L.Rivest, Introduction to Algorithms, PHI, 2000.

Reference:

E. Horowitz, S. Sahni and S. Rajasekharan, Fundamentals of Computer Algorithms, Galgotin, 2000.

MA-8009 NUMERICAL SOLUTIONS OF ORDINARY DIFFERENTIAL EQUATIONS (3-1-0: 4 Credits)

Units	Topics	Lectures
Unit- I	Initial value problems, explicit and implicit single step methods, Euler's method, revised Euler's method, Runge-Kutta methods, system of differential equations.	8
Unit II	Adaptive numerical methods, explicit and implicit multistep methods, predator- corrector methods.	9
Unit III	Hybrid methods, stability analysis of single and multistep methods.	9
Unit IV	Higher order differential equations, Non-uniform step methods, Boundary value problems.	8
Unit V	Convergence of difference schemes, linear eigenvalue problems, non-uniform grid methods for second order boundary value problems.	8

Recomended Books:

1. M. K. Jain, S. R. K. Iyenger and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, Wiley Eastern, 1993.
2. J. D. Lambert, Numerical methods for Ordinary Differential equations, John Wiley & Sons, 1991.

References:

1. M. K. Jain, Numerical Solutions of Differential Equations, Wiley Eastern, 1991.
2. J. D. Hoffman, Numerical methods for Engineers and Scientists, Mc-Graw Hill, 2000.

MA-8010 STOCHASTIC PROCESSES (3-1-0: 4 Credits)

Units	Topics	Lectures
Unit- I	Definition and examples of stochastic process: classification of general stochastic processes into discrete/continuous time, discrete/continuous state spaces, types of stochastic processes elementary problems.	8
Unit II	Markov chains: Definition and examples of Markov chain, transition probability matrix, classificatio n of states, recurrence and simple problems, basic limit theorem of Markov Chain.	9
Unit III	Poisson process and related inter-arrival time distribution, pure birth process, pure death process, birth and death process, statistical inference in MC and Markov processes.	8
Unit IV	Random walk and gambler's ruin problems, branching process, definition and examples of discrete time branching process, renewal theory, elementary renewal theorem and applications, statement and uses of key renewal theorem.	9
Unit V	Stationary process, weakly stationary and strongly stationary processes, branching process, Galton-Watson branching process.	8

Recomended Books:

1. J. Medhi, Stochastic Processes, Wiley Eastern Ltd., New Delhi, 1994.
2. Kishor Shribharbhai Trivedi, Probability & Statistics with reliability, Queuing and Computer Science Applications, PHI, 1992.

References:

1. E. Parzen, Stochastic Processes, Holden-Day, San Francisco, Calif, 1962.
2. L. Kleinrock, Queueing Systems, Vol. – I, II, John Wiley & Sons, 1976.
3. A.Y. Khintchine, Mathematical Methods in Queueing, Grieffen, London, 1960.
4. W. Feller, An Introduction to Probability Theory and its Applications, Vols. I & II, Wiley. 1966.

MA- 8011 MATHEMATICAL MODELLING (3-1-0: 4 Credits)

Units	Topics	Lectures
Unit- I	Model and its different types, finite models, statistical models, stochastic models.	8
Unit II	Formulation of a model, Laws and conservation principles, discrete and continuous models.	9
Unit III	Evaluation of a model. case studies, continuum model, transport phenomena, diffusion and air pollution models.	9
Unit IV	Manipulation of models into its most respective form, microwave heating, communication and information technology.	8
Unit V	Perturbation Theorems, Poincare's linearization theorem, bifurcation and Chaos.	8

Recomended Books:

1. R. Aris, Mathematical Modelling Techniques, Dover, 1994.
2. C. L. Dym and E. S. Ivey, Principles of Mathematical Modelling, Academic Press, 1980.

References:

1. M. S. Klamkin, Mathematical Modelling: Classroom Notes in Applied Mathematics, SIAM, 1986.
2. A. Friedman and W. Littman, Industrial Mathematics for Undergraduates, SIAM, 1994.
3. Y. C. Fung, A First Course in Continuum Mechanics, Prentice Hall, 1969.

MA-8012 WAVELETS (3-1-0: 4 Credits)

Units	Topics	Lectures
Unit- I	Basic Fourier analysis, inner products and orthogonal projections, discrete and fast Fourier transforms, Fourier series for periodic functions.	8
Unit II	Fourier transform, convolution and inversion of Fourier transform, different features of Fourier transform, Fourier transforms with several variables, Shannon's sampling theorem, Heisenberg's uncertainty principle.	9
Unit III	Continuous wavelet transform, discrete wavelet transform, Haar's simple wavelets, simple approximation, approximation with simple wavelet.	9
Unit IV	Ordered fast Haar wavelet transform, In-place fast Haar wavelet transform, In-place fast inverse Haar wavelet transform.	8

Unit V	Two dimensional wavelets, two dimensional approximation with step functions, two dimentional fast Haar wavelet transform, applications of wavelets.	8

Recomended Books:

1. Gilbert G. Walter, Ortogonal Systems with Applications, CRC Press.
2. Yves Nievergelt, Wavelets Made Easy, Birkhauser, Boston, 1999.

References:

1. R.M. Rao and A.S. Bopardikar, Wavelet Transforms: Introduction to theory and applications, Adison We sley.
2. C.K. Chui, An Introduction to Wavelets

MA-8013 RING THEORY (3-1-0: 4 Credits)

Units	Topics	Lectures
Unit I	Basic concepts of rings, modules, operation on ideals and sub-modules, matrix ring, polynomial rings, direct products of rings, field and division rings, idempotent and nilpotent elements in a ring.	8
Unit II	Isomorphism theorems, exact sequences, the group of homomorphism and its properties relative to exact sequences.	9
Unit III	Direct sum and direct products of modules, external and internal direct sums, direct summands, Zorn's lemma, every vector spaces has a basis, free modules and projective modules, torsion free and torsion modules over commutative domains, exact sequences and projectivity.	9
Unit IV	Injective modules, injectivity and divisibility over domains, exact sequences and injectivity, Baer's theorem and its elementary applications, simple modules, semisimple modules (as per Bourbaki), Schur's lemma.	8
Unit V	Equivalent conditions for semisimple modules, Wedderburn structure theorem, Characterization of semisimple rings via projective and injective modules.	8

Recomended Books:

1. I.T Adamson and Oliver and Boyd ,Elementary Rings and Modules , Edinburgh, 1995
2. J.J. Rotman, Van nostrand, Note on Homological Algebra, 1990.

References:

1. N. Jacobson, Basic Algebra II (3rd edition) , Hindustan Publishing Corporation, New Delhi,2002.
2. S. Lang ,Algebra, Second Edition, Wesley, Massachusetts, 1984.
3. I.S.Luther and I.B.S.Passi ,Algebra, Vol. 2: Rings-, Narosa Publishing House, New Delhi,1999.

Electives III & IV

MA-8014 OPERATOR THEORY (3-1-0: 4 Credits)

Units	Topics	Lectures
Unit I	Review of Hilbert spaces, orthonormal bases, uniform, strong and weak convergences.	8
Unit II	Finite rank and compact operators, Hilbert-Schmidt operators.	9
Unit III	Bounded operators on Hilbert spaces; adjoint of bounded operators, algebra of bounded operators, orthogonal projections, self adjoint, normal, isometry and unitary operators.	9
Unit IV	Spectra of bounded operators; positive operators and their square root; projection operators; multiplication operator and differentiation operator.	8
Unit V	Spectral measure; spectral theorem for compact operators, spectral theorem for bounded self adjoint and normal operators.	8

Recomended Books:

1. P. R. Halmos, Introduction to Hilbert spaces and theory of spectral multiplicity, Chelsea Publishing Co., New York, 1957.
2. Erwin Kreyszig, Introductory functional analysis with applications, John Wiley and Sons, 1978.

References:

1. G. Bachman and L. Narici, Functional Analysis, Academic Press, New York, 1966.
2. B.V. Limay, Functional Analysis, 2 nd edition, New Age International, New Delhi, 1996.

MA-8015 GRAPH THEORY **(3-1-0: 4 Credits)**

Units	Topics	Lectures
Unit- I	Graph, degree, incidence, isomorphism, walk, path, cycles, complete graph, operations on Graphs, connectivity, edge & vertex connectivity, cut-vertex, cut-edge, cut-set. Traversability: Eulerian gr aphs &its necessary & sufficient condition, Hamiltonian graphs & its necessary conditions, bipartite graphs and their necessary & sufficient condition.	8
Unit II	Trees: characterizations, forest, rooted tree, binary tree, spanning tree, fundamental cycles.	9
Unit III	Coverings and colorings: covering, independence and domination, coloring of vertices, edges and regions, chromatic number, chromatic polynomials.Planarity: Kuratowski'stheorem,Thickness and crossing numbers.	9
Unit IV	Diagraphs.	8
Unit V	Groups and graphs, matrices and graphs, eigen values of graphs.	8

Recomended Books:

1. F. Harary, Graph Theory, Adison Wesley
2. L.R. Foulds. Narosa, Graph Theory and Application, Narosa

References:

1. J.A. Bondy and USR Murty, American
2. N. Hartfield and G. Ringel, Pearls in Graph Theory, Dover Publication.
3. Claude Berge, Graphs and Hypergraphs, North Holand.

MA- 8016 NUMERICAL SOLUTIONS OF PARTIAL DIFFERENTIAL EQUATIONS

(3-1-0: 4 Credits)

Unit I	Finite difference, schemes for partial differential equations - explicit and implicit schemes, Dirichlet, Neumann and mixed problems.	8 lectures
Unit II	Consistency, stability and convergence - stability analysis by matrix method and von Neumann method, Lax's equivalence theorem.	9 lectures
Unit III	Finite difference schemes for initial and boundary value problems - FTCS backward Euler and Crank-Nicolson schemes, ADI methods, Lax Wendroff method, upwind scheme; CFL conditions.	9 lectures
Unit IV	Finite element method for ordinary differential equations - variational methods, method of weighted residuals, finite element analysis of one-dimensional problems.	8 lectures
Unit V	Three dimensional elliptic problems.	8 lectures

Recomended Books:

1. L. Lapidus and G. F. Pinder, Numerical Solution of Partial Differential Equations in Science and Engineering, John Wiley, 1982.
2. G. D. Smith, Numerical Solutions to Partial Differential Equations, Oxford University Press, 3rd Edn., 1986.

References:

1.C. Johnson, Numerical Solution of Partial Differential Equations by the Finite Element Metod, Dover Publications, 2009.
2. H. P. Langtangen, Computational Partial Differential Equations Springer Verlag, 1999.
3. M.K. Jain, S.R.K. Iyenger and R.K. Jain, Computational Methods for Partial Differential equations, Wiley Eastern, 1994.

MA- 8017 OPERATIONS RESEARCH (3-1-0: 4 Credits)

Unit I	Definition and scope of operational research, different types of models, replacement model and sequencing theory.	8 lectures
Unit II	Inventory problems and their analytical structure, simple deterministic inventory model.	9 lectures
Unit III	Economic lot size models with uniform rate of demand, with different rate of demand in different cycle.	9 lectures
Unit IV	Stochastic demand inventory control; basic characteristics of queueing system, single server finite queuing models.	8 lectures
Unit V	Steady state solution of Markovian queueing model, Multi channel queueing models with infinite space.	8 lectures

Recomended Books:

1. J. K. Sharma, Operations Research: Theory and Applications, Macmillan, 1997.

References:

1. Humdy A. Taha, Operations Research - An Introduction, Prentice Hall of India, New Delhi, 1999.
2. Sharma and Goel, Operation Research.

MA-8018 COMMUTATIVE ALGEBRA (3-1-0: 4 Credits)

Unit I	Preliminaries on rings and ideals, local and semilocal rings, nilradical and Jacobson radical, operation on ideals, extension and contraction ideals, modules and module homomorphisms, submodules and quotient modules, operation on submodules, annihilator of a module, generators for a module, finitely generated modules, Nakayama's lemma, exact sequences.	9 lectures
Unit II	Existence and uniqueness of tensor product of two modules, tensor product of n modules, restriction and extension of ideals, exactness properties of tensor products, flat modules.	8 lectures
Unit III	Multiplicatively closed subsets, saturated subsets, ring of fractions of a ring, localization of a ring, module of fractions and its properties, extended and contracted ideals in a ring of fractions, total ring of fractions of a ring.	8 lectures
Unit IV	Primary ideals, p-primary ideals, primary decomposition, minimal primary decomposition, uniqueness theorems, primary submodules of a module.	9 lectures
Unit V	Chain conditions, ascending chain conditions on modules, maximal condition, Noetherian modules, descending chain condition, minimal condition, Artinian modules, their properties, Noehterian rings, Hilbert basis theorem, Artinian rings, structure theorem for Artinian rings.	8 lectures

Recomended Books:

1. M.F. Atiyah and I.G Macdonald, Introduction to Commutative Algebra, Addison Wesley, 2000.

References:

1. M Reid, Undergraduate Commutative Algebra, London Math. Soc.Student Texts, No. 29, 1995.
2. I.S.Luther and I.B.S.Passi, Algebra, Vol. 2: Rings, Narosa Publishing House, New Delhi, 1999.
3. I.S.Luther and I.B.S.Passi, Algebra, Vol. 3: Modules, Narosa Publishing House, New Delhi, 1999.

MA- 8019 DIFFERENTIAL GEOMETRY (3-1-0: 4 Credits)

Unit I	Theory of space curves, the Serret-Fenet formulas, Gauss theory of surfaces- first and second fundamental form.	9 lectures
Unit II	Weingarten map, principal curvatures, Gaussian curvature, computation of the curvature in standard spaces: sphere, tours, surfaces of revolution etc.	8 lectures
Unit III	Levi-Civita connection-uniqueness, Gauss theorem egregium, Hilbert's theorem on the positivity of curvature at a point on a compact surface in R^3.	8 lectures
Unit IV	Geodesics, equations of geodesics, examples. Jacobi fields, conjugate points etc. Riemannian area element on a surface, Gauss Bonnet theorem.	9 lectures
Unit V	Differentiable manifold, differentiable structure, sub-manifolds, immersions, embeddings, Riemannian connection and curvature.	8 lectures

Recomended Books:

1. Alfred Gray, Modern Differential Geometry of curve and surfaces, CRC Press 1993.
2. Sigurour Helgason, Differential Geometry and Symmetric Spaces, American Mathematical Society, 200 1.

References:

1. Erwin Kreyszig, Differential Geometry, Courier Dover Publications 1991.
2. Thierry Aubin, A course in Differential Geometry, American Mathematical Society, 2001.
3. Kuhnel Wolfgng, Differential Geometry: Curves, Surfaces and Manifolds, McGraw Hill Professionals, 2006.

MA-8020 FUZZY SETS & FUZZY LOGIC (3-1-0: 4 Credits)

Unit I	Overview of crisp sets, fuzzy sets, membership representation, membership functions, properties of membership function, associated terms for fuzzy sets (core, height, support & normal), scalar cardinality and relative cardinality of fuzzy sets, fuzzy cardinality of fuzzy sets, complement, union and intersection of fuzzy sets, standard and nonstandard operations, t-norm and t-conorm. D-cuts, extension principle for fuzzy sets.	8 lectures
Unit II	Fuzzy numbers, arithmetic operations on fuzzy numbers.	9 lectures
Unit III	Cartesian product of fuzzy sets, fuzzy relations and their properties, fuzzy equivalence relations, fuzzy tolerance relations, composition of fuzzy relations and their matrix representations.	9 lectures
Unit IV	Fuzzification & defuzzification methods.	8 lectures
Unit V	Fuzzy logic, linguistic variables, propositional and predicate calculus, fuzzy inference/approximate reasoning, fuzzy rule base, applications.	8 lectures

Recomended Books:

1. M.Ganesh ,Introduction to Fuzzy sets & Fuzzy Logic (3E), PHI

2. T.J. Ross, Ruzzy Logic with Engineering Applications, McGrawHill.

References:

1. G.J. Klir & Bo Yuan, Fuzzy sets and Fuzzy Logic: Theory and Applications, PHI

2. Zimmerman, Fuzzy set theory and its Application, Kluwer Academic Press

MA- 8021 FLUID DYNAMICS (3-1-0: 4 Credits)

Unit I	Review of gradient, divergence and curl, elementary idea of tensor, velocity of fluid, stream lines and path lines, steady and unsteady flows.	9 lectures
Unit II	Velocity potential, vorticity vector, conservation of mass, equation of continuity, equivalence between Eulerian and Lagrngian forms of equation of continuity.	8 lectures
Unit III	Equations of motion in inviscid flud, Euler's equations of motion in rectangular, cylindrical and spherical polar coordinates equations of motion under impulsive forces.	8 lectures
Unit IV	One dimensional inviscid incompressible flow, Bernoulli's equation and its applications, singularities of flow, source, sinks and doublets.	8 lectures
Unit V	Three dimensional flow, Reynolds number, stress and strain analysis, Navier stokes equation, Boundary layer equations.	9 lectures

Texts:

1. Sir Horace Lamb, Hydrodynamics, Cambridge University Press, 1971.

2. L. M. Milne, Theoretical Hydrodynamics, Macmillan and Co., 1960.

References:

1. A.S. Ramsay, A Treatise on Hydromechanics, ELBS.

2. F. Chorlton, A Text Book of Fluid Dynamics, Von Nostrand Reinhold/CBS, 1985.

3. F. M. White, Fluid dynamics, Mcgraw Hill, 2008.

MA- 8022 MEASURE THEORY (3-1-0: 4 Credits)

Unit I	Measure on the real line, Lebesgue outer measure, measurable sets, measurable functions, Borel and Lebesgue measurability.	9 lectures
Unit II	Integration of functions of a real variable, integration of non-negative functions, the general integral, integration of series, Riemann and Lebesgue integrals.	8 lectures
Unit III	Abstract measure spaces, measures and outer measures, extension of a measure, uniqueness of the extension, completion of a measure, measure spaces, integration with respect to a measure.	8 lectures
Unit IV	Inequalities and the L_p spaces, convex functions, Jensen's inequality, inequalities of Holder and Minkowski's, completeness of L_p.	8 lectures
Unit V	Signed measures and the decomposition, the Jordan Decomposition, Radon-Nikodym theorem, some applications of the Radon Nikodym theorem, measurability in a product space, the product measure and Fubini's theorem.	9 lectures

Recomended Books:

1. H. L. Royden, Real analysis, 3rd Ed., Prentice Hall of India, New Delhi, 2005.
2. I. K. Rana, An Introduction to Measure and Integration, Narosa Publishing House, New Delhi, 1999.

References:

1. D,L, Cohn, Measure Theory, Birkhauser, Switzerland,1980.
2. Paul Halmos, Measure Theory, Springer Verlag, New York, 1974.

MA- 8023 FINITE ELEMENT METHOD (3-1-0: 4 Credits)

Unit I	Notation and mathematical preliminaries, **b**asic concepts of finite element methods, elements of function spaces**,** A two point boundary value problem, the maximum principle, Green's function, variational principle**.**	9 lectures
Unit II	Lax-Milgram theorem, piecewise polynomial approximation in function spaces, Galerkin orthogonality and Cea's lemma.	8 lectures
Unit III	Bramble-Hilbert lemma, Aubin-Nitsche duality argument.	8 lectures
Unit IV	Applications to elliptic, parabolic and hyperbolic equations, a priori error estimates.	9 lectures
Unit V	Energy estimates , a posteriori error analysis and reliability, efficiency and adaptivity .	8 lectures

Recomended Books:

1. Dietrich Braess, Larry L. Schumaker, Finite Elements: Theory, Fast Solvers, and Applications in Soli d Mechanics (2nd edition), Cambridge University Press, 2001.
2. C.S. Desai, Introductory Finite Element Method, CRC Press, 2001.
3. C. Johnson, Numerical solution of PDE by Finite Element Method, Cambridge University Press, 1987

References:

1. S. Larsson , V. Thomee, Partial Differential Equations with numerical Methods, Springer, 2003.
2. P. G. Ciarlet, The Finite Element Method for Elliptic Problems, North-Holland, 1978.
3. J. N. Reddy, An Introduction to Finite Element Method, McGraw Hill, 1993.

MA- 8024 CONTROL THEORY (3-1-0: 4 Credits)

Unit I	Motivation, basic results of differential equations, fixed point methods.	9 lectures
Unit II	Observablity of linear and nonlinear systems.	8 lectures
Unit III	Controllability of linear systems, nonlinear systems, controllability with prescribed control, asympototic null controllability.	8 lectures
Unit IV	Stability of linear, perturbed linear and nonlinear systems, Lyapunov stability.	9 lectures
Unit V	Optimal Control of linear time varying, linear time invariant and nonlinear systems.	8 lectures

Recomended Books:

1. J. Klamka, Controllability of Dynamical Systems, Kluwer Academy Publisher, Dordrecht, 1991.
2. R.F. Curtain and A.J. Pitchard, Functional Analysis in Modern Applied Mathematics, Academic Press , New York, 1977.
3. R. Conti, Linear Differential equations and control, Academic Press, London, 1976.

References:

1. K. Balachandran and J. P. Dauer, Elements of Control Theory, Narosa, 2012.
2. R.F. Curtain and H. Zwart, An introduction to Infinite-Dimensional Linear system Theory, Springer Verlag, New York, NY, 1995.

MA- 8025 ADVANCED ALGEBRA (3-1-0: 4 Credits)

Unit I	Algebraic, normal and separable extensions of field, splitting fields, automorphisms of extensions, the fundamental theorem of Galois theory.	9 lectures
Unit II	Finite fields, primitive elements, norm and trace, cyclotonic fields, cyclic extension, solution of polynomial equations by radicals.	8 lectures
Unit III	Commutative rings, localisation, Noetherian and Artinian rings, integral extensions Hilbert's Nullstellensatz, Noether's normalisation, valuation ring.	8 lectures
Unit IV	Modules, direct sum and product, finitely generated modules, tensor product of modules, exact sequences, chain conditions, free modules, projective and injective modules.	9 lectures
Unit V	Categories and functors, hom, modules over principal ideal domains, primary decompositions, Dedekind domains and modules over them.	8 lectures

Recomended Books:

1. M. F. Atiyah and I. G.Macdonald, Introduction to commutative Algebra, Addision Wesley, 1969.
2. P. M. Cohn, Algebra, Vols. I & Vol. II, John Wiley & Sons, 1985 and 1988.

References:

1. N. Jacobson, Basic Algebra, Vols. I & II, W. H. Freeman, 1980 (also published by Hindustan Publis hing Company, Delhi).
2. Dummit & Foote, Abstract Algebra, John Wiley & Sons, 2002.

Recomended books:

1. Elementary Rings and Modules- I.T Adamson, Oliver and Boyd, Edinburgh, 1995
2. Note on Homological Algebra- J.J. Rotman, Van nostrand, 1990.

References:

1. Basic Algebra II (3rd edition)- N. Jacobson, Hindustan Publishing Corporation, New Delhi,2002.
2. Algebra, Second Edition - S. Lang, Wesley, Massachusetts, 1984.
3. Algebra, Vol. 2: Rings- I.S.Luther and I.B.S.Passi, Narosa Publishing House, New Delhi,1999.

MA- 9003 CONTINUUM MECHANICS (3-0-0: 3 Credits)

UNIT-I	Analysis of Strain, Lagrangian and Eulerian finite strain tensor. Geometrical interpretation of the components of strain. Strain quadric of Cauchy, Principal strains and invariants.	9 Lectures
UNIT-II	General infinitesimal deformation. Saint-Venant's equations of compatibility. Finite deformation	8 Lectures
UNIT - III	Analysis of stress-Stress tensor. Equations of equilibrium. Transformation of co-ordinates. Stress quadric of Cauchy. Principal stress and invariants. Maximum normal and shear stresses.	9 Lectures
UNIT-IV	Equations of Elasticity. Generalised Hooks's law. Homogeneous isotropic media, Elastic constants. Strain energy function and its connection with Hooke's law. Uniqueness of solution. Saint-Vernant's principle.	8 Lectures
UNIT-V	Two dimensional problems -Plane stress. Generalised plane stress. Airy stress function.	8 Lectures

Recomended books:

1. Mase, G.E, Schaum's Outline of Continuum Mechanics (Schaum's Outline series), Mc-Graw Hill, 1990.
2. Rabindranath Chatterjee, Mathematical Theory of Continuum Mechanics, Narosa, 1999.

References:

1. C. Truesdell, The elements of continuum Mechanics, Springer-Verlag, 2000.
2. A.C. Eringen, Mechanics of Continuua, Academic Press, Princeton.

MA-9004 COMMUTATIVE ALGEBRA (3-0-0: 3 Credits)

UNIT-I	Preliminaries on rings and ideals, local and semilocal rings, nilradical and Jacobson radical, operation on ideals, extension and contraction ideals, modules and module homomorphisms, submodules and quotient modules, operation on submodules, annihilator of a module, generators for a module, finitely generated modules, Nakayama's lemma, exact sequences.	9 Lectures
UNIT-II	Existence and uniqueness of tensor product of two modules, tensor product of n modules, restriction and extension of scalars, exactness properties of tensor products, flat modules.	8 Lectures
UNIT-III	Multiplicatively closed subsets, saturated subsets, ring of fractions of a ring, localization of a ring, module of fractions and its properties, extended and contracted ideals in a ring of fractions, total ring of fractions of a ring.	8 Lectures

UNIT-IV	Primary ideals, p-primary ideals, primary decomposition, minimal primary decomposition, uniqueness theorems, primary submodules of a module.	9 Lectures
UNIT-V	Chain conditions, ascending chain conditions on modules, maximal condition, Noetherian modules, descending chain condition, minimal condition, Artinian modules, their properties, Noehterian rings, Hilbert basis theorem, Artinian rings, Structure theorem for Artinian rings.	8 Lectures

Recomended books:

1. M.F. Atiyah and I.G Macdonald, Introduction to Commutative Algebra, Addison Wesley,2000.

References:

1. M Reid, Undergraduate Commutative Algebra, London Math. Soc. Student Texts, No.29, 1995.
2. I.S.Luther and I.B.S.Passi, Algebra, Vol. 2: Rings, Narosa Publishing House, New Delhi,1999.
3. I.S. Luther and I.B.S.Passi, Algebra, , Vol. 3: Modules, Narosa Publishing House, New Delhi,1999 .

MA- 9005 ALGEBRAIC TOPOLOGY (3-0-0: 3 Credits)

UNIT-I	Homotopy, Path homotopy. The fundamental group.Covering spaces. The fundamental group of the circle, S1, sphere, S2, Surfaces 2- dimensional, Punctured plane, Technique of calculation.	9 Lectures
UNIT-II	The special Van Kampen theorem. Essential and Inessential maps- Applications.	8 Lectures
UNIT-III	The fundamental theorem of algebra, Brower's fixed point theorem for the disc etc. Triangulations.Simplical complexes. Barycentic subdivision. Simplical mappings, Thesimplical approximation theorem.	9 Lectures
UNIT-IV	Simplical homology groups; Calculations for cone complex, S^n, The Euler-Poincare formula.	8 Lectures
UNIT-V	The Lefschetz fixed point theorem. Singular homology groups	8 Lectures

Text books:

1. Allen Hatchen, Algebraic Topology, Tsinghua University Press, 2005.
2. Robert M Switzer, Algebraic Topology-Homotopy and Homology, Springer Verlag, 1975.

References:

1. Joseph John Rotman, An Introduction to Algebraic Topology, Springer Verlag, 1998.
2. Charles Richard Francis Maunder, Algebraic Topology, Courier Dover Publications, 1996.
3. William S. Massey, a Basic course in Algebraic Topology, Springer Verlag, 1991.

MA-9006 DIFFERENTIAL EQUATIONS AND DYNAMICAL SYSTEMS

(3-0-0: 3Credits)

UNIT-I	Uncoupled linear systems, diagonalization, exponetials of operators, the fundamental theorem for linear systems.	9 Lectures
UNIT-II	Linear systems in R^2, complex eigenvalues, multiple eigenvalues, Jordan forms, stability theory. Non homogenous linear systems.	8 Lectures
UNIT-III	Nonlinear systems: some preliminary concepts and definitions, the fundamental existence-Uniqueness theorem, dependence on initial conditions and parameters.	9 Lectures
UNIT-IV	The flow defined by a differential equations, lineariztion of nonlinear system, stability and Liapunov functions, saddles, Nodes, Foci and centers.	8 Lectures
UNIT-V	Center Manifold theory, normal form theory, Gradient and Hamiltonian systems.	8 Lectures

Recomended books:

1. L. Perko, Differential Equations and Dynamical systems, Springer, 2010.
2. A. Katok, & B. Hasselblatt, Introduction to the modern theory of dynamical systems, Cambridge, 1995.

References:

1. A.G. Ramm and N.S. Hoang, Dynamical Systems Methods and Applications, Willey, 2011.

MA- 9007 TIME SERIES AND FORECASTING (3-0-0: 3 Credits)

UNIT-I	Linear stationary processes, AR, MA, ARMA a nd ARIMA.	9 Lectures
UNIT-II	Identification, estimation of the models; forecasting time series regression.	8 Lectures
UNIT-III	Fourier analysis, spectral representation of a stochastic process.	9 Lectures
UNIT-IV	Properties of ARMA processes in the frequency domain	8 Lectures
UNIT-V	Estimation of the spectrum, Kalmanfilter.	8 Lectures

Recomended books:

1. Dobrivoje Popovic and Ajoy K. Palit., Computional Intelligence in Time Series Forecasting, Springer, 2005.
2. Christopher Chartfield, Time Series Forecasting, CRC Press, 2001.

References:

1. Robert A. Yaffee and Bonnie Macgee, An Introduction to Time Series Forecasting with Applications, Elsevier, 2000.
2. Peter J. Brockwell and Richard A. Daivs, Introduction to Time Series Forecasting, Springer, 2002.

MA-9008 COMPUTATIONAL FLUID DYNAMICS (3-0-0: 3 Credits)

UNIT-I	Basic equations of Fluid Dynamics. Analytical aspects of PDE. Finite volume and finite difference methods on non uniform grids.	9 Lectures
UNIT-II	Stationary convection diffusion equations, Nonstationary convection diffusion equations. Conservation laws.	8 Lectures
UNIT-III	Incompressible plane flows, Stream function and vorticity equations, Conservative form and normalizing systems, Method for solving vorticity transport equation, Basic finite difference forms, Conservative property.	9 Lectures
UNIT-IV	Convergence and stability analysis, Explicit and implicit methods, Stream function equation and boundary conditions, Solution for primitive variables. Simple C F D Techniques, Lax-Wendroff Technique , Mac Cormack's Techniques, finite volume method, application to Euler equations.	8 Lectures
Unit III	Upwind difference scheme, viscous flow solutions, staggeredgrid, SIMPLE Algorithm. Numerical Solutions of Navier-Stokes equations on collocated and on staggered grids.	8 Lectures

Recomended books:

1. T.J. Chung, Computational fluid Dynamics, Cambridge University Press, 2005.
2. C. A. J. Fletcher, Computational Techniques for Fluid Dynamics, Volume 1 & 2, Springer Verlag, 1992.

References:

1. C. Y. Chow, Introduction to Computational Fluid Dynamics, John Wiley, 1979.
2. M. Holt, Numerical Methods in Fluid Mechanics, Springer Verlag, 1977.
3. H. J. Wirz and J. J. Smolderen, Numerical Methods in Fluid Dynamics, Hemisphere, 1978
4. J. D. Anderson, Computational Fluid Dynamics, Mc-Graw Hill, 1995.
5. D. A. Anderson, J. C. Tannehill and R. H. Pletcher, Computational Fluid Dynamics

MA- 9009 ADVANCED ALGEBRA (3-0-0: 3 Credits)

UNIT-I	Algebraic, normal and separable extensions of field, splitting fields, automorphisms of extensions, the fundamental theorem of Galois Theory	9 Lectures
UNIT-II	Finite fields, primitive elements, norm and trace, cyclotonic fields, cyclic extension, solution of polynomial equations by radicals.	8 Lectures
UNIT-III	Commutative rings, localisation, Noetherian and Artinianrings, Integral extensions, Hilbert's Nullstellensatz, valuation rings, Noether's normalization.	9 Lectures
UNIT-IV	Modules, direct sum and product, finitely generated modules, Tensor product of modules, exact sequences, chain conditions, free modules, projective and injective modules	8 Lectures
UNIT-V	Categories and functors, Hom, modules over principal ideal domains, primary decompositions, Dedekind domains and modules over them	8 Lectures

Recomended books:

1. M. F. Atiyah and I. G. Macdonald, Introduction to commutative Algebra, Addision Wesley, 1969.
2. P. M. Cohn, Algebra, Vols. I & Vol. II, John Wiley & Sons, 1985 and 1988.

References:

1. N. Jacobson, Basic Algebra, Vols. I & II, W. H. Freeman, 1980 (also published by Hindustan Publishing Company, Delhi).
2. Dummit & Foote, Abstract Algebra, John Wiley & Sons, 2002.

MA- 9010 MULTIVARIATE ANALYSIS (3-0-0: 3 Credits)

UNIT-I	Bivariate Moment Generating Functions, Characteristics Functions, Bivariate Normal Distributions and its Properties	(9 Lectures)
UNIT-II	Singular and non-singular Multivariate Distributions, Multivariate Normal Distributions, Marginal and Conditional Distributions, Distributions of Linear forms, and Quadratic forms, Cochran's Theorem	(8 Lectures)
UNIT-III	Multiple Regression and Correlation, Correlation coefficient of a Bivariate sample, the distribution when the population coefficient is zero.	(9 Lectures)
UNIT-IV	Tests of hypotheses and confidence region, the asymptotic distribution of a sample correlation coefficient and Fisher's z, Partial correlation coefficient, Multiple Logistic Regression.	(8 Lectures)
UNIT-V	Multinomial Distributions, Multivariate Multinomial Distributions.	(8 Lectures)

Recomended books:

1. T. W. Anderson, An Introduction to Multivariate Analysis (2 nd edition), Wiley, 1984.
2. A. M. Khirsagar, Multivariate Analysis, Marcell Dekker, New York.
3. P. R. Krishnaiah (eds), Some recent developments on real multivariate distributions, Development in Statistics, Vol. I, Academic Press, New York, 1978.

References:

1. N. L. Johnson and S. Kotz, Continuous Multivariate Distributions, John Wiley, New York.
2. M. G. Kendall, Multivariate Analysis, NY, Hamer Press, 1975.
3. A. E. Maxwell, Multivariate Analysis in Behavioural Research, London, Chapman & Hall, 1977.
4. Chatterjee and B. Price, Regression Analysis by Examples, John Wiley, NY, 1977.

MA-9011 ADVANCED FUZZY SET THEORY (3-0-0: 3 Credits)

UNIT-I	Fuzzy sets, representation, membership functions, cardinality of fuzzy sets, complement, union and intersection of fuzzy sets, *t*-norm and *t*-conorm, α -cuts, extension principle for fuzzy sets.	9 Lectures
UNIT-II	Fuzzy Arithmetic: fuzzy numbers, linguistic variables, arithmetic operations on intervals and fuzzy numbers, fuzzy equations.	8 Lectures
UNIT-III	Fuzzy relation: fuzzy equivalence relations, fuzzy compatibility relations, fuzzy ordering relations.	9 Lectures
UNIT-IV	Fuzzification & Defuzzification methods.	8 Lectures
UNIT-V	Fuzzy logic: Multivalued logic, fuzzy propositions, fuzzy quantifiers.	8 Lectures

Recomended books:

1. M. Ganesh, Introduction to Fuzzy sets & Fuzzy Logic (3E), PHI

2. T.J. Ross, Fuzzy Logic with Engineering Applications, McGraw Hill.

References:

1. G.J. Klir & Bo Yuan, Fuzzy sets and Fuzzy Logic: Theory and Applications, PHI
2. Zimmerman, Fuzzy set theory and its Application, Kluwer Academic Press

MA- 9012 ADVANCED ANALYSIS (3-0-0: 3 Credits)

UNIT-I	Vector algebra, dot product, matrices, determinant, several variable calculus: continuity, differentiability, total derivative, directional derivative, partial derivative, Jacobian, chain rule, mean value theorems.	9 Lectures
UNIT-II	Derivatives for functions of several variables, interchange of the order of differentiation, Taylor's theorem, inverse mapping theorem, implicit function theorem.	8 Lectures
UNIT-III	Extremum problems, extremum problems with constraints, Lagrange's multiplier method.	8 Lectures
UNIT-IV	Parametrized curves. Multiple integrals: properties of integrals, existence of integrals, iterated integrals, change of variables.	8 Lectures
UNIT-V	Vector fields, Curl, Gradient, Divergence, Laplacian in cylindrical and spherical coordinates, line integrals, surface integrals, theorems of Green, Gauss and Stokes.	9 Lectures

Recomended books:

1. T.M. Apostol, Mathematical Analysis, Narosa Publishing House.
2. T.M. Apostol, Calculus. Vol. II: Multi-variable Calculus and Linear Algebra, with Applications t o Differential Equations and Probability, John Wiley & Sons Inc.

References:

1. S. Lang, Calculus of Several Variables, Springer.
2. M. Moskowitz and F. Paliogiannis, Functions of Several Real Variables, World Scientific.
3. Spiegel, Murray R., Schaum's Outline of Vector Analysis, Schaum's Outline Series.
4. W. Fleming, Functions of Several Variables, Springer.

MA-9013 WATER WAVE THEORY (3-0-0:3 Credits)

UNIT-I	Equations of motion. two dimensional flow, three dimensional flow, Navier-Stokes equation of motion.,Velocity potential and Laplace equation, Simple irrotational flows. Separation of variables for an axisymmetric flow. Bernoulli equation for unsteady irrotational flow.	9 Lectures
UNIT-II	Classification of water waves, deep water wave. shallow water wave, intermediate water waves, theory of surface wave, finite amplitude water waves,. linear and non-linear diffraction theory.	8 Lectures
UNIT-III	Permutation methods, eigen-function expansion methods, Green's function, multipole method, Diffraction and radiation of water waves, dynamics of floating structures, damping and added-mass, water wave interaction with submerged spherical structures, floating cylindrical structures and rectangular structures.	9 Lectures
UNIT-IV	Wave forces and hydrodynamic coefficients on the structures, Froude-Krylov theory, one dimensional tidal dynamics.	8 Lectures
UNIT-V	Nonlinear long waves in shallow water, Solitary waves. Cnoidal wave, Schrodinger equation, Morison equation.	8 Lectures

Recomended books:

1. J.J. Stoker, Water Waves, Interscience.
2. G.K. Batchelor, An Introduction to Fluid Dynamics, CUP
3. M. Rahman, Water wave: Relating Modern Theory to Advanced Engineering Applications, Clarendon Press, Oxford
4. C. M. Linton & M. McIver, Handbook of Mathematical Techniques for wave/ structures interactions

Refreneces:

1. O.M. Phillips, The Dynamics of Upper Ocean, CUP
2. M. Isaacson and T. Sarpkaya, Mechanics of Wave Forces on Offshore Structures, Van Nostrand.
3. C. C. Mei, The Applied Dynamics of Ocean Surface Waves, World Scientific

MA- 9014 NUMERICAL SOLUTIONS OF PARTIAL DIFFERENTIAL EQUATIONS

(3-0-0: 3 Credits)

UNIT-I	Finite difference Schemes for partial differential equations: explicit and implicit schemes, Dirichlet, Neumann and mixed problems.	9 Lectures
UNIT-II	Consistency, stability and convergence - stability analysis by matrix method and von Neumann method, Lax's equivalence theorem	8 Lectures
UNIT-III	Finite difference schemes for initial and boundary value problems - FTCS, backward Euler and Crank-Nicolson schemes, ADI methods, Lax Wendroff method, upwind scheme; CFL conditions	9 Lectures
UNIT-IV	Finite element method for ordinary differential equations - variational methods, method of weighted residuals, finite element analysis of one-dimensional problems	8 Lectures
UNIT-V	Three dimensional elliptic, hyperbolic problems.	(8 Lectures)

Recomended books:

1. L. Lapidus and G. F. Pinder, Numerical Solution of Partial Differential Equations in Science and Engineering, John Wiley, 1982.
2. G. D. Smith, Numerical Solutions to Partial Differential Equations, Oxford University Press, 3rd Edn., 1986.

References:

1. C. Johnson, Numerical Solution of Partial Differential Equations by the Finite Element Method, Dover Publications, 2009.
2. H. P. Langtangen, Computational Partial Differential Equations Springer Verlag, 1999.
3. M.K. Jain, S.R.K. Iyenger and R.K. Jain, Computational Methods for Partial Differential equations, Wiley Eastern, 1994.

MA- 9015 FLUID DYNAMICS (3-0-0: 3 Credits)

UNIT-I	Review of gradient, divergence and curl, elementary idea of tensor, velocity of fluid, stream lines and path lines, steady and unsteady flows.	9 Lectures
UNIT-II	Velocity potential, vorticity vector, conservation of mass, equation of continuity, equivalence between Eulerian and Lagrngian forms of equation of continuity.	8 Lectures
UNIT-III	Equations of motion in inviscid fluid, Euler's equations of motion in rectangular, cylindrical and spherical polar coordinates, equations of motion under impulsive forces.	9 Lectures
UNIT-IV	One dimensional inviscid incompressible flow, Bernoulli's equation and its applications, singularities of flow, source, sinks and doublets.	8 Lectures
UNIT-V	Three dimensional flow, Reynolds number, stress and strain analysis, Navier stokes equation, Boundary layer equations.	8 Lectures

Recomended books:

1. Sir Horace Lamb, Hydrodynamics, Cambridge University Press, 1971.

2. L. M. Milne, Theoretical Hydrodynamics, Macmillan and Co., 1960.

References:

1. A.S. Ramsay, A Treatise on Hydromechanics, ELBS.

2. F. Chorlton, A Text Book of Fluid Dynamics, Von Nostrand Reinhold/CBS, 1985.

3. F. M. White, Fluid dynamics, McGraw Hill, 2008.

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY

SYLLABI
OF
PG / Ph. D. COURSES
(DEPARTMENT OF CHEMISTRY)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY

(UNDER THE MINISTRY OF EDUCATION, GOVT. OF INDIA)

DEEMED TO BE UNIVERSITY U/S 3 OF THE UGC ACT, 1956

NIRJULI - 791 109 :: ARUNACHAL PRADESH

SYLLABI
OF
PG/ Ph. D COURSES

(DEPARTMENT: CHEMISTRY)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY (NERIST)
(Deemed to be University, U/S 3 Of the UGC Act, 1956)
Nirjuli (Itanagar), Arunachal Pradesh- 791 109

DEPARTMENT OF CHEMISTRY
M.Sc. (CHEMISTRY) SYLLABUS

SEMESTER I

Teaching Scheme			Contact Hours Per Week			Credits
S.N.	**Course code**	**Course title**	**L**	**T**	**P**	**C**
1.	CY 7100	Environmental Chemistry	4	0	0	4
2.	CY 7101	Inorganic Chemistry-I	4	0	0	4
3.	CY 7102	Organic Chemistry-I	4	0	0	4
4.	CY 7103	Physical Chemistry-I	4	0	0	4
5.	CY 7177	Mathematics for Chemists (Audit Course)*	3	0	0	3
6.	CY 7151	Laboratory Work-I (Inorganic Chemistry)	0	0	4	2
7.	CY 7152	Laboratory Work-I (Organic Chemistry)	0	0	4	2
8.	CY 7153	Laboratory Work-I (Physical Chemistry)	0	0	4	2
		Sub Total	**19**	**0**	**12**	**22**

*Credits not to be counted.

SEMESTER II

Teaching Scheme			Contact Hours Per Week			Credits
S.N.	**Course code**	**Course title**	**L**	**T**	**P**	**Credits**
1.	CY 7201	Inorganic Chemistry-II	4	0	0	4
2.	CY 7202	Organic Chemistry-II	4	0	0	4
3.	CY 7203	Physical Chemistry-II	4	0	0	4
4.	CY 7204	Molecular Spectroscopy	3	0	0	3
5.	CY 7251	Laboratory Work-II (Inorganic Chemistry)	0	0	4	2
6.	CY 7252	Laboratory Work-II (Organic Chemistry)	0	0	4	2
7.	CY 7253	Laboratory Work-II (Physical Chemistry)	0	0	4	2
		Sub Total	**15**	**0**	**12**	**21**

SEMESTER III

Teaching Scheme			Contact Hours Per Week			Credits
S.N.	**Course code**	**Course title**	**L**	**T**	**P**	**C**
1.	CY 80**	Major Electives-I/II/III	4	0	0	4
2	CY 80**	(Specialization wise)	4	0	0	4
3	CY 80**		4	0	0	4
4	CY 8151	Laboratory work-III	0	0	12	6
	CY 8152	(Any one, specialization				
	CY 8153	wise)				
5.	CY 80**	Minor Electives-I/II	2	0	0	2
6.	CY 80**		2	0	0	2
		Sub Total	**16**	**0**	**12**	**22**

SEMESTER IV

Teaching Scheme **Contact Hours Per Week** **Credits**

S.N.	Course code	Course title	L	T	P	C
1.	CY 8200	Seminar	0	2	0	2
2.	CY 80**	Major Electives-IV/V	4	0	0	4
3.	CY 80**		4	0	0	4
4.	CY 80**	Minor Electives-III/IV	2	0	0	2
5.	CY 80**		2	0	0	2
6.	CY 8299	Project	0	0	16	8
		Sub Total	**12**	**2**	**16**	**22**
		Total Credits				**87**

LIST OF ELECTIVE COURSES
Major Electives-I/II/III

1. A student will be required to take any one of the following groups of major electives in SEMESTER-III

S.N.	Course code	Course title	L	T	P	C
		Inorganic Chemistry				
1.	CY8001	Organometallic Chemistry of Transition Metals	4	0	0	4
2.	CY8002	Bio-inorganic Chemistry	4	0	0	4
3.	CY8003	Applications of Spectroscopy in Inorganic Chemistry	4	0	0	4
		Organic Chemistry				
1.	CY8004	Application of Spectroscopy to Organic Molecules	4	0	0	4
2.	CY8005	Stereochemistry and Reaction Mechanism	4	0	0	4
4.	CY8006	Natural Products	4	0	0	4
		Physical Chemistry				
1.	CY8007	Electrochemistry	4	0	0	4
2.	CY8008	Chemical Kinetics	4	0	0	4
3.	CY8009	Quantum Chemistry	4	0	0	4

Minor Electives-I/II

2. A student will be required to take any two of the following minor electives in SEMESTER-III

S.N.	Course code	Course title	L	T	P	C
1.	CY8010	Materials Chemistry	2	0	0	2
2.	CY8011	Radio and Radiation Chemistry	2	0	0	2
3.	CY8012	Medicinal Chemistry	2	0	0	2
4.	CY8013	Organic Photochemistry	2	0	0	2
5.	CY8014	Computational Chemistry	2	0	0	2
6.	CY8027	Frontiers in Inorganic Chemistry	2	0	0	2

Major Electives -IV/V

3. A student will be required to take any one of the following groups of major electives in SEMESTER IV.

S.N.	Course code	Course title	L	T	P	C
		Inorganic Chemistry				
1.	CY8015	Rings, Chains and Clusters in Inorganic chemistry	4	0	0	4
2.	CY8016	Special Topics in Inorganic Chemistry	4	0	0	4
		Organic Chemistry				
3.	CY8017	Organic Synthesis	4	0	0	4
4.	CY8018	Heterocyclic Chemistry	4	0	0	4
		Physical Chemistry				
5.	CY8019	Statistical Mechanics	4	0	0	4
6.	CY8020	Physical Methods in Chemistry	4	0	0	4

Minor Electives III/IV

4. A student will be required to take any two of the following minor electives in SEMESTER IV

S.N.	Course code	Course title	L	T	P	C
1.	CY8021	Quantum Mechanics of Atoms and Molecules	2	0	0	2
2.	CY8022	Inorganic Photochemistry	2	0	0	2
3.	CY8023	Bio-organic Chemistry	2	0	0	2
4.	CY8024	Chemical Applications of Group Theory	2	0	0	2
5.	CY8025	Solid State Chemistry	2	0	0	2
6.	CY8026	Nuclear Chemistry	2	0	0	2

The choice of Minor electives will depend upon the expertise/facilities available in the Department.

SEMESTER I

CY 7100 : ENVIRONMENTAL CHEMISTRY

L	T	P	C
4	0	0	4

52 Lectures

1.	**Chemical Equilibrium and The Chemistry of Natural waters:** Introduction to Environmental chemistry, Stoichiometry of chemical reactions, Equilibrium concept, activity and activity coefficient, Solutions to equilibrium problems – exact solutions and approximate solutions; Formation of ion-pairs and complexes in aqueous systems, Calculation of species-concentrations in solutions of complexes; Oxidation-reduction chemistry in natural waters, electron activity measurement (pE), The limits of pE in water / Water stability boundaries, pE–pH diagrams of Fe-H_2O and N_2-H_2O systems; Acid mine drainage; Acid base chemistry in natural waters – the carbonate system; Measurement of organic compounds in water - DO, BOD and COD.	13 lectures
2.	**Organic Pesticides and Non-Pesticide Toxic Organic Compounds:** Types of synthetic organic pesticides - molecular structures and properties, Chemical stability of the pesticides, Photolytic reactions of pesticides, Non-photolytic reactions of pesticides, hydrolysis reactions, oxidation and reduction reactions, degradative reactions; Dioxins– preparation and properties, Chlorophenolic origin of dioxins, Numbering system of dioxin; Polychlorinated biphenyls(PCBs) – their properties and numbering system, Polychlorinated biphenyls contamination by Furans – their properties and numbering system; Toxicity patterns of dioxins, PCBs and Furans, Toxicity Equivalent Factor(TEQ) scale, Polyaromatic hydrocarbons (PAHs) – their properties.	13 lectures
3.	**Atmospheric Chemistry:** Importance of the Atmosphere, Major regions of the Atmosphere, Chemical and Photochemical reactions in the Atmosphere, Free radical reactions in the atmosphere, Chlorofluorocarbons (CFCs) – their properties and Du Pont numbers, Steady-state in the atmospheric reactions, Stratospheric ozone depletion, Catalytic processes of ozone depletion (mechanism-I and II); Greenhouse effect, Energy absorption by Greenhouse gases, Characteristics of Greenhouse gases – spectroscopy of the greenhouse gas molecules, Atmospheric windows; Radio-nuclides, Types of radio-nuclides, Radio-active dating, Modes of radio-nuclide decay, Measuring rate of radio-active disintegration and Health threat, Nuclear fission reaction, The Catastrophe of Chernobyl, The Accident at Three Mile Island.	13 lectures
4.	**Instrumental Methods of Analysis:** UV-Vis Spectrophotometer, Infra-red (IR) spectroscopy, Atomic Emission Spectrophotometer, Atomic Absorption Spectrophotometer, Flame Photometer, Fluorimeter, Gas Chromatography(GC), High Performance Liquid Chromatography(HPLC), Ion- selective electrodes, Chemiluminiscence method, Numerical problems.	13 lectures

Books Recommended:

1. Colin Baird and Michael Cann, *Environmental Chemistry*, 3rd Edn. (2005), W. H. Freeman and Company, New York .
2. Gary W. vanLoon and Stephen J. Duffy, *Environmental Chemistry - A Global Perspective*, 1st Indian Edn., (2008), Oxford University Press.
3. Clair N. Sawyer, Perry L. McCarty and Gene F. Parkin, *Chemistry for Environmental Engineering and Science*, 5th Edn., (2003), Tata McGraw-Hill Publishing Company Ltd, New Delhi.
4. R. M. Harrison and S. J. de Mora, *Introductory Chemistry for the Environmental Sciences*, 2nd Edn., (1995), Cambridge University Press.
5. Julian E. Andrews, Peter Brimblecombe, Tim. D. Jickells, Peter S. Liss and Brian J. Reid, *An Introduction to Environmental Chemistry*, 2nd Edn., (2004), Blackwell Publishing.
6. Ian Pulford and Hugh Flowers, *Environmental Chemistry at a Glance*, (2006), Blackwell Publishing.

7. Stanley E. Manahan, *Environmental Chemistry*, 6th Edn., (1994) Lewis Publishers.
8. V. Subramanian, *A Textbook in Environmental Science* , (2002), Narosa Publishing house, New Delhi.
9. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, *Analytical Chemistry – An Introduction*, Edition (2000) Saunders College Publishing Philadelphia, London.
10. Gilbert M. Masters, *Introduction to Environmental Engineering and Science*, (1994) Prentice-Hall of India Pvt. Ltd., New Delhi.
11. Ian Williams, *Environmental Chemistry – A Molecular Approach,* (2001), John Wiley & Sons, Ltd.

CY 7101: INORGANIC CHEMISTRY - I

L	T	P	C
4	0	0	4

52 Lectures

1.	**VSPER Theory:** Valence Shell Electron Pair Repulsion Theory, stereo chemical rules and explanation of the shapes of molecules and ions of non- transition elements with 2-7 valence shell electron pairs**.**	7 lectures
2.	**HSAB Theory:** Classification of acids and bases as hard and soft; HSAB principle, theoretical basis of hardness and softness; Lewis- acid base reactivity approximation; donor and acceptor numbers, E and C equation; application of HSAB concept**.**	9 lectures
3.	**Electronic Spectra of Transition Metal Complexes:** Spectroscopic ground states; correlation, Orgel energy level and Tanabe-Sugano diagrams for transition metal complexes (d^1-d^9states); calculations of Dq, B and E parameters, Charge transfer spectra; electronic spectra of octahedral and tetrahedral Co (II) complexes and calculation of ligand-field parameters, anomalous magnetic moments, magnetic exchange coupling and spin cross over.	18 lectures
4.	**Metal-Ligand Bonding in Transition Metal Complexes** : Nomenclature, isomerism, chelate effect, Crystal field theory, stereochemistry of coordination compounds; spectrochemical and Nephelauxetic series; splitting of d-orbitals in low symmetry environments, thermodynamic and structural effects: site selection in spinels, Jahn - Teller effects; experimental evidence for metal ligand orbital overlap; ligand field theory, charge transfer spectra, molecular orbital theory of octahedral complexes.	18 lectures

Books Recommended

1. F.A. Cotton and G. Wilkinson , *Advanced Inorganic Chemistry*, 6th Ed. (1999), John Wiley & Sons, New York.
2. James E. Huheey, *Inorganic Chemistry*, 4th Ed. (1993), Addison-Wesley Pub. Co., New York.
3. J. E. Huheey, E.A. Keiter, R.L. Keiter and O.K. Medhi, Principles, Structure and Reactivity, 4th Edn ., 2008, Pearson Education.
4. R.S. Drago, *Physical Methods in Inorganic Chemistry*, International Eds.(1971), Affiliated East West.
5. G.Wilkinson, R.D.Gillars and J.A.McCleverty, *Comprehensive Coordination Chemistry,* 1987, Pergamon
6. A.B.P. Lever, *Inorganic Electronic Chemistry*, 2nd edn., 1984, Elsevier.

CY 7102: ORGANIC CHEMISTRY- I

L	T	P	C
4	0	0	4

52 Lectures

1.	**Delocalized Chemical Bonding :** Conjugation, Cross Conjugation, resonance, hyper-conjugation, tautomerism. Aromaticity in benzenoid and non-benzenoid compounds, Huckel's rule, energy level of S – molecular orbitals, annulenes, anti-aromaticity, homo-aromaticity PMO approach.	10 lectures
2.	**Structure & Reactivity**: Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes. Types of mechanisms. Thermodynamic and kinetic control, Hammond's postulate, transition states and intermediates, isotope effects. Hard and soft acids and bases. Resonance and field effects, steric effects, quantitative treatment. The Hammett equation and linear free energy (LFER) relationship. Substituent and reaction constants, Taft equation.	16 lectures
3.	**(i) Aliphatic Nucleophilic Substitution**: Mechanism and stereochemistry of S_N^1, S_N^2 and S_N^i reactions.	8 lectures
	(ii) Aromatic Nucleophilic Substitution: The S_NAr, $S_{N,}^1$ aryne and S_{RN}^1 mechanisms. Effect of substrate structure, leaving group and attacking nucleophile on reactivity.	6 lectures
4.	**(i) Aliphatic Electrophilic Substitution :** Bimolecular mechanisms S_E^2, S_E^i and S_E^1 mechanisms, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and solvent polarity on reactivity.	6 lectures
	(ii) Aromatic Electrophilic Substitution: Arenium ion mechanism, orientation and reactivity, energy profile diagrams. Ortho / para ratio, Ipso substitution, Diazonium coupling, Vilsmeir reaction, Gattermann – Koch reaction.	6 lectures

Books Recommended:

1. M.B. Smith & Jerry March, *March's Advanced Organic Chemistry*, 7th Edn., John Wiley & Sons, New York.
2. Peter Sykes, *A guide book to Mechanism in Organic Chemistry*, 6th Edn., Orient Longman Ltd., New Delhi.
3. R.T. Morrison and R.N.Boyd, *Organic Chemistry*, 6th Edn., Prentice Hall of India, New Delhi.
4. S.M. Mukherjee and S.P.Singh, *Reaction Mechanism in Organic Chemistry*, 3rd Edn., Mac Millan India Ltd., New Delhi.
5. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, 1 st Edn., Oxford University Press.
6. F.A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and Mechanism, 5 th Edn., Springer.
7. R.K. Bansal, Organic Reaction Mechnisms, 4th Edn., New Age International Publishers, New Delhi.
8. V. K. Ahluwalia and R.K. Parashar, Organic Reaction Mechanisms, 4 th Edn., Narosa Publishing House.
9. P.S. Kalsi, Organic Reaction and their Mechanisms, 1 st Edn., New Age International Publishers, New Delhi.
10. L.G. Wade, Jr. and M.S. Singh, Organic Chemistry, 6 th Edn., Pearson.

CY 7103 : PHYSICAL CHEMISTRY-I

L	T	P	C
4	0	0	4

52 Lectures

1.	**Thermodynamics:** Partial molar properties and their significance, Fugacity, its concepts and determination. Properties of ideal solutions; non-ideal systems-deviations from ideal behaviour, excess functions for non-ideal solutions, calculations of partial molar quantities, determination of partial molar volume and partial molar enthalpy. Application of phase rule to three component systems; second order phase transitions.	10 lectures
2.	**Statistical Thermodynamics:** Concept of distribution, thermodynamic probability and most probable distribution. Ensemble averaging-postulates of ensemble averaging, cannonical and microcannonical ensembles. Boltzmann distribution of particles. Partition function: Transtional, rotational and vibrational partition functions, thermodynamic properties of ideal gases in terms of partition function.	12 lectures
3.	**Quantum Mechanics:** Introduction, Schrodinger equation, postulates and theorems of quantum mechanics. Discussion of solutions of the Schrodinger equation to some model systems viz., particle in box. Theory of angular momentum. Two particle rigid rotor. Linear Harmonic Oscillator. Hydrogen atom.	14 lectures
4.	**Electrochemistry:** Metal / Electrolyte interface: Potential profile across double layer region, potential difference across electrified interfaces. Polarizable and non-polarizable interfaces. Structure of the double layer: Helmholtz-Perrin, Gouy-Chapmann, and Stern models. Butler-Volmer equation under near equilibrium and non-equilibrium condition, exchange current density, Tafel plot.	8 lectures
5.	**Chemical Kinetics:** Composite reactions-types of composite mechanisms, rate equations for composite mechanisms, reversible, simultaneous and consecutive reactions, steady state treatment, rate determining steps, microscopic reversibility and detailed balance, dynamic chain reactions (H_2–Br_2 reaction, decomposition of acetaldehyde and ethane), branching chain: H_2–O_2 reaction.	8 lectures

Books Recommended:

1. J.O'M. Bockris and A. K. N. Reddy, *Modern Electrochemistry*, Vol.2 A & B 2nd Edition (1998) Plenum Press, New York (International Edition).
2. K.J. Laidler, *Chemical Kinetics*, 3rd Edn., (1987), Prentice Hall, New York.
3. P.W. Atkins, *Physical Chemistry*, 8th Edition (e-book) 2011, Oxford University Press, NewYork.
4. I.N. Levine, *Physical Chemistry*, 6th Edn., (2002), Tata McGraw Hill Education Pub. Co.Ltd. New Delhi.
5. J. Raja Ram and J.C. Kuriacose, *Kinetics and Mechanism of chemical Transformations* (2000) MacMillan Publishers India Ltd., New Delhi.
6. Andrew Maczek, *Statistical Thermodynamics*, (1998) Oxford University Press Inc., New York.
7. K.L. Kapoor, *A Textbook of Physical Chemistry* , Vol 2, 3, 4 & 5, Macmillan Ind. Ltd., Delhi
8. P.C.Rakshit, *Physical Chemistry*, 7th Edn., Sarat Book Distributors, Calcutta.
9. Frank.J. Bockhoff, *Elements of Quantum Theory*, 1st Edn., 1969, Addition-Wesley Publishing Company, Inc. Francis T. Bonner, Consulting Editor, Massachusetts/ California/London/Ontario.
10. Thomas Engel, *Quantum Chemistry & Spectroscopy*, 3rd Edn., Pearson, Published by Dorling Kindersley (India) Pvt. Ltd.

CY 7177: MATHEMATICS FOR CHEMISTS

(For students without Mathematics in B.Sc.)

L	T	P	C
3	0	0	3

40 Lectures

1.	**Vectors:** Vectors, dot, cross and triple products, etc. The gradient, divergence and curl, vector calculus, Gauss's theorem, divergence theorem, etc.	6 lectures
2.	**Matrix algebra**: Addition and multiplication, inverse, adjoint and transpose of matrices, special matrices (symmetric, skew- symmetric, Hermitian, skew-Hermitian, unit, diagonal, unitary, etc.) and their properties. Matrix equations: homogeneous, non-homogeneous linear equation and conditions for the solutions, linear dependence and independence. Introduction to vector spaces, matrix eigen values and eigen vectors, diagonalization, determinants (examples from Huckel theory).	10 lectures
3.	**Differential calculus:** Functions, continuity and differentiability, rules for differentiation, applications of differential calculus including maxima and minima (examples related to maximally populated rotational energy levels, Bohr's radius and most probable velocity from Maxwell's distribution etc.), exact and inexact differentials with their applications to thermodynamic properties.	8 lectures
4.	**Integral calculus:** Basic rules for integration, integration by parts, partial fraction and substitution. Reduction formulae, application of integral calculus.	6 lectures
5.	**Elementary Differential equations:** Variables- separable and exact first order differential equations, homogeneous, exact and linear equations. Applications to chemical kinetics, secular equilibrium, quantum chemistry, etc. Solutions of differential equations by the power series method, Fourier series, solutions of harmonic oscillator and Legrende equation, etc. spherical harmonics, second order differential equations and their solutions.	10 lectures

Books Recommended

1. E.Steiner, *The chemistry Mathematics books*, oxford university press.
2. Doggett and Sucliffe, *Mathematics for Chemistry*, Longmann.
3. F.Daniels, *Mathematical preparation for Physical Chemistry*, McGraw Hill.
4. D.M. Hirst, *Chemical Mathematics*, Longmann.
5. J.R.Barrante, *Applied Mathematics for Physical Chemistry*, Prentice Hall.
6. Tebbutt, *Basic Mathematics for Chemists*, Wiley.

SEMESTER II

CY 7201: INORGANIC CHEMISTRY – II

L	T	P	C
4	0	0	4

52 Lectures

1.	**Kinetics and Mechanism of Inorganic Substitution Reactions:** Nature of substitution reaction; energy profile of a reaction, reactivity of metal complexes, labile and inert complexes; isomerization and racemization; prediction of reactivity of octahedral and square planar complexes in terms of VBT and CFT; kinetics of octahedral substitution; acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidences in favour of conjugate mechanism and anation reactions, reactions without metal ligand bond cleavage. Substitution reactions in square planar complexes, the *trans*-effect, mechanism of substitution reaction.	16 lectures
2.	**Electron Transfer Reactions:** Mechanism and rate laws, various types of electron transfer reactions, Marcus-Husch theory, correlation between thermal and optical electron transfer reactions, identification of intervalence transfer bands in solution.	10 lectures
3.	**Metal S- Complexes:** Metal Carbonyls- Preparation, structure and bonding, vibrational spectra of metal carbonyls for bonding and structural elucidation, important reactions of metal carbonyls; preparation, bonding, structure and important reactions of transition metal nitrosyl, dinitrogen and dioxygen complexes; tertiary phosphine as ligand.	16 lectures
4.	**Aspects of Transition Elements, Lanthanides and actinides:** Elements of first transition series and their comparison with second and third series: general periodic trends, chemistry of various oxidation states based on electronic configuration. Splitting of f-orbitals in octahedral field; lanthanide contraction; lanthanide shift reagent; magnetic resonance imaging agents, oxidation states, complexes, magnetic and optical properties of lanthanides and actinides.	10 lectures

Books Recommended:

1. F. Basalo and R.G. Pearson, *Mechanism of Inorganic Reaction,* 2nd Edn., (1967), Wiley Eastern Ltd. New Delhi.
2. D. F. Shriver and P.W Atkins, *Inorganic Chemistry*, 5th Edn., (2009) ELBS, London.
3. F.A. Cotton and G.Wilkinson, *Advanced Inorganic chemistry,* 6th Ed. (1999) John Wiley & Sons, New York.
4. D.N. Sathyanarayana, *Electronic Absorption Spectroscopy and Related Techniques,* (2001) Universities Press (India) Ltd., Hyderabad.
5. J.E. Huheey, E.A. Keiter, R.L.Keiter & O.K. Medhi, *Principles Structure and Reactivity,* 4th Edn., 2008, Pearson Education.

CY 7202: ORGANIC CHEMISTRY – II

L	T	P	C
4	0	0	4

52 Lectures

1.	**Free Radical Reactions:** Types of free radical reactions. Free radical substitution mechanism at aromatic substrate, neighbouring group assistance, Reactivity for aliphatic and aromatic substrates at a bridge-head. Reactivity in the attacking radicals, effect of solvent on reactivity. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts. Free radical rearrangements, Hundsdiecker reaction.	15 lectures
2.	**Addition to Carbon-Carbon Multiple Bonds :** Addition reactions involving electrophile, nucleophile and free radical – Mechanistic and stereochemical aspects, orientation and reactivity, Hydrogenation of double, triple bonds and aromatic ring. Michael reaction, Sharpless asymmetric epoxidation.	12 lectures
3.	**Addition to Carbon – Hetero Multiple Bonds :** Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acid, esters and nitriles. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl compounds, Wittig reaction. Mechanism of reactions – Aldol, Knoevenagel, Claisen, Benzoin, Perkin reactions.	14 lectures
4.	**Elimination reactions :** E_2, E_1, E1cB mechanisms. Orientation of the double bond, Hofmann vs Saytzeff elimination. Effects of substrate structures, attacking base, leaving group and the medium on reactivity. Mechanism and orientation in pyrolytic elimination.	11 lectures

Books Recommended :

1. M. B. Smith & Jerry March's *Advanced Organic Chemistry*, 7th Edn., John Wiley & Sons, New York.
2. Peter Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th Edn., Orient Longman Ltd., New Delhi.
3. R.T. Morrison and R.N. Boyd, *Organic Chemistry*, 6th Edn., Prentice Hall of India, New Delhi.
4. T. H. Lowry and K. S. Richardson, *Mechanism and Theory in Organic Chemistry*, 3rd Edn., Addition – Wesley Longman Inc.(IS Edition).
5. S. M. Mukherjee and S. P. Singh, *Reaction Mechanism in Organic Chemistry*, 3rd Edn., MacMillan Indian Ltd., New Delhi.
6. F.A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and Mechanism, 5 th Edn., Springer.
7. R.K. Bansal, Organic Reaction Mechnisms, 4th Edn., New Age International Publishers, New Delhi.
8. V. K. Ahluwalia and R.K. Parashar, Organic Reaction Mechanisms, 4 th Edn., Narosa Publishing House.
9. P.S. Kalsi, Organic Reaction and their Mechanisms, 1 st Edn., New Age International Publishers, New Delhi.
10. L.G. Wade, Jr. and M.S. Singh, Organic Chemistry, 6 th Edn., Pearson.

CY 7203 : PHYSICAL CHEMISTRY-II

L	T	P	C
4	0	0	4

52 Lectures

1.	**Surface chemistry and catalysis**: Surface tension and capillary rise method, pressure difference across curved surfaces (Young and Laplace equation), vapour pressure droplets, Inter phase region, curved surfaces, Gibbs adsorption isotherm, Surface films on liquids, Catalytic activity at surfaces (volcano curve), estimation of surface area (BET equation), transition state theory of surface reactions: rates of chemisorption and desorption, unimolecular and bimolecular surface reactions, comparison of homogeneous and heterogeneous reaction rates.	16 lectures
2.	**Micelles**: Surface active agents and their classification, micellization, shape and structures of micelles, critical micelles concentration (Philips definition), Monodisperse micelles of ionic and non-ionic surfactants, Thermodynamics of micelle formation, counter ion binding to micelles, temperature and pressure effect on Micelles, Phase rule of solubilization. Micro emulsion, reverse micelles.	14 lectures
3.	**Macromolecules (Polymers):** Definition, types of polymers. Molecular mass number and mass average molecular mass, determination of molecular mass (osmometry, viscosity, diffusion, light scattering and sedimentation methods).	10 lectures
4.	**Thermal Analysis:** Theory, methodology and applications of thermo-gravimetric analysis (TGA), differential thermal analysis (DTA), and differential scanning calorimetry (DSC). Principles, techniques and application of thermometric titration methods**.**	6 lectures
5.	**Polarography:** Origin of Polarography; Current, diffusion and concentration relationships; Ilkovic equation; Current-voltage relationships, Classical d.c. Polarography, Square-wave Polarography, Differential pulse Polarography.	6 lectures

Books Recommended:

1. J.O.M. Bockris and A.K.N. Reddy, *Modern Electrochemistry*, Vol.2, 2nd Edn., (1998) Plenum Press, New York.
2. P.W. Atkins, *Physical chemistry*, 7th Edn., (2002) Oxford University Press, New York.
3. I.N. Levin, *Physical Chemistry,* 5th Edn., (2002), Tata McGraw Hill Pub. Co. Ltd., New Delhi.
4. Y. Moroi, *Micelles: Theoretical and Applied Aspects*, (1992), Springer Science & Business Media, New York.
5. F.W. Billmayer, Jr., *Text Book of Polymer Science,* 3rd Edition (1984), Wiley India Pvt. Ltd (reprinted 2007).
6. J.H. Kennedy, *Analytical Chemistry Principles,* 2nd Edn., (1990) Saunders Holt London.
7. K. J. Laidler, Chemical Kinetics, 3rd Edn., Pearson Education (2007).
8. T.Engel and P. Reid, Physical Chemistry, 2 nd Edn., Prentice Hall Publication 2009.
9. D.Mcquarie and J. Simon, Physical Chemistry a Molecular approach (University Science Books) 1997.
10. D.R. Crow and J.V. Westwood, Polarography, 1 st Edn., (1968), Methuen and Co. Ltd., London.

CY 7204: MOLECULAR SPECTROSCOPY

L	T	P	C
3	0	0	3

40 Lectures

1.	**Time dependent States and Spectroscopy:** Electromagnetic spectrum and molecular processes associated with the regions. Absorption and Emission of radiation. Selection rules. Line shapes and widths. intensity of spectral lines, population of states. Fourier Transform Spectroscopy.	4 lectures
2.	**Rotation and Vibration of diatomic Molecules :** Rotational spectra: classification of molecules into spherical, symmetric and asymmetric tops; diatomic molecules as rigid rotors-energy levels, selection rules and spectral features, isotope effect, intensity distribution, effect of non-rigidity on spectral features; vibrational spectra of diatomics: potential energy of an oscillator, simple harmonic oscillator, energy levels and selection rules, anharmonicity and its effect on energy levels and spectral features: overtones and hot bands, diatomic vibrating-rotator : origin; selection rules; P, Q and R branches; Vibration of polyatomic molecules: fundamental vibration and their symmetry, normal coordinates, overtone and combination frequencies, Fermi resonance. A review of MW and IR spectroscopy. **Raman spectra:** origin, quantum and classical theories, selection rules, pure rotational and vibrational Raman spectra of diatomics, polarization of Raman lines.	11 lectures
3.	**Electronic spectroscopy:** Electronic spectroscopy of diatomic molecules, Frank-Condon factor, Dissociation and pre-dissociation. Lasers: General principles of Laser action, common practical lasers.	9 lectures
4.	**Magnetic Resonance spectroscopy**: Review of angular momentum, Commutation relations. Basic principles and relaxation processes, Magnetic resonance spectrum of hydrogen, shielding and de-shielding effect of nuclei, chemical shift and spin-spin coupling, nuclear overhouser effect. First order spectra: A_3X, AX and AMX systems. Second order spectra: AB system, equivalent nuclei A_2B_2 system. ^{13}C, ^{19}F and ^{31}P NMR spectroscopy.	10 lectures
5.	**NMR (CW and FT):** Comparison of CW NMR with FT NMR; rotating frame of reference. Effect of rf pulse. Fourier Induction Decay (FID). Multiple operation. Measurement of T_1 by inversion recovery method. Spin echo and measurement of T_2.	6 lectures

Books Recommended:

1. J.M. Hollas, *Modern spectroscopy*, 4th Edn., (2003), John Wiley & Sons, Ltd., Chichester.
2. C.N. Banwell and E.M. McCash, *Fundamentals of Molecular spectroscopy*, 4th Edn., (1994), Tata McGraw Hill, New Delhi
3. A. Carrington and A.D. Mc Lachlan, *Introduction to Magnetic Resonance*, (1979), Chapman and Hall, London.
4. R.K. Harris, *Nuclear Magnetic Resonance Spectroscopy: with applications to Chemistry and Chemical Physics,* (1986), Addition Wesley, Longman Ltd. London.
5. G. Herzburg, *Infrared and Raman Spectra of Diatomic Molecules* (1950), Van Nostrand, New York.
6. C.N. Banwell, *Fundamentals of Molecular Spectroscopy*, (1994),Tata McGraw-Hill Company Ltd.
7. K.L. Kapoor, A Textbook of Physical Chemistry, Vol.4, *Quantum Chemistry and Molecular Spectroscopy*, 3rd Edn., Macmillan Ind. Ltd., Delhi.

SEMESTER III

Major Electives –I/II/III

Inorganic Chemistry Specialization

CY 8001: ORGANOMETALLIC CHEMISTRY OF TRANSITION METALS

L	T	P	C
4	0	0	4

52 Lectures

1.	**Metal Carbonyls :** Semibridging carbonyl group, metal nitrosyl carbonyls; tertiary phosphines and arsines as ligands; carbenes and carbines.	8 lectures
2.	**Compounds of Transition Metal -Carbon Bonds :** Alkylidienes, alkylidynes, low valent carbenes and carbynes- synthesis, nature of bond, structural characteristics, nucleophilic and electrophilic reactions on the ligands, role in organic synthesis; Alkyls and aryls of transition metals: Types, routes of synthesis, stability and decomposition pathways, Organocopper in organic synthesis.	14 lectures
3.	**Transition Metal S-Complexes:** Transition metal S-complexes with unsaturated organic molecules, alkenes, alkynes, allyl, diene, dienyl, arene and trienyl complexes, preparations, properties, nature of bonding and structural features. Important reactions relating to nucleophilic and electrophilic attack on ligands and to organic synthesis.	14 lectures
4.	**Transition Metal Compounds in Homogeneous Catalysis:** Stoiciometric reactions for catalysis, homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, hydroformylation, isomerization and polymerization, Waker process, catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxo reaction), oxopalladium reactions, activation of C-H bond.	12 lectures
5.	**Transition Metal Compounds with M-H bonds:** Transition metal compounds with bonds to hydrogen.	4 lectures

Books Recommended:

1. F.A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry* 6th Edn., (1999) John Wiley & Son, New York.
2. James E. Huheey, *Inorganic Chemistry*, 4th Edn., (1993) Addison Wesley Pub. Co., New York.
3. R.H. Crabtree, *The Organometallic Chemistry of the Transition Metals*, 5th Edn., (2009), John Wiley & Son, New York.
4. J.P. Collman, L.S. Hegedus, J.R. Norton and Richard G. Finke *, Principles and Applications of Organotransition Metals Chemistry,* 1st Edn., (1987) University Science Books Mill Valley, California.
5. R.C.Mehrotra and A. Singh, *Organometallic Chemistry*, 1st Edn., 1991, New Age International.

CY 8002: BIO-INORGANIC CHEMISTRY

L	T	P	C
4	0	0	4

52 Lectures

1.	**Role of alkali and alkaline earth metal ions in biological systems:** (i) Na^+ - K^+ pump, (ii) Catalysis of phosphate transfer by Mg^{2+} ion, (iii) Calcium in living cells, transport and regulation, molecular aspects of intramolecular processes, extracellular binding proteins.	8 lectures
2.	**Transport and storage of Dioxygen:** Heme proteins and oxygen uptake, structure and function of hemoglobin, myoglobin, hemocyanins and hemerithrin,model synthetic complexes of iron, cobalt and copper.	12 lectures
3.	**Bioenergetics , ATP Cycle and Interaction of metal complexes with Nucleic Acid:** DNA polymerization, glucose storage, metal complexes in transmission of energy; chlorophylls, photosystem I and photosystem II in cleavage of water, Model systems. **:** Metal ions and metal complex interactions. Metal complexes-nucleic acids, Cytochromes and iron-sulphur proteins.	12 lectures
4.	**Metal Storage transport Proteins and Nitrogenase:** Ferritin, transferritin and hemosiderin; Nitrogenase: Biological nitrogen fixation molybdenum nitrogenase, spectroscopic and other evidence, other nitrogenase model systems.	10 lectures
5.	**Metalloenzymes:** Zinc enzymes-carboxypeptidase and carbonic anhydrase, Iron enzymes-catalase, peroxidase and cytochrome P-450. Copper enzymes-superoxide dismutase. Molybdenum oxatransferase enzymes-xanthine oxidase, coenzyme vitamin $B_{12.}$	10 lectures

Books Recommended:

1. M.N. Hughes, *Inorganic Chemistry of Biological Processes*, 2nd Edn., (1981) John Wiley & Son, New York.
2. W. Kaim and B. Shcewederski, *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of life. An Introduction and guide*, 2nd Edn., 2013, Wiley, New York.
3. S. J. Lippard and J.M. Berg, *Principles of Bioinorganic Chemistry* (1994) University Science Books.
4. I. Bertini, H.B. Grey, S.J. Lippard and I.S. Valentine, *Bioinorganic Chemistry,* (1998) Viva Books Pvt. Ltd., New Delhi.
5. G. L. Eichhorn, *Inorganic Chemistry*, Vol I 2nd Edn., 1971, Elsevier.

CY 8003: APPLICATION OF SPECTROSCOPY IN INORGANIC CHEMISTRY

L	T	P	C
4	0	0	4

52 Lectures

1.	**NMR Spectroscopy**: (i) Use of Chemical shifts and spin-spin coupling for Structural determination, (ii) Double resonance, and Dynamic processes in NMR (iii) Decoupling phenomenon, Nuclear Overhauser Effect, DEPT spectra and structural applications in ^{13}C NMR, (iv) Lanthanides shift reagents, (v) $^{1}HNMR$ of paramagnetic substances, an overview of NMR of metal nucleides with emphasis on ^{195}Pt and ^{119} Sn NMR.	12 lectures
2.	**Electron Spin Resonance Spectroscopy**: Basic principle, Hyperfine splittings (isotropic systems); the g-value and the factors affecting thereof; interaction affecting electron energies in paramagnetic complexes (Zero field splitting and Kramer's degeneracy); Anisotropic effects (the g-value and the hyperfine couplings); The EPR of triplet states; Structural applications to transition metal complexes.	12 lectures
3.	**Mössbauer Spectroscopy**: Basic principles, conditions for Mössbauer spectroscopy spectral parameters (Isomer shift, electric quadruple interactions, and magnetic interactions) temperature dependent effects. Application of the technique to the studies of (i) bonding and structures of Fe^{2+} and Fe^{3+} compounds (ii) Sn^{2+} and Sn^{4+} compounds – nature of M-L bond, coordination number, structure and (iii) detection of oxidation state and inequivalent MB atoms.	10 lectures
4.	**Infrared and Raman Spectroscopy**: Comparison of IR and Raman spectroscopy, application of vibrational spectroscopy in investigating (i) symmetry and shapes of simple AB_2, AB_3 and AB_4, AB_5 and AB_6 molecules on the basis of spectral data, (ii) mode of bonding of ambidentate ligands, ethylene diamine, diketonato complexes, thiocyanate, nitrate, sulphate and urea, application of resonance Raman spectroscopy particularly for the study of active sites of metalloprotiens.	12 lectures
5.	**Mass Spectrometry**: Introduction and interpretation of Mass spectra, effect of isotopes on the appearance of mass spectrum, recognition of the molecular ion peak; Ionization techniques (EI and FAB).	6 lectures

Books Recommended:

1. E.A. Ebsworth, D.W.H. Rankin and S. Cradock, *Structural Methods in Inorganic Chemistry,* 2nd Edn., (1991), Blackwell Scientific Publications, Oxford, London.
2. R.S. Drago, *Physical Method for Chemists*, (1992), Saunders College Publishing, Philadelphia.
3. R.S. Drago, *Physical Methods in Inorganic Chemistry,* 1st Edn.,(1971), (reprint 2012), Affiliated East-West Press, New Delhi.
4. K. Nakamoto, *Infrared and Raman spectra of Inorganic and Coordination Compounds,* 6th Edn., (2008), John Wiley & Son, New York.
5. W. Kemp, *Organic spectroscopy*, 3rd Ed. (1991), MacMillan, London.
6. G. Aruldhas, *Molecular Structure and spectroscopy*, 2nd Edn., 2007, Prentice Hall of India Pvt. Ltd., New Delhi.

Organic Chemistry Specialization

CY 8004: APPLICATION OF SPECTROSCOPY TO ORGANIC MOLECULES

L	T	P	C
4	0	0	4

52 Lectures

1.	**Ultra-Violet Spectroscopy:** Electronic transitions, Beer-Lambert's law, Chromophores and various shifts, solvents and effects of solvents on absorption bands. Absorption and UV spectra of dienes, Polyenes and $D E$ -unsaturated carbonyl compounds. Fieser-Woodward rules for predicting the positions of O_{max} in various type of compounds.	8 lectures
2.	**Infra-red Spectroscopy:** Molecular Vibrations – Stretching and bending, Hooke's Law and its effects on vibrational frequencies, characteristic vibrational frequencies of hydrocarbons and important functional groups. Effects of H-bonding and solvent. IR spectra of aliphatic and aromatic alcohols, aldehydes, ketones, carboxylic acids, esters and amides. IR spectra of lactones and lactams etc. Effects of unsaturation, substituents and ring size on vibrational frequencies of functional groups.	14 lectures
3.	**Proton Magnetic Resonance Spectroscopy:** Magnetic properties of nuclei, nuclear resonance, chemical shift, spin-spin interactions, shielding and deshielding mechanism, anisotropic effects, chemical shift values for protons on O, N etc., deuteration of such protons, spin-spin coupling constant (J), and its magnitude for vicinal, geminal, olefinic protons, long range coupling involving two, three, four and five nuclei, Karplus curve, hindered rotation, stereochemistry, double resonance, shift reagents and solvent effects.	12 lectures
4.	**C-13 NMR Spectroscopy:** Introduction, natural abundance of C^{13} nuclei, NOE, chemical shift, coupling constant. C^{13} NMR spectra of some compounds- hydrocarbons, alcohols, ketones and esters. DEPT and its applications, selective proton decoupling, deuteration.	10 lectures
5.	**Mass Spectrometry:** Introduction to mass spectrometry, its significance, Mass spectrum, general modes of fragmentation, molecular ion, fragmentation of molecular ion, Fragmentation involving common functional groups, meta stable peak, Nitrogen rule, Mc-Lafferty rearrangement, Mass spectra of alkanes, alcohols (aliphatic and aromatic), amines, ethers and esters, carboxylic acids, amino acids.	8 lectures

Books Recommended:

1. J.R. Dyer, *Application of Absorption spectroscopy of organic compounds*, 1965, Prentice Hall, New Delhi.
2. R.M. Silverstein and F.X. Webster, *Spectroscopic identification of organic compounds*, 7th Edn., 2005, John Wiley & Sons, New York.
3. D.H. Williams and I.F. Fleming, *Spectroscopic Method in Organic Chemistry*, 6th Edn., (2007), Tata McGraw Hill, New Delhi.
4. B.Y. Bruice , *Organic Chemistry*, 7th Edn., 2013, Prentice Hall, New Delhi.
5. M.L. Martin, J. J. Delpeuch and G.J. Martin, *Practical NMR Spectroscopy*, Heyden.
6. R.M. Silverstein, G.C. Bassler & T.C. Morrill, *Spectroscopic Identification of Organic Compounds*, 4th Edn.,, John Wiley & Sons, New York.
7. R.M. Silverstein, Francis X. Webster, David J. Kiemle and David L. Bryce, *Spectroscopic Identification of Organic Compounds*, www.wiley.com, *8*th Edn., 2014.

CY 8005: STEREOCHEMISTRY AND REACTION MECHANISM

L	T	P	C
4	0	0	4

52 Lectures

1.	**Stereochemistry :** Conformational analysis of cycloalkanes, effect of conformation on reactivity, steric hindrance. Elements of symmetry, chirality, molecules with more than one chiral center. Projection formulae, threo and erythro isomers, methods of resolution, optical purity, enantiotropic and diastereotropic atoms, groups and faces, stereospecific and stereoslective synthesis. Asymmetric synthesis, optical activity in the absence of chiral carbon.	15 lectures
2.	**Pericyclic reactions:** Molecular orbital symmetry, Frontier orbitals of ethylene, buta-1,3-diene, hexa-1,3,5-triene and allyl system. Classification of Pericyclic reactions: Woodward– Hoffmann correlation diagrams, FMO and PMO approach. Electrocyclic reactions : conrotatory and disrotatory motions 4n, 4n +2 and allyl systems. Cycloaddition – antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3 – dipolar cycloadditions and chelotropic reactions. Sigmatropic Rearrangements – Suprafacial and antarafacial shifts of H, Sigmatropic shifts involving carbon moieties, 3,3 and 5,5 – sigmatropic rearrangements, Claisen, Cope and Aza - Cope rearrangements.	15 lectures
3.	**Neighbouring Group Participation :** Introduction, Stereochemistry and mechanism. Participation by S and V bonds – classical & non-classical carbocations, anchimeric assistance. Effects of entering and leaving groups.	8 lectures
4.	**Rearrangements :** General mechanistic considerations – Nature of migration, migratory aptitude and memory effects. Detailed study of the following rearrangements: Pinacol – pinacolone, Wagner – Meerwein, Demjanov, Benzil – Benzilic acid, Fovorskii, Fries, Beckmann, Hoffmann, Schmidt and Baeyer-Villiger.	14 lectures

Books Recommended:

1. D. Nasipuri, *Stereochemistry of Organic Compounds*, 2nd Edn., Willey Eastern Ltd., New Delhi.
2. E. L. Eliel and S.H. Wilen, *Stereochemistry of Organic Compounds*, (1994) Wiley Interscience, New York.
3. S. M. Mukherjee and S. P. Singh, *Pericyclic Reactions*, Macmillan India Ltd., New Delhi.
4. I. Flemming, *Pericyclic Reactions* (1998), Oxford University Press, Oxford.
5. I. Flemming, *Frontier Orbitals and Organic Chemical Reactions,* 1st Edn.,, Wiley, New York.
6. M.B. Smith & Jerry March, *March's Advanced Organic Chemistry reaction, Mechanism & Structure,* 7th Edn., John Wiley & Sons, New York.
7. Paul de Mayo, *Molecular Rearrangements*, Part I (1963) & II (1964), Interscience Publishers, New York.

CY 8006: NATURAL PRODUCTS

L	T	P	C
4	0	0	4

52 Lectures

1.	**Alkaloids:** Definition, nomenclature, occurrence, isolation, classification based on nitrogen heterocyclic ring. Role of alkaloids in plants and their physiological action. Structure, sterochemistry, synthesis and biosynthesis of : Ephedrine, Quinine and Morphine.	12 lectures
2.	**Steroids :** Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry. Isolation, structure determination and synthesis of Cholesterol. Synthesis of Testosterone, Progesterone and Cortisone.	16 lectures
3.	**Terpenoids and Carotenoids:** Isolation and general method of structure elucidation of terpenoids. Structure determination and synthesis of Geraniol, D-Pinene, Menthol and Camphor. Biosynthesis of terpenoids. Introduction to Carotenoids, Biosynthesis and synthesis of Vitamin A and E-Carotene.	14 lectures
4.	**Flavonoids:** Occurrence, nomenclature, synthesis of Apigenin, Querectin, Diadzein, Cyanidin, Hirsutidin. Biosynthesis of flavonoids: Acetate pathway and Shikimic acid pathway.	10 lectures

Books Recommended:

1. J. Mann, R.S. Davidson, J. B. Hobbs, D.V. Banthrope and J.B. Harborne, *Natural Products Chemistry and Biological Significance*, Longmann, Essex.
2. S.W. Pelletier, *Chemistry of Alkaloids,* Vol 7, 1991 Van Nostrand Reinhold Co., New York.
3. K. W. Bentley, *The Alkaloids*, Vol. I (1957-1965) Interscience Publishers, New York.
4. I. L. Finar, *Organic Chemistry*, Vol.II, 5th Edn., (2002), Longman Ltd., New Delhi.
5. B.A. Bohm, *Introduction to Flavonoids*, 1998, Harwood Academic Publishers.
6. Atta-ur-Rahman, *Studies in Natural Products Chemistry (Bioactive Natural Products),* Vol 46 & 47, Elsevier Sc. Publishers, USA, 2015.
7. L.F. Fieser and M.Fieser, *Steroids* , Reinhold Publishing Corporation, New York.
8. C.W.Shoppee, *Chemistry of Steroids*(1964),2nd Edn., Butterwotrths.
9. I.L.Finar, *Organic Chemistry,* Vol II, 3rd Edn., 2011, Reviewed by Juneja.

Physical Chemistry Specialization

CY 8007: ELECTROCHEMISTRY

L	T	P	C
4	0	0	4

52 Lectures

1.	**Electrolyte Solution:** Introduction, Ion-dipole Mode for Ion-solvent Interactions, Thermodynamic approaches-heat of solvation, relation to compressibility of solvation, quantitative treatment of Debye-Huckel theory of ion-ion interactions, activity coefficient applicability, limitations of Debye-Huckel limiting law, its modification for finite-sized ions, effects of ion-solvent interaction on activity coefficient. Debye-Huckel-Onsagar (D-H-O) theory of conductance of electrolyte solution, its applicability and limitations, Bjerrum's ion-pairs, modification of D-H-O theory to account for ion pair formation, determination of association constant (K_A) from conductance data.	20 lectures

2.	**Electrical Double layer:** Thermodynamics of double layer, electrocapillary equation, determination of surface excess and other electrical parameters-electrocapillarity, excess charge capacitance and relative surface excesses. Metal / water interaction-contact adsorption, its influence on capacity of interface, Complete capacity potential curve, Constant capacity region hump. Specific adsorption - extent of specific adsorption, Adsorption isotherm, rate of adsorption, Semiconductor/ electrolyte interface, Capacity of space charge, Mott-schottky plot.	18 lectures
3.	**Electrode Kinetics:** Review of Butler Volmer- treatment. Polarizable and non-polarizable interfaces. Multi step reactions- a near equilibrium relation between current density and over potential. Concept of rate determining step. Determination of reaction order. stoichiometric number, and transfer coefficient. Electro-catalysis comparison of electro-catalytic activity. Importance of oxygen reduction and hydrogen evolution reactions and their mechanisms.	14 lectures

Books Recommended:

1. J.O'M. Bockris and A. K. N. Reddy, *Modern Electrochemistry*, Vol.2 A & B 2nd Edn., (1998) Plenum Press, New York (International Edition).
2. D.R. Crow, *Principles of Electrochemistry* and Applications, 4th Edn., 1994, CRC Press, Blackie Academic & Professional.
3. D.A. MacInnes, *The Principles of Electrochemistry*, Dover Publications Inc. 1961.

CY 8008: CHEMICAL KINETICS

L	T	P	C
4	0	0	4

52 Lectures

1.	**Fast Reaction:** Experimental Techniques - flow techniques, relaxation methods, flash photolysis.	6 lectures
2.	**Transition State Theory:** Application of statistical mechanics to transition state theory (TST), comparison of transition state theory with experimental results. Thermodynamic treatment of TST theories of unimolecular reactions — treatments of Lindemann, Hinshelwood, Rice-Ramsperger-Kassel (RRK), and Rice-Ramsperger-Kassel-Marcus (RRKM).	14 lectures
3.	**Reactions in Solution:** Reaction between ions; effect of solvent (single & double sphere models) interpretation of frequency factor and entropy of activation, influence of ion strength, salt effect and reaction mechanisms. Reaction involving dipoles. Influence of pressure on reaction rates in solution. Influence of substituents on reaction rates. Electronic theories of organic reactivity. The Hammet equation, significance of V and U. The Taft equation.	14 lectures
4.	**Homogeneous Catalysis:** Mechanism of acid-base catalysis (protolytic and prototropic). Bronsted catalytic law.	8 lectures
5.	**Kinetics of Polymerization Reactions :**Condensation and Addition (free radical, ionic, coordination) polymerization, Co-polymerization.	10 lectures

Books Recommended:

1. M.J. Pilling and A.P.W. Seakins, *Reactions Kinetics,* 2nd Edn., (1998) Oxford Science Publication, New York.

2. K.J. Laidler, *Chemical Kinetics,* 3rd Edn., Pearson Education, 2007.
3. J. Raja Ram and J.C. Kuriacose, *Kinetics and Mechanism of chemical transformations,* 2000, MacMillan Publishers India Ltd., New Delhi.
4. B.G. Cox, *Modern Liquid phase Kinetics*, (1994), Oxford University Primers.

CY 8009: QUANTUM CHEMISTRY

L	T	P	C
4	0	0	4
		52 Lectures	

1.	**Approximation Methods**: Stationary perturbation theory for non-degenerate and degenerate systems with examples. Variation method. Ground state of He atom. Time dependent perturbation theory. Einstein coefficients. Introduction to the methods of self- consistent field theory, Hartree-Fock method, Roothaan equations, Selection of Basis sets. Semi empirical method, Density functional theory.	15 lectures
2.	**Tunneling effect**: Tunneling through a rectangular barrier. Application with examples.	6 lectures
3.	**Electronic structure of atoms:** Electronic configuration, Russell-Saunders terms and coupling schemes. Slater-condon parameters, term separation energies, term separation energies of P^n configuration, term separation energies for the d^n configurations, magnetic effects: spin-orbit coupling and Zeeman splitting.	16 lectures
4.	**Molecular orbital theory**: Huckel theory of conjugated systems, bond order and charge density calculations. Applications to ethylene, butadiene, cyclopropenyl radical, cyclobutadiene etc. Introduction to extended Huckel theory.	15 lectures

Books Recommended:

1. P.W. Atkins and R.S. Friedman, *Molecular Quantum Mechanics*, 5th Edn., 2010 Oxford University Press, Oxford.
2. H. Eyring, J.Walter and G.E. Kimball, *Quantum Chemistry* (1944) John Wiley, New York.
3. I.N. Levine, *Quantum Chemistry*, 7th Edn., 2013, Prentice Hall.
4. A.K.Chandra, *Introduction to Quantum Chemistry*, 3rd revised Edn., 1989, McGraw-Hill Education.

Minor Electives-I/II

CY 8010: MATERIALS CHEMISTRY

L	T	P	C
2	0	0	2
		26 Lectures	

1.	**Synthesis and Characterization of Materials**: Materials and their classification, preparative techniques: Ceramic methods, chemical strategies, chemical vapour deposition; Preparation of nano materials, Langmuir-Blodgett Films, Fabrication of ordered nanostructures. Composition and purity of materials.	9 lectures
2.	**High Tc Oxide Superconductors**: Structural features of cuprate superconductors. 1-2-3 and 2-1-4 cuprate; structure. Normal state properties: anisotropy and temperature dependence of electrical resistance. Superconducting state, heat capacity, coherence length relation between Tc and hole concentration in cuprates; mechanism of superconductivity in cuprates. Applications of high Tc cuprates.	9 lectures
3.	**Organic Materials**: Conducting organics – Metals from molecules, charge transfer materials and conducting polymers, Organic superconductors. Fullerenes. Molecular ferromagnets and ferroelectrics. Liquid crystals: mesomorphic behaviour, optical properties of liquid crystal display devices.	8 lectures

Books Recommended:

1. A.R. West, *Solid State Chemistry and its Application,* 2nd Edn., 2013, John Wiley & Son, Singapore.
2. C.N.R. Rao and J. Gopalkrishnan, *New Directions in solid State Chemistry*, 2nd Edn., 1997, Cambridge Univ. Press.
3. T.V. Ramakrishnan and C.N.R. Rao, *Superconductivity Today,* 2nd Edn., 1999, Wiley Eastern Ltd., New Delhi.
4. P. Ball, *Designing the Molecular World Chemistry at the Frontier,* (1994) Princeton Univ. Press.

CY 8011: RADIO AND RADIATION CHEMISTRY

L	T	P	C
2	0	0	2

26 Lectures

1.	**Radioactivity & Nuclear Properties:** Theory of Radioactive Disintegration, Radioactive Decay Law, Radioactive Equilibrium, Radioactive Series, Artificial Radioactivity, Types of Radioactive Decay, Kinetics of Radioactive Decay, Half-Life, Mean Life, Branching Decay, Mixture of Radioactive Nuclides, Nuclear Mass & Binding Energy, Nuclear Radius & Density, Nuclear Force, Nuclear Potential, Nuclear isomerism, Quantum Numbers, Nuclear Spin, Parity, Quadrupole Moments, Statistics, Nuclear stability, Semi Empirical Mass Formula and its Applications.	6 lectures
2.	**Radiochemistry:** Radiation detection & measurements-Proportional, Geiger-Muller and scintillation counters, semiconductor detectors & autoradiography, Radiochemical principles in the use of tracers; Applications of radioisotopes as tracers (activation analysis, isotope dilution technique, radio-chromatography, neutron absorptiometry & radiometric Age determination, Medicinal and agricultural applications.	12 lectures
3.	**Radiation Chemistry:** Elements of radiation chemistry; Interaction of radiation with matter, interactions of J-radiation with matter, units for measuring radiation absorbed, radiation dosimetry. Radiolysis of water & aqueous solutions: Free radicals in water radiolysis, radiolysis of some aqueous solution; A time scale of radiolytic events.	8 lectures

Books Recommended :

1. H.J. Arnikar, *Essentials of Nuclear Chemistry*, 4th Edn., 1995,(reprint 2014) Wiley Eastern, New Delhi.
2. G.Fridlander, J.W. Kennedy, E.S. Macias, and J.M. Miller, *Nuclear & Radiochemistry,* 3rd Ed. (1981), John Wiley , New York.
3. K. H. Lieser, Nuclear and Radiochemistry: Fundamentals and Applications, 2nd Revised Edn., 2007, Wiley-VCH Verlag GmbH.

CY 8012: MEDICINAL CHEMISTRY

L	T	P	C
2	0	0	2

26 Lectures

1.	**Introduction**: Concepts of Drug, lead compounds and modifications, prodrugs and soft drugs, structure-activity relationship (SAR). Factors effecting bioactivity, resonance, inductive effect, isosterism, bio-isosterism, spatial considerations, concepts of drug receptors. Receptor site theory, Approaches to drug design.	6 lectures

2.	**Antibiotics & Antibacterial**: Introduction, Antibodies containing â- lactam drugs (Penicillins & cephalosporins). Antitubercular (Streptomycin), Broad spectrum (Tetracyclines) Anticancer (actinomycin D). Antibacterial (Ceprofloxacin & Norfloxacin).	6 lectures
3.	**(i) Antimalarials** : Nitrogen heterocycles as antimalarials, structure and reactivity-chloroquine, pamaquine & pyrimethamine. **(ii) Antipyretic analgesis**: Synthesis of paracetamol, novalgin. **(iii) Antihistamines** : Bromazine, cinnarizine, methapyriline **(iv) Hypnotics/Sedatives** : Diazepam, oxazepam and thiopental sodium.	14 lectures

Books Recommended:

1. A.Gringuze, *Introduction to Medicinal chemistry* , 1997, Wiley-VCH.
2. W.O. Foye, *Principles of Medicinal Chemistry*, 3rd Edn., 1988, Lea & Lebiger/Varghese Publishing House, Mumbai.
3. D. Lednicer, *Strategies for organic Drug synthesis and Design*, 2nd Edn., 2008, John Wiley.
4. D.Lednicer and L.A.Mitscher, *The Organic Chemistry of Drug Synthesis*, Vol-I-III, 1980, Wiley Interscience.
5. A. Kar, *Medicinal chemistry,* 3rd Edn., 2006, Wiley Eastern Ltd, New Delhi.
6. A.Burger, *Medicinal chemistry*, Vol-I-III, 7th Edn., 2010, Wiley Interscience Publications, NewYork.
7. N.K. Terrett, *Combinatorial chemistry,* 1st Edn., 1998, Oxford University Press, Oxford.

CY 8013: ORGANIC PHOTOCHEMISTRY

L	T	P	C
2	0	0	2

26 Lectures

1.	**Basics of Photochemistry :** Interaction of electromagnetic radiation with matter, types of excitations, fate of excited molecule, quantum yield, transfer of excitation energy, actinometry.	6 lectures
2.	**Photochemistry of Unsaturated Compounds:** Intramolecular reactions of the olefinic bond-geometrical isomerism, cyclisation reactions, rearrangement of 1,4- and1,5- dienes. Isomerizations, additions and substitutions in aromatic compounds.	7 lectures
3.	**Photochmistry of Carbonyl Compounds :** Intramolecular reactions of carbonyl compounds – saturated, cyclic and acyclic, EJ - unsaturated and DE -unsaturated compounds. Cyclohexadienones. Intermolecular cyclo-addition reactions – dimerisations and oxetane formation.	7 lectures
4.	**Miscellaneous Photochemical Reactions :** Photo-Fries reactions of anilides. Photo-Fries rearrangement. Barton reaction. Di-pi-methane rearrangement. Singlet molecular oxygen reactions.	6 lectures

Books Recommended:

1. K.K.Rohtagi-Mukherji, *Fundamentals of photochemistry*, 3rd Edn., New Age International Publishers.
2. A.Gilbert and L.Baggott, *Essentials of Molecular photochemistry*, 1st Edn., Wiley-Blackwell Scientific Publication.
3. C. H. De Puy and O.L. Chapman, Molecular Reactions and Photochemistry, Prentice Hall of India Pvt. Ltd.

4. N.J. Turro, Modern Molecular Photochemistry (1991), University Science Books, Sausalito, California.

5. Petr Klan and Jakob Wirz, Photochemistry of Organic Compounds, 1st Edn., Wiley.

CY 8014: COMPUTATIONAL CHEMISTRY

L	T	P	C
2	0	0	2

26 Lectures

1.	**Fortran/C programming and Numerical Methods** : Advanced programming features of FORTRAN/C. Basic theory, discussion of algorithms and errors for the following numerical methods. Examples from chemistry should be selected for illustrating the methods. The teacher may select ANY ONE of the following subtopics considering the background of students, available time etc. (i) Solution of Equations: Bisection, regular falsi, Newton-Raphson and related methods for solving, polynomial and transcendental equations. Convergence. Errors and ill- conditioning. (ii) Linear Simultaneous Equations: Gaussian elimination, Gaus –Seidel method, Gauss-Jordan method. Pivoting strategy, Errors and ill conditioning. (iii) Eigenvalues and Matrix Diagonalization: Jacobi and Householder methods, analysis or errors. (iv) Interpolation: Newton forward and backward difference, central differenced formulae. Lagrange and Hermite interpolation. Polynomial wiggle problem. (v) Numerical Differentiation: Solution of simple differential equations by Taylor series and Runge-Kutta methods. (vi) Numerical Integration Newton-cotes formulae, Romberg integration, errors in integration formulae. The students should develop computer programs for some of the above numerical methods.	15 lectures
2.	**Running of Advanced Scientific Packages:** The students are expected to get hands on experience of running a few selected advanced level scientific software packages after & brief introduction to the basic theory and methodology. Ab initio quantum chemical packages such as GAUSSIAN / GAMES with carefully designed exercises for illustrating various features of the packages. Semi-empirical/Dynamics/ simulation packages such as MOPAC, CHARM, AMBER, QUANTA etc. Basic ideas on structure activity relation, drug and catalysis design etc.	11 lectures

Books Recommended:

1. A. C. Nooris, *Computational Chemistry*, 1st Edn., 1982, John Wiley.
2. R. Rajaraman, *Computer Programming in FORTRAN 77*, 4th Edn., 2006, Prentice Hall.
3. C.E. Frogberg, *Numerical Analysis*, 2nd Edn., Macmillan.
4. M.J. Maron, *Numerical Analysis – A practical approach*, 1991, John Wiley.
5. H.M. Antia, *Numerical Methods for Scientists and Engineers*, 2002, Tata McGraw Hill.
6. V. Rajaraman, *Fortran 77*, 1998, Prentice Hall (India), New Delhi.

SEMESTER IV

Major Electives –IV/V

Inorganic Chemistry Specialization

CY 8015: RINGS, CHAINS, AND CLUSTERS IN INORGANIC CHEMISTRY

L	T	P	C
4	0	0	4

52 Lectures

1.	**Isopoly and Heteropoly Acids and Salts**: Synthesis and structural principles with reference to those of V, Nb, Ta, Cr, Mo and W.	10 lectures
2.	**Metal Clusters and Metal-Metal Bonds:** Compounds with metal-metal multiple bonds, metal carbonyl and halide clusters.	10 lectures
3**.**	**Chemistry of Non Transition Elements**: Syntheis, properties, structures and bonding of Higher boranes, carboranes, metallo-boranes and metallo-carboranes, Borazines and Phosphazines.Isolobal concept (Hoffman) in organometallic and metal-cluster chemistry.	16 lectures
4.	**Inorganic polymers**: Classification, Types of Inorganic Polymerization, Comparison with organic polymers, Boron-oxygen and boron-nitrogen polymers, silicones, coordination polymers, sulfur-nitrogen, sulfur-nitrogen-fluorine compounds,chalcogenide clusters -binary and multi- component systems, homolytic inorganic systems.	16 lectures

Books Recommended:

1. F.A. Cotton and G. *Wilkinson Advanced Inorganic Chemistry*, 6th Ed. (1999) John Wiley & Son New Delhi.
2. James E. Huheey, *Inorganic Chemistry*, 4th Ed. (1993) Addison Wesley Pub. Co, New York.
3. N.N. Greenwood and A. Earnshaw, *Chemistry of the Elements,* 2nd Ed. (1997) Butterworth Heinemann, London.
4. Gary L. Miessler and Donald A. Tarr, *Inorganic Chemistry*, 5th Edn., 2014, Prentice Hall International Inc, London.

CY 8016: SPECIAL TOPICS IN INORGANIC CHEMISTRY

L	T	P	C
4	0	0	4

52 Lectures

1**.**	**Macrocyclic Complexes:** Types of macrocyclic ligands – design and synthesis by coordination template effect, di- and poly -nuclear macrocyclic complexes; applications of macrocyclic complexes. Macrocylic systems: Binucleating macrocycles, bicyclic ligand complexes incorporating void adjacent to the metal ion, The cage macrocycles; Host –guest Chemistry: macrocyclic host and non metallic guest. Natural macrocycles: cyclic antibiotics and related systems, natural corrin, porphyrin and related systems.	16 lectures
2.	**Supramolecular Chemistry:** Concept of supramolecular chemistry, Molecular recognition: Molecular receptors for different types of molecules including anionic substrates, design and synthesis of coreceptor molecules and multiple recognition. Supramolecular reactivity and catalysis. Transport processes and carrier design. Supramolecular devices; supramolecular photochemistry, supramolecular electronic, ionic and switching devices. Some examples of self assembly in supramolecular chemistry.	16 lectures

3.	**Molecular Magnetic Materials:** Basic concepts of molecular magnetism, types of magnetic interactions, recent techniques of magnetic susceptibility measurements, inorganic and organic ferro-magnetic materials, low spin – high spin transitions. Isotropic interactions in dinuclear compounds (dipolar, anisotropic and antisymmetric interactions), trinuclear compounds and compounds of high nuclearity, magnetic chain compounds, magnetic long range ordering in molecular compounds: design of molecular magnets, physical investigation and applications.	12 lectures
4.	**Matallomesogens :** Basic concepts, types of meso-phases, synthetic strategies, characterization and applications.	8 lectures

Books Recommended:

1. Jean Marie Lehn, *Supramolecular Chemistry*, (1995) VCH, Weinheim.
2. J.L. Serrano*, Metallomesogens*, (1996) VCH, Weinheim.
3. Oliver Kahn, *Molecular Magnetism*, (1993) VCH, Weinheim.
4. F.A. Cotton, G. Wilkinson, C.A Murillo and M. Bochmann, *Advanced Inorganic chemistry,* 6th Ed. (2003) John Wiley & Sons (Asia), Singapore.
5. L.F.Lindoy, *The Chemistry of Macrocyclic Ligand Complexes*, 1st Edn., 1989, Cambridge University Press.

Organic Chemistry Specialization

CY 8017: ORGANIC SYNTHESIS

L	**T**	**P**	**C**
4	0	0	4

52 Lectures

1.	**Reduction:** Introduction, $LiAlH_4$ and $NaBH_4$ reductions of aldehydes, ketones, nitro and azo groups. Reduction of conjugated systems, Birch reduction, Hydroboration.	12 lectures
2.	**Oxidation:** Oxidation of alcohols and aldehydes with Cr(VI) and Mn(VII) oxidants. Oxidation of C=C, C-H groups, carbonyl compounds, allylic carbon–hydrogen bonds with peracids. Oxidation with Selenium dioxide and Osmium tetroxide, Woodward and Prevost hydroxylation.	12 lectures
3.	**Reagents and Reactions:** Gilman's reagent-Lithium dimethylcuprate. Lithium diisopropylamide (LDA), Dicyclohexyl carbodiimide (DDC), 1,3-Diathiane (Umpolung reagent), Wilkinson's catalyst Wittig reaction, Peterson's synthesis, Quaternary ammonium and phosphonium salts, Crown Ethers.	14 lectures
4.	**Disconnection Approaches to Organic Chemistry:** Synthons and synthetic equivalents, functional group transformation and stereoselective reactions. One group C-C disconnections: alcohols and carbonyl compounds, regioselectivity, alkene synthesis and uses of acetylenes in organic synthesis Two group C-C disconnections: Diels –Alder reaction, 1, 3-difunctionalised compounds, D E - unsaturated ketones, 1, 5- difunctionalised compounds, Michael addition.	10 lectures
5.	**Protection of Functional Groups:** Alcohol, amine, carbonyl and carboxyl groups.	4 lectures

Books Recommended

1. H.O.House, *Modern Synthetic Reaction*, 2nd Ed. (1972), Benjamin Publishing Company, California.
2. L.F. Fieser and M .Fieser, *Reagent for organic synthesis*, Vol. 1-16 Wiley Interscience, New York.

3. P. R. Jenkins, *Organometallic reagents in Synthesis* (1992), Oxford Science Publishers, Oxford
4. J.Clayden , N. Greeves , S. Warren, and P. Wothers, *Organic Chemistry,* 2nd Edn., 2012, Oxford University Press, Oxford.
5. M.B. Smith, *Organic Synthesis,* 6th Edn., 2007, McGraw Hill Inc., New York.
6. F.A.Carey and R.J. Sundberg, *Advanced Organic Chemistry*, Part B, Plenum Press
7. M.B. Smith, *Organic Synthesis*, 2nd Ed.(2001),McGraw- Hill, Inc, New York.
8. M. Harmata, *Strategies and Tactics in Organic Synthesis* , Vol 9, 2013, Academic Press.
9. M.V. Smith, Jerry March, *Advanced Organic Chemistry, Part B, Reactions and Synthesis,* 6th Edn., 2007, Wiley Interscience.

CY 8018: HETEROCYCLIC CHEMISTRY

L	T	P	C
4	0	0	4

52 Lectures

1.	**Nomenclature, Classification and Properties of Heterocycles :** Systematic nomenclature (Hantzsch Widman system) of monocyclic, fused and bridged heterocycles. Aromatic Heterocycles : General chemical behaviour of aromatic heterocycles, classification (structural type), criteria of aromaticity (bond lengths, ring current and chemical shifts in ^{1}H NMR-spectra empirical resonance energy, delocalization energy and Dewar resonance energy) Heteroaromatic reactivity and tautomerism in aromatic heterocycles. Non-aromatic heterocycles: Bond angle and torsional strains and their consequences in small ring heterocycles. Conformation of six-membered heterocycles with reference to molecular geometry, barrier to ring inversion, pyramidal inversion and 1,3-diaxial interaction.	10 lectures
2.	**Small Ring Heterocycles**: Three-membered Heterocycles - Synthesis and reactions of aziridines, oxiranes, thiiranes. Four-membered heterocycles - Synthesis and reactions of azetidines, oxetanes and thietanes. Five membered heterocycles: Chemistry of Furans, Pyrroles and Thiophenes.	15 lectures
3.	**Six-membered Heterocycles with one, two or more Heteroatom :** Synthesis and reactions of pyrylium salts and pyrones, and their comparison with pyridinium salts & Pyridones. Synthesis and reactions of benzopyrylium salts, coumarins and chromones. Synthesis and reactions of diazines, triazines, tetrazines.	15 lectures
4.	**Seven- and Large-membered Heterocycles:** Synthesis and reactions of azepines, oxepines and Azocines.	6 lectures
5.	**Benzo-fused Heterocycles:** Chemistry of Indoles, Quinolines and Isoquinolines.	6 lectures

Books Recommended:

1. R.R.Gupta, M.Kumar and V.Gupta, *Heterocyclic Chemistry*, Vol.1 & 2, Springer Verlag.
2. T.Eicher, S.Hauptmann and A.Speicher, *The Chemistry of Heterocycles: Structure, Reactions, Synthesis and Applications,* 3rd Edn., Wiley-VCH Verlag.
3. J.A.Joule and K.Mills, *Heterocyclic Chemistry*, 4th Edn., Blackwell Publishing.
4. T.L.Gilchrist, *Heterocyclis chemistry*, 3rd Edn., Pearson.

5. R.M. Acheson, *An introduction to the Chemistry of Heterocyclic Compounds*, 3rd Edn., Wiley India Pvt. Ltd.
6. A.R. Katrizky and C.W. Rees, *Comprehensive Heterocyclic Chemistry*, Pergamon Press.
7. R.K. Bansal, Heterocyclic Chemistry, 4th Edn., New Age International Publishers.
8. V.K. Ahluwalia, Heterocyclic Chemistry, 2013, Alpha Science International Ltd., Oxford.

Physical Chemistry Specialization

CY 8019: STATISTICAL MECHANICS

L	T	P	C
4	0	0	4

52 Lectures

1.	**Review of Basic Statistical Mechanics:** A Review of Thermodynamics and Kinetic theory of gases. Phase space, Ensemble. Liouville theorem. Microcanonical ensemble. Quantization of phase space. Classical limit. Various distributions using microcanonical ensembles. Entropy. Gibbs paradox. Entropy of a two level system. Canonical and grand canonical ensembles. Equipartition of energy. Ideal gas in canonical and grand canonical ensembles.	18 lectures
2.	**Partition Function:** Review of rotational, vibrational and translational partition functions. Application of partition function to specific heat of solids and chemical equilibrium. Real gases.	8 lectures
3.	**Bose - Einstein and Fermi-Dirac Statistics :** Einstein condensation. Thermodynamic properties of ideal Bose-Einstein (BE) gas. Degenerate Fermi Gas. Electron in metals. Magnetic susceptibility.	10 lectures
4.	**Fluctuations :** Mean square deviation and fluctuation in ensembles. Concentration fluctuation in quantum statistics.	10 lectures
5.	**Non equilibrium state:** Boltzmann transport equation, particle diffusion, electrical conductivity.	6 lectures

Books Recommended

1. B.K. Agarwal and M. Eisner. *Statistical Mechanics,* 2nd Edn., (1998), John Wiley & Sons Inc, New Delhi.
2. D.A. McQuarrie, *Statistical mechanics*, 1st Edn., 2000, University Science Books.

CY 8020: PHYSICAL METHODS IN CHEMISTRY

L	T	P	C
4	0	0	4

52 Lectures

1.	**Electrochemical Techniques:** Impedance technique – its application for studying electrode kinetics and corrosion. Application of Rotating Disc Electrode (RDE) for measurement of electrochemical rate constant.	12 lectures
2.	**Vibrational Spectroscopy:** Vibration of polyatomic molecules. Nature of normal vibrations and coordinates. IR and Raman transitions. Applications to surface studies. Reflection – Absorption Infrared Spectroscopy (RAIRS).	12 lectures
3.	**Photoelectron spectroscopy :** Principle and applications to studies of molecules and surfaces. UPES and XPS. Auger Electron and X-ray fluorescence spectroscopy (AES and XRF). Electron Energy Loss Spectroscopy (EELS).	14 lectures
4.	**Techniques for Studying Surface Structure:** Low Energy Electron Diffraction (LEED). Scanning Tunneling and Atomic Force Microscopy (STM and AFM).	10 lectures
5.	**Neutron Diffraction:** Principle and applications.	4 lectures

Books Recommended:

1. A.J. Bard and L.R. Faulkner, *Electrochemical Methods*: *Fundamentals and Application,* 2nd edition (2001) John Wiley & Sons, New York.
2. J.M. Hollas, *Modern Spectroscopy,* 4th Edition (2003) John Wiley and Sons, Chichester.
3. C.N. Banwell and E.M. McCash, *Fundamentals of Molecular Spectroscopy,* 4th Edition (1994), 38th reprint, (e-edition 2012), Tata McGraw Hill, New Delhi.
4. E.M. McCash, *Surface Chemistry*, 1st Edn., (2001) Oxford University Press, Oxford.
5. A.K. Cheetham and P Day, *Solid State Chemistry: Techniques*, Vol 1 (1987), Oxford Sc Publications, Clarendon Press.
6. P. Ball, *Designing the Molecular World Chemistry at the Frontier,* (1994), Paperback 1996, Princeton Univ. Press.

Minor Electives –III/IV

CY 8021: QUANTUM MECHANICS OF ATOMS AND MOLECULES

L	T	P	C
2	0	0	2

26 Lectures

1.	**Introduction :** Hydrogen atom. The Variation Theorem-Ritz variation principle. The Variation method for ground state of Helium atom. Time dependent perturbation theory.	8 lectures
2.	**Atomic structure:** Many electron wave functions. Pauli Exclusion Principle, antisymmetric principle, singlet and triplet states, excited state of Helium atom, Atomic term symbols. The self-consistent field method. Slater-type orbital.	10 lectures
3.	**Chemical Binding (Molecular structure):** Born-Oppenheimer approximation, Molecular Orbital (MO) treatment for H_2^+. MO treatment of homo- and hetero nuclear diatomic molecules, Huckel MO treatment of simple and conjugated polyenes.	8 lectures

Books Recommended:

1. I. N. Levine, *Quantum Chemistry*, 5th Edn., (2000), Paperback Ed. (2006), Pearson Ed. Inc., New Delhi.
2. D.A. Mc Quarrie and J.D. Simon, *Physical Chemistry*: *A Molecular Approach*, (1997), University Science Books, New Delhi.
3. J. N. Murrell, S.F.A Kettle and J.M. Tedder, *Valence Theory*, 2nd Edn., (1965), John Wily & Sons Ltd., London.
4. A.K. Chandra, *Introductory Quantum Chemistry*, 4th Edn., (1994), Tata McGraw Hill education, New Delhi.
5. M.Karplus and R.N. Porter, *Atoms and Molecules: An introduction for Students of Physical Chemistry,* (1971), Benjamin-Cummings Publishing Company.
6. Journal of Chemical Technology & Biotechnology, Review: L. Pauling and E.B. Wilson, *Introduction to Quantum Mechanics with Applications to Chemistry,* (1935), McGraw Hill Publishing Co., London.
7. R.K.Prasad, *Quantum Chemistry,* (1993), Wiley Eastern Limited, New-Delhi
8. K.L. Kapoor, *A Textbook of Physical Chemistry*, Vol 4, , Macmillan Ind. Ltd., Delhi
9. Frank.J. Bockhoff, *Elements of Quantum Theory*, 1st Edn., (1969), Addition-Wesley Publishing Company, INC. Francis T. Bonner, Consulting Editor, Massachusetts/ California/London/Ontario.
10. Thomas Engel, *Quantum Chemistry & Spectroscopy*, 3rd Edn., Pearson, Published by Dorling Kindersley (India) Pvt. Ltd.

CY 8022: INORGANIC PHOTOCHEMISTRY

L	T	P	C
2	0	0	2

26 Lectures

1.	**Basic Principles of Photochemistry:** Absorption, excitation, photochemical laws – Franck-condon principle, radiative lifetimes, quantum yield, electronically excited - states, life times-measurements of times. Flash photolysis, stopped flow techniques. Energy dissipation by radiative and non radiative processes, absorption spectra, photochemical stages-primary and secondary processes.	12 lectures
2.	**Properties of Excited States:** Structure, dipole moment, acid base strengths, reactivity. Photochemical kinetics, calculation of rates of radiative processes. Bimolecular deactivation-quenching.	8 lectures
3.	**Excited States of Metal Complexes:** Excited states of metal complexes: comparison with organic compounds, electronically excited states of metal complexes, charge transfer spectra, charge transfer excitation.	6 lectures

Books Recommended

1. D.M. Roundhill, *Photochemistry and Photophysics of Metal Complexes*, (1994), Plenum Press New Delhi.
2. G.J. Ferraudi, *Elements of Inorganic Photochemistry,* 1st Edn., (1988), John Wiley & Sons.
3. V. Balzani and V. Carassiti, *Photochemistry of Coordination Compounds*, (1970), Academic Press. London.
4. O. Horvath and K.L. Stevenson, *Charge Transfer Photochemistry of Coordination complexes*, (1993), VCH Publishers Inc.

CY 8023: BIO-ORGANIC CHEMISTRY

L	T	P	C
2	0	0	2

26 Lectures

1.	**Enzymes and Mechanism of Enzyme Action:** Classification, isolation and purification. Methods of Enzymes analysis. Kinetics of enzyme action – Michaelis Menten equation. Different plots for determination of K_m and V_{max} and their physiological significance: Two substrate reactions, Enzymes inhibition Mechanism of action of chymotrypsin, aldolase, alcohol hydrogenase, and lysozyme.	10 lectures
2.	**Co-enzyme Chemistry:** Cofactors as derived from vitamins; coenzymes prosthetic groups and apoenzymes effect and biological functions of coezymes A, thiamine Pyrophosphate, Pyridoxal phosphate, NAD $^+$ NADP $^+$, FMN, FAD, Lipoic acid and vitamin B_{12}. Mechanisms of reactions catalysed by the above cofactors.	10 lectures
3.	**Biotechnological Applications of Enzymes :** Techniques and methods of immobilization of enzymes, effect of immobilization on enzyme activity , application of immobilized enzymes, use of enzymes in food and drink industry –Brewing and cheese making. Syrups from corn starch, enzymes as targets for drug design.	6 lectures

Books Recommended

1. A.L. Lehninger, *Principles of Biochemistry*, (1992), CBS Publisher, Delhi
2. D .Voet, J.G. Voet and C.W. Pratt, *Fundamentals of Biochemistry*, (1999), Harper and Row Pub, New York.
3. H.R. Mahler and E.H. Cordes, *Biological Chemistry*, 2nd Edn., (1971), Harper and Row Pub., New York.

4. T.C. Bruce and E.H.Cordes, *Bioorganic Mechanism*, Vol I & II (1966), W.A. Bengamin, New York.

5. H. Dugas and C. Penney, *Bioorganic Chemistry*: *A Chemical Approach to Enzyme Action,* (1981), Springer-Verlag, New York.

6. C. Walsh, *Enzymatic Reaction Mechanism*, W.H. Freeman & Co., New York.

CY 8024 : CHEMICAL APPLICATIONS OF GROUP THEORY

L	T	P	C
2	0	0	2

26 Lectures

1.	**Symmetry and Point Groups:** Determination of point group of a molecule. General relations among symmetry elements and operations. Representation of groups, Great orthogonality theorem, construction of character tables for C_{2V} and C_{3V} groups, the direct product. Mulliken symbols for irreducible representations. Symmetry-Adapted Linear combinations: Projection operators, operators to construct SALCs (one dimensional and two dimensional representations).	14 lectures
2.	**Molecular Orbital Theory:** Molecular orbital for AB_4 type molecules, the group theoretical approach to bonding in H_2O and $NH_{3.}$	5 lectures
3.	**Ligand Field Theory:** Splitting of Energy levels and terms in chemical environment, Energy level diagram in tetrahedral environments, the hole formalism, estimation of orbital energies, selection rules and polarization.	7 lectures

Books Recommended:

1. F. A. Cotton, *Chemical Applications of Group Theory*, Wiley Eastern (1976).

2. D. S. Schonland, *Molecular Symmetry: An introduction to Group Theory and its uses in Chemistry*, D. Van Nostrand Company Inc (1965).

3. K. Veera Reddy, *Symmetry and Spectroscopy of Molecules*, (1998), New Age International Pvt. Ltd. New Delhi.

CY 8025: SOLID STATE CHEMISTRY

L	T	P	C
2	0	0	2

26 Lectures

1.	**Reactions, Crystal Defects and Non-Stoichiometry :** General principles, Kinetics of solid state reactions. Perfect and imperfect crystal, intrinsic and extrinsic defects-point defects, line and plane defects, vacancies - Schottky defects and Frenkel defects. Thermodynamics of Schottky and Frenkel defect formation, colour centres, non-stoichiometry and defects.	10 lectures
2.	**Electronic Properties and Band Theory:** Electronic structure of solids-band theory, refinement to simple band theory-k-space and Brillouin zones, band structure of metals, insulators and semiconductors, intrinsic and extrinsic semiconductors, doping semiconductors, p-n junctions and super conductors. (9 Lectures)	9 lectures
3.	**Optical and Magnetic Properties:** Optical reflectance, photoconduction-photoelectric effects. Classification of materials: Quantum theory of paramagnetics, Cooperative phenomena - magnetic domains, hysteresis.	7 lectures

Books Recommended:

1. A.R. West, *Solid State Chemistry and its Application,* 2nd Edn., 2013, John Wiley and Sons, Singapore.

2. L.V. Azaroff, *Introduction to Solids*, (1977), Tata McGraw – Hill New Delhi.

3. H.V.Keer, *Principles of The Solid State*, 1993, Wiley Eastern.

4. N.B.Hannay, *Solid State Chemistry*. 1976, Plenum, New York.

5. D.K.Chakrabarty, *Solid State Chemistry*, 2010, New Age International.

CY 8026: NUCLEAR CHEMISTRY

L	T	P	C
2	0	0	2

26 Lectures

1.	**Nuclear Chemistry:** Introduction, nuclear stability and binding energy. Mass and binding energy systematic. Nuclear isomerism and internal conversion. Nuclear fission and nuclear fusion - fission cross-section, chain fission, fission product and fission yield, mass and charge distribution in fission. Nuclear fusion and stellar energy.	8 lectures
2.	**Radioactive Decay Process:** Alpha decay-penetration of potential barriers, hindered alpha decay, alpha decay energies. Beta Decay, Fermi theory, energy, curie plots, comparative half lives, electron capture, selection rules, forbidden transitions, non conservation of purity neutrinos, Gamma decay life-time of excited states, multipule radiation and selection rules, isomeric transition, internal conversion and Auger effect**.**	12 lectures
3**.**	**Nuclear Energy:** Basic principle of chain reacting systems, the 4-factor formula, classification of reactors, Breeder reactor, Reactor associated problems, Reactor safety, Fuel cycle, Re-processing of spent fuel, Nuclear waste management.	6 lectures

Books Recommended:

1. B.G. Harvey, *Introduction to Nuclear Physic and Chemistry*, 2nd Edn., 1970, Prentice Hall Inc.
2. H.J. Arnikar, *Essentials of Nuclear Chemistry* , 4th Edn., (1995), Wiley Eastern Ltd, New Delhi.
3. G. Fridlander, J.W. Kennedy, E.S. Macias and J.M. Miller, *Nuclear & Radiochemistry* , 3rd Ed. (1981), John Wiley & Sons, New York.

CY 8027 : FRONTIERS IN INORGANIC CHEMISTRY

L	T	P	C
2	0	0	2

52 Lectures

1.	**Supramolecular chemistry**: Concept of supramolecular chemistry, Various types of non-covalent interactions. Hydrogen bonds, C-H...X interactions, Halogen bonds. S S interactions, non – bonded interactions. Various types of molecular recognition, Molecular receptors for different types of molecules including anionic substrates, design and synthesis of coreceptor molecules and multiple recognition. Supramolecular reactivity and catalysis. Transport processes and carrier design. Supramolecular devices; supramolecular photochemistry, supramolecular electronic, ionic and switching devices. Self assembly in supramolecular chemistry.	12 lectures
2.	**Macrocyclic coordination compounds**: Macrocyclic ligands – design and synthesis by coordination template effect, di- and poly -nuclear macrocyclic complexes; applications of macrocyclic complexes. Macrocylic systems: Binucleating macrocycles, The cage macrocycles; Host –guest Chemistry: macrocyclic host and non metallic guest. Natural macrocycles: porphyrin, corrin, phlorin related systems. Nomenclature.	8 lectures
3.	**Coordination compounds in Catalysis**: Stoiciometric reactions for homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, hydroformylation, isomerization and polymerization, Waker process, catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxo reaction), oxopalladium reactions, activation of C-H bond.	6 lectures

Books Recommended :

1. J. E. Huheey, E. A.Keiter, R.L.Keiter & O.K.Medhi, 4 th Edn., 2008, *Inorganic Chemistry- Principles Structure and Reactivity,* Pearson Education.
2. F.A. Cotton and G.Wilkinson, *Advanced Inorganic Chemistry,* 6th Edn., (1999) John Wiley & Sons, New York.
3. D. F. Shriver and P.W Atkins, *Inorganic Chemistry,* 5th Edn., (2010) ELBS, London.
4. Jean Marie Lehn, *Supramolecular Chemistry,* (1995) VCH, Weinheim.
5. L.F.Lindoy, *The Chemistry of Macrocyclic Ligand Complexes,* 1989, Cambridge University Press.

LABORATORY COURSES
SEMESTER I
LABORATORY WORK - I
CY 7151: INORGANIC CHEMISTRY PRACTICAL

L	T	P	C
0	0	4	2

1. Preparation, purification and structural studies (magnetic, electronic and IR) of inorganic complex compounds :
   - *(i)* *trans*-potassium diaqua-bis (oxalato) chromate (III), *trans*- K $[Cr(ox)_2 (H_2O)_2]$
   - *(ii)* *cis*- potassium diaqua-bis (oxalato) chromate (III), *cis*- K $[Cr(ox)_2 (H_2O)_2]$
   - (iii) tris(acetylacetonato) manganese (III), $[Mn(acac)_3]$
   - (iv) Sodium hexa-nitritocobaltate (III), $Na_3[Co (ONO)_6]$
   - (v) Penta-ammine monochlorocobalt (III), $[CoCl(NH_3)_5] Cl_2$.
   - (vi) Penta-ammine aqua-cobalt (III) Chloride, $[Co(H_2O) (NH_3)_5]Cl_3$ by using $[CoCl (NH_3)_5] Cl_2$ as the starting material.
   - (vii) Penta-ammine nitrocobalt (III) chloride, $[Co(ONO) (NH_3)_5]Cl_2$ by using $[CoCl (NH_3)_5]Cl_2$ as the starting material.
   - (viii) Penta-ammine nitrocobalt (III) chloride, $[Co(NO_2) (NH_3)_5]Cl_3$ by using $[Co(ONO) (NH_3)_5]Cl_2$ as the starting material.
   - (ix) $[Cu(NH_3)_4]SO_4.H_2O$.

CY 7152: ORGANIC CHEMISTRY PRACTICAL

L	T	P	C
0	0	4	2

1. Separation, purification & identification of mixture containing two compounds using fractional distillation, crystallization, tlc, column chromatography; functional group identification by chemical tests and IR spectra.
2. Acetylation (Cholesterol), Oxidation (Cyclohexanol), Bromination and nitration of aromatic compounds.

CY 7153: PHYSICAL CHEMISTRY PRACTICAL

L	T	P	C
0	0	4	2

1. Kinetics of saponification of ethyl acetate with sodium hydroxide by titrametric method.
2. Comparison of acid strengths through acid catalyzed methyl acetate hydrolysis.
3. Energy of activation of acid catalyzed hydrolysis of methyl acetate.
4. Distribution coefficient of I_2 between two immiscible solvents.
5. Conductometric titration of a weak acid with strong base.
6. Conductometric titration of a mixture of weak and strong acids.
7. Determination of solubility and solubility product of sparingly soluble salt conductometrically.
8. Conductometric titration of KCl with $AgNO_3$.
9. Conductometric titration of polybasic acid.
10. Molecular weight of a non-electrolyte by cryoscopy method.

SEMESTER II

LABORATORY WORK – II

CY 7251: INORGANIC CHEMISTRY PRACTICAL

L	T	P	C
0	0	4	2

1. Quantitative separation and estimation of the following pairs of metal ions using gravimetric and volumetric methods :
   (i) Ag^+ (Gravimetrically) and Cu^{2+} (Volumetrically)
   (ii) Cu^{2+} (Gravimetrically) and Zn^{2+} (Volumetrically)
   (iii) Fe^{3+} (Gravimetrically) and Ca^{2+} (Volumetrically)
   (iv) Mg^{2+}(Gravimetrically) and Ca^{2+} (Volumetrically)
2. Separation of a mixture of cations/anions by paper chromatographic technique using aqueous/ non aqueous media :
   (i) Pb^{2+} and Ag^+ (aqueous & non-aqueous media)
   (ii) Co^{2+} and Cu^{2+} (non-aqueous media)
   (iii) Cl^- and I^- (aqueous-acetone medium)
   (iv) $Br^-$and I^- (aqueous-acetone medium)

CY 7252: ORGANIC CHEMISTRY PRACTICAL

L	T	P	C
0	0	4	2

1. Reactions- Grignard reaction (triphenyl methanol from ethyl benzoate), Aldol condensation (Dibenzal acetone from benzaldehyde), Cannizzaro reaction taking a suitable substrate, synthesis of aspirin.
2. Determination of no. of hydroxyl groups (acetylation method), Estimation of phenols (acetylation), Bromination of alkenes (cyclohexene/cholesterol/oils etc,) Allylic halogenation(NBS).
3. Determination of iodine/saponification value of an oil.

CY 7253: PHYSICAL CHEMISTRY PRACTICAL

L	T	P	C
0	0	4	2

1. Rate constant of acid catalyzed hydrolysis of sucrose by polarimetric method.
2. Rate constant of acid catalyzed hydrolysis of sucrose by chemical method.
3. Kinetics of decomposition of acidified hydrogen peroxide with potassium iodide and determination of activation energy.
4. Degree of hydrolysis of urea by hydrochloride by kinetics method.
5. Equilibrium constant of $KI + I_2 \rightleftharpoons KI_3$ by distribution method.
6. Phase diagram of a binary organic system (Naphthalene and Diphenyl).
7. Potentiometric titration of a strong acid with strong base using quinhydrone electrode.
8. Potentiometric titration of a redox system (ferrous ammonium sulfate with $K_2Cr_2O_7$).
9. Adsorption of acetic acid on charcoal to verify Freundlich adsorption isotherm.
10. Determination of ionization constant of a weak indicator acid.

SEMESTER III

LABORATORY WORK - III

CY 8151: INORGANIC CHEMISTRY SPECIALIZATION

L	T	P	C
0	0	12	6

1. Synthesis, purification, analysis and structural characterization of coordination complexes of simple and chelating ligands by microanalytical, magnetic susceptibility measurements, IR ,UV and NMR spectroscopy.

   (i) Bis-(acetylacetonato) complexes of Cu (II), Co (II), and VO (IV).

   (ii) Cis-and-trans $[Co(en)_2 (Cl)_2]$.

   (iii) $[Cr(NH_3)_6 Cl_3]$.

   (iv) $[Cr(OAc)_2]. 2H_2O$.

   (v) $[Ti (Urea)_6]. I_3$

(vi) Organotin complexes

(vii) Synthesis of trichlorophenylantiomony (V) hydrate.

(viii) Synthesis of metal acetylacetonate: Magnetic moment, IR, NMR

(ix) Magnetic moment of $Cu(acac)_2 H_2O$

(x) Cis and trans$[Co(en)_2Cl_2]^+$

(xi) Preparation of copper glycine complex-cis and trans bis [glycinato Copper (II)]

(xii) Ion exchange separation of oxidation state of Vanadium.

2. Chromotographic separations

(i) Cadmium and Zinc

(ii) Zinc and magnesium

(iii) Thin layer chromatography separation of nickel, magnesium, cobalt and zinc. Determination of R_f values.

LABORATORY WORK – III

CY 8152: ORGANIC CHEMISTRY SPECIALIZATION

L	T	P	C
0	0	12	6

1. Qualitative analysis - Separation , purification and identification of components of a mixture containing three compounds. To check their purity by tlc and spectral evidences (IR & PMR).
2. Multi step Synthesis – Photochemical reaction (Benzophenone- Benzpinacol-Benzpinacolone), Beckmann rearrangement(Benzophenone- Benzophenone oxime-Benzanilide and Cyclohexanone-Cyclohexanone oxime- Caprolactum), Benzilic acid rearrnangement(Benzoin- Benzil-Benzilic acid) etc.
3. Isolation of organic compounds from Natural sources- Caffeine from tea leaves, nicotine from tobacco, E- carotene from carrot, lycopene from tomato, lactose from milk and oleic acid from olive oil.
4. Separation, purification and identification of organic compounds from mixtures using tlc, column chromatography, microanalysis, UV, IR, PMR and MASS spectra.

LABORATORY WORK – III

CY 8153: PHYSICAL CHEMISTRY SPECIALIZATION

L	T	P	C
0	0	12	6

1. Kinetics of decomposition of benzene diazonium chloride.
2. Conductometric study of the kinetics of saponification of ethyl acetate.
3. Kinetics of reaction of KI with potassium persulphate and study of salt effect.
4. Determination of transport numbers of Cu^{2+} and SO_4^{2-} by Hittorf's method.
5. Conductometric titration of triple mixture ($HCl+NH_4Cl+KCl$) with (i) NaOH and (ii)$AgNO_3$
6. Verification of Debye–Huckel-Onsager equation of conductance.
7. Determination of solubility by (i) conductometry and (ii) potentiometry.

8. Determination of hydrolysis constant of aniline hydrochloride.
9. Determination of thermodynamic ionization constant of a monobasic acid by (i) conductometry and (ii) potentiometry
10. Analysis of halide mixture by differential potentiometry.
11. Comparison of strength of two acids by polarimetric study of kinetics of inversion of cane sugar.
12. Determination of band-gap of a semiconductor.

Books Recommended:

1. J. Bassett, R.C.Denney, G.H.Jeffery and J. Mendham, *Vogel's Textbook of Quantitative Analysis , revised*, 5th Edn., 1989, John Wiley & Sons.
2. W.L. Jolly, *Synthesis and Characterization of Inorganic Compounds*, 1970, Prentice Hall.
3. D. Pasto, C.Johnson and M.Miller, *Experiments and Techniques in Organic Chemistry*, Prentice Hall.
4. K.L. Williamson, D.C.Heath, *Macroscale and Microscale Organic Experiments*, 6th Edn., 2010.
5. H. Middleton, Adward Arnold, *Systemetic Qualitative Organic Analysis*.
6. H. Clark, Adward Arnold, *Handbook of Organic Analysis-Qualitative and Quantitative*.
7. A.R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry,* 5th Edn., 2008, Pearson Education, New Delhi.
8. A.M. James amd F.E.Prichard, *Practical Physical Chemistry*, 3rd revised Edn., 1974, Prentice Hall.
9. B.P. Levitt,Friendly's *Practical Physical Chemistry*, 9th Edn., 1973, Longmann.
10. R.C. Das and B. Behera, *Experimental Physical Chemistry*, Illustrated Edn., 1983, Tata McGraw Hill.
11. J. Derek Woollins, *Inorganic Experiments*, 1994, VCH.
12. Z. Szafran,R.M.Pike and M.M.Singh, *Microscale Inorganic Chemistry*, Paperback 2008, Wiley.
13. G. Marr and B.W.Rockett, *Practical Inorganic Chemistry*, 1972, Van Nostrand.
14. R.L. Shriner and D.Y.Curtin, *The Systematic Identification of Organic Compounds,* 7th Edn., 1998, Wiley.
15. N.D. Cheronis, J.B.Entrikin and E.M. Hodnett, *Semimicro Qualitative Organic Analysis*, 3rd Edn., 1957, Interscience, New York.
16. M.P. Doyle and W.S.Mungall, *Experimental Organic Chemistry*, 1980, John Wiley & Sons, Inc., New York.
17. P.J. Hills, *Small Scale Organic Preparations,* 1964, Hodder and Stoughton Education.
18. R.B. King, (edited by J.J. Fisch and R.B.King), *Organometallic synthesis*, Vol I, p.75, 1965, Academic Press, New York-London.
19. D.P. Shoemaker,C.W.Garland and J.W.Niber, *Experimental Physical Chemistry*, Mc Graw Hill Interscience.
20. B.P. Levitt, *Findlay's Practical Physical Chemistry*, 9th Edn., 1973, Longman group Edition.
21. J.C.Ghosh,*Experiments in Physical Chemistry*, Bharti Bhavan Publishers and Distributors.

Ph. D CHEMISTRY SYLLABUS

CY 9001 : RESEARCH METHODOLOGY

L	T	P	C
4	0	0	4

52 Lectures

I	**Fundamental Laboratory Techniques:** Basic principles, Health and safety, working with liquids, Basic laboratory procedures I, Basic laboratory procedures II, Principles of solution chemistry, pH and buffer solutions.	8 lectures
II.	**Chemical Safety and Disaster Management:** (a) Emergency response: Chemical spills, radiation spills, biohazard spills leaking compressed gas cylinders, fires, medical emergency, accident reporting **,** (b) General Safety: General safety and operational rules, safety equipment's, personal protective equipment's, compressed gas safety, safety practices for disposal of broken glass wares, centrifuge safety, treated biomedical wastes and scientific ethics.	12 lectures
III.	**Information Technology and Library Resources:** The internet and world wide web, internet resources for chemistry using spreadsheets, word processors, databases and other packages, finding and citing information.	10 lectures
IV.	**Communication Skill:** General aspects of scientific writing, writing essays, reporting practical and project work, writing literature survey and review, organizing a poster display, giving an oral presentation examinations.	12 lectures
V.	**Research Problem:** Meaning of research problems, sources of research problems, Criteria/characteristics of a good research problem, errors in selecting a research problem.	10 lectures

Books Recommended:

1. C.R. Kothari, **Research Methodology – Methods & Techniques,** Wishwa Prakshan, New Delhi, 2005.
2. B. Taylor, G. Sinha, and T. Ghoshal, **Research Methodology,** Prentice Hall of India, New Delhi, 2006.
3. F.W. Fifield and D. Kealey, **Principle and Practice of Analytical Chemistry,** 5th Edn., Blacwell Published 2000 [First Indian reprint: 2004]
4. Gary D. Christian, **Analytical Chemistry,** 7th Edn., John Wiley & Sons, 2013.
5. Ramesh Kumari, **Computers and their Applications to Chemistry,** 2nd Edn., Narosa Publishing House, 2007.
6. K. Atkinson, **Elementary Numerical Analysis,** 3rd Edn., John Wiley & Sons, 2004.
7. Robert M. Silverstein, Francis X. Webster, David Kiemle, David L. Bryce, **Spectrometric Identification of Organic Compounds**, 8th Edn., 2014, John Wiley & Sons.
8. P.S. Kalsi, **Spectroscopy of Organic Compounds,** 8th Edn., 2004, New Age International Publishers.
9. Kumar Ranjit, **Research Methodology – A Step by step Guide for Beginners,** 2nd Edn., Pearson Education, Singapore, 2005.
10. Stuart Johnson and Jon Scott, **Study and Communication Skills for the Biosciences,** Oxford University Press, 2nd Edn., 2014.
11. Robert A. Day and Oryx Press, **Write and Publish a Scientific Paper,** 7th Edn., 2012.
12. Paul G. Chapin, **Research Projects and Research Proposals A Guide for Scientists Seeking Funding,** Cambridge University Press, 2014.
13. J. R. Dean, A. M. Jones, D. Holmes, R. Reed, J. Weyers and A. Jones **., Practical Skills in Chemistry,** 2nd Edn., 2012, Pearson Education Ltd. (2002).

CY 9002 : PHYSICAL METHODS IN CHEMISTRY

L	T	P	C
4	0	0	4

1.	**UV-Visible Spectroscopy:** Basic principles, instrumentation and applications in qualitative & quantitative analysis of molecules.	6 lectures
2.	**Chromatographic Techniques:** Basic principles of Column and Thin Layer Chromotographic techniques, Gas Chromatography; HPLC: Introduction basic principle and instrumentation; comparison of GC and HPLC; Qualitative analysis, Quantitative analysis and Applications.	10 lectures
3.	**Atomic Absorption/Emission Spectroscopy:** Basic principles and instrumentation; applications to qualitative and quantitative analysis.	6 lectures
4.	**Polarography & Cyclic Voltametry:** Basic principles, instrumentation and its applications to inorganic and organic molecules. **Cyclic Voltametry:** Reversible and irreversible process; evaluation of potential range in a redox reactions, and applications.	10 lectures
5.	**(a) NMR Spectroscopy:** Basic principles and instrumentation. Applications to qualitative and quantitative analysis. **(b) IR and Raman Spectroscopy:** Basic principles, instrumentation & applications to qualitative identification of structural details of molecules. FT-IR. **(c) Mass Spectroscopy:** Basic principles, instrumentation and applications.	20 lectures

Books Recommended:

1. J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, **Vogel's Text Book of Quantitative Chemical Analysis",** 6th Edn., 2002, Pearson Education Pvt. Ltd., New Delhi.
2. S.M.Khopkar, **Analytical Chemistry – Problems & Solutions**, 2nd Edn., 2013, New Age International Pvt. Ltd., New Delhi.
3. John R.Dyer, **Applications of Absorption Spectroscopy of Organic Compounds,** (reprint 2009), PHI Learning, New Delhi.
4. Hobart H.Willard, D.U. Merritt & J.R.J.A.Dean, **Instrumental Methods of Analysis,** 7th Sub Edn., 1988, Wadsworth Publishing Company.
5. Scoog and West, **Instrumental methods of chemical analysis.** Illustrated Edn., 1971.
6. R.S. Drago, **Physical Methods in Inorganic chemistry,** 2012, Affiliated East-West Press Pvt. Ltd. New delhi.
7. R.S. Drago, **Physical Methods for Chemists,** 1992, Saunders College Publishing, Philadelphia.
8. A. J. Fry, **Electro organic studies,** Page No. 93-95.

CY 9003 : ADVANCED INORGANIC CHEMISTRY

L	T	P	C
4	0	0	4

52 Lectures

I	**Atomic States and Term Symbol** : A systematic approach to term symbols, Assigning term symbols for p^2 and d^2 configuration, Electron-electron interaction and term symbols, Spin-orbit coupling in free ion.	6 lectures
2.	**Coordination Chemistry**: Nomenclature, isomerism, chelate effect, Crystal field theory, stereochemistry of coordination compounds; spectrochemical and Nephelauxetic series; splitting of d-orbitals in low symmetry environments, thermodynamic and structural effects: site selection in spinels, Jahn -Teller effects; experimental evidence for metal- ligand orbital overlap; ligand field theory, charge transfer spectra, molecular orbital theory of octahedral complexes, Electronic spectra of complexes such as $V(H_2O)_6$, $Mn(H_2O)_6$. Orgel diagram, Tanabe-Sugano diagram.	14 lectures
3.	**Electron Transfer Reactions** : Mechanism of redox reactions, Outer sphere mechanism, Excited State outer sphere electron transfer reactions, photochemical reduction of H_2O to H_2, Inner sphere mechanism, photochemical conversion of N_2 to NH_3. Mixed valence complexes, comparison of photochemical and thermal electron transfer processes in mixed valence complexes, Electron transfer involving a bimetallic complex Ru^{2+}/Ru^{3+}, Applications of electron transfer reactions with special reference to bioinorganic chemistry.	8 lectures
4.	**Organometallic Chemistry**: Nature of metal carbon bonds, preparation, structure and properties of metal carbonyls, Carbonylate ions, carbonyl hydride complexes, Isolobal fragments, Nitrosyl complexes (preparation and structure), Di-nitrogen complexes, Nitrogen fixation, Metal alkyls, carbenes, carbynes and carbides. Metal alkene and alkyne complexes, Metal allyl and pentadienyl complexes, Metallocenes, Molecular orbitals of metallocenes, Metal arene complexes. Applications of organometallics in organic synthesis, C-C bond coupling reactions (Heck, sangoshira, Suzuki)	13 lectures
5.	**Bioinorganic chemistry**: Transition metal ions in biology. Metalobiomolecules, Electron carriers, oxygen carriers, Metalloenzymes, Hemoglobin, Myoglobin, Hemocyanin, Hemrythrin, cytochromes, Fe-S proteins, Cytochrome P-450, Peroxidase, Catalase, Ferritin, cytochrome-C oxidase, Blue copper proteins. Metal containing oxidase and reductase class of enzymes (sulfite oxidase, xanthine oxidase, nitrate reductase, DMSO reductase), Zn enzymes (carbonic anhydrase, carboxypeptidase), Nickel containing F-430, role of manganese in water splitting, inorganic chemistry in medicine, platinum complexes.	11 lectures

Books Recommended:

1. J. E. Huheey, E. A.Keiter, R. L. Keiter & O. K. Medhi, **Inorganic Chemistry-Principles Structure and Reactivity**, 4th Edn., 2011, Pearson Education.
2. F. A. Cotton and G.Wilkinson, **Advanced Inorganic Chemistry**, 6th Edn., (1999) John Wiley & Sons, New York.
3. D. F. Shriver and P.W. Atkins, **Inorganic Chemistry**, 5th Edn., (2010) ELBS, London.
4. C. Elschenbroich and A. Salzer, **Organometallics: A Concise Introduction** 3rd Edn., John Wiley and Sons, (2005)

5. B. D. Gupta and A. J. Elias, **Basic Organometallic Chemistry: Concepts, Synthesis and applications,** First Edn., Universities Press, (2010)
6. Rober H . Crabtree, **The Organometallic Chemistry of the Transition Metals,** John Wiley and Sons, 4th Edn., (2005).
7. I. Bertini, H. B. Gray, S. J. Lippard and J. S. Valentine, **Bioinorganic Chemistry**, University Science Books, Mill Valley, 2006.
8. F. Basalo and R. G. Pearson, **Mechanism of Inorganic Reaction**, 2nd Edn., (1967), Wiley Eastern Ltd. New Delhi.
9. D. N. Sathyanarayana, **Electronic Absorption Spectroscopy and Related Techniques** , (2001)Universities Press (India) Ltd., Hyderabad.

CY 9004 : ADVANCED ORGANIC CHEMISTRY

L	T	P	C
4	0	0	4

52 Lectures

1.	**^{13}C-NMR Spectroscopy:** Introduction, comparison between ^{1}H-NMR and ^{13}C-NMR spectroscopy, ^{13}C- NMR scale. Chemical shifts of some important functional groups containing ^{13}C-atoms, Proton coupled and proton decoupled spectra of important organic compounds having different f/groups. Applications of CMR in structure determination, stereochemistry and reaction mechanism. Principles and applications of APT, INEPT and DEPT techniques.	12 lectures
2.	**2D- NMR Spectroscopy:** Principles and applications of the following: 2D- NMR experiments: i) Homonuclear and Heteronuclear J resolved spectroscopy ii) HOMO COSY and TOCSY iii) HETERO COSY , HMQC and HMBC iv) NOESY v) INADEQUATE	8 lectures
3.	**Mass Spectrometry:** Nitrogen rule, Mc Lafferty rearrangement, Metastable peak and its formation, General rules for fragmentation of molecules. Application of mass spectrometry in structure determination of alkanes, cycloalkanes, aromatic compounds, alcohols, amines, ethers and esters, carboxylic acids, amino acids.	8 lectures
4.	**Synthetic strategies in Organic Chemistry:** Retrosynthetic analysis, disconnection approach, topological strategy, Diels-Alder approach, functional-group based approach, Transform-based approach, Structure-goal approach, biogenesis, Target oriented and methodology based synthesis, linear, convergent and divergent methods of synthesis, Umpolung, Asymmetric synthesis. Classification of organic synthesis, combinatorial synthesis, Atom economy, organic magnets.	12 lectures
5.	**(a) Reactions and their Mechanism:** Albright-Goldman, Swern and Corey-Kim oxidation, Alder Rickert reaction, Algar_Flynn-Oyamada reaction, Allan Robinson Reaction, Delepine reaction, Appel reaction for the synthesis of alkyl halide, Bamberger reaction, Dowd-Beckwith ring expansion, Balz-Schiemann fluorination, Corey-Claykovsky epoxidation and cyclopropanation, Sakurai alkylation, Conia-ene , Stetter and van Leusen reaction. **(b) Rearrangements:** Pumerrer, Smiles, Westphalen-Lettre rearrangements	12 lectures

Books Recommended:

1. J. R. Dyer, **Applications of Absorption of spectroscopy of organic compounds,** 1978, Prentice Hall, New Delhi.
2. R. M. Silverstein, F. X. Webster, D.J.Kiemle and D.L. Bryce, **Spectrometric identification of organic compounds,** 8th Edn., Wiley.
3. D. H. Williams and I. F. Fleming, **Spectroscopic Method in Organic Chemistry, 6**th Edn., Tata McGraw Hill, New Delhi.

4. P. Y. Bruice , **Organic Chemistry,** 7th Edn., Pearson.
5. M. L. Martin, J. J. Delpeuch and G. J. Martin, **Practical NMR Spectroscopy,** Heyden, 1980.
6. R. M. Silverstein, G. C. Bassler and T.C. Morrill, **Spectrometric Identification of Organic Compounds,** 4th Edn., John Wiley & Sons, New York.
7. Y. R. Sharma, **Elementary Organic Spectroscopy: Principles and Chemical Applications,** 1st Edn., S. Chand & Co Ltd, New Delhi.
8. T. I. Ataa-ur-Rahman, Iqbal M. Choudhury , **Applications of NMR spectroscopy Vol I & Vol II,** Bentham Science Publishers (2015).
9. M. Magdalena and J. Bravo, **Structure Elucidation in Organic Chemistry-The search for Right Tools,** Wiley-VCH (2015).
10. T. D. W. Claridge **, High Resolution NMR Technique in Organic Chemistry,** 2nd Edn., Elsevier.
11. Jeremy K.M. Sanders and Brian K. Hunter, **Modern NMR Spectroscopy: A Guide for Chemists,** Oxford University Press (1993).
12. Laszlo kurti and Barbara Czako, **Strategic Applications of Named reactions in Organic Synthesis,** Elsevier, Academic Press, New York.
13. Bradford P.Mundy, Michael G. Ellerd and Frank G. Favaloo, Jr, **Name reactions and reagents in Organic Chemistry,** 2ndEdn., Wiley Interscience.
14. Reinhard Bruckner, **Advaced Organic Chemistry: Reaction Mechanisms,** Academic Press, (2002).
15. F. A. Corey and R.J. Sundberg, **Advanced Organic Chemistry: Part B: Reaction and Synthesis,** 5th Edn., Springer.
16. E. J. Corey and X.-M. Cheng, **The logic of chemical synthesis,** Wiley.
17. G. Q. Lin, Y.-M. Li and A. S. C. Chan, **Principles and applications of asymmetric synthesis**, Wiley.
18. B. M. Trost and I. Fleming, **Comprehensive Organic Synthesis: Selectivity, Strategy and Efficiency in Modern Organic Chemistry**, Elsevier.
19. S. Worren, **Designing Organic Synthesis,** Wiley & Sons, Inc, New York, (1978).
20. F. Serratosa and J. Xicart, **Organic Chemistry in Action: The design of Organic Synthesis**, 2nd Edn., Elsevier (1996).

CY 9005 : ADVANCED PHYSICAL CHEMISTRY

L	T	P	C
4	0	0	4

52 Lectures

I	**Catalysis:** Broad categories of catalysts. General method for the preparation of catalysts. Homogeneous and Heterogeneous, Positive, negative and auto catalysed reactions. Induced reactions, promoters and poisons. Theory of catalysis: intermediate compound formation and adsorption theory, characteristic of catalytic reaction and activation energy of catalysed reactions. Surface area by BET method. Determination of pore volume and pore size distribution. Mechanism of surface-catalysed reactions. The Langmuir-Hinshelwood mechanism. Specificity in Enzyme Catalysed reactions; Michaelis–Menten mechanism; Acid-base catalysis.	16 lectures
II	**Photochemistry:** Types of photochemical reactions; Laws of Absorption (Grothuss-Draper law & Einstein's law); Quantum yield; Inter-System Crossing, Chemiluminescence. Kinetics of important Photochemical reactions. Reaction between Hydrogen and Oxygen; Explosion limits.	8 lectures
III	**Thermodynamic Properties of Liquids and Solutions:** Structure of liquids, relationship between structure and the thermodynamics properties, molecular theory of monoatomic and polyatomic liquids, thermodynamics of phase equilibria, statistical molecular description of phase transitions, chemical potential and partial molar quantities, mixing and excess thermodynamic properties of mixtures	9 lectures
IV	**Electrochemistry:** Electrode-electrolyte interface: The electrical double layer. The Helmholtz-Perrin parallel-plate model, the Gouy-Chapman diffuse charge model and the Stern model. Corrosion: Electrochemical mechanism of corrosion. Types of corrosion, various methods of corrosion control. Cyclic Voltammetry: Principle, instrumentation, reversible and irreversible cyclic voltammograms. Applications of Cyclic voltammetric study.	9 lectures
V.	**Environmental Chemistry:** Properties of water, Distribution of species in aquatic systems – single variable diagrams, two variable diagrams, Redox reactions in water chemistry - p^E / p^H diagram, Acid-base chemistry in natural waters; Biogeochemical cycles (carbon cycle, nitrogen cycle, phosphorus cycle); solving acid-base problems in aqueous systems- exact solution & approximate solution; Concept of BOD, COD, TOC; Criteria pollutants and Pollutants Standard Index (PSI).	10 lectures

Books Recommended:

1. K.J. Laidler, **Chemical Kinetics,** 3rd Edn., (1987), Prentice Hall, New York.
2. A.A. Frost and R.G. Pearson, **Kinetics and mechanism: A study of Homogeneous Chemical Reactions,** John Wiley & Sons, Inc., New York-London, 1961.
3. J. Raja Raman and J. C. Kuriacose, **Kinetics and Mechanism of Chemical Transformations**, New Delhi, McMillan Publishers, 2009.
4. G.C. Bond, **Heterogeneous Catalysis: Principles and Applications,** 2nd Edn., Oxford Science Publishers, 1987.
5. C. N. Satterfield, **Heterogeneous Catalysis in practice**, McGraw-Hill Company, 1980.
6. Edited by B. Vishwanathan, S. Sivasanker and E.V. Rama Swamy, **Catalysis**, **Principles and applications**, Narosa Publishing House.
7. J.C. Kuriacose, **Catalysis**,Macmillan.
8. Von N.J. Turro and W.A. Benzamin, **Molecular Photochemistry,** Inc., New York-Amsterdam, 1965.
9. K.K. Rohatgi-Mukherjee, **Fundamentals of Photochemistry**, New Age International, 1978.
10. A. Gilbert and J. Baggott, **Essentials of Molecular Photochemistry**, 1st Edn., 1991, Wiley-Blackwell.
11. C.H.J. Wells, **Introduction to Molecular photochemistry**, 1972, Chapman and Hall.

12. C.H. DePuy and O.L. Chapman, **Molecular Reactions and Photochemistry**, Pearson Education Ltd., 1972.
13. R. S. Berry, S. A. Rice and J. Ross, **Physical Chemistry**, 2nd Ed., Oxford University Press, New York, 2000.
14. A. Ben-Naim, **Water and Aqueous Solutions: Introduction to a Molecular Theory, 1974, Springer (1st Printing Edition).**
15. D. A. McQuarrie, **Statistical Mechanics**, 1st Edn., 2000, University Science Books.
16. Y. Marcus, **Introduction to Liquid State Chemistry**, John Wiley & Sons Ltd., New York, 1977.
17. K. S. Pitzer, **Thermodynamics**, 3+Ed., McGraw Hill, New York, 1995.
18. J.O'm Bockris and A.K.N. Reddy, **Modern Electrochemistry 2A & 2B**, Plenum Publishers (reprinted 2013).
19. S. Glasstone, **Introduction to Electrochemistry,** D.Van Nostrand Company, Inc. New York-London.
20. D. Pletcher and F.C. Walsh, **Industrial Electrochemistry**, 2nd Edn., 1990, Springer Netherland.
21. Edited by C. Charlot, **Modern Electro analytical methods**, Elsevier Publishing Company, London and D.Van Nostrand Co.Inc., Princeton 1958.
22. D.A. Skoog, F. J. Holler and T.A. Nieman, **Principles of Instrumental analysis**, 5th Edn., Philadelphia, Saunders College Pub., Harcourt Brace College Publishers.
23. D.A. Skoog, D.M. West, F.J. Holler, **Analytical Chemistry-An Introduction**, 7th Edn., Saunders College Publishing, Fort Worth Tex.
24. D.A. Skoog and J.J. Leary, **Principles of Instrumental Analysis, 4th Edn.,** Saunders College Publishing, Philadelphia, 1992.
25. Gary W. vanLoon and Stephen J. Duffy, **Environmental Chemistry-A Global Perspective,** 1st Indian Edn. (2008), Oxford University Press.
26. Colin Baird and Michael Cann, **Environmental Chemistry**, 3rd Edn. (2005), W. H. Freeman and Company, New York.
27. Daniel B. Botkin and Edward A. Keller, **Environmental Science – Earth as a Living Planet**, 6th Edition, 2007, John Wiley & Sons Inc.
28. Ian Williams, Environmental chemistry – A Molecular Approach, 2001, John Wiley & Sons, Inc.
30. Stanley E. Manahan, **Environmental Chemistry**,6thEdn. (1994), Lewis Publishers.
31. V. Subramanian, **A Textbook in Environmental Science**, (2002), Narosa Publishing house, New Delhi.

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY

SYLLABI
OF
PG / Ph. D. COURSES
(DEPARTMENT OF PHYSICS)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY
(UNDER THE MINISTRY OF EDUCATION, GOVT. OF INDIA)
DEEMED TO BE UNIVERSITY U/S 3 OF THE UGC ACT, 1956
NIRJULI - 791 109 :: ARUNACHAL PRADESH

SYLLABI
OF
PG/ Ph. D COURSES

(DEPARTMENT OF PHYSICS)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY (NERIST)

(Deemed to be University, U/S 3 Of the UGC Act, 1956)
Nirjuli (Itanagar), Arunachal Pradesh- 791 109

M.Sc. Physics

COURSE STRUCTURE

SEMESTER	COURSE CODE	COURSE TITLE	L	T	P	Cr
I	PH7101	Classical Mechanics	3	1	0	4
	PH7102	Mathematical Physics	3	1	0	4
	PH7103	Computational Physics & Programming	3	1	0	4
	PH7104	Quantum Mechanics-I	3	1	0	4
	PH7151	General Physics Laboratory-I	0	0	6	3
	PH7152	Computer Laboratory	0	0	6	3
			12	**4**	**12**	**22**
II	PH7201	Electrodynamics	3	1	0	4
	PH7202	Statistical Mechanics	3	1	0	4
	PH7203	Elementary Condensed Matter Physics	3	1	0	4
	PH7204	Quantum Mechanics-II	3	1	0	4
	PH7251	General Physics Laboratory-II	0	0	6	3
	PH7252	Condensed Matter Physics Laboratory	0	0	9	5
			12	**4**	**15**	**24**
III	PH8101	Atomic and Molecular Physics	3	1	0	4
	PH8102	Electronics	3	1	0	4
	PH8103	Nuclear Physics	3	1	0	4
	PH810*	Special Paper I	3	1	0	4
	PH8151	Optics & Nuclear Physics Laboratory	0	0	6	3
	PH8152	Electronics Laboratory	0	0	9	5
			12	**4**	**17**	**24**
IV	PH8201	Group Theory and Applications	3	1	2	5
	PH820*	Special Paper II	3	1	0	4
	PH825*	Special Paper Laboratory	0	0	6	3
	PH80**	Elective	3	0	0	3
	PH8299	Project	0	0	16	8
			9	**2**	**16**	**23**

Total Credits 93

***Each specialization will consist of two theory courses and one laboratory course in the fourth semester.**

PH7101 : Classical Mechanics **3 1 0 4**

UNIT-I	**Introductory concepts and Lagrange's equation:** Degree of freedom, constraints in configuration space: holonomic and non-holonomic constraints, generalized coordinates, principle of virtual work, D'Alembert's principle and Lagrange's equations, generalized force, Lagrange's equations for non-holonomic constraints, the two-body central force problem, virial theorem. **Variational principles**: Hamilton's principle, derivation of Lagrange's equation from Hamilton's principle, extension of Hamilton's principle to non-holonomic systems, conservation theorems and symmetry properties, the principle of least action.	10 lectures
UNIT-II	**Hamilton's equations and canonical transformations:** Legendre transformation and the Hamilton equations of motion, cyclic coordinates and conservation theorems, Routh's procedure. The equations of canonical transformation, Poisson brackets and other canonical invariants; equations of motion, Liouville's theorem.	9 lectures
UNIT-III	**Hamilton-Jacobi theory:** The Hamilton-Jacobi equation for Hamilton's principal function, example : the harmonic oscillator ; the Hamilton- Jacobi equation for Hamilton's characteristic function ; separation of variables in the Hamilton-Jacobi equation ; action-angle variables in systems of one degree of freedom, action-angle variables for completely separable systems ; the Kepler problem in action angle variables; analogy between Hamilton – Jacobi equation and Schrödinger equation.	10 lectures
UNIT-IV	**The rigid body:**The kinematics of rigid body motion: the Euler angles, Euler's theorem on the motion of a rigid body, finite rotations, infinitesimal rotations, rate of change of a vector; the rigid body equations of motion: angular momentum and kinetic energy of motion about a point, the inertia tensor and the moment of inertia, the principal axis transformation, the Euler equations of motion.	10 lectures
UNIT-V	**Small oscillations:** Formulation of the problem, principal axis transformation, frequencies of free vibrations and normal coordinators, forced vibrations and the effect of dissipative forces**.**	3 lectures

Recommended Books:

1. Classical Mechanics,Herbert Goldstein, 2nd Edition
2. Classical Mechanics, N.C. Rana and P.S. Joag,
3. Classical Mechanics, G. Aruldhas,

PH7102: Mathematical Physics **3 1 0 4**

UNIT-I	**Elementary differential geometry:** Topological space, continuous mappings, homeomorphism, differential manifolds, diffeomorphisms, connected and simply connected space.	4 lectures
UNIT-II	**Functions of complex variables:**Complex variables, calculus of residues, conformal maps and their applications, branch cut.	10 lectures
UNIT-III	**Integral and discrete transforms:** Fourier, Hilbert and Laplace transforms, dispersion relations, convolution.	4 lectures
UNIT-IV	**Linear operators and matrices:** Vectors and matrices, eigenvalue problem, properties of eigenvectors and eigenvalues, normal modes, tensors.	10 lectures
UNIT-V	**Differential equations:** Separation of variables, boundary value problem, Sturm-Liouville's problem, Green's function for ODEs and PDEs, ill posed boundary value problems.	10 lectures
UNIT-VI	**Differential equations of physics:** PDEs of Laplace, Poisson, Helmholtz, Klein-Gordon, Shrodinger and Maxwell; wave, scalar potential and diffusion equations.	4 lectures

Recommended Books:

1. Mathematical Methods for Physicists, G. Arfken, H.Weber and F.E. Harris, 7th Edition (Academic Press, 2012)
2. Advanced Engineering Mathematics, E. Kreyszig (Dover, 1998)
3. Mathematical Physics, Mathews & Walker, 2nd Edition (Pearson, 1971)
4. Differential Geometry, E. Kreyszig (Dover, 2003)

PH7103 : Computational Physics & Programming **3 1 0 4**

UNIT-I	**Numerical Analysis:** Methods for determination of zeroes of linear and non-linear algebraic equations and transcendental equations, solutions of simultaneous linear equations, Iterative method, Matrix inversion.	10 lectures
UNIT-II	**Linear fitting and interpolation**: Interpolation with equally spaced and unevenly spaced points, curve fitting, polynomial, least square and cubic spline fitting.	8 lectures
UNIT-III	**Numerical differentiation and integration**: Newton-cotes formulae, Error estimates, Gauss'method. Numerical solution of ordinary differential equation: Euler and Runge-Kutta methods.	8 lectures
UNIT-IV	**Random variate**: Monte-Carlo evaluation of integrals and error analysis, methods of importance sampling, Random walk, rejection Method, Metropolis algorithm.	6 lectures
UNIT-V	**Programming:** Elements of Computer programming with C ++.	10 lectures

Recommended Books:

1. Computational Methods in Physics & Engineering, SamuelS. M.Wong, World Scientific
2. Introductory Methods of Numerical Analysis, S. S. Sastry, Prentice Hall of India
3. Programming in C^{++}, E. Balagurusamy, Tata McGraw Hill

PH7104 : Quantum Mechanics-I **3 1 0 4**

UNIT-I	**(i) Recapituations:** Chronological evolution of quantum mechanics, wave particle dualism, uncertainty principle, wave packets in space and time. **(ii) Formalism of quantum mechanics:** development of the wave equation, the Schrodinger wave equation, statistical interpretation of the wave function, probability density and probability current density, Ehrenfest's theorem, stationary states, energy eigenfunctions, one dimensional square wave potential, parity. **(iii) Some bound state problems:** Linear harmonic oscillator, spherically symmetric potential, the hydrogen atom, particle in a spherical cavity.	14 lectures
UNIT-II	**Operator algebra:** Eigenfunctions and eigenvalues, expectation values, Dirac bra-kets, completeness and closure property, Hilbert space of state vectors, minimum uncertainty product, form of minimum packet, coordinate and momentum representation, unitary transformations.	12 lectures
UNIT-III	**Pictures of representations:** Schrodinger, Heisenberg and interaction pictures, matrix theory of harmonic oscillator, derivation of Hamiltonian of atomic electron in an em-field, equation of election in uniform magnetic field.	8 lectures
UNIT-IV	**Approximation methods for bound states:** Stationary perturbation theory- non-degenerate and degenerate states, Stark effect, variation method, WKB approximation.	8 lectures

Recommended Books:

1. Quantum Physics, Stephen Gasiorowicz, 3rd Edition(Wiley)
2. Quantum Mechanics: Theory and Applications, A. K. Ghatak and S. Lokanathan(Springer)
3. Quantum Mechanics, Cohen and Tannoudji, 1st Edition(Wiley)
4. Quantum Mechanics, G. Aruldhas, 2nd Edition(Prentice Hall of India)

PH 7201: Electrodynamics **3 1 0 4**

UNIT-I	**Introduction to vectors and tensors:** Vectors, tensors, vector calculus, curvilinear coordinates, Dirac delta function. **Electrostatics and magnetostatics:** Multipole expansion for localized charge distribution, static electric and magnetic fields in material media, Maxwell's equations, electrostatic and magnetic boundary conditions, boundary value problems using Laplace's equation in Cartesian and spherical coordinates, method of images.	14 lectures
UNIT-II	**Maxwell's equations and electromagnetic waves:** Maxwell's equations for time varying fields, the continuity equation, Poynting theorem, polarization and conductivity, plane wave in dielectric and conducting media.	6 lectures
UNIT-III	**Special theory of relativity:** Postulates of STR, homogenous Lorentz transformation,kinematics and dynamics in Minkowski space, Lorentz covariance of Maxwell's equations, Lorentz transformation of E and B, momentum 4-vector, continuity equation.	8 lectures
UNIT-IV	**Communication in different channels:** Wave propagation in plasmas, critical reflection, surface waves and medium frequency communication, wave guides, transmission lines, dipole antenna and antenna array.	6 lectures
UNIT-V	**Radiation from accelerated charges:** Scalar and vector potentials, Coulomb and Lorentz gauge, retarded potentials, Lienard-Wiechert potentials, radiation from accelerated charges, applications to communication and RADAR.	8 lectures

Recommended Books:

1. Classical Electricity & Magnetism, Panofsky and Phillips, 2nd Edition(Dover)
2. Electromagnetic Fields & Waves, P. Lorrain, D. R. Corsion and F. Lorrain, 3 rd Edition (Freeman) 1987)
3. Foundations of Electromagnetic theory, J. R. Reitz & F.J. Millford, 4 th Edition(Pearson)
4. Introduction to Electrodynamics, D.J. Griffiths, 4th Edition(Pearson)

PH7202 : Statistical Mechanics **3 1 0 4**

UNIT-I	**Introduction to Statistical Methods**: Random walk, binomial distribution, Gaussian and Poisson distributions, elements of ensemble theory-micro canonical, canonical and grand canonical ensembles, partition function, thermodynamic functions.	12 lectures
UNIT-II	**Formulation of quantum statistics:** Postulates of quantum statistical mechanics, density matrix, harmonic oscillator, an electron in magnetic field, Wigner's function.	8 lectures
UNIT-III	**Ideal Bose systems:** Thermodynamicbehavior of an ideal Bose gas, phonons, liquid helium & superfluidity.	6 lectures
UNIT-IV	**Ideal Fermi systems:** Thermodynamic behaviour of an ideal Fermi gas, magnetic behavior of an ideal Fermi gas, Pauli paramagnetism and Landau diamagnetism.	6 lectures
UNIT-V	**Statistical mechanics of interacting systems:** Cluster expansion for a classical gas, virial expansion of the equation of state, quantum cluster expansion, thermodynamics of phase transition in a van der Waaal system, Ehrenfest criterion, statistical mechanics of magnetic phase transition, Landau theory of 1st & 2nd order phase transition.	10 lectures

Recommended Books:

1. Statistical Mechanics, K. Huang (Wiley)
2. Statistical Mechanics, R.K. Pathria and P.D. Beale (Academic Press)
3. Statistical Physics, L.D. Landau and E.M. Lifshitz, 3rd Edition (Butterworth-Heinamann)
4. Statistical Mechanics, F. Mandl, 2nd Edition (Wiley-Backwell)

PH7203: Elementary Condensed Matter Physics 3 1 0 4

UNIT-I	**Crystal lattices and symmetry:** Crystalline Periodicity, amorphous structures, elements of crystallography, concept of point and space groups, Bragg scattering, atomic form factor, structure factor, reciprocal lattice, and Brillouin zone, Ewald sphere, electron and neutron diffraction.	12 lectures
UNIT-II	**Specific heat and lattice vibrations:** vibrational modes of a linear lattice, phonons and quantization, normal modes, acoustic and optical modes, vibrational modes of a di-atomic linear lattice, Einstein and Debye model of specific heat.	8 lectures
UNIT-III	**Free electron theory of solids:** energy levels and density of states in one, two and three- dimensions. electrical conductivity, thermal conductivity and Wiedemann – Franz ratio, specific heat contribution.	8 lectures
UNIT-IV	**Electronic properties of solids**: Bloch theorem in a periodic structure, origin of energy bands, Kronig-Penney model, nearly free electron model, tight binding model, effective mass, overlapping of energy bands.	6 lectures
UNIT-V	**Semiconductors:** intrinsic and extrinsic semiconductors, carrier density in intrinsic and extrinsic semiconductors, expression for Fermi levels, recombination process, pho-toconductivity, Hall effect in metals and semiconductors, band structure of Ge and Si.	8 lectures

Recommended Books:

1. Solid State Physics, A.J. Dekker (MacMillan)
2. Introductory Solid State Physics: H.P. Myers, 2nd Edition (CRC Press)
3. Introduction to Solid State Physics, C. Kittel, 8th Edition (Wiley)
4. Crystallography Applied to Solid State Physics : A.R. Verma and O.N. Srivastava (New Age)

PH7204 : Quantum-Mechanics-II 3 1 0 4

UNIT-I	**Angular momentum matrices:** spin matrices and eigenfuntions, addition of angular momentum, CG coefficients.	8 lectures
UNIT-II	**System of identical particles:** permutation symmetry, symmetric and anti-symmetric wave functions, Pauli exclusion principle, spin functions for two and three electron atoms, helium atom (ground state and first excited state).	8 lectures
UNIT-III	**Time dependent perturbation:** semi-classical treatment of radiation, intensity ratio of transitions in alkali atoms.	6 lectures
UNIT-IV	**Quantum theory of scattering:** cross sections, partial wave analysis, phase shifts, optical theorem, Schrodinger'sequation as an integral equation, Green's function, Lippman-Schwinger equation, Born approximation, Coulomb scattering.	8 lectures
UNIT-V	**Relativistic wave mechanics:** Klein-Gordon equation for a free particle, solution of the Klein-Gordon equation, a spin zero particle in Coulomb field, fine structure, Dirac equation for a free particle, anti-commuting relations of the Dirac matrices, spin of Dirac particle, Dirac equation, Dirac equation in Coulomb field.	12 lectures

Recommended Books:

1. Quantum Mechanics, L.I. Schiff (McGraw-Hill Book, New York).
2. Quantum Mechanics: Theory and Applications, A. K. Ghatak and S. Lokanathan (Macmillan India Ltd.).
3. Quantum Mechanics, Cohen and Tannoudji.
4. Quantum Mechanics, Ahruldhas.

PH 8101 : Atomic, Molecular And LASER Physics 3 1 0 4

UNIT-I	**Atomic physics:** Central field approximation, Hartree and Hartree-Fock approximation, Thomas-Fermi statistical rule, hydrogen atom spectrum, electron spin, Stern-Gerlach experiment, spin-orbit interaction, two electron systems, LS-JJ coupling schemes, fine structure, spectroscopic terms and selection rules, hyperfine structure, exchange symmetry of wave functions, Pauli's exclusion principle, periodic table, alkali type spectra, equivalent electrons, Hund's rule, Zeeman and Paschen-Back effect of one and two electron systems-selection rules-Stark effect.	12 lectures
UNIT-II	**Molecular physics**: Covalent, ionic and van der Waals interactions, Born-Oppenheimer approximation, Heitler-London and molecular orbital theories of H2, bonding and anti-bonding MOs, Huckel's molecular approximation-applications, vibrational structure and vibrational analysis, rotational Raman spectra and influence of nuclear spin, Franck-Condon principle, dissociation energy.	10 lectures
UNIT-III	**Vibration of polyatomic molecules:**Symmetry of molecules, symmetry elements and point groups, proper and improper rotations and their matrix representation, normal co-ordinates and normal modes of vibrations, infrared absorption and Raman scattering from molecular vibrations and rotations and selection rules.	8 lectures
UNIT-IV	**Lasers:**Basic elements of a laser, threshold condition, four-level laser system, CW operation of laser, critical pumping rate, population inversion and photon number in the cavity around the threshold, output coupling of laser power, role of plane and conical cavity resonators, longitudinal and transverse cavity modes, mode selection, switching and mode locking, ultra short pulses.	12 lectures

Recommended Books:

1. Introduction to Atomic Spectra, H.E. White (McGraw Hill)
2. LASERS-Theory and Application, K. Thyagrajan and A.K. Ghatak (Plenum Press)
3. Physics of Atoms and Molecules, Bransden and Joachan.
4. Vibrational Spectroscopy Theory & Application, D. N. Sathyanarayan.

PH8102 : Electronics 3 1 0 4

UNIT-I	**Devices and circuits:** Semiconductor devices (diodes, BJT, FET)-structure, device characteristics, opto-electronics (solar cells, photo-detectors, LEDs), zener diode as voltage regulator, application of diode as clamper, clipper, voltage multiplier, transistor biasing, operating point and load line, single stage amplifier, feedback and oscillators.	16 lectures
UNIT-II	**Differential amplifier:** Introduction to operational amplifiers, inverting, non-inverting and differential mode, uses of opamp as inverting amplifiers, adder, subtractor, integrator and differentiator.	6 lectures
UNIT-III	**Digital electronics:** Elementary ideas of binary numbers, hexadecimal and octal and interconversion, logic gates (AND, OR, NOT). Universal gates – NAND, NOR, logic families, De Morgan's theorem, laws of Boolean algebra, S-O-P and P-O-S representation, Karnaugh map.	10 lectures
UNIT-IV	**Arithmetic circuits:** Half adder, full adder, half subtractor and full subtractor, decoder/ demultiplexer, data selector/multiplexer and encoder. **Sequential digital systems:** flip-flops, shift registers and counters. **Digital applications:** Schmitt trigger, multivibrators.	10 lectures
UNIT-V	**Modulation and Demodulation:**Need of modulation, types of modulation, analysis of AM, demodulation, diode detector.	4 lectures

Recommended Books:

1. Electronic Devices and Circuits, J. Millman, C. Halkias and S Jit, 3rd Edition (McGraw Hill)
2. Opamps and Linear Integrated Circuits, R.A. Gayakwad, 4th Edition (Prentice Hall of India)
3. Digital Fundamentals, T. L. Floyd, 11 th Edition (Peasron)
4. Electronic Principles, A.P. Malvino, 6 th Edition (McGraw Hill)

PH 8103 : Nuclear Physics **3 1 0 4**

UNIT- I	**Basic properties of nuclei and their stability**: Nuclear Radius, Nuclear Excited states, Nuclear angular momentum, and parity, Nuclear magnetic Dipole and electric quadrupole moments, Nuclear masses and Binding Energy, Semi-empirical mass formula (Liquid drop mode & Beta(E)-stability. **Two body problem and nuclear forces**: The deuteron, experimental data, normalization of deuteron wavefunctions and its root-mean square radius, Properties of Nuclear Forces, Exchange Character of Nuclear Forces (Yukawa theory).	9 lectures
UNIT - II	**Nuclear models**: The Nuclear model (single particle)- magic Numbers, Spin-orbit coupling, consequence of shell model, predictions of magnetic-dipole and electric-quadrupole moments, angular momenta of nuclear ground-state, failures of the shell model. The collective Nuclear Model, rotational and Vibrational states.	7 lectures
UNIT-III	**Nuclear reactions**: Types of Nuclear reactions and conservation Laws, reaction dynamics and Q-equation, Cross-sections, partial wave analysis of reaction cross-sections, optical model,compound Nucleus reactions, Direct reactions, resonance reactions-Briet-Wigner formula. **Nuclear Decays:** **(i) Alpha decay:** Occurrence of D-decay, Gamow's theory, barrier penetration, decay constant for D-decay, Angular momentum and parity in D-decay . **(ii) Beta decay**: Modes of E-decay, Energy release and neutrino hypothesis, Fermi theory of E-decay, Curie Plots, comparative half-life, allowed and forbidden transitions, selection rules, parity violation in E-decay processes. **(iii) Gamma transitions**: Energetic of J-decay, excited states and decay constant, angular momentum and parity selection rules, Life-time for J-emission, internal conversion.	12 lectures
UNIT-IV	**Nuclear fission and fusion:** Fission process, characteristics of fission, energy released in fission, types of fission reactor, basic fusion process, characteristics of fusion, thermonuclear fusion, solar fusion.	6 lectures
UNIT-V	**Elementary particle physics:** Basic interactions in nature, classification of elementary particles, the eight fold way, conservation laws- Baryons, Leptons, muon numbers, strangeness and hypercharge, Gellmann-Nishijima formula, quark model.	8 lectures

Recommended Books:

1. Quarks and Leptons: An introductory course in Modern Particle Physics, F. Halzen and A. D. Martin
2. Concepts of Nuclear Physics, B.L. Cohen (McGraw Hill)
3. An Introduction to Nuclear Physics, W.N. Cottingham and D.A. Greenwood, 2nd Edition (Cambridge University Press)
4. Introductory Nuclear Physics, K.S. Krane, 3rd Edition (Wiley).

PH8104 :Condensed Matter Physics (Special Paper-I) **3 1 0 4**

UNIT-I	**Optical properties:** Transverse plasma frequency & propagation of electromagnetic wave in a material, Longitudinal plasma frequency & Plasmon, Electrostatic screening, Thomas-Fermi dielectric function, Polariton & LST relation, Polaron, Exciton, Raman effect in crystal, Kramers-Kronig relation.	12 lectures
UNIT-II	**Properties of ferroelectric materials:** Review of optical and dielectric properties of solids, Dielectric classification andproperties of representative ferroelectrics, the dipole theory of ferro-electricity, objections against the dipole theory, ionic displacements and the behavior of $BaTiO_3$ above the Curie temperature, the theory of spontaneous polarization of $BaTiO_3$,Thermodynamics of ferroelectric transitions, ferroelectric domains.	12 lectures
UNIT-III	**Magnetic properties of solids:** Quantization of orbit in a magnetic field {Landau levels}, DeHaas Van Alphen Effect, Magnetic breakdown, magnetoresistance, quantum theory of dia,paramagnetism, transition and rare-earth elements, Ferromagnetic, anti-ferromagnetic andFerri-magnetic order, molecular fields, direct and indirect exchange interaction, Heisenbergand Ising model, domain theory, Bloch wall, spin waves, magnons.	10 lectures
UNIT-IV	**Superconductivity:** Superconductivity, Meissner effect, Thermodynamics of superconducting state, London equations, coherence length, idea of BCS theory, flux quantization, Ginzberg-Landau theory, Josephson tunnelling, SQUIDs,Introduction to high temperature superconductivity.	8 lectures

Recommended Books:

1. Solid State Physics, A.J. Dekker (MacMillan)
2. Introductory Solid State Physics: H.P. Meyers and H.P. Myers, 2 nd Edition (CRC Press)
3. Introduction to Solid State Physics, C. Kittel, 8th Edition (Wiley)
4. Crystallography Applied to Solid State Physics : A.R. Verma and O.N. Srivastava (New Age)

PH 8201 :Group Theory and Applications **3 1 2 5**

UNIT- I	**Groups and their representations**: introduction, invariant subspaces and reducible representations, the Schur's lemmas, orthogonality theorem and its interpretation, characters of a representation, C_{4v}, the regular representation, symmetrized basis functions for irreducible representations, other reducible representations, direct product of representations.	12 lectures
UNIT-II	**Lie Groups and Lie algebras:** Lie groups, axial rotation groups SO(2), SO(3), Lorentz group, special unitary groups SU(2) and SU(3), generators of U(n) and SU(n), Lie algebra and representations of a Lie group.	12 lectures
UNIT-III	**Group theory in quantum mechanics:** Hilbert spaces in quantum mechanics, transformations of a function, space and time displacements, symmetry of Hamiltonian, reduction due to symmetry, matrix element theorem and selection rules, dynamical symmetry, time reversal and space inversion symmetries, atomic symmetries, irreducible tensor operators, matrix elements of tensor operators.	12 lectures
UNIT-IV	**Crystallographic and molecular symmetries:** Crystallographic point groups, translation group and space group, molecular point groups, irreducible representations of point groups,double groups,crystal field splitting of atomic levels.	10 lectures
UNIT-V	**Group theory in solid state physics:** problem of the electronic structure of crystals, translation group and reciprocal lattice, irreducible representation of a space group, free electron energy bands (one-, two-, three-dimensional lattices), energy bands of real crystals.	10 lectures

Recommended Books:

1. Elements of Group Theory for Physicists, A.W. Joshi (Wiley Eastern)
2. Chemical Applications of Group Theory, F.A. Cotton, 3 rd Edition (Wiley-Blackwell)
3. Mathematical Methods for Physicists, G. B. Arfken and H. J. Weber (Academic Press)
4. Molecular Symmetry and Group Theory, R.L. Carter, 3 rd Edition (Wiley-Blackwell)

PH 8202 : Condensed Matter Physics (Special Paper -II) **3 1 0 4**

UNIT- I	**Lattice defects:** Lattice defects and configuration entropy, the number of vacancies and interstitials as a function of temperature, formation of lattice defects in metals, interstitial diffusion in metals, self-diffusion in metals, elastic constants of metals, the interpretation of slip, dislocations: edge and screw dislocations, estimates of dislocation densities.	8 lectures
UNIT-II	**Quantum structures**: Heterojunctions, quantum confinement in one, two and three dimensions, e.g., super lattices, quantum wires and quantum dots, nanoparticles.	6 lectures
UNIT-III	**Soft condensed matter physics:** Intermolecular forces in liquids, dispersion, colloids, interaction in colloids, association colloids. **Liquid crystals**: definition, types of liquid crystals, classification of the mesophases, liquid crystals of rod like molecules (N, Ch and smectic phases).	8 lectures
UNIT-IV	**Materials preparationtechniques**: various methods of crystal growth, preparation of amorphous materials, thin film preparation (polycrystalline & amorphous), galss and glass transition, synthesis of low dimensional materials, lithography, arc discharge, thermal evaporation, sputtering, chemical vapour deposition, pulsed laser deposition, molecular beam epitaxy, electrodeposition and sol-gel technique.	8 lectures
UNIT-V	**Material characterization and instrumentation**: Material characterization :X-ray diffraction (XRD), XPS, Introduction to microscopy: advantages and disadvantages of optical microscopy over electron microscopy, scanning electron microscopy, transmission electron microscopy, scanning tunneling microscopy, atomic force microscopy, Introduction to thermal analysis: phase changes, crystalline and amorphous fractions-DSC thermo-gravimetric methods-TGA, DTA, Energy dispersive analysis: X-ray (EDX), neutron scattering and neutron diffraction, ESR and NMR, Different optical measurements: optical absorption and transmission study by UV-Vis spectrophotometer, photo-luminescence (PL), FTIR and Raman spectroscopy, electrical measurements.	12 lectures

Recommended Books:

1. Solid State Physics, A.J. Dekker (MacMillan)
2. Introductory Solid State Physics: H.P. Meyers and H.P. Myers, 2 nd Edition (CRC Press)
3. Introduction to Solid State Physics, C. Kittel, 8th Edition (Wiley)
4. Crystallography Applied to Solid State Physics : A.R. Verma and O.N. Srivastava (New Age)

PH 8001:Plasma Physics (Elective) **3 0 0 3**

UNIT- I	**Introduction:** definition and occurrence of plasma, Saha equation, concept of plasma temperature, Debye shielding, plasma applications, plasma frequency, motion of charged particle in electromagnetic field, parallel acceleration and magnetic mirror effect, plasma applications.	12 lectures
UNIT-II	**Plasma as a fluid:** equation of motion, plasma approximation, plasma oscillations, electron and ion plasma waves- their dispersion relations and properties, electromagnetic waves in plasma, plasma diffusion, and resistivity, single fluid MHD equation, plasma instability: two stream instability.	10 lectures
UNIT-III	**Kinetic theory of plasma and its applications:**Velocity distribution function, kinetic equation, Landau dumping, relation to hydrodynamics.	6 lectures
UNIT-IV	**Non-linear effects of plasma:** nonlinear phenomena in plasma, linear and non-linear waves in plasma, concept of pseudo potential (Sagdeev potential), theory of plasma sheath and its relation to nonlinear waves (soliton), Bohm sheath criteria and Mech number.	8 lectures
UNIT-V	**Plasma in controlled thermonuclear reactor:** introduction to thermonuclear fusion, magnetic confinement, tokamak, ITER.	6 lectures

Recommended Books:

1. Introduction to Plasma Physics and Controlled Fusion, Vol 1: Plasma physics, F. F. Chen (Springer)
2. Plasma Physics: Basic Theory with Fusion Applications, K. Nishikawa and M. Wakatani (Springer)
3. Fundamentals of Plasma Physics, JA Bittencourt, 3rd Edition (Springer)
4. Physics of Partially Ionised Plasmas, V. Krishan (Cambridge University Press)

PH 8002: Molecular Biophysics (Elective) **3 0 0 3**

UNIT-I	**Basic concepts:** biological polymers: nucleic acids, nucleosides and nuclestides, three dimentional DNA structure, RNA, nucleic acid conformation, proteins : primary secondary, tertiary and quaternary structures, noncovalent forces.	12 lectures
UNIT-II	**Determining protein structure:** dispersion forces, electrostatic interaction, van der Waals potentials, hydrogen bonds, entropic forces, DNA and protein folding, conformational energy, calculation, theoretical quantum chemical methods, enzyme catalysis, enzyme-controlled modifications, denaturation, replication, mutation, intercalation, neurotransmitters, membranes.	10 lectures
UNIT-III	**Functional role of DNA and protein**.: Biomolecular Recognition, Drug Design, Interaction of Proteins with other Macromolecules, Forces Stabilizing DNA and Protein Structure, Charge Transport Through DNA, Non-Linear Excitations and Their Propagation.	10 lectures
UNIT-IV	**Experimental Techniques:** Absorption and Fluorescence Spectroscopy, FTIR and UV Spectroscopy, Nuclear Magnetic Resonance, X-ray Diffraction and Molecular Structure, Atomic Force Microscopy, Molecular Dynamics, Potential Energy Contour Tracing, Photodimenrization	10 lectures

Recommended Books:

1. Biophysics, An Introduction, R. Cotterill (Wiley)
2. Principles of Protein Structure, G.E. Schulz & R.H. Shirmer (Springer)
3. Essentials of Biophysics, P. Narayanan (New Age International)
4. Fundamental Techniques of Biophysics and Molecular Biology, P. Kumar (Path Finder)

PH 8003: Laser Physics (Elective**)** **3 0 0 3**

UNIT-I	**Basic concepts:** Laser idea, characteristic properties of lasers, idea of negative temperature and population inversion, amplification in the medium, line broadening mechanism, homogeneous and inhomogeneous line broadening, inhomogeneously broadened transitions, hole burning, optical pumping, efficiency of pumping, rate of pumping, electrical pumping.	14 lectures
UNIT-II	**Basic principle and laser types:** laser threshold conditions, rate equations for three level lasers and four level lasers, continuous wave laser behavior, pumping power requirements, output power from three level and four level lasers for steady state operation, Ruby laser, Argon ion laser, Nd-YAG lasers, diode lasers, CO_2 laser, dye lasers.	12 lectures
UNIT-III	**Nonlinear processes:** Propagation of electromagnetic waves in nonlinear medium, self focusing, phase matching condition, fibre lasers, stimulated Raman scattering and Raman lasers, CARS.	8 lectures
UNIT-IV	**Laser applications:** Cooling and trapping of atoms, evaporative cooling and Bose-Einstein condensation, SERS, TERS, Spectroscopy in nanomaterials and biomolecules.	8 lectures

Recommended Books:

1. Principles of Lasers, O. Svelto, 4th Edition (Plenum Press)
2. Laser Cooling and Trapping, H.J. Metcalf and P. Straten (Springer)
3. Lasers and Nonlinear Optics, B.B Laud (Wiley)
4. Laser Physics, P. W. Milonni and J. H. Eberly (Wiley-Backwell)

PH 8004 : Liquid Crystals (Elective**)** **3 0 0 3**

UNIT-I	**Liquid Crystals:** definition, classification of the mesophases: liquid crystals of rod like molecules (N, Ch and Smectic phases), liquid crystals of disk like molecules, polymer liquid crystals, polymer dispersed liquid crystals, ferroelectric liquid crystals, lyotropic liquid crystals, polymorphism in thermotropic liquid crystals.	12 lectures
UNIT-II	**Statistical theories of nematic order:** definition of long range orientation order parameter, Maier-Saupe theory and its applications, the mean field approximation, evaluation of the order parameter.	6 lectures

UNIT-III	**Liquid crystal models:** Short range order effects in isotropic phase, the Landau – de Gennes model, Leboh1-Lasher model, magnetic and electric birefringence, extension of Maier- Saupe theory to semectic A : McMillan's model, continuum theory of smectic A.	10 lectures
UNIT-IV	**Thermal properties of liquid crystals:** Isotropic-nematic and nematic- smectic A phase transitions, structural studies of liquid crystals using X-ray diffraction, electrical properties.	6 lectures
UNIT-V	**Applications of liquid crystals:** nematics, cholesterics, ferroelectric liquid crystals, polymeric liquid crystals and polymer dispersed liquid crystals, introduction to liquid crystal displays: twisted nematic display device.	8 lectures

Recommended Books:

1. Liquid Crystals, S. Chandrasekhar, 2nd Edition (Cambridge University Press)
2. The Physics of Liquid Crystals, P. G. de Gennes and J. Prost, 2nd Edition (Clarendon Press)
3. Liquid Crystals and Polymers, G. D. Arora (Swarup & Sons)
4. The Molecular Dynamics of Liquid Crystals, Edited by G. R. Luckhurst and C.A. Veracini (Kluwer Academic)

PH 8005 :Basic Vacuum Science & Cryogenic (Elective) **3 0 0 3**

UNIT-I	**Vacuum Science:** Basics of vacuum science, Different types of pumps: rotary, diffusion, ion,turbo molecular and cryogenic pumps, Application of vacuum in research and Industry.	10 lectures
UNIT-II	**Measurement of Vacuum**: Classification of gauges, Vacuum gauges: McLeod, pirant,penning, hot cathode Ionization gauge.	12 lectures
UNIT-III	**Low Temperature Physics:** Production of low temperature, Liquefaction of nitrogen andHelium, Cryogenic storage and insulation, design of cryostat, Safety considerations.	10 lectures
UNIT-IV	**Cryogenic thermometry**: Gas and vapour pressure thermometers, thermocouple, resistance,and semiconductor diode and capacitance thermometers.	10 lectures

Recommended Books:

1. G.K. White; Experimental techniques in Low temperature physics
2. Ramdall F. Barron; Cryogenic systems
3. V.V. Rao, T.B. Ghosh and K.L. Chopra ; Vacuum Science & Technology

PH8006 : Particle Physics (Elective) **3 0 0 3**

UNIT-I	**Introduction:** Classification of elementary particles,photon, anti-particles, neutrinos, strange particles, the eightfold way classification, Gellman-Nishijima formula, properties and types of quarks, the quark model, the standard model.	10 lectures
UNIT-II	**Elementary particle dynamics:** the four fundamental forces, quantum electrodynamics, quantum chromodynamics, asymptotic freedom, weak interactions, decays and conservation laws.	10 lectures
UNIT-III	**Symmetries:** Groups and conservation laws, spin and orbital angular momentum, addition of angular momenta, spin ½, parity, charge conjugation, CP violation, time reversal and CPT theorem.	12 lectures
UNIT-IV	**Electrodynamics of quarks and hadrons:** electron-quark interactions, hadron production in e^+e^- scattering, elastic and inelastic electron-proton scattering, parton and Bjorken scaling, quark distribution functions.	10 lectures

Recommended Books:

1. Introduction to Elementary Particles, D. Griffiths (Wiley India)
2. Quarks and Leptons: An Introductory Course in Modern Particle Physics, F. Halzen and A. D. Martin (W iley India)
3. An Introduction to Quarks and Partons, F. E. Close (Academic Press)

M.Sc. (Physics) Practicals

FIRST SEMESTER:

PH7151: General Physics Laboratory I **0 – 0 – 6 – 3**

1. To measure the magnetic field for circular conductor loop.
2. To verify the existence of discrete atomic energy levels and to evaluate the quantum of energy transfer from electron beam to atoms by Frank Hertz experiment.
3. To find the value of Planks constant (h) using a photo cell.
4. To determine the electronic charge by using rectifier equation in case point contact Germanium rectifier.
5. To analyze waves (Square, Triangular, clipped sine wave) using Fourier analysis kit.
6. Determine Boltzmann constant by P–N junction diode and hence find the value of η of LED.
7. Determination of stopping potential of the material of photo cell & determination of maximum kinetic energy of the photoelectron.
8. Study the elastic and plastic extension of material wires.

PH7152: Computer Laboratory **0 – 0 – 6 – 3**

1. To find the roots of an equation using Bisection method.
2. To find the roots (or Zeros) of a real valued function using Newton – Raphson method.
3. To find the least square linear regression of data.
4. To find the numerical approximation of definite integrals using Simpson's rule.
5. To find the approximate solutions of ordinary differential equations using Runge – Kutta method.
6. To solve a system of linear equation using Gauss elimination method and inverse matrix method.

SECOND SEMESTER:

PH7251: General Physics Laboratory II **0 – 0 – 6 – 3**

1. To determine the Stefan's constant using Stefan's constant kit.
2. Determination of photo conductivity.
3. Determination of capacitance.
4. Determination of Rydberg constant for hydrogen.
5. Determination of refractive index by Abbe refractometer.
6. Verification of de Broglie wave.
7. To Study the Zeeman effect.

PH7252: Condensed Matter Physics Laboratory **0 – 0 – 9– 5**

1. Determination of g factor by ESR.
2. Determination of specific heat capacity of solid (Ag,Al).
3. Determination of energy band gap of semiconductor.
4. Study of Hysteresis loss of given sample.
5. Study of lattice parameters.
6. Determination of specific heat capacity of solid (Ag,Cu).
7. Study of Hall Effect.
8. Determination of Curie temperature of given sample during cooling.
9. Determination of Curie temperature of given sample during heating.

THIRD SEMESTER:

PH8151: Nuclear Physics Laboratory **0 – 0 – 6 – 3**

1. Study of characteristics of GM tube and determination of its operating voltage, platue length and slope.
2. Verification of inverse square law using J rays.
3. Estimation of efficiency of GM tube.
4. Determination of short half life.
5. Determination of linear absorption co-efficient (μ) and the mass absorption co-efficient of the absorbing materials.

6. Study of energy resolution characteristics of scintillation spectrometer as a function of applied voltage and determination of best operating voltage.
7. Study of Cs-137 spectrum and calculation of FWHM and resolution of given scintillation detector.
8. Study of Co-60 spectrum and calculation of resolution of detector in terms of energy.
9. Energy calibration of J rays spectrum (study of linearity).

Optics Laboratory

1. Determination of wave length of LASER light by Michelson interferometer.
2. Determination of wave length of light by Febry Perot interferometer.
3. Determination of wave length of sodium light by Michelson interferometer.
4. Determination refractive index of transparent slice by interference method.
5. Line Spacing of gating by Bragg's diffraction condition.
6. Wave length of light used by single/double slit diffraction method.

PH8152: Electronics Laboratory **0 – 0 – 9– 5**

1. Design and verification of half and full wave rectifier with and without filters.
2. Design and verification of diode clipping circuits both biased and unbiased.
3. Design and verification of clamping circuit with and without reference.
4. Design and verification of astable and bistable multivibrators.
5. Design and verification of adder circuit using OP-AMP.
6. Design and verification of subtractor circuit using OP-AMP.
7. Design and verification of differentiator circuit using OP-AMP.
8. Design and verification of integrator circuit using OP-AMP.
9. Design and verification of AND, OR and NOT gate using universal gate.
10. Design and verification of Half adder logic circuit.
11. Design and verification half subtractor logic circuit.
12. Design and verification of SR flip flop.
13. Design and verification of clocked SR flip flop.
14. Design and verification of edge triggered JK flip flop.
15. Design and verification of shift register using JK flip flop.
16. Design and verification of 8 MOD counter.

FOURTH SEMESTER:

PH 825* Special Paper Laboratory **0 – 0 – 6 – 3**

1. Determination of ultrasonic velocity by ultrasonic interferometer.
2. Determination of g factor by ESR.
3. Determination of thermal conductivity of aluminum.
4. Study of Hall effect.
5. Study of dielectric constant.
6. Determination of thermal conductivity.
7. Verification of susceptibility of given liquid.
8. Study of thermo luminescence of alkali halide crystals.

Ph.D. Physics

COURSE STRUCTURE

S. No.	COURSE CODE	COURSE TITLE	L	T	P	Cr
1	PH9001	Research Methodology in Physics	3	0	0	3
2	PH9002	Lasers, Instrumentation and Applications	3	0	0	3
3	PH9003	Group Theory, Spectroscopy and Diffraction Method	3	0	0	3
4	PH9004	Luminescent Materials and Their Applications	3	0	0	3
5	PH9005	Lie Algebraic Techniques in Physics	3	0	0	3
6	PH9006	Climate Physics	3	0	0	3
7	PH9007	Plasma Physics	3	0	0	3
8	PH9008	Modern Applications of Spectroscopy	3	0	0	3
9	PH9009	Microwave Electronics and Antenna Theory	3	0	0	3

Note: Total credits earned for the Ph.D. course work will be as per academic bye laws. Research Methodology is a compulsory course for Ph. D. course work.

PH9001 : Research Methodology in Physics

(Pre-PhD course work compulsory paper) **3 0 0 3**

UNIT-I	**Definition of the problem:** identifying and formulating the problem, techniques involved in solving problem: (a) exact analytical solutions of equations involved, (b) numerically solving equations, (c) simulating the problem on a computer, Monte Carlo or molecular dynamics approach, (d) experimental observations and theoretical modeling.	10 lectures
UNIT-II	**Research design and ethics**: review of research literature, purpose and use of literature review, locating relevant information, uses of library and electronic databases, identification of gaps in reasearch, formulation of research problem, definition of research objective, preparation and presentation of literature review, theoretical models and frame work, scientific ethics, copyrights and plagiarism.	10 lectures
UNIT-III	**Analyzing data:** errors and analysis of errors, introductory probability and stochastic processes, descriptive statistics and correlations.	8 lectures
UNIT-IV	**Using computers in research:** Handling different operating systems, (a)literature survey using web, handling search engines, (b) computer usage for collecting/analyzing data, simulations using Fortran/ C++/Mathematica/Matlab/Molden, (c) preparation of research articles, thesis and presentation, research papers: using word processing software-MS Word/Latex/others, drawing graphs and diagrams-Origin/Statistica/Excel/others, seminar presentations-Power point or oral and poster presentations.	14 lectures

Recommended Books:

1. How to Write and Publish, R. A. Day and B. Gastel (Cambridge University Press)
2. Probability and Statistics for Engineers and Scientists, S. Ross (Academic Press)
3. Research Methodology: Methods and Techniques, C. R. Kothari (Vishwa Prakashan)
4. Data Reduction and Error Analysis for Physical Sciences, P.R. Bevington and D.K. Robinson (http://www.physast.uga.edu/files/phys3330_fertig/BasicErrorAnalysis.pdf)

PH9002 : Lasers, Instrumentation and Applications

(Pre-PhD course work optional paper) **3 0 0 3**

UNIT-I	**Different lasers: Principle** and working of CO2 laser and qualitative description of longitudinal and TE laser systems, threshold condition for oscillation in semiconductor laser, semiconductor lasers, diode laser, p-n-junction laser, GaAs laser, Nd-YAG lasers, principle and working of dye laser, free electron laser.	8 lectures
UNIT-II	**Nonlinear processes:** wave propagation in an anisotropic crystal, polarization response of materials to light, harmonic generation, second harmonic generation, sum and difference frequency generation, phase matching, third harmonic generation, bistability, self focusing, fiber lasers, stimulated Raman scattering, CARS.	8 lectures
UNIT-III	**Novel applications of laser:** cooling and trapping of atoms, principles of Doppler and polarization gradient cooling, qualitative description of ion traps, optical traps and magneto-optical traps, evaporative cooling and Bose-Einstein condensation.	8 lectures
UNIT-IV	**Detectors and spectroscopic techniques:** grating spectrographs and spectrometers based on Czerry-Turner and Ebert mountings, thermal detector, photodiode, photomultiplier tube, channel electron multiplier, charge coupled detector, principle and working of a double beam infrared spectrophotometer, Raman spectrometer, principle and working of Fourier transform spectrometers.	10 lectures
UNIT-V	**Relaxation in liquids-theory and experiment:**introduction, Langevin equation, Fokker-Plank equation, Smoluchowski equation, Raman line shape measurement, ultrafast chemical reactions, single molecule spectroscopy, phase relaxation.	8 lectures

Recommended Books:

1. Laser spectroscopy: Basic Concepts and Instrumentation, W. Demtroder, 3rd Edition (Springer)
2. Principles of Lasers, O. Svelto, 4th Edition (Plenum Press)
3. Laser Cooling and Trapping, P. N. Ghosh
4. Molecular Relaxation in Liquids, B. Bagchi (Oxford University Press)

PH9003: Group Theory, Spectroscopy and Diffraction Method

(Pre-PhD course work optional paper) **3 0 0 3**

UNIT-I	**Symmetry:**Group, symmetry elements, symmetry operations and their matrix representations, point groups and character tables.	10 lectures
UNIT-II	**Vibrational spectroscopy and character tables:** normal modes of vibrations, infrared and Raman spectroscopy, selections rules.	6 lectures
(**UNIT-III**	**Molecular orbital theory and character tables:** molecular orbital theory background, polyatomic molecules, transition metal complexes and ligand field splitting.	8 lectures
UNIT-IV	**Electronic spectroscopy:** interpretation, group theory applications and transition moment integral, hot bands.	6 lectures
UNIT-V	**Crystallography and groups:** crystallographic space groups, crystallographic point groups, point group theorem, crystallographic restriction theorem.	6 lectures
UNIT-VI	**Crystallography and diffraction:** diffraction techniques, X-ray diffraction patterns, indexing pattern, data collection and data analysis.	6 lectures

Recommended Books:

1. Symmetry and Spectroscopy, D.C. Harris and M.D. Bertolucci (Dover)
2. Chemical Applications of Group Theory, 3rd Edition, F.A. Cotton (Wiley-Blackwell)
3. Introduction to Crystallography, D.E. Sands (Dover)
4. X-ray Strucure Determination: A Practical Guide, G. H. Stout and L.H. Jensen (Wiley)

PH9004: Luminescent Materials and Their Applications

(Pre-PhD course work optional paper) **3 0 0 3**

UNIT-I	**General Aspects:** Luminescence and its simple explanation, difference between thermal and luminescence emission, positive, negative, secondary and non-radiative luminescence, rate and duration of luminescence, Stoke's rules and luminescence yield.	8 lectures
UNIT-II	**Types of luminescence:** classification of luminescence on the basis of (i) time dependence of emission: phosphorescence and fluorescence (ii) nature of exciting energy source: photoluminescence, cathodoluminescence and thermoluminescence.	8 lectures
UNIT-III	**Theory of luminescence:** band theory and configuration coordinate models, Randal and William's theory for derivation of the phosphorescence and thermoluminescence intensity equations.	7 lectures
UNIT-IV	**Lumiscent materials:** explanation of terms-activator, self activator, role of impurity in luminescent materials and preparation of pure and impurity activated materials in amorphous, crystalline and pellet forms. Instrumentation and techniques involved in measurement of luminescent, recording of fluorescence, phosphorescence and thermoluminescence emission.	11 lectures
UNIT-V	**Physical and chemical effects on luminescence:** effects of thermal, mechanical, impurity, radiation aspects of luminescence, applications of luminescence in various fields.	8 lectures

Recommended Books:

1. Luminescence in Crystals (translated), E.G. Garlie (Wiley)
2. Theory of Luminescence, B.F. Steponov and V.P. Gribkovskii (Springer)
3. Luminescence of Inorganic Solids, P. Goldberg (Academic Press)
4. National Symposium on TL and its application – Published report BARC 1975.

PH9005: Lie Algebraic Techniques in Physics

(Pre-PhD course work optional paper) **3 0 0 3**

UNIT-I	**Lie algebras:** basic concepts, Lie superalgebras, direct sum, ideals, semi-simple Lie algebras, semi-direct sum, Killing form, compact and noncompact algebras, derivations, nilpotent algebras, invariant operators, structure of Lie algebras, Cartan-Weyl form, root vectors, Dynkin diagrams, isomorphism, enveloping algebras.	10 lectures
UNIT-II	**Irreducible representations:** abstract characterization, irreducible tensors, contractions, tensor representations, fundamental representations of unitary algebras, isomorphisms of spinor algebras, dimensions of representations, action of Lie algebra, tensor products, non-canonical chains.	10 lectures
UNIT-III	**Casimir and tensor operators:** Casimir operators of Lie algebras and extended Lie algebras, complete set of commuting operators, eigenvalues of Casimir operators, coupling and recoupling coefficients, Wigner-Eckart theorem, nested algebras, Racah's factorization lemmas, adjoint operators, coupled tensor operators, reduction formula.	12 lectures
UNIT-IV	**Realizations of Lie algebras:** boson realization, fermion realization, differential realization, matrix realization, spectrum generating algebras, dynamic symmetries, degeneracy algebras, dynamical algebras.	10 lectures

Recommended Books:

1. Lie Algebras and Applications, F. Iachello (Springer)
2. Lie Algebras, N. Jacobson (Dover)
3. Lie Groups and Lie Algebras, A. Das and S. Okubo (Hindustan Books)
4. Algebraic Theory of Molecules, F. Iachello and R.D. Levine (Oxford University Press)

PH9006: Climate Physics

(pre-PhD course work optional paper) **3 0 0 3**

UNIT-I	**Radiative transfer:** spectra of short and long wave radiations, description of radiative transfer, equation of radiative transfer, absorption characteristics of gases, radiative transfer in a plane parallel atmosphere, thermal equilibrium, thermal relaxation, greenhouse effect.	8 lectures
UNIT-II	**Aerosols and clouds:** aerosol morphology, microphysics and macrophysics of clouds, radiative transfer in aerosols and clouds, roles of clouds and aerosols in climate.	8 lectures
UNIT-III	**Atmospheric motion:** geostrophic equilibrium, vertical shear of geostrophic wind, frictional geostrophic motion, curvilinear motion, weakly divergent motion.	8 lectures
UNIT-IV	**Wave propagation:** description of wave propagation, acoustic waves, buoyancy waves, Lamb wave, Rossby wave, wave absorption, nonlinear consideration.	8 lectures
UNIT-V	**General circulation:** forms of atmospheric energy, heat transfer in a zonally symmetric circulation, heat transfer in a laboratory analogue, quasi-permanent features, fluctuations of the circulation.	8 lectures
UNIT-VI	**Influence of ocean:** composition and structure, role in heat budget, role in carbon cycle, wind driven circulation, buoyancy driven circulation, inter-annual changes.	6 lectures

Recommended Books:

1. Physics of Atmoshere and Climate, M.L. Salby, 2nd Edition (Cambridge University Press)
2. An Introduction to Atmospheric Thermodynamics, A. A. Tsonis, 2 nd Edition(Cambridge University Press)
3. Elementary Climate Physics, F.W. Taylor (Oxford University Press)
4. Fundamentals ofAtmospheric Physics, M. L. Salby, Vol. 61 (International Geophysics), Ist Ed., academic Press, 1996.

PH 9007: Plasma Physics

(pre-PhD course work optional paper) **3 0 0 3**

UNIT-I	**Introduction:** Plasma-definition, Concept of Plasma Temperature, Debye shielding, plasma frequency, motion of charged particle in electromagnetic field, parallel acceleration and magnetic mirror effect, plasma applications.	10 lectures
UNIT-II	**Plasma as a fluid:** Fluid equation of motion, fluid drifts, plasma approximation, Plasma oscillations, Electron and ion plasma waves- their dispersion relations and properties, electromagnetic waves in plasma, Hydromagnetic waves, plasma diffusion and resistivity, single fluid MHD equation, concept of plasma E, plasma instability: two-stream instability, Rayleigh-Taylor instability.	12 lectures
UNIT-III	**Kinetic theory of plasma and its application:** Velocity Distribution function, Vlasov equationand Folker –Plank equation, Landau damping, BGK modes.	6 lectures
UNIT-IV	**Nonlinear Effects in plasma:** Nonlinear phenomena in plasma, Linear and non-linear waves in plasma , Introduction to Reductive Perturbation Method of Nonlinear Plasma Wave, concept of Pseudo Potential (Sagdeev Potential), Theory of Plasma Sheath and its relation to Nonlinear Waves (Soliton). Bohm sheath criteria and Mech number.	8 lectures
UNIT-V	**Plasma in controlled thermonuclear rector:** Introduction to controlled thermonuclear fusion, magnetic confinement; Tokamak, ITER.	4 lectures
UNIT-VI	**Plasma Simulation:** Fluid simulation and kinetic simulation, Basics of PIC, Vlasov and MD simulation.	2 lectures

Recommended Books:

1. Francis F Chen; Introduction to plasma physics and controlled fusion vol. I.
2. K. Nishikawa; Plasma physics basic theory with fusion applications.
3. J. A. Bittencourt; Fundamentals of plasma physics.

PH-9008: MODERN APPLICATIONS OF SPECTROSCOPY

(pre-PhD course work optional paper) **3 0 0 3**

UNIT-I	**GROUP THEORY AND ITS APPLICATION TO SPECTROSCOPY :** Symmetry elements, symmetry operations and groups, Molecular point groups, Character table for point groups, Selection Rules, Properties of Irreducible representation, Polarised, Raman spectra , IR and Raman activity.	8 lectures
UNIT 2 :	**ANALYSIS OF MOLECULAR VIBRATIONS :** Molecular vibrations, Normal modes of vibrations, Vibrational energy, Force field, Different types of force fields, Force constants, Secular equations, Evaluation of force constants, important molecular constants and theirdetermination.	8 lectures
UNIT 3 :	**ULTRAVIOLET - SPECTROSCOPY :** UV and visible spectroscopy, Transition of organic molecules, Colour and light absorption, theory of electronic spectroscopy , Bathochromic effect , Instrumentation and sampling, Choice of solvent, Applications , Qualitative and Quantitative Analysis.	8 lectures
UNIT 4 :	**IR AND RAMAN SPECTROSCOPY :** Theory of IR spectroscopy , IR spectrometers , Sample Handling Techniques ,Applications of IR Spectroscopy. Raman activity , Use of Lasers in spectroscopy, Theory, Raman intensities and bondpolarizability , Applications to organic, Inorganic and Physical chemistry.	9 lectures
UNIT 5 :	**APPLICATIONS OF SPECTROSCOPY :** Recording and analysis of IR and Raman spectra of complicated molecules, groupfrequencies , intensities of Raman and IR bands, structure determination , Pharmaceuticalapplications ,biosensors-SERS-TERS, Raman in nanomaterials and biomolecules.	9 lectures

Recommended Books:

1. Raman, K.V. 1998. Group theory and its applications to Chemistry. Tata McGraw Hill Co., New Delhi.
2. Colthup, N.B., Daly, L.V. and Wiberly, 1975. Introduction to IR and RamanSpectroscopy. Academic Pres s, New York.
3. Silverstein Bassler and Morrill 1900. Spectroscopic Identification of OrganicCompounds. John-Wiley.
4. A. Tiwari, Anthony P. F. Turner , 2014 , Biosensors Nanotechnology, S. publishing LLC & **Wiley.**

PH 9009: Microwave Electronics and Antenna Theory

(pre-PhD course work optional paper) **3 0 0 3**

UNIT-I	Transmission lines, smith chart, waveguides, rectangular cavity, modes in waveguides and cavities, dielectric filled wave guides, dielectric slab guide, modal expansion of fields and its applications.	8 lectures
UNIT II:	Microwave transistor, microwave tunnel diode, varactor diode, Schottky diode, Microwave generation and amplification, avalanche effect devices: Gunn diode, klystron, reflex klystron: power output and efficiency; traveling wave tubes, magnetron.	6 lectures
UNIT III:	Attenuators, phase shifters, matched loads, detectors and mounts, slotted-sections, E-plane tee, H-plane tee, hybrid tees, directional couplers, tuners, circulators and isolators. Signal generators: fixed frequency, sweep frequency and synthesized frequency oscillators; frequency meters, VSWR meters, measurements of frequency, attenuation, VSWR and impedance.	8 lectures
UNIT IV:	Dipole, monopole, microstrip, wire, loop and helix antennas, aperture antenna-slot, waveguide and horn antenna; parabolic reflector antenna. Antenna characteristics: radiation patterns, directive gain, side lobe, back lobe, polarization, co-polarization and cross polarization level, frequency range, beam width, input impedance, bandwidth, efficiency. Microstrip antenna: Different substrate materials, rectangular and circular patch, feed for microstrip antennas: probe feed, microstrip line feed, aperture feed, electromagnetically fed microstrip patch.	14 lectures
UNIT V:	Microwave integrated circuits: different planar transmission lines, characteristics of microwave integrated circuits.	6 lectures

Recommended Books:

1. Rizzi, P.A., Microwave Engineering, (Prentice-Hall, 1999)
2. Griffiths, D. J., Introduction to Electrodynamics, (Prentice-Hall, 2009)
3. Jackson, J. D., Classical Electrodynamics, 3rd edition, (John Wiley & Sons, 1998)
4. Pozar, D. M., Microwave Engineering, 3rd edition(Wiley India Pvt. Ltd, 2009)
5. Liao, S. Y., Microwave Devices and Circuits, 3rd edition(Princeton Hall, 2000)
6. Collin, R. E, Foundations for Microwave Engineering, (McGraw-Hill, 1992)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY

SYLLABI
OF
PG / Ph. D. COURSES
(DEPARTMENT OF FORESTRY)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY

(UNDER THE MINISTRY OF EDUCATION, GOVT. OF INDIA)

DEEMED TO BE UNIVERSITY U/S 3 OF THE UGC ACT, 1956

NIRJULI - 791 109 :: ARUNACHAL PRADESH

SYLLABI
OF
PG/ Ph. D COURSES

(DEPARTMENT OF FORESTRY)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY (NERIST)
(Deemed to be University, U/S 3 Of the UGC Act, 1956)
Nirjuli (Itanagar), Arunachal Pradesh- 791 109

M. Sc. (Forestry) COURSE STRUCTURE

Semester	Course code	Course title	Credits L T P T
I semester			
	FR 7101	Forest Systematics and Ethnobiology	3-0-2 =4
	FR 7102	Forest Ecology & Biodiversity Conservation	3-0-2 =4
	FR 7103	Forest Protection	2-0-2 =3
	FR 7104	Forest Tree Improvement	3-0-0 =3
	FR 7105	Forest Biotechnology	3-0-2 =4
	MA 7109	Biostatistics	3-1-0 =4
			22
II semester			
	FR 7201	Silviculture	3-0-0 =3
	FR 7202	Plantation Forestry	3-0-0 =3
	FR 7203	Forest Policies and Instruments	3-0-0 =3
	FR 7204	Social Forestry and Agroforestry	3-0-0 =3
	FR 7205	Wildlife Conservation and Ecotourism	4-0-0 =4
	AE 7223	Forest Hydrology and Watershed Management	2-1-0 =3
			19
III semester			
	FR 8101	Wood Science & Technology	3-0-2 =4
	FR 8102	Forest Goods & Services	3-0-2 =4
	FR 8103	Forest Geo-informatics	3-0-2 =4
	FR 8104	Forest Resource Management	3-0-0 =3
	FR 8105	Forest Seed Technology	2-0-2 =3
	FR ------	Elective	3-0-0 =3
			21
IV semester			
	FR 8299	Project	0-0-16=8
			8

Note: Field visit to protected areas, forest based industries, community forest sites, sacred groves, technology demonstration sites and forest based systems would be part of the curriculum in all the semester.

AUDIT COURSES FOR B.Sc. Agriculture and Horticulture STUDENTS ONLY

I Semester

FR-7177 Forest Science – I 3 0 0 =3

II Semester

FR-7277 Forest Science –II 3 0 0 =3

List of Electives for M. Sc. III Semester		
FR-8001	Global Climate Change	3-0-0=3
FR-8002	Economics of Agroforestry System	3-0-0=3
FR-8003	Forest Genetic Diversity and Conservation	3-0-0=3
FR-8004	Rangeland and Pasture Management	3-0-0=3

Ph.D.(Forestry) COURSE STRUCTURE

Semester	Course code	Course title	Credits L T P T
	FR 9001	Concept of Forestry	3-0-0 =3
	FR 9002	Climate Change and Forestry	3-0-0 =3
	FR 9003	Timber & Non-TimberForest Products	3-0-0 =3
	FR 9004	Wildlife Management	3-0-0 =3
	FR 9005	Applied Microbiology	3-0-0 =3
	FR 9006	Agroforestry	3-0-0 =3
	FR 9007	Nursery and Plantation Technology	3-0-0 =3
	FR 9008	Forest Ecology and Management	3-0-0 =3
	FR 9009	Remote Sensing and GIS in Forestry	3-0-0 =3
	FR 9010	Wood Technology	3-0-0 =3
	FR 9011	Principles & Techniques in Biotechnology	3-0-0 =3
	FR 9012	Research Methodology	4-0-0 =4

Department: Forestry

Programme - M.Sc. SEMESTER- I

FR 7101 Forest Systematics and Ethnobiology **3-0-2=4**

Unit I	Principles of Systematics (taxonomy), Systems of classifications; Post Darwinian systematics; Concept of species and genera; Modern trends in Taxonomy, Biosystematics & Numerical Taxonomy; Phenetic, Cladistic, Omega and Alpha taxonomy; Role of taxonomy in management and conservation of forest.	9-Lectures
Unit II	Concept of characters; Botanical keys, their use and construction; Principles of plant nomenclature; Concept of ICBN (Melbourne Code 2011); Typification; Principle of Priority; Valid publication, Naming of new taxon; Taxonomic literature: Classical literatures, Icons, Flora, Revision and Monograph, Taxonomic research in India, Botanical survey of India, Herbaria of India and abroad.	9-Lectures
Unit III	Characterization and Economic importance of selected order and Families of Dicots and Monocots I: Ranales (Magnoliaceae & Annonaceae), Guttiferales (Clusiaceae & Dipterocarpaceae), Malvales (Malvaceae & Sterculiaceae), Ruttales (Rutaceae & Meliaceae), Rosales (Rosaceae & Leguminosae)	8-Lectures
Unit IV	Characterization and Economic importance of selected order and Families of Dicots and Monocots II: Myrtales (Combretaceae & Myrtaceae), Rubiales (Rubiaceae), Verbenales (Verbenaceae), Asterales (Asteraceae), Unisexuales (Euphorbiaceae & Moraceae), Orchidales (Orchidaceae), Palmales (Arecaceae), Poales (Poaceae)	8-Lectures
Unit V	Scope, objectives and methodologies of ethnobiology (Ethnobotany and Ethnozoology); Ethnobotany in relation to health care and drug discovery (Ethnomedicine & Ethnopharmacology), Contribution of wildlife products to human welfare; Hunting of wildlife; Importance and prospects of Ethnobiological studies in North Eastern India.	8-Lectures

Practicals:

1. Plant collection and Herbarium Technique.
2. Survey, collection and identification of tree flora Phytography (description of plants) and identification of the family, genus and species with the help of Taxonomic literature (Flora etc.).
3. Preparation and submission of minimum twenty herbarium specimens.
4. Preparation of field note book pertinent to floristic study.
5. Methods and field practices of Ethnobotany and ethnozoology.
6. Collection and preservation of traditionally used dead biological samples.

Suggested Readings:

1. A Text Book of Forest Taxonomy, MP Singh, MP Nayar& RP Ray, Amol Publication, New Delhi, 1994.
2. An Introduction to Plant Taxonomy, C.Jeffery, Cambridge University Press, Cambridge, 1982.
3. Plant Taxonomy – O.P. Sharma, Tata Mac Graw Hill, New Delhi, 1993.
4. Taxonomy of Angiosperms Nair R. Publisher: Aph Publishing Corporation. 2010
5 Plant Taxonomy: Advances and Relevance, 1st Edition: A. K. Pandey, et al. CBS Publisher; 2010
6. Plant Taxonomy and Biosystematics, C. A. Stace, Edward Arnold, London, 1989.
7. Introduction to the Principle of Taxonomy, V.V. Sivarajan, edited by N. K. P. Robson, Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, Calcutta.
8. Ethnobotany-Gary J. Martyn,Chapman& Hall, London,1995.
9. Methods and Approaches in Ethnobotany – SK Jain (Ed). SEB, Lucknow.

FR 7102 Forest Ecology & Biodiversity Conservation **3-0-2=4**

Unit I	Forest ecology, Major forest types of the world, India & Northeast India; Forest ecosystem structure and function; Forest Productivity and Ecosystem energetics; Litter production and decomposition,	9-Lectures
Unit II	Biogeochemical cycling; Nutrient conservation strategies; Disturbance in forest ecosystems; Forest succession and Mechanisms of succession; Disturbance and diversity; Fragmentation and Heterogeneity; Ecosystem management.	9-Lectures

Unit III	Biodiversity-levels, estimation and inventory; Importance of biodiversity; Planning, survey, monitoring and sampling strategies in biodiversity assessment; Gap analysis; Biodiversity hotspots; Extinction of species; Threat to biodiversity; Climate change and biodiversity; IUCN threatened category; *Ex situ* and *In situ* conservation techniques; Population viability analysis and minimum viable population size.	8-Lectures
Unit IV	Conservation of forest biodiversity; concept of matrix in conservation; Conservation genetics; Conservation of medicinal plants in the tropics; National Biodiversity Authority; Conservation at species, habitat and landscape levels; Species conservation projects in India; International organizations for biodiversity conservation; Intellectual property rights.	8-Lectures
Unit V	Convention on biodiversity; Biodiversity act of India; Role of institutions and policy making in conservation; Community involvement and biodiversity conservation; International conservation laws, Valuation of biodiversity and conservation economics.	8-Lectures

Practicals :

1. Study of forest community structure and its successional status
2. Estimation of productivity of forest ecosystem, Methods of vegetation analysis.
3. Measurement of biomass and productivity.
4. Quantification of litter production and decomposition.
5. Biodiversity survey, inventory and monitoring.
6. Field visits to natural forest reserves, national parks, wildlife sanctuaries, botanical gardens and arboreta.

Suggested Readings:

1. Forest Ecology: A foundation for sustainable management, 2nd Edition, Kimmins, J. P. (1996), Prentice Hall Press.
2. Forest Ecosystems 2nd Edition, Perry D. A., Oren R. and Hart S. C. (2008) The John Hopkins University Press, Baltimore.
3. Ecology, Environment and Resource Conservation, Singh J. S., Singh S. P. and Gupta S. R. (2006), Ana maya Publications, New Delhi.
4. Conservation Biology, Dyke, F. V. (2008), Springer Science, USA.
5. Fundamentals of Conservation Biology 3rd Edition, HunterJr, M.L. and Gibbs, J.P. (2007), Blackwell Publishing Ltd.
6. Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach, David B. Lindenmayer, D.B. and Franklin, J.F. (2013), Island Press, USA.
7. Principles of Conservation Biology, 3rd Edition, Groom, M.J., Meffe,G.K. and Carroll, C.R. (2005), Sinauer Associations, Inc., Massachusetts.
8. Handbook of Biodiversity Methods: Survey, Evaluation and Monitoring, Hill,D., Fasham, M., Tucker, G. , Shewry, M. and Shaw, P. (2005), Cambridge University Press, New York.
9. Biological diversity-The coexistence of species on changing landscape, Huston, M. A. (1994), Cambridge University Press.
10. Introduction to Conservation Genetics, Frankham, R., Ballou, J.D. and Briscoe, D.A. (2002), Cambridge University Press.

FR 7103 Forest Protection **2-0-2 = 3**

Unit I	Introduction, Need and Importance of forest protection, Factors affecting forest health, Role of forest pathology and entomology in forest protection, Types of parasitism; Fungi in forest community, Symptoms caused by pathogens and insects, Principles of disease/insect control, Strategies for integrated pest and disease management, Invasive alien species and their management.	5-Lectures

Unit II	Fungi as agents of tree diseases & their management: etiology, symptoms, epidemiology and control of important diseases of nurseries, natural stands, plantations and avenue trees: root system decay and management, stem and foliar diseases of hard woods and conifers and their control, Decline diseases of complex biotic and abiotic origin, pathological consideration of urban tree management and intensively managed forest plantations.	5-Lectures
Unit III	Biodegradation of timber: types of wood decay, detection, gross characters and effect of decay on wood, wood discoloration, decay in living trees, factors affecting heart rots, compartmentalization of decay in trees, management of heart rots; Role of mycorrhizae in tree health, Viruses, Bacteria, Nematodes & Angiospermic parasites as agents of tree diseases & their management, forest weeds and their control.	6-Lectures
Unit IV	Forest pest, Classification of pests, Methods of estimation of forest crop losses by pests and other factors like adverse weather, forest fires and weeds; Factors influencing the pest populations, Measurement of pest population. Forest fire: techniques and application of prescribed/controlled burning. Types of forest fire, Factors affecting fire spread, Impact of forest fire on forest-beneficial and harmful; Techniques and measures of forest fire management.	6-Lectures
Unit V	Wildlife damages in nurseries, natural forest and plantations, Damage control methods, Forest grazing: Advantage and disadvantage, Grazing management system in forest, Effect of acid rains and air pollutants on forest health, Concept of Integrated pest management and its approach in forest protection, other control methods such as biological, physical and chemicals.	6-Lectures

Practicals:

1. Identification and characterisation of important group of pathogens: Fungi, Bacteria and Nematodes affecting nursery and forest crop.
2. Study of disease symptoms caused by different group of plant pathogens.
3. Assessment of health of plants in forest nursery and plantations.
4. Identification and characterisation of parasitic flowering plants affecting forest/plantation crops.
5. Isolation and identification of mycorrhizal fungi from rhizospheric soils and determination of root infection percentage.
6. Study of diseased plant samples to identify pathogen, diseases and their control measures.
7. Identification of causes of deteriorating the forest health
8. To study the major pest species of forest tree species.
9. Assessment and ranking of forest pest species based on severity.
10. Impact assessment of livestock grazing system in forest.
11. To study the role of local community towards forest protection.
12. Assessment of forest dweller pressure on forest and control tactics.

Suggested Readings:

1. Tree Diseases Concept, by Manion PD., Prentice Hall, 1991.
2. Principles of Forest Pathology by Tainter, F.H. and F.A. Baker. J., Wiley & Son, Inc., New York, 199 6.
3. Forest Pathology by Bakshi BK., Controller of Publications, GOI. 1976
4. Forest Entomology by Jha LK &SenSarna PK., Ashish Publ. House, 1994.
5. Indian Forest Insects By Stebbings EP., JK Jain Bros, 1977.
6. Insect Pest Management: Techniques for environmental protection by Jack E. Rechcigl and Nancy A. Rec hcigl, Ann Arbor Press Chelsea, Michigan, 1999.
7. Diseases of Trees and Shrubs by Sinclair, W.A., Lyon, H.H. and Johnson, W.T. Cornell University Pres s. 1987.
8. Field and laboratory guide to tree pathology by Blanchard, R.O. &Tattar, T.A. New York, USA, Academi c Press. 1997.
9. Forest health: its assessment and status by J. Innes. Wallingford, UK, CAB International. 1995.
10. Plant pathologist's pocketbook. 3rd edition by J.M. Waller, J.M. Lenné& S.J. Waller. Wallingford, UK , CABI Publishing. 2001.
11. Decline and dieback of trees and forests. W.M. Ciesla& E. Donaubauer, FAO Forestry Paper 120, Rome, 1994.
12. Tree Pests and Diseases: An Arborists' Field Guide by Guy Watson, Publisher: The Arboricultural Association, 2013.

FR 7104 Forest Tree Improvement **3- 0- 0 = 3**

Unit I	Principles and concepts of tree breeding and improvement. Reproduction and population genetic structure, population dynamics. Floral morphology, floral initiation and breeding systems. Flowering manipulation. Genetic consequences of variation in reproductive biology.	8-Lectures
Unit II	Quantitative inheritance, heritability, genetic advance/gain combining ability and their application. Genetic, environmental and phenotypic expression of trees.	8-Lectures
Unit III	Genetic basis of tree breeding and selection practices in forest trees. Patterns of environmental variation-species and provenance trials in forest trees. Seed stands (seed production areas) Plus tree selection, progeny trials and establishment of seed orchard.	9-Lectures
Unit IV	Quantitative genetics in forestry, sampling, planning and layout, design analysis, variance allocations (components, genotypic and environmental concepts), heritability, correlations. Incomplete block design, trend-free block design and generalized lattice designs and their analysis.	9-Lectures
Unit V	Genetic consequences of hybridization. Back cross breeding, heterosis breeding, breeding for resistance to insect pest, diseases, air pollution and for wood properties. Recent techniques in tree improvement.	8-Lectures

Suggested Readings:

1. Burley J & Styles BT. 1976. Tropical Trees: Variation, Breeding and Conservation. Academic Press
2. Mandal AK & Gibson GL. (eds.). 1997, Forest Genetics and Tree Breeding.CBS.
3. Surendran C, Sehgal RN & Parmathama M. (Eds.). 2003. A Text Book of Forest Tree Breeding. ICAR.
4. Wright, JW. 1976. Introduction to Forest Genetics. Academic Press.
5. Zobel BJ & Talbert J. 1984, Applied Forest Tree Improvement. John Wiley & Sons.

FR 7105 Forest Biotechnology **3-0-2 = 4**

Unit I	Introduction to nucleic acids-DNA and RNA, structural and functions, nucleotides and nucleosides; synthesis, transcription and translation of DNA; molecular maps and markers, chloroplast, mitochondrial and plasmid DNA-structure and functions; DNA barcodes; PCR, gel electrophoresis, blotting techniques, genome sequencing-protein and nucleotides, CRISPR technology.	9-Lectures
Unit II	Principles and techniques of plant tissue culture : cellular totipotency, Type of explants callus culture and micropropagation, protoplast isolation and fusion, somaclonal variation and applications, somatic embryogenesis; haploid production, embryo rescue, artificial seed production and cryopreservation.	8-Lectures
Unit III	Principles, tools and techniques in recombined DNA technology: *Agrobacterium* mediated gene transfer in plant, structure and function of Ti and Ri plasmids, reporter genes; direct gene transfer techniques; genetically modified forest crops and their applications; N-fixation and *Nif* gene in legume and non legumes.	8-Lectures
Unit IV	Secondary metabolites in plants- production of phenolic, alkaloids, and terpenoid compounds, *in-vitro* production of secondary metabolites-fermentation and bioreactors; Single cell protein and mushroom cultivation.	9-Lectures
Unit V	Introduction to bioinformatics, collecting and storing sequences-nucleotides and proteins, biological databases-characteristics, categories, navigation and retrieval systems; sequence analysis-pairwise and multiple sequence alignments, phylogenetic analysis, microarray analysis; Computer aided drug design; BIG Data, Online biological databases.	8-Lectures

Practicals:

1. To prepare reagents and buffers for DNA isolation and gel electrophoresis.
2. To isolate total genomic DNA from plant tissue/ fungal hyphae by modified CTAB method.
3. To detect and visualize of DNA in agarose gel electrophoresis.
4. To optimize a standard PCR reaction with ITS (ITS1+ITS4) Primers.
5. To optimize a standard PCR reaction with RAPD Primers.

6. To purify amplified DNA from PCR reactions for sequencing.
7. To digest and analyze PCR amplified DNA using restriction endonucleases.
8. To induce formation of callus in plant tissues using MS medium.
9. To micropropagate plants with meristem and shoot tip culture.
10. To isolate plant protoplasts using enzymes.
11. To search DNA/Protein sequence homology and learn pairwise alignment using BLAST.
12. To align and analyze DNA sequences using multiple sequence alignment tools (CLustal) and MEGA Softw are.

Suggested Readings:

1. A text book of Biotechnology, R. C. Dubey, S. Chand & Co., New Delhi, 2009.
2. Molecular Biotechnology: Principles and applications of Recombinant DNA. (2nd Edition), by B.G. Glick and J. J. Pasternak, ASM Press, Washington D.C. (First Indian Reprint, Replika Press Pvt. Ltd., New Delhi), 2001.
3. Plant Molecular Biotechnology, by S. Mahesh, New Age International Publishers, New Delhi, 2008.
4. An Introduction to Plant Tissue Culture, 1st Edition, by K.K. De, New Central Book Agency, Kolkata, 1992.
5. An introduction to Plant Tissue Culture, by M.K. Razdan, India Book House Pvt. Ltd., New Delhi, 2007.
6. DNA Fingerprinting in Plants-Principles, Methods and Applications, 2nd Edition, by K. Weising, H. Nybom, K. Wolf and G. Kahl, CRC Press (Taylor and Francis Group, Boca Raton (First Indian Reprint, Saurabhi Pr inters Pvt. Ltd.), 2009.
7. Principles of gene manipulation and genomics by Primrose, SB & Twyman, RM, &th edition, Blaclwell publishing, 2006.

SEMESTER- II

FR 7201 Silviculture 3-0-0= 3

Unit I	Silviculture and its scope in forestry; Classification of Silvicultural systems; Topographic, climatic, edaphic and biotic factors; Silvicultural practices for tropical, subtropical, temperate and alpine forests.	9 Lectures
Unit II	Forest regeneration; Factors affecting regeneration; Gap-phase regeneration; Regeneration survey; Intermediate operations and their effects on growth and yield; Control of under-storey and over-storey vegetation; Forest Nursery	8 Lectures
Unit III	Modern techniques of forest regeneration and their role in Silviculture; Stand establishment; Techniques in early stand establishment; Advances in coppice Silviculture; Stand protection and health management; Judging successful establishment of forests.	9 Lectures
Unit IV	Methods of thinning and their impact on wood quality and yield; Evaluation of active and passive site preparation; Analysis of different techniques of Silviculture in forest stand management; Ecophysiology of tree growth.	8 Lectures
Unit V	Silviculture of some economically important species in India including their distribution, phenology, Silvicultural character, regeneration, management, economic value of utilization.	8 Lectures

Suggested Readings:

1. Dwivedi AP. 1993. *A Text Book of Silviculture*. International Book Distributors, Dehradun.
2. Ford ED. 1984. *Nutrition of Plantation Forests*. Academic Press.
3. Kadambi K. 1993. *Silviculture and Management of Teak*. Vedams Books International.
4. Khanna LS. 1996. *Principle and Practice of Silviculture*. International Book Distributors.
5. Ram Prakash and Khanna, LS, 1983. *Theory and Practices of Silvicultural Systems*. International Book Distributors, Dehradun.

FR 7202 Plantation Forestry 3-0-0=3

Unit I	Plantation forestry: Scope & Importance; role in meeting the wood demand; Plantation forestry in India, purpose of plantation, factors determining scale and rate of plantation, Choice of land and species for plantation.	8 Lectures
Unit II	Production technology for quality planting stock, preliminary site preparation for establishing plantation; Planning programme, time of planting, planting pattern, spacing, planting method.	8 Lectures

Unit III	Nutritional dynamics and irrigation of plantation; Mechanization in plantation, protection and after care of plantation, pruning and thinning of plantation for quality wood production, rotation in plantation; Pest and disease management of plantation; Failure of Plantation; Sustainable yield and long term productivity of plantation.	9 Lectures
Unit IV	Plantation crops of North East India; Case studies in plantation of *Anthocephalus, Duabanga, Dipterocarpus,* Rubber, *Alnus nepalensis,* Pine, *Gmelina,* Teak, *Shorea,* Bamboo, etc.	9 Lectures
Unit V	Plantation for Industrial use and wasteland management.	8 Lectures

Suggested Readings:

1. Dwivedi A. P.1993. *Forestry in India.* Surya Publ.
2. Evans J. 1982. *Plantation Forestry in the Tropics.* Clarendon Press, Oxford.
3. Kumar V. 1999. *Nursery and Plantation Practices in Forestry.* Scientific Publ.
4. Luna R. K. 1989. *Plantation Forestry in India.* International Book Distributors.
5. Ram Prakash, Chaudhari DC & Negi S. S. 1998. *Plantation and Nursery Techniques of Forest Trees.* International Book Distributors, Dehradun.
6. Evans, J and Turn, J. W. 2004. Plantation Forestry in the Tropics (Third edition). Oxford University Press.

FR 7203 Forest Policies and Instruments 3-0-0 =3

Unit I	Forest policy – Relevance and scope; History of policy development, National Forest Policies 1894, 1952 and 1988.	9-Lectures
Unit II	Study of the salient features of the following acts: The Indian Forest Act 1927, The Wildlife (Protection) Act 1972, The Forest (Conservation) Act 1980, Important Forest Rules and Guidelines; National Biodiversity Act (2002), Biodiversity Rules 2004, Tribal Act 2006.	9-Lectures.
Unit III	General principles of criminal law; Indian Panel Code, criminal procedure code; Indian evidence act applied to forestry matters. Institutions (formal and informal), Organization, structure and functioning; Report of National Commission on Agriculture (1976); Shifting agriculture regulation acts, Public Interest Litigation (PIL).	8-Lectures
Unit IV	Supreme court ban on felling, National Environmental Policy, National Biodiversity Action Plan, State Bamboo policies. Traditional land and forest management procedures and customary laws, Intellectual Property Right and bioresource patenting.	8-Lectures
Unit V	International treaties and conventions-CBD, CCD, CITES, CCC, RAMSAR convention, Kyoto Protocol, Forest principle.	8-Lectures

Suggested Readings:

1. The Indian Forest Act 1927 along with Forest Conservation Act, 1980 Natraj Publishers, Dehradun, 1998.
2. Hand book of Environment, Forest & Wildlife Protection Laws in India, Natraj Publishers, Dehradun, 1988.
3. Negi, S.S. 1997. Forest Policy and Law. International Book Distributors, Dehradun.
4. Shetty, B. J. 1981. A Manual of Law for Forest Officers, Sharada Press, Mangalore.

FR 7204 Social Forestry and Agroforestry 3-0-0=3

Unit I	Introduction to community forestry, History and evolution of community forest management in India, Resources benefits sharing, Institutional, financial and legal aspects of community forestry and social forestry.	8-Lectures
Unit II	Theory and practice of participatory approaches, Participatory rural appraisal (PRA) and micro planning, planning, implement and enhancement of forestry activities and increasing local people's benefits from forestry development with special reference to NE India.	8-Lectures
Unit III	Agroforestry: The concepts and principles, tree crop interface, interaction effects, environmental factors in Agroforestry, ecological benefits, diagnosis and design of Agroforestry models, criteria of good forestry design, design and analysis of Agroforestry experiments, carbon pools and fluxes in forest ecosystems affected by shifting cultivation. To impart knowledge on recent development on Agroforestry model and its economics with special reference to North East Region, National Agroforestry Policy – 2014.	9-Lectures

Unit IV	The use of economics in diagnosis and design of Agroforestry systems; cost and benefits in Agroforestry; valuation of inputs and outputs; environmental outputs. Recent trend in Agroforestry research and development, Agroforestry land use system and their salient feature, modelling in Agroforestry, intercropping, mixed intercropping, fodder bank, woodlots.	9-Lectures
Unit V	Problems and prospects of shifting cultivation and sustainable agriculture of tropical forest soils, nutrient management in forest soil (organic & inorganic fertilizers), liming and biological nitrogen fixation; soil fertility and fertilization. Soil degradation and erosion-causes, impacts and management in forest ecosystems.	8-Lectures

Suggested Readings:

1. Nair, P.K.R. 1993. An Introduction to Agroforestry. Kluwer.
2. Dwivedi, A.P. 1992. Agroforestry: Principles and Practices. Oxford & IBH.
3. Chundawat, B.S. and S.K. Gautam. 1993. Textbook of Agroforestry. Oxford & IBH Publishing CO. PVT.LTD. New Delhi.
4. Arnold, J. E. M. 1991.Community Forestry*: Ten Years in Review*. Community Forestry Note 7, revised edition. Rome: Food and Agriculture Organization.
5. Soils of Tropical Forest Ecosystems (1998). A.Schulte and D. Ruhiyat (Edrs), Springer Verlag, Heidel berg, Germany.
6. Khosla, P.K. and Khurana, D.K. 1987. Agroforestry for rural needs. Vol. 1 and II.
7. SenSarma, P.K. and Jha, L.K. 1993. Agroforestry. Indian Perspectives. APH Publishing Corporation, New Delhi

FR 7205 Wildlife Conservation and Ecotourism 4-0-0 = 4

Unit I	Wildlife conservation: Definition, Concept, Needs; Conservation issues, Wildlife conservation & management principles, Wildlife conservation strategy, Conservation in practice: Protected area and its types, Management measures of protected areas, Action plan for the conservation/management of wildlife in India, Important wildlife zones in India.	11-Lectures
Unit II	Wildlife population: Population estimation methods: direct and indirect methods. Age and stage structure, Constraints in measurement of wildlife populations. Wildlife harvesting, Animal behaviour as a conservation tool for wild animals, Investigating food habits and food preference of terrestrial vertebrates, Detecting stability and causes of change in population density of wildlife, Animal home range & territory, Carrying capacity.	11-Lectures
Unit III	Wildlife habitats: Measures of habitat factors, Habitat analysis evaluation & improvement /manipulation; *Ex-situ* and *in-situ* wildlife conservation measures: Role of Zoo, National Parks, Wildlife sanctuaries, Biosphere reserve. Wildlife monitoring: Population, Disease, predation, habitat for the conservation of terrestrial wild animals, Management of rangelands, forest & wildlife corridors, Wildlife damage/conflict: appraisal, control and management methods.	11-Lectures
Unit IV	Wildlife Ecotourism: Definition and classification, limitations and problems, Mass tourism versus ecotourism, World Tourism Organization, International organizations and NGOs promoting ecotourism, Guideline for community based ecotourism programs.	11-Lectures
Unit V	Ecotourism in protected areas, Planning ecotourism in protected areas, Park tourism, Tourism Zone: resource innovatory, visitor carrying capacity, Feasibility plans for effective eco-tourism: Signage, Area map, hides and Machan, nature trail, visitor centre, picnic sides; Ecotourism for sustainable development of PA's, Ecotourism as a business opportunity for local, Economic inflow-outflow in ecotourism area.	12-Lectures

Suggested Readings:

1. Research techniques in animal ecology: Controversies and consequences by Boitani L. and Fuller T.K., Bishen Singh Mahendra Pal Singh, Dehra Dun, India, 2002.
2. Conservation Medicine: Ecological health in practice by Aguirre A.A., Ostfeld R.S., Tabor G.M., Hous e C., Pearl M.C., Oxford University Press, 2002.
3. Concept in wildlife management by Hosetti B.B. Daya Publishing House, Delhi, 1997.
4. Ecotourism and Sustainable Development by Honey M., Iceland Press, 1998.
5. Global Ecotourism Policies and Case Studies by Luck M and Kirstges T., Channel View Publication, 200 2.
6. Ecotourism: A guide for planners and managers by Kreg Lindberg, Meganepler Wood and David Engeldrum, Vol.1, 2,& 3. Natraj Publication, Dehradun,1999.

AE 7223 Forest Hydrology and Watershed Management **2-1-0=3**

Unit I	Concept of forest hydrology, hydrological cycle and its components; analysis of precipitation data, infiltration modeling.	5-Lectures
Unit II	Estimation of evaporation, evapo-transpiration, and run-off; concept of hydrograph and its component, methods of base flow separation, unit hydrograph, Watershed delineation	5-Lectures
Unit III	Concept of watershed and objectives of watershed management, causes and consequences of watershed deterioration, delineation and coding of watershed, geo-morphological characteristics of watershed affecting runoff, Sedimentation: definition, types and methods of measurement, Soil erosion.	6-Lectures
Unit IV	Soil survey: definition and its type, codification of soil survey; Land capability classification: objectives, characteristics, land capability ratings and determination of different land capability classes.	6-Lectures
Unit V	Watershed inventory, prioritization and treatment of watersheds, Landslides and its control, torrents control; role of horticulture, forestry and agro-forestry in watershed management, Watershed work plan, economic evaluation of watershed management projects. Successful case studies of watershed management in India, Sustainable watershed development planning.	6-Lectures

Suggested readings:

1. Hydrology: Principles, Analysis and Design, H.M. Raghunath, 3rd edition, New Age International, New Delhi
2. Land and Water Management, V.V.N. Murty and M. K. Jha, 5 th edition, Kalyani Publishers, New Delhi
3. Watershed Planning and Management, Rajvir Singh, Yash Publishing House, Bikaner – 334003, India
4. Hydrology, Soil Conservation and Watershed Management, Ghanshyam Das, PHI, New Delhi – 110001
5. Soil and Water Conservation Engg., R. Sureswh, 2nd revised edition, Standard Publishers Distributors, 1705 B, NaiSarak, Delhi – 110006

SEMESTER- III

FR 8101 Wood Science and Technology **3-0-2=4**

Unit I	Gross characteristics of stem wood – Growth increments, plane of reference in the stem, sapwood and heartwood, transformation of sapwood into heartwood, lustre, odour, grain, texture, figure, weight and hardness of wood.	8-Lectures
Unit II	The Woody Cell Wall: Distribution of chemical constituents in the cell wall, wall structure of tracheids, fibres and parenchyma cells, modifications of cell wall-pitting of cell wall, perforation of cell wall, thickenings of cell wall, wart structures and vestured pitting, special forms of cell wall.	9-Lectures
Unit III	Wood water relationship, absorption behaviour and wood drying, Refractory and non refractory behaviour of wood, Wood seasoning, types-air, kiln and special seasoning methods like chemical, high temperature drying, vacuum drying, etc.	9-Lectures
Unit IV	Wood preservation - wood preservatives and their properties, preparation of wood for preservation, different wood preservation processes and their advantages and disadvantages.	8-Lectures

Unit V	Wood adhesives – types, characteristics and their applications, wood impregnation and compregnation. Introduction to wood modification, its needs and scope, impregnated, compregnated, compressed, thermal and chemical modification of wood.	8-Lectures

Practicals:

1. To identify different types of cells in gymnosperms.
2. To identify different types of cells in angiosperms.
3. To study normal rings, discontinuous rings, double and multiple rings in trees.
4. Isolation of wood elements by using Franklin's Method.
5. Isolation of wood elements by using Schultze's Method.
6. To study characteristics of compression wood.
7. To study characteristics of tension wood.
8. To study different types of kilns.
9. To study types of sheds for stacking timbers.
10. To study sap displacement methods of wood preservation.
11. To study hot and cold process of wood preservation.
12. To study different types of stacks of timber for seasoning.
13. Preparation of different types of natural adhesives.
14. Determination of moisture content of wood samples.
15. Determination of wood density of wood samples by water displacement method.

Suggested Readings:

1. Textbook of Wood Technology by A. J.Panshin and C. de Zeeuw, McGraw Hill Book company, New York, 198 0
2. The Anatomy of Wood: its diversity and variability by K. Wilson and D.J.B.White, Stobart & Sons Ltd. London,1986
3. Wood Seasoning Technology by C.N. Pandey and V.K. Jain, ICFRE, 1992
4. Wood Preservation Manual by F.A.O. (Reprinted) IBD Dehra Dun, 1986
5. Composite Woods - Research and Development, K.S. Shukla, and S P. Singh, ICFRE- Dehradun, 1994.
6. Timber Industries and Non Timber Forest Products, M.B. Shrivastava, CBS Publishers and Distributors, New Delhi, 2005.
7. Atlas of woody plant stems, F.H., Schweingruber, A. Borner and E.D. Schulze, Springer, 2006.

FR 8102 Forest Goods and Services 3-0-2=4

Unit I	Forest Goods and services: the concept and its evolution; History of development of Timber Extraction, Extraction methods, conversion of timber, Multiple applications of wood.	8-Lectures
Unit II	Non - timber forest products- Present production, their management, export and import of non-timber forest products, dependence of people on NTFPs.	8-Lectures
Unit III	Important NTFPs: Gums, Resins, Bamboos, Canes, Oil seeds, Tannins, Dyes, Tendu leaves, Broom grass.	9-Lectures
Unit IV	Pulp and Paper, Lac and Shellac, Cutch & Katha, Cocoa, Alcoholic beverages.	9-Lectures
Unit V	Forest Ecosystem Services: Important ecosystem services, their importance and valuation.	8-Lectures

Practicals:

1. To study different methods of sawing of timbers.
2. To study different types of tools used for felling of trees.
3. To study different types of tools used for conversion of timbers.
4. Identification and collection of different NTFPs.
5. To study morphological features of bamboos.
6. To study preparation of beedies.
7. Identification of host plants of *Lacifer lacca.*
8. To study operation and maintenance of power chain saw.
9. To study operation and maintenance of circular saw.
10. Identification and collection of resins available in and around Nirjuli
11. Identification and collection of gums available in and around Nirjuli
12. To study multiple application of woods.
13. To isolate and study xylem elements from different kinds of paper.

Suggested Readings:

1. Indian Forest Products, Vol. I & Vol. II, By ICFRE, Dehradun, 1970
2. Minor Forest Products of India by T. Krishnamuruty, Oxford & IBH Publishing Co. Pvt.Ltd. New Delhi, 1993
3. Composite wood-Research and Development by K.S. Shukla and S.P. Singh, ICFRE Dehra Dun, 1993
4. Forests: The non-wood resources by A.P. Dwivedi, IBD Dehra Dun, 1992

FR 8103 Forest Geo-informatics **3-0-2=4**

Unit I	Introduction to remote sensing, Types of remote sensing, Electromagnetic spectrum, Energy-matter interaction, Spectral reflections of earth features, Atmospheric windows, Sensors resolution.	9 Lectures
Unit II	Photogrammetry; Platforms; Satellites; Remote sensing of vegetation, soil and water; Data acquisition, storage and retrieval; Spatial and spectral transforms; Multispectral and hyper-spectral remote sensing systems; Thermal infrared and microwave remote sensing.	9 Lectures
Unit III	Visual image interpretation; Digital image processing; Introduction to GPS: Principles, segments, factors affecting GPS; Spatial and non-spatial data, Raster and vector data conversion, Thematic classification.	8 Lectures
Unit IV	Fundamental of GIS; Data models and data structure; Input of map data; Spatial database management; Spatial analysis; Satellite imagery, uses and limitation; Remote sensing and GIS.	8 Lectures
Unit V	Introduction to GIS software packages; ArcGIS, ERDAS, IDRISI, ISROGIA, GIS and GPS applications in management of natural resources, land use/land cover mapping, environmental impact analysis; Development of GIS data base for decision making purposes.	8 Lectures

Practicals :

1. Introduction to remote sensed data and its resolutions.
2. Introduction to GPS and GIS techniques; Download, import and export of different satellite data
3. Raster, vector and reference data and its importance.
4. Demonstration and hands on practice on interpretation of satellite data and digital image processing.
5. Sub-setting, un-superwise and super-wise classification.
6. Map composition; Projection and re-projection.
7. Preparation of land use and land cover maps and its ground verification.

Suggested Readings:

1. Principles of GIS for land resources assessment by Burrough, P.A. 1990, Oxford Publications.
2. Remote sensing and Image interpretation by Lillisend, T.M. and Kiefer, F.E. 1994, John Wiley Publish ers.
3. Remote Sensing and its application by Narayan, LRA 1999. Orient Longman Ltd.
4. Remote Sensing and Geographical Information Systems by Reddy, A, 2002, BSP, Hyderbad.
5. Text Book of Remote Sensing and Geographical Information Systems by Sahu KC, 2008, Atlantic Publishers, New Delhi
6. Fundamentals of GIS by Chakraborty and Sahoo RN 2007. Viva Books, Ansari Road, Daryaganj, New Delhi – 110 002.

FR 8104 Forest Resource Management **3-0-0 =3**

Unit I	Forest management: historical perspective in forest management; Essentiality of forest management; Characteristics of normal forests, Principles of sustained yield.	8-Lectures
Unit II	Classical approaches for yield regulation in forest management: Salient features and strategies; Site quality evaluation and importance; Stand density; rotational period, optimum rotational problem, problem with single rotational period.	8-Lectures
Unit III	Sustainable forest management; Criteria & Indicators in Indian perspective; Forest certification; International cooperation and resource mobilization for forest management; Importance of working plan and its recent development.	8-Lectures
Unit IV	Forest resource quantification and valuation: Principles of quantification and valuation; Interest and investment; Valuation of forest land and timber stand; total economic value, Natural and environmental resource accounting-methods and implications.	9-Lectures

Unit V	Allocation of natural resource over time, Risks and uncertainties in resource allocation; Elements of resource economics; Non-renewable and renewable resources; Theory of depletion; Models of renewable resource harvesting; Growth functions, Production and yield functions; Externalities and property rights; forest products marketing; Inter-regional and international trade in forest products.	9-Lectures

Suggested Readings:

1. Ram Parkash. 1986. Forest Management. International Book Distributors , Dehradun.
2. David, D.S. and Johnson, K.N. 1987. Forest Management. McGraw Hill Book Co., New York.
3. Osmaston, F.C. 1984. Management of forests, IBD, Dehra Dun.
4. Bouman, O.T. and Brand, D.G. 1997. Sustainable Forests. Food Products Press, London.
5. Nautiyal, J.C. 1988. Forest Economics-Principles and applications. Natraj Publications, Dehradun.
6. Kerr, J.M., Marothia, D.K., Singh, K., Ramaswamy, C. &Beritley, W.R. 1997. Natural Resource Economi cs: Theory and applications in India. Oxford & IBH.
7. Sharma, L.C. 1980. Forest Economics, Planning and Management. International Book Distributors, Dehradun.
8. FAO. 1986. Guidelines to Practical Project Appraisal. Natraj Publication .

FR 8105 Forest Seed Technology 2-0-2= 3

Unit I	History and development of seeds technology, Importance of seed in present day in forestry, seed morphology: introduction, terminology, seed dormancy: introduction, casual factors of seed dormancy, development of seed dormancy, Orthodox and recalcitrant seeds, ISTA rules, metabolism, hormonal regulation of seed dormancy, breaking of seed dormancy, inheritance of seed dormancy, biological significance.	6-Lectures
Unit II	Seed germination - Introduction, mechanism, factors that control germination, inhibitors and promoters, factors affecting germination, practical importance of germination.	5-Lectures
Unit III	Seed collection and handling- Introduction, assessment of seed requirement, seed collection time and maturity, method of seed collection, seed extraction, seed drying and cleaning, Storage of tree seed and protection. Seed testing - Introduction, history of seed testing, procedure for development of seed testing rules, essential of seed testing, seed vigour, indirect test of viability.	6-Lectures
Unit IV	History of seed certification and quality control, necessity for seed legislation, agencies involved in quality seed programme, seed zones, salient feature of Seed Act, Seed Certification Board - Seed Committee and their functions.	5-Lectures
Unit V	Seed protection and quarantine, quality seed production- genetic improvement, plus tree and seed production area, seed orchards, economics of quality seed production, Vegetative propagation: Introduction, rooting stem cutting, root cuttings, grafting and budding, air layering.	6-Lectures

Practicals:

1. Identification of forest seeds.
2. Collection and submission of important tree seeds (min. 20 tree species).
3. Different storage methods, viability and germination.
4. Collection and processing of seeds/ fruits. Tests of viability viz., cutting, hydrogen peroxide, excised embryo test, tetrazolium test.
5. Seed health testing primarily to the presence or absence of disease-caused organisms such as fungi, bacteria, virus and animal pests, Recording, calculation and use of results of seed treatment. Visit of forest seed orchard.

Suggested Readings:

1. Khullar, P., Thapliyal, R.C., Beniwal, B.S., Vakshasya, R.K., and A. Sharma. 1991. ICFRE Publication .
2. Agrawal, P.K. and M. Dadlani. 1987. Techniques in Seed Science and Technology, South Asian Publisher s, Delhi.
3. Agrawal, R.L. 1996. Seed Technology. Oxford & IBH, Publishing Co., New Delhi.

4. Anon. 1965. Field Inspection Manual and Minimum Seed Certification Standards, NSC Publication, New Delhi.
5. M. K. Sadhu. 1996. Plant Propagation, New Age International, New Delhi.
Ahuja, P.S. et al. 1989. Towards developing "Artificial Seeds" by shoot and root encapsulation. In: Tissue Culture and Biotechnology of Medicinal and Aromatic Plants. CIMAP, Lucknow, India, P. 22-28.

ELECTIVE COURSES

FR 8001 Global Climate Change **3-0-0=3**

Unit I	Climate change: History and future; Major green house gases, future climatic predictions; Ozone depletion and UV radiation effects. Factors responsible for climate change, Evidences of climate change.	9 Lectures
Unit II	Concept of global change, major global change issues, impact of human activities on global change; Major impacts on forests; Environment and development policies; Pollution control laws; United Nation Framework Convention on Climate Change, IPCC, Kyoto Protocol, WTO and Environment.	9 Lectures
Unit III	Economic and Ecological impacts of climate change; Modeling the impacts of climate change; Impact of climate change on Indian forest; Global and regional strategies to combat climate change.	8 Lectures
Unit IV	Climate change and implications for sustainable forest management; Adaptation of forest trees to climate, Case studies on the management of certain tree species in India.	8 Lectures
Unit V	Global and regional strategies to combat climate change, Action around the world, Climate change mitigation programmes in India; Electric power, futures in five developing countries.	8 Lectures

Suggested Readings:

1. Claussen E, Cochran VA & Davis DP. 2001. *Climate Change: Science, Strategies and Solutions.* Pew Centre on Global Climate Change, USA.
2. Committee on Abrupt Climate Change. 2002. *Abrupt climate change: Inevitable Surprises.* National Research Council, Ocean Studies Board, National Academics Press, Washington.
3. Koskela J, Buck A & Teissier du Cros E. 2007. *Climate Change and Forest Genetic Diversity: Implications for Sustainable Forest Management in Europe.* 2007. Biodiversity International, Rome, Italy.
4. Anonymous 2006. Report of the National Forest Commission. Govt. of India, New Delhi.
5. Claussen E, Cochran VA & Davis DP. 2001. Climate Change: Science, Strategies and Solutions. Pew Centre on Global Climate Change, USA.
6. Committee on Abrupt Climate Change. 2002. Abrupt climate change: Inevitable Surprises. National Research Council, Ocean Studies Board, National Academics Press, Washington.

FR 8002 Economics of Agroforestry Systems **3-0-0=3**

Unit I	Basic principles of economics applied to agroforestry. Importance of economics in agroforestry; Optimization techniques- planting, budgeting and functional analysis.	9-Lectures
Unit II	Role of time, risk and uncertainty in decision making.	9-Lectures
Unit III	Benefits, costs and productive objectives; Cost/benefits analysis in Agroforestry; Valuation of inputs and outputs; distribution of cost and benefits	8-Lectures
Unit IV	Financial and socio-economic analysis of agro-forestry projects.	8-Lectures
Unit V	Principles of financial management and harvesting, post harvest handling marketing of agroforestry products including benefits sharing.	8-Lectures

Suggested Readings:

1. Dwivedi, A. P. 1992. Agroforestry : Principles and Practices. Oxford & IBH.
2. Nair, P.K.R., Rai, M.R. & Buck, L.E. 2004. New Vistas in Agroforestry. Kluwer.
3. Nair, P.K.R. 1993. An Introduction to Agroforestry. Kluwer.
4. Ong, C.K. & Huxley, P.K. Tree Crop Interaction-A Physiological Approach. ICRAF.
5. Thampan, P.K. 1993. Trees and Tree farming. Peekay Tree Crops Development Foundation.

6. Young, A. 1997. Agroforestry for Soil Management. CABI.
7. Chundawat, B. S. and Gautam, S. K. 1993. Textbook of agroforestry, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

FR 8003 Forest Genetic Diversity and Conservation 3-0-0=3

Unit I	Biological diversity-concept and levels; Genetic diversity in forest trees, medicinal and aromatic plants; Definition, characteristics and importance for tree breeding. Genetic erosion and equilibrium; Techniques to assess genetic diversity; Analysis of karyotypic variation in forest genetic resources.	8-Lectures
Unit II	Molecular approaches for assessing genetic diversity; Inventory and monitoring biodiversity: sampling strategies for genetic diversity assessments, neutral allele models; Effects of sampling, climate and degradation on genetic diversity; Factors influencing levels of genetic diversity in woody plant species and non-wood species; Conservation of genetic diversity for forest crops.	9-Lectures
Unit III	Techniques for survey and assessment of endangered plants; Rarity patterns and endemism, implications of rarity; Concept of island biogeography; Managing corridors and natural habitat fragments; Monitoring and recovery plans for endangered plants; Plant community reserves; Managing wild flora tourism impacts and urbanization of rare plants.	9-Lectures
Unit IV	Laws and policies; Methods for maintenance of conservation: Gene banks, arboreta, gardens, breeding populations as repositories of gene conservation; Rare, endangered and endemic plants (IUCN); Germplasm introduction and exchange.	8-Lectures
Unit V	Intellectual Property rights (IPR): Nature and issues involved, IPR on biological diversity and plant varieties; Plant Breeders' Rights; Geographical indications (GI): benefits & protection of GI, national & international level; Convention on Biological Diversity (CBD), Regulation of biodiversity: National Biodiversity Authority (NBA) and State Biodiversity Board (SBB); Biodiversity Act and its impact in forest resources.	8-Lectures

Suggested Readings:

1. FAO. 1985. *Forest Tree Improvement* , FAO Pub.
2. FAO, FLD, IPGRI. 2004. *Forest genetic resources conservation and management. Vol. 1: Overview, concepts and some systematic approaches*. International Plant Genetic Resources Institute, Rome, Italy.
3. FAO, DFSC, IPGRI. 2001. *Forest genetic resources conservation and management. Vol. 2: In managed natural forests and protected areas (in situ).* International Plant Genetic Resources Institute, Rome, Italy.
4. FAO, FLD, IPGRI. 2004. *Forest genetic resources conservation and management. Vol. 3: In plantations and genebanks(ex situ)*. International Plant Genetic Resources Institute, Rome, Italy
5. Fins L, Friedman ST and Brotschol JV. 1992. *Handbook of Quantitative Forest Genetics*, Kluwer. 32
6. B. Zobel and J. Talbert 1984. Applied Forest Tree Improvement. John Wiley and Sons New York.

FR 8004 Rangeland and Pasture Management 3-0-0 = 3

Unit I	Rangeland: Definition, Values of rangeland, Types of rangeland, Global distribution of rangeland; Rangeland condition classification, Factors affecting the rangeland condition, Rangeland management issues.	8-Lectures
Unit II	Grassland types of India, Grassland cover, distribution and status of India; Threats to grassland of India, Causes and effect of overgrazing; Grazing system and management, Grazing plan development: Design and layout, Fence Design and Layout, Water System Design and Layout, Heavy Use Area Planning.	8-Lectures
Unit III	Rangeland management: Grazing methods; Types of enclosures, Effect of closure, Tools of rangeland management like fire, prescribed grazing, weed control, invasive species control, soil erosion control, water conservation, fertilization; Rangeland management- Before, during and after drought; National forest policy on grazing; Grazing rights and concessions in different states of India.	9-Lectures

Unit IV	Pasture: Definition, Kinds of pasture, Why pasture 'Run out", Growth form of pasture, Improvement of the pasture land, Recognizing and correcting a declining forage yield, in pasture land.	8-Lectures
Unit V	Pasture management: Pasture Forage and Livestock Management, Pasture Soil Fertility Management, Pasture Brush and Weed Control, Sacrificial Paddock Management, Grazing system monitoring. Development of watering places for range and pasture stock, Burning of pasture lands and its effects on forage production.	9-Lectures

Suggested Readings:

1. Range management: Principles and Practices (6th Edition) by Jerry L. Holecheck, Rex D. Pieper, Carlton H. Herbel, Prentice Hall, 2010.
2. Principle and practice of rangeland management, J.B. Lal, International Book Distributors, Dehradun, 1990.
3. Rangeland and pasture management by Arthur W. Sawpson, John Wiley & Sons Inc,1923.
4. Grazing systems planning guide by Kevin Blanchet, Howard Moeching and J. Dejong-Hughes, USDA, Natural Resource Conservation Science,2003.
5. Rangeland Ecology and Management by Harold Heady and R. Dennis Child, Westview Press, 1999.
6. Range management by Laurene Alexander Stoddar, Arthur D. Smith, Megraw Hill, 1943.

AUDIT COURSES FOR B.Sc. Agriculture and Horticulture STUDENTS ONLY

SEMESTER - I

FR 7177 Forest Science- I **3-0-0=3**

Unit I	Forestry definition and scope, Forest Classification, Natural resources, Sustainable development, Forest degradation, Forest soils, Forest management.	8-Lectures
Unit II	Agroforestry objectives and scope, Agroforestry systems, D & D technique in Agroforestry, Social forestry objectives and scope; Choice of tree species, Tree-crop interactions, Social forestry programmes in India.	9-Lectures
Unit III	Plant propagation, Propagation by vegetative structures like bulbs, tubers, corms, rhizomes, runners, offsets and suckers, Layering, Grafting and budding, Seeds : collection and extraction, seed dormancy, germination, viability, testing, seed quarantine and legislation, seed certification.	9-Lectures
Unit IV	Scope and objects of silviculture, Locality factors, Topographic factors, Edaphic factors, Biotic factors, Natural and artificial regeneration,Growth and development of trees and forests, Reproduction of trees, Silviculture practices and Management of forest nursery soil.	8-Lectures
Unit V	Forest Nursery: location, Importance and object, Classification, Selection of site, area, fencing, layout, Preparation of beds, Pre-germination treatments, Sowing of seeds, Time of sowing, weeding, shading, irrigation, Planting out and transplanting, Maintenance of soil fertility, Nursery register.	8-Lectures

Suggested Readings:

1. A Text book of Silviculture by A.P. Dwivedi, 1993, IBD, Dehradun.
2. Principles and Practice of Silviculture by L.S. Khanna, 1993KB Publ.,Dehradun.
3. A Hand Book of Forestry by S. S. Negi, 1981, IBD, Dehradun.
4. Plant Propagation by M. K. Sadhu, 1996, New Age International, New Delhi.
5. Plantation and Nursery Techniques of Forest Trees by Ramprakash, IBD.

SEMESTER - II

FR 7277 Forest Science II **3-0-0=3**

Unit I	Forest Products: Introduction and their classification. Felling techniques, Felling season and Felling rules, Conversion and storage of timber.	8-Lectures
Unit II	Gross features of wood; Microscopic features of softwoods and hardwoods, Identification of timbers.	8-Lectures

Unit III	Introduction of Wood seasoning and wood preservation, Important NTFPs and their management.	.8-Lectures
Unit IV	Forest mensuration and its objectives, Accuracy, Measurements of diameter and girth of trees, breast height measurement rules, Introduction of different types of instruments, their advantages and disadvantages.	9-Lectures
Unit V	Measurement of height, tree form, volume and age of trees.	9-Lectures

Suggested Readings:

1. Forests-The Non-wood Resources, A.P. Dwivedi, International Book Distributors, Dehradun, 1993.
2. Minor Forest Products of India, T. Krishnamurty, Oxford & IBH Publications, Co. Ltd, New Delhi, 1993 .
3. A handbook of forest utilization, T. Mehta, International Book Distributors, Dehra Dun, 1981.
4. Indian Forest Utilization. Vol. II, FRI Publications, Dehradun, 1971.
5. Non-Wood Forest Products in Asia, P.B. Durst, W. Ulrich and M. Kashio, Oxford & IBH Publications, CO. Ltd, New Delhi, 1993.

COURSE STRUCTURE FOR Ph.D. STUDENTS ONLY

FR 9001 Concept of Forestry 3-0-0=3

Unit I	Forestry: definition, Objective and Scope, Types of forestry, Forest Classification, Needs of Forest conservation and management, Forest soils; Social forestry, Agroforestry, Choice of tree species for social and agroforestry, Social forestry programme in India.	9-Lectures
Unit II	Silviculture: Definition, objectives, Factors affecting silviculture practices-biotic and abiotic factors, Silviculture systems, Forest regeneration, Types of regeneration, Forest nurseries.	8-Lectures
Unit III	Plant propagation: Propagation by vegetative structures, Layering, Grafting and Budding, Gross and Microscopic features of softwoods and hardwoods, Identification of timbers; Wildlife conservation, concept, causes of decline of wildlife species and their population, Threatened species concept.	9-Lectures
Unit IV	Wood seasoning and preservation methods, NTFPs and their management; Forest Products: Introduction and their classification, Felling techniques, Felling season and Felling rules, Conversion and storage of timber.	8-Lectures
Unit V	Forest mensuration: Objectives, Uses in forest management, Methods of measurement of diameter and girth of trees, Breast height measurement rules, Types of instruments use in plant measurement and their advantages and disadvantage; Measurement of height, tree form, volume and age of trees.	8-Lectures

Suggested Readings:

1. A Text book of Silviculture by A.P. Dwivedi, 1993, IBD, Dehradun.
2. Principles and Practice of Silviculture by L.S. Khanna, 1993KB Publ.,Dehradun.
3. A Hand Book of Forestry by S. S. Negi, 1981, IBD, Dehradun.
4. Plant Propagation by M. K. Sadhu, 1996, New Age International, New Delhi.
5. Plantation and Nursery Techniques of Forest Trees by Ramprakash, IBD.
6. Minor Forest Products of India, T. Krishnamurty, Oxford & IBH Publications, Co. Ltd, New Delhi, 1993 .
7. A handbook of forest utilization, T. Mehta, International Book Distributors, Dehra Dun, 1981.
8. Indian Forest Utilization. Vol. II, FRI Publications, Dehradun, 1971.
9. Non-Wood Forest Products in Asia, P.B. Durst, W. Ulrich and M. Kashio, Oxford & IBH Publications, CO . Ltd, New Delhi, 1993.
10. Forest Mensuration by Chaturvedi & Khanna L. S. International Book Distributors, Dehra Dun.
11. Forests-The Non-wood Resources, A.P. Dwivedi, International Book Distributors, Dehradun, 1993.

FR 9002 Climate Change and Forestry 3-0-0=3

Unit I	Introduction to changes in the earth's climate. Definition of climate change: Scientific evidence, process and consequences for society and ecosystems; Interpretation of past climatic conditions from proxy records; Patterns of climate variability.	9-Lectures
Unit II	Processes that cause climate change, An overview of mechanisms, Atmosphere, Climate change, Global warming as a possible trigger for climate change, Limited predictability close to an instability, Changes in natural modes of the atmosphere- ocean system, Possible future changes in the hydrological cycle.	9-Lectures
Unit III	Economic and Ecological impacts of climate change, Recent scientific studies in the ecological and social sciences, Modeling the impacts of climate change and its effect on coastal resources, Potential impact on Indian water resources.	8-Lectures
Unit IV	Climate change and water, IPCC, El nino, La nina, Climate change and implications for sustainable forest management. Impact of climate change on Indian forest, Adaptation of forest trees to climate, Case studies on the management of certain tree species in India.	8-Lectures
Unit V	Global and regional strategies to combat climate change, Action around the world, Climate change mitigation programs in India, Electric power, futures in five developing countries.	8-Lectures

Suggested Reading:

1. Claussen, E., Cochran, V.A. & Davis, D.P. 2001. *Climate Change: Science, Strategies and Solutions.* Pew Centre on Global Climate Change, USA.
2. Committee on Abrupt Climate Change. 2002. *Abrupt climate change: Inevitable Surprises.* National Research Council, Ocean Studies Board, National Academics Press, Washington.
3. Koskela, J., Buck, A. &Teissier du Cros, E. 2007. *Climate Change and Forest Genetic Diversity: Implications for Sustainable Forest Management in Europe.* 2007. Biodiversity International, Rome, Italy.
4. Sarkar, A. N. 2010. Global climate change beyond Copenhagen. New Pentagon Earth Printers, New Delhi.
5. Rana, S.V.S. 2009. Essentials of Ecology and Environmental Science Fourth edition, PHI, Pvt. Ltd, New Delhi – 110001

FR 9003 Timber & Non-Timber Forest Products 3-0-0=3

Unit I	Forest Goods and services: the concept and its evolution; History of development of Timber Extraction, Extent of utilization, Extraction, conversion and marketing of timber, Multiple applications of wood.	9-Lectures
Unit II	Silvicultural practices and wood quality, Sapwood and heartwood, Heartwood formation, Juvenile wood, Stemwood, Branch wood and Root Wood.	9-Lectures
Unit III	Non-timber forest products- Present production, their management, export and import of non-timber forest products, dependence of people on NTFPs.	8-Lectures
Unit IV	NTFPs: Production, processing and trade; Fibres and Flosses; Essential & non essential oils; Tans & Dyes; Important aromatic and medicinal plants.	8-Lectures
Unit V	Cutch and Katha; Gums & Resins; Rubber; Alcoholic beverages, oil seeds, Beedi leaves.	8-Lectures

Suggested Readings:

1. Forests – The Non-wood Resources, A.P. Dwivedi, International Book Distributors, Dehradun, 1993.
2. Minor Forest Products of India, T. Krishnamurty, Oxford & IBH Publications, Co. Ltd, New Delhi, 1993.
3. A handbook of forest utilization, T. Mehta, International Book Distributors, Dehra Dun, 1981.
4. Indian Forest Utilization. Vol. II, FRI Publications, Dehradun, 1971.
5. Non-Wood Forest Products in Asia, P.B. Durst, W. Ulrich and M. Kashio, Oxford & IBH Publications, CO. Ltd, New Delhi, 1993.

FR 9004 Wildlife Management **3-0-0=3**

Unit I	Wildlife Management: Definition, Objectives, Needs of wildlife management, Status of wildlife management in India, Population indices, Status of threatened species, Wildlife Population: Growth, Dispersal, Dispersion, Distribution, Fluctuation, Competition, Predation.	8-Lectures
Unit II	Wildlife conservation and management: Population estimation methods: direct and indirect methods, Age and stage structure, Constraints in measurement of wildlife populations Wildlife harvesting, Wildlife habitats: Measures of habitat factors, Habitat analysis evaluation &improvement /manipulation; Conservation in practice: How population become extinct and how it can be prevented from extinction, Rescue and recovery of near threatened species, Protected area, Types of protected areas, Management measures of protected areas.	9-Lectures
Unit III	Wildlife damage control: History. development and principle of animal control, current methods of animal control, Electric fence construction, Trench, Rubble wall designs, etc., Impact of wildlife on woody vegetation.	8-Lectures
Unit IV	Wildlife capture and handling techniques: Live trapping, mist netting, rocket netting, chemical capture techniques, drugs, factors affecting drug action, equipments, plan of operation for different animals. Studies of Wildlife management equipments and its role in wildlife management.	8-Lectures
Unit V	Wildlife tourism management: Tourism Zone: resource innovatory, visitor carrying capacity, visitor statistics, feed-back & evaluation. Education of tourists: Signage area map, hides and machan, nature trail, visitor centre, picnic sides. Involvement of local people: Human pressure areas, settlement impact analysis, forest product collection, evaluation of resource loss, Anti-poaching operations etc.	9-Lectures

Suggested Readings:

1. Primack, R.B. 1993. Essentials of Conservation Biology, Sinauer Associates Inc. Publishers, Sunderla nd, Massachusetts, U.S.A.
2. Anthony R.E. Sinclair, John M. Fryxell and Graeme Caughley 2006. Wildlife ecology, Conservation and Management, Second Edition. Blackwell Publishing.
3. Hosetti, B.B. 2008. Concept in Wildlife management, 3rd Revised and Enlarged Edition, Daya Publishing House, Delhi
4. Singh, S.K. 2005. Text book of Wildlife Management. International Book Distributing Co.Lucknow, U.P.

FR 9005 Applied Microbiology **3-0-0= 3**

Unit I	Microbial life and techniques: Microbial world and their importance, Classification of microorganisms, Microbiological methods- microscopy, sterilization, micrometry, culture techniques, isolation, purification & maintenance of microbial cultures, microbial nutrition, Bacterial genetics - methods of gene transfer in prokaryotes.	8-Lectures
Unit II	Microbial diversity: Habitats & niches of microorganisms - rhyzosphere, phyllosphere, endophytic, soil, water, air and other habitats, bacterial, fungal and actinomycetes diversity, role of microbes in ecosystem functioning, litter decomposers, fungi & forests, wood decaying, coprophillous, keratinophillous, entomogenous, carnivorous fungi & bacteria and their importance.	9-Lectures
Unit III	Symbiotic microbes: Nitrogen fixers & phosphate solubilizers (symbiotic and free living) in forests, their role in nutrient cycling, PGPRs, actinorrhizal and mycorrhizal associations, their types and importance in plant health, biofertilizers.	8-Lectures
Unit IV	Microbial processes & bioprospecting: Fermentation-fermenter/ biorector, plant design and working principles, Production of bioactive natural compounds- antibiotics, biosurfactants, steroids, colorants, mycoprotien, microbial polysaccharides, recombinant vaccines, nutraceuticals and proteins, Ethanol production.	8-Lectures

Unit V	Beneficial and harmful microbes: Microbial diseases of forest vegetation: disease cycle, parasitism, classification of plant diseases, symptoms, Koch's Postulates, Methods of plant disease controls– exclusion, cultural, biological and chemical, Strategies for integrated disease management; Beneficial microbes - biopesticides, bioremediation, bioleaching, MEOR, Wild edible fungi.	9-Lectures

Suggested Readings:

1. Microbial Biotechnology-Fundamentals of Applied Microbiology, by Glazer, AN & Nikaido, H, Second Edi tion, Cambridge University Press, 2008.
2. Microbiology by Pelczar, M. J., Chan, E. C. S. & Krieg, N. R., Tata McGraw-Hill Pub. Co. Ltd., New D elhi, 1986.
3. Principles of Forest Pathology by Tainter, F. H. & Baker, F. A., Hohn Wiley & Sons, Inc., New York, USA, 1996.
4. Tree Disease Concepts by Manion, Paul D., Prentice-Hall, Inc., New Jersy, USA, 1981.
5. Process Biotechnology Fundamentals by Mukhopadhyay, SN, Third Edition, Viva Books, New Delhi, 2010.
6. The Industrial Microbiology, Patel, AH, MACMILLAN India Limited, 1999.

FR 9006 Agroforestry 3-0-0=3

Unit I	Introduction to Agroforestry, Agroforestry definition, History and evolution of Agroforestry management in India, Overview of Indian agriculture- its structure and constraints, impacts of green revolution.	8-Lectures
Unit II	Theory and practice of participatory approaches of Agroforestry, implement and enhancement of Agroforestry activities and increasing local people's benefits from Agroforestry development with special reference to NE India.	8-Lectures
Unit III	To impart knowledge on recent development on Agroforestry model and its economics with special reference to North East Region. Agroforestry: the concepts and principles, tree crop interface, interaction effects, environmental factors in Agroforestry, ecological benefits, diagnosis and design of Agroforestry models, criteria of good forestry design, design and analysis of Agroforestry experiments.	8-Lectures
Unit IV	The use of economics in diagnosis and design of Agroforestry systems; cost and benefits in Agroforestry; valuation of inputs and outputs; environmental outpuse. Recent trend in Agroforestry research and development, Agroforestry land use system and their salient feature. Modelling in Agroforestry. Intercropping mixed intercropping, fodder bank, woodlots.	9-Lectures
Unit V	Problems and prospects of shifting cultivation and sustainable agriculture of tropical forest soils, nutrient management in forest soil (organic & inorganic fertilizers), liming and biological nitrogen fixation; soil fertility and fertilization. Soil degradation and erosion-causes, impacts and management in forest ecosystems.	9-Lectures

Suggested Readings:

1. Nair, P.K.R. 1993. An Introduction to Agroforestry. Kluwer.
2. Dwivedi, A.P. 1992. Agroforestry: Principles and Practices. Oxford & IBH.
3. Chundawat, B.S. and S.K. Gautam. 1993. Textbook of Agroforestry. Oxford & IBH Publishing CO. PVT.LTD. New Delhi.
4. Arnold, J. E. M. 1991.Community Forestry*: Ten Years in Review*. Community Forestry Note 7, revised edition. Rome: Food and Agriculture Organization.
5. Soils of Tropical Forest Ecosystems (1998). A.Schulte and D. Ruhiyat (Edrs), Springer Verlag, Heidel berg, Germany.
6. Khosla, P.K. and Khurana, D.K. 1987. Agroforestry for rural needs. Vol. 1 and II.
7. SenSarma, P.K. and Jha, L.K. 1993. Agroforestry. Indian Perspectives. APH Publishing Corporation, Ne w Delhi.
8. Huxley, P. 1999. Tropical agroforestry. Blackwell Science, Oxford. ISTS, Solan, H.P.
9. Young, A. 1989. Agroforestry for Soil Conservation. C A B International Council for Research in Agroforestry. 265p

FR 9007 Nursery and Plantation Technology **3 0 0 =3**

Unit I	Establishment of forest nursery*:* Nursery, its categories, objects and importance, selection of nursery site, layout and establishment, seed sowing techniques in nursery, transplanting of seedling, vegetative propagation, management of containerized seedling production, preparation of potting mixture, calendar of operations.	9-Lectures
Unit II	Management of forest nursery*:* Water management, determining nursery water requirement, irrigation system, protection of seeds, shade management, disinfection, weeding and soil working, nutrient management, nutrient storage.	9-Lectures
Unit III	Symptom of mineral deficiency and toxicity, nutrient deficiencies, dusters, sprayers, role of plants growth substances. Root culturing, management of disease in nursery, insect pest of forest nurseries and their management.	8-Lectures
Unit IV	Plantation techniques of selected commercial plant species (tea, sal, teak, deodar, gamari, cashew, casuarinas, eucalyptus and poplar). Failure of plantations – reasons and mitigation; Ecological factors and long-term productivity.	8-Lectures
Unit V	Plantation cycle, transplantation; Different Plantation pattern; Intercropping, Management of Plantation- Cultural operations carried out in different plantations. Crop rotation.	8-Lectures

Suggested Readings:

1. FAO 1978. Establishment techniques for plantations, FAO Publications, Rome, Italy.
2. Kumar, V. 1999. Nursery and plantation practices in Forestry, Scientific Publishers, Jodhpur.
3. Luna, R.K. 1989. Plantation forestry in India, IBD, Dehra Dun.
4. Luna, R.K. 1996. Plantation trees. IBD, Dehra Dun.
5. Ram Prakash, 1986. Nursery plantation techniques in forestry in India. Suman Book House, Delhi.

FR 9008 Forest Ecology and Management **3-0-0=3**

Unit I	Concepts of ecology and ecosystem, Ecosystem energetics, Production and decomposition of organic matter, Nutrient cycling.	8-Lectures
Unit II	Forest geography, Succession and climax, Habitat fragmentation, Causes of forests degradation, natural resources conservation, Conservations laws & acts.	9-Lectures
Unit III	Biological diversity, Forest management: scope, objectives and principles, Normal forest characteristics, Principle of sustained yield.	8-Lectures
Unit IV	Increment and rotation, Growth and stand structure of even - and uneven aged stands, Development of forest management/working plan.	8-Lectures .
Unit V	Site quality and its assessment, Stocking, density and spacing, Multiple use forest management, Management of farm plantations. Valuation of tree, timber stand, the land and the forest.	9-Lectures

Suggested Readings:

1. Singh, J.S, Singh, S.P and Gupta, SR. 2006. Ecology, Environment and Resource Conservation. Anamaya Publ. New Delhi.
2. Hosetti, B.B. 1997. Concepts in wildlife management. Daya Publishing House, Delhi.
3. Khan, T.I. and Al-Ajmi, D.N. 1999. Global biodiversity conservation measures, Pointer Publishers, Jaipur.
4. Odum, 1996 E.P. Fundamentals of Ecology. Natraj Publishers, Dehradun.
5. Sinha, P.C. 1998. Wildlife and forest conservation. Anmol Publishing Pvt.Ltd., New Delhi.

FR 9009 Remote Sensing and GIS in Forestry **3-0-0=3**

Unit I	Principles and basic concepts of remote sensing; Energy sources and types; EMR; Interaction of radiation with atmosphere; Spectral responses; Satellites and Sensors; Platforms; Types of resolution; Landsat and IRS programmes.	9-Lectures
Unit II	Visual image interpretation: elements, keys, techniques; Digital image processing: preprocessing, image enhancement, transformation and classifications; Raster, vector, spatial and non-spatial data; Remote sensing data storage formats.	8-Lectures

Unit III	Data Input and Editing; Raster and vector data models, Fundamentals of Global Positioning System (GPS), Instrumentation of GPS, Limitations, processing methods, Data collection methods. Practical exposure on GPS.	8-Lectures
Unit IV	Geographic information system: introduction, scope and applications. Integration of Remote Sensing and GIS, Subsetting and Mosaicking, Creating and Editing new layers, Adding and Updating attribute information, Annotations and Labeling. Ground truthing and Image classification; Map concepts.	9-Lectures
Unit V	GIS applications: Joint forest management, Forests change detection, Forest resources management, Site suitability for plantations & re-forestation, Wildlife conservation and migration, Ecotourism development.	8-Lectures

Suggested Readings:

1. Text Book of Remote Sensing and GIS, A.M. Reddy, BSB Publication, Hyderabad, 2002.
2. Remote Sensing of the Environment, R.J. Jensen, Pearson and Education, 2003.
3. Remote Sensing and Image Interpretation, T.M. Lilisand, R.W.Kiefer and J.W. Chipman, Wiley and Sons, 2004.
4. Remote Sensing: Models and Methods for Image Processing, R.A. Schowengerdt, Elsevier Publication, 2006.
5. Text Book of Remote Sensing and GIS, K.C. Sahu ATLANTIC Publication, New Delhi, 2008.

FR 9010 Wood Technology 3-0-0=3

Unit I	Wood and its formation, Characteristics and properties of wood. Growth-related defects in wood.	8 Lectures
Unit II	Physical and mechanical properties of wood, Reaction wood – anatomy, physical and chemical properties of reaction wood, effect of tension wood and compression wood on wood products.	9-Lectures
Unit III	Wood anatomy and the environment, Dendrochronology and dendroclimatology, Figure in wood, Advantages of quarter sawn and plane sawn timber.	9-Lectures
Unit IV	Wood adhesives – types, characteristics and their applications, wood impregnation and compregnation.	8-Lectures
Unit V	Introduction to wood modification, its needs and scope, chemical modification of wood.	8-Lectures

Suggested Readings:

1. Textbook of Wood Technology by A. J. Panshin and C. de Zeeuw, McGraw Hill Book company, New York, 1980.
2. Juvenile Wood in Forest Trees by B.J. Zobel and J. R. Sprague, Springer, 1998.
3. The Anatomy of Wood: its diversity and variability by K. Wilson and D.J.B.White, Stobart& Sons Ltd. London,1986.
4. Wood Seasoning Technology by C.N. Pandey and V.K. Jain, ICFRE, 1992.
5. Wood Preservation Manual by F.A.O. (Reprinted) IBD Dehra Dun, 1986.

FR 9011 Principles & Techniques in Biotechnology 3-0-0=3

Unit I	Introduction: Biotechnology - past, present and future, scopes and applications of biotechnology, Biosafety guidelines and regulations, prevention and misuse of biotechnology, IPR, IPP, & Patents in biotechnology.	8-Lectures
Unit II	Plant tissue culture: Principles of *In Vitro* culture techniques, cellular totipotency, callus & organ culture, micropropagation, organogenesis, somatic embryos & artificial seeds, protoplast isolation, fusion & hybridization, somaclonal variation, triploid production, transgenic plants & crop improvement, *in vitro* establishment of mycorrhizae.	9-Lectures

Unit III	Bioprospecting: Bioprospecting of natural products from microorganisms and plants-primary and secondary metabolites, enzymes, single cell proteins (SCPs), fermentation technology, fermenters/ bioreactors, biodegradation and bioremediation, biosensors, biofuels, nitrogen fixation and genetics of diazotrophs.	9-Lectures
Unit IV	Molecular techniques: DNA and RNA as genetic materials. DNA isolation & purification, gel electrophoresis - Agarose and polyacrylamide gel electrophoresis, DGGE, quantification & quality of DNA, restriction, size determination of DNA fragments, ligation, genetic transformation, PCR technology & its applications RT-PCR, molecular markers, DNA sequencing and analysis.	8-Lectures
Unit V	Genetic engineering: Tools of Genetic Engineering-restriction and modification, restriction, enzymes, *Agrobacterium* mediated transformations, Microarrays of cDNA & oligonucleotide, detection, Micro array design & fabrication, detection technology, computational analysis of micro array data, genome editing-CRISPR Technology.	8-Lectures

Suggested Readings:

1. A Text Book of Biotechnology by R. C. Dubey, S. Chand & Co. Ltd., New Delhi, 2009
2. Principles of gene manipulation and genomics by Primrose, SB & Twyman, RM, &th edition. Blaclwell publishing, 2006.
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA (2nd Edition) by B.R. Glick and J.J. Pasternak, ASM Press, Washington, DC, 1998.
4. Molecular Biology: Principles & Practice by Siwach & Singh, Laxmi Publications P. Ltd., New Delhi, 2010.
5. Molecular Cloning: A laboratory Manual, 2nd Edition (Vol I-IV), by Sambrook, J. Fritsch, E. F. and Maniatis, T., Cold Spring Harbor Laboratory, Cold Spring harbor, New York, 1989.
6. An Introduction to Plant Tissue Culture, 1st Edition, K.K. De, New Central Book Agency, Kolkata, 1992.
7. Molecular Biotechnology: Principles and applications of Recombinant DNA. 2nd Edition, by B.G. Glick and J. J. Pasternak, ASM Press, Washington D.C. (First Indian Reprint, Replika Press Pvt. Ltd., New Delhi), 2001.
8. Plant Molecular Biotechnology, by S. Mahesh, New Age International Publishers, New Delhi, 2008.

FR 9012 Research Methodology **4-0-0=4**

Unit I	Basic concepts on Research: Definition, Objectives and Types of Research, Technique involved in defining a problem; Significance of literature, types of research designs Reports/ manuscripts/ thesis and report writing: Layout of research report, different steps in writing report, Types of reports, oral presentation, Mechanics in writing a research report, Ethical issues in research, Plagiarism, Citation, Impact factor and citation index, H-index, Basic concepts of paper writing.	11-Lectures
Unit II	Data collection: Experiments and surveys, Collection of primary data methods, Guideline for constructing questionnaire/Schedule survey, Secondary data collection methods, Data preparation: Data preparation process, Measurements and Scaling; Design of sample surveys: Sample design, Sampling and non-sampling errors, Sample survey Vs. Census survey, Types of designs.	11-Lectures
Unit III	Descriptive statistics: Measurement of central tendency, Measure of dispersion, Kurtosis, Measures of relationship: Covariance, Karl's Pearson's Coefficient of correlation, Rank correlation; Data analysis and statistical treatments: Elements and types of data analysis, Statistics in scientific research, Least Significant Difference (LSD), Nonparametric test like Mann Whitney U test, Kruskul Wallis test, Spearman's rank correlation.	11-Lectures
Unit IV	Hypothesis and fitness tests: Hypothesis: Definition, Basic concepts of concerning testing of hypothesis, Null and alternate hypothesis, Testing hypothesis, Procedure for hypothesis testing, Hypothesis testing for mean, variance, proportion; P-value approach, limitation of the tests of hypothesis, Probability and significance levels, T-test, F-test, ANOVA, Correlation, Regression, Principal Component Analysis (PCA), Chi-Square test.	11-Lectures

Unit V	Basics in instrumentation: Laboratory Safety Measures, Principles and handlings of instruments: Polymerase Chain Reaction (PCR), Electrophoresis techniques, Microtomy and Micrometry, Fixatives and Staining, Microscopy, Herbarium techniques, Nitrogen analyser, Spectrophotometry, Flame photometry, GPS, Soxhlet apparatus, Canopy analyser, Statistical and GIS software, Cytological techniques, Camera trap technique, Radio telemetry, Microchip, Range finder.	12-Lectures

Suggested Readings:

1. Kothari, C.R. and Gaurav, G. 2014. Research methodology: methods and techniques, Third edition, New Age International Publishers, New Delhi.
2. Kothari, C.R. 2004. Research Methodology: An Introduction, Delhi, New Age.
3. Krishnaswami, K.N., Mathiarajan,M. 2008. Management Research Methodology, Integration of Principles and Techniques, New Delhi. Dorling Kindersley (India Pvt. Ltd, Pearson Education.
4. Rao,P.S.S. and Richard,J.2010. Introduction to Biostatistics and Research Methods.
5. Kumar, R. 2009. Research Methodology: a step by step guide for Research. New Delhi, Pearson Education.
6. Bajapai P.K. 2006. Biological Instrumentation and Methodology, New Delhi, S Chand and co Ltd.
7. Neogi,U.K.2011. Research Methodology: Tools and Techniques, Variety Books Publisher's Distributers, New Delhi.
8. Zar,J.H. 1999. Biostatistical Analyses. Dorling Kindersley (India Pvt. Ltd), New Delhi.

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY

SYLLABI
OF
PG / Ph. D. COURSES
(DEPARTMENT OF CENTRE FOR MANAGEMENT STUDIES)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY
(UNDER THE MINISTRY OF EDUCATION, GOVT. OF INDIA)
DEEMED TO BE UNIVERSITY U/S 3 OF THE UGC ACT, 1956
NIRJULI - 791 109 :: ARUNACHAL PRADESH

SYLLABI
OF
PG/ Ph. D COURSES

(DEPARTMENT: CENTRE OF MANAGEMENT STUDIES)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY (NERIST)

(Deemed to be University, U/S 3 Of the UGC Act, 1956)
Nirjuli (Itanagar), Arunachal Pradesh- 791 109

Year : First **Semester- I**

Sl No.	Course Code	Course Description	L	T	P	Credit
1	MB7101	Principles of Management	3	0	0	3
2	MB7102	Business Economics	3	0	0	3
3	MB7103	Quantitative Techniques	3	0	0	3
4	MB7104	Accounting for Managers	3	0	0	3
5	MB7105	Operations Management	3	0	0	3
6	MB7106	Business Law	3	0	0	3
7	MB7107	Organizational Behaviour	3	0	0	3
8	MB7108	Business Environment	3	0	0	3
9	MB7151	Business Communication and IT Lab	0	0	4	2
		Total Credits				**26**

Year : First **Semester- II**

Sl No.	Course Code	Course Description	L	T	P	Credit
1	MB7201	Marketing Management	3	0	0	3
2	MB7202	Research Methodology	3	0	0	3
3	MB7203	Human Resource Management	3	0	0	3
4	MB7204	Management Information System	3	0	0	3
5	MB7205	Financial Markets Institutions & Services	3	0	0	3
6	MB7206	Business Ethics & Corporate Governance	3	0	0	3
7	MB7207	Financial Management	3	0	0	3
8	MB7208	Cost and Management Accounting	3	0	0	3
		Total Credits				24
		Cumulative Credit (I + II)				**50**

Year : Second **Semester- I**

Sl No.	Course Code	Course Description	L	T	P	Credit
1	MB8101	Project Management	3	0	0	3
2	MB8102	Strategic Management	3	0	0	3
3	MB8151	Enterprise Resource Planning	0	0	4	2
4		Specialization Group -1 Elective 1**	3	0	0	3
5		Specialization Group -1 Elective 2**	3	0	0	3
6		Specialization Group -2 Elective 1**	3	0	0	3
7		Specialization Group -2 Elective 2**	3	0	0	3
8	MB8199	Industrial Training (Non Credit)*	0	0	4	2
		Total Credits				20
		Cumulative Credit (I + II+III)				70

LIST OF ELECTIVES (2nd Year First Semester):

(A)	**Finance Specialization**		**L**	**T**	**P**	**Credit**
1	MB 8110	Security Analysis and Portfolio Management	3	0	0	3
2	MB 8111	Corporate Taxation	3	0	0	3
(B)	**Marketing Specialization**		**L**	**T**	**P**	**Credit**
3	MB 8120	Sales and Distribution Management	3	0	0	3
4	MB 8121	Marketing of Services	3	0	0	3
(C)	**HR Specialization**		**L**	**T**	**P**	**Credit**
5	MB 8130	Strategic Human Resource Management	3	0	0	3
6	MB 8131	Industrial Relations and Labour Legislations	3	0	0	3
(D)	**Operations Specialization**		**L**	**T**	**P**	**Credit**
7	MB 8140	Supply Chain Management	3	0	0	3
8	MB 8141	Computer Integrated Manufacturing	3	0	0	3
(E)	**Systems Specialization**		**L**	**T**	**P**	**Credit**
9	MB 8144	Decision Support System	3	0	0	3
10	MB 8145	DBMS &Data Warehousing	3	0	0	3

Year : Second **Semester- I**

Sl No.	Course Code	Course Description	L	T	P	Credit
1	MB8201	International Business	3	0	0	3
2	MB8202	Total Quality Management & Six Sigma	3	0	0	3
3	MB8299	Dissertation	0	0	16	8
4		Specialization Group -1 Elective 1**	3	0	0	3
5		Specialization Group -1 Elective 2**	3	0	0	3
6		Specialization Group -2 Elective 1**	3	0	0	3
7		Specialization Group -2 Elective 2**	3	0	0	3
		Total Credits				26
		Cumulative Credit (I + II+III+IV)				96

LIST OF ELECTIVES (2nd Year Second Semester):

(A)	**Finance Specialization**		**L**	**T**	**P**	**Credit**
1	MB 8210	International Financial Management	3	0	0	3
2	MB 8211	Financial Derivatives and Risk Management	3	0	0	3
(B)	**Marketing Specialization**		**L**	**T**	**P**	**Credit**
3	MB 8220	Integrated Marketing Communication	3	0	0	3
4	MB 8221	Consumer Behaviour and Retail Marketing	3	0	0	3
(C)	**HR Specialization**		**L**	**T**	**P**	**Credit**
5	MB 8230	Performance Management, Training and Development	3	0	0	3
6	MB 8231	Organisational Change and Development	3	0	0	3
(D)	**Operations Specialization**		**L**	**T**	**P**	**Credit**
7	MB 8240	Materials Management	3	0	0	3
8	MB 8241	Advanced Production Management	3	0	0	3
(E)	**Systems Specialization**		**L**	**T**	**P**	**Credit**
9	MB 8244	Systems Analysis and Design	3	0	0	3
10	MB 8245	Data Mining& Soft Computing	3	0	0	3

SEMESTER-I (1ST YEAR)
PRINCIPLES OF MANAGEMENT

Course Code:MB-7101 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Nature and Functions of Management, Tasks of a Professional Manager, Social Responsibilities of Business, Manager and Environment, Systems Approach to Management, Levels in Management, Managerial Skills.	**8 Hours**
Unit-II	Planning, Steps in Planning Process, Scope and Limitations, Short Range and Long Range Planning, Flexibility in Planning,Characteristics of a Sound Plan, Management by Objective (MBO), Policies and Strategies, Scope and formulation, Decision Making, Techniques and processes	**8 Hours**
Unit-III	Organising, Organisation Structure and Design, Authority Relationships, Delegation of Authority and Decentralisation, Interdepartmental Coordinator, emerging Trends in corporate Structure, Strategy and Culture, Impact of Technology on Organisational design, Formal and Informal Organisation, Network Structure.	**8 Hours**
Unit-IV	An Overview of Staffing, Manpower planning, and related aspects: Leading functions, Skills and Styles; Controlling, Prerequisites of Control Systems, Control Process, Methods, Tools and Techniques of Control, Design of control mechanism, Choices in Control.	**8 Hours**
Unit-V	Comparative Management Styles and approaches, Japanese Management Practices, Organisational Creativity and Innovation, Management of Innovation, Entrepreneurial Management, Benchmarking, Best Management Practices across the world, Select cases of Domestic &International organisations, Management of Diversity.	**10 Hours**

Text Books:

1. Koontz & Weihrich: Management, McGrawHill
2. Stoner & Wankel: Management, Prentice-Hall
3. Peter F. Drucker: Practice of Management, Pan Books
4. L.M Prasad: Principles of Management, S.Chand and Sons, New Delhi
5. Stephen P Robbins: Fundamentals of Management, Pearson Education
6. Banerjee: Management Essentials, SAGE Publication.

BUSINESS ECONOMICS

Course Code:MB-7102 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Ten principles of economics,the market forces of supply and demandElasticity and its applicationsthe costs and economics of production	**8 Hours**
Unit-II	Firms in competitive markets: Monopoly; Oligopoly; Monopolistic competition	**8 Hours**
Unit-III	Theory of cost; theory of production; Factors of production	**8 Hours**
Unit-IV	Pricing decisions, General theory of pricing, Peak load pricing, Pricing over life cycle of a product, Cost plus pricing, Multi-product pricing, Transfer pricing and Cost oriented prices	**8 Hours**
Unit-V	Macroeconomics – Basic concepts: Measuring a nation's income; Concepts of GDP, GNP, PPP; measuring the cost of living; Production and growth, the monetary system, Money growth and inflation; Open-economy	**10 Hours**

Text Books:

1. Gupta G.S., Managerial Economics, Tata McGraw-Hill.
2. Mankiw N G, Principles of Microeconomics, Cengage Learning
3. Dwivedi, D. N., Managerial Economics, Vikas Publishing House Pvt. Ltd, 7th Edition, 2008
4. Shapiro, Edward, Macroeconomic Analysis, Galgotia Publications (P) Ltd, 5th Edition, 2002
5. Thomas, Christopher R & Maurice, S Charles, Managerial Economics: Concepts and Applications, TataMcG raw Hill, 8th Edition, 2007.

6. Banik: The Indian Economy, SAGE Publication.
7. Nattrass:Macroeconomics Simplified: SAGE Publication
8. Suresh:Economy and Society: SAGE Publication

QUANTITATIVE TECHNIQUES

Course Code:MB-7103 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Basic Mathematics for Management: Basic calculus and application, matrix algebra and applications, Input-Output Model.	**9 Hours**
Unit-II	Measures of Central Tendency, Measures of Variation, Skewness, Kurtosis, Correlation, and Regression.	**9 Hours**
Unit-III	Basic concepts of Probability, Discrete and continuous probability, Decision theory.	**8 Hours**
Unit-IV	Linear Programming, Graphical Method, Simplex Method, Sensitivity Analysis, Duality, and Integer Programming.	**8 Hours**
Unit-V	Game theory, Zero sum Games, Non zero sum Games, Markov Chains.	**8 Hours**

Text Books:

1. Hamdy A Taha, Operations Research, PHI, 7th Edition.
2. Levin and Rubin, Statistics for Management, PHI, New Delhi
3. Mouhammed, Quantitative Methods for Business and Economics, PHI, New Delhi
4. Sharma, J.K. Mathematics for Business and Economics. Asian Books Private Limited: New Delhi, 2012
5. Anthony, M. and Biggs, N. Mathematics for Economics and Finance: Methods and Modelling; CUP, 2012
6. Mohanty: Statistics for Behavioural and Social Sciences: SAGEPublication

ACCOUNTING FOR MANAGERS

Course Code :MB-7104 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Introduction: Accounting Concepts and Convention, Accounting as an information system, Accounting Equation, Double Entry systems of accounting, Journal Entry, Books of Accounts, Accounting Cycle, Classification of Accounting- Financial Accounting, Cost Accounting and Management Accounting.	**9 Hours**
Unit-II	Preparation of Ledger, Cash Book, Bank Reconciliation Statement, Trial Balance. Capital and Revenue Expenditure, Deferred Revenue Expenditure, Capital and Revenue Receipts.	**6 Hours**
Unit-III	Depreciation, Definition, Causes, Necessity of providing for depreciation, Methods of Calculating Depreciation: Straight Line Method and Written Down Value Method; Provisions and Reserves, Profit and loss Statement, Balance sheet.	**12 Hours**
Unit-IV	Accounting Standards and Applicability: Indian Accounting Standards, IFRS, Convergence; Disclosure of Accounting Policies (AS-1), Valuation of Inventories (AS-2), Depreciation Accounting (AS-6), Income Recognition & Accrual Income (AS-9), Accounting of Fixed Assets (AS-10), Accounting for Intangible Assets (AS-26), Accounting for Investments (AS-13), Financial Instruments Recognition and Measurement (AS 30)	**9 Hours**
Unit-V	Contemporary issues in accounting: Accounting for Non- profit Organisation, Human Resource Accounting, Accounting of Banking and Insurance Company, Environmental Accounting.	**6 Hours**

Text Books:

1. Mukherjee H. Financial Accounting, Tata McGraw-Hill
2. Radhaswamy, Gupta, Advanced Financial Accounting, Sultan Chand
3. Maheswari, S. N., Financial Accounting, Sultan Chand, New Delhi,13th Edition, 2003
4. Webster, W.H., Accounting for Managers, Tata Mc Graw-Hill, New Delhi, 2nd Edition, 2004
5. Shim, J. K & Siegel, Joel G., Financial Accounting, Tata Mc Graw-Hill Publishing, New Delhi, 2nd Edition, 2004
6. Lal, Jawahar, Accounting for Managers, Himalaya Publishing House, New Delhi, 3rd Edition, 2002
7. Marriott: Introduction to Accounting: SAGE Publication.

OPERATIONS MANAGEMENT

Course Code: MB-7105 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Introduction to Operation Management, Types of Production systems, designing of Production system, Designing Service Processes, Measuring Service Quality using SERVQUAL.	**7 Hours**
Unit-II	Outsourcing, Offshoring, Facility Location Planning, Transportation Model for location Planning, Ardalan Heuristic for Location Planning of Service Facilities.	**9 Hours**
Unit-III	Facility Capacity and Layout Planning, Assignment Model in Layout Model, Load-Distance Analysis in Process Layouts.	**9 Hours**
Unit-IV	Project Management, Network Diagrams, Critical Path Methods, Program Evaluation and Review Techniques, Application of Microsoft Project.	**9 Hours**
Unit-V	Inventory Management, Types of Costs, Monte Carlo Simulations in Inventory Management, Material Requirement Planning, Operation Scheduling.	**8 Hours**

Text Books:

1. Hamdy A Taha, Operations Research, PHI, 7th Edition
2. Bedi, Production Opertion Management, OXFORD UNIVERSITY PRESS, 2nd Edition.
3. Vohra. Quantitative Techniques in Management. Tata McGraw Hill Publishing Company:New Delhi, 2009.
4. Sharma. Operations Research - Theory and Applications. Macmillan India Limited: New Delhi, 2013

BUSINESS LAW

Course Code: MB-7106 **L-T-P** (3-0-0), **Credit**-3

Unit-I	The Indian Contract Act, 1872, Definition of contract, nature and elements of a valid contract, Nature, offer and acceptance consideration,Agreement vis-a-vis contract, void agreement & voidable contractCapacity to contract, Free Consent,Legality of Object, Contingent contracts.	**8 Hours**
Unit-II	Indian Partnership act, Sale of Goods Act, Insurance Act- 1938 Salient features.	**9 Hours**
Unit-III	Membership, Kinds of Share Capital, Debentures, Board of Directors-Composition, Qualification, Appointment, Power & Duties, andRemoval.	**9 Hours**
Unit-IV	Salient features of Factories Act 1948, Trade Union act, Industrial Dispute Act.	**8 Hours**
Unit-V	Salient features of Consumer Protection Act, 1986, The Information Technology Act, 2000, Competition Act.	**8 Hours**

Text Books:

1. Kapoor, N D, Mercantile Law, Sultan Chand
2. Seth Tejpal, Business Law, Pearson
3. Business Law including Company Law, Gulshan S.S, Kapoor G.K, New Age International Publications.
4. Mercantile and Commercial Laws, RohiniAggarawal, Taxmann's Publication
5. Legal Aspects of Business, A Pathak, Mcgraw Hill Education

ORGANISATIONAL BEHAVIOUR

Course Code: MB-7107 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Introduction to Organization: Concept, Structure, Types of Organization. Significance of Organizational Behaviour.	**9 Hours**
Unit-II	Determinants of Individual Behaviour: Personality - Concept, Determinants and Theories. Perception - Perceptual Process, Selectivity and Managing Perception. Managerial Implications of Perception. Learning - Concept, Theories and Managerial Implications.	**9 Hours**
Unit-III	Motivation: Concept and Its relevance for Individual and Organization. Theories - Maslow, Herzberg, McClelland, Vroom's, Equity. Group and Individual: Group and Group Dynamics, Team Building process and Skills required for Team Management.	**9 Hours**

Unit-IV	Communication- Concept, Process, Barriers, their remedies. Leadership - Concept, Theories and Styles. Implications for different Stakeholders.	**8 Hours**
Unit-V	Group Activities: Concept, Types and Formation of Groups. Intergroup Behaviour. Interpersonal Communication and Its Impact on Group. Group Problem Solving. Transactional Analysis. Stress and Behaviour: Concept and Nature of Stress. Sources of Managerial Stress. Stress and Personality. Verbal and Non-Verbal Indicators of Stress - Assessment and Management	**8 Hours**

Text Books:

1. Robbins, Judge, Sanghi. Organization Behaviour. Pearson Education: New Delhi, 2008
2. Khanka S.S. Organization Behaviour. S.Chand and Company: New Delhi, 2009
3. Luthans Fred, Organizational Behavior, Mc Graw Hill India, New Delhi, 9th Edition 2002
4. Mcshane Steven L., Glinow Mary Ann Von & Sharma Radha R., Organizational Behaviour, Tata McGraw Hill , New Delhi, 4th Edition, 2008
5. Ivancevich John M., Konopaske Robert & Matteson Michael T., Organizational Behavior and Management, Tata Mc Graw Hill India, New Delhi, 7th Edition, 2006.
6. Nahavandi: Organization Behaviour, SAGE Publication.
7. Sinha: Culture and Organizational Behaviour: SAGE Publication.

ORGANISATIONAL BEHAVIOUR

Course Code: MB-7107 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Introduction to Organization: Concept, Structure, Types of Organization. Significance of Organizational Behaviour.	**9 Hours**
Unit-II	Determinants of Individual Behaviour: Personality - Concept, Determinants and Theories. Perception - Perceptual Process, Selectivity and Managing Perception. Managerial Implications of Perception. Learning - Concept, Theories and Managerial Implications.	**9 Hours**
Unit-III	Motivation: Concept and Its relevance for Individual and Organization. Theories - Maslow, Herzberg, McClelland, Vroom's, Equity. Group and Individual: Group and Group Dynamics, Team Building process and Skills required for Team Management.	**9 Hours**
Unit-IV	Communication- Concept, Process, Barriers, their remedies. Leadership - Concept, Theories and Styles. Implications for different Stakeholders.	**8 Hours**
Unit-V	Group Activities: Concept, Types and Formation of Groups. Intergroup Behaviour. Interpersonal Communication and Its Impact on Group. Group Problem Solving. Transactional Analysis. Stress and Behaviour: Concept and Nature of Stress. Sources of Managerial Stress. Stress and Personality. Verbal and Non-Verbal Indicators of Stress - Assessment and Management	**8 Hours**

Text Books:

1. Robbins, Judge, Sanghi. Organization Behaviour. Pearson Education: New Delhi, 2008
2. Khanka S.S. Organization Behaviour. S.Chand and Company: New Delhi, 2009
3. Luthans Fred, Organizational Behavior, Mc Graw Hill India, New Delhi, 9th Edition 2002
4. Mcshane Steven L., Glinow Mary Ann Von & Sharma Radha R., Organizational Behaviour, Tata McGraw Hill , New Delhi, 4th Edition, 2008
5. Ivancevich John M., Konopaske Robert & Matteson Michael T., Organizational Behavior and Management, Tata Mc Graw Hill India, New Delhi, 7th Edition, 2006.
6. Nahavandi: Organization Behaviour, SAGE Publication.
7. Sinha: Culture and Organizational Behaviour: SAGE Publication.

BUSINESS ENVIRONMENT

Course Code: MB-7108 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Meaning, concepts, and components of Business Environment-Economical, Social, Political, Cultural, Physical and Natural, Technological, Economic Systems – Capitalism, Socialism, Communism and Mixed –Economic System. Business and Society in India.	**8 Hours**
Unit-II	Management Structure and forms of Business – Family Management to Professional Management, Sustainable development of the firm; MNCs; Foreign Capital and Collaboration.	**9 Hours**
Unit-III	Industrial Policies, Industrial (D&R) Act, Exim policies, Export Oriented Units and SEZs.	**9 Hours**
Unit-IV	Regulatory environment of Business; RBI, SEBI, IRDA, TRAI, FIPB etc.	**8 Hours**
Unit-V	LPG; Competition and overview of WTO and GATS; Current and future perspectives of Indian Industries and Management.	**8 Hours**

Text Books:

1. Francis Cherunilam: Business Environment, Himalaya Publishing House, New Delhi
2. Paul, Justin, Business Environment – Text and Cases, McGraw Hill, 2nd Edition, 2008
3. Misra, S. K &Puri, V. K., Economic Environment of Business, Himalaya Publishing House, 5th Edition,2 009.
4. Mittal, Vivek, Business Environment, Excel Books, 1st Edition, 2007
5. Dayal, Vikram& Chopra, Kanchan, Handbook of Environmental Economics in India, Oxford University Pres s, India, 1st Edition, 2009
6. Business Environment: Concepts and Techniques, Vandana Sharma, Book Enclave.
7. Conklin:Cases in the Environment of Business, SAGE Publication.

BUSINESS COMMUNICATION AND IT LAB

Course Code:MB-7151 **L-T-P** (3-0-0), **Credit**-3

Ice-Breaking Session Activity: Talking to each other and find out various likes and dislikes of the person sitting next. The student may speak about him and what did he like most etc.
Analysing Strengths and Weaknesses Activity: to prompt the students to speak on their strengths and weaknesses.
Speech with Expression Activity: On a given situation a student has to frame a short speech keeping in view of the body lan guage.
Extempore Activity: To speak on a given topic without any time for preparation such as: Anger, corruption, fre edom etc.
Group Discussion Activity: Stages of group discussion is to be explained i.e. Storming, Norming, Forming and Performi ng. Teams are to be made of five or six and topics should be given for discussion.
Face off Activity: Teams are to be made of five or six. The teams are supposed to argue on the same topic and justify.
Mock Interviews Activity: Selecting panel members from the students and asking the students to face the interview. T he interviewers could again be a panel member on a rotation basis.
Poster Presentation Activity: The students can prepare posters of various current issues and have a discussion without P PT.PPT - The do's and don'ts of PPT is to be at first explained and then they can prepare PPT. Seminar Pres entation

Writing Practices Report Writing, which would include planning and preparation of a report; Technical Writing; Documentation and Note Taking; Error Analysis
Organizing a Meeting Preparation of Agenda
Public Speeches Activity: Students to be introduced to various speeches and then prepare speeches to address an audience. **Turncoats (It helps a student to handle a situation)** Activity: A student has to start speaking on given topic by the instructor and suddenly the mode of the topic is to be changed and the student has to continue to speak without stopping. Case Studies
Analysis on Active Listening Skills Activity: To make a student listen to an audio and repeat the information of the audio. Case Studies on Communication Barriers and Feedback
Grooming and Dressing Activity: It can be made to follow through case analysis and see them in front of a mirror and mark on whatareas they should improve, with the help of the instructor. SWOT Analysis, Tests on Personality can be introduced.
Fundamentals Of SQL: Basics of SQL – Data Definition Language, Data Manipulation Language, Date Retrieval Language, Sharing of data, joining of Tables.
Introduction to Statistical Packages Reading Data – Using the Data Editor – Working with output – STATISTICAL PROCEDURES: Linear Regression – Chi-Square Test, ANOVA, Factor Analysis, Cluster analysis, Conjoint Analysis.
Introduction to Computerized Accounting Applications of Computers in Accounting –Creation of groups, ledgers – Voucher types – Preparation of Vouchers – Report Generation: Account books, List of Accounts, Trial balance, Profit and Loss Account, Balance sheet, Cash Flow Statement.

Text Books:

1. Lesikar, R. V. & Flatley, M. E., Basic Business Communication Skills for Empowering the Internet Generation, Tata McGraw Hill Publishing Company Ltd. New Delhi, 2005
2. Ludlow, R& Panton, F., The Essence of Effective Communications, Prentice Hall of India Pvt. Ltd, New Delhi, 1998
3. Thill, J. V. &Bovee, G. L., Excellence in Business Communication, McGraw Hill, New York, 1993
4. Oracle: A Beginner's Guide, Tata McGraw Hill Publishing Company Limited, New Delhi.
5. SPSS for Windows Manual
6. Advance Tally ERP 9 - Dream Tech Press
7. Fernandez: Corporate Communications, SAGE Publication.
8. Duck: The Basics of Communication, SAGE Publication.

Software Packages (Proprietary and Open Source)

1.	SPSS	6.	TALLY
2.	SYSTAT	7.	LINGO
4.	R	8.	ORACLE CRYSTAL BALL
5.	MATLAB	9.	MICROSOFT PROJECT

SEMESTER-II (1ST YEAR)

MARKETING MANAGEMENT

Course Code: MB-7201 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Understanding Marketing, Marketing in a developing economy, Marketing tasks and Philosophies.	**7 Hours**
Unit-II	Marketing environment and planning; Marketing research, segmentation, targeting, and positioning; marketing mix.	**10 Hours**
Unit-III	Consumer buying behaviour, and industrial/ institutional buying behaviour; buying decision process; influences and models of buying behaviour.	**8 Hours**
Unit-IV	Marketing offerings, Product decisions and strategies, Product Lifecycle and new product development, Branding and Packaging decisions, Pricing objectives and strategies; factors considered in pricing and Practices.	**9 Hours**
Unit-V	Marketing communication, Advertising and Publicity, Personal selling and Sales Promotion; Distribution Management- strategies and practices in respect of marketing channels and physical distribution.	**8 Hours**

Text Books:

1. Kotler, Keller, Koshy, Jha,Marketing Management-A South Asian Perspective, Pearson, 13th Edition
2. Stanton, William J., Pandit, Ajay, Walker, Bruce J. &Etzel, Michael J., Marketing – Concepts and Cas es, Tata McGraw Hill publishing company Ltd., New Delhi, 13th Edition, 2006
3. Ramaswami, V. S. &Namakumari, S., Marketing Management - Planning, Implementation & Control, Mc Mila n India Ltd., New Delhi, 3rd Edition, 2008
4. Saxena, Rajan, Marketing Management, Tata McGraw Hill Publishing Company Ltd., New Delhi, 3rd Editio n, 2007
5. Perreault, William D. & McCarthy, Jerome Jr. E., Basic Marketing – A Global Managerial Approach, Tat a McGraw Hill Publishing Company Ltd., New Delhi.14th Edition, 2002.
6. Clow: Cases in Marketing Management, SAGE Publication.
7. Venugopal:Marketing Management, SAGE Publication.

RESEARCH METHODOLOGY

Course Code: MB-7202 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Introduction to Research and Statistics: Role of Research in Business, Value of information, Cost of information, Ethics in Research. Research Process, Decision to undertake research, Introduction to Research Design, Types of research.Sources of Data, Scales of Measurement, Validity and reliability.	**7 Hours**
Unit-II	Observation: Different types of observation, Criteria of selection of an ideal method in different situations,Self-Reported Data. Qualitative Research Methods: Focus group, Behaviour mapping, consumer journey, Delphi study, extreme users' interview Quantitative Research Methods: Various types of Interviews: Mail Interview, Person to Person Interviews, Telephonic Interviews .Data collection using electronic interface like the Internet. Pilot survey and how to conduct one	**7 Hours**
Unit-III	Components of the questionnaire, steps in questionnaire design, Question content, Response formatOpen ended question Vs. Multiple choice questions including various types for question formats. Question wordings - various principles thereof. Common blunders while designing Questionnaires, Creative questionnaire design.	**7 Hours**
Unit-IV	Population defined, Sampling Frame, Sampling Vs. Census, Steps in selecting a sample. Various types of Sampling Methods - Probabilistic: Simple Random Sampling Stratified Random Sampling, Cluster Sampling. Non Probabilistic: Convenience Sampling, Judgment Sampling and Quota Sampling. Dangers of using Non Probabilistic Sampling procedures.Sample Size determination.Concepts of errors in research - Sampling and Non sampling errors and measures to reduce errors.	**7 Hours**

Unit-V	Introduction to Data Analysis, Introduction to SPSS package. Data Processing: Editing, Coding, Decoding, and Data Entry Hypothesis formulation. Hypothesis Testing, type I error, type II error Univariate Data Analysis Techniques: t-test (independent sample t- test, one sample t-test) Bivariate Data Analysis Techniques: Chi Square, Z- test for difference between means, Paired Sample T test (t- tests for difference between means) Introduction to Multivariate Data Analysis Techniques-Factor Analysis, Cluster Analysis, Conjoint Analysis, Multidimensional Scaling; Research Report Writing: The format, Bibliography.	**14 Hours**

Text Books:

1. N K Malhotra: Marketing Research: An Applied Orientation, 5th edition, Prentice Hall 2007.
2. R I Levin & D S Rubin: Statistics for Management, 7th Edition, Pearson 1994.
3. Cooper, R. Donald & Schindler, S. Pamela, Business Research Methods, Tata McGraw Hill, 9th Edition,2 006
4. Kothari, C. R., Research Methodology, New Age Publishers, 2nd Edition, 2004
5. Creswell: Research Design, SAGE Publication.

HUMAN RESOURCE MANAGEMENT

Course Code:MB-7203 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Introduction To Human Resources Management: Context and Concept of People Management in a Systems Perspective – Organisation and Functions of the HR and Personnel Department – HR Structure and Strategy; Role of Government.	**9 Hours**
Unit-II	HR Planning and Selection: Human Resource Information System (HRIS), Manpower Planning – Selection System including Induction – Performance and Potential Appraisal; Coaching and Mentoring; HRM issues and practices in the context of outsourced manpower.	**9 Hours**
Unit-III	Personnel Development and Retirement: Training and Development – Methods, Design & Evaluation of T & D Programmes; Career planning Development – Promotions and Transfers	**9 Hours**
Unit-IV	Financial Compensation, Productivity and Morale: - Compensation Issues & Management – Job Evaluation – Productivity, ESOP, Employee Morale and Motivation; Quality of Work Life	**9 Hours**
Unit-V	Building Relationships and Facilitating HR Development: Managing Conflicts, Collective Bargaining, Workers Participation in Management and Managerial Decision Making – A Discussion on Concept, Mechanics and Experience.	**6 Hours**

Text Books:

1. PramodVerma: PERSONNEL MANAGEMENT IN INDIAN ORGANISATIONS, (Oxford & IBM Publishing Co. Ltd.).
2. Bohlander, Snell, Sherman: MANAGING HUMAN RESORUCES (Thomson – South Western)
3. Pattnaik B, Human Resource Management, PHI
4. Rao, V. S. P., Human Resource Management, Excel Books, New Delhi, 2nd Edition, 2005
5. Rao, Subha, Essentials of Human Resource Management, Himalaya Publications, Kolkata, 5th Edition, 20 09
6. York, Kenneth M., Applied Human Recourse Management, SAGE Publication, New Delhi, 1st edition,2011
7. Wilton: An Introduction to Human Resource Management, SAGE Publication.

MANAGEMENT INFORMATION SYSTEM

Course Code: MB-7204 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Introduction: An overview of MIS Structure, MIS subsystems, Application of MIS in other disciplines.Decision making process: Phases in the decision making process, Behavioural models of the decision maker/decision making.	**8 Hours**
Unit-II	Concepts of Information: Definition, Information Presentation, Quality of Information, Value of Information, Human as Information Processor. Levels of MIS Systems- TPS, MIS, DSS, ESS	**8 Hours**
Unit-III	Design of MIS- Information systems requirements, Strategies for the determination of Information requirements, Enterprise Analysis, strategic business analysis, Database requirements, User interface requirements. Implementation of MIS system.	**8 Hours**
Unit-IV	Basic concepts of computer Networks & Internet; Introduction to networks; LAN, WAN, Data Communication, Transmission media and transmission Infrastructure. Introduction to communication protocol: TCP/IP, OSI Model.	**9 Hours**
Unit-V	Common service provided by internet, basics of E-commerce, classification, B2B, B2C, C2C, influence of E-commerce on business	**8 Hours**

Text Books:

1. Davis, G. B. & Olson, M. H. Management Information System, Tata McGraw Hill, NewDelhi,2011.
2. Jawadekar, W.S. Management Information System: Text and Cases (Third Edition), TataMcGrawHill, New D elhi, 2008
3. Pendse, Business Analysis, PHI,2008.
4. Murthy C. S. V., Management Information System, Himalaya Publication, New Delhi, 3rd Edition, 2010
5. Dash, M. R &Laha, J., Managerial Computing, Vrinda Publication, New Delhi, 1st Edition, 2010

FINANCIAL MARKETS INSTITUTIONS AND SERVICES

Course Code: MB-7205 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Financial System: Introduction, Components of financial system, Functions and Nature and role of financial institutions and financial markets. Financial system and economy, reforms in financial systems.	**8 Hours**
Unit-II	Financial Markets: Money Market and instruments, Capital Market- Functions, Types of capital market- New Issue mechanism and secondary market transactions, Derivatives Market, Debt Market.	**8 Hours**
Unit-III	Financial Institutions: Development Financial Institutions, Banking and nonbanking financial institutions, Mutual funds and Insurance.	**8 Hours**
Unit-IV	Financial Services: Investment Banking, Depositories and custodians, Factoring, Leasing and Hire purchase, Financial Inclusion and Microfinance.	**8 Hours**
Unit-V	Financial Regulation and regulatory bodies: RBI — Role of RBI, Monetary policies of RBI; SEBI — Role of SEBI in the primary and secondary market, Investor protection measures; IRDA— Investor protection measures, Reinsurance	**10 Hours**

Text Books:

1. The Indian financial system: Markets, Institutions and Services- Pathak Bharati V.
2. Financial Services- M.Y Khan
3. Financial Markets &Institutions-S Gurusamy, McGraw Hill Education (India) Private Limited; 3rd Editi on
4. Madura, J., Financial Institutions and Markets, Thomson Publication, New Delhi, 2007.
5. Kothari:Financial Services in India, SAGE Publication.
6. Mittra:Financial Planning, SAGE Publication.

BUSINESS ETHICS AND CORPORATE GOVERNANACE

Course Code:MB-7206 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Meaning, Nature and Importance of Business Ethics; Ethics in work place; Ethical issues in Marketing, Finance, HRM, Operations, Accounting areas. Indian and Global ethical scenario. (Case Study on Enron etc.)	**8 Hours**
Unit-II	Managerial Issues in Business Ethics and ethical dilemma –Benefits of Managing Ethics in Work Place – Organisation Ethics Development System (OEDS), Tools for managing ethics- Developing and administering Code of ethics.	**8 Hours**
Unit-III	Work Ethics – Work Culture – Ethical Theories; Organisational ethos and values for different stake holders; reporting ethical standards- global and Indian practices.	**8 Hours**
Unit-IV	CSR- Legal requirements and emerging trends; Conscious capitalism, Firms of endearment; Organisation specific case studies.	**8 Hours**
Unit-V	Corporate Governance- Meaning and Historical perspectives; corporate governance and stakeholders- Principles and Legal requirements	**10 Hours**

Text Books:

1. Corporate Governance: Principles, Policies and Practices by A. C. Fernando
2. Business Ethics: Managing Corporate Citizenship and Sustainability in the Age of Globalization, Andrew Cran, Dirk Matten, Oxford University Press, USA
3. Business Ethics: Concepts and Cases, Manuel G. Velasquez, Prentice Hall
4. Business Ethics, William H. Shaw, Wadsworth Publishing Company
5. Sarkar: Corporate Governance in India, SAGE Publication.

FINANCIAL MANAGEMENT

Course Code:MB-7207 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Introduction:Concept, scope, classification of finance function, objectives of financial management, profit maximization vs. wealth maximization, FinancialStatement Analysis and Modelling-Concepts, scope and limitations.	**4 Hours**
Unit-II	Sources of finance**:** Short term sources-Public deposits, Cash Credit limit/Overdraft, Letter of Credit, Commercial papers, Factoring. Long term sources- Shares, Debentures/Bonds, Leasing, Hire-purchase, Venture capital, New financial instruments.	**10 Hours**
Unit-III	Financing decisions:Cost of capital, Cost of equity, Cost of preference shares, Cost of retained earnings, weighted average cost of capital. Leverage, Trading on equity, factors affecting trading on equity, merits and limitations, operating leverage, financial leverage and combined leverage. Capital structure:Concepts and determinants of capital structure, Approaches to establish appropriate capital structure-EBIT-EPS, Cost of capital & Valuation, Cash Flow approach.	**12 Hours**
Unit-IV	Investment decisions: Capital budgeting-Nature, scope, techniques (traditional and discounted cash flow). Working capital management:Concept of working capital, Factors affecting working capital requirements, Computation of working capital requirements.	**12 Hours**
Unit-V	Dividend decision:Dividend and its types, Factors influencing dividend decision, Dividend payment-retention decision: a. Dividend theories of relevance: Walter's model, Gordon's model b. Dividend theories of irrelevance: MM Hypothesis	**4 Hours**

Text Books:

1. Pandey I M, Financial Management, Vikas Publications
2. Khan, M Y, Financial Management, Tata McGraw-Hill

3. Brigham, Financial management Theory and Practice, Cengage
4. Chandra, P., Financial Management, Tata McGraw Hill, New Delhi, 7th Edition, 2008
5. James, C. Vanhorne, Financial Management and Policy, Prentice Hall of India Pvt. Ltd., New Delhi, 12 th Edition, 2003

COST AND MANAGEMENT ACCOUNTING

Course Code: MB-7208 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Introduction:Cost – Meaning, Objective, Elements of Cost, Classification of Cost for Managerial Decision making, Cost Accounting – Meaning, Objective, Installation of Costing System, Cost centre and Cost Unit – Definition & Concept, Objectives and Types, Cost Sheet.	**8 Hours**
Unit-II	Material Cost: Components- EOQ, Inventory Levels-ABC Method and methods of Inventory pricing. Labour Cost and Remuneration- Labour cost concepts, time keeping, time booking, works study; methods of remuneration and wages payment (Halsey Plan, Rowan Plan, Piece rate system): Overheads: Meaning, Classification of overheads, methods of segregating semi variable costs; collection, allocation, apportionments, reapportionment, absorption of overheads.	**8 Hours**
Unit-III	Costing Methods:Job Order Costing, Contract Costing, Process Costing, Activity Based Costing.	**8 Hours**
Unit-IV	Management Accounting: Concept, Need, Importance and Scope. Nature. Absorption and Marginal Costing: Absorption Costing – Meaning and Limitations, Marginal Cost – Definition and Nature. Marginal Costing – Net Profit under Marginal Costing and Absorption Costing, Difference between Marginal Costing and Absorption Costing. C-V-P Analysis	**8 Hours**
Unit-V	Budgetary Control and Standard Costing:Budget and Budgetary Control System – Meaning & Concept, Objectives, Advantages, Limitations, Types of Budgets, Zero based Budgeting; Standard Costing and Variance Analysis.	**10 Hours**

Text Books:

1. M.N Arora, Cost and Management Accounting, Vikas Publications
2. Jain and Narang, Advanced Cost Accounting, Kalyani
3. Bhattacharyya A K, Principles and Practices of cost accounting, PHI
4. Horngren, C. T., Dator, S. M & Foster, G., Cost Accounting–A Managerial Emphasis, Prentice Hall of I ndia Pvt. Ltd., NewDelhi , 3rd Edition, 2003
5. Kishore, R. M., Cost & Management Accounting (Text & Cases), Taxman Publication Pvt. Ltd, New Delhi, 5th Edition 2011

SEMESTER-I (2ND YEAR)

PROJECT MANAGEMENT

Course Code: MB-8101 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Project – Meaning – classification – importance of project management – An Integrated Approach – Project Portfolio Management System – The Need – Choosing the appropriate Project Management structure: Organizational considerations and project considerations – steps in defining the project – project Rollup – Process breakdown structure – Responsibility Matrices – External causes of delay and internal constraints.	**8 Hours**
Unit-II	Project feasibility studies: Opportunity studies, General opportunity studies, specific opportunity studies, pre-feasibility studies, functional studies or support studies, feasibility study – components of project feasibility studies – Managing Project resources flow – project planning to project completion: Pre-investment phase, Investment Phase and operational phase – Project Life Cycle – Project constraints.	**8 Hours**
Unit-III	Project Evaluation under certainty: Net Present Value, Benefit Cost Ratio, Internal Rate of Return, Urgency, Payback Period, ARR – Project Evaluation under uncertainty – Methodology for project evaluation – Commercial vs. National Profitability – Social Cost Benefit Analysis, Commercial or National Profitability, social or national profitability.	**8 Hours**
Unit-IV	Developing a project plan: Developing the project network – constructing a project network (Problems) – PERT – CPM – crashing of project network – resource levelling and resource allocation – how to avoid cost and time overruns – Steps in Project Appraisal Process – Project Control Process – control issues – project audits – the project audit process – project closure – team, team member and project manager evaluations.	**8 Hours**
Unit-V	Managing versus leading a project - managing project stakeholders – social network building (Including management by wandering around) – qualities of an effective project manager – managing project teams – Five Stage Team Development Model – Situational factors affecting team development – project team pitfalls.	**10 Hours**

Text Books:

1. Chandra P, Projects:Planning Analysis selection, Financing, Implementation and Review,Tata McGraw-Hi ll
2. Gopalakrishnan P and Ramamoorthy, V.E., Project Management,Macmillan
3. B.B. Goel, Project Management – Principles and Techniques, Deep and Deep
4. Clifford F. Gray and Erik W. Larson, Project management – The Managerial Process, Tata McGraw Hill.

STRATEGIC MANAGEMENT

Course Code:MB-8102 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Concepts of Strategic Management: Strategic Management, Values, Visions, and Mission Statements, Types of Strategy, Changes in the approach to Strategic Management.	**8 Hours**
Unit-II	Strategy Analysis (External Environment): Scanning, Monitoring, and forecasting changes in Environments, Porters Five Force Framework.	**8 Hours**
Unit-III	Strategy Analysis (Internal Environment): Differential Firm Performance, Value Chain Analysis, Resource Based View Strategy, Sustainable Competitive Advantage, Assessing Organisational Performance.	**9 Hours**
Unit-IV	Strategy Formulation: Business Level Strategy, Generic Competitive Strategy, Industry Life Cycle, Growth Strategies, Related Diversification, Unrelated Diversification, Implementing Growth Strategies, Portfolio Analysis, Corporate Parenting, International strategy and globalisation.	**9 Hours**
Unit-V	Strategy Implementation: Organisational System and Strategic Change, Strategic Leadership, Corporate Governance.	**10 Hours**

Text Books:

1. Henry, Understanding Strategic Management, Oxford University Press, 2009.
2. Haberberg, Adrian, and Alison Rieple. Strategic Management: Theory and Application. NewDelhi: Oxford University Press, 2008.
3. Kazmi, Azahar, Strategic Management and Business Policy, Tata Mc Graw Hill, 2010
4. Hamel, G. &Prahalad, C. K., Competing for Future, HBS Press, 2008
5. Prasad, L. M., Business Policy and Strategy, Sultan Chand & Sons, 2009
6. Wheelen, Thomas L. & Hunger David J., Strategic Management and Business Policy, Pearson, 2009
7. Strategic Management: The Indian Context, R. Srinivasan, PHI

ENTERPRISE RESOURCE PLANNING

Course Code: MB-8104 **L-T-P** (0-0-4), **Credit**-2

Unit-I	Introduction to ERP-History and Development, ERP and Business Process Re-engineering; Introduction and development of SAP, Modules in mySAP.	**9 Hours**
Unit-II	Overview of Enterprise Structure and Materials Management- Enterprise structure in MM, Defining of Organisations Units and its Assignment.	**9 Hours**
Unit-III	Master Data in Materials Management-Creation and maintenance of Material master, vendor master and concept about purchasing master data	**10 Hours**
Unit-IV	Procurement Process-Understanding of Procurement cycle, Phases of procurement process (Purchase Requisitions, Request for Quotation, Quotation Maintenance, Price comparison	**12 Hours**
Unit-V	Purchase Order- Concept, creation, document type, item category and order processing. Goods Receipt-Basics of Material movement types, transfer posting, material document and accounting document.	**8 Hours**
Unit-VI	Invoice verification-Concept, Debit and Credit memos. Stock transfer-Concept, one step transfer, two step stock transfer; Sub-contracting and consignment process; Service procurement; Physical Inventory; Price determination; Split valuation; Release Procedure and Integration with FI, SD.	**8 Hours**

Text Books:

1. Leon, Alexis, Enterprise Resource Planning, Tata McGraw Hill Education, 2nd Edition, 2007
2. Radhakrishnan, R. &Balasubramanian, S., Buisness Process Reengineering: Text & Cases, PHI, 2008
3. Jaiswal, Mahadeo& Ganesh, Vanapalli, Textbook of Enterprise Resource Planning, Macmillan Publishers India, 2011
4. SAP Materials Management, MukeshSukla, Tata McGraw Hill Publications
5. SAP MM: Functionality and Technical Configuration, Martin Murray, SAP Press

SECURITY ANALYSIS AND PORTFOLIO MANAGEMENT

Course Code:MB-8110 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Introduction to Investment. Define investment. Investment alternatives. Time value of Money. Risk and return in investment. Real return-nominal return. Historical and expected return. Risk-valuation of risk. Sources of risk- Portfolio risk. Power of diversification. Markowitz Model, The process of investment trading and settlement – margin trading etc, types of orders.	**8 Hours**
Unit-II	Security analysis and equity valuation: The fundamental analysis. EIC Framework economic analysis- variables tracked industry analysis- variables tracked- company analysis- variables analysed. Sources of information and trouble shots of financial statements. Behaviour finance Technical analysis Methods and techniques of technical analysis, Efficient Market Hypothesis	**10 Hours**
Unit-III	Theories of capital market CAPM, Sharpe Model, Arbitrage theory and multifactor model, Portfolio Analysis, Listing down data inputs,Selection and construction of optimal portfolios.	**8 Hours**

Unit-IV	Fixed Income Securities & Portfolio Management Investment in bonds, types of bonds, Investment process in bonds. Portfolio Revision, Portfolio Management, Portfolio Evaluation – Sharpe, Jensen, Treynor & Fama Net Selectivity	**8 Hours**
Unit-V	Securitisation and Mortgage Backed Security (MBS):Fixed Rate and Adjustable Rate Mortgages, Measures of Prepayment, Creation of MBS, Valuation, Mortgage Derivatives Fixed Income Portfolio Management: Matched Funding, Horizon Matching, Indexation, Portfolio Insurance. Fixed Income derivatives:Mechanism of FRA, IRF and IRS	**10 Hours**

Text Books:

1. Investments- Bodie, Kane, Mohanty P, Tata McGraw-Hill, New Delhi
2. Portfolio Management- Kevin, PHI, New Delhi
3. Security Analysis and Portfolio Management- Fischer and Jordan, PHI, New Delhi
4. Investment Analysis and Portfolio Management, Reilly and Brown, Cengage Learning
5. Security analysis and Portfolio Management, P Pandian, Vikas Publications.
6. Technical Analysis of Financial Markets: A Comprehensive guide to Trading methods and applications, PHI

CORPORATE TAXATION

Course Code: MB-8111 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Principles of Taxation; Tax Structure in India, Tax Authorities, Salient features of Income Tax Act 1961, Direct Taxes - (individual), Computation of Income Tax under Salaries, House Property, Other sources	**8 Hours**
Unit-II	Computation of Income Tax under Capital Gains, Business and Profession	**8 Hours**
Unit-III	Assessment of Companies	**8 Hours**
Unit-IV	Set- off and Carry forward of losses, Clubbing of Income, Filing of Return, Advance Tax, Assessment	**8 Hours**
Unit-V	Indirect Taxes - Excise Duty, Customs Act, VAT, Service Tax. GST etc., Managerial Prospective of Taxation.	**10 Hours**

Text Books:

1. Singhania Vinod K.Direct Taxes, Taxmann Publication, New Delhi, 2015.
2. Datey: Taxman's Indirect Tax, Taxmann Publication, New Delhi, 2015
3. Indirect Tax Management and Practise, Mohd. Rafi, Bharat Publication House
4. Taxation Law and Practise, Balachandran V., Thothadri S., PHI .

SALES AND DISTRIBUTION MANAGEMENT

Course Code: MB-8120 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Personal Selling: Types of selling – Alternative Sales Structures: Network Marketing – Mail order selling – Elements of direct marketing – Teleshopping – Telemarketing – Systems selling. The selling process – Strategies and Styles – formulating sales objectives – Sales forecasting – Estimating market and Sales Potentials.	**8 Hours**
Unit-II	The Sales Force: Size of the sales force, sales organization based on customer, geography, product and combinations and current trends – sales training programs and motivating the sales force – sales force compensation, sales incentives and sales force evaluation – controlling the sales effort – sales quotas, sales territories, sales audit.	**10 Hours**
Unit-III	Physical Distribution: participants in the physical distribution function, the environment of physical distribution – Channel Design strategies and structures, selecting channel members, setting distribution objectives and tasks – Target markets and channel design strategies.	**8 Hours**
Unit-IV	Managing the Marketing Channel: Product, Pricing and Promotion issues in channel Management and Physical Distribution – Motivating channel members – Evaluating channel member performance – Vertical marketing systems – Retail co-operatives, Franchise systems and corporate marketing systems.	**8 Hours**

Unit-V	E-enabled selling and distribution: e-Commerce and e-retailing as a channel of distribution, Electronic intermediaries, Disintermediation and Re-intermediation, e-enabled logistics management and tracking systems.	**6 Hours**

Text Books:

1. Still, R., Cundiff, E. and Govoni, N.: Sales Management, Decisions, Strategies and Cases.Pearson, 20 08
2. Coyle, J.J., Bardi, E.J. and Langley, C.J.: The Management of Business Logistics: A Supply Chain Per spective. Tata McGraw Hill, 7th Edition, 2003.
3. Stanton, W. & Spiro, R., Management of Sales Force, Mc Graw Hill, Singapore, 10th Edition, 2010
4. Havaldar, K. &Cavale V., Sales and Distribution Management: Text and Cases, Tata McGraw Hill, New De lhi, 7th Edition, 2009
5. Gupta, S. L., Sales and Distribution management, Excel Books, New Delhi, 1st Edition, 2009
6. Panda, T. &Sahadev, S., Sales & Distribution Management, Oxford University Press, New Delhi, 10th Ed ition, 2008

MARKETING OF SERVICES

Course Code: MB-8121 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Marketing Of Services - Introduction - Growth of the Service Sector - The Concept of Service - Characteristics of Services- Classification of Services - Designing the Service - Blueprinting, Using Technology, Developing Human Resources, Building Service Aspirations	**8 Hours**
Unit-II	Marketing Mix In Services Marketing - The Seven Ps - Product Decisions, Pricing Strategies and Tactics, Promotion of Services and Placing or Distribution Methods for Services - Additional Dimensions in Services Marketing - People, Physical Evidence and Process.	**10 Hours**
Unit-III	Strategic Marketing Management For Services - Matching Demand and Supply through Capacity Planning and Segmentation - Internal Marketing of a Service - External versus Internal Orientation of Service Strategy.	**8 Hours**
Unit-IV	Delivering Quality Services - Causes of Service-Quality Gaps: The Customer Expectations versus Perceived Service Gap, Factors and Techniques to Resolve this Gap - Gaps in Service - Quality Standards, Factors and Solutions - The Service Performance Gap - Key Factors and Strategies for Closing the Gap - External Communication to the Customer: the Promise versus Delivery Gap - Developing Appropriate and Effective Communication about Service Quality.	**10 Hours**
Unit-V	Marketing of Services with Special Reference to (a) Financial Services, (b) Health Services, (c) Hospitality Services including Travel, Hotels and Tourism, (d) Professional Services, (e) Public Utility Services, (f) Communication Services, (g) Educational Services	**6 Hours**

Text Books:

1. A. Payne: The Essence of Services Marketing, Pearson.
2. V.A. Zeithaml, M. J. Bitner, D Gremler, A. Pandit: Service Marketing, McGrawHill
3. Lovelok, C.: Services Marketing: People, Technology, Strategy; Pearson 2003
4. Apte, Govinda: Services Marketing, Oxford, 2009
5. Nargundkar: Services Marketing: Text and Cases; Tata McGrew Hill, 2004

STRATEGIC HUMAN RESOURCE MANAGEMENT

Course Code: MB-8130 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Strategic management of Human resources: An introduction, Business strategy- An introduction to market driven strategy, Resource driven strategy	**8 Hours**
Unit-II	Human resource system- its macro and micro dimensions, Strategic HR planning, Strategic approach to manpower acquisition –recruitment and selection	**10 Hours**
Unit-III	Strategic development of human resources, Strategic approach to management structure, job design and work system, Strategic management of performance	**8 Hours**
Unit-IV	Strategic approach to compensation and benefits, Strategic approach to Industrial relations, outsourcing and its HR implications, Mergers and acquisitions and HRM	**10 Hours**
Unit-V	Human Resource Evaluation- An Overview, Rationale for HR Evaluation, Measures of HRM Performance, Approaches to HR Evaluations. Career Management, Mentoring Relationship, Work-life Balance	**6 Hours**

Text Books:

1. Kandula, Srinivas R., Strategic Human Resource Development, PHI, New Delhi, 1st Edition, 2001
2. Mello, Jeffrey A., Strategic Human Resource Management, Cengage Learning India Private Limited, New Delhi, 2nd Edition, 2008
3. Viswanathan, Rajeesh, Strategic HRM, Himalaya Publishing House, Mumbai, 1st Edition, 2010
4. Regis, Richard, Strategic Human Resource Management & Development; Excel Books, New Delhi, 1st Editi on, 2008.
5. Dessler, Gary, Human Resource Management, Pearson Prentice Hall, New Delhi, 10th Edition, 2008

INDUSTRIAL RELATIONS AND LABOUR LEGISLATIONS

Course Code: MB-8131 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Introduction - Concept and Determinants of Industrial Relations – Industrial Relations in India – Managing IR Changes – IR and Productivity – Technology and IR – Effective Communication Systems and IR Management – Indian Culture & IR.	**8 Hours**
Unit-II	Trade Unions, Need & importance of sound Union–management relations, measure to improve union-management relations, hindering factors in union-management relations. Industrial conflict: Meaning, causes, machinery for settlement of industrial disputes.Labour Administration – ILO, ILC and Indian Constitutional Provisions in Relation to Labour Administration – Central Machinery of Labour Administration – Labour Administration at the State, District and Local Levels. Contemporary Trends and Future of Industrial Relations in India.	**10 Hours**
Unit-III	Labour legislation – historical evolution – growth of labour problems – agencies integrated in labour problems – principles of labour legislation – labour and the constitution – origin and growth of labour legislation in India.	**8 Hours**
Unit-IV	Factories act 1948 – contract labour act 1970 – the shops and establishment act 1947 – the trade union act 1926 – the industrial disputes act 1947.	**10 Hours**
Unit-V	Payment of wages act 1936 – payment of bonus act 1965 – payment of gratuity act 1972. The Employees state insurance act 1948 – The employees provident funds and miscellaneous act 1952 – workmen's compensation act 1923 – the employees' pension scheme 1995.	**6 Hours**

Text Books:

1. Mamoria, C. B., Mamoria, S. &Gankar, S. V., Dynamics of Industrial Relations, Himalaya Publishing Ho use, Mumbai, 16th Edition, 2008.
2. Venkatratnam, C. S., Industrial Relations, Oxford University Press, New Delhi, 1st Edition, 2006
3. Sinha, P. R. N., Sinha, I. B. &Shekhar, S. P., Industrial Relations, Trade Unions and Labour Legisla tion, Pearson, Delhi, 2006
4. Kapoor, N. D., Handbook of Industrial Law, Sultan Chand & Sons, New Delhi, 13th Edition, 2005
5. Mallik, P. L., Handbook of Labour and Industrial Law, Eastern Book, Lucknow, 7th Edition, 2000

SUPPLY CHAIN MANAGEMENT

Course Code: MB-8140 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Introduction to Supply Chain Management, Logistics Network Configuration, Inventory Management and Risk Pooling.	**8 Hours**
Unit-II	The Value of Information, Supply Chain Integration.	**8 Hours**
Unit-III	Strategic Alliances, Procurement and Out Sourcing Strategies.	**8 Hours**
Unit-IV	International issues in Supply Chain Management, Coordinated Product and Supply Chain Design.	**8 Hours**
Unit-V	Customer value and Supply chain Management, Information Technology for Supply Chain Management, Decision – Support Systems for Supply Chain Management, SCM software module.Technology in SCM.	**10 Hours**

Text Books:

1. Designing and Managing the Supply Chain: Concepts, strategies and Case studies, by Simchi-levi, D., P.Kaminsky, and E.Simichi-Levi, Irwin/McGraw-Hill, Newyork, 2003 (Text Book)
2. Supply Chain Management: Strategy, Planning and Operations by Sunil Chopra and Peter Meindi, Prentic e Hall, Inc, 2001.
3. Purchasing and Supply Management by Leenders, Fearon, Flynn, Johnson.

COMPUTER INTEGRATED MANUFACTURING

Course Code: MB-8141 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Introduction, automation in production system, automation principle and strategies. Automation and control technologies: introduction to automation-basic elements of an automated system, advanced automation functions, levels of automation.	**8 Hours**
Unit-II	Industrial control system- process industries vs discrete manufacturing industries, continuous vs discrete control, computer process control. Sensors actuators; Numerical controls; Industrial Robotics; Discrete Control using programmable logic controller and personal computers.	**8 Hours**
Unit-III	Material handling and identification technologies: introduction to material handling; material transport system; automated storage system; automatic data capture.	**8 Hours**
Unit-IV	Manufacturing systems: introduction to manufacturing systems; group technologies and cellular manufacturing; flexible manufacturing systems.	**8 Hours**
Unit-V	Quality control systems: inspection technologies, Probe Technologies, coordinate measuring machines, inspection principles and practices. Manufacturing support system: product design and CAD/CAM, SCADA in production systems, lean production and agile manufacturing.	**10 Hours**

Text Books:

1. Groover MP, Automation, Production system, and Computer Integrated Manufacturing.
2. Computer Aided Production Management- Mahapatra, PHI, New Delhi
3. Industrial engineering and Management- Reddy, C. NathaMuhi, New Age International Publishers, New De lhi

DECISION SUPPORT SYSTEMS

Course Code: MB-8144 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Decision Support Systems – Definition – Characteristics & capabilities of DSS – Components of DSS-database, Model base, Communication subsystem & User – Classes of DSS.	**8 Hours**
Unit-II	DSS hardware and software – Group DSS – components & typology – Constructing a DSS – development process.	**8 Hours**
Unit-III	DSS development tools – Yardsticks for choosing DSS software – Executive information and support systems.	**8 Hours**

Unit-IV	Illustrative DSS applications – Portfolio Management – Human Resource Management, Marketing Decision Support System, Small Business Application, Manufacturing DSS.	**8 Hours**
Unit-V	Expert Systems – fundamentals – Types of expert systems – Developing ES – Problems & Limitations of ES.	**10 Hours**

Text Books:

1. EfralmTurbon: DECISION SUPPORT SYSTEM AND EXPERT SYSTEMS, Macmillan.
2. Ralph H. Sprange, Jr. and Eric. D.Carlson: BUILDING EFFECTIVE ESS, Prentice Hall
3. Ralph H. Sprange, JR. & Huga, J. Watson (Eds.): DSS-PUTTING THEORY INTO PRACTICE, Prentice Hall.
4. R. Jayshankar: DECISION SUPPORT SYSTEMS, Tata McGraw Hill.
5. Janakiraman and Sarukesi, Decision Support Systems, Prentice Hall of India, New Delhi.

DBMS &DATA WAREHOUSING

Course Code: MB-8145 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Overview and Fundamentals, Database oriented approach to Data Management; History of DatabaseApplications; DBMS Architectures; Data Dictionary, Data Models, Data Definitions, DataModification Models.	**8 Hours**
Unit-II	Entity Relational Model: Design and Construction, ER diagram conversion to relational model;Relational Model, Basic Relational Algebra, Basic Relational Calculus;Query Languages: SQL, SQL Constructs, Query Compositions, Transaction Processing, Embedded SQL Integrity Constraints.	**8 Hours**
Unit-III	Normalization, Level of Normalization and their use, Dependencies, Keys, Concepts of Keys;Indexing and Hashing, Tables Clustering.	**8 Hours**
Unit-IV	Concurrency Control Techniques, Concurrency Control Based on Timestamp Ordering; DatabaseSecurity Concepts; Levels of security; Database Recovery Techniques; Recovery Techniques Basedon Deferred Update, Recovery Techniques Based on Immediate Update; Recent trends in DatabaseManagement.	**8 Hours**
Unit-V	Data ware house and Data Mining, BusinessIntelligence, OLAP, Search Engines, Intelligent Agents, Groupware Technology for KnowledgeTransfer, Knowledge Portal.	**10 Hours**

Text Books:

1. Elmasri, R, Navathe, S; Fundamentals Of Database Systems, Pearsons.
2. Abraham Silberschatz, Henry Korth, S. Sudarshan; Database System Concepts; Tata McGraw Hill.
3. Narang Rajesh: Database Management Systems, Prentice Hall of India Private Limited, NewDelhi
4. Connolly: Database Systems: A Practical Approach to Design, Implementation, and Management, Pearson Education (Singapore) Pvt. Ltd., Delhi

SEMESTER-II (2ND YEAR)

INTERNATIONAL BUSINESS

Course Code: MB-8201 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Growing relevance of globalisation; drivers and restrains of globalisation; internationalisation stages and orientation; international trade, international business environment and trade blocs (EU, NAFTA,SAARC etc.)	**9 Hours**
Unit-II	GATS/WTO- Historical evolution and rounds of discussion, declaration, India in global setting trade.	**8 Hours**
Unit-III	Global networking of operations, global sourcing and location strategy; MNCs and International trade.	**8 Hours**
Unit-IV	Market entry strategies and market coverage strategies; International product decisions and pricing for international markets; international distribution and promotion	**9 Hours**
Unit-V	International monetary system and foreign exchange market; international economic organisations like World Bank, ADB etc.	**8 Hours**

Text Books:

1. International Business- Text and Cases- Francis Cherunilam, PHI Publications.
2. International Business- K Aswathappa, Tata McGraw-Hill, New Delhi
3. International Financial Management- P.G Apte, Tata McGraw-Hill, New Delhi
4. Strategies for the Future: Understanding International Business, A.N Mathur, IIM Ahmadabad Business Books.
5. International Business, R.M Joshi, Oxford Higher Education.

TQM AND SIX SIGMA

Course Code: MB-8202 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Management of Total Quality, TQM, Service Quality Vs Product Quality, Strategic Quality Planning – Strategic Planning Process, Strategic Quality Management, Definition of Quality, Control and Service Quality. Human Resource Development and Management – Organizing for involvement, Training and development, selection, performance appraisal, compensation systems, Total quality oriented HRM.	**8 Hours**
Unit-II	Management of Process Quality – Process inspection Vs. Process Control, Statistical Process Control, Basic approach to SQC, Quality Function Deployment, Just-in-Time, Customer Focus and Satisfaction-Process Vs Customer, Internal Customer conflict, Quality focus, Drivers of customer satisfaction, measurement of customer satisfaction, Service quality Vs. Customer retention, Customer retention Vs. Profitability.	**8 Hours**
Unit-III	Bench Marking – The evolution of benchmarking, the essence of bench marking, benefits of bench marking, strategic bench marking, operational bench marking, bench marking process. Organizing for Total Quality Management – Systems approach, organizing for quality implementation, People dimension to move to TQM, small groups and employee involvement. Cost of quality – Three views of quality costs, quality costs, accounting system and quality management.	**8 Hours**
Unit-IV	Review of control charts, ISO 9000, Reengineering, Baldrige Award. Six Sigma-Definition, Approaches for Six Sigma, Steps of Six Sigma DMAIC, Steps of Six Sigma DMADV,Types of Six Sigma Belts, Benefits of Six Sigma.	**8 Hours**
Unit-V	Kaizen – Introduction, Key Elements of Kaizen, Classification of Kaizen, Benefits of Kaizen, Steps of Implementation of Kaizen Blitz, Guidelines for Kaizen Team, Quick and Easy KaizenSystem, Poka Yoke – Characteristics of Poka yoke, Levels of Poka Yoke, classification of Poka Yoke, Places where Poka Yoke Works Well, Principles of Poka Yoke, Poka Yoke Devices,Steps of Poka Yoke, Benefits and limitations of Poka Yoke.	**10 Hours**

Text Books:

1. Omachonn; V.K., Ross, J.E., Principles of Total Quality, Lucie Press, Florida, 1994.
2. Summers, C.S., Quality Management: creating and Sustaining Organizational Effectiveness, Prentice-Hall of India, New Delhi.
3. Mohanty, R. P &Lakhe, R. R., Handbook on Total Quality Management, Jaico Publishing, 11th Edition, M umbai, 2010
4. Mohanty, R. P &Lakhe, R. R., TQM in the Service Sector, Jaico Publishing, Mumbai, 5th Edition, 2011
5. Evans, R. James & William, M. Lidsay, The Management and Control of Quality, South-Western Thomson L earning, 5th Edition, 2002

INTERNATIONAL FINANCIAL MANAGEMENT

Course Code: MB-8210 **L-T-P** (3-0-0), **Credit**-3

Unit-I	International Finance – Meaning, scope and significance, International finance functions in the context of globalization, InternationalMonetary System, Balance of Payments.	**8 Hours**
Unit-II	International Exposure and Risk- Classification and measuring of exposure and risks of MNCs- Transaction Exposure, Translation Exposure (Consolidation) and Economic Exposure: Managing and Hedging Risks and Exposure- Internal Techniques and External Techniques, Hedging with Money market, forward and futures market, options and swap market.	**10 Hours**
Unit-III	International Financial Markets- Domestic and Offshore Markets, Euro Markets, International Banking and Money markets, International Bond Markets, International equity markets and Instruments.	**8 Hours**
Unit-IV	Foreign exchange rate, international parity theories, exchange rate determination and forecasting, foreign exchange markets, foreign exchange quotations, trading and settlement in foreign exchange markets, foreign exchange markets in India.	**10 Hours**
Unit-V	Multinational Cash management, short term financing, risk management and treasury and forex, tax implications of MNCs operations.	**6 Hours**

Text Books:

1. P G Apte, International Financial Management, Tata McGraw-Hill
2. Mundra Jeff, Multinational Financial Management, PHI
3. Fundamentals of International Financial Management- Kevin S., PHI, New Delhi
4. International Financial Management- MilindSathye, Larry Rose, Larissa Allen, Rae Weston- Willy India Edition.

FINANCIAL DERIVATIVES AND RISK MANAGEMENT

Course Code: MB-8211 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Financial Derivatives:Introduction, Definition of Financial Derivative , Features, Types of Derivatives, Basic Financial Derivatives, History of Derivatives Market, Use of Derivatives, Critiques of Derivatives. Traders in Derivative Markets, Factors contributing to the growth of Derivatives. Financial Derivatives Market in India.	**8 Hours**
Unit-II	Forwards, and Futures Market, Contracting & Pricing**:** Forward contract, Features of Forward contract, Classification of Forward Contracts. Margin determination, Introduction, Financial Futures contracts, Types of Financial Futures, Contracts, Evolution of Futures Market in India, Operators/Traders in Future Market, Functions and growth in Future Market, Future Market trading Mechanism, Theories of Future prices. Hedging Concepts – Long, Short, Cross. Forward prices Vs Future prices.	**10 Hours**
Unit-III	Options: Pricing and Trading Mechanism**:** Introduction, concept, Types, Distinction between option and futures contracts, Mechanics of option Markets, Properties of Stock options.Determinants of option pricing, Black – Scholes option pricing model, Binomial Option pricing model, Trading Strategies with option, Hedging with options.	**8 Hours**
Unit-IV	SWAP market: Interest Rate SWAP, Currency SWAP, and Valuation of SWAP	**10 Hours**
Unit-V	Currencies.Over view of Commodity Derivatives, Weather, energy, Carbon trading and insurance derivatives, Multi period options.	**6 Hours**

Text Books:

1. Options, Futures and Other Derivatives- Jhon C. Hull
2. Financial Institutions and Markets- Meir Kohn, Oxford University Press, New Delhi
3. Paul Wilmott Introduces Quantitative Finance-John Willy & Sons Ltd.

INTEGRATED MARKETING COMMUNICATION

Course Code: MB-8220 **L-T-P** (3-0-0), **Credit**-3

Unit-I	An Introduction to Integrated Marketing Communication (IMC): Meaning and Role of IMC in Marketing, IMC tools, Role of Advertising Agencies and other marketing organizations providing marketing services and perspectives on IMC.	**8 Hours**
Unit-II	Understanding communication process: Source, Message, Channel factors, Communication response hierarchy – AIDA model, Hierarchy of effect model, Innovation Adoption mode, Information Processing Model, The Standard learning Hierarchy, Attribution Hierarchy, and low involvement hierarchy. Consumer Involvement – The Elaboration Likelihood (ELM) Model, the Foote, Cone and Belding (FCB) Model.	**10 Hours**
Unit-III	Planning for Marketing Communication (Marcom):Establishing Marcom Objectives and Budgeting for Promotional Programmes – Setting communication objectives, Sales as marcom objective, DAGMAR approach for setting ad objectives. Budgeting for marcom- Factors influencing budget, Theoretical approach to budgeting viz, Marginal analysis and Sales response curve, Method to determine marcom budget.	**8 Hours**
Unit-IV	Developing the Integrated Marketing Communication Programme and Measuring Effectiveness**:** Planning and development of creative marcom. Creative strategies in advertising, sales promotion, publicity, event sponsorships etc. Creative strategy in implementation and evaluation of marcom – Types of appeals and execution styles. Media planning and selection decisions – steps involved and information needed for media planning.	**10 Hours**
Unit-V	Branding decision and measures to develop brand equity, copy testing, copy research, evaluating sales promotion programs. Evaluating effectiveness of IMC campaign.	**6 Hours**

Text Books:

1. Advertising & Promotions an IMC Perspective – Shah and D'Souza – Tata McGraw-Hill
2. Integrated Marketing Communication – Niraj Kumar – Himalaya Publishing House
3. Advertising Management with Integrated Brand Promotion – Thomas O'Guinn– Universityof Illinois, Chri s Allen - University of Cincinnati, Cengage Learning
4. Chunawalla, Sethia, Advertising: Theory and Practice, Himalaya Publication House, 7th Edition, 2008
5. Rossiter, John R., Percy, Larry, Advertising and Promotion Management, Mc Graw Hill, 2008
6. Aaker, David A., Advertising Management, Prentice Hall India, 5th Edition, 2008

CONSUMER BEHAVIOUR AND RETAIL MARKETING

Course Code: MB-8221 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Consumer Behaviour and Marketing Action: An overview – Consumer involvement, decision-making processes and purchase behaviour and marketing implications – Consumer Behaviour Models	**8 Hours**
Unit-II	Environmental influences on consumer behaviour – Cultural influences – Social class, reference groups and family influences - Opinion leadership and the diffusion of innovations – Marketing implications of the above influences.	**10 Hours**
Unit-III	Strategic marketing applications – Market segmentation strategies – Positioning strategies for existing and new products, Re-positioning, perceptual mapping – Marketing communications – Source, message and media effects. Store choice and shopping behaviour – In-Store stimuli, store image and loyalty – Consumerism – Consumer rights and Marketers' responsibilities.	**8 Hours**

Unit-IV	Retailing – Strategy and environment:An overview of retailing – Types of stores – Product retailing vs. Service retailing – Non-store retailing Retail strategy – Achieving competitive advantage and positioning Retailing environment – legal, social, economic, technological, issues Trends in the Indian Retailing Industry	**8 Hours**
Unit-V	Store location and layout:Retail store location and layout – Country/Region analysis – Trade area analysis – Site evaluation and selection. Store design and layout – Comprehensive store planning Exterior design and layout – Interior store design and layout – Interior design elements. Merchandise planning and pricing:Planning merchandise needs and merchandise budgets – Methods for determining inventory evaluation – Assortment planning, buying and vendor relations ; Merchandise pricing – Price strategies – Psychological pricing – Mark-up and markdown strategies	**8 Hours**

Text Books:

1. Bannet, Peter D &Kassarjian, Harold, H.:Consumer Behaviour, Prentice Hall of India, New Delhi. , 200 0
2. Peter, Paul J & Olson, Jerry: Consumer Behaviour and Marketing Strategy, Tata McGrawHill, 2005
3. Batra, S &Kazmi, S, Consumer Behavior Text & Cases , Excel Books, New Delhi, 2nd Edition,2008
4. Loudon, D & Della, Bitta A., Consumer Behavior, Tata McGraw Hill, New Delhi, 4th Edition, 2009
5. Levy, Michael, Weitz Barton A. &Pandit, Ajay, Retail Management, Tata McGraw-Hill, 6th Edition, 2009 , New Delhi
6. Pradhan, Swapna, Retail Management, Tata McGraw-Hill, 2nd Edition, 2007
7. Bajaj, Chetan, Tuli Rajnish & Srivastava, Nidhi V, Retail Management, Oxford University Press, 8thEd ition, 2007

PERFORMANCE MANAGEMENT, TRAINING & DEVELOPMENT

Course Code: MB-8230 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Performance Management (PM) Conceptual Frame Work: Introduction to Performance Management, nature, scope, importance, process of Performance Management, link between Performance Management and Performance Appraisal, Benefits of Performance Management, Performance Planning, Role Analysis and Evaluating Performance Management.	**8 Hours**
Unit-II	360^0 feedback, Assessment centres, Performance reviews, Coaching and Counselling, Performance Management in Manufacturing, Services and IT Sector with special reference to NALCO, State Bank of India, Infosys and ITC, Strategies for improving performance.	**10 Hours**
Unit-III	Need for Training and Development – Role of Development officers – administrators, consultants, designers and instructors – determining training needs – potential macro needs – usefulness of training – development of competency-based training programs – Evaluation of training programs.	**8 Hours**
Unit-IV	Methods of training – on the job training – off the job training – choosing optimum method – the lecture – field trips – panel discussion – behaviour modelling – interactive demonstrations – brain storming – case studies – action mazes, incident process, in-baskets, team tasks, buzz-groups and syndicates, agenda setting, role-plays – reverse role plays, rotational role plays, finding metaphors, simulations, business games, clinics, critical incidents, fish bowls, T-groups, data gathering, grouping methods, transactional analysis, exception analysis.	**10 Hours**
Unit-V	Need for development – differences between training and development – management development program – career development program – counselling – evaluation of programs – job evaluation – methods and techniques.	**6 Hours**

Text Books:

1. Janakiram, B., Training & Development, Biztantra, New Delhi, 2007
2. Sahu, R. K., Training for Development, Excel Books, New Delhi 7th Edition, 2006
3. Armstrong, Michael & Baron, Angela, Performance Management, Jaico Pub. House, Ahmedabad, 1st Edition , 2006
4. Kandula, Srinivas R., Performance Management: Strategies, Interventions, Drivers, PHI, New Delhi, 1s tEdition, 2007
5. Rao, T. V., Performance Management and Appraisal Systems, Response Books, New Delhi, 1st Edition, 20 04
6. Cardy, Robert L., Performance Management, PHI, New Delhi, 1st Edition, 2008

ORGANISATIONAL CHANGE AND DEVELOPMENT

Course Code: MB-8231 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Organisational Change:Concept, forces and types of organizational change - External and Internal, Recognizing the need for change, problem diagnosis, The Six-Box organizational Model, The 7-S framework, Identifying alternate change techniques , Resistance to change, Managing resistance to change, The process of organizational change. Incremental Change Vs Disruptive Change.	**8 Hours**
Unit-II	Managing Change :Managing Change: Planning, Creating the support system, Internal Resource Persons (IRP) and External agent, managing the transition, organization restructuring, reorganizing work activities, strategies, process oriented strategies, competitor and customer oriented strategies.	**10 Hours**
Unit-III	Lewin's Perspective and other models	**8 Hours**
Unit-IV	Organisational Development: Organisational change and process Consultation**,** Organisation Development - OD process, OD Interventions, Action Research orientation, Evaluating OD Effectiveness.	**10 Hours**
Unit-V	Strategic Interventions, Techno-structural Interventions, Human process Interventions, Human ResourceManagement Interventions.OD Practices in Indian organisation.	**6 Hours**

Text Books:

1. French, W.L & Bell, C.H: Organisational Development, Behavioral Science Intervention for Organisatio n Improvement, Prentice Hall, New Delhi, 2009
2. Thornbill, A: Managing Change, Pearson Education, New Delhi, 2008
3. Cummings, T. G. and Worley, C. G.: Organization Development and Change, Thomson Southwestern, Singap ore, 7th edition, 2005
4. K. Harigopal: Management of Organisational Change, Response Books, New Delhi, 2001

MATERIALS MANAGEMENT

Course Code: MB-8240 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Fundamentals of Materials Management; Material cycle; Forecasting; Production Planning andMaterials Requirements	**8 Hours**
Unit-II	Materials Procurement; Tendering; Types of Tenders, E tendering platform.	**8 Hours**
Unit-III	Storage and warehousing concepts, Receipt, Warehouse type, Layout, issue of materials and updating ofrecords; Manpower and equipment;	**8 Hours**
Unit-IV	Material Classification, Need and usage of classification, Single-dimensional classification, Multidimensionalclassifications; Materials Codification, Usage of codification, Codification types; Testing of Material.	**8 Hours**
Unit-V	Inventory Systems for different demand situations, deterministic models; Economic Order Quantity (EOQ)under different situations of pricing, demand and delivery;MRP and MRP-II - technical requirements, Software usage in Inventory management; Contemporaryscenario. MM software module.	**10 Hours**

Text Books:

1. Arnold, Chapman: Introduction to Materials Management: Pearson
2. Gopalkrishnan and Sundarsan: Material Management: An Integrated Approach, Prentice Hall of India Pri vate Limited, New Delhi.
3. K. Dutta: Materials Management: Procedures, Text and Cases, Prentice Hall of India Private Limited, New Delhi
4. Purchasing and Materials Management, Nair- Vikas Publishing House Pvt. Ltd., New Delhi

ADVANCED PRODUCTION MANAGEMENT

Course Code: MB-8241 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Advanced Production System Concept – Forecasting using Multiple Regression (Matrix Method), Productivity Improvement Strategies – Introduction to CIM – Recent Trends in Manufacturing Process.	**8 Hours**
Unit-II	Single Facility Location Problem, Multi-facility Location Problem – Minimax Location Problem – Computerized Layout Techniques – ALDEP, CRAFT, Group Technology – Rank Order Clustering Algorithm.	**8 Hours**
Unit-III	Aggregate Planning: Concepts, Mathematical model. Master Scheduling – Single Machine Scheduling: SPT rule, EDD rule, Branch and Bound Algorithm to Minimize Mean Tardiness. Flow Shop Scheduling: Johnson's algorithm and its extension, Branch and Bound Technique to minimize makespan, CDS heuristic – Job Shop Scheduling: priority rules, Active schedule generation – Travelling Salesman Problem and its use to solve Single Machine Scheduling Problem with dependent set up time.	**10 Hours**
Unit-IV	Assembly Line Balancing: RPW technique, COMSOAL – Resource Allocation and Resource Levelling in Project Networks – Replacement Analysis: - Due to Wear and Tear, Economic Life Determination Maintenance and Failure analysis –Break Down Maintenance and Preventive Maintenance, and Condition Monitoring, Total Productive Maintenance – Use of Simulation for Maintenance Management Decision.	**10 Hours**
Unit-V	Inventory Models – Quantity Discounts – Probabilistic Models – P&Q Systems of Inventory – ABC Classification – VED Analysis – FSN Analysis – XYZ Analysis – Review of Control Charts for Variables and Attributes – Introduction to Sampling – Design of Single Sampling Plan.	**6 Hours**

Text Books:

1. Panneerselvam. R., PRODUCTION AND OPERATIONS MANAGEMENT, (Prentice Hall, New Delhi, 2005)
2. Everett E. Adam & Ronald J. Ebert: PRODUCTION AND OPERATIONS MANAGEMENT, (Prentice Hall, 1994).
3. Production Planning and Control- Text and Cases, Mukhopadhay, PHI, New Delhi

SYSTEM ANALYSIS AND DESIGN

Course Code: MB-8244 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Overview of Systems: Introduction to System, Characteristics of a System, Elements of a System, Types of System, System Development Life Cycle.	**8 Hours**
Unit-II	Requirement Analysis of a System: *Initial Investigation:* Project selection, Requirement Specification, Fact Finding. *Feasibility study:* Economic Feasibility, Technical Feasibility, Behavioural Feasibility. *Tools of Structured Analysis:* Decision Tree/Table, Structured English, Data Dictionary, Context Diagram, Data Flow Diagrams.	**8 Hours**
Unit-III	Designing a System: Introduction to Data Models, Types of Data Models, Relationship Model concepts, Entity Relationship Diagram, Relational Schema Diagrams, Normalization of Data, Database design, Input/ Output design, Process Design.	**8 Hours**
Unit-IV	Implementation and Maintenance of the System: *System implementation:* Testing and Evaluation, Installation, Documentation, Training. *System Maintenance:* Process of Maintaining Information System, Types of Maintenance, Cost of Maintenance, Managing Maintenance.	**8 Hours**
Unit-V	Managing and Updating Systems – Training – Conversion Methods – Post Implementation Review. Hardware and Software Selection – Overall Economic Analysis.	**10 Hours**

Text Books:

1. Awad, E.M. System Analysis & Design, Golgotia Publication, New Delhi, 2002.
2. Garg, V.K. & Srinivasan, S. Workbook on System Analysis & Design (Second Edition), Prentice Hall of India, New Delhi, 2009.
3. Modern Systems Analysis and Design- Hopper, George, Valacich, Panigrahi- Pearson Education, New Delh i.
4. Analysis & Design of Information Systems- Rajaraman, PHI, New Delhi

DATA MINING & SOFT COMPUTING

Course Code: MB-8245 **L-T-P** (3-0-0), **Credit**-3

Unit-I	Data Mining Basics: Definition, Knowledge Discovery in Databases vs. Data Mining, Database Management System vs Data Mining, Application of Data Mining, Data Mining Technique, Issues and Challenges of Data Mining.	**8 Hours**
Unit-II	Association Rule Mining Techniques: A Priori Algorithm, Partition Algorithm, Pincer-Search Algorithm, Dynamic Item set Counting Algorithm, FP-tree Growth Algorithm, and Other Algorithms.	**8 Hours**
Unit-III	Clustering Techniques: Partitioning Algorithms, k-Medico Algorithm, Hierarchical Clustering, Other Clustering Techniques, Decision Tree Techniques	**8 Hours**
Unit-IV	Soft Computing Techniques: Fuzzy Logic, Neural Network, Genetic Algorithm, Rough Sets.	**19 Hours**
Unit-V	Web Mining: Definition, Web Content Mining, Web Structure Mining, Text Mining.	**8 Hours**

Text Books:

1. Pujari,A.K. Data Mining Techniques, University Press (India) Private Ltd, Hyderabad,2001.
2. Han, J. &Kamber, M. Data Mining: Concepts and Techniques (Second Edition), MorganKaufmann Publishers , San Francisco, C.A., 2006.
3. David, H., Heikki, M. &Padhraic, S. Principles of Data Mining, PHI Learning, New Delhi.
4. Neural Network, Fuzzy Logic & Genetic Algorithm: Synthesis and Application- S. Rajasekharan, G.A, VijaylaxshmiPai, PHI, New Delhi
5. Fuzzy Logic with Engineering applications- T.J Ross, Tata McGraw-Hill, New Delhi.

****

CENTRE FOR MANAGEMENT STUDIES

Curriculum/Course Work Structure for Ph.D. (Management)

S.N.	Course code	Course title	L	T	P	Credits
1.	MB 9101	Research Methodology	4	0	0	4
2.	MB 9102	Management Principles and Practices	4	0	0	4
3.	MB 9103	Statistics for Business Decision Making	4	0	0	4
4.	MB 9104	Advanced Marketing Management	4	0	0	4
5.	MB 9105	Advanced Financial Management	4	0	0	4
6.	MB 9106	Advanced Human Resource Management	4	0	0	4
7.	MB 9107	Advanced Operations Management	4	0	0	4
8.	MB 9108	Advanced Systems Management	4	0	0	4

MB 9101 RESEARCH METHODOLOGY

Unit-I	Concept of Research Meaning and importance of Research Types of Research Selection and formulation of Research Problem Research Design
Unit-II	Research Methods (a) Traditional Methods Historical, Institutional, Legal, Philosophical, Comparative, Ethical methods etc. (b) Modern Methods Survey of Literature, Sampling method, Questionnaire, Schedule etc, Interview method and Focus Group discussion, Observation Method, Case Study method, Content analysis, Delphi method, Statistical Method, Experimental method, Brainstorming Techniques etc.
Unit-III	Population defined, Sampling Frame, Sampling Vs. Census, Steps in selecting a sample. Various types of Sampling Methods - Probabilistic: Simple Random Sampling Stratified Random Sampling, Cluster Sampling. Non Probabilistic: Convenience Sampling, Judgment Sampling and Quota Sampling. Dangers of using Non Probabilistic Sampling procedures.Sample Size determination.Concepts of errors in research - Sampling and Non sampling errors and measures to reduce errors.
Unit-IV	Data Collection and Data Analysis Types of data (a) Primary, Secondary and Tertiary Data. (b) Construction and adaptation of instruments, Administration of questions and tests, Tabulation of data. (c) Data organization in SPS S and Excel (d) Graphical representation of data. Analysis of Data (a) Discussion and Interpretation of results. (b) Testing of Hypothesis: Logical an d Statistical Techniques.
Unit-V	Report Writing (a) Organization of the Research Report Preliminaries, Contents of Report, Bibliography, Appendices (b) Style Manuals (c) Criteria for the evaluation of the Research Report.

Text Books:

1. N K Malhotra: Marketing Research: An Applied Orientation, 5th edition, Prentice Hall 2007.
2. R I Levin & D S Rubin: Statistics for Management, 7th Edition, Pearson 1994.

MB 9102 MANAGEMENT PRINCIPLES & PRACTICES

Unit-I	Nature and Functions of Management, Tasks of a Professional Manager, Social Responsibilities of Business, Manager and Environment, Systems Approach to Management, Levels in Management, Managerial Skills.
Unit-II	Planning, Steps in Planning Process, Scope and Limitations, Short Range and Long Range Planning, Flexibility in Planning, Characteristics of a Sound Plan, Management by Objective (MBO), Policies and Strategies, Scope and formulation, Decision Making, Techniques and processes
Unit-III	Organising, Organisation Structure and Design, Authority Relationships, Delegation of Authority and Decentralisation, Interdepartmental Coordinator, emerging Trends in corporate Structure, Strategy and Culture, Impact of Technology on Organisational design, Formal and Informal Organisation, Network Structure.
Unit-IV	An Overview of Staffing, Manpower planning, and related aspects: Leading functions , Skills and Styles; Controlling, Prerequisites of Control Systems, Control Process, Methods, Tools and Technique s of Control, Design of control mechanism, Choices in Control.
Unit-V	Comparative Management Styles and approaches, Japanese Management Practices, Organisational Creativity and Innovation, Management of Innovation, Entrepreneurial Management, Benchmarking, Best Management Practices across the world, Select cases of Domestic & International organisations, Management of Diversity.

Text Books:

1. Koontz & Weihrich: Management, McGraw Hill
2. Stoner & Wankel: Management, Prentice-Hall
3. Peter F. Drucker: Practice of Management, Pan Books
4. L.M Prasad: Principles of Management, S. Chand and Sons, New Delhi
5. Stephen P Robbins: Fundamentals of Management, Pearson Education
6. Banerjee: Management Essentials, SAGE Publication.

MB 9103STATISTICS FOR BUSINESS DECISION MAKING

UNIT I	INTRODUCTION : Statistics Definition, Types. Types of variables Organising data - Descriptive Measures. Basic definitions and rules for probability, conditional probability independence of event s, Baye's theorem, and random variables, Probability distributions: Binomial, Poisson, Uniform and Normal distributions.
UNIT II	SAMPLING DISTRIBUTION AND ESTIMATION : Introduction to sampling distributions, sampling distribution of mean and proportion, application of central limit theorem, sampling techniques. Estimation: Point and Interval estimates for population parameters of large sample and small samples , determining the sample size.
UNIT III	TESTING OF HYPOTHESIS - PARAMETIRC TESTS : Hypothesis testing: one sample and two sample tests for means and proportions of large samples (z-test), one sample and two sample tests for means of small samples (t-test), F-test for two sample standard deviations. ANOVA one and two way.
UNIT IV	NON-PARAMETRIC TESTS : Chi-square test for single sample standard deviation. Chi-square tests for independence of attributes and goodness of fit. Sign test for paired data. Rank sum test. Kolmogorov - Smirnov test for goodness of fit, comparing two populations. Mann Whitney U test and Kruskal Wallis test. One sample run test, rank correlation.
UNIT V	CORRELATION, REGRESSION AND TIME SERIES ANALYSIS : Correlation analysis, estimation of regression line. Time series analysis: Variations in time series, trend analysis, cyclical variation s, seasonal variations and irregular variations, forecasting errors.

REFERENCES:

1. Richard I. Levin, David S. Rubin, Statistics for Management, Pearson Education, 7th Edition, 2011.
2. Aczel A.D. and Sounderpandian J., "Complete Business Statistics", 6th edition, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2012.
3. Srivatsava TN and Shailaja Rego, Statistics for Management, Tata McGraw Hill, 2008.
4. Ken Black, Applied Business Statistics, 7th Edition, Wiley India Edition, 2012.
5. Anderson D.R., Sweeney D.J. and Williams T.A., Statistics for business and economics, 11th edition, Thomson (South Western) Asia, Singapore, 2012.
6. N. D. Vohra, Business Statistics, Tata McGraw Hill, 2012

MB 9104ADVANCED MARKETING MANAGEMENT

Unit-I	Marketing Concepts Approaches to Marketing Core concepts of marketing - Marketing Process Functions of Marketing. Marketing Environment The changing marketing environment Analysing needs and trends in Macro Environment and Micro Environment. Market Segmentation Bases for market segmentation of consumer goods, industrial goods and services Market Targeting and positioning strategies.
Unit-II	Marketing Mix Four P's Its significance in the competitive environment Product and Product Line Product Mix Product Life Cycle Managing the product in Product Life Cycle. New Product Decision Process Types of new products Test Marketing of a new product, Packaging Purpose, Types and New Trends in packaging. Physical Distribution Importance and role of distribution in marketing Introduction to the various channels of distribution Promotion Tools Sales Promotion, Advertising, Personal Selling, Direct Marketing and Online Marketing as promotion tools.
Unit-III	Strategic Marketing: Strategy Formulation Vision, Mission, Objectives and Goals of business and their relationship with Strategic Marketing Management. Considerations for formulation of marketing strategies for all components of Product, Price, Promotion and Distribution. Strategic Marketing analysis SWOT Analysis, GAP Analysis Competitive Analysis Porter's 5 forces Model of competition, BCG Matrix, GE 9 Cell Model as basic foundation of Strategic Marketing, McKinsey's 7s framework for analysing and improving organizational effectiveness. Marketing Strategy Implementation Integration of Marketing Strategies and their application to different business sectors FMCG, Industrial, & Services. Constraints in marketing strategy implementation.

Unit-IV Rural & Agricultural Marketing- Rural marketing Features, Significance, Scope and Limitations. Segmentation in rural marketing Classification of products and services in rural marketing Marketi ng Mix for rural products. Innovative Distribution Channels like ITC E-choupal, Godrej Adhar, HUL Shakt i. Agriculture Marketing Definition, Scope, Concept and Objectives, Differences in Agricultural and Consumer Marketing, Constraints in Agricultural marketing. Cooperative Marketing Concept, History, Functions Reasons for slow progress of cooperative sector. SCM in Agri Business i.e. Cold Chains, Organized procurement & warehousing.

Unit-V Virtual Marketing- Role of the Internet: technological development, development of ecommerce, different commercial models, diverse roles of websites. Internet strategy: virtual value chain, dis-intermediation, cybermediaries. Consumer behaviour: flow theory; Hoffman's Many-to-Many model; Internet branding and loyalty; Internet communities; how the Internet is changing consumer behaviour. Internet market research: secondary research, online focus groups, MEGS, web surveys, Email surveys. Internet promotion: advertising: types, measurement, effectiveness, integration; affiliation marketing, PR; word-on-line; direct marketing.

References:

1. Principles of Marketing - Philip Kotler and Gary Armstrong
2. Marketing - Stanton, Michael Etzel, Walker (TMH)
3. Chaffey, Mayer, Johnston, Ellis-Chadwick (2000) Internet Marketing, Prentice Hall
4. Hanson, W. (1999) Principles of Internet Marketing, International Thomson Publishing
5. Sterne, J. (1999) World Wide Web Marketing, 2nd edition, John Wiley & Sons.
6. Straus, J. and Frost R. (1999) Marketing on the Internet, Prentice Hall.
7. Business Policy & Strategic Management Azar Kazmi
8. Strategic Marketing-David W.Cravens ,Nigel f.Piercy
9. Marketing Strategy, TMH Ed. - Boyd Walker, Mullins Larrech
10. Agricultural Marketing in India S. S Acharya and N L Agarwal -Oxford & IBH Publishing Co Pvt Ltd Calcutta
11. Agribusiness Management in India Text & Cases - Dr. Subhash Bhave
12. Journals and periodicals.

MB 9105ADVANCED FINANCIAL MANAGEMENT

Unit-I Introduction to Financial Management, Financial environment of Business-General financial environment, Introduction to financial Markets. Time value of money and applications.

Unit-II Probability theory for financial management- Univariate and Multivariate theory. Portfolio Theory: Risk and Return, Measuring returns, setting up the optimal Portfolio Problem, Mathematical Investigation of Efficient frontier. Capital Asset pricing Model (CAPM) and multi factor model.

Unit-III Financial Time series analysis- Introduction to Time Series Analysis, Nature of time series data, difference equations,Stochastic process: Stationary versus Non-stationary Stochastic Process, Tests of Stationarity: Correlogram, Unit Root Tests, Random Walk Models.

Unit-IV Multivariate Times Series Analysis-Vector Autoregression Model (VAR):Estimation and Identification,Variance decomposition and Impulse response functions,Causality applying Granger Causality Tests and VAR model,Forecasting using a VAR model.Modelling Volatility: Time varying volatility model: ARCH, GARCH models and its extension

Unit-V Structured Finance: Introduction-Definition of Structured Finance, Major Types of Structured Finance Products, Case Study: How Enron has affected the Boundaries of Structured Finance. Some Issues Related to Credit Derivatives-Credit Default Swaps, Credit Default Swap Index, Basket Default Swaps, Asset Swaps, Total Return Swaps, Economics of a Total Return Swap. Securitization Structure-Use of Interest Rate Derivatives in Securitization Transactions, Credit Enhancement.

References:

1. Principles of Corporate Finance- Brealey and Myers, TMH, New Delhi.
2. Structured Finance and Collateralised Debt Obligations-J.M Tavakoli, Wiley Finance.
3. Time series analysis- J.D Hamilton, Princeton University Press.
4. Introductory Econometrics for Finance- Chris Brooks, Cambridge University Press.
5. Introduction to Securitization- Frank J Fabozzi, John Wiley & Sons.
6. Essential Mathematics for Market Risk Management- S Hubbert, John Wiley & Sons.

MB 9106ADVANCED HUMAN RESOURCE MANAGEMENT

Unit-I	Introduction to Human Resources Management: Context and Concept of People Management in a Systems Perspective Organisation and Functions of the HR and Personnel Department HR Structure and Strategy; Role of Government.
Unit-II	HR Planning and Selection: Human Resource Information System (HRIS), Manpower Planning Selection System including Induction Performance and Potential Appraisal; Coaching and Mentoring; HRM issues and practices in the context of outsourced manpower.
Unit-III	Strategic management of Human resources: An introduction, Business strategy- An introduction to market driven strategy, Resource driven strategy. Human resource system- its macro and micro dimensions, Strategic HR planning, Strategic approach to manpower acquisition recruitment and selection.
Unit-IV	Strategic development of human resources, Strategic approach to management structure, job design and work system, Strategic management of performance. Strategic approach to compensation and benefits, Strategic approach to Industrial relations, outsourcing and its HR implications, Mergers and acquisitions and HRM.
Unit-V	Human Resource Evaluation- An Overview, Rationale for HR Evaluation, Measures of HRM Performance, Approaches to HR Evaluations. Career Management, Mentoring Relationship, Work-life Balance.

REFERENCES:

1. Pramod Verma: PERSONNEL MANAGEMENT IN INDIAN ORGANISATIONS, (Oxford & IBM Publishing Co. Ltd.).
2. Bohlander, Snell, Sherman: MANAGING HUMAN RESORUCES (Thomson South Western)
3. Pattnaik B, Human Resource Management, PHI
4. Rao, V. S. P., Human Resource Management, Excel Books, New Delhi, 2nd Edition, 2005
5. Rao, Subha, Essentials of Human Resource Management, Himalaya Publications, Kolkata, 5th Edition, 2009
6. York, Kenneth M., Applied Human Recourse Management, SAGE Publication, New Delhi, 1st edition, 2011.
7. Kandula, Srinivas R., Strategic Human Resource Development, PHI, New Delhi, 1st Edition, 2001
8. Mello, Jeffrey A., Strategic Human Resource Management, Cengage Learning India Private Limited, New Delhi, 2nd Edition, 2008
9. Viswanathan, Rajeesh, Strategic HRM, Himalaya Publishing House, Mumbai, 1st Edition, 2010
10. Regis, Richard, Strategic Human Resource Management & Development; Excel Books, New Delhi, 1st Edition, 2008.

MB 9107ADVANCED OPERATIONS MANAGEMENT

Unit-I	Advanced Production System Concept Forecasting using Multiple Regression (Matrix Method), Productivity Improvement Strategies Introduction to CIM Recent Trends in Manufacturing Process.
Unit-II	Single Facility Location Problem, Multi-facility Location Problem Minimax Location Problem Computerized Layout Techniques ALDEP, CRAFT, Group Technology Rank Order Clustering Algorithm.
Unit-III	Industrial control system- process industries vs discrete manufacturing industries, continuous vs discrete control, computer process control. Sensors actuators; Numerical controls; Industrial Robotics; Discrete Control using programmable logic controller and personal computers.
Unit-IV	Introduction to Supply Chain Management, Logistics Network Configuration, Inventory Management and Risk Pooling.
Unit-V	Inventory Systems for different demand situations, deterministic models; Economic Order Quantity (EOQ) under different situations of pricing, demand and delivery; MRP and MRP-II - technical requirements, Software usage in Inventory management; Contemporary scenario. MM software module.

References:

1. Production and Operations Management- R. Panneerselvam-PHI.
2. Introduction to Materials Management- Arnold, Chapman, Pearson.
3. Automation, Production system, and Computer Integrated Manufacturing- Groover MP,PHI.
4. Designing and Managing the Supply Chain: Concepts, strategies and Case studies, by Simchi-levi, D., P.Kaminsky, and E.Simichi-Levi, Irwin- McGraw-Hill.

MB 9108 ADVANCED SYSTEMS MANAGEMENT

Unit-I	Decision Support Systems Definition Characteristics & capabilities of DSS Components of DSS-database, Model base, Communication subsystem & User Classes of DSS.
Unit-II	Entity Relational Model: Design and Construction, ER diagram conversion to relational model; Relational Model, Basic Relational Algebra, Basic Relational Calculus; Query Languages: SQL, SQL Constructs, Query Compositions, Transaction Processing, Embedded SQL Integrity Constraints.
Unit-III	Normalization, Level of Normalization and their use, Dependencies, Keys, Concepts of Keys; Indexing and Hashing, Tables Clustering.
Unit-IV	Soft Computing Techniques: Fuzzy Logic, Neural Network, Genetic Algorithm, Rough Sets.
Unit-V	Data Mining Basics: Definition, Knowledge Discovery in Databases vs. Data Mining, Database Management System vs Data Mining, Application of Data Mining, Data Mining Technique, Issues and Challenges of Data Mining.

References:

1. Decision Support System and Expert Systems- EfralmTurbon, Macmillan.
2. Database System Concepts- Abraham Silberschatz, Henry Korth, S. Sudarshan- TMH.
3. Fuzzy Logic with Engineering applications- T.J Ross, TMH.
4. Neural Network, Fuzzy Logic & Genetic Algorithm: Synthesis and Application- S. Rajasekharan, G.A, Vijaylaxshmi Pai, PHI.
5. Principles of Data Mining, David, Heikki, Padhraic-PHI.

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY

SYLLABI
OF
PG / Ph. D. COURSES
(DEPARTMENT OF HUMANITIES & SOCIAL SCIENCES)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY
(UNDER THE MINISTRY OF EDUCATION, GOVT. OF INDIA)
DEEMED TO BE UNIVERSITY U/S 3 OF THE UGC ACT, 1956
NIRJULI - 791 109 :: ARUNACHAL PRADESH

SYLLABI
OF
PG/ Ph. D COURSES

(DEPARTMENT OF HUMANITIES & SOCIAL SCIENCES)

(Revised and Approved by the 24th Academic Council Meeting, held on 6th May, 2017)

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY (NERIST)

(Deemed to be University, U/S 3 Of the UGC Act, 1956)
Nirjuli (Itanagar), Arunachal Pradesh- 791 109

DEPARTMENT OF HUMANITIES
COURSES FOR PG PROGRAMME
Post Graduation (M. Tech.) Programme

HS 7001: ORGANISATIONAL BEHAVIOUR **4 Credits (3-1-0)**

Unit-I	Organizational Behavior: Definition, Scope and Importance. The Organization and the individual, Forces affecting organizational behavior, Challenges and opportunities for OB, Changing profiles of Employees and Customers, Impact of Globalization and Information technology on Organizational Behavior.	9 lectures
Unit-II	Individual dimensions of organizational behavior: Individual differences, Personality theories, Attitudes and Job satisfaction, Perceptual Process, Impression Management.	8 lectures
Unit-III	Leadership: Basic approaches, Conflict, Organizational change, Management of change, Resistance to change, change agents. Communication Process and barriers, Organizational culture and its effectiveness.	8 lectures
Unit-IV	Groups: Group dynamics, group structure, functions, group decision making, group interaction, Types of groups, Understanding work teams. Team effectiveness and team building.	8 lectures
Unit-V	Motivation: Process, Theories, Behavior modification, Motivation and work environment, Performance Appraisal, Stress Management.	9 lectures

Recommended Books:

1. Organizational Behavior- Robbins,S.P., Judge, T.A. and Sanghi, Seema, Pearson Prentice Hall, New Delhi, India.
2. Organizational Behavior - Luthans, Fred, Mc Graw Hill, International Edition.
3. Organizational Behavior – Rao, V.S.P, Excel Books, New Delhi.
4. Developing Managerial skills in Organizational Behaviour - Mainiero, Lisa A. and Tromley, Cheryl L. , Printice Hall India, New Delhi.
5. Understanding Organizational Behavior - Pareek, Udai, Oxford University Press.

HS 7002 : Research Methodology : **3 Credit (3-0-0)**

Unit-I	Introduction to Research Methodology: Importance of Research in Decision Making, Defining Research Problem and Formulation of Hypothesis, Experimental Design.	9 lectures
Unit II	Data Collection and Measurement; Methods of Data Collection, Sampling and sampling Designs, Data Presentation and Analysis; Data Processing.	9 lectures
Unit III	Attitude Measurement and Scales; Statistical Analysis and Interpretation of Data, Non-Parametric Tests, Multivariate analysis of Data.	8 lectures
Unit IV	Measures of Central Tendency and Dispersion, Correlation, Regression, Model building and Decision Making.	9 lectures
Unit V	Report Writing and Presentation: Substance of Reports, formats of Reports, Presentation of Report.	7 lectures

Recommended Books:

1. Research Methodology – C. R. Kothari, New Age Publications, New Delhi, 2005.
2. Research Methodology – B. Taylor, G. Sinha & T. Ghoshal, Prentice Hall of India, ND. 2007.
3. Research Methodology – R. Panneersalvam, Prentice Hall of India, New Delhi, 2007.
4. Management Research Methodology – K. N. Krishnaswamy, A. I. Sivakumar& M. Mathirajan, Pearson Education, New Delhi, 2008.

HS-7003 MANAGEMENT OF HUMAN RESOURCES **CREDITS (3-0-0)**

Unit-I	HRM: Definition, Scope, and Objectives, Function of HRM, challenges of environmental factors on HRM, HR impacts on organizational performance, HRM and Personnel Management.	9 lectures
Unit-II	Human Resource Planning, Job analysis, Recruitment, Selection, Induction and Placement.	8 lectues
Unit-III	Developing human resources, Training and development, Training Methods, administration, Perception and communication, Performance Appraisal and Job evaluation.	9 lectures
Unit-IV	Retention strategies, socialization of employees, motivation concepts, application of motivation concepts, strategies for work life balance, Quality of work-life.	9 lectures
Unit-V	Employee mobility, promotions and transfer, employee welfare, safety and health, Grievance handling, Collective bargaining, Stress managing strategies.	8 lectures

Recommended Books:

1. Human Resource and Personal Management: Text and Cases - K. Aswathappa, Tata McGrow Hill Publishing Company Limited, New Delhi.
2. Human Resource Management: Text and cases - VSP Rao, Excel Books, New Delhi.
3. Human Resource Management: Mirza S. Saiyadain, Tata McGrow Hill Publishing Company Limited, New Delhi.
4. Human Resource Management: S. P. Robbins, Prentice Hall of India, New Delhi.
5. Human Resource Management: Dipak Kumar Bhattacharyya, Excel Books, New delhi.

HS-7004 Marketing Management : **CREDITS (3-0-0)**

Unit-I	Understanding Marketing Management : Marketing in a developing Economy, Marketing of Services	8 lectures
Unit-II	Marketing Planning and Organization : Planning Marketing Mix, Market Segmentation, Marketing Organizations, marketing Research and its Applications.	8 lectures
Unit-III	Marketing environment and consumers : Determinants of Consumer Behaviour, Models of Consumer Behaviour, Indian consumer Environment.	8 lectures
Unit-IV	Marketing Offerings : Product Decisions and Strategies, Product Life Cycle and New Product Development, Branding and Packaging Decisions, Pricing and Practices.	8 lectures
Unit-V	Promotion and distribution : Marketing communications, advertising and publicity, Personal Selling and Sales Promotion, Sales Forecasting, Distribution Strategy, managinf Sales and Personal Marketing.	10 lectures

Recommended Books:

1. Marketing Management - A South Asian Perspective - Philip Kotler, Koshi, Jha, (13th Edition) Pearson Education, New Delhi, 2007
2. Marketing Management - Tapan K. Panda, 2nd Edition, Ecell Books, 2008.
3. Marketing Management - Arun Kumar, & N. Minakshi, Vikash Publishing House, 2006.

HS 7005 : Project Management : **Credit (3-0-0)**

Unit-I	Definition of Project, Need of Project Management, Project Development Cycle, Project Planning, Project Environment analysis, Project Report Preparation; Preliminary Screening, and Feasibility Report preparation and analysis.	8 lectures
Unit II	Project Evaluation; Market and Demand analysis, Demand Forecasting, Technical, Financial, Socio-economic, Environmental and Entrepreneurial analyses of project, Project Selection Criteria, Project Implementation.	9 lectures
Unit III	Resource Planning and Allocation, Estimation of Project Cost, Cost of Capital, Means of Finance, Working Capital requirement, Profitability projection, Cash Flow Analysis, Beak-even analysis.	9 lectures
Unit IV	Financial Analysis, Financial Statements, Balance Sheet, Ratio Analysis, Depreciation of Fixed Assets, Social Benefit-Cost Analysis.	8 lectures
Unit V	Project Review Techniques, Network Technique, Programme Evaluation Review Technique (PERT), Network scheduling, CPM, Activity scheduling, Time-cost trade-offs.	8 lectures

Recommended Books:

1. Project Management- R. Panneerselvam& P. Senthilkumar, PHI, New Delhi, 2009.
2. Project Management for Business and Technology- John M. Nicholas, Pearson Education, New Delhi, 2009.
3 Project Formulation, Implementation and Appraisal - P. Chandra. Tata McGraw Hill, New Delhi, 2006.
4. Financial Management- Prasanna Chandra, Tata McGraw Hills Publishing Co. Ltd, New Delhi.
5. Project Management- Harold Kerzner, CBS Publisher and Distributor, New Delhi. 2004

Post Graduation (Ph. D.) Programme

HS 9001 : Research Methodology : **Credit (4-0-0)**

Unit-I	Introduction to Research Methodology: Importance of Research, Types of Research, Steps in Research, Defining Research Problem and Formulation of Hypothesis, Experimental Design.	9 lectures
Unit II	Data Collection and Measurement; Methods and Techniques of Data Collection, Sampling and sampling Designs, Data Presentation and Analysis; Data Processing.	9 lectures
Unit III	Attitude Measurement and Scales; Statistical Analysis and Interpretation of Data, Non-Parametric Tests, Multivariate analysis of Data.	8 lectures
Unit IV	Measures of Central Tendency and Dispersion, Correlation, Regression, Model building and Decision Making.	9 lectures
Unit V	Report Writing and Presentation: Substance of Reports, formats of Reports, Presentation of Report.	7 lectures
Unit VI	Univariate, Bivariate & Multi-variate analysis of data by using SPSS.	14 lectures

Recommended Books:

1. Research Methodology – C. R. Kothari, New Age Publications, New Delhi, 2005.
2. Research Methodology – B. Taylor, G. Sinha & T. Ghoshal, Prentice Hall of India, ND. 2007.
3. Research Methodology – R. Panneersalvam, Prentice Hall of India, New Delhi, 2007.
4. Management Research Methodology – K. N. Krishnaswamy, A. I. Sivakumar& M. Mathirajan, Pearson Education, New Delhi, 2008.

HS 9002 : Quantitative Techniques for Decision Making : **Credit (3-0-0)**

Unit-I	Basic Mathematics for Management: Quantitative Decision Making-An overview, Functions and Progressions, Basic Calculus and applications, Matrix algebra and applications.	8 lectures
Unit II	Data Collection and Analysis: Collection of Data, Presentation of Data, Measures of Central Tendency, Measures of Variation and Skewness.	9 lectures
Unit III	Probability and Probability Distributions: Basic concepts of Probability, discrete and continuous Probability distributions, Decision Theory.	8 lectures
Unit IV	Sampling and Sampling Distributions: Sampling Methods, Sampling Distributions, Testing of Hypotheses, Chi Square Tests etc.	9 lectures
Unit V	Forecasting Methods: Business forecasting, Correlation, Regression, Time Series analysis.	8 lectures

Recommended Books:

1. Quantitative Techniques for Managerial Decisions – U. K. Srivastave, G. V. Shenoy & S. C. Sharma, New Age International Publishers, 2008,
2. Quantitative Techniques – C. R. Kothari, Vikas Publishing House Pvt. Ltd., 2007.
3. Quantitative Techniques for Decision Making – M. P. Gupta & R. B. Khanna, Prentice Hall of India, New Delhi, 2007.
4. Business Statistics – L. K. Sharma, Pearson Education, Delhi, 2008.

HS 9003 Entrepreneurship Development: **3 Credit (3-0-0)**

Unit-I	Definition, Importance of entrepreneurship, Difference between Entrepreneurship and Entrepreneur, Entrepreneurial Motivation, Entrepreneurial goal setting. Characteristics of entrepreneurs. Types of entrepreneurs, Rural entrepreneurship, Women entrepreneurship. Rural and agri-business industries.	8 lectures
Unit-II	Business Venture launching: Identification of investment opportunities, Project formulation, Preliminary Report, Feasibility Report , Preliminary Screening, Surveying, market demand forecasting. Project Analysis.	9 lectures
Unit-III	Project Evaluation; Means of financing and Profitability Projection of the project, Time value of money, Cash Flow Analysis, Ratio Analysis, Balance Sheet Preparation, Break-even Analysis.	8 lectures
Unit-IV	Cost of Project, Cost of production, Material cost, Labour cost, Working Capital, Capital Depreciation, salvage value.	7 lectures
Unit-V	Project selection criteria; Qualitative and Quantitative Methods; Delphi and Jury of Executives opinion method, Pay back period, Accounting Rate of return, Net Present Value, Internal Rate of Return, Cost-benefit Ratio methods.	8 lectures

Recommended Books:

1. Entrepreneurship Development, B.S. Rathore& J.S. Saini, Wiley Eastern Pvt.
2. Agri-Business and Entrepreneurship, Rajgopal, Indian Books & Periodicals
3. Entrepreneurship: Starting a New Business, Anderson, Allied publishers ltd.
4. Entrepreneurship Development: S. S. Khanka, Soltan Chand & Sons, New Delhi.
5. Management and Entrepreneurship: KanishkaBedi, Oxford Publication, New Delhi.

HS 9004 : Project Management and Financial Analysis: **3 Credits (3-0-0)**

Unit-I	Definition of Project, Need of Project Management, Project Development Cycle, Project Planning, Project Environment analysis, Project Report Preparation; Preliminary Screening, and Feasibility Report preparation and analysis.	8 lectures
Unit II	Project Evaluation; Market and Demand analysis, Demand Forecasting, Technical, Financial, Socio-economic, Environmental and Entrepreneurial analyses of project, Project Selection Criteria, Project Implementation.	8 lectures
Unit III	Resource Planning and Allocation, Estimation of Project Cost, Cost of Capital, Means of Finance, Working Capital requirement, Profitability projection, Cash Flow Analysis, Beak-even analysis.	9 lectures
Unit IV	Financial Analysis, Financial Statements, Balance Sheet, Ratio Analysis, Depreciation of Fixed Assets, Social Benefit-Cost Analysis.	9 lectures
Unit V	Project Review Techniques, Network Technique, Programme Evaluation Review Technique (PERT), Network scheduling, CPM, Activity scheduling, Time-cost trade-offs.	8 lectures

Recommended Books:

1. Project Management- R. Panneerselvam& P. Senthilkumar, PHI, New Delhi, 2009.
2. Project Management for Business and Technology- John M. Nicholas, Pearson Education, New Delhi, 2009.
3. Project Formulation, Implementation and Appraisal - P. Chandra. Tata McGraw Hill, New Delhi, 2006.
4. Financial Management- Prasanna Chandra, Tata McGraw Hills Publishing Co. Ltd, New Delhi.
5. Project Management- Harold Kerzner, CBS Publisher and Distributor, ND. 2004

HS9005 : Financial Accounting and Business Management: 3 Credit (3-0-0)

Unit-I	**Scope and Objectives of Financial Management:** Evolution and Scope of Financial Management, Functions of Finance Managers, Objectives pf the firm, Profit Vs Wealth Maximization.	8 lectures
Unit II	**Working Capital Management:** Concept of Working Capital, Estimation of Working Capital and Working Capital needs, Management of Receivables, Management of Inventories.	9 lectures
Unit III	**Financial Accounting:** Cost of Capital and Capital Structure: Leverage, Cost of Capital and Value of the firm, NI, NOI and traditional approaches, A critical review of MM Theory, EBIT-EPS analysis and Capital Structure, Sources of Long Term Finance.	8 lectures
Unit IV	**Capital Budgeting:** Need and Importance, Evaluation of Investment Decisions, Identification of Cash Inflow and Outflows, Methods of Capital Budgeting-Payback Period, ARR,PV Method, Profitability Index Method, IRR, Capital Rationing, Risk Analysis.	9 lectures
Unit V	**Management of Earning:** Decision regarding payout and retention, Determinants of Dividend Policy, Various Models of Dividend and their effect on Value of Firm, Dividend Policy in practice, Bonus Issue.	8 lectures

Recommended Books:

1. Introduction to Financial Management- Iqbal Mathur, Macmillan Publishing Co. New Work
2. Financial Management- Prasanna Chandra, Tata McGraw Hills Publishing Co. Ltd, ND.
3. Financial Management – I. M. Pandey, Vikash Publishing House, New Delhi.
4. Fundamentals of Financial Management – Preeti Singh, Ane Books India, New Delhi, 2008.
5. International Financial Management – V. K. Bhalla, Anmol Publications Pvt. Ltd., ND.2006.

HS 9011 : Macro Economics and International Trade : 3 Credits (3-0-0)

Unit-I	Meaning of Macroeconomics, National Income accounting, Keynesian model of income determination, Money and interest.	8 lectures
Unit II	Theory of Consumption and Investment, Business Cycle, Inflation Theory, Inflationary measures, Multiplier and acceleration effects.	9 lectures
Unit III	Concept of International Trade, Business: Regional Trading Blocs, International Financial Organizations, Theories of International Trade and Investment, WTO.	8 lectures
Unit IV	Global Finance Market: Foreign Exchange Market, Exchange Rate Determination and Forecasting, Financing Foreign Trade, International Equity Investment.	9 lectures
Unit V	Trade Policy and Performance of India: Foreign Trade Policy, Import Substitution, Balance of Payment, Major Problems of India's Export Sector, Look East Policy and North East Region.	8 lectures

Recommended Books:

1. International Business concept, environment and strategy - Vyuptakesh Sharan, Pearson Education, New Delhi.
2. International Business – K Aswathappa, Tata McGraw Hill, New Delhi.
3. International Financial Management - P. G. Apte, Tata McGraw Hill, New Delhi.
4. International Economics – Robert J. Carbaugh, Thomson South – Western Division, Indian Edition, 2008.
5. Macroeconomic Analysis – Edward Shapiro, Galgotia Publications (P) Ltd., New Delhi, 1997.

HS 9012 : Economic Growth Models and Development : 3 Credits (3-0-0)

Unit-I	Economic Growth and Development, their differences, Measures of economic development, Factors of growth and development, Obstacles to growth and development, Agricultural Development, Industrial Development, Small Scale Industries Development, Forest Development and Tribal Development.	9 lectures
Unit II	Partial Theories of Development; Theory of Big Push, Theory of Balanced Growth, Strategy of Unbalanced Growth and Theories of Social and Technological Dualism.	8 lectures
Unit III	General Theories of Economic Growth and Development and Various Growth Models. Harod-Domar growth model, Solow's growth model, Johan Robinson's model, etc.	8 lectures
Unit IV	Causes of Underdevelopment, Balanced and unbalanced economic growth, Measures of Development, Economic Planning, Choice of Techniques, Allocation of Investment resources, mobilisation of Resources.	9 lectures
Unit V	Population Problem, Unemployment Problem, Problems of Small Scale Industries, Measures for solving these problems, Human Capital Formation and Knowledge Management for Economic Development.	8 lectures

Recommended Books:

1. Introduction to Financial Management- Iqbal Mathur, Macmillan Publishing Co. New Work Economic Policy and Planning – V. G. Mankar, New Age International Publishers, ND. 1995.
2. Economics of Development and Planning – S. K. Misra and V. K. Puri, Himalaya Publishing House, New Delhi, 2005.

HS 9013 : Theory and Practice of Public Finance : 3 Credits (3-0-0)

Unit-I	Public Finance – Definition, Public Revenue, Sources of Public Revenue, Public Expenditure, Effects of Public Expenditures, Public Debts, Fiscal Policies. Deficit Finance.	8 lectures
Unit II	Taxable Capacity and its measures, Various principles of Taxation, Theories of Taxation, Canons of Sound Taxation, Effects of Taxation, Choices of Taxes, Incidence and Shifting of Taxes.	9 lectures
Unit III	Types of Taxes, Direct and Indirect Taxes. Personal Income tax, Tax on Corporate Income, Capital Gains Tax, Wealth Tax, Expenditure Tax, Death Duty and Gift Tax, Commodity Taxes, Agricultural Taxes in India, Excise duty, GST, etc.	9 lectures
Unit IV	Discussion of various Fiscal Policies and Economic Activities.	8 lectures
Unit V	Public Revenue – Direct Taxes and Indirect Taxes, Financial Relations between Centre and States, Local Finance, War Finance, Indian Fiscal Federation.	8 lectures

Recommended Books:

1. Public Finance Theory and Practice – V. G. Mankar, Himalaya Publishing House, N. D. 1997.
2. Public Finance Theory and Practice – K.P.M. Sundharam & K.K. Andley, S. Chand & Company Ltd., New. Delhi. 2003.
3. Public Finance Theory and Practice – S. K. Singh, S. Chand & Company Ltd., New. Delhi. 2003.

HS 9006: INTERNATIONAL HUMAN RESOURCE MANAGEMENT **3 Credits (3-0-0)**

Unit-I	Human Resource Management in International Context; Cross cultural differences and managerial implication; National Culture & HRM, Business imperatives and other non- cultural influences on HRM.	8 Hrs.
Unit - II	Role of Culture in International HRM**;** Organisational Processes in International HRM**;** International Institutions & HRM- International Labour Organisation, European Union.	8 Hrs.
Unit - III	Recruitment and selection in International Context; Training and Development; Compensation Management; Performance Management; Industrial Relations.	9 Hrs.
Unit - IV	HRM practices in world' leading economy - Countries especially in Japan, U. K, Arab Middle East, Turkey, USA, China and India.	9 Hrs.
Unit - V	Special Issues in IHRM; The Role of the Global HR Manager; International Joint ventures; Hiring Dilemmas.	8 Hrs.

Recommended Books:

1. Dowling, Welch & Schuler - International HRM , Excel Books
2. Sengupta& Bhattacharya - International HRM , Excel Books
3. Monir.H. Tayeb – International HRM: A MNC Perspective, Oxford.
4. Human Resource Management, K. Aswathappa, Tata McGraw Hill, New Delhi.

HS 9007: Knowledge Management **3 Credits (3-0-0)**

Unit-I	The Nature of Knowledge; Introduction to Knowledge Management	8 Hrs.
Unit -II	Knowledge Management Solutions; Factors Influencing Knowledge Management	9 Hrs.
Unit- III	Knowledge Management Assessment; Knowledge Elicitation; Knowledge Discovery Systems.	9 Hrs.
Unit -IV	Knowledge Capture Systems; Knowledge Sharing Systems.	8 Hrs.
Unit - V	Knowledge Application Systems; The future of Knowledge Management.	8 Hrs.

Recommended Books:

1. Knowledge Management –Becerra-Fernandez, Gonzalez &Sabherwal, Pearson Education
2. Knowledge Management – Debowski, John wiley& Sons.

HS 9008 CORPORATE SOCIAL RESPONSIBILITY **3 Credits (3-0-0)**

Unit-I	Corporate Social Responsibility –Concept, Nature, Scope of CSR, Objectives of CSR, Changing expectations of Social Responsibility, the four faces of social responsibility.	8 Hrs.
Unit- II	CSR& Social IssuesDifferent Aspects of Enterprise social responsibility, Gender sensitivity as ethical issue- pedagogy of the liberated, social development.	7 Hrs.
Unit -III	Corporate Governance-Role of Corporate Governance, a framework of social orientations, nature of the corporation, thought action (TA) analysis, OSHA Model for better behavioural analysis.	8 Hrs.
Unit -IV	Role Players; Role of Board of Directors, Role of Auditors SEBI and Government, Growth of Corporate Governance in India.	9 Hrs.
Unit – V	Business Ethics and Corporate Governance .	10 Hrs.

Recommended Books:

1. CorporateGovernance: Principles, Policies, and Practices – Fernando, Pearson Education
2. Murthy C.S.V, Business Ethics, Himalaya Publishing house
3. Machiraju, H.R. Corporate Governance, Himalaya Publishing House

HS 9009: EMOTIONAL INTELLIGENCE AND CREATIVITY **Credit (3-0-0)**

Unit-I	Introduction to Emotional Intelligence –The Role of Emotion, Types of emotions, The role of intelligence, Concept of Emotional Intelligence, Mental Intelligence and Emotional Intelligence, Importance, Myths about emotional intelligence, Emotional Competence	09 Hrs.
Unit- II	The nature of Emotional Intelligence, Emotional Intelligence Applied.	08 Hrs.
Unit- III	BCD Model of Emotional Intelligence –Emotional Awareness, Commitment and Development of Emotional Intelligence, Applying Emotional Intelligence in Organizations, Managing Emotional Intelligence.	09 Hrs.
Unit - IV	Introduction to Creativity-Creativity definition, Nature of creativity, Creative Approach, Role of Creativity in decision making, Stages in Creative Process, Creativity and Innovation, Innovation Generation, Innovation Diffusion.	08 Hrs.
Unit -V	Creativity in Organizations –Characteristics of creative individuals, Methods of enhancing creativity, inducing factors, Conditions in Creativity, Ways to Block Creativity.	08 Hrs.

Recommended Books:

1. Goleman Daniel, Emotional Intelligence, Bantam Books
2. Bradberry Travis, Emotional Intelligence, Quickbook
3. Luthans, Fred, Organizational Behaviour, Ninth Edition, McGraw Hill International.

HS 9010: HUMAN RESOURCE INFORMATION SYSTEMS **3 Credits (3-0-0)**

Unit-I	Introduction to HRM and HRIS –Evolution of HRM and HRIS: The Role of IT, Introduction, Historical Evolution of HRM and HRIS, HR Activities, Interface between HR and Technology, a Primer of HRIS. Database Concepts and Applications in HRIS: Data, Information and knowledge, Database management systems, Key Relational Database Terminology.	9 Hrs.
Unit -II	Systems Considerations in the design of an HRIS: Planning for Implementation – Introduction, HRIS Customers/Users: Data Importance, HRIS Architecture, Best of Breed, system Implementation Process, Determining HRIS needs. Planning and analysis planning, The Big 3- The global positioning system of HRIS, Gap Analysis. System Design and Acquisition- Working with vendors, assessing system Feasibility, cost justifying HRIS investments. HRIS Cost benefit analysis, estimating the timing of benefits and costs, estimating the valued indirect benefits, avoiding common problems, packaging the analysis for decision makers.	8 Hrs.
Unit -III	Project Management Development and HRIS, Acceptance of the HRIS ProjectManagement, The IT Perspective and The HRM perspective. Change Management: Implementation, Integration and Maintenance of HRIS- Introduction the management of change, models of the change process, why do systems failure occurs? Organizational & Individual issues in HRIS implementation, HRIS.HR Administration and HRIS- Introduction, equal employment opportunity, HR strategic goal achievement and the balanced scorecard.	9 Hrs.
Unit -IV	Job analysis and HR Planning –Talent management, job analysis, a framework of strategic HR planning, HRIS Utilization for talent management and HR Planning: The current status. Recruitment and Selection in an internet context- Recruitment and Technology, Summary of Online Recruitment, Selection and Technology, Summary of selection. Training and Development: Strategic Implications and Learning Organizations – Training Metrics and Cost Benefit Analysis.	8 Hrs.
Unit V	Developing an Information System, Examples of Applications-HRIS Applications in Training, Performance Management, Compensation, Benefits, Payroll and the HRIS, Increasing importance of International HRM, HR programs in global organizations, HRIS applications in IHRM. Information Security and Privacy in HRIS- Threats to information security, components of information security, legal requirements for information security, role of HR in Information Security., Auditing the System.	8 Hrs.

Recommended Books:

1. Kavanagh Michael J and Thite Mohan , Human Resource Information Systems , Sage Publications
2. A Handbook of Human Resource Management Practice, Michael Armstrong, Kogan Page

NORTH EASTERN REGIONAL INSTITUTE OF SCIENCE & TECHNOLOGY