SYLLABI OF
DEGREE MODULE
[TECHNOLOGY & FORESTRY]

(REVISED AND APPROVED BY THE 33RD ACADEMIC COUNCIL MEETING HELD ON 4TH DECEMBER, 2021)

North Eastern Regional Institute of Science & Technology
[Deemed to be University u/s 3 of UGC Act, 1956]
[Under Ministry of Education, Govt. of India]
Nirjuli (Itanagar) :: Arunachal Pradesh - 791 109
www.nerist.ac.in

REVISED SYLLABUS

FOR

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(TECHNOLOGY & FORESTRY)

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PREFACE

The syllabi of U.G. Programmes have been revised and approved in the 33rd Academic Council Meeting held on 04.12.2021. The Academic Programme of NERIST in Technology Stream has been designed to consist of three modules, i.e., Certificate (2 years after Class 10), Diploma (1 additional year after Certificate, if Certificate CGPA is less than 6.5) and B.Tech. (4 year after Certificate with CGPA more than 6.5 or Class 12). In Applied Science Stream, four years B.Sc. Programme is offered in Forestry.

The syllabi for Certificate, Diploma [2+1] and Degree Programmes of NERIST are unique and innovative and have been prepared by the faculty members of the Institute appropriately incorporating the requirements of AICTE, UGC, and ICAR guidelines.

The following norms have been followed in presenting the structures and contents.

COURSE CODE:

Courses are denoted by codes comprising of two letters and five digits. The letters indicate the department which is offering the courses. Additionally, some specific letters are also used to denote specific cases, viz., ES for Engineering Sciences, ED for Extra-Curricular Activities and Discipline, MO for Open Elective courses to be taken from MOOC.

The five digits of the number used for denoting a course have the following descriptions:

i. The first digit from the left stands for the module (1 for Certificate or Diploma, 2 for Degree).
ii. The second digit from the left stands for the year.
iii. The third digit 1 or 2 from the left stands for the odd or even semester respectively for the compulsory courses.
iv. The third digit '0' from the left represents an elective course.
v. The fourth and fifth digits from the left are used for course number of which 00 to 49 are reserved for theory courses or courses with more theory component and 50 to 99 are for practice courses which doesn't have any theory examination.

Besides the following course codes are specifically reserved:

MYS77 – Audit Course

MYS79 – Industrial Training

MYS88 – Extra-Curricular Activities and Discipline

MYS89 – Seminar

MYS99 – Project

"M" stands for Module, **"Y**" stands for year, and **"S"** stands for Semester.

COURSE CREDIT:

Lecture/Tutorial: One hour per week per semester is equivalent to one credit. Extra tutorials, whenever applicable do not carry any credits.

Practice: Two hours per week per semester is equivalent to one credit. If the number of practice hour is an odd number, then the credits equivalent to the next higher even number of hours will be assigned. For example, 3 hours of practice will carry 2 credits, 5 hours carries 3 credits and so on.

UNITIZATION:

The courses have been unitized for five units. Each unit has been assigned specific number of contact hours, which has been fixed @ 14 contact hours per lecture credit of the course.

RECOMMENDED BOOKS:

Suggestions on the recommended books have been given at the end of each course, which may be supplemented by the Course Coordinator, if required.

CONTENTS

DEPARTMENT OF FORESTRY

Year I Semester I						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CS21101	Information and Communication Technology	2	0	2	3
2.	CY21101	Plant Biochemistry	1	0	2	2
3.	HS21101	Communication Skills and Personality Development	2	0	2	3
4.	MA21102	Basic Mathematics	2	0	0	2
5.	FR21101	Introduction to Forestry	2	0	0	2
6.	FR21102	Dendrology	2	0	2	3
7.	FR21103	Introduction to Agronomy and Horticulture	2	0	2	3
8.	FR21104	Wood Anatomy	2	0	2	3
9.	NP21161	NCC – I / NSS – I	0	0	2	0
10.	NP21162	Physical Education – I	0	0	2	0
					Total	**21**

Year I Semester II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	MA21202	Statistical Methods and Experimental Designs	2	0	2	3
2.	FR21201	Plant Physiology	2	0	2	3
3.	FR21202	Theory and Practice of Silviculture	2	0	2	3
4.	FR21203	Geology and Soils	2	0	2	3
5.	FR21204	Wildlife Biology	2	0	2	3
6.	FR21205	Forest Protection	2	0	2	3
7.	FR21206	Plant Cytology and Genetics	1	0	2	2
8.	NP21261	NCC – II / NSS – II	0	0	2	0
9.	NP21262	Physical Education – II	0	0	2	0
					Total	**20**

Year II Semester III						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CE22121	Forest Survey and Engineering	2	0	2	3
2.	FR22101	Environmental Studies and Disaster Management	2	0	2	3
3.	FR22102	Ornithology and Herpatology	2	0	2	3
4.	FR22103	Ethnobotany, Medicinal and Aromatic plants	2	0	2	3
5.	FR22104	Tree Improvement	2	0	2	3
6.	FR22105	Principles of Agroforestry	2	0	2	3
7.	FR22106	Forest Mensuration	2	0	2	3
8.	NP22161	NCC – III / NSS – III	0	0	2	0
9.	NP22162	Physical Education – III	0	0	2	0
					Total	**21**

Year II Semester IV						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	FR22201	Forest Management	2	0	2	3
2.	FR22202	Silviculture of Indian Trees	2	0	2	3
3.	FR22203	Wood Products and Utilization	2	0	2	3
4.	FR22204	Forest Ecology and Biodiversity	2	0	2	3
5.	FR22205	Soil Biology and Fertility	2	0	2	3

6.	FR22206	Seed Technology and Nursery Management	2	0	2	3
7.	FR22207	Forest Tribology and Anthropology	2	0	0	2
8.	FR22208	Rangeland and Livestock Management	1	0	2	2
9.	FR22266	Study Tour of State Forest	0	0	0	0
					Total	**22**

Year III Semester V						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	AE23121	Forest Hydrology and Watershed Management	2	0	2	3
2.	HS23102	Entreprenuership Development and Business Management	2	0	0	2
3.	FR23101	Climate Science	2	0	2	3
4.	FR23102	Plantation Forestry	2	0	2	3
5.	FR23103	Forest Extension and Community Forestry	2	0	2	3
6.	FR23104	Logging and Ergonomics	1	0	2	2
7.	FR23151	Geomatics	1	0	4	3
8.	FR23152	Experiential Learning	0	0	10	5
					Total	**24**

Year III Semester VI						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS23202	Forest Economics and Marketing	3	0	0	3
2.	HS23203	Marketing of Non-Timber Forest Products	2	0	2	3
3.	FR23201	Wood Science and Technology	2	0	2	3
4.	FR23202	Forest Laws, Legislation and Policies	2	0	0	2
5.	FR23203	Certification of Forest Products	2	0	0	2
6.	FR23204	Recreation and Urban Forestry	1	0	2	2
7.	FR23205	Wildlife Management	1	0	2	2
8.	FR23251	Experiential Learning	0	0	10	5
9.	FR23266	All India Study Tour	0	0	0	0
					Total	**22**

Year IV Semester VII						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	FR 24179	Forestry Work Experience*****	0	0	40	20
					Total	**20**

Year IV Semester VIII						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	FR24201	Agricultural Informatics	2	0	2	3
2.	FR24202	Forest Biotechnology	2	0	2	3
3.	FR24203	Agroforestry Systems and Management	2	0	2	3
4.	FR24204	Forest Inventory and Yield Prediction	1	0	2	2
5.	FR24205	Restoration Ecology	1	0	2	2
6.	FR24299	Project Work and Dissertation	0	0	20	10
7.	ED24288	Extra-Curricular Activities and Discipline	0	0	0	02
					Total	**25**

*Students shall be attached with the forest and allied departments/ villages heads etc. for field work and experience for the periods mentioned in content.

Course Content

FR21101	Introduction to Forestry: 2 Credits (2-0-0)	
Unit I	Forests: Definition, role, benefits; History of Forestry. Classification of forests: high forests, coppice forests, virgin forest and secondary forests; pure and mixed forests; even and uneven aged stands.	5 lectures
Unit II	Forest types of India; Agroforestry, Farm forestry, Social forestry, Joint Forest Management; Important Acts and Policies related to Indian forests.	5 lectures
Unit III	Climate Change: forestry options for mitigation and adaptation; Carbon sequestration; Important events/dates related to forests and environment. Introduction to world forests: geographical distribution and their classification; factors influencing global forests distribution; productivity and increment of world forests.	6 lectures
Unit IV	Forest resources and forestry practices in different regions of the world: Western Europe, North America, Central Africa, Australia, Central America, Russia, Japan, China and India. General problems of forest development and economy.	6 lectures
Unit V	Forest-based industries in the developed and developing countries. Trade patterns of forest based raw materials. Recent trends in forestry development in the world. National and international organizations in Forestry.	6 lectures

Books:

1. Beazley, M. (1981). The International Book of Forest. Simon and Schuster, Inc., New York, USA.
2. Champion, H.G. and Seth, S.K. (1968). A Revised Survey of the Forest Types of India. Manager of Publications, Government of India, New Delhi. India.
3. Dwivedi, A.P. (1989). Text Book of Silviculture. International Book Distributors Dehra Dun, India.
4. Grebner, D.L., Bettinger, P. and Siry, J.P. (2013). Introduction to Forestry and Natural Resources. Academic Press, London, UK.
5. Khanna, L.S. (2015). Principles and Practices of Silviculture. Khanna Bandhu, New Delhi, India.
6. Mather, A.S. (1990). Global Forest Resources. Belhaven Press, London, UK.
7. Mehta, T. (2008). Hand Book of Forest utilization. International Book Distributors Dehra Dun, India.
8. Persson, R. (1992). World Forest Resources. Periodical Experts, New Delhi, India.
9. Westoby, J. (1991). Introduction to World Forestry, John Wiley & Sons.

FR21102	Dendrology: 3 Credits (2-0-2)	
Unit I	Introduction: importance and scope of dendrology. Principles and systems of plant classification systems: Detailed study of Bentham and Hooker natural system, its advantages and disadvantages. Plant nomenclature: objectives, principles and Code of Botanical Nomenclature.	5 lectures
Unit II	Role of vegetative morphology in identification of woody forest flora; Peculiarities of bole, general form of woody trunk and deviations like buttresses, flutes, etc.; Morphology and description of barks of common trees; Characteristics of blaze, bark colour, exudations etc.	6 lectures
Unit III	Morphology of leaf, different types of leaves, colour of leaves in some species as (regular) features of identification; Reproductive morphology of plants with reference to description and identification of reproductive parts.	5 lectures
Unit IV	Detailed study, diagnose features, floral variations, distribution, economic importance, systematic position as per Bentham & Hooker system of classification of the families: Magnoliaceae, Annonaceae, Guttiferae, Dipterocarpaceae, Malvaceae, Sterculiaceae, Tiliaceae, Rutaceae, Meliaceae, Sapindaceae, Anacardiaceae, Leguminosae.	6 lectures
Unit V	Rhizophoraceae, Combretaceae, Myrtaceae, Rubiaceae, Sapotaceae, Apocyanaceae, Bignoniaceae, Lamiaceae, Lauraceae, Euphorbiaceae, Orchidaceae, Palmae and Poaceae. Brief description of the families: Bombacaceae, Santalaceae, Casuarinacea.	6 lectures

Books:

1. Singh, M.P., Nayar, M.P. and Ray, R.P. (1994). A Text Book of Forest Taxonomy, Amol Publication, New Delhi.
2. Vasudeven, R. and Nair, S.P. (1997). Nangia Taxonomy of Angiosperm, APH Publishing Corporation Delhi.
3. Sharma, O.P. (2012). Plant Taxonomy (2nd Edition), Tata McGraw Hill New Delhi.
4. Pandey, B.P. (1997). Taxonomy of Angiosperm (Systematic Botany), S. Chand & Company Ltd. Ramnagar, New Delh.
5. Sambamurty, V.S.S. (2019). Taxonomy of Angiosperm, IK International Pvt. Ltd.
6. Jeffrey, C. (1982). An introduction to Plant Taxonomy Cambridge University Press, Cambridge.
7. Singh, G. (2000). Plant Systematics. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
8. Hardin, W., Harrar, E.S. and White, F.M. (1995). Textbook of Dendrology (8th Edition). McGraw-Hill Companies, London.
9. Mishra, S. R. (2012). Textbook of Dendrology Discovery Publishing Pvt. Ltd.

FR21103	**Introduction to Agronomy and Horticulture: 3 Credits (2-0-2)**	
Unit I	Agronomy: scope and its role in crop production. Major Field crops of India: classification, area, distribution and productivity of major Field crops. Farming and cropping systems: mono, sole and multiple cropping, relay, sequential and inter cropping.	6 lectures
Unit II	Tillage: definition, objectives, types of tillage, tillage implements. Tilth: characteristics of good tilth; Soil productivity and fertility. Crop nutrition: nutrients, classification. Nutrient sources: organic manures, fertilizers, biofertilizers; Integrated nutrient management; Importance of water in plant growth. Soil properties influencing moisture availability: texture, structure and organic matter status; Irrigation and drainage.	6 lectures
Unit III	Weed control: definition and characteristics of weeds, classification of weeds, damages due to weeds, benefits of weeds. Control vs prevention of weeds: methods of weed control; Classification of herbicides; Integrated weed management; Soil and its management.	5 lectures
Unit IV	Horticulture: Definitions and importance; economic importance and classification of horticultural crops, their culture and nutritive value, area and production. Exports and imports: fruit, vegetables, plantation and spice crops; Soil and climate, principles, planning and layout; management of orchards; Planting systems and planting densities.	5 lectures
Unit V	Principles and methods of pruning and training of fruit; plantation crops; use of growth regulators in horticulture crops; Horticultural zones of state and country.	6 lectures

Books:

1. Reddy, T.Y. and Reddi, S.G.H. (1992). Principles of Agronomy, pp.512-513.
2. Reddy, S.R. and Ramu, Y.R. (2016). Agronomy of field crops. Kalyani Publishers.
3. Chadha, K.L. (2002). Hand book Horticulture. ICAR, New Delhi.
4. Chadha, K.L. (1997). Ornamental Horticulture in India, ICAR, New Delhi.
5. Katyal, S.L. (1963). Fruit Culture in India, ICAR, New-Delhi.

FR21104	**Wood Anatomy: 3 Credits (2-0-2)**	
Unit I	Introduction to wood anatomy; Classification of plant kingdom; Gymnosperms versus angiosperms; Kinds of woody plants. The plant body: a tree and its various parts.	5 lectures
Unit II	Meristems: promeristem, primary meristem, secondary meristem. Simple tissues: parenchyma, collenchyma, sclerenchyma and the vascular tissues. Parts of the primary body: typical stems and roots of dicots and monocots.	5 lectures
Unit III	Secondary growth in woody plants; Mechanism of wood formation in general, and with special reference to typical dicot stem; Ray initials and fusiform initials; anticlinal and periclinal division; Physiological significance of wood formation; The macroscopic features of wood: sapwood, heartwood, pith, early	6 lectures

	wood, late wood, growth rings, wood rays, etc.; Sapwood versus heart wood: anatomical differences, Transformation of sapwood to heartwood, factors affecting transformation.	
Unit IV	Microscopic features of wood, Prosenchymatous elements, tracheids, vessels, fibers. Parenchymatous elements: parenchyma and rays, resin canals, gum canals, latex canals, infiltrants in wood. Three dimensional features of wood: transverse, tangential and radial surfaces; Elements of wood cell walls; The structure and arrangement of simple pit, bordered pits; Extractives in wood; Comparative anatomy of gymnosperms and angiosperms.	6 lectures
Unit V	Anatomical features of common Indian timbers: classification into porous and nonporous woods, ring porous and diffuse porous woods; Effect of growth rate on wood properties; Juvenile wood and mature wood.	6 lectures

Books:

1. Hoadley, B. (2000). Identifying wood-Accurate results with simple tools. Taunton Press, Newtown, USA.
2. Panshin, A.J. and De Zeeuw, C. (1980). Textbook of wood technology, 4th Ed. McGraw-Hill. New York, USA.
3. Rao, R.K. and Juneja, K.B.S. (1992). Field identification of fifty important timbers of India. Indian Council of Forestry Research and Education, New Forest, Dehra Dun.
4. Wilson, K. and White, D.J.B. (1986). The anatomy of wood, its diversity and variability, Stobart and sons Ltd. London.
5. Esau, K. (1993). Plant Anatomy, Wiley Eastern Ltd., New Delhi.
6. Nair, M.N.B. (1998). Wood Anatomy and major uses of wood, Selangor D. E. Malaysia.
7. Eames, A.J. and MacDanials, L.H. (1999). An introduction to plant anatomy, Tata McGraw Hill, New Delhi.

NP21161	**NCC – I / NSS – I: Non Credit (0-0-2)**
NCC – I	Introduction to NCC, defense services, system of NCC training, foot drill, sizing, forming up in three ranks, open and close order march, dressing, getting on parade, dismissing and falling out, saluting, marching, arms drill, shoulder arm, order arm, present arm, guard of honour, ceremonial drill.
NSS – I	Aims and objectives of NSS. NSS logo, motto etc. Orientation of students in national problems, study of philosophy of NSS, fundamentals rights, directive principles of state policy, Village adoption.

NP21162	**Physical Education – I: Non Credit (0-0-2)**
Concept of Physical Education-Meaning, need & importance, aim & objectives. Conditioning exercises-warming up, warming down (general & specific), and flexibility exercise. Physical Fitness exercises for speed, strength, agility, endurance and coordination. Posture & Concept-Definition, values of good posture, causes & draw backs of bad posture, Common postoral deviation, their causes and correct exercise Kyphosis, Scoliosis, Lordosis Knock knee & Bowlegs, Flatfoot. Running ABC'S, walking ABC'S-Major games-Rules and regulations of important games, Skill development in any one of the games-Football, Basketball & Ball badminton. Indoor games - Participation in one of the indoor games - Shuttle badminton & table tennis. Athletic Events-Rules & regulations of athletic events, Participation in any of the athletic events–Broad jump, high jump and short put. Conduct of Health Related Physical Fitness Test (TPFP): One mile run/Beep test, Sit-Up 60 sec, Sitandr each, Modified pull-ups. NOTE: (one to be selected major games, in door games and Athletic events).	

FR21201	**Plant Physiology: 3 Credits (2-0-2)**	
Unit I	Introduction to tree physiology. Photosynthesis: C3, C4 and CAM plants; Photorespiration; factors affecting photosynthesis and respiration.	6 lectures
Unit II	Plant - water relations: concept of water potential, ascent of sap and water balance; Stomatal physiology, stomatal conductance – resistance. Mineral nutrition: macro/micro nutrients; Water relations of forest trees, transpiration from forest canopies, evapotranspiration models of forest stands; Water use efficiency of forest stands.	5 lectures
Unit III	Plant growth regulators and their classification; Tree structure, growth and	6 lectures

	development, growth kinetics; Growth regulation and co-ordination, plant growth analysis; Canopy architecture; Forest Biomes, carbon balance and dry matter production in forest trees, GPP and NPP of forest stands; carbon cycling; Nutrient dynamics and plant growth; Nutrient cycling of C,N,P,S.	
Unit IV	Sun plants and shade plants, shade tolerance; Temperature influence on forest development, energy budgets. Low and high temperature: Physiological adaptations for high temperature, chilling injury.	5 lectures
Unit V	Water stress: mechanism of drought tolerance and drought resistances, physiological basis of drought avoidance and tolerance; Salinity stress, its effects on tree growth, Resistance to salinity; Forest and microclimate.	6 lectures

Books:

1. Hopkins, W.G. and Huner, N.P.A. (2008) Introduction to plant physiology. Wiley.
2. Stephen P. (2007). Physiology of Woody Plants, 3rd Edition.Academic Press.
3. Larcher, W. (2003). Physiological Plant Ecology: Ecophysiology and Stress Physiology of Functional Groups. Springer Science & Business Media.
4. Lambert, Chapin, F.S. and Pons, T.L. (1998). Plant Physiological Ecology. Springer Scientific+ Business Media Inc. New York.
5. Landsberg, J.J. (1986). Physiological Ecology of Forest Production. Academic Press Inc., London.
6. Landsberg, J.J. and Gower, S.T. (1997). Applications of Physiological Ecology to Forest Management. Academic Press Inc., London.
7. Nobel P.S. (2005). Physicochemical and Environmental Plant Physiology. Elsevier Academic Press, Amsterdam.
8. Salisbury, F.B. and Ross, C.W. (2004). Plant Physiology. Thomson Asia Ptd, Ltd. Singapore.
9. Taiz, L. and Zeiger, E. (2010). 5th edition Plant Physiology. Sinauer Associates, Inc., Massachusetts.

FR21202	**Theory and Practice of Silviculture: 3 Credits (2-0-2)**	
Unit I	Definitions: Forests and Forestry; Silviculture: objectives and scope, relation with other branches of Forestry. Site factors: climatic, edaphic, physiographic, biotic and their interactions.	5 lectures
Unit II	Trees and their distinguishing features, growth and development; Root growth, fine root/coarse root production; Direct and indirect benefits from trees, biophysical interactions, trees and buffering functions; C-stock and sequestration potential of forests/plantations.	5 lectures
Unit III	Silvicultural systems: definition, scope and classification; Systems of concentrated regeneration, systems of diffused regeneration, accessory systems, clear felling systems, shelterwood systems, selection systems, coppice systems, culm selection system in bamboo, canopy lifting system; Silvicultural systems followed in other countries.	6 lectures
Unit IV	Regeneration of forests: objectives, ecology of regeneration; Natural regeneration: seed production, seed dispersal, germination and establishment, requirement for natural regeneration, advance growth, coppice, root sucker, regeneration survey.	6 lectures
Unit V	Artificial regeneration: objectives, advantages and disadvantages; Factors governing the choice of regeneration techniques. Tree planting: Sowing v/s planting different kinds of pits. Tending and cultural operations: weeding, release operations, singling, cleaning, liberation cutting.	6 lectures

Books:

1. Baker, F.S. (1950). Principles of Silviculture. McGraw-Hill, New York, USA.
2. Champion, H.G. and Trevor, G. (1936). Handbook of Silviculture. Cosmo Publication, New Delhi, India.
3. Daniel, T.W., Helms, J.A. and Baker, F.S. (1979). Principles of Silviculture. Mc Graw Hill, New York, USA.
4. Duryea, M.L. and Landis, T.D. (eds.). (1984). Forest Nursery Manual: Production of bare root seedlings. Martinus Nijhoff & Dr W. Junk Publishers, Boston/Lancaster.
5. Dwivedi, A.P. (1993). Text Book of Silviculture. International Book Distributors, Dehra Dun, India.
6. Gunter, S., Weber, M.M., Stimm, B. and Mosandl, R. (2011). Silviculture in the Tropics. Springer-Verlag, Berlin.
7. Haig, I.T., Huberman, M.A. and Aung-Din, U. (1986). Tropical Silviculture, Vol. I & II.

8. Khanna, L.S. (2015). Principles and Practices of Silviculture. Khanna Bandhu, New Delhi, India.
9. Kostler, J. (1956). Silviculture. International Book Distributors, Dehradun, India.
10. Lal, J.B. (2003). Tropical Silviculture. New Imperatives: New Systems. International Book Distributors, Dehradun, India.

FR21203	**Geology and Soils: 3 Credits (2-0-2)**	
Unit I	Introduction to geology, its significance, composition of earth's crust, soil as a natural body, major components by volume; Pedology, rock types, classification. Soil forming minerals: definition, classification, silicates, oxides, carbonates, sulphides, phosphates occurrence; Weathering of rocks and minerals, factors-involved, weathering indices; Factors of soil formation, parentmaterial, climate, organism, relief, time. Soil forming processes: eluviations and illuviation, formation of various soils; Elementary knowledge of soil classification, soil orders; Forest soils characteristics, distinguishing features, changes in physical and chemical properties compared to agricultural soils.	5 lectures
Unit II	Physical parameters: texture, definition, methods of textural analysis; Stokes law, textural classes, use of textural triangle, absolute specific gravity, definition, apparent specific gravity/bulk density-factors, relation between bulk density and particle density; Pore space-definition, factors affecting capillary and non-capillary porosity,soil colour-its significance, colour variable-hue, value, chroma; Munsell colour chart factors influencing parent material, soil moisture, organic matter.	6 lectures
Unit III	Soil structure, definition, classification; factors influencing genesis of soil structure, soil consistency, plasticity, Atterberg's constants; Soil air composition, factors influencing amount of air space; Soil temperature, sources and distribution of heat, factors influencing, measurement.	5 lectures
Unit IV	Chemical properties: soil colloids organic- humus-inorganic-secondary silicate-clay-hydrousoxides; Soil organic matter decomposition; concept of pH-soil acidity, nutrient availability, soil buffering capacity; A brief overview of saline, sodic and calcareous soils.	6 lectures
Unit V	Soil water: forms, soil moisture contents, hygroscopic coefficient, wilting point, field capacity-moisture equivalent, maximum water holding capacity, energy concepts, pF scale measurement, gravimetric, electric and tensiometer methods; Pressure plate and pressure membrane apparatus; Neutron probe, soil water movement, saturated and unsaturated infiltration and percolation.	6 lectures

Books:

1. Biswas, T.D. and Mukherjee, S. K. (1987). Test Book of Soil Science, Tata McGraw Hill Publishing Co., New Delhi
2. Weil, R.R. and Brady, N.C. (2017). The Nature and Properties of Soils. 15th edition. Pearson Education.
3. Brady, N. C. (1990). Nature and Properties of Soils. 10th ed., Macmillan Publishing Co. Inc. New York
4. Foth, H.D. and Turk, L. M. (1972). Fundamental of Soil Science. 5th edn. Wiley Eastern Pvt.Ltd., New Delhi
5. Gupta, P.K. (2007). Soil, Plant, Water and Fertilizer Analysis. Published by AGROBIOS (India), Jodhpur
6. Indian society of soil science (ISSS). (2002). Fundamentals of Soil Science. Published by Indian Society of Soil Science, IARI, New Delhi
7. Indian Society of Soil Science (ISSS). (2015) Fundamental of Soil Science. 2nd Edition. Indian Society of Soil Science, IARI, New Delhi.
8. Jaiswal, P.C. (2006). Soil, Plant and Water Analysis. 2nd Edn. Kalyani Publishers, Ludhiyana.
9. Pritchett, W.L. and Fisher R, F. (1987). Properties and Management of Forest Soils. John Wiley, New York.
10. Sanchez, P.A. (2019) Properties and Management of Soils in the Tropics. 2nd edition. Cambridge University Press.

FR21204	Wildlife Biology: 3 Credits (2-0-2)	
Unit I	History of wildlife conservation. Introduction to wildlife: definition, wildlife value and importance; Conservation issues & threats, uses, concept of conservation; Classification of mammals, status and distribution of endemic, rare and threatened species of wildlife.	6 lectures
Unit II	Basic requirements of wildlife. Welfare factors: food, water, shelter, space. Limiting factors: food chain, food web, ecological pyramids.	5 lectures
Unit III	Wildlife Ecology: biotic factors, biological basis of wildlife. Productivity: effect of light and temperature on animals; Prey -predator relations and population structure and dynamics.	5 lectures
Unit IV	Wildlife habitat: classification of habitats, niche, territory, home range, territoriality, edge, ecotone, cruising radius; Carrying capacity: qualifiers, pinch period. Habitat improvement: food, water, shelter improvement.	6 lectures
Unit V	Animal behaviour and adaptation, method of communication; Territorial behaviour, reproductive behaviour, litter & clutch size, aestivation & hibernation, camouflage, mimicry; adaptation.	6 lectures

Books:

1. Berwick, S.H. and Saharia, V.B. (1995). Wildlife Research and Management. Oxford University Press, New Delhi.
2. Dasmann, R.F. (1982). Wildlife Biology. Wiley Eastern Ltd. New Delhi.
3. Davil, J.W. et al. (1981). Infectious diseases of wild mammals. Ed. II. Iowa State University Press, USA.
4. International Zoo Books, Published by New York Zoological Society, New York.
5. Johnsingh, A.J.T. and Manjrekar N. (2014). Mammals of South Asia. Vol. I. University Press.
6. John Singh, A.J.T. and Manjrekar, N. (2015). Mammals of South Asia. II. University Press.
7. Krebs, C. and Davis, N. (1978). Introduction to behavioral ecology. Oxford University Press.
8. Mathur, R. (1985). Animal Behaviour. Oxford University Press.
9. Menon, V. (2014). Indian Mammals: A field guide. Hachette.
10. Prater, S.H. (1971). The Book of Indian Animals. Oxford University press, Bombay.

FR21205	Forest Protection: 3 Credits (2-0-2)	
Unit I	Introduction and importance of protection in Indian Forestry; Classification of injurious agencies; injury to forest due to fires, causes and character of forest fires, types of fire, fire prevention activity, fire suppression, fire fighting equipments, fire control policy and objectives; Fire fighting in other countries. Forest pathology: importance, objectives and principles; Tree disease classification, causes, symptoms.	6 lectures
Unit II	Etiology, disease cycle, mode of spread and epidemiology; principles of tree disease management including chemical, biological, cultural and silvicultural practices; Disease due to physiological causes, Abiotic diseases; Forest weeds and weed management; Management of woody climbers, parasites and epiphytes; Nursery diseases and their management.	5 lectures
Unit III	Losses due to forest tree diseases: symptoms, mode of spread, etiology, epidemiology and control measures of root diseases (wilt, root and butt rot), stem diseases (heart rots, stem blisters, rusts, stem wilt, cankers, pink disease, gummosis, water blister) and foliar diseases (rust, powdery mildew, leaf spot, leaf and twig blight, abnormal leaf fall, needle blight etc.).	5 lectures
Unit IV	Injury to forest due to man, wild and domestic animals, adverse climatic factors, lopping and cutting for fuel wood; Encroachment types, control of encroachment, illegal felling of trees, method of control legislation; Forest entomology in India.	6 lectures
Unit V	Methods and principles of insect pest control: cultural, mechanical, physical, silvicultural, legal, biological and chemical, integrated pest management; Classification of forest pests, types of damages and symptoms; Concept of insect injury levels, categories of pests, factors for outbreak of pests, nature of	6 lectures

	damage and management; Insect pests of forest seeds, forest nursery, standing trees, plantation forest, freshly felled trees, finished and store timbers and their management.	

Books:

1. Tainter, F.H. and Baker, F.A. (1996). Principles of Forest Pathology. John Wiley & Sons, New York, USA.
2. Paul, D. M. (1990). Tree Disease Concepts. Prentice-hall, Inc. New Jersey.
3. Wayne, S. and Howard, H.L. (2005). Diseases of Trees and Shrubs, 2nd edition, Comstock Publishing Associates.
4. Strouts, R.G., Winter, T.G. (2013). Diagnosis of ill health in trees, 2nd Edition, Forestry Commission, TSO.
5. Horst, R. Kenneth (2013). Field Manual of Diseases on Trees and Shrubs, Springer Netherlands.
6. Bakshi, B.K. (1976). Forest Pathology; Principles and Practices in Forestry. Pub. Comptroller of Publications, Delhi.
7. Basher, A.E.S. (1983). Forest Fires and Their Control. Gulab Primlani Amerind Publishing, New Delhi.
8. Elton, C.S. (2000). The Ecology of Invasions by Animals and Plants. University of Chicago Press.
9. Fuller, M. (1991). Forest Fires. Wiley Nature Editions, New York.
10. Johnson, A.E. and Miyanishi, K. (2001). Forest Fires: Behavior and Ecological Effects. Academic Press.
11. Khanna, L.S. (1988). Forest Protection. Khanna Bandhu, Dehradun.
12. Luna, R.K. (2007). Principles and Practices of Forest Fire Control. International Book Distributors, Dehradun.
13. Negi, S.S. (1999). Handbook of Forest Protection. International Book Distributors.
14. Pathak, V.N., Khatri, N.K. and Pathak, M. (2000). Fundamentals of Plant Pathology. Eds. Agribios (India), Jodpur.
15. Singh, R.S. (2002). Introduction Principles of Plant Pathology. Oxford & IBH, New Delhi.

FR21206	**Plant Cytology and Genetics: 2 Credits (1-0-2)**	
Unit I	History of genetics, Mendel's principles of inheritance, segregation, independent assortment; Cell structure and functions, cell organelles. Cell reproduction: mitosis & meiosis and its significance.	3 lectures
Unit II	Chromosome theory of inheritance; Modification to Mendelian inheritance, multiple alleles, codominance, gene interaction, epistasis, pleotrophy, polygenic inheritance, penetrance and expressivity, cytoplasmic inheritance.	3 lectures
Unit III	Linkage and crossing over, cytological consequence of crossing over; Detection of linkage and linkage maps; Chromosomal aberrations numerical and structural.	3 lectures
Unit IV	Structure of DNA and types and its replication; Chromosomes - its structure and function; Fine structure of gene.	2 lectures
Unit V	Gene expression and their functions; RNA its structure function and types. Gene action, protein synthesis; Mutation, its classification and uses.	3 lectures

Books:

1. Gupta, P.K. (1999). Cytogenetics Rastogi Publishers, Meerut.
2. Fletcher, H. and Hickey, I. (2012). Genetics. Garland Science.
3. Garner, E.J., Simmons, M.J. and Sunstad, P.D. (2008). Principles of Genetics (8th edn.) Wiley India (P.) Ltd., Daryaganj, New Delhi.
4. Strickberger, M.W. (1996). Genetics (3rd edn.). Mac Millan Publishing Co., New Delhi.
5. Tamarin, R. (2002). Principles of Genetic (7th Ed). Tata McGraw-Hill Education.
6. White, T.L., Adams, W.T., and Neale, D.B. (2007). Forest Genetics. CABI.
7. Singh, B.D. (2014) Fundamentals of Genetics Paperback. Kalyani Publication.

NP21261	**NCC – II / NSS – II: Non Credit (0-0-2)**
NCC – II	Weapon training – rifle bayonet, light machine gun, sten machine carbine, introduction and characteristic stripping, assembling and cleaning, loading, unloading and firing. Field craft, visual training, targets, judging distance, fire discipline and fire control orders, battle craft, field signals, description of ground, section formation, section battle drill, scouts and patrols, ambush.

NSS – II	Socio-economic structure of Indian society, population problems, brief of Five Year Plan. Functional literacy, non-formal education of rural youth, eradication of social evils, village adoption continued.

NP21262	**Physical Education – II: Non Credit (0-0-2)**
Concept of Health -Physical health, mental health, social health, spiritual health, spectrum of health. Fitness & wellness - Motor components. Regular exercises. Amount of training, Scientific way of training, Rest and relaxation, conditioning, Good posture, Heredity, Environment, Standard of living, Balance Diet, Stress &tension, Drugs, Intoxication. Means of Fitness Development Aerobic activities, anaerobic activities, Sports & Games, Yoga, and Recreational Activity. Safety Education–Swimming. Yoga-Meaning & importance of Yoga. Role of Yoga in life, Teaching of Yoga. Physical Fitness test-TPFP Fitness test: One mile run/ Beep test, Sit-Up 60 sec, Sit and reach, Modified pull-ups. Major Games-Rules and regulations of important game, Skill development in 508 509 Report of the ICAR Fifth Deans' Committee Report of the ICAR Fifth Deans' Committee any one of the game- Hockey, Volley ball, Hand ball and Kho Kho. Indoor Games-Participation in one of the indoor games - (Table Tennis & Badminton). Athletic events - Rules & regulations of athletic events participation in anyone of the athletic events - Triple jump, Discus throw and Javelin throw. NOTE: (one to be selected, major games, in door games and Athletic events).	

FR22101	**Environmental Studies and Disaster Management: 3 Credits (2-0-2)**	
Unit I	Environmental studies: definition, scope and importance. Natural Resources, forest resources, water resources, mineral resources, food resources, energy resources and land resources.	5 lectures
Unit II	Ecosystems: concept of ecosystems and ecology, structure and functions of ecosystems; Biodiversity conservation, environmental pollution, solid waste management; Social issues.	5 lectures
Unit III	Environmental ethics, Wasteland reclamation, EIA, Environment Protection Act 1986 and its amendments, Air (Prevention and control of Pollution) Act 1981 and its amendments, Solid waste management rules, 2016.	6 lectures
Unit IV	Water (Prevention and control of Pollution) Act 1974 and its amendments. Wildlife Protection Act 1972 and its amendments, Forest Conservation Act 1980 and its amendments; Issues involved in enforcement of environmental legislation.	6 lectures
Unit V	Public awareness, environment and human health, women and child welfare; Natural disasters, climatic change, man-made disasters; Disaster management.	6 lectures

Books:

1. Ambasht, R.S. and Ambasht, N.K. (2008). A Text Book of Plant Ecology. CBS Publishers and Distibutors. New Delhi, India.
2. Gupta, H.K. (2003). Disaster Management. Indian National Science Academy. University Press, India.
3. Hodgkinson, P.E. and Stewart, M. (1991). Coping with Catastrophe. A Handbook of Disaster Management. Taylor & Frances/Routledge.
4. Misra, R. (1968). Ecology Work Book. Oxford and IBH Publishing Company, New Delhi, India.
5. Sharma, V.K. (2001). Disaster Management. National Centre for Disaster Management, India.
6. Sharma, P.D. (2014). Ecology and Environment. Rastogi Publications. New Delhi, India.
7. Singh, J.S., Singh, S.P. and Gupta, S.R. (2010). Ecology Environment and Resource Conservation. Anamaya Publishers, New Delhi, India.
8. Singh, J.S., Singh, S.P. and Gupta, S.R. (2014). Ecology Environmental Science and Conservation. S. Chand Publishing, New Delhi, India.

FR22102	**Ornithology and Herpetology: 3 Credits (2-0-2)**	
Unit I	History of ornithology in India. Origin and ancestry of birds, classification of Indian birds; A brief knowledge of bird morphology and anatomy; Skeleton,	6 lectures

	feathers, skin, beak and taxidermy; Thermoregulation in birds.	
Unit II	Bird ecology and behaviour: migration and territorial behaviour, feeding, song and nest, eggs and egg laying. Various types of bird: water birds, scavenger birds, frugivorous birds, pet birds, seed dispersal birds and pollinator birds.	6 lectures
Unit III	Importance of birds to different terrestrial ecosystems; Bird watching, Bird conservation and management in India; Important bird areas of India, Red Data Book, birds of India; Wetland conservation, Ramsar sites of India; Classification of birds.	6 lectures
Unit IV	Amphibians and Reptiles: classification, diversity, morphology, adaptation, distribution, and ecology; differences and similarities; Threatened amphibians and reptiles of northeast.	5 lectures
Unit V	Conservation of threatened reptiles: conservation techniques, survey methods, capture, handling and release guidelines; Snakebite avoidance, treatment, snake myths and FAQs, threats.	5 lectures

Books:

1. Ali, S. and Ripley, D.S. (1990). A compact Handbook of Birds of Indian subcontinent. Oxford University press, Bombay.
2. Daniel, J C. (2002). The Book of Indian Reptiles. Bombay Natural History Society, Bombay.
3. Das, I. (1995). Turtles and Tortoises of India. Oxford University Press. Bombay.
4. Das, I. (2002). A photographic guide to Snakes and other reptiles of India. New Holland Publishers (UK) Ltd.
5. Grimmet, R., Inskipp, T. and Inskipp, I. (2003). Handbook of Birds of Indian subcontinent. Oxford University press.
6. Grimmet, R. Inskipp, T and Nameer, P.O. (2007). Birds of southern India, BNHS series.
7. Gururaja, KV. (2012). Pictorial Guide to frogs and toads of the Western Ghats. IISc. Bangalore.
8. Kazmierczak, K. and Van Perlo B. (2000). A field guide to the birds of the Indian subcontinent, Yale University Press, New Haven. CT.
9. Kentwood, D. W. (2007). The Ecology and Behavior of Amphibians. The University of Chicago Press, Chicago.
10. Rasmussen, P.C. and Anderton, J.C. (2012). Birds of South Asia: The Ripley guide. Vol. I and II, Smithsonian Institution and Lynx Edicions, Washington DC and Barcelona.
11. Wallace, G.J. and Mahan, H.D. (2005). An Introduction to Ornithology. 3rd Ed. McMillion publishing company. New York.
12. Whitaker, R. and Captain, A. (2004). Snakes of India. The Field Guide. Draco Books. Chengalpattu, Tamil Nadu.
13. Duellman, W.E. and Trueb, L. (1986). Biology of Amphibians. John Hopkins University Press, Maryland.
14. Thomas, R. A. Current. Herpetology class notes. On Blackboard.

FR22103	**Ethnobotany, Medicinal and Aromatic Plants: 3 Credits (2-0-2)**	
Unit I	Definition and scope of ethnobotany; Terms employed in relation to ethnobotany and its relationship with man and domestic animals; Ethnic people and their contribution in therapeutic and ethnobotanical knowledge especially with respect to medicinal and allied aspects; Important plants and their folk uses for medicines, food, dyes, tans, etc.; Methods and tools in Ethnobotanical studies; Ethnobotany of tribals in north east India.	6 lectures
Unit II	Traditional Botanical Knowledge: concepts; Major tribes of Northern, Central, North East and Andaman and Nicobar Islands. Ethnobotany of the plants from following families: Guttiferae (Clusiaceae), Malvaceae, Fabaceae, Mimosaceae, Caesalpinaceae, Combretaceae, Umbelliferae (Apiaceae), Rubiaceae, Asteraceae, Ebenaceae, Apocynaceae, Asclepiadaceae, Euphorbiaceae, Lauraceae, Palmaceae, Poaceae, Liliaceae, Coniferae, Santalaceae, Thymeliaceae.	5 lectures
Unit III	Role of medicinal and aromatic plants in Indian economy; Important essential oil yielding plants in India, methods of extraction of essential oils, properties and evaluation of essential oils.	6 lectures

Unit IV	Detailed study of Lemon grass, Citronella, Palmarosa, Vetiver, Japanese mint, Eucalyptus, Jasmine, Patchouli and Geranium - botany, climate and soil requirements, planting cultural and manorial practices; harvesting, curing and oil extraction.	5 lectures
Unit V	Medicinal plants in India with special reference to NE India: history, origin, distribution, botany, cultivation, extraction of active principles and uses of different medicinal plants like *Atropa, Cinchona, Rauvolfia, Opium, Sandal, Acorus, Cannabis, Digitalis, Strychnos nux-vomica, Aconitum, Neem, Dioscorea, Costus, Solanum* etc. Cultivation practices of medicinal plants like *Adhathoda zylanica*, *Sida cordifolia, Sterospermum colais*, *Plumbago zylanica*, *Tinospora cordifolia*, *Kaemferia glanga*, *Indigofera tinctoria;* Conservation packages for the medicinal plants collected in wild.	6 lectures

Books:

1. Atul, C.K. and Kapur, B.K. (1982). Cultivation and utilization of medicinal plants. RRL, CSIR, Jammu-Tawi.
2. Chopra, R.N., Nayar, S.L. and Chopra, I.C. (1956). Glossary of Indian medicinal plants. CSIR, New Delhi.
3. Cunningham, A. (2014). Applied Ethnobotany: "People, Wild Plant Use and Conservation". Taylor & Francis,
4. EIRI Board. (2007). Handbook of Medicinal and Aromatic Plants: Cultivation, Utilisation and Extraction
5. Cotton, C.M. (1997). Ethnobotany. Principles and applications. John Wiley and Sons Ltd.
6. Gunther, E. (1975). The essential oils. Robert, K Krieger Pub. Co., New York.
7. Jain, S.K. (2010). Manual of Ethnobotany (2nd Ed). Scientific Publishers, India.
8. Maheshwari, J.K. (2000). Ethnobotany and medicinal plants of Indian subcontinent. Scientific Publishers, Jodhpur, India.

FR22104	**Tree Improvement: 3 Credits (2-0-2)**	
Unit I	Introduction: History and development of tree improvement, its relation to other disciplines of forestry; Reproduction in forest trees; Anthesis and pollination, their importance in tree breeding; Incompatibility and sterility.	5 lectures
Unit II	Quantitative inheritance and its relevance in forestry; Genetic, environmental and interaction, components of variation, heritability and genetic advance; Genetic basis of tree breeding. Natural variability in trees: types and importance, forces that change variability.	5 lectures
Unit III	Breeding objectives and concepts of breeding in self-pollinated, cross pollinated and vegetatively propagated crops; Provenance testing. Selection: seed production areas, seed orchards; Progeny trial and improvement of seed orchards; Combining ability and genetic gain. Hybridization in trees: back cross breeding, heterosis breeding, mutation breeding, ploidy breeding; Exotic forestry.	6 lectures
Unit IV	Breeding of important tree species; Breeding procedures for development of hybrids/varieties of various crops; DUS testing, Concepts of Geographical indications; Artificial hybrids in trees, crossing in trees, problems and perspectives, crossing hybrids and hybrid breakdown. Hybrid nomenclature in trees: Future of hybrid in applied tree improvement.	6 lectures
Unit V	Breeding for resistance to insect pest's diseases, air pollution and for wood properties; Vegetative propagation and clonal forestry; Conservation of forest tree germplasm; Recent techniques in tree improvement.	6 lectures

Books:

1. White, A.T.L. and Adams (2010). Forest Genetics.
2. Bedell P. E. (2007). Tree Breeding for Genetic Improvement of Tropical Tree Species (1st Ed).
3. Surendran, C., Sehgal, R.N. and Parmathma, M. (Eds.) (2003). A text book of Forest Tree Breeding. ICAR, New Delhi.
4. Wright, J. (2012). Introduction to Forest Genetics. Elsevier.
5. Zobel, B. and Talbert, J. (2003). Applied Forest Tree Improvement. Blackburn Press.
6. Singh B. D. (2015) Plant Breeding, Principal and Methods, Kalyani publication.

FR22105	Principles of Agroforestry: 3 Credits (2-0-2)	
Unit I	Overview of the Agriculture scenario, its structure and constraints; Concept of sustainable agriculture and land use management; Paradigm shift in Agriculture development, impacts of green revolution. Agrobiodiversity: significance, threats and conservation strategies.	6 lectures
Unit II	Agroforestry: definition and scope, rising demands of fuel wood, fodder and timber; Social, ecological, and economic reasons for agroforestry; History of agroforestry; Components of Agroforestry, provisioning and regulator services of agroforestry.	6 lectures
Unit III	Nutrient cycling, soil improvement, increased production and productivity, microclimate amelioration and carbon sequestration. Tree-crop interaction in agroforestry: definition, kind of interaction, positive interactions, complementarity, compatibility, mutualism, commensalism. Negative interactions: allelopathy and competition. Interaction management: aboveground and belowground interactions. Manipulation of density, space, crown and roots.	7 lectures
Unit IV	Tree Management: structure and growth of trees, crown and root architecture; Agroforestry practices to minimize negative interaction coppicing, thinning, pollarding and pruning.	4 lectures
Unit V	Crop planning and management: selection of suitable crops, management of nutrients, water and weeds; Classification of agroforestry systems, National Agroforestry Policy 2014-national and international organizations in Agroforestry.	5 lectures

Books:

1. Huxley, P.A. (ed). (1983) Plant Research and Agroforestry, ICRAF, Nairobi, Kenya.
2. Huxley, P. (1999). Tropical Agroforestry. Wiley.
3. Kumar, B.M. and Nair, P.K.R (eds). (2011). Carbon Sequestration Potential of Agroforestry Systems: Opportunities and challenges. Advances in Agroforestry 8. Springer Science, The Netherlands.
4. Michael, P. (1984). Ecological Methods for Field and Laboratory Investigations.Tata McGraw-Hill Pub.Co. New Delhi.
5. Nair, P.K.R, Rao MR, and Buck, L.E (eds), (2004). New Vistas in Agroforestry: A Compendium for the 1st World Congress of Agroforestry, Kluwer, Dordrecht, The Netherlands.
6. Nair, P.K.R. (1993). An Introduction to Agroforestry. Kluwer Academic Publishers, Dordrecht, The Netherlands.
7. Nair, P.K.R. Agroforestry Systems in the Tropics. Springer.
8. Nair, P.K.R., Kumar, B.M. and Vimala D. N. (2009). Agroforestry as a strategy for carbon sequestration. J. Plant Nutr. Soil Sci. 172: 10–23.
9. Pathak, P.S. and Newaj, R. (eds.) (2003). Agroforestry: Potentials and Opportunities. Agrobios, Jodhpur.

FR22106	Forest Mensuration: 3 Credits (2-0-2)	
Unit I	Forest Mensuration: definition and objectives, scales of measurement, units of measurements, precision, bias and accuracy; Measurement of diameter and girth, place of measurement, rules governing BH measurements, instruments used in measurements; Diameter and girth classes.	6 lectures
Unit II	Measurement of height: definitions, methods of measurement of height, ocular, non instrumental and instrumental methods; Sources of error in height measurements-leaning trees.	6 lectures
Unit III	Tree stem form: Metzgr's theory, form factor- types of form factor-form height for quotient-form class; Measurement of area: cross sectional area, basal area, bole surface area.	5 lectures
Unit IV	Volume measurements of standing trees: logs-branch wood- formulae-involved, definitions; Volume tables, preparation of volume tables, graphical method and regression method.	5 lectures
Unit V	Determination of growth of trees: increment, CAI & MAI, Increment percent, determination of age of trees, determination of growth of trees; Classification of increments. Measurement of tree crops: objects, crop diameter, crop height, crop age, crop volume.	6 lectures

Books:

1. Chaturvedi, A.N and L.S. Khanna (2011). Forest Mensuration and Biometry (5th edition). Khanna Bandhu. Dehra Dun.
2. Forest Mensuration: A Handbook for Practitioners. 2006. Forestry Commission Publications.
3. Husch, B., Beers, T.W. and Kershaw, J. J.A. (2002). Forest Mensuration (4th edition). John Wiley & Sons, Nature.
4. Laar, V. A. and Akca, A. (2007). Forest Mensuration. Managing Forest Ecosystems. Vol.13. Springer.
5. Manikandan, K. and Prabhu, S. (2012). Indian Forestry. Jain Brothers. New Delhi.
6. West, P.W. (2009). Tree and Forest Measurement (2nd edition). Springer.

NP22161	**NCC – III / NSS – III: Non Credit (0-0-2)**
NCC – III	Field engineering, map reading, conventionalsigns, grid systems, use of service protractor, prismatic compass and its use, self defence, general principles, precautions and training, attacks and counterattacks, marching and searching, first aid, hygiene and sanitation, civil defence, leadership and NCC song.
NSS – III	Awareness programmes, consumer awareness, highlights of consumer act. Environment enrichment and conservation, health, family welfare and nutrition, village adoption – continued.

NP22162	**Physical Education – III: Non Credit (0-0-2)**
Lifestyle diseases & dietary and lifestyle changes that reduce the incidence of chronic diseases. Obesity, Coronary heart diseases (CAD), Ischemic stroke Diabetes Mellitus, Blood pressure, Osteoporosis. Injuries– Injuries in sports. Prevention of sports injuries. First aid training in sportsSprain, Fractures, Burns, Snakebite, Drowning, Unconscious victim, First aid ABC, First aid CPR, Sling and Splint and carrying techniques. Yoga continuation. Major games, Rules & regulation of important games, Skill development in any one of the game-Cricket, Football, Basketball, Volley Ball and Net ball. Athletic events-Rules & regulations of athletic events–participation in any one of the athletic events-short & long distance running. Anyone to be selected major games and Athletics events. Adventure training-On Land– Trekking, High Altitude Trekking, Rock Climbing, Mountaineering. In water-River Crossing.	

FR22201	**Forest Management: 3 Credits (2-0-2)**	
Unit I	Definition, scope, objective and principles of forest management, organization of state forests. Sustained yield: definition, principles and limitations. Sustainable forest management: criteria and indicators; Increasing and progressive yields.	6 lectures
Unit II	Rotation: definitions, various types of rotations, length of rotations, choice of type and kind of rotation. Normal forest: definitions, basic factors of normality; Factors governing the yield and growth of forest stands. Working plan: preparations, objectives and uses, forest maps and their uses. Joint forest management: concept and principles.	6 lectures
Unit III	Modern tools in forest management. Introduction to the concept of forestry as a common property resource: definition, scope and necessity of community forestry. Forests and man: Forestry in support to agriculture, animal husbandry and horticulture, development of cottage industry in rural environment.	5 lectures
Unit IV	National Forest Policy 1988 and the importance of people in forest conservation; Community forest management, community forest development, social, economical and environmental aspects, community forest development through NGOs, civil societies. Citizen groups: Gender dimensions in Community forest management.	5 lectures
Unit V	Social Forestry: definition, NCA report of 1976, need and purpose, social forestry for fodder production, fuel wood, leaf manure, timber production; Integrated rural development approach with proper marketing facility; Employment generation in raising, tending and harvesting of tree crops; Place	6 lectures

	of social forestry in the national forest policy of India, role of forest department.	

Books:

1. BalaKathiresan, S. (1986). Essentials of Forest Management, Nataraj Publishers, Dehradun.
2. Bhattacharya, P., Kandya A.K. and Kumar, K. (2008). Joint Forest Management in India, Aavishkar Publisher, Jaipur.
3. Desai, V. (1991). Forest Management in India– Issues and Problems. Himalaya Publisher House, Bombay.
4. Edmunds, D. and Wollenberg, E. (2003). Essentials of Forest Management. Natraj Publishers, Dehradun.
5. Jerome, L.C. (1983). Timber Management: A Quantitative Approach. John Wiley and Sons.
6. National Working Plan Code. (2014). MoEF, New Delhi.
7. Prakash, R. (1986). Forest Management. IBD, Dehradun, India.
8. Recknagel, A.B. and Bentley. J. (1988). Forest Management. IBD, Dehradun.
9. Trivedi, P.R. and Sudarshan, K.N. (1996). Forest Management. Discovery publications, New Delhi.

FR22202	**Silviculture of Indian Trees: 3 Credits (2-0-2)**	
Unit I	Origin, distribution, general description, phenology, silvicultural characters of important trees and their regeneration methods; Silvicultural systems, stand management practices, pest and diseases and economic importance of tree species.	5 lectures
Unit II	Silviculture of broad-leaved species: *Tectona grandis*, *Shorea robusta*, *Dalbergia latifolia*, *Dalbergia sissoo*, *Anogeissus* spp., *Terminalia* spp., *Santalum album*, *Swietenia macrophylla*, *Albizia* spp., *Pterocarpus marsupium*, *Gmelina arborea*, *Pterocarpus santalinus*, *Azadirachta indica*, *Hopea parviflora*, *Lagerstroemia microcarpa*, *Quercus* spp.	6 lectures
Unit III	Silviculture of Bamboos and rattans, harvest and management practices in Northeast India.	5 lectures
Unit IV	Silviculture of Conifers: *Abies* spp., *Picea smithiana*, *Cedrus deodara*, *Pinus* spp. *Taxus wallichiana, Cupresus* spp.	6 lectures
Unit V	Fast growing MPTs: *Eucalyptus* spp., *Casuarina equisetifolia*, *Leucaena leucocephala*, *Ailanthus excelsa*, *Grevillea robusta*, *Pongamia pinnata*, *Melia* spp., *Acacia* spp., *Populus* spp.	6 lectures

Books:

1. Bebarta, K.C. (1998). Teak: Ecology, Silviculture, Management and profitability. International Book Distributors, Dehra Dun, India.
2. Champion, H.G. and Griffith, A.L. (1989). Manual for General Silviculture for India. ICFRE Booklets on Tree Species.
3. Kadambi, K. (1993). Silviculture and Management of Teak. Nataraj Publishers, Dehra Dun, India.
4. Lamprecht, H. (1989). Silviculture in the Tropics. GTZ, GmBH, FRG.
5. Troup, R.S. (1922). Silviculture of Indian Trees, Vol. 1-4, Revised and Enlarged Edition, Forest Research Institute and Colleges, Dehra Dun, 1975.
6. Renuka, C., Pandalai, R.C. and Mohanan, C. (2002). Nursery and Silvicultural Techniques for Rattan. Kerala Forest research Institute.
7. Dwivedi, A.P. (1989). Text Book of Silviculture. International Book Distributors, Dehra Dun, India.
8. Khanna, L.S. (2015). Principles and Practices of Silviculture. Khanna Bandhu, New Delhi, India.
9. Prakash, R. (2007). Plantation and Nursery Technique of Forest Trees. International Book Distributors, Dehra Dun, India.
10. Negi, S.S. (2006). Hand Book of Silviculture of Indian Trees. Bishen Singh Mahendra Pal Singh, Dehra Dun, India.
11. Negi, S.S. (1985). Siviculture of Indian Trees. Bishen Singh Mahendra Pal Singh, Dehra Dun, India.
12. Banik,R.L. (2016) Silviculture of South Asian Priority Bamboos. Springer.

FR22203	**Wood Products and Utilization: 3 Credits (2-0-2)**	
Unit I	Uses of wood; Growth of wood based industry in India, effect of globalization; Importance of forest based industries in relation to Indian economy.	6 lectures
Unit II	Wood as a source of energy and chemicals, wood as raw material for	5 lectures

	industries like pulp, paper, rayon, composite woods and improved woods.	
Unit III	Description of different forest based industries: paper and pulp, furniture, bamboo, sports goods, pencil making, match box and splint making; Use of wood of lesser known forest species for commercial purposes. Structural uses of Timber: bridges and other super structures; Decorative uses of wood.	5 lectures
Unit IV	Introduction to wood modification, its need and scope, chemical modification of wood (acetylation, reaction with isocyanates, acetates, ethers, epoxides etc.); Primary conversion, sawing and veneering; Composite wood, plywood, laminated wood, core board, sandwich board, fibre board, particle board, manufacturing process, uses and properties.	6 lectures
Unit V	Adhesives used in manufacture of composite wood; Improved wood, compressed wood, impregnated wood etc., manufacturing process, uses and properties; Manufacture of rayon and match; Wood carving and handicrafts; Destructive distillation of wood; Saccharification of wood; Production of wood molasses, alcohol and yeast.	6 lectures

Books:

1. Baldwin, R. F. (1981). Plywood manufacturing practices. Revised 2nd Ed. Miller and Freeman Publication, Inc. USA.
2. FRI [Forest Research Institute] (1976). Indian forest utilization. Volume I and II. Forest Research Institute and colleges, Dehradun.
3. Hoadley, B. (2000). Understanding Wood: A Craftsman's guide to wood technology. Taunton Press. Newtown, USA.
4. Mehta, T. (1981). A handbook of forest utilization. IBD Dehradun.

FR22204	**Forest Ecology and Biodiversity: 3 Credits (2-0-2)**	
Unit I	Historical development of ecology; Levels of biological organization; Major forest ecosystem, forest environment, major abiotic and biotic components and their interaction.	6 lectures
Unit II	Trophic levels: food chains, food webs, ecological pyramids and energy flow. Population ecology: population dynamics and carrying capacity, life table and its importance in forest management, nutrient cycling.	6 lectures
Unit III	Community ecology: species interactions. Ecological succession: theories of succession, climax vegetation types; Forest management and succession; Biogeography.	5 lectures
Unit IV	Autecology of important tree species, perturbation ecology. Biodiversity and conservation: distribution of diversity in different life forms, biodiversity hotspots, diversity measurement and diversity indices.	6 lectures
Unit V	Principles of conservation biology, *Ex-situ* and *In-situ* conservation, genetic and evolutionary principles in conservation; Biosphere concept, conservation efforts in India and worldwide.	5 lectures

Books:

1. Ambasht, R.S. and Ambasht, N.K (2008). A Text Book of Plant Ecology. CBS Publishers and Distibutors. New Delhi, India.
2. Frankel, O.H., Brown, A.H.D., Burdon, J.J. (1995). The Conservation of Plant Biodiversity. Cambridge University Press. Cambridge.
3. Michael, P. (1984). Ecological Methods for Field and Laboratory Investigations. Tata McGraw-Hill Publishing Company, New Delhi.
4. Misra, R. (1968). Ecology Work Book. Oxford and IBH Publishing Company, New Delhi, India.
5. Misra, R. and Puri, G.S. (2013). Indian Manual of Plant Ecology. Scientific Publishers, Jodhpur, India.
6. Misra, K.C. (1991). Manual of Plant Ecology. Oxford and IBH Publishing Company, New Delhi.
7. Montagnini, F. and Jordan, C.F. (2005). Tropical Forest Ecology: The Basis for Conservation and Management. Springer.
8. Odum, E.P. (1996). Fundamentals of Ecology. Natraj Publishers, Dehra Dun, India.
9. Sagwal, S.S. (1995). Forest Ecology of India. Pioneer Publishers, India.

10. Sharma, P.D. (2014). Ecology and Environment. Rastogi Pabulications. New Delhi, India.
11. Singh, J.S., Singh, S.P. and Gupta, S.R. (2010). Ecology Environment and Resource Conservation. Anamaya Publishers, New Delhi, India.

FR22205	**Soil Biology and Fertility: 3 Credit (2-0-2)**	
Unit I	Introduction, forest soils vs. cultivated soils, special features of forest soils, forest soil formation and vegetation development. Pedogenic processes: podzolization and laterization; Properties of soils under different forest ecosystems; Forest floor, stratification, types of humus.	6 lectures
Unit II	Essential nutrient elements: occurrence, availability and their functions; Diagnosis of nutrient deficiencies, visual symptoms, soil fertility evaluation methods; Site productivity and nutrient cycling in forest soils; N, P and K, macro and micronutrient fertilizers and their uses.	5 lectures
Unit III	Forest soil-biology: distribution of various microorganisms in soil ecosystem and their interaction effects; Role of microorganisms in soil fertility; Mineral transformations-carbon cycle with reference to organic matter decomposition and humus formation, Microbial degradation of cellulose & lignin.	6 lectures
Unit IV	Bio-fertilizers and their importance; Nitrogen fixation- *Rhizobium*, tree legume symbiosis, *Frankia* X non-legume symbiosis, asymbiotic and associative N_2 fixation; Nitrification and denitrification in forest ecosystems.	5 lectures
Unit V	Microbial transformation of phosphorous, sulphur, and micronutrients. Mycorrhizae: types, biology and importance with specific relevance to tree crops and mobilization of phosphorus and micro-nutrients; Rhizosphere and phyllosphere concept. Fertility management of forest soils; Integrated nutrient management in plantation forestry.	6 lectures

Books:

1. Weil, R.R. and Brady, N.C. (2017). The Nature and Properties of Soils. 15th Edition, Pearsons, New Delhi.
2. Burges, A. and Raw, F. (1967). Soil Biology. Acad. Press, New York.
3. Mengel, K. and Kirkby, A. (1978). Principles of Plant Nutrition. International Potash Institute, Switzerland.
4. Pritchett, W.L. and Fisher, R.F. (1987). Properties and Management of Forest Soils. John Wiley, New York.
5. Tisdale, L.S. Nelson, L.W. and Beaton, J. D. (1985). Soil Fertility and Fertilisers. Macmillan Publishing Company, New York.
6. Havlin, J.L., Samuel, L., Tisdale, Werner L., Nelson, J. and Beaton, D. (2013). Soil Fertility and Fertlizers. 8th Edition. Pearson.
7. Young, A. (1989). Agroforestry for Soil Conservation. CAB International, U.K.

FR22206	**Seed Technology and Nursery Management: 3 Credits (2-0-2)**	
Unit I	Importance of seed in present day forestry, seed and fruit development, seed dispersal; Planning and methods of seed collection, collection of immature fruits. Fruit and seed handling: maintaining viability and identity, special precautions for recalcitrant seeds.	5 lectures
Unit II	Seed processing, methods of extraction. Operations after extraction: cleaning, grading and control of moisture level; Factors affecting drying of orthodox seeds. Seed storage: definition, purpose, recalcitrant seeds; Harrington's rule of thumb, seed maturity, parental and annual effects; Seed storage and its methods, storage containers. Seed dormancy: types of dormancy and treatments for breaking dormancy.	6 lectures
Unit III	Seed dressing and pelleting. Seed testing: definition, ISTA rules, sampling, seed weight, moisture- authenticity, seed health; Germination testing, germination equipment, conditions for selected species. Germinationevaluation: germinationtestingin nursery, indirect tests of viability; Seed Act and Seed Certification.	5 lectures
Unit IV	Introduction and scope of Forest nursery; Nursery establishment. Siteselection:	6 lectures

	Planningandlayoutofnurseryarea, Types of forest nursery, types of nursery beds, preparation of beds, fumigation; Methods of seed sowing and mulching, seedling growth and development, pricking, weeding, hoeing, rotation, organic matter supplements and cover crops, mycorrhizae, fertilization, root culturing techniques, lifting windows, grading, packaging; Storing and transportation.	
Unit V	Containerised nurserytechniques, planting techniques for containerizedstock; Plantingbare-rootseedlings; Methods for field handling and planting bare-root stock. Containerised nursery technique: type and size of containers, merits and demerits of containerized nursery, root trainer techniques. Preparation of ingredient mixture; Study of important nursery pests and diseases and their control measures.	6 lectures

Books:

1. Agrawal, R.L. (1986). Seed Technology. Oxford - IBH Publishing Co. New Delhi.
2. Bewely, J.D and Black, M. (1985). Seed- Physiology of development and germination.
3. Bose, T.K.; Mitra, S.K. and Sadhu, M.K. (1986). Propagation of tropical and sub-tropical Horticultural crops.NayaPrakash, Calcutta.
4. Chin, H.F. and Roberts, E.H. (1980). Recalcitrant Crop Seeds. Tropical Press Sdn. Bhd. Kuala Lumpur - 22-03, Malaysia.
5. Evans, J. and Turnbull, J.W. (2004). Plantation Forestry in the Tropics. 3rd edition. Oxford University Press.
6. Hartmann, H.T. and Kester, D.E. (1968). Plant propagation – principles and practice prentice – Hall of India Private Limited, New Delhi.
7. ISTA (1993). International Rules for Seed Testing Rules. International Seed Testing Association, Zurich, Switzerland, 1993.
8. Khullar, P. et al. (1992). Forest Seed. ICFRE, New Forest, Dehra Dun.
9. Leadem, C.L. (1984). Quick Tests for Tree Seed Viability. B.C. Ministry of Forests and Lands, Canada.
10. Napier, I. and Robbins, M. (1989). Forest Seed and Nursery Practice in Nepal. Nepal-UK Forestry Research Project, Kathmandu.
11. Prakash, R. (1990). Propagation Practices of Important Indian Trees. International Book Distributors, Dehra Dun.

FR22207	**Forest Tribology & Anthropology: 2 Credits (2-0-0)**	
Unit I	Meaning, scope and development of Anthropology; Relationships with other disciplines, applications of Anthropology; Main branches of Anthropology, their scope and relevance; Human evolution and emergence of Man. Phylogenetic status, characteristics and geographical distribution. Principles of Prehistoric Archaeology. Chronology: Relative and Absolute Dating methods.	6 lectures
Unit II	Culture, society, marriage, family, kinship, economic and political organization, social control, religion; Anthropological theories, language and communication, race and racism; Ethno-archaeology in India; Demographic profile of India, caste system in India.	5 lectures
Unit III	Definition and characteristics of a tribe; Tribes and aborigines- an anthropological perspective; Racial classification and distribution of tribes; Tribes in India and North East India; Tribal economy; Tribals and Constitution of India.	5 lectures
Unit IV	Administration of tribal areas in independent India, appraisal of tribal development, problems of tribal identity and integration in the mainstream; Relation between tribes and forests, forest as their immediate environment, forests as the means of livelihood. Girijan habitat: changes consequent to government control of forests.	6 lectures
Unit V	Forest management and tribal welfare, management conflicts and way forward; Role of forest department in tribal welfare; Role of non-wood forest products in the economy of tribal's, Tribal Cooperative Societies, Social forestry and tribal welfare.	6 lectures

Books:

1. Furer-Haimendorf, C.V. (1985). Tribes of India - the struggle for survival. OUP. New Delhi
2. Hasnain, N. (2007). Tribal India. New Royal Book Company
3. Hasnain, N. (2011). Indian Anthropology. Palaka Prakashan
4. Sharma, R.N. and Bakshi, S. (1984). Tribes and tribal development. Uppal Publ. House, New Delhi
5. Sharma, R.N. and Sharma, R.K. (1997). Anthropology. Atlantic Publishers & Distributors.
6. Thakur, D. (1986). Socio-economic development of tribes in India. Deep and Deep Publications, New Delhi.

FR22208	**Rangeland and Livestock Management: 2 Credits (1-0-2)**	
Unit I	Rangeland: definition, scope and importance/value, types and distribution around world. Grasses: characters, grassland types of India and their distribution, ecological status of Indian grasslands, cattle and fodder resources of India.	3 lectures
Unit II	Rangeland management: definition, objectives, issues, principles of rangeland and grassland management for maximizing forage yield and quality; Feeding habit and grazing behaviour of range animals. Carrying capacity: definition and method of calculation; Grazing: season of grazing, methods and their merits and demerits, design and layout of grazing systems.	3 lectures
Unit III	Establishment and improvement of rangeland/grasslands: selection of species, rangeland seeding & planting, cultural practices, iming, fertilizer application, burning, grazing and cutting intensity; Storage of fodder, silage and hay, methods of preparation, hay banks; Fodder trees and shrubs.	3 lectures
Unit IV	Definition and importance of livestock management, important breeds of important livestock e.g. cattle, buffalo, sheep and goat; Breeding and reproductive management for higher productivity. Feeding management: types of feedstuffs available for feeding livestock, methods of feeding, assessing nutritive value of feed and fodder, estimation of digestible nutrients and energy in feedstuffs.	3 lectures
Unit V	Rangeland and grassland protection: principles of rationing, types of enclosures, effect of closures; Prevention and control of diseases; Study of National forest policy on grazing, grazing rights and concessions.	2 lectures

Books:

1. Banerjee, G.C. (2010). A text book on Animal Husbandry, 8th Edition, Oxford and IBH New Delhi.
2. Holechek, J.L. et al. (1989). Range Management. Prentice Hall, New Jersey.
3. Sastry, N.S.R. and Thomas C.K. (2005). Livestock Production Management, Kalyani Publishers, New Delhi.
4. Singh, R.V. (1982). Fodder trees of India. Oxford and IBH New Delhi.
5. Ward, H.M. (1980). Grasses. A handbook for use in the field and laboratory, Scientific Pub., Jodhpur.
6. Holecheck, J.L., Rex, D., Pieper C. and Herbel, H. (2010). Range Management: Principles and Practices (6th Edition) by, Prentice Hall.
7. Lal, J.B. (1990). Principle and practice of rangeland management, International Book Distributors, Dehradun.
8. Arthur, W.S. (1923). Rangeland and pasture management by, John Wiley & Sons Inc.
9. Kevin, B., Howard M. and Dejong-Hughes, J. (2003). Grazing systems planning guide, USDA, Natural Resource Conservation Science.
10. Harold, H. and Child, R.D. (1999). Rangeland Ecology and Management Westview Press.
11. Arthur, D.S. (1943). Range Management by Laurence Alexander Stoddart, Mcgraw-Hill.

FR22266	**Study Tour of State Forest: Non Credit (0-0-0)**	
	Study tour of one week duration in the respective States/part of India. To familiarize the students with the fauna, flora and other research activities of SAUs, Research institute, forest industries, Govt. and private organizations of different parts of respective states/ part of India. To expose the students to various national / heritage monuments as part of national integration activity.	One week duration

FR23101	Climate Science: 3 Credits (2-0-2)	
Unit I	Agrometeorology: definition, aim and scope; Factors and elements of weather and climate; Composition and structure of atmosphere; Air and soil temperature regimes, atmospheric humidity, types of clouds and precipitation, hails and frost.	5 lectures
Unit II	Cyclones, anticyclones and thunderstorms; Solar radiations components and effect on plant growth; Effect of weather and climate on the growth and development of crops; Climatic normals for crops and trees; Agro climatic zones of India; Evaporation and transpiration.	6 lectures
Unit III	Climate change: understanding climate change and its consequences; Global warming and its effects on Forest; Forest and climate change: vulnerability and adaptability; Evidence of forest disturbance due to climate change.	5 lectures
Unit IV	Climate change influence on agro-forestry: Climate resilient forestry; Economic worth of carbon storage in forest; Forest and UN convention on climate change: NATCOM initiatives; Decision making in emission of Green House Gases (GHG).	6 lectures
Unit V	Kyoto protocol; Awareness about climate change; National action plan for climate change: Green India mission; Indian Network for Climate Change Assessment (INCCA); State Action Plans on Climate Change.	6 lectures

Books:

1. Ghadekar, S.R. (2003). Meteorology. Agromet Publishers, Nagpur.
2. Lenka, D. (1997). Climate, weather and crop in India. Kalyani Publishers, New Delhi.
3. Mavi, H.S. (1994) Agrometerology. Oxford & IBH, New Delhi.
4. Rao, GSLHVP. (2003). Agrometeorology, KAU, Thrissur, Kerala.
5. Seemann, J., Chirkov, Y.I., Lomas, J. and Primault, B. (2012). Agrometeorology. Springer, Berlin Heidelberg.
6. Varshney, M.C. and Pillai, P.B. (2003). Textbook of Agrometeorology. ICAR, New Delhi.

FR23102	Plantation Forestry: 3 Credits (2-0-2)	
Unit I	Plantations: definition and scope; Development of plantation forestry in India; Plantation organization and structure; Land and plantation development; Plantation planning: national and regional planning, project appraisal, project implementation and its feasibility studies.	6 lectures
Unit II	Plantation silviculture: choice of species, plantation establishment, plantation maintenance, nutrition in plantations, use of fertilizers; Major pest and disease in plantations, sanitation and control measures.	5 lectures
Unit III	Dynamics of stand growth: CCF, MCA, stand density management in plantations; Thinning regimes: improvement fellings; Site quality evaluation, stand basal area, site index, plantation productivity assessment.	6 lectures
Unit IV	Stock assessment: MAI, sustainability of plantations; Plantation records, plantation journal; Industrial plantations: Paper and pulp wood, match wood, plywood plantations; Plantations yielding NTFPs; Energy plantation, high density short rotation plantations; Petro crops, avenue plantations.	6 lectures
Unit V	Plantations as potential carbon sinks: Economic factors in plantation development, social and cultural considerations.	5 lectures

Books:

1. Evans, J. and Turnbull, J.W. (2004). Plantation Forestry in the Tropics. The Role, Silviculture and Use of Planted Forests for Industrial, Social, Environmental and Agroforestry Purposes. Oxford University Press, Oxford, UK.
2. Bowen, G.D. and Nambiar, E.K.S. (1984). Nutrition on Plantation Forests. Academic Press.
3. Dwivedi, A.P. (1989). Text Book of Silviculture. International Book Distributors, Dehra Dun, India.
4. Evans, J. and Turnbull, J.W. (2004). Plantation Forestry in the Tropics. The Role, Silviculture and Use of Planted Forests for Industrial, Social, Environmental and Agroforestry Purposes. Oxford University Press, Oxford, UK.

5. Krishnapillay, B. (2000). Silviculture and Management of Teak Plantations. Unasylva.
6. Kumar, V. (2015). Nursery and Plantation Practices in Forestry. Scientific Publishers, Jodhpur, India.
7. Luna, R. K. (1989). Plantation Forestry in India.International Book Distributors, Dehra Dun, India.
8. Nambiar, E.K.S. and Brown, A.G. (1997). Management of Soil, Nutrients and Water in Tropical Plantation Forests. Australian Centre for Internat. Agricultural Research.
9. Nambiar, E.K.S., Cossalter, C. and Tiarks, A. (1998). Site Management and Productivity in Tropical Plantation Forests. Workshop Proceedings, South Africa.
10. Suzuki, K., Ishii, K., Sakurai, S. and Sasaki, S. (2006). Plantation Forestry in the Tropics. Springer Tokyo.

FR23103	**Forest Extension and Community Forestry: 3 Credits (2-0-2)**	
Unit I	Forest Extension: Introduction, human behavior and psychology; Concept, scope, principles philosophy and objectives of extension education; Forestry extension education: Extension education: meaning, definition, nature, scope, objectives, principles, approaches and history.	5 lectures
Unit II	Forestry extension: process, principles and types of education; Formal, informal non-formal education; People's participation in Forestry programmes. Elements of extension education: man himself, man's environment and man's created devices. Rural Development: meaning, definition, objectives and genesis; Transfer of technology programmes like lab to land programme (LLP), national demonstration (ND), and front line demonstration (FLD), KrishiVigyan Kendras (KVK), Van Vigyan Kendras, Technology Assessment and Refinement Programme (TARP) of ICAR/ICFRE. Communication: meaning, definition, elements and selected models.	6 lectures
Unit III	Audio-visual Aids: Importance, classification and selection. Programming planning process: meaning, scope, principles and steps. Evaluation: Meaning, importance and methods; Scope and importance of Participatory Rural Appraisal (PRA): Rural social groups, primary and secondary groups, formal, informal group, temporary, permanent groups, references group, classification of group.	5 lectures
Unit IV	Community Forestry: Introduction to the concept of forestry as a common property resource; Definition, scope and necessity of community forestry. Forests and man: Forestry in support to agriculture, animal husbandry and horticulture; Development of cottage industry in rural environment. NFP 1988 and the importance of people in forest conservation: Community forest management, community forest development, social, economical and environmental aspects, community forest development through NGOs, civil societies, citizen groups; Gender dimensions in community forest management.	6 lectures
Unit V	Social Forestry: Definition need and purpose, historic development; Social Forestry for fodder, fuel wood, leaf manure and timber production, NTFPQ; Integrated rural development approach with proper marketing facility; Employment generation in raising, tending and harvesting of tree crops. Joint Forest Management: concept, legislation, rules, importance. Case studies of JFM implementation: problems and prospects; Microplan preparation; JFMCs, FDCs, VFCs, CBOs, NGOs and Co-operative Societies.	6 lectures

Books:

1. FAO (1984). Forestry extension, making it work, An international journal of forestry and forest industries, Unasylva - No. 143, Published by FAO.
2. Jha, L.K. and Sen Sarma, P. K. (2008). A Manual of Forestry Extension Education, Published by VEDAMS.
3. Sim, D. and Hilmi, H.A. (1987). Forestry Extension Methods, FAO Forestry Paper-80.
4. Jalihal K.A., Veerabhadraiah, V. (2007). Fundamentals of Extension Education and Management in Extension, Concept Publishing Company.
5. Balakathiresan, S. (1986). Essentials of forest management. Nataraj Publishers, Dehradun.
6. Bullock, R.C.L. and Hanna, K.S. (2012). Community Forestry Local Values, Conflict and Forest Governance. Cambridge University Press.

7. Gunter, J. (Ed.). (1973). The Community Forestry Guidebook (http://www.forrex.org/ sites/default/ files/ forrex_series/FS15.pdf).
8. Ojha, H.R., Timsina, N.P., Kumar, C., Banjade, M.R. and Belcher, B. (2007). Communities, Forests and Governance: Policy and Institutional Innovations from Nepal. Adroit Publishers, New Delhi, India.
9. Roy, S.B. and Chatterjee, M. (1994). Joint Forest Management. Inter India Publications.
10. Tiwari, K.M. (1983). Social forestry for rural development. International Book Distributors.
11. Vyas, G. P.D. (2006). Community Forestry. Agrobios, India.

FR23104	**Logging and Ergonomics: 2 Credits (1-0-2)**	
Unit I	Definition and scope of logging, logging plan and execution; Location and demarcation of the area for logging and estimation of produce available for extraction.	2 lectures
Unit II	Implements used in logging operation: traditional and improved tools; Felling rules and methods; Work contracts related to felling and removing (contract system, convener systems etc.); Conversion, measurement and description of converted material.	3 lectures
Unit III	Means of transport of timber: carts, dragging, skidding, overhead transport, ropeways, skylines; Transport by road and railways; Transport by water, floating, rafting and concept of booms.	3 lectures
Unit IV	Non-destructive sampling methods of wood; Grading and storage of timber in the depots for display and disposal; temporary and final storage; Timber Depots: types, lay out and management; Systems of disposal of timber.	3 lectures
Unit V	Ergonomics: definition, components and provision of energy; Requirement of energy and rest periods; Effect of heavy work, posture, weather and nutrition. Personal protective equipments: safety helmets, ear and eye protections. Accidents: causes, statistics, safety rules and first aids.	3 lectures

Books:

1. Brown, N.C. (2002). Principles and methods of harvesting of timber. Biotech books, Delhi.
2. Staaf, K.A.G. and Wiksten, N.A. (1984). Tree Harvesting Techniques. Martinus Nijhoff /DR W. Junk Publishers, Netherlands.
3. FRI [Forest Research Institute] (1976). Indian forest utilization. Volume I and II. Forest Research Institute and colleges, Dehradun.
4. GFC [Guyana Forestry Commission] (2002). Code of practice for timber harvest. 2nd Ed.Georgetown, Guayana.
5. Hakkila, P. (1989). Utilization of residual forest biomass. Springer-verlag, Berlin.
6. Jones, J.T. (1993). A guide to logging aesthetics. Northeast Regional Agricultural Engineering Service, Ithaca, New York.
7. Mehta, T. (1981). A handbook of forest utilization. IBD Dehradun.
8. Wakermann, A.E. (2002). Harvesting timber crops. Biotech books, Delhi.

FR23151	**Geomatics: 3 Credits (1-0-4)**	
Unit I	Remote sensing: Introductionand classification; Active and passive remote sensing; Aerial and space remote sensing; Interaction of electromagnetic radiation with atmosphere and earth surface.	2 lectures
Unit II	Aerial photographs: types, photo interpretation elements and keys. Satellite remote sensing: platforms and sensors; Satellite systems; Indian Remote Sensing Programme.	3 lectures
Unit III	Visual and digital image processing; Application of satellite based remote sensing techniques in forestry; Vegetation mapping using satellite imagery; Forest cover monitoring and damage assessment; Thermal and Microwave remote sensing.	3 lectures
Unit IV	Introduction to GIS: Differences between GIS and conventional cartography; Spatial and non-spatial data, Integration of attribute data with spatial data; Raster and Vector data; Thematic over lays in GIS; topology building and DEM.	3 lectures

Unit V	Application of GIS in forestry: Maps and its projection, Toposheet and Map reading, Global Positioning System (GPS) applications in resource inventory, Global Navigation Satellite System, GIS software.	3 lectures

Books:

1. Campbell, J.B. (2002). Introduction to Remote Sensing. Third edition. Taylor and Francis, London.
2. Environment System Research Institute (1999). GIS for Everyone. Redlands, CA: ESRI.
3. Jackson, M.J. (1992). Integrated Geographical Information Systems. International Journal of Remote Sensing.
4. Jensen, R.J. (2003). Remote Sensing of the Environment. An Earth Resource Perspective. Pearson and Education.
5. Joseph, G. (2005). Fundamentals of Remote Sensing. Second edition. Universities Press.
6. Lillesand, T.M., Kiefer, W.R. and Chipman,J.W. (2004). Remote Sensing and Image Interpretation. Fourth edition. John Wiley & Sons, Inc., USA.
7. Reddy, O.G.P. and Sarkar, D. (2012). RS and GIS in Digital Terrain Analysis and Soil Landscape Modelling. NBSS & LUP, Nagpur.
8. Reddy, A.M. (2002). Text Book of Remote Sensing and GIS, BSB Publication, Hyderabad, India.
9. Schowengerdt, R.A. (2006). Remote Sensing: Models and Methods for Image Processing. Elsevier Publication, Oxford, London, UK.

FR23152	**Experiential Learning: 5 Credits (0-0-10)**
Module I	**Production and Marketing of High Value Forest Produce:** Project formulation, Market survey and prioritization of species. The species (imported and indigenous) that are currently available in the market has to be surveyed through personal visits to timber markets, saw mills, forest depots etc. Lesser known, but highly utilizable indigenous species of timbers will be given priority. Fast rotation timber species raised under various trials will also be included to the extent possible. Potential of different species for various end uses will be determined. Timber samples have to be converted into sticks / smaller sizes / macerated through appropriate procedures such as sawing and sizing in a saw mill or maceration in a laboratory. Mechanical tests: Static bending, compressive tests-across and along the grain. Finding out safe working stresses of lesser known or exotic/new species. Wood database currently available in the department will be updated based on the test results. Wood conversion in an integrated saw mill, turnery for handicrafts, joineries and furniture making. Data analysis, project report writing, presentation and final examination.
Module II	**Raising Quality Planting Materials for Forest Regeneration:** Project formulation, Identification of species (grasses, trees, medicinal plants & wild fruits) for nursery raising, time of collection of plant material from selected seed sources, quantity of seed/plant material required, nursery area (open and protected), inputs required, schedule for intercultural operation-seed treatment, sowing, weeding, fertigation, root hardening treatments. Assessment of demand in local/potential markets and institutions. Collection, handling, processing and storage of planting material. Identification of superior seed sources, seed collection, treatment and storage. Vegetative propagation under controlled and ambient conditions. Collection of vegetative propagules. Treatment and processing of bare root and containerized seedlings. Data analysis, project report writing, presentation and final examination.
Module III	**Apiculture:** Project formulation, Apiculture-Scope and importance of beekeeping, bee's classification, hives, social organization, extraction of honey and other products. Marketing of honey and bee wax and their value addition. Costs benefit analysis. Data analysis, project report writing, presentation and final examination.
Module IV	**Ecotourism:** Socio- economic feasibility analysis for initiating ecotourism projects. Tour planning and site development. Social engineering and natural resource management. Study of environmental and social impacts of ecotourism and mitigation strategies. Potential of

	ecotourism as a business. Data analysis, project report writing, presentation and final examination.
Module V	**Wild Animal Health Management:** Basic concepts of disease and health conditions. Review of major diseases of Indian wild mammals, birds, amphibians and reptiles. Epidemiology of disease. Disease and population dynamics. Disease transmission between domestic and wild populations. Malnutrition, starvation, dehydration as disease syndromes. Condition, health and nutritional assessment in free-ranging populations (page no. 518, 519 of ICAR Fifth Deans' Committee Report). Control of disease planning and management of wildlife health programmes. Zoonoses. Data analysis, project report writing, presentation and final examination.

FR23201	**Wood Science and Technology: 3 Credits (2-0-2)**	
Unit I	Kinds of woods: hardwood, softwood, bamboos and palms; Merits and demerits of wood as a raw material; Physical features of wood; Electrical, thermal and acoustic properties of wood.	6 lectures
Unit II	Mechanical properties of wood: like tension, compression, bending, shearing, cleavage, hardness, impact resistance, nail and screw holding capacities; Suitability of wood for various uses based on mechanical and physical properties.	5 lectures
Unit III	Wood water relationship: shrinkage, swelling, movement, fibre saturation, equilibrium moisture content; Wood seasoning: merits, principles and types; air seasoning, kiln seasoning and chemical seasoning; Refractory classes of timbers; kiln schedules; Seasoning defects and their control.	5 lectures
Unit IV	Classification of timbers based on durability; Wood preservation; principles, processes, need, types of wood preservatives (Water soluble, oil based, etc.); General idea about fire retardants and their usage. Non-pressure methods: steeping, dipping, soaking open tank process, Boucherie process. Pressure methods: full cell process, empty cell process (Lowry and Rueping).	6 lectures
Unit V	Wood machining: Sawing techniques, kind of saws: cross cut, edging, cudless, hand, circular and bow saws; Wood working, tools used in wood working (parting, slicing, shaping, measuring and marking tools); Various stages in wood working: Reaction wood, Compression wood, tension wood; Physical and mechanical properties of reaction wood.	6 lectures

Books:

1. Bowyer, J.L., Shmulsky, R. and Haygreen, J.G. (2007). Forest products and wood science: An introduction. 5th Ed. Blackwell publishing, Ames, IA.
2. Brown, H.P. (1985). Manual of Indian wood technology. International books and periodicals supply service, New Delhi.
3. FRI [Forest Research Institute]. (1976). Indian forest utilization. Volume I and II. Forest Research Institute, Dehradun.
4. Panshin, A.J. and De Zeeuw, C. (1980). Textbook of wood technology, 4th Ed. McGraw-Hill.New York, USA:
5. USDA [U.S. Department of Agriculture]. Wood handbook - Wood as an engineered material (1999). U.S. Department of Agriculture, Forest Service. Forest Products Laboratory, Madison, WI.

FR23202	**Forest Laws, Legislation and Policies: 2 Credits (2-0-0)**	
Unit I	National Forest Policies: scope and importance, comparative analysis of all forest policies. Indian judicial system: legal definitions, application of penal code to forests.	5 lectures
Unit II	General principles of criminal law: legal principles of punishment, Criminal procedure code, the law of evidence and the Indian Evidence Act, 1872 as applied to forestry matters; Code of Civil Procedure, 1908.	5 lectures
Unit III	Indian Forest Act, 1927 and its revision; Assam Forest Regulation Act 1891;	6 lectures

	Forest (Conservation) Act, 1980.	
Unit IV	Wild Life Protection Act 1972 with its amendments; Brief description about other major forest laws of regional, national and international significance.	6 lectures
Unit V	Biological Diversity Act. 2002; Discussion of court verdicts on issues of utmost importance to conservation.	6 lectures

Books:

1. Dutta, R. and Yadav, B. (2012). Supreme Court on Forest Conservation. Universal Law Publishing Co., New Delhi, India.
2. Joy, P. P. (2012). Set up your criminal practice. Swamy Law House, Ernakulam.
3. Shetty, B. J. (1985), A Manual of Law for Forest Officers, Sharda Press, Mangalore.
4. Takwani, C. K. T and Thakker, M. C. (2012). Takwani Criminal Procedure. Lexis Nexis Butterwarths Wadhwa, Nagpur.
5. Negi S. S. (1996). Forest Laws , BSMPS, Dehradun.

FR23203	**Certification of Forest Products: 2 Credits (2-0-0)**	
Unit I	Definition of forest certification; Responsible sourcing of wood; Principal stages in the process of certification.	6 lectures
Unit II	Producer's motivation for supplying certified forest products; Key aspects of certification; Principles of sustainable forest management; Origin of certification.	5 lectures
Unit III	Organizations responsible for certification; Legislations and policies of importance; Certification schemes in operation; Forest Stewardship Council (FSC); Programme for Endorsement of Forest Certification Schemes (PEFC) etc.	6 lectures
Unit IV	CIFOR certification tool kit; Indian scenario in certification; International trade in tropical logs and sawn wood; Pros and cons of certification.	5 lectures
Unit V	Potential for certifying forests and forest products of India; Tracing illegal logging; Identification of species and region of origin; Timber tracing through genetic methods and (analysis of stable isotope ratios).	6 lectures

Books:

1. Bass, S. (1996.). Introducing forest certification. A report prepared by the Forest Certification Advisory Group (FCAG) for DGVII of the European Commission. European Forest Institute, Discussion Paper 1. 30p. Details available at: http://www.giz.de/Themen/de/dokumente/end28-inenpenennt-certification-verification-forest-manage.pdf
2. Bass, S., Thornber, K., Markopoulos, M., Roberts, S. and Grieg-gran, M. (2001). Certification's Impact on forests, stakeholders and supply changes. International Institute for Environment and Development, London.
3. Conroy, M.E. (2007). Branded! How the "certification revolution" is transforming global corporations. New Society publishers, Gabriola Island, BC.
4. Gupta, H.S., Yadav, M., Sharma, D.K. and Singh, A.M. (2013). Ensuring sustainability in forestry: certification of forests. TERI, New Delhi.

FR23204	**Recreation and Urban Forestry: 2 Credits (1-0-2)**	
Unit I	Forest recreation: definition and scope, social and environmental aspects of recreation components, approaches in forest recreation.	3 lectures
Unit II	Principles and elements of landscaping: types of landscape designs formal, Persian and Mughal designs, informal, British and Japanese designs.	2 lectures
Unit III	Landscape components: plant and other components, lawn, pergolas, hedges, edges, topiary, balloon, arbours, carpet beds, trees, flower beds, annuals and climbers.	3 lectures
Unit IV	Practices of landscaping: tools and implements for landscaping. Specialised gardens: butterfly, water, bog or marsh, terrace, roof, sunken, indoor and rock; Planning and planting programmes in institutional and industrial complexes, roads, bridges, parking area and other structures.	3 lectures

Unit V	Urban forestry: definition and scope, uses of urban forests. Management of urban forest: Arboriculture and its importance in urban forestry.	3 lectures

Books:

1. Douglar, J., Hort, R.A. and Ranganadhan, S. (1982). Forest Farming. Natraj Publications, Dehra Dun, India.
2. Gopikumar, K. (2008). Arboriculture Principles and Practices. Khanna Bandhu, Dehra Dun, India.
3. Hamm, W.E. and Cale, D.N. (1987). Wild Land Recreation. John Wiley and Sons, New York, USA.
4. Miller, R.W. (1988). Urban Forestry. Prentice Hall International Ltd. London.
5. Singh, S.P. (1986). Planting of Trees. B.R. Publishing Corporation, New Delhi.
6. Urban Forestry and Urban Greening. An International Journal aimed at presenting high quality research with urban and peri-urban woody and non-woody vegetation and its use, planning, design, Elsevier Publications.

FR23205	**Wildlife Management: 2 Credits (1-0-2)**	
Unit I	Wildlife management: definition, objectives and goals; History of wildlife management and conservation in India; Principals of wildlife management; Wildlife values.	2 lectures
Unit II	Distribution of wildlife species: zoogeographic regions of the world; Major biomes of the world; Biogeographic zones of India; Factors affecting the distribution pattern of wildlife.	3 lectures
Unit III	Habitat requirements of animals. Wildlife habitat management: tools and techniques; fire, livestock grazing, restoration, control of exotic species; NTFPs collection; Red Data Book and IUCN revised red list categories.	3 lectures
Unit IV	Wildlife population management: wildlife census, purpose, techniques, difficulties, equipments required. Census methods: direct and indirect methods, sample and total counts, indices, encounter rates and densities, block counts, road side counts, dung counts, pug mark census, water hole census, line transect, statistical analysis; Telemetry. Captive wildlife: zoos and safari parks; Captive breeding for conservation; Management of threatened, isolated and fragmented, over-abundant and problem species population.	3 lectures
Unit V	Wildlife Law: Wildlife (Protection) Act, 1972 and its, Amendments; Central Zoo Authority of India; Protected area and its concept and categories; Major protected areas of India. Special projects for wildlife conservation: Project Tiger, Elephant, Lion, Crocodile, and Musk Deer. Translocation: Introduction and reintroduction of species; Wildlife corridors; MAB, CITES. Wildlife Damage: Appraisal, control and management; Healthcare, disease management and nutrition in wild animals.	3 lectures

Books:

1. Davil, J.W. et al. (1981). Infectious diseases of wild mammals. Ed. II. Iowa State University Press, USA.
2. Krebs, C. and Davis, N. (1978). Introduction to behavioral ecology. Oxford University Press.
3. Lever, C. (1985). Naturalised mammals of the world. John Wiley, London.
4. Mills, L.S. (2013). Conservation of Wildlife Populations Demography, Genetics and Management (Ed.2). Wiley-Blackwell.
5. Rajesh, G. (1995). Fundamentals of Wildlife Management, Justice Home, Allahabad.
6. Sawarkar, B. Wildlife Management. Wildlife Institute of India. Dehra Dun.
7. Wildlife Institute of India (2004). Compendium on the notes on the course Captive management of Endangered Species. Wildlife Institute of India. Dehra Dun.
8. Wodroffe, G. (1981). Wildlife conservation and modern zoo. Saiga Publishing Co., England.
9. Hosetti, B.B. (1997). Concept of wildlife Management, Daya Pub. House, New Delhi.
10. Dunbar, A.A. (1988). Preservation of wildlife in India, Daya Publishing House, New Delhi.
11. Singh, S.K. (2005). Text book of wildlife management, IDBC publishers, Lucknow.
12. Raj, M. (2012). Wildlife Ecology and Management, Assam Book Depot, Guwahati.

FR23251	Experiential Learning: 5 Credits (0-0-10)
Module I	**Production and Marketing of High Value Forest Produce:** Project formulation. Market survey and prioritization of species. The species (imported and indigenous) that are currently available in the market has to be surveyed through personal visits to timber markets, saw mills, forest depots etc. Lesser known, but highly utilizable indigenous species of timbers should be given priority. Fast rotation timber species raised under various trials should also be included to the extent possible. Potential of different species for various end uses should be determined. Timber samples have to be converted into sticks / smaller sizes / macerated through appropriate procedures such as sawing and sizing in a saw mill or maceration in a laboratory. Mechanical tests: static bending, compressive tests-across and along the grain. Finding out safe working stresses of lesser known or exotic/new species. Wood database currently available in the department should be updated based on the test results. Project report preparation and presentation, final examination. Wood conversion in an integrated saw mill, turnery for handicrafts, joineries and furniture making. Data analysis, project report writing, presentation and final examination.
Module II	**Raising Quality Planting Materials for Forest Regeneration:** Project formulation. Identification of species (grasses, trees, medicinal plants & wild fruits) for nursery raising, time of collection of plant material from selected seed sources, quantity of seed/plant material required, nursery area (open and protected), inputs required, schedule for intercultural operation-seed treatment, sowing, weeding, fertigation, root hardening treatments. Assessment of demand in local/potential markets and institutions. Collection, handling, processing and storage of planting material. Identification of superior seed sources, seed collection, treatment and storage. Vegetative propagation under controlled and ambient conditions. Collection of vegetative propagules. Treatment and processing of bare root and containerized seedlings. Data analysis, project report writing, presentation and final examination.
Module III	**Apiculture:** Project formulation, Apiculture-Scope and importance of beekeeping–Bees classification–Hives –Social organization –extraction of honey and other products. Marketing of honey and bee wax and their value addition. Cost Benefit analysis. Data analysis, project report writing, presentation and final examination (As per page no.520, 521 of the ICAR Fifth Deans' Committee Report).
Module IV	**Ecotourism:** Socio- economic feasibility analysis for initiating ecotourism projects. Tour planning and site development. Social engineering and natural resource management. Study of environmental and social impacts of ecotourism and mitigation strategies. Potential of ecotourism as a business. Data analysis, project report writing, presentation and final examination.
Module V	**Wild Animal Health Management:** Basic concepts of disease and health conditions. Review of major diseases of Indian wild mammals, birds, amphibians and reptiles. Epidemiology of disease. Disease and population dynamics. Disease transmission between domestic and wild populations. Malnutrition, starvation, dehydration as disease syndromes. Condition, health and nutritional assessment in free-ranging populations. Control of disease planning and management of wildlife health programmes. Data analysis, project report writing, presentation and final examination.

FR23266	All India Study Tour: Non Credit (0-0-0)	
	To familiarize the students with the flora, fauna and other research activities of universities offering forestry courses, research institutes, forest industries, Govt. and private organization of different parts of India. To expose the students to various national / heritage monuments as part of national integration activity.	Three weeks duration

FR24179	Forestry Work Experience: 20 Credits (0-0-40)	
Orientation (10 days)	Conducting various exercises for exposing the students on the recent trends in the field of forestry, transactional analysis, personality development, soft skills etc. and to prepare students for the rigours of professional life after completing B.Sc. Forestry programme.	1 Credit
Forest Range Training Programme (50 days)	Visit to modern forest nurseries, herbal gardens and watersheds, study the felling and logging operations, timber lots and important industrial products, study working plan, enumeration, volume and yield calculation & compartment history files, study the 'CAT' (Catchment Area Treatment Plan) and FDA (Forest Development Agencies). Use of forestry equipments/ instruments, Study the regeneration and management of important forestry tree species, Sample plots, layout studies, stump analysis, preparation of local volume tables. Study the working of other Forestry related organizations/industries. At the Wild Life Sanctuaries/National Parks/Tiger Reserves, the students are expected to learn about the aspects related with the preparation of the Management Plans/Conservation Plans, to undertake and familiarize the various wildlife population enumeration techniques and the biodiversity assessment techniques. To undertake pilot studies on the man-animal conflict and other issues in the forest areas etc.	12 Credits
Industrial placement (20 days)	Attachment with Forest based industries like Wood Workshop, Saw Mills, Wood Seasoning and Preservation Treatment Plants, Pulp and Paper Industries, Aromatic and Medicinal Plant Units, Carpentry, bamboo and reed crafts, other Wood Products Industries, rubber, NWFP etc. Works to be under taken includes study the nature of industrial and business organization–structure, raw material–collection and processing of raw-material, hands on practicals, production and management process, marketing and financial management.	3 Credits
Weapon Training and First-Aid Training (5+3=8 days)	Hands on training in the handling of various kinds of weapons and their operation, limitations and precautions during their use. Getting basic knowledge on different first aid practices which are required in case of field emergencies, like snakebite, animal attack, poachers and accidents. Also to learn about the first aid to be given to wild animals in distress and volunteering in rural health services.	1 Credit
Socio-Economic Surveys and Village Attachment (20 days)	Data collection, use of PRA techniques with respect to village profile including socioeconomic and cultural status, farm technology used, homesteads, agro forestry, and biodiversity etc., Bench Mark survey of plant resources (cropping pattern, homesteads, agro forestry, biodiversity, yield system etc.), Schedule development, tabulation, analysis and preparing plan of work. Understanding local forestry and other village level institutions (Panchayat, Village Forest Committees, corporations, youth/women groups etc.), People's participation in developmental programmes with special reference to forestry. Exercises on the use of extension methods and teaching aids for 'Transfer of Technology'.	2 Credits
Report writing and presentations (12 days)	Compilation of the work/experience detailing the objectives, places and persons visited, work done, experiences/skills gained and suggestions for improvement of training. Presentation of the report before faculty. The assessment will be based on Project Report evaluation and viva-voce.	1 Credit

FR24201	Agricultural Informatics: 3 Credits (2-0-2)	
Unit I	Computer Programming: General Concepts, documentation and program maintenance; Debugging programs, Errors; Introduction to Visual Basic, Java, Fortran, C/ C++, etc.; Concepts and standard input/output operations;	7 lectures

	Variables and Constants; Operators and Expressions; Flow of control; Inbuilt and user defined functions; programming techniques for agriculture/forestry.	
Unit II	e-Agriculture: concepts, design and development; Application of innovative ways to use information and communication technologies (IT) in agriculture/forestry; ICT for data collection; Formation of development programmes; monitoring and evaluation of programmes.	7 lectures
Unit III	Computer models in agriculture/forestry: statistical, weather analysis and crop simulation models; Concepts, structure, inputs-outputs files, limitation, advantages and application of models for understanding plant processes; Sensitivity, verification, calibration and validation.	5 lectures
Unit IV	IT application for computation of water and nutrient requirement of crops; Computer-controlled devices (automated systems) for Agri-input management; Smartphone mobile apps in Agriculture for farm advises, market price, postharvest management etc; Geospatial technology: concepts, techniques, components and uses for generating valuable agri-information.	5 lectures
Unit V	Decision support systems: taxonomy, components, framework, classification and applications in agriculture/forestry; DSS, Agriculture Information/Expert System, Soil Information Systems etc. for supporting farm decisions; Preparation of contingent crop-planning and crop calendars using IT tools.	4 lectures

Books:

1. Chakravorty, R. (2006). Agri Informatics: An Introduction (Industry Series) ICFAI University Press.
2. Deogirikar, A. and Kshirsagar, S. (2019). A Text Book of Agri – Informatics. Publisher: M/s Shri Rajlakshi Prakashan, Aurngabad ISBN: 9789384710897.
3. Mahapatra, S.K, Mohanty, S.K., Bhuiya, J. and Pradhan, J. (2019). Introductory Agri-Informatics. Publisher: Jain Brothers (2019) ISBN-10: 8183602967.
4. Vanitha, G. and Kalpana, M. (2015). Agro-Informatics. NIPA New Delhi.

FR24202	**Forest Biotechnology: 3 Credits (2-0-2)**	
Unit I	Plant Biotechnology: Concepts, history, scope and importance in tree Improvement; Totipotency and morphogenesis; Nutritional requirements of *in-vitro* cultures; Techniques of *in-vitro* cultures.	6 lectures
Unit II	Micropropagation and *in-vitro* culture: Anther culture, Pollen culture, Ovule culture, Embryo culture etc.; Test tube fertilization; Endosperm culture; Factors affecting above *in-vitro* culture; Applications and achievements.	6 lectures
Unit III	Somaclonal variation: Types, reasons; Somatic embryogenesis and synthetic seed production technology; Protoplast isolation, Culture, manipulation and fusion; Products of somatic hybrids and cybrids; Applications in tree improvement.	6 lectures
Unit IV	Genetic engineering: Restriction enzymes; Vectors for gene transfer. Gene cloning: Direct and indirect method of gene transfer; Transgenic plants and their applications; Achievements and biosafety regulations.	5 lectures
Unit V	Blotting techniques: DNA finger printing and bar coding. DNA based markers: RFLP, AFLP, RAPD, SSR, VNTRS, CAPS, SNPs, ESTs and DNA Probes; Mapping QTL: Future prospects; MAS and its application in tree improvement.	5 lectures

Books:

1. Dubey, R.C. (2009). A Text Book of Biotechnology, S. Chand & Co., New Delhi.
2. Bajaj, Y.P.S. (Ed.) (1988). Biotechnology in Agriculture and Forestry Crops, Springer - Verlag, Berlin.
3. Dhawan, V. (2012). Applications of Biotechnology in Forestry and Horticulture. Springer US

4. Guptha, P.K. (2000). Elements of Biotechnology. Rastogi publications, Meerut.
5. Neumann, K.H., Kumar, A. and Sopory, S.K. (2008). Recent Advances in Plant Biotechnology and Its Applications. I. K. International Pvt. Ltd.
6. Punia, M.S. (1998). Plant Biotechnology and Molecular Biology. A laboratory manual. Scientific Publishers, Jodhpur.
7. Thieman, W.J. and Palladino, M.A. (2009). Introduction to Biotechnology, Second Edition. Pearson Benjamin Cummings, San Francisco.

FR24203	**Agroforestry Systems and Management: 3 Credits (2-0-2)**	
Unit I	Agroforestry: Definition, scope and components of agroforestry; Rising demands of fuel wood, fodder and timber; Social, ecological, and economic reasons for agroforestry; Agrosilvicultural systems; Improved fallows in shifting cultivation: soil dynamics in shifting cultivation, Taungya systems, Alley cropping, structural and functional attributes.	6 lectures
Unit II	Land use and land capability classification: overview of agroforestry around the world. Agroforestry systems in India: Classification of agroforestry systems, structural, functional, agro-ecological, socio-economic and physiognomic basis.	5 lectures
Unit III	Multipurpose trees and shrubs on farmlands; agricultural fields-Plantation crop combinations; commercial crops under shade of planted trees and natural forests; Windbreaks and Shelterbelts.	5 lectures
Unit IV	Silvopastoral systems: protein banks, live fence of fodder trees and hedges; trees and shrubs in pastures. Pastoral silviculture systems: grassland and tree management in the humid, arid and semi-arid regions. Agrosilvopastoral systems; tropical home gardens: structural and functional attribute. Other systems: apiculture, sericulture and mixed woodlots.	6 lectures
Unit V	Major Agroforestry practices in different agroecological zones of India: arid and semi-arid regions; agroforestry practices for wasteland reclamation; Agroforestry practices with reference to North East India; Agroforestry practices for wetlands and waterlogged areas; Non-wood forest products based agroforestry; Soil fertility improvement and water conservation through agroforestry; Socio-economic analysis of various agroforestry systems.	6 lectures

Books:

1. Huxley, P.A. (ed.) (1983). Plant Research and Agroforestry, ICRAF, Nairobi, Kenya.
2. Huxley, P. 1999). Tropical Agroforestry. Wiley.
3. Kumar, B., Nair, P.K.R. (eds). (2006). Tropical Homegardens: A Time-Tested Example of Sustainable Agroforestry. Volume 3 in the Book Series “Advances in Agroforestry”. Springer Science, The Netherlands.
4. Kumar, B.M. (2011). Species richness and aboveground carbon stocks in the homegardens of central Kerala, India. Agriculture, Ecosystems and Environment. 140: 430–440.
5. Kumar, B.M. and Nair, P.K.R. (2004). The enigma of tropical homegardens. Agroforestry Systems. 61: 135–152.
6. Kumar, B.M. and Nair, P.K.R (eds.) (2011). Carbon Sequestration Potential of Agroforestry Systems: Opportunities and challenges. Advances in Agroforestry, Springer Science, The Netherlands: 307p.
7. Nair, P.K.R., Rao, M.R. and Buck, L.E. (eds.) (2004). New Vistas in Agroforestry: A Compendium for the 1st World Congress of Agroforestry, Kluwer, Dordrecht, The Netherlands.
8. Nair, P.K.R. (1993). An Introduction to Agroforestry. Kluwer Academic Publishers, Dordrecht, The Netherlands.
9. Nair, P.K.R. (2012). Agroforestry Systems in the Tropics. Springer.
10. Pathak, P.S. and Newaj, R. (eds.) (2003). Agroforestry: Potentials and Opportunities. Agrobios, Jodhpur.

FR24204	Forest Inventory and Yield Prediction: 2 Credits (1-0-2)	
Unit I	Yield: In regular and irregular forests; Estimation of growth and yield of stands; Types of sampling and sampling design	3 lectures
Unit II	Forest Inventory: Definition, objectives; Types of enumeration; Tree assessment techniques; Measurement of wood volume, tree volume and tree volume tables.	2 lectures
Unit III	Types of sampling units: Fixed area and point sampling units; horizontal point sampling; Plots, strips, topographical units; sampling intensity; Sampling and non-sampling errors.	3 lectures
Unit IV	Inventory designs used in India: Organization of field work and conduct of enumeration; Estimation of growth and yield prediction in forest stands; Stand structure.	3 lectures
Unit V	Growth of stand: Methods of predicting future growth of stands, stand density, canopy density, crown competition factor; Yield tables: definition, preparation of yield table, application and use of yield tables, stand table-definition and use.	3 lectures

Books:

1. Chapman, H.H. and Meyer, W.H. (2008). Manual of Forest Mensuration. Methods and Techniques. Asiatic Publishing House, New Delhi.
2. Chaturvedi, A.N. and Khanna, L.S. (2011). Forest Mensuration and Biometry. Khanna Bandhu. Dehra Dun, India.
3. Chaturvedi A.N., Khanna, L.S. (2011). Forest Mensuration. International Book Distributors, Dehra Dun, India.
4. Heindjik, D. (1975). Forest Assessment. International Book Distributors, Dehra Dun, India.
5. Husch, B., Beers, T.W. and Kershaw, Jr. J.A. (2002). Forest Mensuration. John Wiley & Sons, Nature.
6. Kangas, A. and Maltamo, M. (2006). Forest Inventory. Methodology and Applications. Managing Forest Ecosystems. Springer. Report of the ICAR Fifth Deans' Committee Report of the ICAR.
7. Philip, M.S. (1994). Measuring Trees and Forest. AB International, UK.
8. Scott, C.T. and Gove, J.H. (2002). Forest Inventory. Encyclopedia of Environmetrics. John Wiley & Sons.
9. Shiver, B.D. and Borders, B.E. (1996). Sampling Techniques for Forest Resource Inventory. John Wiley and Sons, New York.
10. Spurr, H.S. (1952). Forest Inventory. John Wiley and Sons, New York.

FR24205	Restoration Ecology: 2 Credits (1-0-2)	
Unit I	Degraded lands: Concept, classification, status, extent and causes of degraded lands/wastelands; different types of degraded lands; physical, chemical and biological land degradation.	3 lectures
Unit II	Soil erosion: Types, causes and mechanism; measures to control erosion; ravine and sand dune formation and their control measures. Salt affected soils: classes of salt affected soils, causes, extent and their effects on plant growth and afforestation/reclamation practices.	3 lectures
Unit III	Acid soils: definition, characteristics, causes and afforestation. Water logged areas: impact on plant growth and bio-drainage techniques; Afforestation and reclamation of denuded hills and slopes, land slips and landslides, avalanche and cold desert, mined out, dry, rocky and murramy areas.	3 lectures
Unit IV	Desertification: Definition, impact and causes, prevention and counter measures (shelter belts and wind breaks). Soil pollution: Types, effects and control measures through forestry techniques.	2 lectures
Unit V	National and state level programmes on degraded lands/wasteland development; Role of Government agencies and NGO's in degraded lands/wasteland development programme.	3 lectures

Books:

1. Kumar, A. and Pandey, R.N. (1989). Wastelands Management in India. Ashish Publishing House, New Delhi.
2. Buol, S.W., Kole, F.D. and McGracken, R.J. (1975). Soil Genesis and Classification. Oxford and IBH Publ, New Delhi.

3. Butler, B.E. (1980). Soil Classification for Soil Survey. Clerneder Press-Oxford Publ. Co., London, UK.
4. Gregersen, H., Draper, S. and Elz, D. (eds.) (1989). People and Trees. The Role of Social Forestry in Sustainable Development. EDI Seminar Series, The World Bank, Washington, D.C.
5. Hegde, N.G. (1987). Handbook of Wasteland Development. BAIF, Pune.
6. Hegde, N.G. and Abhyankar (eds.) (1986). The Greening of Wastelands. BAIF, Pune.
7. IARI (1960). Soil Survey Manuel, IARI. New Delhi.
8. ICAR (1977). Desertification and its Control. ICAR, New Delhi.
9. National Commission on Agriculture (1976). Report of the National Commission on Agriculture, Part IX.
10. Prasad, V.N. (1985). Principles and Practices of Social cum Community Forestry. International Book Distributors, Dehra Dun, India.
11. Shah, S.A. (1988). Forestry for People. ICAR, New Delhi.
12. Sharma, S.C., Chaturvedi, R.B. and Mishra, O.P. (1990). Utilization of Wastelands for Sustainable Development in India. Concept Publishing Co. New Delhi.
13. Maiti, S.K. (2013) Ecorestoration of of the Coal Mine Degraded Lands. Springer.

FR24299	**Project Work and Dissertation: 10 Credits (0-0-20)**
	This course shall provide the B.Sc., Forestry students an understanding of the principles and procedures of the experimental design, layout, analysis and interpretation of data and technical writing. Each student shall work on a specific research project to be identified with the help of the supervising teacher. They shall also prepare and present a proposed plan of work (PPW) specifying the objectives and procedures of the study and present the same before an audience consisting of faculty and students. The research work will be conducted leading to the preparation of a project report in the format and style of M.Sc. Thesis. Evaluation will be done based on the quality of work, quality of report and its presentation before an audience consisting of faculty and students.

FR21121	**Biology for Engineers: 3 Credits (2-1-0)**	
Unit I	Introduction: Biology is as important a scientific discipline as Mathematics, Physics and Chemistry.Fundamental differences between science and engineering by drawing a comparison between eye and camera, bird flying and aircraft. Major inventions and discoveries in biological sciences. Classification of organisms: Concepts of morphological, biochemical or ecological classifications. Hierarchy of life forms at phenomenological level. Classification based on (a) cellularity- Unicellular or multicellular (b) ultrastructure-prokaryotes or eucaryotes. (c) energy and Carbon utilization -Autotrophs, heterotrophs, lithotropes (d) Ammonia excretion–aminotelic, uricoteliec, ureotelic (e) Habitata- acquatic or terrestrial (e) Molecular taxonomy- three major kingdoms of life. Model organisms for the study of biology come from different groups. *E. coli, S. cerevisiae, D. Melanogaster, C. elegance, A. Thaliana, M. musculus*.	6 lectures
Unit II	Genetics and Cytology: “Genetics is to biology what Newton’s laws are to Physical Sciences”. Mendel’s laws. Concept of allele, Gene mapping, Gene interaction, Epistasis. Meiosis and Mitosis. Concepts of inheritance, recessive and dominant characters. Mapping of phenotype to genes. Human genetics, single gene disorder, concept of complementation. Information Transfer: Molecular basis of information transfer. DNA as a genetic material. Hierarchy of DNA structure- from single stranded to double helix to nucleosomes. Concept of genetic code and properties. Gene in terms of complementation and recombination.	6 lectures
Unit III	Biomolecules Purpose: Molecules of life, monomeric units and polymeric structures of biomolecules. Sugars, starch and cellulose. Amino acids and proteins. Nucleotides and DNA/RNA. Two carbon units and lipids. Macromolecular analysis: Proteins- structure and function. Hierarch in protein structure. Primary secondary, tertiary and quaternary structure. Proteins as enzymes, transporters, receptors and structural elements.	6 lectures

Unit IV	Metabolism**:** The fundamental principles of energy transactions in physical and biological world. Thermodynamics as applied to biological systems. Exothermic and endothermic versus endergonic and exergonic reactions. Concept of Keq and its relation to standard free energy. Spontaneity. ATP as an energy currency. Photosynthesis and cellular respiration. Glycolysis and Krebs cycle, Energy yielding and energy consuming reactions. Enzymes**:** Enzyme as biological catalysis, classification and properties. Mechanism of enzyme actionwith examples. Enzyme kinetics and kinetic parameters. RNA catalysis.	5 lectures
Unit V	Microbiology: Concept of single celled organisms. Concept of species and strains. Identification and classification of microorganisms (bacteria, fungi, virus, mycoplasmas, etc.). Microscopy. Ecological aspects of single celled organisms. Sterilization and media compositions. Growth kinetics.	5 lectures

Books:

1. Lisa; Cain, M, L.; Wasserman, S. A.; Minorsky, P. V.; Jackson, R. B. Pearson Education Ltd.
2. Outlines of Biochemistry, Conn, E.E; Stumpf, P.K; Bruening, G; Doi, R.H., John Wiley and Sons.
3. Principles of Biochemistry (V Edition), By Nelson, D. L.; and Cox, M. M.W.H. Freeman and Company.
4. Molecular Genetics (Second edition), Stent, G. S.; and Calender, R.W.H. Freeman and company, Distributed by Satish Kumar Jain for CBS Publisher.
5. Microbiology, Prescott, L.M J.P. Harley and C.A. Klein 1995. 2nd edition Wm, C. Brown Publishers.

DEPARTMENT OF AGRICULTURAL ENGINEERING

Year I Semester I						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	PH21101	Engineering Physics	4	0	2	05
2.	MA21101	Mathematics – I	3	1	0	04
3.	ES21100	Basic Electrical Engineering	3	1	2	05
4.	ES21151	Engineering Graphics and Design	0	0	6	03
5.	AE21101	Soil Science and Crop Production	2	1	0	03
Total						**20**

Year I Semester II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CY21202	Engineering Chemistry – B	3	1	2	05
2.	MA21201	Mathematics – II	3	1	0	04
3.	ES21200	Programming for Problem Solving	3	0	2	04
4.	ES21251	Workshop Practice	0	0	6	03
5.	HS21201	Communication Skills	2	0	2	03
6.	AE21201	Engineering Thermodynamics	2	1	0	03
7.	ES21277	Environmental Science (Audit)	2	0	0	00
Total						**22**

Year II Semester III						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	MA22101	Mathematics – III	3	1	0	04
2.	ES22100	Engineering Mechanics	3	1	0	04
3.	ES22101	Basic Electronics Engineering	3	0	2	04
4.	AE22101	Agricultural Surveying	2	0	2	03
5.	AE22102	Soil Mechanics	2	0	2	03
6.	AE22103	Agricultural Process Engineering	2	0	2	03
Total						**21**

Year II Semester IV						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS22201	Entrepreneurship and Startups	3	0	0	03
2.	HS22277	Indian Constitution (Audit)	2	0	0	00
3.	AE22201	Fluid Mechanics	2	0	2	03
4.	AE22202	Strength of Materials	2	1	0	03
5.	AE22203	IC Engines	2	1	0	03
6.	AE22204	Soil and Water Conservation Engineering	2	0	2	03
7.	AE22205	Transfer Processes in Food Engineering	2	1	0	03
8.	AE22206	Renewable Sources of Energy	2	1	0	03
Total						**21**

Year III Semester V						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS23101	Principles of Economics	3	0	0	03
2.	HS23177	Essence of Indian Knowledge and Tradition (Audit)	2	0	0	00
3.	AE23101	Irrigation Engineering	2	0	2	03
4.	AE23102	Drainage Engineering	2	0	2	03
5.	AE23103	Farm Tractors	2	0	2	03
6.	AE23104	Machine Theory and Design	2	1	0	03
7.	AE23105	Unit Operations in Dairy and Food Engineering	2	1	0	03
8.	AE23166	Study Tour (Audit)	0	0	0	00
Total						**18**

Year III Semester VI						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS23201	Organizational Behaviour	3	0	0	03
2.	MO230**	Open Elective – I (From MOOC)	3	0	0	03
3.	AE23201	Hydrology and Watershed Management	2	1	0	03
4.	AE23202	Farm Machinery – I	2	0	2	03
5.	AE23203	Food Process Technology	2	0	2	03
6.	AE230**	Programme Elective – I	*	*	*	03
7.	AE230**	Programme Elective – II	*	*	*	03
8.	AE23289	Seminar	0	0	2	01
Total						**22**

Year IV Semester VII						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	**240**	Open Elective – II	*	*	*	03
2.	AE24101	Tractor Systems and Performance	2	0	2	03
3.	AE24102	Groundwater and Pump Engineering	2	1	0	03
4.	AE24103	Farm Produce and Storage Engineering	2	0	2	03
5.	AE240**	Programme Elective – III	*	*	*	03
6.	AE240**	Programme Elective – IV	*	*	*	03
7.	AE24199	Project – I	0	0	6	03
8.	AE24179	Industrial Training (Audit)	0	0	0	00
Total						**21**

Year IV Semester VIII						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	MO240**	Open Elective – III (From MOOC)	3	0	0	03
2.	**240**	Open Elective – IV	*	*	*	03
3.	AE24201	Farm Machinery – II	2	0	0	02
4.	AE240**	Programme Elective – V	*	*	*	03
5.	AE240**	Programme Elective – VI	*	*	*	03
6.	AE24299	Project – II	0	0	12	06
7.	ED24288	Extra-Curricular Activities and Discipline	0	0	0	02
Total						**22**

List of Electives

Programme Electives – I & II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	AE23001	Agricultural Instrumentation	2	0	2	03
2.	AE23002	Building Construction and Cost Estimation	2	1	0	03
3.	AE23003	Command Area Development	2	1	0	03
4.	AE23004	Food Plant Utilities and Sanitation	2	1	0	03
5.	AE23005	Mechanics of Tillage and Traction	2	1	0	03
6.	AE23006	Precision Farming	2	0	2	03
7.	AE23007	Processing of Milk and Milk Products	2	0	2	03
8.	AE23008	Testing of Tractors and Farm Equipment	2	0	2	03
9.	AE23009	Wasteland Development	2	1	0	03

Programme Electives – III & IV						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	AE24001	Ergonomics	2	0	2	03
2.	AE24002	Floods and Droughts	2	1	0	03
3.	AE24003	Food Processing Equipment Design	2	1	0	03
4.	AE24004	Food Quality and Control	2	0	2	03
5.	AE24005	Hydraulic Drives and Controls	2	1	0	03
6.	AE24006	Modelling and Simulation for Agricultural Applications	2	1	0	03
7.	AE24007	On-Farm Water Management	2	1	0	03
8.	AE24008	Refrigeration and Air-Conditioning	2	1	0	03
9.	AE24009	Remote Sensing and GIS for Land and Water Management	2	1	0	03

Programme Electives – V & VI						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	AE24021	Agricultural Meteorology and Climate Change	3	0	0	03
2.	AE24022	Agricultural Safety	3	0	0	03
3.	AE24023	Computer Application in Agriculture	1	0	4	03
4.	AE24024	Design of Soil Conservation Structures	2	1	0	03
5.	AE24025	Development of Processed Products	2	0	2	03
6.	AE24026	Food Packaging Technology	2	0	2	03
7.	AE24027	Introduction to Computer Aided Design	1	0	4	03
8.	AE24028	Pressurized Irrigation Systems	2	0	2	03
9.	AE24029	Tractor System Design	2	1	0	03

Open Elective – II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	AE24041	Geo-Informatics	2	1	0	03

Open Elective – IV						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	AE24042	Computer Aided Design	1	0	4	03

Course Content

AE21101	Soil Science and Crop Production: 3 Credits (2-1-0)	
Unit I	Definition of soil, Rocks and minerals. Soil formation and classification. Soil survey methods. Land use capability and mapping. Major soil types of India, soil texture, soil temperature and soil air.	6 lectures
Unit II	Soil colloids, cation and anion exchange in soils, soil reactions and buffering capacity. Soil humus and its formation, C:N ratio. Significance of macro and micro nutrients, Soil and water testing, Soil fertility management. Important fertilizers. Saline and alkali soils and their reclamations.	6 lectures
Unit III	Principles of tillage. Tilth and its characteristics. weeds and their control, Fertilization and plant protection.	5 lectures
Unit IV	Classification of crop, cropping systems, mono, double and multiple cropping. Relay cropping and mixed cropping, crop rotation, Concept of dry farming.	5 lectures
Unit V	Cultivation practices of important field crops, improved varieties, seed rate, time and method of sowing, maturing. Effect of different weather parameters on crop growth and development.	6 lectures

Books:

1. Fundamentals of Soil Science, D. Henrry, John Wiley and Sons, New York, 1990.
2. Soils, An introduction toSoils and Plant Growth, R.W. Miller and R.L. Donajue, Prentice Hall Inc., 1990.
3. Basic Concepts of Soil Science, A.K. Kolay, Wiley Eastern Ltd., New Delhi, 1993.
4. Fundamentals of Agronomy, G.C. De, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 1989.

AE21201	Engineering Thermodynamics: 3 Credits (2-1-0)	
Unit I	Thermodynamic systems, surroundings, thermodynamic properties, processes and cycles, thermodynamic equilibrium, path and point function. Zeroth law of thermodynamics and measurement of temperature. Work in various quasi-static processes. Heat transfer.	4 lectures
Unit II	First law of thermodynamics: Open system and closed system, application to flow processes. Internal energy and enthalpy. Limitations of first law of thermodynamics.	4 lectures
Unit III	Heat engine, refrigerator and heat pump. Classical statements of second law of thermodynamics. Reversibility and irreversibility. Carnot cycle. Reversible heat engine. Entropy: Concept, t-s diagrams, principles and applications.	8 lectures
Unit IV	Properties of pure substances and mixtures: Phase change of pure substances, p-v, p-t, p-v-t, t-s and Mollier diagram of pure substances. Equation of state, gas laws, Dalton's law of partial pressure, entropy of gas mixtures.	7 lectures
Unit V	Thermodynamic cycles: Steam power cycle, Otto, Diesel and dual cycle.	5 lectures

Books:

1. Engineering Thermodynamics, P.K. Nag, 2nd Ed., Tata McGraw Hill Pub. Co. Ltd. New Delhi, 1985.
2. Heat and Thermodynamics, M.W. Zimnansky and R.H. Dittman, International Edition, McGraw Hill Book Co., Auckland, 2000.
3. Introduction to Thermodynamics, Y.V.C. Rao, Wiley Eastern Ltd., New York, 1993.
4. Fundamentals of Classical Thermodynamics, G.J. Van Wyten, R.E. Sonntag and C. Borgnakke, 2nd Ed., Wiley Eastern Ltd., New York, 1998.

AE22101	Agricultural Surveying: 3 Credits (2-0-2)	
Unit I	Basics of scale, chain survey, compass survey, plane table survey, and levelling.	8 lectures
Unit II	Principles and methods of theodolite survey; trigonometrical levelling.	3 lectures
Unit III	Curves; tacheometric survey; hydrographic survey; photogrammetric survey.	6 lectures

Unit IV	Electronic distance measurement – distance measurement from wave phase difference; total station and uses; global positioning systems (GPS and DGPS); geographic information system (GIS); digital terrain model (DTM) and digital elevation models (DEM).	6 lectures
Unit V	Triangulation and trilateration; map projections and basics of remote sensing.	5 lectures

Books:

1. Surveying Vol. I&II, B.C. Punamia, Laxmi Publications, New Delhi, 2005.
2. Surveying Vol. I&II, S.K. Duggal, Tata McGraw-Hill, New Delhi, 1996.
3. Surveying and Levelling, N.N. Basak, Tata McGraw-Hill, New Delhi, 1994.
4. Surveying and Levelling Vol. I&II, T.P. Kanetkar and S.V. Kulkarni, Vidyarthi Griha Prakashan, Pune, 2000.
5. Surveying, M. Das Saikia, B.M. Das, M.M. Das, PHI Learning, New Delhi, 2010.

AE22102	**Soil Mechanics: 3 Credits (2-0-2)**	
Unit I	Preliminary definitions and relationships, three phase system of soil, determination of index properties, classification of soils.	8 lectures
Unit II	Soil water: analysis of effective and neutral pressures under different hydraulic pressures at different points below the soil.	5 lectures
Unit III	Darcy's law, determination of permeability by laboratory and field methods, horizontal and vertical hydraulic conductivity and seepage analysis using flownet.	5 lectures
Unit IV	Stress distribution under point, line and circular load condition, compaction, consolidation and shear strength analysis using Mohr circle.	6 lectures
Unit V	Analysis of active and passive earth pressures on retaining wall, Rankine's theorem of earth pressure and bearing capacity of soils.	4 lectures

Books:

1. Soil Mechanics SI Version, T.W. Lambe and R.V. Whitman, Wiley Eastern Ltd., New Delhi, 1979.
2. Principles of Soil Mechanics and Foundation Engineering, V.N.S. Murthy, UBSPD, New Delhi, 2001.
3. Soil Mechanics and Foundations, B.C. Punia, Ashok Kumar Jain and Arun Kumar Jain, 13th Ed., Laxmi Publications Pvt. Ltd., New Delhi, 1994.
4. Soil Engineering in Theory and Practice, Part-I, A. Singh and G.R. Chowdhury, CBS Publishers and Distributors, Delhi, 1994.

AE22103	**Agricultural Process Engineering: 3 Credits (2-0-2)**	
Unit I	Importance of engineering properties of biological materials.	5 lectures
Unit II	Cleaning, sorting and grading operations; Screening: effectiveness of screening; Machineries for cleaning, sorting & grading	5 lectures
Unit III	Drying utilities of agricultural produce: Psychrometric, theory of grain drying, drying methods, different types of grain dryers.	7 lectures
Unit IV	Milling of cereals, pulses & oilseeds: Milling of wheat, paddy and pulses; Parboiling of paddy; Processing of oilseed, oil extraction methods.	6 lectures
Unit V	Storage of agricultural produce: physiology of food grain during storage. Grain storage structure; Different types of storage structures; Aeration and fumigation.	5 lectures

Books:

1. Fundamentals of Food Process Engineering, R.T. Toledo, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1997.
2. Unit Operations of Chemical Engineering, W. McCabe, J. Smith and P. Harriot, 5th Ed., McGraw Hill Book Co., New York, 1993.
3. Transport Processes and Unit Operations, C.J. Geankopolis, 3rd Ed., Prentice Hall of India, New Delhi, 1999.
4. Food Engineering Operations, J.G. Brennan, Butters Cowell and Lilley, 3rd Ed., Elsevier Applied Science, Amsterdam, 1990.
5. Engineering Properties of Foods, M. A. Rao, Syed S.H. Rizvi and Ashim K. Datta, 4th Ed., CRC Press, Florida, 2014.
6. Unit Operations of Agricultural Processing, K.M. Sahay and K.K. Singh, 3rd Ed., Vikas Publishing House, New Delhi, 2003.

AE22201	Fluid Mechanics: 3 Credits (2-0-2)	
Unit I	Basic Concepts and Definitions – Distinction between a fluid and a solid; Density, Specific weight, Specific gravity, viscosity, Newton law of viscosity; surface tension, capillarity, Bulk modulus of elasticity, compressibility.	4 lectures
Unit II	Fluid Statics - Fluid Pressure: Pressure at a point, Pascals law, Manometer, Hydrostatic pressure and force: horizontal, vertical and inclined surfaces. Buoyancy and stability of floatingbodies.	4 lectures
Unit III	Fluid Kinematics- Classification of fluid flow, Stream line, path line, streak line and stream tube; stream function, velocity potential function, continuity equations.	7 lectures
Unit IV	Fluid Dynamics- Equations of motion - Euler's equation; Bernoulli's equation ; applications of Bernoulli's equation, laminar and turbulent flow in pipes, general equations for head loss.	8 lectures
Unit V	Dimensional and model Analysis, Application of dimensional analysis, model studies, Dimensionless numbers to fluid flow problem.	5 lectures

Books:

1. Hydraulics and Fluid Mechanics, P.N. Modi and S.M. Seth, Standard Book House, Nai Sarak, Delhi., 1999.
2. Fluid Mechanics & Hydraulic Machines, R.K. Bansal, Laxmi Publication Pvt. Ltd., New Delhi, 2000.
3. A Text Book of Hydraulics, Fluid Mechanics and Hydraulic Machines, R.S. Khurmi, S. Chand and Company, New Delhi, 2000.
4. A Text Book of Fluid Mechanics and Hydraulic Machines in S.I Units. R.K. Rajput, S. Chand and Company.

AE22202	Strength of Materials: 3 Credits (2-1-0)	
Unit I	Introduction to Strength of Materials: Stress, strain, Hooke's law, relationship of elastic constants, concept of shear stress, stress-strain relationship, Poisson's ratio, stress-strain diagrams for uniaxial loading.	6 lectures
Unit II	Deformation of axially loaded members and statically indeterminate problems, torsion of circular shafts, strength of shaft, stress and deflections in closed coiled helical springs subjected to axial forces.	5 lectures
Unit III	Reactions for statically determinate beams, relationships between load, shearing force and bending moment, shear force and bending moment diagrams.	5 lectures
Unit IV	Theory of simple bending and shearing stresses in beams. Members subjected to combined loads.	6 lectures
Unit V	Beam deflections: Double integration method and Area moment method.	6 lectures

Books:

1. Strength of Materials, F. L. Singer and A. Pytel, Harper & Row Publisher, New York, 1980.
2. Strength of Materials and Mechanics of Structures, Vol. I & II, B.C. Punmia, Standard Publishers & Distributors, Delhi, 1988.
3. Mechanics of Structures, Vol. I & II, 15th Ed., S.B. Junnarkar, Charotar Publishing House, Anand, 2000.
4. Mechanics of Materials, J.M. Gera and S. P. Timoshenko, 2nd Ed., CBS Publishers & Distributors, Delhi, 1980.

AE22203	IC Engines: 3 Credits (2-1-0)	
Unit I	IC Engine: Basic classification, components and material of construction. CI and SI engines and their fundamental differences.	3 lectures
Unit II	Working principles of engine. Valve timing, ignition timing, and firing order. Power efficiencies and their measurements.	6 lectures
Unit III	Fuel and combustion: Important qualities of CI and SI engine fuels, and their rating. Combustion in CI and SI engines. Fuel system of CI and SI engines.	6 lectures

Unit IV	Ignition system. Intake and exhaust systems: air cleaner, mufflers, super chargers and turbo chargers. Exhaust treatment systems like DPF, DOC and catalytic converter.	6 lectures
Unit V	Cooling system: Purpose and types of cooling, heat transfer during cooling, coolant and antifreeze, cooling system maintenance. Lubrication system: Theory of lubrication, types and properties of lubricant, types of lubrication system and their maintenance.	7 lectures

Books:

1. Fundamental of Internal Combustion Engine, P.W. Gill, J.H. Smith and E.J. Ziurys, 1st Ed., Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 1954.
2. A course in Internal combustion Engine, M.L. Mathur and R. P. Sharma, 7th Ed., Dhanpat Rai and Sons, Delhi, 1994.
3. Engine and Tractor Power, Carroll E. Goering and Alan C. Hansen, American Society of Agricultural Engineers. Michigan, 2004.

AE22204	**Soil and Water Conservation Engineering: 3 Credits (2-0-2)**	
Unit I	Hydrologic cycle, precipitation, infiltration, evaporation, runoff.	6 lectures
Unit II	Land use capability classification, types and estimation of water and wind erosions.	5 lectures
Unit III	Conservation measures for hill slopes, agricultural lands, gullies; vegetative waterways and their design; stream bank erosion and its control.	8 lectures
Unit IV	Water harvesting and farm ponds, rate of sedimentation and loss of storage.	5 lectures
Unit V	Introduction to watershed management.	4 lectures

Books:

1. Soil and Water Conservation Engineering, G.O. Schwab, R.K. Frevert, T.W. Edminster and K.K. Barnes, 3rd Ed., John Wiley and Sons, New York, 1981.
2. Land and Water Management Engineering. V.V.N. Murthy, 2nd Ed., Kalyani Publishers, Ludhiana, 1985.
3. Introductory Soil and Water Conservation Engineering. B.C. Mal, Kalyani Publishers, Ludhiana, 1995.
4. Soil Conservation, Norman Hudson, B.T. Batsford, London, 1981.
5. Soil and Water Conservation Engineering, R. Suresh, 2nd Ed., Standard Publishers Distributors, Delhi, 1997.
6. Hydrology and Soil Conservation Engineering, Ghanshyam Das, Prentice Hall of India Pvt. Ltd. New Delhi, 2000.

AE22205	**Transfer Processes in Food Engineering: 3 Credits (2-1-0)**	
Unit I	Introduction to transfer process; Steady state conduction; Fourier law. Convection and radiation heat transfers; equations for radiative, convective and overall heat transfers for various geometries; Heat flow through slab, sphere and cylinder.	6 lectures
Unit II	Heat Exchangers: General introduction; Application of different types of heat exchanger; Fouling factor; Design concept of heat exchanger.	5 lectures
Unit III	Heat exchanger flow: parallel, counter flow and cross flow. Concept of LMTD, effectiveness, NTU, use of charts for LMTD and LTU calculations. Design of tube in tube, shell and tube and plate heat exchangers.	7 lectures
Unit IV	Newtonian, and non-Newtonian fluids, laminar and turbulent flow through pipes and plates.	5 lectures
Unit V	Introduction to mass transfer and their application in food engineering. Diffusive and convective mass transfer.	5 lectures

Books:

1. Transport Process and Unit Operations, C.J. Geankopolis, 3rd Ed., Prentice Hall of India, New Delhi, 1999.
2. Heat Transfer, J.P. Holman, 8th Ed., McGraw Hill Book Co., New York, 1977.
3. Transport Phenomena, Robert Byron Bird, Edwin N. Lightfoot and Warren E. Stewart, 8th Ed., John Wiley and Sons, New York. 1977.
4. Heat Transfer - A Basic Approach, M.N. Ozisik, McGraw Hill Book Co., New York, 1985.

AE22206	Renewable Sources of Energy: 3 Credits (2-1-0)	
Unit I	Concept and limitation of Renewable Energy Sources (RES), classification of RES: Solar, wind, geothermal, biomass, ocean energy sources, comparison of renewable energy sources with non-renewable sources.	4 lectures
Unit II	Solar energy conversion into heat by different collectors. Solar thermal devices. Natural and forced convection drying system, Solar Photo voltaic system. Energy through photovoltaic power generation and cost economics.	6 lectures
Unit III	Energy available in wind, lift and drag. Basis of wind energy conversion. Effect of wind speed and angle of attack. Types of windmill rotors, determination of torque coefficient, working principle of wind power plant.	6 lectures
Unit IV	Biomass and its resources. Pyrolysis of biomass to produce solid, liquid and gaseous fuels. Types of gasifier, biomass cook stoves for rural energy needs, briquetting and characteristics of briquettes. Economics of gasification of biomass.	6 lectures
Unit V	Biogas: Types of biogas plants, biogas generation, factors affecting biogas generation and usages, design consideration, application and advantages of biogas spent slurry.	6 lectures

Books:

1. Non-Conventional Sources of Energy, G. D. Rai, 4th Ed., Khanna Publishers, Delhi, 1996.
2. Non-Conventional Sources of Energy, O. P. Singhal, 1st Ed., Saroj Prakashan, Allahabad, 1996.
3. Solar Energy, S. P. Sukhatme, 2nd Ed., Tata McGraw Hill Publishing Co. Ltd. New Delhi, 1996.
4. Biotechnology, other Alternative Technologies for Utilization of Biomass/Agricultural Wastes, A. Chakraborty, 1st Ed., Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 1989.
5. Bioenergy and Biofuel from Biowaste and Biomass, B.P. Lamsal and R.D. Tyagi, ASCE, 2010.

AE23101	Irrigation Engineering: 3 Credits (2-0-2)	
Unit I	Major and medium irrigation schemes of India, purpose of irrigation, merits and demerits of irrigation, Sources of irrigation water, present status of development and utilization of different water resources of the country; measurement of irrigation water, water lifts and irrigation pumps.	6 lectures
Unit II	Soil-plant-water relationships, crop water requirement, irrigation efficiencies, irrigation scheduling.	6 lectures
Unit III	Land grading and field layout for efficient irrigation systems; water conveyance and its control.	4 lectures
Unit IV	Farm irrigation methods: border, check basin, furrow - adaptability, specification	6 lectures
Unit V	Sprinkler and drip methods of irrigation – adaptability and layout	6 lectures

Books:

1. Irrigation Theory and Practice, A.M. Michael, 2nd Ed., Vikas Publishing House, New Delhi, 2008.
2. Fundamentals of Irrigation Engineering, Bharat Singh, 8th Ed., New Chand and Brothers, Roorkee, 1997.
3. Drainage Engineering, J.N. Luthin, John Wiley and Sons, New York, 1970.
4. Irrigation Engineering, G.S. Birdie, and R.C. Das, 2nd Ed., Dhanpat Rai and Sons, New Delhi, 1996.

AE23102	Drainage Engineering: 3 Credits (2-0-2)	
Unit I	Water logging – causes and impacts; drainage, objectives of drainage, surface drainage coefficient, types of surface drainage; sub-surface drainage: purpose and benefits.	4 lectures
Unit II	Drainage investigations, planning of surface and subsurface drainage systems; Hydraulic conductivity, drainable porosity, water table; derivation of Hooghoudt's and Ernst's drain spacing equations.	8 lectures
Unit III	Drainage structures, vertical, bio, ditch, tube and mole drains.	4 lectures
Unit IV	Salinity measurement, classification of salt affected soils; Reclamation of saline and alkaline soils, salt balance equation.	6 lectures

Unit V	Leaching requirement for saline soils, gypsum requirement for alkali soils, Irrigation water quality, Water management insalt affected areas , conjunctive use of fresh and saline water.	6 lectures

Books:

1. Land Drainage, Principles, Methods and Applications, Bhattacharya AK and Michael AM, Vikas Publication House, Noida (UP), 2013.
2. Drainage Principles and Applications, Ritzema H.P., ILRI Publication, Second Edition (Completely Revised), 1994.
3. Principles of Agricultural Engineering Vol-II, Michael AM. and Ojha TP., 5th Edition. Jain Brothers Publication, New Delhi, 2014.
4. Agricultural Drainage-Principles and Practices, Kadam U.S., Thokal R.T., Gorantiwar S.D. and Powar A.G. Westville Publishing House, New Delhi, 2007.
5. Drainage Engineering, J.N. Luthin, John Wiley and Sons, New York, 1970.

AE23103	**Farm Tractors: 3 Credits (2-0-2)**	
Unit I	Various sources of farm power: Mechanical, electrical and renewable sources. Status of farm power in India. Types of off-road vehicles. Trends in tractor design.	4 lectures
Unit II	Engine features: Combustion chamber, engine balancing, and flywheel. Engine performance characteristics: Torque, power and fuel consumption.	6 lectures
Unit III	Power transmission system of tractor: Clutch, gearbox, differential, final drive, PTO and brake.	7 lectures
Unit IV	Tractor steering system: Ackermann steering geometry, components and their adjustments. Electrical and electronic system: Alternator, starter motor, battery and wiring harness.	6 lectures
Unit V	Power tiller: Clutch, transmission gear, steering and brake. Tractor, power tiller and implement cost estimation, break even analysis.	5 lectures

Books:

1. Tractor and their Power Units, John B. Liljedahl, W.M. Carleton, P.K. Turnquist and H. Makotohoki, 4th Ed., CBS Publishers & Distributors, New Delhi, 1977.
2. Off-Road Vehicle Engineering Principles, Carroll E. Goering, Marvin L. Stone, David W. Smith and Paul K. Turnquist, American Society of Agricultural Engineers. St. Joseph, Michigan, 2003.
3. Engine and Tractor Power, Goering, Carroll E. and Alan C. Hansen, American Society of Agricultural Engineers. St. Joseph, Michigan, 2004.

AE23104	**Machine Theory and Design: 3 Credits (2-1-0)**	
Unit I	Kinematics of motion: plane, rectilinear and curvilinear motion; linear and angular displacement, velocity and acceleration.	4 lectures
Unit II	Kinetics: centrifugal and centripetal forces, mass moment of inertia, angular momentum, torque, work, power, energy, principle of conservation of energy.	6 lectures
Unit III	Mechanisms: kinematic links, pairs and chains. Velocity and acceleration in mechanism.	6 lectures
Unit IV	Design of threaded fasteners, keys and coupling, shafts, belt-pulleys, chain-sprocket, and springs.	6 lectures
Unit V	Clutches and brakes: Types and design. Flywheel: Design consideration, energy variation, inertia, and failure criteria. Gear: spur, helical and bevel gear.	6 lectures

Books:

1. Machine design – An Integrated Approach, R.L. Norton, 2nd Ed., Pearson Education South Asia, New Delhi, 2012.
2. Design of Machine Elements, M F Spott, Prentice Hall of India, New Delhi, 1998.
3. Design of Machine Elements, V.B. Bandari, Tata McGraw Hill, New Delhi, 1998.
4. Mechanical Engineering Design, J.E. Shiegley and L.D. Mischke, McGraw Hill International, Auckland, 1998.

AE23105	Unit Operations in Dairy and Food Engineering: 3 Credits (2-1-0)	
Unit I	Material and energy balances involving solids, liquids and gases in dairy & food processing systems.	5 lectures
Unit II	Size reduction: Principles of size reduction. Energy requirement, machineries. Mixing and agitation: Principles of mixing. Mixing elements for low, moderate and high viscous materials. Mixing of solids.	6 lectures
Unit III	Dairy operations: homogenization, Heat transfer process: pasteurization, sterilization, Refrigeration, freezing, freeze concentration.	5 lectures
Unit IV	Separation process: filtration, centrifugation, sedimentation, distillation, solid liquid extraction, gas absorption, adsorption, crystallization, humidification and dehumidification. Membrane separation. Cyclone separation.	7 lectures
Unit V	Principle of Drying, different drying methods: conduction, convection & radiation drying. Microwave drying, Irradiation, freeze drying. Evaporation: methods & design concept, steam economy	5 lectures

Books:

1. Fundamentals of Food Process Engineering, R.T. Toledo, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1997.
2. Unit Operations in Chemical Engineering, W. McCabe, J. Smith and P. Harriot, 5th Ed., McGraw Hill Book Co., New York, 1993.
3. Transport Processes and Unit Operations, C.J. Geankopolis, 3rd Ed., Prentice Hall of India, New Delhi, 1999.
4. Food Engineering Operations, J.G. Brennan, N.D. Butters, N.D. Cowell and A.E.V. Lilley, 3rd Ed., Elsevier Applied Science, Amsterdam, 1990.

AE23201	Hydrology and Watershed Management: 3 Credits (2-1-0)	
Unit I	Hydrology and its development, hydrologic cycle, measurement of hydrologic components, precipitation data analysis, stream flow measurement.	4 lectures
Unit II	Infiltration modeling, ET estimation methods, runoff computation methods, relationship between rainfall and runoff.	6 lectures
Unit III	Hydrograph, synthesis and analysis, base flow separation, unit hydrograph theory and its applications, synthetic hydrograph, S-curve.	6 lectures
Unit IV	Flood peak, design flood and computation of probable flood; principles of flood routing, channel and reservoir routing.	5 lectures
Unit V	Definition of watershed, geomorphological analysis of watershed, watershed prioritization, principles and practices of sustainable and integrated watershed management; watershed workplan.	7 lectures

Books:

1. Engineering Hydrology, K. Subramanya, Tata McGraw-Hill, New Delhi, 1994.
2. Elementary Hydrology, V.P. Singh, 1st Ed., Prentice Hall of India, New Delhi, 1994.
3. Hydrology: Principles, Analysis and Design, H.M. Raghunath, 3rd Ed., New Age International, New Delhi, 2001.
4. Watershed Planning and Management, R.V. Singh, Yash Publishing House, Bikaner, 2000.
5. Soil and Water Conservation Engineering, R. Suresh, 2nd Ed., Standard Publisher and Distributors, New Delhi, 1997.

AE23202	Farm Machinery – I: 3 Credits (2-0-2)	
Unit I	Scope, need and constraints of mechanization. Types of implements: Mounted, semi mounted, trailed and self-propelled. Implement performance parameters: Field capacity, field efficiency.	4 lectures
Unit II	Tillage implement: Tillage methods, Mould board plough, disc plough, chisel plough, subsoiler, cultivator, harrows, rotary plough, lister, ridger, puddler and leveller.	6 lectures
Unit III	Sowing and planting equipment: Methods of sowing, functions, types of furrow opener and metering mechanism. Precision planting. Seed drill and planter:	6 lectures

	Power transmission system and calibration. No-till drill, strip-till drill and transplanter.	
Unit IV	Plant protection equipment: Principles of atomization drip and drift, types of sprayers and their various components. Types of dusters. Interculture equipment: Manual and power operated.	6 lectures
Unit V	Harvesting equipment: Principles of cutting. Shear type harvesting devices: Mower, reaper, binder, windrower, and their adjustment. Threshing equipment: Principles of threshing, various types of threshers, and types of threshing cylinders. Thresher performance analysis.	6 lectures

Books:

1. Principles of Farm Machinery, R.A. Kepner, Roy Bainer and E.L. Berger, 1st Ed., CBS Publishers and Distributors, New Delhi, 1987.
2. Engineering Principles of Agricultural Machines, A.K. Srivastava, C.E. Goering and R.P. Rohrbach, 2nd Ed., American Society of Agricultural Engineers, Michigan, 2005.
3. Farm Machinery and Equipment, 6th Ed., H.P. Smith and L.H. Wilkis, Tata McGraw Hill Publishing Co. Ltd. New Delhi, 1988.
4. Principles of Agricultural Engineering, Vol.-I, A.M. Michael and T.P. Ojha, 3rd Ed., Jain brothers, New Delhi, 1978.

AE23203	**Food Process Technology: 3 Credits (2-0-2)**	
Unit I	Thermal processing of foods: Kinetics of microbial death, process calculations for canning, pasteurization and sterilization of foods. Concept of minimal food processing.	5 lectures
Unit II	Chemical preservatives. Food preservation by fermentation, curing, pickling and smoking; use of enzymes in food processing. F&V technology: Concept of fruits & vegetables preservation, drying technology. Technology of beverages.	7 lectures
Unit III	Cereal technology: Products based on cereals, bakery products, extruded puffed and malted food products.	4 lectures
Unit IV	Technology of milk and dairy products : fluid milk; evaporated /condensed milk, milk powders, cheese, ice-cream, butter, ghee, infant food, fermented milk products and indigenous milk products.	6 lectures
Unit V	Foods Packaging: Concept of food packaging, food packaging materials, Food packaging methods. Effects of processing on quality of foods. Indian food laws. HACCP & GMP concepts.	6 lectures

Books:

1. The Technology of Food Preservation, N.W. Desrosier and J.N. Desrosier, 4th Ed., CBS Publishers and Distributors, New Delhi, 1987.
2. Principles of Food Science, Part-II (Physical priniciples of food preservation) M. Karel, O.R. Fennema and D.B. Lund, Marul Pekker Inc., New York, 1975.
3. Technology of Cereals, N.L. Kent, Pergamen, U.K., 1975.
4. Principles of Food Processing, Richard W. Hartel and Dennis R. Heldman, Aspen Publishers, Inc., Maryland 1997.
5. Introduction to Food Engineering, R. Paul Singh and Dennis R. Heldman, 4th Ed., Academic Press, London, 2007.

AE24101	**Tractor Systems and Performance: 3 Credits (2-0-2)**	
Unit I	Human factors engineering: Operators exposure to environment, noise and vibration, operator machine interface, operator sitting. Safety of operator: Roll over protective structure and cab.	5 lectures
Unit II	Hydraulic system: Components such as pump, valve, actuator; working principle, symbols, flow circuit, automatic draft control system, automatic position control system, power steering.	7 lectures

Unit III	Traction mechanics, traction parameters, factors affecting traction performance, weight transfer, traction prediction models.	6 lectures
Unit IV	Drawbar performance, ballasting, determination of centre of gravity and moment of inertia of tractor. Tractor-implement matching.	6 lectures
Unit V	Tractor test codes and standards, engine and drawbar performance tests, hydraulic power and lifting capacity tests.	4 lectures

Books:

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

AE24102	**Ground Water and Pump Engineering: 3 Credits (2-1-0)**	
Unit I	Occurrence and movement of groundwater, groundwater resources development and utilization, artificial recharge techniques.	4 lectures
Unit II	Well hydraulics; steady and unsteady flow towards a well in confined, unconfined; pumping tests	7 lectures
Unit III	Design, construction and development of tube wells.	7 lectures
Unit IV	Water lifting devices, reciprocating pump, centrifugal pump, characteristic curves and selection of pump.	7 lectures
Unit V	Economics of water pumping.	3 lectures

Books:

1. Water Well and Pump Engineering, A.M. Michael and S.D. Khepar, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
2. Water Wells and Pumps, A.M. Michael, S.D. Khepar and S.K. Sondhi, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
3. Ground Water Hydrology, D.K. Todd, 2nd Ed., John Wiley and Sons, New York, 1995.
4. Ground Water, H.M. Raghunath, Wiley Eastern Limited, New Delhi, 1982.

AE24103	**Farm Produce and Storage Engineering: 3 Credits (2-0-2)**	
Unit I	Concept of water activity of foods, isotherm models, preservation of foods by lowering water activity. Drying of cereals, pulses & oilseed: EMC, psychrometry, drying mechanism of cereals, analysis of thin layer & deep bed drying, different types of dryers and their performance evaluation. Solar dryer.	7 lectures
Unit II	Importance of engineering properties of food in food processing. Milling technology: Milling of wheat, paddy and oil seeds. Parboiling of paddy. Oil extraction methods.	7 lectures
Unit III	Types and functional requirements of storage structures. Grain pests and rodents control. Pressure theory in grain storage. Grain flow behviour in storage structure. Aeration and fumigation in storage structure. Scheduling of aeration.	5 lectures
Unit IV	Design features of various storage structures: controlled atmospheric storage, modified atmosphere storage, cold storage and frozen storage. Management of cold storage.	5 lectures
Unit V	Material handling: Application, conveyer, elevator. Design concept	4 lectures

Books:

1. Food Engineering and Dairy Technology, H.G. Kessler, Freising, West Germany: Verlag A. Kessler, 1981.
2. Handling and Storage of Food Grains, Food and Agriculture Organization of the U.N., Rome, 3rd Ed., Oxford IBH Pub. Co. Pvt. Ltd., New Delhi, 1980.

3. Storage of Potatoes, A. Rastovski and A.J.H. Van Es, International Book Distribution, Deharadun, 1989.
4. The Technology of Food Preservation, N.N. Desosier and J.N. Desosier, 4th Ed., CBS Publishers and Distributors, New Delhi, 1987.
5. Preservation and Storage of Grains, Seeds and their Bye Products, J.L. Multon, CBS Publishers and Distributors, New Delhi, 1989.

AE24201	Farm Machinery – II: 2 Credits (2-0-0)	
Unit I	Forces acting on implement: Mould board plough, disc plough and disc harrow. Hitching of implements: vertical and horizontal hitching of pull type implement, mounted type implement.	8 lectures
Unit II	Fertilizer applicator: types of metering device, factors affecting discharge rate and uniformity. Harvesting equipment: cutting pattern and force analysis of conventional cutter bar.	7 lectures
Unit III	Combine harvester: functions, construction and working principles, types, performance parameters. Harvesting machines for potato, groundnut and maize.	6 lectures
Unit IV	Chaff cutter: manual and power operated, chopping cylinders, capacity and energy requirement.	3 lectures
Unit V	Performance evaluation of tillage implements, sowing and planting equipment, plant protection equipment, harvesting and threshing equipment.	4 lectures

Books:

1. Principles of Farm Machinery, R.A. Kepner, Roy Bainer and E.L. Berger, 1st Ed., CBS Publishers and Distributors, New Delhi, 1987.
2. Farm Machinery and Maintenance, H.P. Smith and L.H. Wilkis, 6th Ed., Tata McGraw Hill Publishing Co. Ltd. New Delhi, 1986.
3. Principles of Agricultural Engineering, Vol.-I, A.M. Michael and T.P. Ojha, 3nd Ed., Jain Brothers, New Delhi, 1978.
4. Farm Machinery, T.P.Singh, PHI Learning Pvt. Ltd., 2016.

AE23001	Agricultural Instrumentation: 3 Credits (2-0-2)	
Unit I	Fundamentals of instruments: generalized configuration, structure and functional description.	4 lectures
Unit II	Devices for temperature, pressure, moisture content, force, stress and strain measurement.	7 lectures
Unit III	Devices for displacement, velocity, torque, acceleration, noise and vibration measurement.	7 lectures
Unit IV	Microprocessors and microcontrollers, deflection bridges, amplifiers, ADC, DAC.	5 lectures
Unit V	Software and computer application to instrumentation. Data acquisition system, data transmission and recording.	5 lectures

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.

AE23002	Building Construction and Cost Estimation: 3Credits (2-1-0)	
Unit I	Properties and classification of building materials like bricks, lime, cement, sand, coarse aggregates, timber, asbestos, glass etc.	5 lectures
Unit II	Constructional elements such as brick, stone work, mortar, concrete, plastering, painting, ceiling, roofing etc.	5 lectures
Unit III	Design of beams, columns and column footings, roof slabs, roof trusses etc.	9 lectures

Unit IV	Concept of detailed and abstract estimates, introduction to departmental schedules, estimation procedure for building, sheds and roads.	4 lectures
Unit V	Factors affecting building costs, cost evaluation of design and planning alternatives for building and estate development, measurement and pricing, economic methods for evaluating investments in buildings and building systems: cost-in-use, benefit-to-costs and savings-to-investment ratios, rate of return, net benefits, payback.	5 lectures

Books:

1. Farm Structures, H.J. Barre and L.L. Sammet, John Wiley and Sons Pvt. Ltd., New York, 1950.
2. Farm Service Buildings, H.E. Gray, McGraw Hill Book Co., New York, 1955.
3. Farm Buildings in Punjab, A.P. Bhatnagar, 1st Ed., PAU Ludhiana, 1976.
4. Planning Farm Buildings, John C. Wooley, McGraw Hill Co., New York, 1953.
5. Estimating and Costing, B.N. Dutta, UBS publishers, 2000.

AE23003	**Command Area Development: 3 Credits (2-1-0)**	
Unit I	Status of irrigation projects in India, Types of minor irrigation system in India.	3 lectures
Unit II	Land grading field layout: Land grading, survey and design, land leveling design methods, construction procedures and contour leveling.	7 lectures
Unit III	Concept of command area, irrigation planning in an irrigated command area, irrigation scheduling polices - rotational and other methods of irrigation, water distribution in a command area.	7 lectures
Unit IV	Design of inverted siphons and outlets, pressure conduits, lining of irrigation conveyance system, estimation of seepage loss from unlined channels.	6 lectures
Unit V	On farm development works; Farmers' participation in command area development; cost estimation, Use of GIS and RS in Command area.	5 lectures

Books:

1. Irrigation Engineering and Hydraulic Structures, S.K. Garg, Khanna Publishers, New Delhi, 2006.
2. Watershed Planning and Management, R.V. Singh, Yash Publishing House, Bikaner, 2000.
3. Land and Water Management Engineering, V.V.N. Murty, 2nd Ed., Kalyani Publishers, New Delhi, 1985.
4. Irrigation Theory and Practice, A.M. Micheal, Vikas Publishing House Pvt. Ltd., New Delhi, 1985.

AE23004	**Food Plant Utilities and Sanitation: 3 Credits (2-1-0)**	
Unit I	Boiler: properties of steam, boiler types, accessories to boilers, pressure vessel design, heat transfer in boilers, design of fire tube and water tube boilers, economizer, draught in boilers, performance of boilers, flue gas analysis, water treatments for boilers.	7 lectures
Unit II	Water treatments for microbiological safety.	3 lectures
Unit III	Cleaning of processing plants: chemistry, microbiology, CIP, Detergent and the types.	5 lectures
Unit IV	Waste water treatment: analysis of oxygen demand, BOD, COD, analysis of gas transfer, aerobic and anaerobic decomposition of waste water, biochemical reaction kinetics, analysis of biological growth, design of reactors, effects of recycle, design of trickle filters. design of batch and continuous type effluent treatment system.	8 lectures
Unit V	Process plant automation - analogue, digital control system, Temperature and pressure measurements and valve.	5 lectures

Books:

1. Thermal Engineering, P.L. Ballaney, Khanna Publishers, Delhi, 1995.
2. Water Treatment, F.I. Belan, Mir Publications, Moscow, 1985.
3. Waste Water Engineering - Treatment, Disposal and Reuse, George Tchobanoglous, Franklin Louis Burton, H. David Stensel, Metcalf & Eddy Inc., 1987.
4. Principles of Food Sanitation, N.G. Marriott, 4th Ed., CBS Publishers and Distributors, New Delhi, 1999.

AE23005	Mechanics of Tillage and Traction: 3 Credits (2-1-0)	
Unit I	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.	7 lectures
Unit II	Mechanics of simple tillage tools. Design consideration and performance evaluation of different tillage tools.	5 lectures
Unit III	Traction elements. Theories for predicting thrust and rolling resistance. Methods of improving traction, evaluation of performance of traction devices. Tyre size, load and pressure relationship.	5 lectures
Unit IV	Tractor stability: Centrifugal force, rear axle torque and drawbar leverage, new methods in tractor control to enhance the performance. Ballasting and its effects.	5 lectures
Unit V	Handling characteristics of vehicles: Steering geometry, steady-state handling characteristics of a two-axle vehicle, neutral steer, under steer and over steer.	6 lectures

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, USA, 1956.
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.

AE23006	Precision Farming: 3 Credits (2-0-2)	
Unit I	Protected cultivation: Introduction, History, origin, development, National and International Scenario, components of green house, perspective, Types of green houses, polyhouses /shed nets, Cladding materials, Plant environment interactions - principles of limiting factors, solar radiation and transpiration, greenhouse effect, light, temperature, relative humidity, carbon dioxide enrichment,	7 lectures
Unit II	Design and construction of green houses - site selection, orientation, design, construction, design for ventilation requirement using exhaust fan system, selection of equipment, Greenhouse cooling system - necessity, methods - ventilation with roof and side ventilators, evaporative cooling, different shading material fogging, combined fogging and fan-pad cooling system, design of cooling system, maintenance of cooling and ventilation systems, pad care etc.	5 lectures
Unit III	Greenhouse heating - necessity, components, methods, design of heating system. Root media - types - soil and soil less media, composition, estimation, preparation and disinfection, bed preparation. Planting techniques in green house cultivation. Irrigation in greenhouse and net house - Water quality, types of irrigation system, components, design, installation and material requirement.	5 lectures
Unit IV	Fogging system for greenhouses and net houses -introduction, benefits, design, installation and material requirement. Maintenance of irrigation and fogging systems. Fertilization - nutrient deficiency symptoms and functions of essential nutrient elements, principles of selection of proper application of fertilizers, fertilizer scheduling, rate of application of fertilizers, methods, automated fertilizer application.	6 lectures
Unit V	Greenhouse climate measurement, control and management. Insect and disease management in greenhouse and net houses Selection of crops for greenhouse cultivation, major crops in greenhouse – irrigation requirement, fertilizer management, cultivation, harvesting and post harvest techniques; Economic analysis.	5 lectures

Books:

1. Singh Brahma and Balraj Singh. 2014. Advances in protected cultivation, New India Publishing Company.
2. Sharma P. 2007. Precision Farming. Daya Publishing House New Delhi.
3. Green house Technology, the future concept of Horticulture by Arupratan Ghosh, Kalyani Publishers, Ludhiana.
4. Green house Technology for Controlled Environment by G.N. Tiwari, Narosa Pub. House Pvt. Ltd., New Delhi

AE23007	**Processing of Milk and Milk Products: 3 Credits (2-0-2)**	
Unit I	Milk Definition. Classification of milk. Physico-chemical properties of Milk Constituents. Food and Nutritive value of milk	6 lectures
Unit II	Dairy operations: homogenization, Heat transfer process: pasteurization, sterilization, UHT	6 lectures
Unit III	Manufacture, Packaging and Storage of Pasteurized milk- Receiving Filtration/ Clarification - Cooling - Storage of raw milk. Standardisation	7 lectures
Unit IV	Preparation of milk products and methods: flavoured milk, butter, yoghurt, cream ghee, ice-cream, cheese, shrikhand and khoa.	5 lectures
Unit V	Quality control in milk processing. Marketing concept of dairy products. Design and concept of dairy plant.	4 lectures

Books:

1. Outline of Dairy Technology, S. Dey, Oxford University Press, Oxford, 1997.
2. Milk and Milk Products, Clarence Henry Eckles, Willes Barnes Combs and Harold Macy, 4th Ed., Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1998.
3. Indian Dairy Products, K.S. Rangana and K.T. Acharya, Asia Publishing House, New Delhi, 1974.
4. Principles of Dairy Processing, J.N. Warner, New Age International Pvt. Ltd., New Delhi, 1976.

AE23008	**Testing of Tractors and Farm Equipment: 3 Credits (2-0-2)**	
Unit I	Importance of testing, general regulations for testing, test terminologies. Types of tests: Confidential, commercial and batch. Testing facilities in India and abroad for tractor and agricultural equipment. Test codes: OECD, Nebraska, ISO and BIS.	4 lectures
Unit II	Agricultural tractor power test: PTO performance test, test for engine, belt pulley test, and drawbar test.	7 lectures
Unit III	Test for hydraulic power, lifting capacity and maintenance of lift load. Air cleaner oil pull-over test, assessment of power drop and wear.	5 lectures
Unit IV	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.	7 lectures
Unit V	Testing of various farm machines and their main components for functional performance, wear, strength, force, and power requirement.	5 lectures

Books/Reference materials:

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, 2nd Edition, United Nation International Development Organization, 1995.

AE23009	**Wasteland Development: 3 Credits (2-1-0)**	
Unit I	Waste lands: definition and classification.	3 lectures
Unit II	Degraded soils: saline and sodic soils, acid soils, eroded soils; quality of water; erosion.	6 lectures

Unit III	Waste land development: agronomic, aquacultural, engineering, forest management practices.	8 lectures
Unit IV	Rehabilitation of degraded pasture; sand dunes and their stabilization; management of saline and sodic soils; shifting cultivation and land degradation; rehabilitation of ravine lands.	8 lectures
Unit V	Irrigation water: quality and standards; utilization of saline water in agriculture.	3 lectures

Books:

1. Technology for Waste Land Development, I.P. Abrol and V.V. Dhruva Naryana, 1st Ed., ICAR Publication, New Delhi, 1990.
2. Technology of Waste Lands Development, Ram Prasad, 1st Ed., Associated Publishing Co., New Delhi, 1988.
3. Waste Land Management in India, Anil Kumar and R.N. Pandey, 1st Ed., Ashish Publishing House, New Delhi, 1989.

AE24001	**Ergonomics: 3 Credits (2-0-2)**	
Unit I	Definitions and development of ergonomics. Human-machine system. Anthropometry: Workspace design principles, seat design and tractor operator workplace layout.	4 lectures
Unit II	Physical work: Work physiology, physiological strain, physical workload, muscle physiology, physical and muscular fatigue in agricultural operation. Working posture, work-rest schedule.	7 lectures
Unit III	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.	7 lectures
Unit IV	Biomechanics and human motion, manual material handling, manual material handling hazards, musculoskeletal injuries and disorders.	5 lectures
Unit V	Quantitative and qualitative visual displays, signals and warning lights, warning signs and warning labels, vision at the workplace.	5 lectures

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. Introduction to Human Factors and Ergonomics, R.S. Bridger, CRC Press, 2017.

AE24002	**Floods and Droughts: 3 Credits (2-1-0)**	
Unit I	Floods - causes of occurrence, flood classification - probable maximum flood, standard project flood, design flood,	5 lectures
Unit II	Flood estimation - methods of estimation; estimation of flood peak -rational method, empirical methods, unit hydrograph method	5 lectures
Unit III	Statistics in hydrology, flood frequency methods - log normal, Gumbel's extreme value, log-Pearson type-III distribution; depth-area-duration analysis. Flood forecasting. Flood routing - channel routing, Muskingum method, reservoir routing, modified Pul's method	8 lectures
Unit IV	Drought: causes of drought, drought in India, classification, drought indices, consequences of drought,	6 lectures
Unit V	Drought preparedness, mitigation, preparation of contingency crop table	4 lectures

Books:

1. Applied Hydrology, Mutreja, K.N. 1990. Tata McGraw-Hill Publishing Co., New York, Delhi.
2. Land and Water Management Engineering, V.V.N. Murty, 2nd Ed., Kalyani Publishers, New Delhi, 1985.

AE24003	Food Processing Equipment Design: 3 Credits (2-1-0)	
Unit I	Engineering properties of food materials and energy balance calculations for preliminary estimations of plant capacity and equipment sizes. Preparations of flow sheets for material movement and utility consumption in food plant.	6 lectures
Unit II	Materials of construction: welding and machining of stainless steel. Design of storage vessels for liquid foods and grains. Pressure vessels design and design of vessel for drum drying.	6 lectures
Unit III	Design of fluid conveyance system: pipe, sanitary pipe fittings and valves. Design of CIP systems.	4 lectures
Unit IV	Design of evaporator calandria, vapour separator and condensor. Design of grain processing machines. Design of conveying equipment: belt, screw and bucket.	7 lectures
Unit V	Design of heat exchange equipment: plate, scraped surface and extended surface heat exchangers for heating and cooling of gas and liquid.	5 lectures

Books:

1. Process Heat Transfer, D.Q. Kern, McGraw Hill Book Co., New York, 1988.
2. Fundamental of Food Process Engineering, Romeo T. Toledo, CBS Publishers & Distributors, New Delhi, 1997.
3. Fundamentals of Food Engineering, S.C. Charm, 3rd Ed., AVI Publication Co., Connecticut, 1978.
4. Food Engineering and Dairy Technology, H.G. Kessler, V.A. Kessler, Freising, Germany, 1981.

AE24004	Food Quality and Control: 3 Credits (2-0-2)	
Unit I	Basics of Food Science and Food Analysis, Concept, objectives and need of food quality. Measurement of colour, flavour, consistency, viscosity, texture and their relationship with food quality and composition.	6 lectures
Unit II	Sampling: purpose, sampling techniques, sampling procedures for liquid, powdered and granular materials, Quality control, Quality control tools, Statistical quality control, Sensory evaluation methods, panel selection methods, Interpretation of sensory results.	7 lectures
Unit III	Instrumental method for testing quality. Food adulteration and food safety. TQM and TQC, consumer preferences and acceptance,	4 lectures
Unit IV	Food Safety Management Systems GAP, GHP, GMP, Hazards and HACCP (Hazard analysis and critical control point), Sanitation in food industry (SSOP), Food Laws and Regulations in India, FSSAI, Food grades and standards BIS, AGMARK, PFA, FPO, ISO 9000, 22000 Series. CAC (Codex Alimantarious ommission)	7 lectures
Unit V	Traceability and Quality Assurance system in a process plant, Bio safety and Bioterrorism	4 lectures

Books:

1. Ranganna S. Hand book of Analysis and Quality Control for Fruit and Vegetable Products.
2. Norman N. Potter and Joseph H. Hotchikss. Food Science. Chapman and Hall Pub.
3. Acharya, K T Everyday Indian Processed foods. National Book Trust.
4. Mudambi Sumati R., Shalini M. Rao and M V Rajgopal. Food Science. New Age InternationalPublishers.
5. Negi H.P.S., Savita Sharma, K. S. Sekhon. Hand book of Cereal technology. Kalyani Pub.
6. Srivastava R.P. & Kumar Sanjeev. Fruit and Vegetable Preservation: Principles and Practices. International Book Distributing Company.
7. The Food Safety and Standards Act along with Rules & Regulations. Commercial Law Publishers (India) Pvt. Ltd.
8. Kalia M. 2002. Food Analysis and Quality Control. First Edition. Kalyani Publishers. New Delhi.
9. Harry T. Lawless · Hildegarde Heymann. 2010. Sensory Evaluation of Food: Principles and practices Second Edition. Springer New York.

AE24005	Hydraulic Drives and Controls: 3 Credits (2-1-0)	
Unit I	Hydraulic Basics: Pascal's Law, Flow, Energy, Work, and Power. Hydraulic Systems, Color Coding, Reservoirs, Strainers and Filters, Filtering Material and Elements. Accumulators, Pressure Gauges and Volume Meters, Hydraulic Circuit, Fittings and Connectors.	7 lectures
Unit II	Pumps, Pump Classifications, operation, performance, Displacement, Design of Gear Pumps, Vane Pumps, Piston Pumps. Hydraulic Actuators, Cylinders, Construction and Applications, Maintenance, Hydraulic Motors.	7 lectures
Unit III	Valves, Pressure-Control Valves, Directional- Control Valves, Flow-Control Valves, Valve. Installation, Valve Failures and Remedies, Valve Assembly, Troubleshooting of Valves	4 lectures
Unit IV	Hydraulic Circuit Diagrams and Troubleshooting, United States of American Standards Institute USASI Graphical Symbols Tractor hydraulics, nudging system, ADDC.	7 lectures
Unit V	Pneumatics: Air services, logic units, Fail safe and safety systems Robotics: Application of Hydraulics and Pneumatics drives in agricultural systems, Programmable Logic Controls (PLCs)	3 lectures

Books:

1. Kepner RA, Roy Barger & EL Barger. Principles of Farm Machinery. CBC Publishers & Distributors, New Delhi.
2. Srivastava A K, Carroll E. Goering & Roger P. Rohrbach, Engineering Principles of Agricultural Machines. ASAE Text Book No. 6 Publ. ASAE, ISBN 0-929355-33-4.
3. Pinches Michael J. & John G. Ashby. Power Hydraulics. Prentice Hall International (UK) Ltd.
4. Liljedahl J B and Others. Tractors and Their Power Units. CBS Publishers, New Delhi.

AE24006	Modelling and Simulation for Agricultural Applications: 3 Credits (2-1-0)	
Unit I	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.	6 lectures
Unit II	Linear algebra and least Squares: Solving systems of linear equations. Least squares regression and curve fitting.	4 lectures
Unit III	Ordinary differential equations: Numerical integration and solving 1^{st} order, ordinary differential. System of ordinary differential equations: Converting 2^{nd} order and higher ODEs to systems of 1^{st} order ODEs. Solving systems of ODEs.	6 lectures
Unit IV	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.	6 lectures
Unit V	Introduction to Simscape® for modelling of physical systems. Using Simscape® for modelling different tractor subsystems like body and tire, braking system, hydraulics and suspension.	6 lectures

Books/ Study materials:

Numerical Methods for Engineers and Scientists: An Introduction with Applications Using MATLAB, Amos Gilat and Vish Subramiam. Wiley, 2008.

Klee, H. and Allen, R. Simulation of Dynamic Systems with MATLAB and Simulink, 2^{nd} Ed., 2011, CRC Press.

AE24007	On-Farm Water Management: 3 Credits (2-1-0)	
Unit I	Design of canals in Alluvial and Non-Alluvial Soil and associated structures, Selection of cross drainage works	4 lectures
Unit II	Design, evaluation and hydraulics of surface irrigation methods: border, check basin, furrow	7 lectures
Unit III	Design, evaluation and hydraulics of sprinkler, drip and micro sprinklers	7 lectures

Unit IV	Drainage investigations, planning and design of surface and subsurface drainage systems; drainage of sloping lands	6 lectures
Unit V	Leaching requirements: reclamation of saline and sodic soils and water quality of irrigation water	4 lectures

Books:

1. Irrigation Engineering, N.N. Basak, Tata McGraw Hill Publishing Co. Ltd. New Delhi., 2001.
2. Irrigation Engineering and Hydraulic Structures, S.K. Garg, Khanna Publishers, Delhi., 1999.
3. Irrigation Theory and Practice, A.M. Micheal, Vikas Publication, New Delhi
4. Design of Minor Irrigation and Canal Structure, C.S. Murthy, Wiley Eastern Ltd. New Delhi, 1991.
5. Fundamentals of Irrigation and On-farm Water Management: Volume 1, Ali, Hossain. Springer-Verlag New York.
6. Drainage Engineering, J.N. Luthin, John Wiley and Sons, New York, 1970.

AE24008	**Refrigeration and Air-Conditioning: 3 Credits (2-1-0)**	
Unit I	Principles of refrigeration, - units, terminology, production of low temperatures, air refrigerators working on reverse Carnot cycle and Bell Coleman cycle.	4 lectures
Unit II	Vapour refrigeration-mechanism, P-V, P-S, P-H diagrams, vapor compression cycles, dry and wet compression, super cooling and sub cooling. Vapour absorption refrigeration system.	5 lectures
Unit III	Common refrigerants and their properties. Design calculations for refrigeration system. Cold storage plants. Thermodynamic properties of moist air, perfect gas relationship for approximate calculation, adiabatic saturation process, wet bulb temperature and its measurement, psychometric chart and its use, elementary psychometric process.	9 lectures
Unit IV	Air conditioning - principles -Type and functions of air conditioning, physiological principles in air conditioning, air distribution and duct design methods	6 lectures
Unit V	Fundamentals of design of complete air conditioning systems - humidifiers and dehumidifiers - cooling load calculations, types of air conditioners - applications.	4 lectures

Books:

1. A Course in Thermodynamics and Heat Engines, Kothandaraman C P Khajuria P R and Arora S C. 1992. Dhanpet Rai and Sons, 1682 Nai Sarak, New Delhi.
2. Engineering Thermodynamics, Khurmi R S. 1992. S Chand and Co. Ltd., Ram Nagar, New Delhi.
3. Thermodynamics and Heat Power Engineering, Mathur M L and Mehta F S. 1992. Dhanpat Rai and Sons 1682 Nai Sarak, New Delhi.
4. Thermal Engineering, Ballney P. L. 1994. Khanna Publishers, New Delhi.
5. Engineering Thermodynamics, Nag P K.1995. Tata McGraw Hill Publishing Co.Ltd., 12/4 Asaf Ali Raod, New Delhi.

AE24009	**Remote Sensing and GIS for Land and Water Management: 3 Credits (2-1-0)**	
Unit I	Basics of remote sensing, energy sources and radiation principles, energy interactions with earth surface features and atmosphere; reflectance curves.	5 lectures
Unit II	Earth resource satellites, sensors, micro-wave remote sensing.	5 lectures
Unit III	Aerial photographs; elements of photogrammetry; interpretation of aerial photographs; interpretation of satellite images.	6 lectures
Unit IV	Digital image processing: image rectification, enhancement, classification and its accuracy.	6 lectures
Unit V	Geographic information system; GIS data models; overview of GIS software; GPS; application of RS and GIS technologies in land and water resources.	6 lectures

Books:

1. Introduction to Environmental Remote Sensing, E.C. Barret and L.F. Curtis, 3rd Ed., Chapman and Hall, London, 1992.
2. Remote Sensing and Geographical Information System, Mangi Reddy, 2nd Ed., B.S. Publications, 2002.
3. Remote Sensing and Image Interpretation, I.M. Lillesand and R.W. Keifer, John Wiley and Sons Inc., New York, 2000.
4. Fundamentals of Geographic Information System, Michael N. DeMers, 2nd Ed., John Wiley & Sons, 1999.
5. Geographic Information Systems in Water Resources Engineering, Lynn E. Johnson, CRC publications, 2009.
6. GIS for Water Resource and Watershed Management, Edited by John G. Lyon, Taylor and Francis, 2003.

AE24021	**Agricultural Meteorology and Climate Change: 3 Credits (3-0-0)**	
Unit I	Agricultural meteorology: Meaning and scope, Earth atmosphere - its composition, extent and structure, instruments for measuring weather parameters, cyclone, anticyclone.	10 lectures
Unit II	Nature and properties of solar radiation, solar constant, depletion of solar radiation, short wave, long wave and thermal radiation, net radiation, albedo; Energy balance of earth	8 lectures
Unit III	Atmospheric humidity, concept of saturation, vapor pressure, cloud: significance, formation, classification; precipitation: classification, monsoon-mechanism and importance in Indian agriculture; climate classification.	8 lectures
Unit IV	Weather Characteristics of Indian agroecosystems, Weather hazards, agriculture and weather relations, Weather forecasting: types, data sources, and forecasting.	8 lectures
Unit V	Climate change: causes, impact on agriculture and water resources, global warming, fundamentals of numerical models: general circulation, regional circulation, models. Mitigation of climate change: renewable energy resources.	8 lectures

Books:

1. Agrometeorology, S.R. Reddy and D.S. Reddy, Kalyani Publishers, 2007.
2. Text Book of Agricultural Meteorology, M.C. Varshneya and P. Balakrishna Pillai, Indian Council of Agricultural Research, New Delhi, 2006.
3. Atmosphere, Weather and Climate, Roger, G. Barry and Richard, J. Chorley, 8th Ed., Routledge, Taylor and Francis Group, London, 2003.
4. General Climatology, Howard J. Critchfield, 4th Ed., Prentice-Hall of India Private Limited, New Delhi, 2002.
5. Global Climate Change and Agricultural Production, F. Bazzaz and W. Sombrock, FAO, Daya Publishing House, Delhi, 2005.
6. Global Warming and Climatology, Chanchal Singh, Akansha Publishing House, New Delhi, 2007.

AE24022	**Agricultural Safety: 3 Credits (3-0-0)**	
Unit I	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 II	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 III	Occupational safety and health principles in agriculture; Hazards and injury prevention and control: industrial safety and health approach, public health approach.	11 lectures
Unit IV	Safety engineering principles; Hierarchy hazard control; roll over protective structure (ROPS); warning sign and warning labels; machine guarding.	9 lectures
Unit V	Provincial, national and international regulations and legislation for prevention of accidents; injury compensation.	4 lectures

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.

AE24023	Computer Application in Agriculture: 3 Credits (1-0-4)	
Unit I	Introduction to programming and problem solving. Programming basics: loops and decisions, structures, functions, objects and classes, arrays and strings, pointers.	2 lectures
Unit II	Introduction to C programming: Structure, constants, variables, data types, expressions using operators, managing input and output operations, decision making, looping, arrays, strings and pointers.	4 lectures
Unit III	Microsoft Visual basic.net: GUI design, controls, data handling, input and output operations, decision making, functions and database.	3 lectures
Unit IV	Microsoft excel: Data handling, analysis, and presentation using graphs and charts.	2 lectures
Unit V	C and visual basic programming, spread sheet for agricultural applications: Soil conservation structure design, farm machinery design, and traction analysis.	3 lectures

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.

AE24024	Design of Soil Conservation Structures: 3 Credits (2-1-0)	
Unit I	Flow through open channel, specific energy, specific force, hydraulic jump.	5 lectures
Unit II	Hydrologic, hydraulic and structural design of drop spillway.	5 lectures
Unit III	Hydrologic, hydraulic and structural design of chute spillway.	5 lectures
Unit IV	Hydrologic, hydraulic and structural design of drop inlet spillway; design, construction and maintenance of gabion structures.	5 lectures
Unit V	Design and stability analysis of earthen dams.	8 lectures

Books:

1. Open Channel Hydraulics, V.T. Chow, McGraw Hill Book Co., New York, 1973.
2. Irrigation Engineering and Hydraulic Structures, S.K. Garg, 9th Ed., Khanna Publishers, Delhi, 1989.
3. Land and Water Management Engineering, V.V.N. Murty, 2nd Ed., Kalyani Publishers, New Delhi, 1985.
4. Soil and Water Conservation Engineering, R. Suresh, 2nd Ed., Standard Publisher and Distributors, New Delhi, 1997.
5. Hydrology and Soil Conservation Engineering, G. Das, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.

AE24025	Development of Processed Products: 3 Credits (2-0-2)	
Unit I	Process design, Process flow chart with mass and energy balance, Unit operations and equipments for processing	4 lectures
Unit II	New product development, Technology for value added products from cereal, pulses and oil seeds, Milling, puffing, flaking, Roasting, Bakery products, snack food	6 lectures
Unit III	Extruded products, oil extraction and refining, Technology for value added products from fruits, vegetables and spices,	6 lectures
Unit IV	Canned foods, Frozen foods, dried and fried foods, Fruit juices, Sauce, Sugar based confection, Candy, Fermented food product, spice extracts,	7 lectures
Unit V	Technology for animal produce processing, meat, poultry, fish, egg products, Health food, Nutra-ceuticals and functional food, Organic food.	5 lectures

Books:

1. Transport processes and unit operations, Geankoplis C. J. Prentice-Hall.
2. Fundamentals of Food Engineering, Rao, D. G. PHI Learning Pvt. Ltd., New Delhi.
3. Food Science, Norman N. Potter and Joseph H. Hotchikss, Chapman and Hall Pub.
4. Everyday Indian Processed foods, Acharya, K T. National Book Trust.

5. Food Science, Mudambi Sumati R., Shalini M. Rao and M V Rajgopal, New Age International Publishers.
6. Hand book of Cereal Technology, Negi H.P.S., Savita Sharma, K. S. Sekhon, Kalyani Pub.

AE24026	**Food Packaging Technology: 3 Credits (2-0-2)**	
Unit I	Factors affecting shelf life of food material during storage, Interactions of spoilage agents with environmental factors as water, oxygen, light, pH, etc. and general principles of control of the spoilage agents; Difference between food infection, food intoxication and allergy. Packaging of foods, requirement, importance and scope, framework of packaging strategy, environmental considerations,	6 lectures
Unit II	Packaging systems, types: flexible and rigid; retail and bulk; levels of packaging; special solutions and packaging machines, technical packaging systems and data management packaging systems, Different types of packaging materials, their key properties and applications, Metal cans, manufacture of two piece and three-piece cans, Plastic packaging, different types of polymers used in food packaging and their barrier properties. manufacture of plastic packaging materials, profile extrusion, blown film/ sheet extrusion, blow molding, extrusion blow molding, injection blow molding, stretch blow molding, injection molding.	7 lectures
Unit III	Glass containers, types of glass used in food packaging, manufacture of glass and glass containers, closures for glass containers. Paper and paper board packaging, paper and paper board manufacture process, modification of barrier properties and characteristics of paper/boards. Relative advantages and disadvantages of different packaging materials; effect of these materials on packed commodities.	4 lectures
Unit IV	Nutritional labelling on packages, CAS and MAP, shrink and cling packaging, vacuum and gas packaging; Active packaging, Smart packaging, Packaging requirement for raw and processed foods, and their selection of packaging materials, Factors affecting the choice of packaging materials, Disposal and recycle of packaging waste, Printing Course Curriculum – Undergraduate Degree Programme in Agricultural Engineering and labelling, Lamination,	7 lectures
Unit V	Package testing: Testing methods for flexible materials, rigid materials and semi rigid materials; Tests for paper (thickness, bursting strength, breaking length, stiffness, tear resistance, folding endurance, ply bond test, surface oil absorption test, etc.), plastic film and laminates (thickness, tensile strength, gloss, haze, burning test to identify polymer, etc.), aluminium foil (thickness, pin holes, etc.), glass containers (visual defects, colour, dimensions, impact strength, etc.), metal containers (pressure test, product compatibility, etc.).	4 lectures

Books:

1. Food Packaging Technology, Coles, R., McDowell, D., Kirwan, M.J. 2003. Blackwell Publishing Co.
2. Food Packaging Materials, Gosby, N.T. 2001. Applied Science Publication.
3. A Handbook on Food Packaging, John, P.J. 2008. Narendra Publishing House.
4. Food Packaging Materials, Mahadevia, M., Gowramma, R.V. 2007. Tata McGraw Hill.
5. Food Packaging and Shelf life: A Practical Guide, Robertson, G. L. 2001. Narendra Publishing House.
6. Food Packaging: Principles and Practice. Second Edition, Robertson, G. L. 2005. Taylor and Francis Pub.

AE24027	**Introduction to Computer Aided Design: 3 Credits (1-0-4)**	
Unit I	Introduction to 3-d modelling using CAD: Screen components, invoking commands, dialog boxes, saving, closing and managing workspaces.	3 lectures
Unit II	Coordinate systems, object selection methods, setting units type and precision.	2 lectures
Unit III	Drawing different two-dimensional objects like lines, arcs, rectangle, ellipse, regular polygon, polylines. Hatching patterns, editing sketched objects.	3 lectures

Unit IV	Creating text and tables: Annotative objects, creating and editing text, inserting table in the drawing.	3 lectures
Unit V	Dimension: Fundamental dimensioning terms, creating linear, angular, inspection and associative dimensions. Geometric dimensioning and tolerance: Characteristics and symbols used.	3 lectures

Books:

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 Publishing House Pvt. Ltd., New Delhi, 2010.

AE24028	**Pressurized Irrigation Systems: 3 Credits (2-0-2)**	
Unit I	Present status, scope and potential problems; inventory of resources – water source, crop and soil information, land topography; data requirement; general rules for design	5 lectures
Unit II	Indigenous micro irrigation systems: pitcher, suction irrigation, bamboo drip irrigation system, low cost drip irrigation systems	4 lectures
Unit III	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	8 lectures
Unit IV	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	8 lectures
Unit V	Problems and maintenance of pressurized irrigation systems	3 lectures

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.
5. Micro irrigation for Crop Production, Developments in Agricultural Engineering Series, Vol. 13, Freddie R. Lamm, James E. Ayars, Francis S. Nakayama, Elsevier, 2006.

AE24029	**Tractor System Design: 3 Credits (2-1-0)**	
Unit I	Engine performance characteristics, selection of engine for tractors. Design principles: engine components and engine systems.	5 lectures
Unit II	Design of tractor chassis. Tractor stability analysis: Longitudinal and lateral stability.	7 lectures
Unit III	Design of gearbox: Sliding mesh, constant mesh and Synchromesh gearbox. Design principles of CVT, automatic and dual clutch transmission.	7 lectures
Unit IV	Design of clutch: Positive and friction clutch. Design of brake: Shoe, band and disc type. Differential and final drive.	5 lectures
Unit V	Design and selection of wheels and tracks. Recent advances and trends of design of tractors and its systems.	4 lectures

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. Turnquist and H. Makoto, 4th Ed., 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.

AE24041	Geo-Informatics: 3 Credits (2-1-0)	
Unit I	Basics of remote sensing, energy sources and radiation principles, energy interactions with earth surface features and atmosphere; reflectance curves.	5 lectures
Unit II	Earth resource satellites, sensors, micro-wave remote sensing.	5 lectures
Unit III	Aerial photographs; elements of photogrammetry; interpretation of aerial photographs; interpretation of satellite images.	6 lectures
Unit IV	Digital image processing: image rectification, enhancement, classification and its accuracy.	6 lectures
Unit V	Geographic information system; GIS data models; overview of GIS software; GPS; application of RS and GIS technologies.	6 lectures

Books:

1. Introduction to Environmental Remote Sensing, E.C. Barret and L.F. Curtis, 3rd Ed., Chapman and Hall, London, 1992.
2. Remote Sensing and Geographical Information System, Mangi Reddy, 2nd Ed., B.S. Publications, 2002.
3. Remote Sensing and Image Interpretation, I.M. Lillesand and R.W. Keifer, John Wiley and Sons Inc., New York, 2000.
4. Fundamentals of Geographic Information System, Michael N. DeMers, 2nd Ed., John Wiley & Sons, 1999.
5. Geographic Information Systems in Water Resources Engineering, Lynn E. Johnson, CRC publications, 2009.
6. GIS for Water Resource and Watershed Management, Edited by John G. Lyon, Taylor and Francis, 2003.

AE24042	Computer Aided Design: 3 Credits (1-0-4)	
Unit I	Introduction to 3-d modelling using CAD: Screen components, invoking commands, dialog boxes, saving, closing and managing workspaces.	3 lectures
Unit II	Coordinate systems, object selection methods, setting units type and precision.	2 lectures
Unit III	Drawing different two-dimensional objects like lines, arcs, rectangle, ellipse, regular polygon, polylines. Hatching patterns, editing sketched objects.	3 lectures
Unit IV	Creating text and tables: Annotative objects, creating and editing text, inserting table in the drawing.	3 lectures
Unit V	Dimension: Fundamental dimensioning terms, creating linear, angular, inspection and associative dimensions. Geometric dimensioning and tolerance: Characteristics and symbols used.	3 lectures

Books:

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 Publishing House Pvt. Ltd., New Delhi, 2010.

AE23121	Forest Hydrology and Watershed Management: 3 Credits (2-0-2)	
Theory		
Unit I	Hydrology: Importance, scope and definitions, hydrological cycle, energy and water balance equations, precipitation, rain and snow hydrology.	6 lectures
Unit II	Interception, infiltration, evaporation and transpiration: paired watersheds, surface water, run-off processes and hydrograph; Soil water energy concept, movement, availability and measurement.	6 lectures
Unit III	Watershed management: an approach for sustainable productivity, principles and practices; Introduction to land use capability: classification; Soil erosion: types and mechanics of water erosion and its control, stream bank erosion and its control.	6 lectures
Unit IV	Methods for water conservation: water harvesting techniques; Role of trees in water conservation: natural terracing, species suitability; Recharging of water springs.	5 lectures
Unit V	Forest treatment and water yield; Application of GIS in watershed delineation.	5 lectures

Books:

1. Bennet, H. H. (1965). Elements of Soil conservation. Mc Graw Hill Book Co. Inc. New York.
2. Dhruva, N.V.V. (1993). Soil and Water Conservation Research in India, ICAR, New Delhi.
3. Dhruva, N.V.V., Sastry G. and Patnaik, U.S. (1997). Watershed Management. Indian Council of Agricultural Research, New Delhi.
4. Singh, G. et al. (1988). Manual of Soil and Water Conservation. Oxford IBH Publishing Co. New Delhi.
5. Hamilton, L.S. (1983). Tropical Forested Watersheds: hydrologic and soils response to major uses or conversions. International Book Distributors, Dehra Dun.
6. Hamilton, L.S. (ed.). (1983). Forest and Watershed Development and Conservation in Asia and the Pacific. International Book Distributors, Dehra Dun.
7. Hewlett, J.D. and Nutter, W.L. (1969). An Outline of Forest Hydrology. University of Georgia Press, Athens.
8. Hudson, N. (1981). Soil Conservation. BT Batsford Limited, London.
9. Lal, R. (2000). Integrated Watershed Management in the Global Ecosystem. CRC Press, London.
10. Michael, A.M. (2008). Irrigation theory and practice, Vikas Publsh. House Pvt. Ltd.
11. Morgan, R.P.C. (1988). Soil Erosion and Conservation. English Language Book. Society, Longman, London.
12. Murthy, V.N.N. (1983). Land and Water Management Engineering, Kalyani Publishers, New Delhi.
13. Ramarao, M.S.V. (1962). Soil Conservation in India, ICAR, New Delhi.
14. Riedl, O. and Zachar, D. (1984). Forest Amelioration. Elsevier, Amsterdam.
15. Satterlund, D.R. (1972). Wildland Watershed Management. The Ronald Press Company, New York.
16. Rao, S.K.V. (2000). Watersheds, Comprehensive Development. B. S. Publications, Hyderabad.
17. USDA (1961). A Manual on Conservation of Soil and Water. Oxford and IBH Publishing Company.

DEPARTMENT OF CIVIL ENGINEERING

Year I Semester I						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	PH21102	Introduction to Mechanics	4	0	2	5
2.	MA21101	Mathematics – I	3	1	0	4
3.	ES21100	Basic Electrical Engineering	3	1	2	5
4.	ES21151	Engineering Graphics and Design	0	0	6	3
5.	FR21121	Biology for Engineers	2	1	0	3
Total						**20**

Year I Semester II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CY21202	Engineering Chemistry – B	3	1	2	5
2.	MA21201	Mathematics – II	3	1	0	4
3.	ES21200	Programming for Problem Solving	3	0	2	4
4.	ES21251	Workshop Practice	0	0	6	3
5.	HS21201	Communication Skills	2	0	2	3
6.	CE21201	Engineering Mechanics	2	1	0	3
Total						**22**

Year II Semester III						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	MA22101	Mathematics – III	3	1	0	4
2.	ES22101	Basic Electronics Engineering	3	0	2	4
3.	CE22101	Mechanics of Solid	2	1	0	3
4.	CE22102	Introduction to Fluid Mechanics	2	0	2	3
5.	CE22103	Surveying and Geomatics	2	0	2	3
6.	CE22104	Geotechnical Engineering – I	2	0	2	3
7.	CE22105	Transportation Engineering – I	2	0	2	3
8.	CE22106	Environmental Engineering – I	2	0	2	3
Total						**26**

Year II Semester IV						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS22201	Entrepreneurship and Startups	3	0	0	3
2.	ME22221	Basics of Mechanical Engineering	2	0	0	2
3.	CE22201	Instrumentation and Sensor Technologies for Civil Engineering Applications	1	1	2	3
4.	CE22202	Energy Science and Engineering	2	0	0	2
5.	CE22203	Structural Analysis and Design of Steel Structures	4	0	0	4
6.	CE22204	Design of RCC Structures	2	1	0	3
7.	CE22205	Hydrology and Water Resources Engineering	2	1	0	3
8.	CE22251	Computer-aided Civil Engineering Drawing	0	0	4	2
9.	HS22277	Indian Constitution (Audit)	2	0	0	0
Total						**22**

Year III Semester V						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS23101	Principles of Economics	3	0	0	3
2.	HS23177	Essence of Indian Knowledge and Tradition (Audit)	2	0	0	0
3.	CE23101	Structural Analysis	2	1	0	3
4.	CE23102	Geotechnical Engineering – II	2	0	2	3
5.	CE23103	Environmental Engineering – II	2	0	2	3
6.	CE23104	Transportation Engineering – II	2	0	2	3
7.	CE23105	Materials Testing and Evaluation	1	1	2	3
8.	CE23106	Disaster Preparedness and Planning	1	1	0	2
9.	CE23166	Study Tour (Audit)	0	0	0	0
Total						**20**

Year III Semester VI						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS23201	Organizational Behaviour	3	0	0	3
2.	MO230**	Open Elective – I (From MOOC)	3	0	0	3
3.	CE23201	Construction Engineering & Management	2	0	0	2
4.	CE230**	Programme Elective – I	3	0	0	3
5.	CE230**	Programme Elective – II	3	0	0	3
6.	CE230**	Programme Elective – III	3	0	0	3
7.	CE230**	Programme Elective – IV	3	0	0	3
8.	CE23289	Seminar	0	0	2	1
Total						**21**

Year IV Semester VII						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	**24***	Open Elective – II	*	*	*	3
2.	CE24101	Engineering Economics and Estimation	2	1	0	3
3.	CE24102	Engineering Geology	2	0	2	3
4.	CE240**	Programme Elective – V	3	0	0	3
5.	CE240**	Programme Elective – VI	3	0	0	3
6.	CE24199	Project – I	0	0	6	3
7.	CE24179	Industrial Training	0	0	0	3
Total						**21**

Year IV Semester VIII						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	MO240**	Open Elective – III (From MOOC)	3	0	0	3
2.	**240**	Open Elective – IV	*	*	*	3
3.	CE240**	Programme Elective – VII	3	0	0	3
4.	CE240**	Programme Elective – VIII	3	0	0	3
5.	CE24299	Project – II	0	0	12	6
6.	ED24288	Extra-Curricular Activities and Discipline	0	0	0	2
Total						**20**

List of Electives

Programme Elective – I						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CE23001	Pavement Materials	3	0	0	3
2.	CE23002	Pavement Design	3	0	0	3
3.	CE23003	Public Transportation Systems Planning	3	0	0	3
4.	CE23004	Traffic Engineering and Management	3	0	0	3
5.	CE23005	Urban Transportation Planning	3	0	0	3
6.	CE23006	Geometric Design of Highways and Transportation facilities	3	0	0	3
7.	CE23007	Intelligent Transportation Systems	3	0	0	3

Programme Elective – II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CE23011	Construction Productivity	3	0	0	3
2.	CE23012	Building Construction Practice	3	0	0	3
3.	CE23013	Construction Project Planning and System	3	0	0	3
4.	CE23014	Advanced Concrete Technology for Construction	3	0	0	3
5.	CE23015	Contracts Management	3	0	0	3
6.	CE23016	Construction Equipment and Automation	3	0	0	3
7.	CE23017	Repairs and Rehabilitation of Structures	3	0	0	3

Programme Elective – III						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CE23021	Mathematical Modeling in Environmental Engineering	3	0	0	3
2.	CE23022	Advanced Wastewater Treatment Techniques	3	0	0	3
3.	CE23023	Solid Waste Management	3	0	0	3
4.	CE23024	Industrial Pollution and Control	3	0	0	3
5.	CE23025	Environmental Impact Assessment	3	0	0	3
6.	CE 23026	Solid and Hazardous Waste Management	3	0	0	3
7.	CE 23027	Air Pollution Engineering	3	0	0	3

Programme Elective – IV						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CE23031	River Engineering	3	0	0	3
2.	CE23032	Transient Flow Analysis	3	0	0	3
3.	CE23033	Computational Methods in Hydraulics and Environmental Engineering Applications	3	0	0	3
4.	CE23034	Open Channel Hydraulics	3	0	0	3
5.	CE23035	Hydro-Power Development	3	0	0	3
6.	CE23036	Hydraulic Engineering	3	0	0	3

Programme Elective – V						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CE24001	Water Quality Engineering	3	0	0	3
2.	CE24002	Surface Hydrology	3	0	0	3
3.	CE24003	Environmental Hydrology	3	0	0	3
4.	CE24004	Groundwater Hydrology	3	0	0	3

5.	CE24005	Flood Control and River Training Works	3	0	0	3
6.	CE24006	Water Resources Systems	3	0	0	3
7.	CE24007	Design of Hydraulic Structures	3	0	0	3

Programme Electives – VI						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CE24011	Design of Steel Structures	3	0	0	3
2.	CE24012	Matrix Methods of Structural Analysis	3	0	0	3
3.	CE24013	Theory of Elasticity	3	0	0	3
4.	CE24014	Finite Element Methods	3	0	0	3
5.	CE24015	Advanced Mechanics of Solids	3	0	0	3
6.	CE24016	Structural Dynamics	3	0	0	3

Programme Electives – VII						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CE24021	Advanced Design of RCC Structures	3	0	0	3
2.	CE24022	Bridge Engineering	3	0	0	3
3.	CE24023	Elements of Earthquake Engineering	3	0	0	3
4.	CE24024	Earthquake Resistant Structures	3	0	0	3
5.	CE24025	Design of Offshore and Coastal Structures	3	0	0	3
6.	CE24026	Prefabricated Structures	3	0	0	3

Programme Elective – VIII						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CE24031	Advanced Soil Mechanics and Foundations	3	0	0	3
2.	CE24032	Machine Foundations	3	0	0	3
3.	CE24033	Earth and Earth Retaining Structures	3	0	0	3
4.	CE24034	Principles and Practices in Geotechnical Engineering	3	0	0	3
5.	CE24035	Ground Improvement Techniques	3	0	0	3
6.	CE24036	Reinforced Earth and Geotextiles	3	0	0	3

Course Content

ES21151	Engineering Graphics and Design: 3 Credits (0-0-6)
Unit I	Lines lettering & dimensioning.
Unit II	Engineering curves: Conic sections, Cycloid, Involute, Spiral, Helix etc. Projection of Points straight lines & planes.
Unit III	Projection of solids.
Unit IV	auxiliary views, and sectional views. Development of surfaces, Intersection of solids and Isometric drawings/views
Unit V	Related drawings on AUTO-CAD.

Books:

1. Elementary Engineering Drawing (53e), N.D. Bhatt and V. M. Panchal, Charotar Publishing House, Anand, 2014.
2. Engineering Drawing+ AutoCAD, K. Venugopal and Prabhu Raja, New Age International Publishers, New Delhi, 2011.
3. Engineering Drawing & Graphic Technology, French T.E., Vierck C.J. & Forester R.J., McGraw Hill International, Singapore, 1993.
4. Engineering Drawing with an Introduction to AutoCAD, Dhananjay Jolhe, Mc Graw Hill International, Singapore, 2017.
5. Engineering Drawing (3e), Basant Agrawal and C M Agrawal, Mc Graw Hill International, Singapore, 2019.

CE21201	Engineering Mechanics: 3 Credits (2-1-0)	
Unit I	Equilibrium in Space: Forces in space, Rectangular components of a force in space, Unit vectors, Force defined by its magnitude and two points on its line action, Addition of concurrent forces in space, Equilibrium of a particle in space.	5 lectures
Unit II	Trusses, Frames and Machines: Simple, compound and complex trusses, Method of Joints, Zero-force members, Method of sections, Structures containing multi-force members, Analysis of determinate frames, simple machines.	7 lectures
Unit III	Principle of Virtual Work - Displacements, work due to a force and a couple, virtual displacement, applications; Potential energy and stability - Conservative systems and potential energy, Gravitational and elastic potential energy, Principles of potential energy, Stability of equilibrium.	5 lectures
Unit IV	Distributed Forces: Center of gravity of a two dimensional body, Centroid of areas, First moment of areas, Center of gravity of composite areas, Resultant of a general distributed force system, Moment of Inertia of an area, Radius of gyration of an area, Parallel axis theorem, Moment of Inertia of composite areas.	6 lectures
Unit V	Plane Kinematics of Rigid Bodies - Translation, rotation and general plane motion, velocities in relative motion, instantaneous center of velocity, accelerations in relative motion.	5 lectures

Books:

1. Vector Mechanics for Engineers, Statics and Dynamics (Special Indian Edition), Beer and Johnston, Mc Graw Hill Education (India), New Delhi, 2019.
2. Engineering Mechanics, Statics and Dynamics, R. C. Hibbeler, Pearson Education Asia Pvt. Ltd., New Delhi, 2017.
3. Engineering Mechanics, Statics and Dynamics, Meriam and Kraige, John Wiley & Sons INC, N.Y., 1997.
4. Engineering Mechanics (5e), S Timoshenko, D H Young, J V Rao and Sukumar Patil, Tata McGraw Hill Education, New Delhi, 2017.
5. Engineering Mechanics (7e), S S Bhavikatti, New Age International Publisher, New Delhi, 2019.

CE22101	Mechanics of Solid: 3 Credits (2-1-0)	
Unit I	Mechanical Properties of Material, Axial Load, Direct shear, and Torsion: Stress-strain diagram for mild steel in tension and compression, Elastic behavior, Yield point, Strain hardening point, Stress-strain behavior of brittle materials, Hooke's law, Modulus of Resilience, Modulus of toughness, Poisson's ratio, Elastic deformation of an axially loaded member, Thermal stress, Direct shear stress, Shear strain, Modulus of rigidity, Torsion of a circular shaft, Power transmission, Deformation of a circular shaft, Angle of twist.	8 lectures
Unit II	Shear and Bending Moment Diagrams, Pure Bending: Shear force and bending moment at any point along the length of a beam, Regions of distributed loads, Concentrated loads and moments, Shear force and bending moment diagrams, Bending of a straight beam, Simple beam theory, Bending stress and its distribution, Composite beams, Transformed section.	8 lectures
Unit III	Transverse Shear: Shear on the horizontal face of a beam element, Horizontal shear per unit length, Transverse shear stress, The shear formula, Distribution of shear stress on the cross-section of a beam, Shear stress in the web of a thin walled section.	4 lectures
Unit IV	Plane Stress Transformation: General equation of transformation of plane stress, Principal stresses- magnitudes and their planes, Max shear stress and its plane, Mohr circle for plane stresses, Analytical and graphical solution of problems of plane stress.	4 lectures
Unit V	Deflection of Beams: Deformation of a beam under transverse loading, The elastic curve, Moment-curvature relationship, Slope and deflection by direct integration, Boundary and continuity conditions, Equation of the elastic curve, Maximum deflection.	4 lectures

Books:

1. Elements of Strength of Materials, Timoshenko and Young, CBS Publisher, New Delhi, 2003 /2018(eBook edition).
2. Strength of Material, G.H. Ryder, MacMillan, ELBS, London, 1969.
3. Engineering Mechanics of Solids (latest edition), E.P. Popov, Pearson India Education Services, Chennai, 2015.
4. Mechanics of Materials (ebook), Gere & Timoshenko, CBS Publications, New Delhi, 2018.
5. Strength of Material, Andrew Pytel and Ferdinanal L. Singer, Harper Collins Publishers, India, New Delhi, 1991.

CE22102	Introduction to Fluid Mechanics: 3 Credits (2-0-2)	
Unit I	Properties of fluid: mass density, relative density, viscosity, fluid pressure, pressure head. Fluid statics - Pressure at a point, units of measurement, manometers.	5 lectures
Unit II	Forces on plane areas, line of action of force, force components on curved surfaces.	5 lectures
Unit III	Fundamentals of fluid flow - steady, unsteady, uniform, non-uniform, one dimensional, two dimensional and three dimensional flows; Streamline, stream tube, irrotational flow, velocity potential, stream function, flow net, motion of a fluid element, acceleration of a fluid particle in a velocity field, fluid rotation, fluid deformation.	6 lectures
Unit IV	Equation of continuity, energy equation and its applications.	4 lectures
Unit V	Fluid measurements - velocity measurement, Pitot tube, coefficient of discharge, coefficient of velocity, coefficient of contraction, orifices, orifice meter, venturimeter, time to empty tanks, weirs and notches.	8 lectures

Books:

1. Hydraulics and Fluid Mechanics including Hydraulics Machines, Modi, P.N. and S.M. Seth, Standard Book House, Delhi, 2011.
2. Theory and Problems of Fluid Mechanics, Subramanya, K, Tata McGraw Hill, New Delhi, 2013.
3. Fluid Mechanics through Problems, Garde R.J., New Age International, New Delhi., 1989.
4. A Text Book of Fluid Mechanics, Rajput, R.K., S. Chand & Co, New Delhi., 1998.
5. Fluid Mechanics Hydraulics & Hydraulic Machines, Arora, K.R., Standard Publishers & Distributions, Delhi., 1999.

CE22103	**Surveying and Geomatics: 3 Credits (2-0-2)**	
Unit I	Surveying: chain, compass, plane table surveying and leveling. Triangulation system, strength of figures, selection and inter-visibility of stations, signals &towers, base line measurement, reduction to mean sea level, satellite stations, reduction to centre.	7 lectures
Unit II	Theory of errors and triangulation adjustments - types of errors, principle of least squares, laws of weights, normal equations, method of correlates, station and figure adjustments.	5 lectures
Unit III	Photogrammetry- definition & scope, branches of photogrammetry, photogrammetric methods, stereo-pairs, relief displacement and tilt distortion, flight planning, ground control, plotting instruments.	5 lectures
Unit IV	Astronomical survey - terms and definitions, formula of spherical trigonometry, methods used culmination of stars, circumpolar stars, measurement of times and their conversions, instruments used; Related practice.	5 lectures
Unit V	Principle of Electronic Distance Meter (EDM), its component parts and their Functions, use of EDM. Use of micro optic Theodolite and Electronic Digital Theodolite. Use of Total Station, Use of function keys. Measurements of Horizontal angles, vertical angles, distances and coordinates using Total Station, Traversing, Profile Survey and Contouring with Total Station. Remote Sensing – Overview, Remote sensing system, Applications of remote sensing in Civil engineering, land use / Land cover, mapping, disaster management. Use of Global Positioning System (G.P.S.) instruments. Geographic Information System (GIS): Overview, Components, Applications, Software for GIS. Introduction to Drone Surveying.	6 lectures

Books:

1. Surveying Vol. II & III, B.C. Punamia, Laxmi Publication, New Delhi, 2016.
2. Surveying & Levelling Vol. II, T.P. Kanetkar & S.V. Kulkarni, Pune Vidyarthi Griha Prakashan, Pune, 2010.
3. Surveying Vol. II, S.K. Duggal, Tata McGraw Hill, New Delhi, 2013.
4. Plane & Geodetic Surveying for Engineers Vol. II, David Clark, C.B.S., New Delhi, 1983.
5. A Text Book of Advanced Surveying, R. Agor, Khanna Publishers, Delhi, 2002.
6. Surveying, A. Barmister & S. Raymond, Longman, English Language Book Society, London, 1992.
7. Surveying and Levelling, Basak, N. N., McGraw Hill Education (India) Pvt. Ltd., Noida.
8. Survey I and Survey II, Duggal, S. K., Tata McGraw Hill Education Pvt. Ltd., Noida.
9. Surveying, Saikia, M D.; Das. B.M.; Das. M.M., PHI Learning Pvt. Ltd., New Delhi.
10. Surveying and Levelling, Subramanian, R., Oxford University Press. New Delhi.
11. Textbook of Surveying, Rao, P. Venugopala Akella, Vijayalakshmi, PHI Learning Pvt. Ltd., New Delhi.
12. Textbook of Surveying, Venkatramaiah, C, Universities Press, Hyderabad.
13. Surveying theory and practice, Anderson, James M and Mikhail, Edward M, Mc Graw Hill Education, Noida.
14. Plane Surveying, De, Alak, S. Chand Publications, New Delhi.
15. Introduction to Geographic Information Systems by Chang Kang-tsung (Karl), 2015.
16. Remote Sensing and Image Interpretation, Thomas Lillesand, Ralph W. Kiefer and Jonathan Chipman, John Wiley & Sons, 2015.

CE22104	Geotechnical Engineering – I: 3 Credits (2-0-2)	
Unit I	Introduction, definitions and relationships; Index properties of soils.	5 lectures
Unit II	Soil classification; Soil structure.	3 lectures
Unit III	Soil compaction; Permeability and Seepage.	5 lectures
Unit IV	Effective stress; Stress distribution in soil mass; One dimensional consolidation;	8 lectures
Unit V	Shear strength of soils and shear tests.	7 lectures

Books:

1. Murthy V.N.S, Textbook of Soil Mechanics and Foundation Engineering, ISBN: 9788123913629, 9788123913629, CBS Publishers & Distributors; 1st edition (2008).
2. Singh Alam, Soil Engineering in Theory and Practice, Vol 1, Fundamentals and General Principles, CBS Publishers & Distributors; 4th edition (2002).
3. Das B.M., Fundamentals of Geotechnical Engineering, Brookes & Cole Publications, ISBN-10: 0534492940, ISBN-13: 978-0534492946, 2nd revised edition (2004).

CE22105	Transportation Engineering – I: 3 Credits (2-0-2)	
Unit I	Geometric Design of Highways - Factors, cross-section elements,	4 lectures
Unit II	Sight distances, horizontal and vertical curves, and transition curves, Related Practice.	6 lectures
Unit III	Traffic Engineering: Introduction, traffic characteristics.	6 lectures
Unit IV	Traffic sign and signal, traffic control devices.	4 lectures
Unit V	Railways: Geometrics for Broad Gauge, Cant deficiency, Sleeper Density, Design of Ballast Depth. Points and Crossings, Station and Yards, Signals.	8 lectures

Books:

1. Highway Engineering, S K Khanna , C E G Justo and A.Veeraraghavan, Nem Chand & Brothers, Roorkee, India, 2015.
2. Principles of Transportation Engineering, P. Chakroborty and A. Das, Prentice Hall of India Pvt. Ltd., 2003.
3. Railway Engineering, Chandra, Satish, Agarwal, M.M., OXFORD University Press, New Delhi, 2013.
4. A Text Book of Railway Engineering, Arora and Saxena, Dhanpat Rai & Sons, New Delhi, 2010.

CE22106	Environmental Engineering – I: 3 Credits (2-0-2)	
Unit I	Introduction, Estimation of quantity of water, per capita demand, design period, population forecasting.	5 lectures
Unit II	Sources of water and their suitability with regard to quality & quantity, storage capacity of reservoirs, water quality parameters, standards.	5 lectures
Unit III	Treatment of water- screenings, sedimentation, aeration, coagulation and flocculation, filtration & disinfection, Storage Reservoir, distribution system, methods of water supply.	5 lectures
Unit IV	Sewerage system, estimation of quantity of sewage, dry weather flow (DWF), wet weather flow (WWF), variation in flows, hydraulic design of sewers, pumping of sewage.	5 lectures
Unit V	Characteristics of sewage, strength of sewage, population equivalent, treatment of sewage- primary and secondary treatments, oxidations ponds, sewage disposal, self–purification of streams, sludge digestion and disposal, concept of air pollution control.	8 lectures

Books:

1. Environmental Engineering Vol. I: Water Supply Engineering, S.K. Garg, Khanna Publications, Delhi, 2017.
2. Environmental Engineering Vol II: Sewage Disposal and Air Pollution Engineering, S.K. Garg, Khanna Publications, Delhi, 2018.
3. Environmental Engineering, Peavy, Tachobanoglous & Rowe, McGraw Hill International, N.Y., 2017.
4. Wastewater Engineering: Treatment, Disposal and Reuse, Metcalf & Eddy, Tata McGraw Hill, New Delhi, 2017.

5. Water Supply Engineering (Environmental Engineering Vol. I): P. N. Modi, Standard Book House, N. Delhi. 2010.
6. Water Supply & Sanitary Engineering, G.S. Birdi and J.S. Bindie, Dhanpat Rai Publishing Co., New Delhi, 2010.

CE22201	**Instrumentation and Sensor Technologies for Civil Engineering Applications: 3 Credits (1-1-2)**	
Unit I	Fundamentals of Measurement, Sensing and Instrumentation covering definition of measurement and instrumentation, physical variables, common types of sensors; Describe the function of these sensors.	2 lectures
Unit II	Use appropriate terminology to discuss sensor applications; and qualitatively interpret signals from a known sensor type, types of instrumentation, Sensor Specifics, Permanent installations, Temporary installations.	2 lectures
Unit III	Sensor Installation and Operation covering to: i) Predict the response of sensors to various inputs; ii) Construct a conceptual instrumentation and monitoring program; iii) Describe the order and methodology for sensor installation; and iv) Differentiate between types of sensors and their modes of operation and measurement and v) Approach to Planning Monitoring Programs, Define target, Sensor selection, Sensor siting, Sensor Installation & Configuration, Advanced topic, Sensor design, Measurement uncertainty	4 lectures
Unit IV	Data Analysis and Interpretation covering a) Fundamental statistical concepts, b) Data reduction and interpretation, c) Piezometer, Inclinometer, Strain gauge, etc. d) Time domain signal processing, e) Discrete signals, Signals and noise and f) a few examples of statistical information to calculate are: Average value (mean), On average, how much each measurement deviates from the mean (standard deviation), Midpoint between the lowest and highest value of the set (median), Most frequently occurring value (mode), Span of values over which your data set occurs (range)	3 lectures
Unit V	Frequency Domain Signal Processing and Analysis covering Explain the need for frequency domain analysis and its principles; Draw conclusions about physical processes based on analysis of sensor data; Combine signals in a meaningful way to gain deeper insight into physical phenomena, Basic concepts in frequency domain signal processing and analysis, Fourier Transform, FFT (Fast Fourier Transform), Example problems: Noise reduction with filters, Leakage, Frequency resolution	3 lectures

Books:

1. Measurement and Instrumentation Principles (3e), Alan S Morris, Butterworth Hienemann, 2001.
2. Electronic Instrumentation and Measurements 2nd/e, David A. Bell, Oxford Press 2007.
3. Principle of Electrical Measurement, S. Tumanski, Taylor & Francis, 2006.
4. Measurement Theory for Engineers, Ilya Gertsbakh (2010), Springer.

CE22202	**Energy Science and Engineering: 2 Credits (2-0-0)**	
Unit I	Introduction to Energy Science: Scientific principles and historical interpretationto place energy use in the context of pressing societal, environmental and climate issues; Introduction to energy systems and resources; Introduction to Energy, sustainability & the environment	5 lectures
Unit II	Energy Sources: Overview of energy systems, sources, transformations, efficiency, and storage. Fossil fuels (coal, oil, oil-bearing shale and sands, coal gasification) - past, present & future, Remedies & alternatives for fossil fuels - biomass, wind, solar, nuclear, wave, tidal and hydrogen; Sustainability and environmental trade-offs of different energy systems; possibilities for energy storage or regeneration (Ex. Pumped storage hydro power projects, superconductor-based energy storages, high efficiency batteries).	5 lectures

Unit III	Energy & Environment: Energy efficiency and conservation; introduction to cleanenergy technologies and its importance in sustainable development; Carbon footprint, energy consumption and sustainability; introduction to the economics of energy; How the economic system determines production and consumption; linkages between economic and environmental outcomes; How future energy use can be influenced by economic, environmental, trade, and research policy.	5 lectures
Unit IV	Civil Engineering Projects connected with the Energy Sources: Coal miningtechnologies, Oil exploration offshore platforms, Underground and under-sea oil pipelines, solar chimney project, wave energy caissons, coastal installations for tidal power, wind mill towers; hydro power stations above-ground and underground along with associated dams, tunnels, penstocks, etc.; Nuclear reactor containment buildings and associated buildings, design and construction constraints and testing procedures for reactor containment buildings; Spent Nuclear fuel storage and disposal systems.	5 lectures
Unit V	Engineering for Energy conservation: Concept of Green Building and GreenArchitecture; Green building concepts (Green building encompasses everything from the choice of building materials to where a building is located, how it is designed and operated); *LEED ratings;* Identification of energy related enterprises that represent the breath of theindustry and prioritizing these as candidates; Embodied energy analysis and use as a tool for measuring sustainability. Energy Audit of Facilities and optimization of energy consumption.	8 lectures

Books:

1. Renewable Energy (3e), Boyle Godfrey, Oxford University Press, 2012.
2. Energy Systems and Sustainability: Power for a Sustainable Future, Bob Everett, Godfrey Boyle, Oxford University Press, 2012.
3. Real Goods Solar Living Sourcebook: The Complete Guide to Renewable Energy Technologies and Sustainable Living, (Eds.) Schaeffer, John, 2007.
4. Jean-Philippe; Zaccour, Georges (Eds.), Energy and Environment Set: Mathematics of Decision Making, Loulou, Richard; Waaub, XVIII, 2005.
5. Energy and the Environment, (2e), Ristinen, Robert A. Kraushaar, Jack J. AKraushaar, Jack P. Ristinen, Robert A., John Wiley, 2006.
6. UNDP (2000), Energy and the Challenge of Sustainability, World Energy assessment.
7. Energy & Environment: A Primer for Scientists and Engineers, E H Thorndike, Addison-Wesley Publishing Company, 1976.

CE22203	**Structural Analysis and Design of Steel Structures: 4 Credits (4-0-0)**	
Unit I	Three hinged arches, cables and suspension bridges; Influence line diagram for reaction, shear and bending moment for determinate beams, arches and trusses.	10 lectures
Unit II	Deflection by moment-area, conjugate beam, and energy methods. Design of riveted, welded and bolted connections.	16 lectures
Unit III	Degree of indeterminacy and stability; Principle of superposition, Betti's Law, Castigliano's theorem; Analysis of indeterminate beams by strain-energy and virtual work methods.	10 lectures
Unit IV	Design of tension and compression members; design of columns with splicing, lacing and battening.	10 lectures
Unit V	Design of beam-column connections; Column bases, foundation; Roof trusses.	10 lectures

Books:

1. Theory and Analysis of Structure Vol. II, O.P. Jain and A S Arya, Nem Chand & Brothers, Roorkee, India, 1976.
2. Basic Structural Analysis, C.S. Reddy, Tata McGraw Hill, New Delhi, 1996.
3. Theory of Structures, Timoshenko & Young, McGraw Hill International, Singapore, 1965.

4. Steel Structures, A S Arya and J L Ajmani, Nem Chand & Brothers, Roorkee, India, 1996.
5. Design of Steel Structure, P. Dayaratnam, Wheelers Publishing, Allahabad, 2004.
6. Design of Steel Structure, Kazmi and Jindal, Prentice Hall of Inida, New Delhi, 1987.

CE22204	Design of RCC Structures: 3 Credits (2-1-0)	
Unit I	Introduction to design; Concrete and Reinforced Concrete. Philosophy of Limit State Design; Different limit states. Characteristic strengths and loads; codal provisions; design values/parameters.	6 lectures
Unit II	Design for flexure of singly and doubly reinforced rectangular beams. Design for flexure of flanged beams T and L beams.	6 lectures
Unit III	Design of beams for shear, torsion, development and bond, control of deflections in beams and slabs.	6 lectures
Unit IV	One way, Two way and Continuous slabs.	5 lectures
Unit V	Axially loaded short and long columns. Uniaxial bending of columns, Isolated footings.	5 lectures

Books:

1. Limit State Design of Reinforced Concrete, 2nd Edition, P C Varghese, Prentice Hall of India, New Delhi, 2002.
2. Reinforced Concrete Design, 2nd Edition, S Unnishrishna Pillai and Davdas Menon, Tata McGraw Hill, New Delhi, 2003.
3. Design of Reinforced Concrete Design, N Subramanian, Oxford University Press, New Delhi, 2013.
4. Limit State Design of Reinforced Concrete, B C Punmia, Ashok K. Jain and Arun K Jain, Laxmi Publications, Delhi, 2007.
5. IS: 456-2000, Code of Practice for Plain and Reinforced Concrete, BIS, New Delhi.
6. SP 16 Design Aids to IS 456 1978, BIS, New Delhi.
7. SP 24 Explanatory Handbook on IS 456 Code of Practice for Plain and Reinforced Concrete, BIS, New Delhi.
8. SP 34 Handbook on Concrete Reinforcement and Detailing, BIS, New Delhi.

CE22205	Hydrology and Water Resources Engineering: 3 Credits (2-1-0)	
Unit I	Hydrological cycle - precipitation, measurement of precipitation, mass curve, hydrograph, point rainfall, depth-area-duration relationships, depth area duration curve, maximum intensity duration frequency curve. evapotranspiration and infiltration.	5 lectures
Unit II	Stream flow measurement, measurement of stage and velocity; Rainfall - runoff characteristics, rainfall runoff correlation, flow duration curve, flow mass curve.	6 lectures
Unit III	Hydrographs - definition, influencing factors and components of a hydrograph, base flow separation, effective rainfall, unit hydrograph, use and limitations.	6 lectures
Unit IV	Groundwater - forms of surface water, aquifer, aquitard, aquiclude, aquifuse; Aquifer properties, specific yield and specific retention, Darcy's law, hydraulic conductivity, transmissibility - steady flow in a well.	6 lectures
Unit V	Crops and crops season; Soil - water relationships, field capacity, consumptive use, requirement and frequency of irrigation; Canal irrigation, Canal outlets. Water logging and Canal lining. River training works.	5 lectures

Books:

1. Engineering Hydrology, Subramanya, K., Tata McGraw Hill, New Delhi, 2013.
2. Hydrology, Principles, Analysis and Design, Raghunath, H.M., New Age International, New Delhi, 2014.
3. Applied Hydrology, Chow, VT, D R Maidment and L W Mays, McGraw Hill Book Company, New York, 1988.
4. Elementary Hydrology, Singh, V.P., Prentice-Hall India, New Delhi, 1994.
5. A Text Book of Hydrology, Rani Reddi, P.J., Laxmi Publications, New Delhi ,1999.
6. Irrigation and Water Power Engineering. Punmia, B.C. and Pandey, B.B. Lal, Laxmi Publication, Delhi, 2009.
7. Irrigation Engineering, Asawa, G.L., New Age International, New Delhi, 1993.

CE22251	Computer-aided Civil Engineering Drawing: 2 Credits (0-0-4)
Unit I	Introduction to concept of drawings, Interpretation of typical drawings, Planning drawings to show information concisely and comprehensively; optimal layout of drawings and Scales; Introduction to computer aided drawing, coordinate systems, reference planes. Commands: Initial settings, Drawing aids, Drawing basic entities, Modify commands, Layers, Text and Dimensioning, Blocks. Drawing presentation norms and standards.
Unit II	SYMBOLS AND SIGN CONVENTIONS: Materials, Architectural, Structural, Electrical and Plumbing symbols. Rebar drawings and structural steel fabrication and connections drawing symbols, welding symbols; dimensioning standards MASONRY BONDS: English Bond and Flemish Bond – Corner wall and Cross walls - One brick wall and one and half brick wall.
Unit III	BUILDING DRAWING: Terms, Elements of planning building drawing, Methods of making line drawing and detailed drawing. Site plan, floor plan, elevation and section drawing of small residential buildings. Foundation plan. Roof drainage plans. Depicting joinery, standard fittings & fixtures, finishes. Use of Notes to improve clarity.
Unit IV	PICTORIAL VIEW: Principles of isometrics and perspective drawing. Perspective view of building. Fundamentals of Building Information Modelling (BIM) (3) Total 15 sessions It may be advisable to conduct Theory sessions along with Lab demonstrations. List of Drawing Experiments: 1. Buildings with load bearing walls including details of doors and windows. 09 2. Taking standard drawings of a typical two storeyed building including all MEP, joinery, rebars, finishing and other details and writing out a description of the Facility in about 500 - 700 words.
Unit V	RCC framed structures. Reinforcement drawings for typical slabs, beams, columns and spread footings. Industrial buildings - North light roof structures – Trusses. Perspective view of one and two storey buildings.

Books:

1. Civil Engineering Drawing, Subhash C Sharma & Gurucharan Singh Standard Publishers, 2005.
2. Working with AUTOCAD 2000 with updates on AUTOCAD 2001, Ajeet Singh, Tata- Mc Graw-Hill Company Limited, New Delhi, 2002.
3. AUTOCAD for Engineers and Designers, Sham Tickoo Swapna D (2009), Pearson Education.
4. Engineering Drawing and Graphics + AUTOCAD Venugopal, New Age International Pvt. Ltd., 2007.
5. Building Drawing and Detailing, Balagopal and Prabhu (1987), Spades publishing KDR building, Calicut.
6. Corresponding set of CAD Software Theory and User Manuals.
7. Civil Engineering Drawing, Malik R.S., Meo, G.S. (2009), Computech Publication Ltd New Asian.
8. A Course in Civil Engineering Drawing, Sikka, V.B. (2013), S.K. Kataria & Sons.

CE23101	Structural Analysis: 3 Credits (2-1-0)	
Unit I	Method of Consistent Deformations, Least Work and Three Moment Equations: Static and Kinematic indeterminacies, Stiffness and Flexibility Methods.	4 lectures
Unit II	Analysis of single-degree and multi-degree indeterminate beams by Method of Consistent Deformations, Least Work and Three Moment Equations, Settlement of supports.	4 lectures
Unit III	Slope Deflection Method: Slope deflection equations, Fixed end moments, Equations of equilibrium, Member end moments and shears, Analysis of continuous beams with or without settlement of supports, Frames without and with side-sways, Frames with inclined legs.	5 lectures
Unit IV	Moment Distribution Method: Member stiffness, Carryover moments, Carryover factor, Distribution factors, Basic concepts and operations in the Moment Distribution Method, Analysis of continuous beams, Frames without and with side-sways, Frames with inclined legs. Kani's Method: Rotation factors, Rotation moments, Basic operations in Kani's Method, Analysis of continuous beams with varied support conditions, Settlement of supports, Analysis of symmetric frames with line of symmetry passing through the beam or column.	7 lectures

Unit V	Two Hinged Arches and Indeterminate Trusses: Two hinged arches, Horizontal thrust, Analysis of two hinged semi-circular and segmental arches by method of least work, Parabolic arches with secant variation of Moment of inertia, Shear force, Normal thrust, and Radial shear at any point in the arch. Indeterminate Trusses: Internal and external indeterminacies, Analysis of trusses up to total two degrees of indeterminacy by method of least work. Influence Lines for Statically Indeterminate Structures: Muller Breaslau's principle and its application in drawing ILD for indeterminate structures.	8 lectures

Books:

1. Basic Structural Analysis, C S Reddy, Tata McGraw Hill, New Delhi, 1996.
2. Structural Analysis, Aslam Kassimali, PWS Publications, 1999.
3. Elementary Structural Analysis, S Utku, C H Norris and J B Wilbur, McGraw Hill Inc., Singapore, 1991.
4. Intermediate Structural Analysis, C K Wang, McGraw Hill International, Singapore, 1983.
5. Structural Analysis, R C Hibbeler, Pearson Education, New Delhi, 2008.
6. Structural Analysis, A Ghali and A M Neville, Chapman and Hall, London, 1989.
7. Structural Analysis, Coates, Cutie and Kong, ELBS, London, 1987.
8. Theory of Structures, Timoshenko and Young, McGraw Hill NY, 1965.
9. Elementary Theory of Structures, Yuan-Yu Hseieh and S T Mau, Prentice Hall Inc, NJ, 1995.
10. Fundamentals of Structural Analysis, 4th Edition, Kenneth M Leet, Chia-Ming Uang and Anee M Gulbert, McGraw-Hill International Edition, New York, 2011.

CE23102	**Geotechnical Engineering – II: 3 Credits (2-0-2)**	
Unit I	Soil exploration: purpose and planning, boring methods, soil sampling, observation of ground water tables, standard penetration tests, cone penetration tests, coring of rocks, geophysical exploration.	5 lectures
Unit II	Slope stability analysis: infinite and finite slopes, earth and rockfill dams, filter criteria.	5 lectures
Unit III	Lateral earth pressure: introduction, earth pressure at rest, active and passive earth pressures, Rankine's and Coulomb's theories, graphic solution for Coulomb's active earth pressure, cantilever and anchored sheet pile walls, braced cuts.	5 lectures
Unit IV	Shallow-foundations: bearing capacity: general concepts, Terzaghi's theory, effect of groundwater table, the general bearing capacity equation, eccentrically loaded foundations, plate load tests, foundation settlements.	5 lectures
Unit V	Deep foundations: Piles, types, bearing capacity of single pile and pile groups, pile load tests, settlement of piles, negative skin friction; Shaft and caisson foundations. Foundations on expansive soils; Elements of machine foundations; Laterally loaded piles- Cantilever method.	8 lectures

Books:

1. Day, Robert W., Geotechnical and Foundation Engineering: Design and Construction ISBN-13: 978-0071341387, ISBN-10: 0071341382, McGraw-Hill Professional; 1st edition (1999).
2. Murthy V.N.S, Textbook of Soil Mechanics and Foundation Engineering, ISBN: 9788123913629, 9788123913629, CBS Publishers & Distributors; 1st edition (2008).
3. Singh Alam, Soil Engineering in Theory and Practice, Vol 1, Fundamentals and General Principles, CBS Publishers & Distributors; 4th edition (2002).
4. Coduto Donald P., Geotechnical Engineering: Principles and Practices, Prentice Hall. Inc., 2nd edition (2010).
5. Das B. M., Sivakugan Nagaratnam, Principles of Foundation Engineering, Cengage Learning; 9th edition (2018), ISBN-10: 9781337705028, ISBN-13: 978-1337705028, ASIN: 1337705020.
6. Cernica John N., Geotechnical Engineering: Soil Mechanics and Foundation Design, John Wiley & Sons (1997), ISBN-10: 0471168742, ISBN-13: 978-0471168744.
7. Sutton, B. H. C., Solving Problems in Soil Mechanics, Prentice Hall; 2nd edition (1993) ISBN-10: 0582089719, ISBN-13: 978-0582089716.
8. Head, K. H., Manual of Soil Laboratory Testing, Vol. I, II, & III, John Wiley & Sons (1996).
9. Saran Swami, Analysis and Design of Sub-Structures: Limit state Design, CRC Press (2006).

CE23103	Environmental Engineering – II: 3 Credits (2-0-2)	
Unit I	Biological & physico-chemical principles in environmental Engineering, reaction kinetics - elementary reactions, rates of reactions, stoichiometry of reactions, homogeneous and heterogeneous reactions, biochemical reactions. Mass balance relationships - point form of continuity equation, mass balance equation, classification of reactor types, reactor dynamics, development of mathematical model for ideal reactors, field reactors.	7 lectures
Unit II	Design of water treatment facilities: principles & design of primary settling tanks, tube settlers, rapid mixing unit, flocculates, rapid sand filter and disinfection unit, design of distribution system.	6 lectures
Unit III	Design of wastewater treatment facilities: aerobic – principle & design of activated sludge process, trickling filter, aerated lagoons, oxidation ditches, oxidation ponds, fish ponds and maturation ponds, rotating biological contactors; Anaerobic - Anaerobic digesters, anaerobic filters, UASB reactors & hybrid reactors.	7 lectures
Unit IV	Solid wastes – classification and characteristics, principle of solid waste management, collection, handling and disposal of solid wastes.	4 lectures
Unit V	Air pollution and its control: air pollutants, their standards, methods & equipment for control of air pollutants; Environmental impact assessment: introduction, principles & methods of EIA, environmental legislation.	4 lectures

Books:

1. Environmental Engineering, H.S. Peavy, D.R. Rowe & G. Tachobanoglous, McGraw Hill International, New York, 2017.
2. Environmental Engineering, G. Kiely, Tata McGraw Hill Education Private Limited, New Delhi, 2009.
3. Chemistry for Environmental Engineering, Sawyer, C.N., McCarty, P.L., Parkin, G.F., Tata McGraw-Hill, 2003.
4. Wastewater Treatment Concept and Design Approach: G. L. Karia & R. A. Christian, PHI, N. Delhi, 2017.
5. Wastewater Treatment for Pollution Control and Reuse, S. J. Arceivala, Asolekar, Tata McGraw Hill, New Delhi, 2017.
6. Wastewater Engineering: Treatment, Disposal & Reuse, (4e), Metcalf & Eddy, Tata McGraw Hill, New Delhi, 2017.
7. Wastewater Treatment Plants: Planning, Design & Operation, S.R. Qasim, CRC Press, Book World Enterprises, Mumbai, 2010.
8. 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.
9. Management of Organic Waste: Sunil Kumar & Ajay Bharti, INTECH.
10. Air Pollution & its Control, Perkins, McGraw-Hill, New York, 1986.
11. Methods of Environmental Impact Assessment, Peter Moris and Riki Therivel, UCL Press, London, 1995.
12. Environmental Impact Assessment: Canter, McGraw Hill Education Private Limited, New Delhi, 2014.

CE23104	Transportation Engineering – II: 3 Credits (2-0-2)	
Unit I	Highway capacity and Level of Service concepts, characteristics of uninterrupted traffic, capacity and LOS of Uninterrupted facilities, PCU.	6 lectures
Unit II	Characteristics of interrupted traffic, design of signalized intersections-operation, regulation, conflict area, capacity and LOS of signalized intersections, signal coordination.	4 lectures
Unit III	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.	6 lectures
Unit IV	Airport Engineering: terminal area concept; Runway cross-section details, orientation, length fixation, practical difficulties and corrections; Runway geometric design, taxiway and apron arrangement, basic runway patterns and runway numbering.	6 lectures
Unit V	Highway Pavements: types, components, structural action, design considerations.	6 lectures

Books:

1. Transportation Engineering and Planning, C.S. Papacostas, Prentice-Hall India, 2001.
2. Principles of Transportation Engineering, P. Chakroborty and A. Das, Prentice Hall of India Pvt. Ltd., 2003.
3. Traffic Engineering: Transport Planning, L. R. Kadiyali, Khanna Publishers, Delhi 2011.
4. Highway Engineering, S K Khanna, C E G Justo and A. Veeraraghavan, Nem Chand & Brothers, Roorkee, India, 2015.
5. Highway Engineering, R Srinivasa Kumar, Universities Press, Hyderabad India, 2011.
6. Airport: Planning & Design, Khanna & Arora, Nem Chand & Brothers, Roorkee, India, 1990.

CE23105	**Materials Testing and Evaluation: 3 Credits (1-1-2)**	
Unit I	Introduction to Engineering Materials covering, Cements, M-Sand, Concrete (plain, reinforced and steel fibre/ glass fibre-reinforced, light-weight concrete, High Performance Concrete, Polymer Concrete).	3 lectures
Unit II	Ceramics, and Refractories, Bitumen and asphaltic materials, Timbers, Glass and Plastics, Structural Steel and other Metals, Paints and Varnishes, Acoustical material and geo-textiles, rubber and asbestos, laminates and adhesives, Graphene, Carbon composites and other engineering materials including properties and uses of these.	3 lectures
Unit III	Introduction to Material Testing covering, what is the “Material Engineering”? Mechanical behavior and mechanical characteristics; Elasticity – principle and characteristics; Plastic deformation of metals; Tensile test – standards for different material (brittle, quasi-brittle, elastic and so on) True stress – strain interpretation of tensile test.	2 lectures
Unit IV	hardness tests; Bending and torsion test; strength of ceramic; Internal friction, creep – fundaments and characteristics; Brittle fracture of steel – temperature transition approach; Background of fracture mechanics; Discussion of fracture toughness testing – different materials; concept of fatigue of materials; Structural integrity assessment procedure and fracture mechanics.	3 lectures
Unit V	Standard Testing & Evaluation Procedures covering, Laboratory for mechanical testing; Discussion about mechanical testing; Naming systems for various irons, steels and nonferrous metals; Discussion about elastic deformation; Plastic deformation; Impact test and transition temperatures; Fracture mechanics – background; Fracture toughness – different materials; Fatigue of material; Creep.	3 lectures

Books:

1. Building Construction Handbook (6th ed.), Chudley, R., Greeno, R. ButterworthHeinemann.
2. Highway Materials and Pavement Testing, Khanna, S.K., Justo, C.E.G and Veeraragavan, A, ' Nem Chand& Bros, Fifth Edition.
3. Various related updated & recent standards of BIS, IRC, ASTM, RILEM, AASHTO, etc. corresponding to materialsused for Civil Engineering applications.
4. Mechanical Testing of Engineering Materials, Kyriakos Komvopoulos (2011), Cognella.
5. Mechanical Behaviour of Materials, E.N. Dowling (1993), Prentice Hall International Edition.
6. Annual Book of ASTM Standards, American Society for Testing and Materials (ASTM).
7. Related papers published in international journals.

CE23106	**Disaster Preparedness and Planning: 2 Credits (1-1-0)**	
Unit I	Introduction - concepts and definitions: disaster, hazard, vulnerability, risksseverity, frequency and details, capacity, impact, prevention, mitigation).	2 lectures
Unit II	Disasters - classification; natural disasters (floods, draught, cyclones, volcanoes, earthquakes, tsunami, landslides, coastal erosion, soil erosion, forest fires etc.); manmade disasters (industrial pollution, artificial flooding in urban areas, nuclear radiation, chemical spills, transportation accidents, terrorist strikes, etc.); hazard and vulnerability profile of India, mountain and coastal areas, ecological fragility.	3 lectures

Unit III	Disaster Impacts - Disaster impacts (environmental, physical, social, ecological, economic, political, etc.); health, psycho-social issues; demographic aspects (gender, age, special needs); hazard locations; global and national disaster trends; climate change and urban disasters.	3 lectures
Unit IV	Disaster Risk Reduction (DRR) - Disaster management cycle – its phases; prevention, mitigation, preparedness, relief and recovery; structural and non-structural measures; risk analysis, vulnerability and capacity assessment; early warning systems, Postdisaster environmental response (water, sanitation, food safety, waste management, disease control, security, communications); Roles and responsibilities of government, community, local institutions, NGOs and other stakeholders; Policies and legislation for disaster risk reduction, DRR programmes in India and the activities of National Disaster Management Authority.	4 lectures
Unit V	Environment and Development - Factors affecting vulnerability such as impact of developmental projects and environmental modifications (including of dams, landuse changes, urbanization etc.), sustainable and environment friendly recovery; reconstruction and development methods.	2 lectures

Books:

1. http://ndma.gov.in/ (Home page of National Disaster Management Authority), http://www.ndmindia.nic.in/ (National Disaster management in India, Ministry of Home Affairs).
2. Pradeep Sahni, 2004, Disaster Risk Reduction in South Asia, Prentice Hall.
3. Singh B.K., 2008, Handbook of Disaster Management: Techniques & Guidelines, Rajat Publication.
4. Ghosh G.K., 2006, Disaster Management, APH Publishing Corporation.
5. Disaster Medical Systems Guidelines. Emergency Medical Services Authority, State of California, EMSA no. 214, June 2003 7.
6. Inter Agency Standing Committee (IASC) (Feb. 2007). IASC Guidelines on Mental Health and Psychosocial Support in Emergency Settings. Geneva: IASC.

CE23201	**Construction Engineering and Management: 2 Credits (2-0-0)**	
Unit I	Basics of Construction- Unique features of construction, construction projectstypes and features, phases of a project, agencies involved and their methods of execution.	4 lectures
Unit II	Construction project planning- Stages of project planning: pre-tender planning, pre-construction planning, detailed construction planning, role of client and contractor, level of detail. Process of development of plans and schedules, work break-down structure, activity lists, assessment of work content, concept of productivities, estimating durations, sequence of activities, activity utility data; Techniques of planning- Bar charts, Gantt Charts. Networks: basic terminology, types of precedence relationships, preparation of CPM networks: activity on link and activity on node representation, computation of float values, critical and semi critical paths, calendaring networks. PERT- Assumptions underlying PERT analysis, determining three time estimates, analysis, slack computations, calculation of probability of completion.	6 lectures
Unit III	Construction Methods basics: Types of foundations and construction methods; Basics of Formwork and Staging; Common building construction methods (conventional walls and slabs; conventional framed structure with blockwork walls; Modular construction methods for repetitive works; Precast concrete construction methods; Basics of Slip forming for tall structures; Basic construction methods for steel structures; Basics of construction methods for Bridges.	7 lectures
Unit IV	Construction Equipment basics: Conventional construction methods Vs Mechanized methods and advantages of latter; Equipment for Earthmoving, Dewatering; Concrete mixing, transporting & placing; Cranes, Hoists and other equipment for lifting; Equipment for transportation of materials. Equipment Productivities.	6 lectures

Unit V	Planning and organizing construction site and resources- Site: site layout including enabling structures, developing site organization, Documentation at site; Manpower: planning, organizing, staffing, motivation; Materials: concepts of planning, procurement and inventory control; Equipment: basic concepts of planning and organizing; Funds: cash flow, sources of funds; Histograms and S-Curves. Earned Value; Resource Scheduling- Bar chart, line of balance technique, resource constraints and conflicts; resource aggregation, allocation, smoothening and leveling. Common Good Practices in Construction.	5 lectures

Books:

1. Building Construction Varghese, P.C., Prentice Hall India, 2007.
2. National Building Code, Bureau of Indian Standards, New Delhi, 2017.
3. Construction Technology, Chudley, R., ELBS Publishers, 2007.
4. Construction Planning, Methods and Equipment, Peurifoy, R.L. McGraw Hill, 2011.
5. Construction Methods and Management, Nunnally, S.W. Prentice Hall, 2006.
6. Construction Project management, Theory & Practice, Jha, Kumar Neeraj, Pearson Education India, 2015.
7. Project Planning with PERT and CPM, Punmia, B.C., Khandelwal, K.K., Laxmi Publications, 2016.

CE24101	**Engineering Economics and Estimation: 3 Credits (2-1-0)**	
Unit I	Basic Principles and Methodology of Economics. Demand/Supply – elasticity – Government Policies and Application. Theory of the Firm and Market Structure. Basic Macro-economic Concepts (including GDP/GNP/NI/Disposable Income) and Identities for both closed and open economies. Aggregate demand and Supply (IS/LM). Price Indices (WPI/CPI), Interest rates, Direct and Indirect Taxes. Public Sector Economics – Welfare, Externalities, Labour Market. Components of Monetary and Financial System, Central Bank – Monetary Aggregates; Commercial Banks & their functions; Capital and Debt Markets. Monetary and Fiscal Policy Tools & their impact on the economy – Inflation and Phillips Curve.	6 lectures
Unit II	Elements of Business/Managerial Economics and forms of organizations. Cost & Cost Control – Techniques, Types of Costs, Lifecycle costs, Budgets, Break even Analysis, Capital Budgeting, Application of Linear Programming. Investment Analysis – NPV, ROI, IRR, Payback Period, Depreciation, Time value of money (present and future worth of cash flows). Business Forecasting – Elementary techniques. Statements – Cash flow, Financial. Case Study Method. Indian economy - Brief overview of post-independence period – plans. Post reform Growth, Structure of productive activity. Issues of Inclusion – Sectors, States/Regions, Groups of people (M/F), Urbanization. Employment– Informal, Organized, Unorganized, Public, Private. Challenges and Policy Debates in Monetary, Fiscal, Social, External sectors.	6 lectures
Unit III	Estimation / Measurements for various items- Introduction to the process of Estimation; Use of relevant Indian Standard Specifications for the same, taking out quantities from the given requirements of the work, comparison of different alternatives, Bar bending schedules, Mass haul Diagrams, Estimating Earthwork and Foundations, Estimating Concrete and Masonry, Finishes, Interiors, MEP works; BIM and quantity take-offs; adding equipment costs; labour costs; rate analysis; Material survey-Thumb rules for computation of materials requirement for different materials for buildings, percentage breakup of the cost, cost sensitive index, market survey of basic materials. Use of Computers in quantity surveying	5lectures
Unit IV	Specifications – Types, requirements and importance, detailed specifications for buildings, roads, minor bridges and industrial structures. Rate analysis – Purpose, importance and necessity of the same, factors affecting, task work, daily output from different equipment/ productivity.	5 lectures

Unit V	Tender – Preparation of tender documents, importance of inviting tenders, contract types, relative merits, prequalification. general and special conditions, termination of contracts, extra work and Changes, penalty and liquidated charges, Settlement of disputes, R.A. Bill & Final Bill, Payment of advance, insurance, claims, price variation, etc. Preparing Bids- Bid Price buildup: Material, Labour, Equipment costs, Risks, Direct & Indirect Overheads, Profits; Bid conditions, alternative specifications; Alternative Bids. Bid process management. Introduction to Acts pertaining to – Minimum wages, Workman's compensation, Contracts, Arbitration, Easement rights.	6 lectures

Books:

1. Principles of Economics, Mankiw Gregory N. (2002), Thompson Asia.
2. Managerial Economics, Mote, S. Paul, G. Gupta (2004), Tata McGraw Hill.
3. Indian Economy, Misra, S.K. and Puri (2009), Himalaya.
4. Textbook of Business Economics, Pareek Saroj (2003), Sunrise Publishers.
5. Estimating, Costing Specifications & Valuation M Chakravarty.
6. Handbook of Construction Management, Joy P K, Macmillan.
7. Building & Engineering Contracts, B.S. Patil.
8. Relevant Indian Standard Specifications.
9. World Bank Approved Contract Documents.
10. FIDIC Contract Conditions.
11. Acts Related to Minimum Wages, Workmen's Compensation, Contract, and Arbitration.
12. Estimating and Costing in Civil Engineering: Theory and Practice including Specification and Valuations.
13. Estimating and Costing in Civil Engineering, Dutta, B.N., (Theory & Practice), UBS Publishers, 2016.

CE24102	**Engineering Geology: 3 Credits (2-0-2)**	
Unit I	Basic principles of geology, origin of earth – various theories, structure of earth crust, evidences, age of earth.	6 lectures
Unit II	Rocks: Primary classification, texture and structure of igneous, sedimentary and metamorphic rocks; Rock forming minerals – physical properties, their engineering significance.	6 lectures
Unit III	Weathering and erosion, soil formation conservation and erosion control, geological works by wind, water and glaciers and their resulting features;	6 lectures
Unit IV	Structural geology-bed, dip, strike, folds, faults, joints and unconformity; Rocks as a construction material; Geophysical investigations – principles and methods, Earthquakes and landslides.	6 lectures
Unit V	Aquifers and underground water; Selection of site for dams, reservoir, tunnels and highways, Geological mapping; related practices, Introduction to remote sensing.	4 lectures

Books:

1. A Geology for Engineers, Blyth, FGH and de Freitas, M.H., ELBS, 8/e.
2. Engineering Geology, F. G. Bell, Butterworth-Heinemann (Elsevier) 2/e, 2007.
3. A Text Book of Engineering & General Geology, Praveen Singh, S.K. Kataria & Sons, Ludhiana, 1990.
4. A Text Book of Geology, P. K. Mukherjee, The World Press Private Limited, Kolkata, 1990.
5. Engineering Geology for Civil Engineers, D. Venkat Reddy, Oxford & IBH, New Delhi, 1995.
6. Structural Geology, M P Billings, Prentice Hall of India, New Delhi, 1972.

CE23001	**Pavements Materials: 3 Credits (3-0-0)**	
Unit I	Road making aggregates – classification, properties of aggregates, design of aggregate gradation.	10 lectures
Unit II	Bituminous road binders – penetration grade, emulsions, cut backs and modified binders; rheology of bituminous binders, modified binders.	12 lectures
Unit III	Mix design – Marshall method and Superpave procedure; design of emulsified mixes, visco-elastic and fatigue properties of bituminous mixtures, resilient modulus of pavement materials.	10 lectures

Unit IV	Requirements of paving concrete, design of mixes for recycling of bituminous and concrete pavement surfaces.	6 lectures
Unit V	Soil stabilization techniques.	4 lectures

Books:

1. A. G. Correia, Flexible Pavements, A. A. Balkema Publishers, 1996.
2. P. H. Wright, Highway Engineering, John Wiley & Sons, 1996.
3. S. K. Khanna, C. E. G. Justo and A. Veeraragavan, Highway Materials and Pavement Testing, New Chand & Bros., 2013.
4. G. N. Durhan, W. A. Marr, and W. L. DeGroff, Resilient Modulus Testing for Pavement Components, ASTM International, U.S.A., 2003.
5. S. E. Zoorob, A. C. Collop, and S. F. Brown, Performance of Bituminous and Hydraulic Materials in Pavements, CRC Press, 2002.
6. R. N. Hunter, Bituminous Mixtures in Road Construction, Thomas Telford Services Ltd., 1995.
7. ASTM, Annual Book of ASTM Standards – Section IV, Vol. 04.03, ASTM International, 2002.
8. D. Croney, and P. Croney, Design and Performance of Road Pavements, McGraw- Hill, 1998.

CE23002	**Pavement Design: 3 Credits (3-0-0)**	
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

Books:

1. A. G. Correia, Flexible Pavements, A. A. Balkema Publishers, 1996.
2. P. H. Wright, Highway Engineering, John Wiley & Sons, 1996.
3. S. K. Khanna, C. E. G. Justo and A. Veeraragavan, Highway Materials and Pavement Testing, New Chand & Bros., 2013.
4. G. N. Durhan, W. A. Marr, and W. L. DeGroff, Resilient Modulus Testing for Pavement Components, ASTM International, U.S.A., 2003.
5. S. E. Zoorob, A. C. Collop, and S. F. Brown, Performance of Bituminous and Hydraulic Materials in Pavements, CRC Press, 2002.
6. R. N. Hunter, Bituminous Mixtures in Road Construction, Thomas Telford Services Ltd., 1995.
7. ASTM, Annual Book of ASTM Standards – Section IV, Vol. 04.03, ASTM International, 2002.
8. D. Croney, and P. Croney, Design and Performance of Road Pavements, McGraw- Hill, 1998.
9. Principles of Pavement Design, E.T. Yoder and M.W. Hitczak, John Wiley and Sons Inc, NY, 1975.
10. Highway Engineering, S K Khanna, C E G Justo and A. Veeraraghavan, Nem Chand & Brothers, Roorkee, India, 2015.
11. Pavement Analysis and Design (2nd Edition) Edition by Huang, Yang H. Prentice Hall, 2003.
12. Pavement Design: R Srinivasa Kumar, Universities Press, Hyderabad India, 2013.
13. Soil Engineering in Theory and Practice Vol 1: Fundamentals and General Principles, Alam Singh & G R Chowdhuri, CBS, ND, 1994.
14. IRC: 37-2012, Guidelines for the design of Flexible Pavement (Third revision). Indian Roads Congress.
15. IRC: 58-2015, Guidelines for the design of plain jointed rigid pavements for highways (fourth revision). Indian Roads Congress.

CE23003	**Public Transportation System Planning: 3 Credits (3-0-0)**	
Unit I	Modes of public transportation and application of each to urban travel needs, comparison of transit modes and selection of technology for transit service.	10 lectures

Unit II	Transit planning, estimating demand in transit planning studies, demand modeling.	6 lectures
Unit III	development of generalized cost, RP & SP data and analysis techniques.	6 lectures
Unit IV	Functional design and costing of transit routes, models for planning of transit routes, scheduling; management and operations of transit systems.	10 lectures
Unit V	Integrated public transport planning; operational, institutional, and physical integration; models for integrated planning; case studies.	10 lectures

Books:

1. Vuchic Vukan R., Urban Transit: Operations, Planning and Economics, Wiley, 2005.
2. Gray G. E., and Hoel L. A., Public Transportation, Prentice Hall, 1992.
3. Tyler N., Accessibility and the Bus System – Concepts and Practice, Thomas Telford, 2002.
4. Tiwari G., Urban Transport for Growing Cities – High Capacity Bus System, MacMillan India Ltd., 2002.

CE23004	**Traffic Engineering and Management: 3 Credits (3-0-0)**	
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, design of signalized intersections, capacity and LOS of signalized intersections, actuated signal control, signal coordination.	10 lectures
Unit III	Traffic Analysis and Management: Capacity and Level of Service concepts, Queuing models and applications, Basics of traffic management.	6 lectures
Unit IV	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.	6 lectures
Unit V	Design of parking, lighting and terminal facilities, simulation of traffic systems, statistics and probability in traffic engineering, trends in traffic engineering.	10 lectures

Books:

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

CE23005	**Urban Transportation Planning: 3 Credits (3-0-0)**	
Unit I	Introduction to transportation planning; Urban Travel and Transportation Systems Characteristics, systems approach to transportation planning; types of models; 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.	12 lectures
Unit II	Travel Demands Forecasting; four-stage sequential modeling approach.	6 lectures
Unit III	Trip generation; trip distribution; modal split; trip assignment.	6 lectures
Unit IV	Transport Behavior of Individuals and Households, land use-transport models; public transport planning, integration of different modes.	10 lectures
Unit V	Travel demand management measures; case studies. Introduction to Urban Freight Transportation and Urban Mass Transportation Systems.	8 lectures

Books:

1. Modelling Transport, J. de D. Ortuzar and L.G. Willumsen, John Wiley and Sons, 2001.
2. Transportation Engineering - An Introduction, C.J. Khisty and B.K. Lall, Prentice Hall of India Pvt. Ltd., 2002.
3. Transportation Engineering and Planning, C. S. Papacostas and P. D. Prevedouros, Prentice Hall of India Pvt. Ltd., 2001.
4. Principles of Transportation Engineering, P. Chakroborty and A. Das, Prentice Hall of India Pvt. Ltd., 2003.
5. Principles of Urban Transport Systems Planning, B.G. Hutchinson, McGraw- Hill Book Co., New York, 1974.
6. Traffic Engineering and Transport Planning, L.R. Kadiyali, Khanna Publishers, New Delhi, 2000.
7. Public Transportation, G. E. Gray and L. A. Hoel, Prentice Hall, New Jersey, 1992.

CE23006	**Geometric Design of Highways and Transportation Facilities: 3 Credits (3-0-0)**	
Unit I	Geometric design provisions for various transportation facilities as per AASHTO, IRC and other guidelines.	10 lectures
Unit II	Discussion of controls governing geometric design, route layout and selection, elements of design – sight distances, horizontal alignment, transition curves, super elevation and side friction; vertical alignment: grades, crest and sag curves.	10 lectures
Unit III	Highway crosssectional elements and their design for rural highways, urban streets and hill roads; at-grade inter-sections – sight distance consideration and principles of design, channelisation, mini round-abouts, layout of round-abouts.	8 lectures
Unit IV	Inter-changes: major and minor interchanges, entrance and exit ramps, acceleration and deceleration lanes.	4 lectures
Unit V	Bicycle and pedestrian facility design; parking layout and design; terminal layout and design.	10 lectures

Books:

1. M. Rogers, Highway Engineering, Wiley-Blackwell Publishing, 2008.
2. P. H. Wright, Highway Engineering, John Wiley & Sons, 1996.
3. C. H. Oglesby, and R. G. Hicks, Highway Engineering, John Wiley & Sons, 1982.
4. R. L. Brockenbrough, and K. J. Boedecker, Highway Engineering, 2nd Ed., McGraw-Hill, 2019.

CE23007	**Intelligent Transportation Systems: 3 Credits (3-0-0)**	
Unit I	Introduction to Intelligent Transportation Systems (ITS) – Definition of ITS and Identification of ITS Objectives, Historical Background, Benefits of ITS – ITS Data collection techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic Information Systems (GIS), video data collection.	10 lectures
Unit II	Telecommunications in ITS – Importance of telecommunications in the ITS system, Information Management, Traffic Management Centres (TMC). Vehicle – Road side communication – Vehicle Positioning System ITS functional areas – Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control Systems (AVCS), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS).	10 lectures
Unit III	ITS User Needs and Services – Travel and Traffic management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, Advanced Vehicle safety systems, Information Management.	10 lectures
Unit IV	Automated Highway Systems – Vehicles in Platoons – Integration of Automated Highway Systems.	6 lectures
Unit V	ITS Programs in the World – Overview of ITS implementations in developed countries, ITS in developing countries.	6 lectures

Books:

1. ITS Hand Book 2000: Recommendations for World Road Association (PIARC) by Kan Paul Chen, John Miles.
2. Sussman, J. M., Perspective on ITS, Artech House Publishers, 2005.
3. National ITS Architecture Documentation, US Department of Transportation, 2007 (CD-ROM).

CE23011	**Construction Productivity: 3 Credits (3-0-0)**	
Unit I	Definition of Productivity, Impact of productivities on construction duration and costs; Measuring productivities of construction equipment, Staff and Labour and typical benchmarks for the same; Productivity analysis from Daily Progress Reports.	12 lectures
Unit II	Lean Construction concepts of Value Adding activities, Non-Value Adding Activities and Non-Value Adding but Necessary Activities.	8 lectures
Unit III	Productivity measurements by special Lean Construction-oriented field methods such as Work Sampling, Task time analysis.	6 lectures
Unit IV	Foreman Delay Surveys; Productivity improvement measures such as Value Stream Mapping, Location-Based management Systems, 5S, good Housekeeping, etc.	8 lectures
Unit V	Use of specialist software such as Vico for productivity studies.	8 lectures

Books:

1. Construction project management: planning, scheduling and controlling, K.K. Chitkara, Tata McGraw-Hill, 2008.
2. Decision support system and Intelligent systems, E. Turban and J.E. Aronson, Prentice Hall of India, 2003.
3. Data warehousing fundamentals: A comprehensive guide for IT professionals, P. Ponniah, John Wiley & Sons Inc. 2001.
4. Management information system, S. Sadagopan, Prentice Hall of India, 1997.
5. Computer Network, S. Tanenbaum, Prentice Hall of India, 2003.
6. Engineering Economics, Panneerselvam, R., Prentice Hall of India Private Limited New Delhi.
7. Operations Research – An Introduction, Taha, Hamdy A., Prentice Hall of India Private Limited New Delhi, 2006.
8. Heavy Construction Planning, Equipment and Methods, Jagman Singh, Oxford & IBH Publishing Co., New Delhi, 1997.
9. Quantitative Techniques in Management, Vohra, N.D., Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 1990.

CE23012	**Building Construction Practice: 3 Credits (3-0-0)**	
Unit I	Specifications, details and sequence of activities and construction co-ordination, site clearance, marking earthwork.	4 lectures
Unit II	Masonry, stone masonry, bond in masonry, concrete hollow block masonry, flooring, damp proof courses, construction joints, movement and expansion joints, pre cast pavements.	10 lectures
Unit III	Building foundations, basements, temporary shed, centering and shuttering, slip forms, scaffoldings, de-shuttering forms, Fabrication and erection of steel trusses, frames, braced domes, laying brick, Weather and water proof, roof finishes, acousticand fire protection	12 lectures
Unit IV	Sub-structure construction: techniques of box jacking, pipe jacking, under water construction of diaphragm walls and basement, Tunnelling techniques, Piling techniques, well and caisson, sinking, cofferdam, cable anchoring and grouting, driving diaphragm walls.	8 lectures
Unit V	Super Structure Construction - Launching girders, bridge decks, off shore platforms - special sheet piles - shoring for deep cutting - well points - Dewatering and stand by Plant equipment for underground open excavation. Prerequisite forms for shells - techniques for heavy decks - in-situ pre-stressing	8 lectures

	in high rise structures, Material handling - erecting light weight components on tall structures - Support structure for heavy Equipment and conveyors - Erection of articulated structures, braced domes and space decks.	

Books:

1. A Text Book of Building Construction, S.P. Arora, and S.P. Bindra, Dhanpat Rai Publications, New Delhi, 2005.
2. Building Constructions, Varghese, P.C., Prentice Hall, 2007.
3. Building Construction, Sharma & Kaul, S. Chand & Company Pvt, New Delhi, 1998.
4. Construction Equipment and Management, Sharma S.C. Khanna Publishers, New Delhi, 2013.
5. Management in Construction Industry, Dharwadkar, P.P., Oxford IBH, New Delhi, 1992.
6. Construction Project Planning and Scheduling, Patrick, C., Pearson, 2012.
7. Related IS Codes.
8. Related CPWD Publications.

CE23013	**Construction Project Planning and System: 3 Credits (3-0-0)**	
Unit I	Definition of Projects; stages of project planning: pre-tender planning, pre-construction planning, detailed construction planning, role of client and contractor, level of detail. Process of development of plans and schedules, work break-down structure, activity lists, assessment of work content, concept of productivities, estimating durations, sequence of activities, activity utility data; Techniques of planning - Bar charts, Gantt Charts.	7 lectures
Unit II	Networks: basic terminology, types of precedence relationships, preparation of CPM networks: activity on link and activity on node representation, computation of float values, critical and semi critical paths, calendaring networks. PERT-Assumptions underlying PERT analysis, determining three time estimates, analysis, slack computations, calculation of probability of completion.	8 lectures
Unit III	Allocation of resources, materials, equipment, staff, labour and finance, resource levelling and optimal schedules, project orgabnisation, documentation and reporting systems. control & monitoring; temporary structures in construction; construction methods for various types of structures; Major Construction equipment; Automation & Robotics in Construction; Modern Project management Systems; Advent of Lean Construction; Importance of Contracts Management; Planning and organizing construction site and resources- Site: site layout including enabling structures, developing site organization, Documentation at site; Manpower: planning, organizing, staffing, motivation.	12 lectures
Unit IV	Materials: concepts of planning, procurement and inventory control; Equipment: basic concepts of planning and organizing; Funds: cash flow, sources of funds; Histograms and S-Curves. Earned Value; Resource Scheduling- Bar chart, line of balance technique, resource constraints and conflicts; resource aggregation, allocation, smoothening and levelling. Common Good Practices in Construction; Project Monitoring & Control - Supervision, record keeping, periodic progress reports, periodical progress meetings.	8 lectures
Unit V	Updating of plans: purpose, frequency and methods of updating. Common causes of time and cost overruns and corrective measures. Basics of Modern Project management systems such as Lean Construction; Use of Building Information Modelling (BIM) in project management; Quality control: concept of quality, quality of constructed structure, use of manuals and checklists for quality control, role of inspection, basics of statistical quality control. Safety, Health and Environment on project sites: accidents; their causes, effects and preventive measures, costs of accidents, occupational health problems in construction, organizing for safety and health.	7 lectures

Books:

1. Project Management, S. Chowdary, TMH, 1998.
2. Total Project Management (12e), P. K. Joy, Macmillan.
3. Project Planning Analysis (7e), P. Chandra, TMH, 2009.
4. Principles of Construction Management, Roy Pilcher, McGraw-Hill Companies, 1992.
5. Project Management in Construction, Walker Antony, Wiley-Blackwell, 2015.
6. Building Constructions, P.C. Varghese, Prentice Hall, 2007.
7. Building Construction, Sharma & Kaul, S. Chand & Company Pvt. Ltd., New Delhi, 1998.
8. Construction Equipment and Management, S.C. Sharma, Khanna Publishers, New Delhi, 2013.
9. Management in Construction Industry, P. P. Dharwadkar, Oxford IBH, New Delhi, 1992.
10. Construction Project Planning and Scheduling, C. Patrick, Pearson, 2012.
11. CPM in Construction Management, J.O. Brien, and F.L. Plotnick, Mcgraw Hill, 2010.
12. Project Planning and control with PERT and CPM, B.C. Punmia, and K.K. Khandelwal, Laxmi Publications, 2002.
13. Construction Project Planning and Scheduling, Charles, Patrick, Pearson Education.
14. Construction Planning, R.L Peurifoy, and J. Clifford Schexnayder, Equipment and Methods, T.M.H., International Book Company.
15. Engineering Economics, R. Panneerselvam, (2e), Prentice- Hall of India Private Limited New Delhi, 2013.
16. A management Guide to PERT/ CPM: with GERT/PDM/DCPM and other Networks, Wiest, D. Jerome and K. Ferdinanad Levy, Prentice Hall of India Private Limited, New Delhi, 2016.
17. Construction Engineering and Management, (4e), S. Seetharaman, Umesh Publications New Delhi, 1999.

CE23014	**Advanced Concrete Technology for Construction: 3 Credits (3-0-0)**	
Unit I	Cement: Hydration products of cement, Microstructure of hydrated cement paste (hcp), Transition zone, effects of microstructures of hcp on engineering properties of concrete; Structure of concrete, Fracture mechanics of concrete, Future trend of development in concrete.	8 lectures
Unit II	Mix Proportioning of high strength concrete and special concretes by BIS, IRC, ACI and British methods.	7 lectures
Unit III	Advanced cementitious composites: Fibre reinforced concrete (FRC), specific requirements FRC for blast proof structures and airfield; Polymer concrete composites.	7 lectures
Unit IV	High workability concrete for multi-storeyed buildings: Pumpable, Self compacting, High performance and Extra high performance of concrete. Low workability concrete for highways and dams: Dry lean concrete, Pavement quality concrete, Roller compacted concrete, Mass concrete.	12 lectures
Unit V	Durability assessment of concrete structures: ND tests of concrete; Permeability of concrete under different pressure conditions; Degradation of concrete; Health assessment, repair and rehabilitation of major concrete structures.	8 lectures

Books:

1. Properties of Concrete, A. M. Neville, Longman, ELBS, London, 1996.
2. Concrete Microstructure, P. K. Mehta and Paulo J. M. Monterio, Properties and Materials, Indian Concrete Institute, 1997.
3. Advanced Concrete Technology, Zongjin Li, John Wiley & Sons, 2011.
4. Handbook on Advanced Concrete Technology, N. V. Nayak and A. K. Jain, Narosa Publishing House, New Delhi, 2012.
5. Handbook on repair and rehabilitation of RCC building, CPWD, 2019.
6. IRC: 44Guidelines for Cement Concrete Mix Design for Pavements (Second Revision), 2008.
7. IRC: SP:62-2014, Guidelines for Design and Construction of Cement Concrete Pavements for Low Volume Roads.
8. IRC: SP:49-2014 Guideline for the Use of Dry Lean Concrete as Sub-Base for rigid Pavement.
9. IS 456: 2000, Plain and Reinforced Concrete - Code of Practice, (4th Revision), BIS.
10. IS 10262: 2009, Concrete Mix Proportioning – Guidelines BIS.
11. IS 383, 1970, Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, BIS.

CE23015	Contracts Management: 3 Credits (3-0-0)	
Unit I	Introduction, importance of contracts, overview of contract management, overview of activities in contract management; planning, people, resource management	7 lectures
Unit II	Contract: types of contracts, parties to a contract; contract formation, formulation of contract, contract start-up, managing relationships;	8 lectures
Unit III	Common contract clauses (Notice to proceed, rights and duties of various parties, notices to be given, Contract Duration and Price. Performance parameters; Delays, penalties and liquidated damages; Force Majeure, Suspension and Termination. Changes & variations, Notices under contracts; Conventional and Alternative Dispute Resolution methods.	10 lectures
Unit IV	Various Acts governing contracts, contract administration and payments, contract management in various situations, contract management in NCB works, contract management in ICB works contracts, Contract for supply of goods, design and installation contracts, Contract Management in Consultancy	10 lectures
Unit V	Managing Risks and Change- Managing Risks, Managing Change; Contract Closure and Review - Ending a Contract, Post-Implementation Review; Legal Aspects in Contract Management - Contract Management Legal View, Dispute Resolution, Integrity in Contract Management; Managing Performance- Introduction, Monitoring and Measurement	7 lectures

Books:

1. CPWD Works Manual, 2019.
2. CPWD Standard Operating Procedures (SOPs), 2019.
3. CPWD, General Conditions of Contracts (GCC) for Construction Works, 2019
4. CPWD, General Conditions of Contracts (GCC) for Maintenance Works, 2019.
5. Human Resource Management in Construction Projects: Strategic and Operational Approaches, Loosemore M., Dainty A., Lingard, H., Spon Press London, 2003.

CE23016	Construction Equipment and Automation: 3 Credits (3-0-0)	
Unit I	Conventional construction methods vs. mechanized methods and advantages of latter.	4 lectures
Unit II	Equipment for Earthmoving, Dewatering; Concrete mixing, transporting and placing; plastering machines.	14 lectures
Unit III	Prestressing jacks and grouting equipment; Cranes, Hoists and other equipment for lifting.	8 lectures
Unit IV	Equipment for transportation of materials.	4 lectures
Unit V	Equipment Productivities; Use of Drones for spread out sites; Use of robots for repetitive activities.	12 lectures

Books:

1. Modern Construction Management, F. Harris, R. McCaffer and F. Edum-Fotwe, Blackwell Publishing, 2006.
2. Construction Management Fundamentals, C. J. Schexnayder and R. E. Mayo, McGraw Hill, New Delhi, 2003.
3. Construction planning and equipment, and methods, R.L. Peurifoy and C.J. Schexnayder, 6th Edn., Tata McGraw-Hill, 2006.
4. Heavy Constructon-Planning, equipment and methods, J. Singh, Oxford & IBH Publishing Co. Pvt., 1993.
5. Professional construction management including C.M., Design construct and general contracting, D.S. Berrie and B.C. Paulson, 3rd Edn., McGraw Hill International edition, 1992.
6. PERT and CPM principles and Applications, L.S. Srinath, 3rd Edn., Affiliated east-west press Pvt Ltd, 2001.
7. Construction engineering Networks: Techniques, planning and management, D.G. Carmichael, Ellis Horwood Publishers Chichester 1989.
8. Construction project management: planning, scheduling and controlling, K.K. Chitkara, Tata McGraw-Hill, 2008.

9. Decision support system and Intelligent systems, E. Turban and J.E. Aronson, Prentice Hall of India, 2003.
10. Operations Research – An Introduction, Taha, Hamdy A., Prentice- Hall of India Private Limited New Delhi (2006).

CE23017	**Repairs and Rehabilitation of Structures: 3 Credits (3-0-0)**	
Unit I	Maintenance and Repair Strategies Maintenance, Repair and Rehabilitation, Facets of Maintenance, importance of Maintenance, Various aspects of Inspection, Assessment procedure for evaluating a damaged structure, causes of deterioration.	6 lectures
Unit II	Strength and Durability of Concrete – Quality assurance for concrete – Strength, Durability and Thermal properties, of concrete – Cracks, different types, causes – Effects due to climate, temperature, Sustained elevated temperature, Corrosion – Effects of cover thickness.	8 lectures
Unit III	Special Concretes – Polymer concrete, Sulphur infiltrated concrete, Fibre reinforced concrete, High strength concrete, High performance concrete, Vacuum concrete, Self-compacting concrete, Geopolymer concrete, Reactive powder concrete, Concrete made with industrial wastes.	10 lectures
Unit IV	Techniques for Repair and Protection Methods – Non-destructive Testing Techniques, Epoxy injection, Shoring, Underpinning, Corrosion protection techniques – Corrosion inhibitors, Corrosion resistant steels, Coatings to reinforcement, cathodic protection.	8 lectures
Unit V	Repair, Rehabilitation and Retrofitting of Structures – Evaluation of root causes; Underpinning & shoring; some simple systems of rehabilitation of structures; Guniting, shotcreting; Non-Destructive testing systems; Use of external plates, carbon fibre wrapping and carbon composites in repairs. Strengthening of Structural elements, Repair of structures distressed due to corrosion, fire, Leakage, earthquake – Demolition Techniques – Engineered demolition methods – Case studies.	10 lectures
Books:		

1. CPWD Maintenance Manual: 2012.
2. CPWD Hand Book on Repairs and Rehabilitation of Structures.
3. CPWD Hand Book on Seismic Retrofit of Buildings.
4. GCC Maintenance Works 2019.
5. Assessment and Renovation of Concrete Structure, Ted Kay, John Wiley & Sons, Inc. New York, 1992.
6. Repair of Concrete Bridges, Mallett G.P., Thomas Telford Services Ltd., Quay, London E 144 JD. 1994.
7. Construction Maintenance & Repair of Highway Bridges, Rakshit K.S., 1994.
8. Properties of Concrete, Naville A. M., 2nd edition, Pitman Publishing Company, Bath, U.K. 1973.

CE23021	**Modeling in Environmental Engineering: 3 Credits (3-0-0)**	
Unit I	Principles of modelling, continuity equations, mass balance relationships, mathematical models for ideal and field reactors.	10 lectures
Unit II	Water quality modelling, mathematical models for rapid and slow sand filters.	8 lectures
Unit III	Biological & biochemical reaction, reaction kinetics of aerobic and anaerobic processes, process mechanisms for different treatment systems.	8 lectures
Unit IV	Development of mathematical models for different biological treatment systems such as activated sludge process, rotating biological contactor, aerobic & anaerobic filters.	8 lectures
Unit V	Development of mathematical models for UASB reactors and hybrid reactors, solution techniques for various models.	8 lectures
Books:		

1. Principle of Surface Water Quality Modeling and Control, R.V. Thomann & J.A. Mullor, Harper & Row Publications, New York, 1984.

2. Physico–Chemical Processes for Water Quality Control, W.J. Webber, Jr., Wiley Intersciences, New York, 1976.
3. Process Chemistry for Water and Wastewater Treatment, Benefield, Judkins & Weand, Prentice Hall Inc., New Jercy, 1982.
4. Stream Sanitation Engineering, E.B. Phelps, John Wiley and Sons, New York, 1982.
5. Wastewater Engineering: Treatment, Disposal & Reuse, Metcalf & Eddy, Tata McGraw Hill, New Delhi, 1991.
6. Air Pollution & its Control, Perkins, McGraw Hill International, New York, 1986.
7. Environmental Engineering, H.S. Peaviy, D.R. Rowe & G. Tachobanoglous, McGraw Hill International, New York, 1985.
8. Environmental Engineering, G. Kiely, McGraw Hill International, New York, 1997.
9. Environmental Systems Modeling, R. K. Prasad, Standard Publishers Distributors, New Delhi, 2019.

CE23022	**Advanced Wastewater Treatment Techniques: 3 Credits (3-0-0)**	
Unit I	Introduction, necessity for advanced wastewater treatment, various treatment techniques.	10 lectures
Unit II	Removal of residual suspended solids by granular medium filtration and micro-screening, control of nutrients, biological nitrification and denitrification.	8 lectures
Unit III	Removal of nitrogen by physical, chemical & biological process, removal of phosphorous by biological methods.	8 lectures
Unit IV	Removal of toxic compounds and refractory organics.	8 lectures
Unit V	removal of dissolved inorganic substances.	8 lectures

Books:

1. Pollution & its Containment, ICE, London, 1984.
2. Physico-Chemical Processes for Water Quality Control, W.J. Webber, Jr., Wiley Interscience, New York, 1976.
3. Hazardous Waste Management, La Grega, Buckingham & Evans, McGraw Hill International, New York, 1994.
4. Wastewater Engineering: Treatment, Disposal & Reuse, Metcalf & Eddy, Tata McGraw Hill, New Delhi, 1991.
5. Water Technology, Gray, Viva Book Private Limited, New Delhi, 1999.
6. Biological Control of Nitrogen in Wastewater Treatment, D. Barnes and P J Bliss, E & F N Spoon, London, 1983.

CE23023	**Solid Waste Management: 3 Credits (3-0-0)**	
Unit I	Introduction, principles of solid waste management, material flow in society, functional elements of solid waste management.	6 lectures
Unit II	Classification and characteristics of solid wastes – physical, chemical and biological of characteristics and its determination.	8 lectures
Unit III	Solid waste generation in a society and estimation of generation rate, on-site handling and storage, equipment used.	8 lectures
Unit IV	Collection of solid wastes, transfer and transport, processing of solid wastes, equipment used.	8 lectures
Unit V	Ultimate disposal of solid wastes, sanitary landfills, processes occurring in sanitary land-fills, control of gases and leachate. Energy recovery – methods and means, day-to-day solid waste management.	12 lectures

Books:

1. 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.
2. Hazardous Waste Management, La Grega, McGraw Hill International, New York, 1994.
3. Evironmental Pollution: Solid Waste, S G Misra and D Prasad, Venus Publishing House, New Delhi, 1992.
4. Wastewater Engineering: Treatment, Disposal & Reuse, Metcalf & Eddy, McGraw Hill, New Delhi, 1991.
5. Environmental Engineering, H.S. Peavy, D.R. Rowe & G. Tachobanoglous, McGraw Hill International, New York, 1985.
6. Environmental Engineering, G. Kiely, Tata McGraw Hill Education Private Limited, New Delhi, 2009.

CE23024	Industrial Pollution and Control: 3 Credits (3-0-0)	
Unit I	Introduction, types of industrial pollution: water, air, land and noise pollution, causes and effects.	8 lectures
Unit II	Pollution monitoring and principal control measures.	6 lectures
Unit III	Industrial wastes, types, characteristics, standards, treatment methods and disposal.	12 lectures
Unit IV	Case studies of some typical industries- textiles, leather, fertilizer, pulp & paper mill, slaughterhouse & sugar industries & petroleum refinery.	10 lectures
Unit V	Basic concepts of ecology & ecological balance.	6 lectures

Books:

1. Wastewater Treatment, M.N. Rao & A.K. Data, Oxford & IBH, New Delhi, 1987.
2. Environmental Engineering, Gerard Kiely, McGraw Hill, New York, 1997.
3. Hazardous Waste Management, M D La Grega, P L Buckingham & J.C. Evans., McGraw Hill International, New York, 1994.
4. Industrial Pollution and Control, S.P. Mahajan, Tata McGraw Hill, New Delhi, 1985.
5. Air Pollution, M.N. Rao & H.V.N. Rao, Tata McGraw Hill, New Delhi, 1989.
6. Industrial Water Pollution Control, W W Eckenfelder Jr, McGraw Hill International, Singapore, 1989.

CE23025	Environmental Impact Assessment: 3 Credits (3-0-0)	
Unit I	Introduction, definition, principle & methods of environmental impact assessment (EIA), current status of EIA.	10 lectures
Unit II	Socio- economic impact, impacts of noise, traffic, landscape, air and climate, soils and geology etc.	8 lectures
Unit III	Case studies of EIA.	6 lectures
Unit IV	Impact predictions and monitoring, interactions between impacts - predictions and integrating of interactions.	10 lectures
Unit V	Environmental audit.	8 lectures

Books:

1. Pollution and its Containment, ICE, London, 1984.
2. Physico-Chemical Processes for Water Quality Control, W.J. Webber, Jr., Wiley Interscience, New York, 1976.
3. Methods of Environmental Impact Assessment, Peter Morris & Riki Therivel, UCL Press, London, 1995.
4. Environmental Risks and Hazards, S.L. Cutter, Prentice Hall of India Pvt. Ltd., New Delhi, 1999.
5. Environmental Impact Assessment: Theory and Practice, P Wathern, Unwin Hyman, London, 1988.

CE23026	Solid and Hazardous Waste Management: 3 Credits (3-0-0)	
Unit I	Relevant Regulations Municipal solid waste (management and handling) rules; hazardous waste (management and handling) rules; biomedical waste handling rules; fly ash rules; recycled plastics usage rules; batteries (management and handling) rules; Municipal Solid Waste Management – Fundamentals Sources; composition; generation rates; collection of waste; separation, transfer and transport of waste; treatment and disposal options.	8 lectures
Unit II	Hazardous Waste Management – Fundamentals Characterization of waste; compatibility and flammability of chemicals; fate and transport of chemicals; health effects, Radioactive Waste Management – Fundamentals Sources, measures and health effects; nuclear power plants and fuel production; waste generation from nuclear power plants; disposal options.	8 lectures
Unit III	Physicochemical Treatment of Solid and Hazardous Waste Chemical treatment processes for MSW (combustion, stabilization and solidification of hazardous wastes); physicochemical processes for hazardous wastes (soil vapour extraction, air stripping, chemical oxidation); ground water contamination and remediation.	8 lectures

Unit IV	Biological Treatment of Solid and Hazardous Waste Composting; bioreactors; anaerobic decomposition of solid waste; principles of biodegradation of toxic waste; inhibition; co-metabolism; oxidative and reductive processes; slurry phase bioreactor; in-situ remediation.	10 lectures
Unit V	Environmental Risk Assessment Defining risk and environmental risk; methods of risk assessment; case studies. Landfill design Landfill design for solid and hazardous wastes; leachate collection and removal; landfill covers; incineration.	8 lectures

Books:

1. 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.
2. Hazardous Waste Management: Charles A. Wentz, McGraw Hill, 1995.
3. Management of Organic Waste: S. Kumar & A. Bharti, INTECH, 2012.
4. Waste Management Practices, John Pichtel. CRC Press, Taylor and Francis Group 2005.
5. Hazardous Waste Management, LaGrega, M. D. Buckingham, P. L. and Evans, J.C. McGraw Hill International Editions, New York, 2001.
6. Hazardous Wastes - Sources, Pathways, Receptors, Richard J. Watts, John Wiley and Sons, New York, 1998.

CE23027	**Air Pollution Engineering (3-0-0)**	
Unit I	Introduction and Scope. Environmental Systems: Source, Pollutant Transport and Impact on Receptor. Environmental Quality and Pollution: Air-Water quality parameters, units for expression; beneficial uses of water; water quality criteria and standards, air quality criteria, health effects and Indian national air quality standards (including methods for standard setting).	8 lectures
Unit II	Disposal, Fate and Transport of Waste: (i) pollutant dispersion in lakes, reservoirs, rivers, ground water, disposal and stream quality standards, (ii) air pollution dispersion, transportation and chemical transformation, meteorological parameters, simple box and gaussian type model for point, area and line (vehicular sources) (iii) Tutorials and simulated examples.	12 lectures
Unit III	Air Pollution Sources and Assessment of Air Pollution Load– preparation of emission inventory, its presentation (data base) and interpretation. Air Pollution Control Particulate removal mechanism and processes; reduction of gaseous pollution dry and wet scrubbing.	8 lectures
Unit IV	Solid and Hazardous Waste Management: generation, collection, classification, processing and disposal, composting, land filling, incineration, hazardous waste definition and disposal. Noise Pollution: causes, measurements, prevention and control.	6 lectures
Unit V	Environmental policies and regulations; water act, water cess act air act, environmental protection act, hazardous and biomedical waste rules, public liability insurance act, EIA notification, and regulatory mechanism. Environmental Impact Assessment (EIA): Assessment Procedure – Identification, prediction and evaluation; EIA methodologies; EIA statement and report preparation; examples and simulated case studies.	8 lectures

Books:

1. Environmental Pollution Control Engineering C. S. Rao, Wiley, 2018.
2. Air Pollution Control Technology Handbook, Karl B. Schnelle, Jr., Russell F. Dunn and Mary Ellen Ternes, CRC Press, 2017.
3. 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.
4. Environmental Impact Assessment, Canter, L. W., 2014.

CE23031	River Engineering (3-0-0)	
Unit I	Overview of river engineering- river classifications, thresholds in river morphology, hydraulic geometry, meander plan form, geomorphic analysis of river channel responses.	8 lectures
Unit II	Hydraulics of river flow- fundamentals of alluvial channel flows, uniform and unsteady cases, shear stress distribution, flow resistance in rivers.	8 lectures
Unit III	Scouring and its criteria- physical properties of sediments, sediment movement in rivers, shear stress, Shields diagram, scouring around bridge piers and embankments, river bed forms.	8 lectures
Unit IV	Regime rivers- analysis of river meanders, design of stable alluvial channels-regime concept, dimensional model studies for rivers, braided rivers, scaling and hierarchy in braided rivers, alternate bars, bed load transport in braided gravel-bed rivers.	8 lectures
Unit V	River training and stabilization- stream bank erosion, bank protection, flow control structures, bank protection and river training along braided rivers.	10 lectures

Books:

1. Fluvial Processes in River Engineering, H. H. Chang, John Wiley, 1988.
2. Fundamentals of Fluvial Geomorphology, R. Charlton, Taylor and Francis, 2007.
3. Braided Rivers: Process, Deposits, Ecology and Management, H. Gregory, Blackwell Publishing, 2006.
4. Sediment Transport-Theory and Practice, C. T. Yang, McGraw Hill Companies, Inc., New Delhi, 1996.
5. Fluvial Forms and Processes, D. Knighton, Edward Arnold, Baltimore, MD, 1984.
6. Rivers Form and Process in Alluvial Channels, Richards, K., Methuen, NY, 1982.
7. River Mechanics, Vol. I and II, H.W. Shen, Water Resources Publication, Fort Collins, CO., 1971.
8. Applied fluvial geomorphology for river engineering management, C. R. Thorne, R. D. Hey, and M. D. Newson, John Wiley & Sons, 1997.

CE23032	Transient Flow Analysis (3-0-0)	
Unit I	Introduction, surge movement in channels, two-dimensional shallow water wave equation, numerical scheme for unsteady open channel flow.	10 lectures
Unit II	Problems in handling mixed flow region.	8 lectures
Unit III	unsteady flow in closed conduits and their solution.	8 lectures
Unit IV	Transients caused by pumps, methods of controlling transient in pipes	8 lectures
Unit V	Analysis of surge tanks; transient ground water flow.	8 lectures

Books:

1. Hydraulic Transients, Chaudhry, H., Tata McGraw Hill, 1998.
2. Applied hydraulic transients, Chaudhry, H., Van Nostrand Reinhold, New York, 1987.
3. Hydraulic Transients, Streeter, V.L. and Wylie, E.B., McGraw Hill, New York,1967.

CE23033	Computational Methods in Hydraulics and Environmental Engineering Applications (3-0-0)	
Unit I	Introduction – computing techniques – numerical methods – finite difference and finite element methods.	10 lectures
Unit II	Applications in surface and ground water modeling.	8 lectures
Unit III	Solute transport problems.	8 lectures
Unit IV	Pipe network analysis.	8 lectures
Unit V	Artificial intelligence – applications.	8 lectures

Books:

1. Introduction to Computational Fluid Dynamics, Pradip Niyogi, S. K. Chakrabarty, M. K. Laha, Pearson Education, 2005.
2. An Introduction to Finite Element Method, J. N. Reddy, Tata McGraw-Hill, New Delhi, 2003.
3. Applied Hydrology, Chow, V.T, Maidment, D.R., Mays.L.W., McGraw Hill, 1988.
4. Numerical methods for Engineers, Chapra, S.C, Canale, R.P, McGraw Hill, 1990.
5. Applied Finite Element Analysis, Segerlind, L.J., John Wiley & Son, 1984.
6. Ground Water Hydrology, Todd, D.K., Wiley, 1993.

CE23034	Open Channel Hydraulics (3-0-0)	
Unit I	Uniform flow, properties, design of channel for uniform flow.	10 lectures
Unit II	Gradually varied flow theory, computation of surface profiles in gradually varied flow, rapidly varied flow.	8 lectures
Unit III	Flow over spillways; Hydraulic jump: location, control and stabilization.	8 lectures
Unit IV	Channel design and transitions.	8 lectures
Unit V	Unsteady flow: basic equations; Uniformly progressive flow; Velocity of flood wave.	8 lectures

Books:

1. Open Channel Hydraulics, V.T. Chow, McGraw Hill International. New York, 1959.
2. Open Channel Flows, M Hanif Chowdhury, Prentice Hall Inc, NJ, 1993.
3. Flow in Open Channels, Subramanya K, Tata McGraw Hill, New Delhi, 1997.
4. Flow through Open Channels, Ranga Raju KG, Tata McGraw Hill, New Delhi,1994.

CE23035	Hydro-Power Development (3-0-0)	
Unit I	Hydro vs. thermal power, run-off river plant, storage, pumped storage, tidal and diversion plant.	10 lectures
Unit II	Water power potential, mass curve, load duration curve, peak percentage curve, types of power supply, reservoir operation.	10 lectures
Unit III	Power conduits, unsteady flow in power canal and power tunnel;	6 lectures
Unit IV	Penstock-economic diameter, supports such as anchor blocks and saddles, expansion joints; Surge tank, water hammer in penstock.	6 lectures
Unit V	Design of intake structures; Type of hydroelectric turbine; Selection of turbines; Power house details.	10 lectures

Books:

1. Hydraulics and Fluid Mechanics including Hydraulics Machines, Modi, P.N. and S.M. Seth, Standard Book House, Delhi, 2011.
2. Handbook of Hydroelectric Engineering, P.S. Nigam, Nem Chand & Bros, Roorkee, India, 1985.
3. Water Power Engineering, M.M. Dandekar & K.N. Sharma, Vani Educational Book, Vishwa Prakashan, Delhi, 2013.

CE23036	Hydraulic Engineering (3-0-0)	
Unit I	Dimensional analysis and Similitude: Nature of dimensional analysis, Rayleigh method, Buckingham's Pi-theorem, determination of Pi-groups, dimensionless groups of significance, flow similarity and model studies.	8 lectures
Unit II	Flow through Pipes: Loss of head through pipes, Darcy-Wiesbatch equation, minor losses, total energy equation, hydraulic gradient line, Pipes in series, equivalent pipes, pipes in parallel, flow through laterals, flows in dead end pipes, siphon, power transmission through pipes, nozzles. Analysis of pipe networks: Hardy Cross method, water hammer in pipes and control measures, branching of pipes, three reservoir problem.	8 lectures
Unit III	Basic control volume: approach, control volume equation, continuity equation, momentum equation, Application of all basic equations: forces on bends, flow through nozzles, moment of momentum equation.	8 lectures
Unit IV	Drag and lifts: flow around submerged objects, effect of viscosity on development of drag, effect of streamlining, drag for two-dimensional body, terminal velocity, lift on circular cylinder, concept of boundary layer, thickness of boundary layer along a thin plate, laminar boundary layer.	9 lectures
Unit V	Open channel hydraulics: one dimensional method of flow analysis, velocity distribution, kinetic energy, specific energy, critical depth, sub-critical, critical and super-critical flows, uniform flows, Manning's formula, normal depth, hydraulically efficient channel section, hydraulic jump.	9 lectures

Books:

1. Engineering Fluid Mechanics, C.T. Crowe, D.F. Elger, J.A. Roberson, John Wiley & Sons, Inc. 2001.
2. Theory and Problems of Fluid Mechanics, Subramanya, K., Tata McGraw Hill, New Delhi, 1993.
3. Hydraulics and Fluid Mechanics including Hydraulics Machines, Modi, P.N. and S.M. Seth, Standard Book House, Delhi 1998.
4. Fluid Mechanics through Problems, Garde R.J., New Age International, New Delhi, 1989.
5. Fluid Mechanics Fundamentals and Applications, Cengel, Y.A. and Cimbala, J.M., Tata McGraw-Hill Company Limited, New Delhi, 2006.
6. Fluid Mechanics, White, F.M., McGraw-Hill Book Co. International Student Edition, Singapore, 2014.

CE24001	**Water Quality Engineering (3-0-0)**	
Unit I	Sources of water pollution, laws and regulations, measures of water quality, water quality criteria, decay kinetics.	10 lectures
Unit II	Pollution in rivers and streams: contaminant transport process, Longitudinal dispersion, dissolve oxygen models in rivers, introduction to waste load allocation model.	10 lectures
Unit III	Groundwater quality modeling: groundwater flow equation, hydrodynamic dispersion, advection-dispersion equations, point and non-point source problems.	10 lectures
Unit IV	Water quality in lakes and reservoirs: Natural processes, Eutropication and nutrient recycling.	6 lectures
Unit V	Water quality model, restoration and management.	6 lectures

Books:

1. Water supply and pollution control, Viessman, Jr. Warren, Hammer, M. J., Perez, E. M. and Chadik, P. A. PHI Learning Private Limited, New Delhi, 2009.
2. Environmental Engineering, G. Kiely, McGraw Hill Singapore, 1998.
3. Water Quality Engineering in Natural Systems, D. A. Chin, John Wiley & Sons, 2006.
4. Environmental Systems Modeling, R. K. Prasad, Standard Publishers Distributors, New Delhi, 2019.

CE24002	**Surface Hydrology (3-0-0)**	
Unit I	Basic concepts of hydrology; structure and composition of atmosphere, air mass, cold and warm fronts, atmospheric temperature and its variations.	8 lectures
Unit II	Vapor pressure and relative humidity; evaporation and evapo-transpiration; types and forms of precipitation; measurement of precipitation and other atmospheric parameters.	8 lectures
Unit III	Hydrograph analysis; probability, risk and uncertainty analysis for hydrologic and hydraulic design.	8 lectures
Unit IV	Flood routing – hydrologic and hydraulic routing - developing algorithms; hydrologic real time forecasting.	10 lectures
Unit V	Urban hydrology; time series analysis.	8 lectures

Books:

1. V.T. Chow, Maidment, D.R., Mays, L.W., Applied Hydrology, McGraw Hill, 1988.
2. D.K. Todd, Ground Water Hydrology, Wiley, New York, 1998.
3. L.W. Mays, Water Resources Engineering, John Willey and Sons, US, 2001.
4. C. T. Haan, Statistical Methods in Hydrology, Iowa State University Press, 1977.
5. D. R. Maidment, Handbook of Hydrology, McGraw Hill, 1993.

CE24003	**Environmental Hydrology (3-0-0)**	
Unit I	Basic concepts of environmental hydrology; water cycle, water balance and hydrological processes.	8 lectures
Unit II	Environment and water; hydrology and climate, physical and biological interactions; water-related environmental problems.	8 lectures

Unit III	Hydrological characteristics of India; drinking water, drinking water regulation and standards, water testing; forest hydrology, hydrological processes in forested area; urban hydrology, urbanization and hydrological processes, runoff process and flood; storm water storage and infiltration, reconstruction of urban water cycle.	8 lectures
Unit IV	Domestic, industrial, commercial, agriculture, and public water uses; water rights and development; water pollution and water quality policy, point and non-point source pollution and control, self-purification; sewage treatment.	9 lectures
Unit V	Groundwater pollution, background and measurements of groundwater contamination, sources and fate of contaminants, organic solvents, phosphate and nitrate, remediation.	9 lectures

Books:

1. Environmental Hydrology, A.D. Ward and S.W. Trimble, 2nd Edition. Lewis Publishers, CRC Press, 2004.
2. Hydrology: An Environmental Approach, Watson and Burnett, CRC Press, 1995.
3. Soil and Water Management Systems, G. O. Schwab, D. Fangmeier Delmar, Elliot, William J., John Wiley & Sons, 1996.

CE24004	**Groundwater Hydrology (3-0-0)**	
Unit I	Occurrence of groundwater, groundwater movement, saturated and unsaturated flow. groundwater 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 modelling 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

Books:

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

CE24005	**Flood Control and River Training Works (3-0-0)**	
Unit I	Concept of probability and probability distribution: basic concepts, properties of random variables.	8 lectures
Unit II	Discrete probability distribution, normal distribution, continuous probability distributions, confidence intervals.	8 lectures
Unit III	Flood frequency analysis: Log normal distribution, Log Pearson type III distribution, Gumbel's method.	9 lectures
Unit IV	Flood control measures: structural & non-structural measures.	9 lectures
Unit V	River training works: rivers, their behavior, control and training.	8 lectures

Books:

1. Irrigation and Water Power Engineering, B.C. Punmia & B.B. Lal, Laxmi Publications, New Delhi, 1986.
2. Flood Control Engineering, S.N. Ghosh, Oxford and IBH, New Delhi, 1986.
3. Statistical Methods in Hydrology, R.T. Clarke, Jonh Wiley & Sons, New York, 1994.

CE24006	**Water Resources Systems (3-0-0)**	
Unit I	Objectives and methods of water resources development.	6 lectures
Unit II	Economic analysis, and discounting techniques; Condition of project optimality.	10 lectures
Unit III	Analytical optimization techniques for multipurpose water resources projects by linear, non-linear and dynamic programming.	12 lectures
Unit IV	Optimization by simulation.	6 lectures
Unit V	Mathematical model for large scale multipurpose projects.	8 lectures

Books:

1. Water Resource Systems Planning & Analysis, Loucks, D.P., J.R. Stedinger & D.A. Haith, Prentice Hall, Inc., N.J., 1981.
2. Water Resources System, Hall, W.H., and J. Dracup, McGraw Hill International, NY, 1970.
3. System Analysis and Design. R J Augilar, Prentice Hall Inc, NJ, 1973.
4. Operation Research, Taha, H.A., Prentice Hall of India, New Delhi, 1997.
5. Introduction to Optimum Design, J.S. Arora, Mc Graw Hill, NY, 1989.

CE24007	**Design of Hydraulic Structures (3-0-0)**	
Unit I	Canal headworks: location of headworks on rivers, different units of head works, afflux, waterway and different levels for weir construction, undersluices, design of weir.	6 lectures
Unit II	Sub-Surface flow: seepage forces, theory of seepage, seepage equation, method of determination of seepage pressure, sheet pile at the upstream end, sheet pile at the downstream end, intermediate sheet pile, depressed floor, determination of exit gradient, uplift force on the floor of canal.	8 lectures
Unit III	Cross-drainage structure: need of cross-drainage structure, types of cross-drainage structures, selection of the type of cross-drainage structures, design of cross-drainage structures, waterway and head way of the stream, head loss through cross-drainage structure, design of transitions for the canal waterway.	6 lectures
Unit IV	Classification of Embankment dams: Gravity Dam, Embankment dam, Butress Dam; Gravity dams: forces on a gravity dam, causes of failure of a gravity dam, stress analysis in gravity dams, design of gravity dams. Embankment dams: classification of embankment dams, factors influencing the design of an embankment dam, general design criteria for embankment dams.	12 lectures
Unit V	Channel design: Kennedy and Lacey's regime theory, sediment transport, incipient motion of sediment transport, critical tractive force approach, bed load, suspended load, bed-material load, wash load; Design of rigid-boundary channels carrying clear water, design of alluvial channels.	10 lectures

Books:

1. Irrigation and Water Power Engineering. Punmia, B.C. and Pandey, B.B. Lal, Laxmi Publication, Delhi, 2009.
2. Irrigation Engineering, Asawa, G.L., New Age International, New Delhi, 1993.
3. Irrigation Water Resources and Water Power Engineering, Modi, P.N., Standard Book House, Delhi, 2014.
4. Fundamentals of Irrigation Engineering, Singh, Bharat, Nem Chand & Bros, Roorkee, 1997.
5. Hydraulic Structures, 4 th edition, Novak, P., Moffat, A. I. B., Nalluri, C. and Narayanan, R. Taylor & Francis London, UK. 2007.

CE24007	**Design of Hydraulic Structures (3-0-0)**	
Unit I	Canal headworks: location of headworks on rivers, different units of head works, afflux, waterway and different levels for weir construction, undersluices, design of weir.	6 lectures
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Books:

1. Irrigation and Water Power Engineering. Punmia, B.C. and Pandey, B.B. Lal, Laxmi Publication, Delhi, 2009.
2. Irrigation Engineering, Asawa, G.L., New Age International, New Delhi, 1993.
3. Irrigation Water Resources and Water Power Engineering, Modi, P.N., Standard Book House, Delhi, 2014.
4. Fundamentals of Irrigation Engineering, Singh, Bharat, Nem Chand & Bros, Roorkee, 1997.
5. Hydraulic Structures, 4 th edition, Novak, P., Moffat, A. I. B., Nalluri, C. and Narayanan, R. Taylor & Francis London, UK. 2007.

CE24011	**Design of Steel Structures (3-0-0)**	
Unit I	Plastic Analysis of Steel Structures: plastic bending, plastic modulus, shape factor, moment curvature relationship, plastic moment capacity, lower and upper bound theorems, analysis of beams and frames.	10 lectures
Unit II	Introduction to Limit State Method of Design and IS-800: 2007: Limit States for Steel design, Limit States of Strength, Limit States for Serviceability, Actions (Loads), Probabilistic basis of design, Characteristic loads and strengths, Partial safety factors, Design loads and strengths, Classification of cross-sections, Types of elements, Combination of loads, Criteria for failure/Collapse of steel.	6 lectures
Unit III	Design of Connections: Bolted and welded connections; Types of bolts and bolted joints, Load transfer mechanism, Failure of Bolted joints, Strength and Efficiency of bolted joint; Types of welds, Assumptions in the analysis of welded joints, Design of groove, fillet, intermittent fillet, butt, and plug and slot welds, Applications.	6 lectures
Unit IV	Design of Tension and Compression Members, and Column Bases: Types of tension members, Net sectional area, Effective net area, Types of failure, Design strength of tension members; Effective lengths of columns, Slenderness ratio, Types of sections, Types of buckling, Classification of cross-sections, Design of axially loaded compression members; Types of column bases, Design of Slab and Gusseted bases.	10 lectures
Unit V	Design of Beams, Plate Girders, and Roof Trusses: Behaviour of beams in flexure under ultimate loads, Classification of Cross-sections, Bending and shear strengths of beams, Design procedures for Rolled and Built-up sections; Elements of Plate Girders, Proportioning of web and flanges, Design of vertical, horizontal and load bearing stiffeners, Curtailment of flange plates; Selection of type of truss, Loads on roof truss, Analysis of roof truss, Selection of sections for the members, Connections.	10 lectures

Books:

1. Limit State Design of Steel Structures, S.K Duggal, Tata McGraw Hill Education Pvt Ltd, New Delhi, 2011.
2. Limit State Design of Steel Structures, Rama Chandra and Virendra Gehlot, Scientific Publishers (India), Jodhpur, 2010.
3. Limit State Design of Steel Structures, I. C. Syal and Satinder Singh, Standard Publishers Distributors, New Delhi, 2015.
4. Design of Steel Structures, N Subramanian, Oxford University Press, New Delhi, 2008.
5. Plastic Methods of Structural Analysis, B. G. Neal, Chapman & Hall, London, 1965.
6. Ductile Design of Steel Structures, M. Bruneau, China-Ming Uang, and Andrew Whittaker, Mc Graw Hill, NY, 1998.
7. IS-800: 2007: General Construction in Steel-Code of Practice, BIS, New Delhi, 2007.

CE24012	Matrix Methods of Structural Analysis (3-0-0)	
Unit I	Types of framed structures and their deformations.	8 lectures
Unit II	Static and kinematic indeterminacy.	6 lectures
Unit III	Force and displacement equations.	6 lectures
Unit IV	Formulation of member and global stiffness and flexibility matrices for 2D framed structures; Equivalent joint loads.	10 lectures
Unit V	Formulation of member and global stiffness and flexibility matrices for 3D framed structures equivalent joint loads.	12 lectures

Books:

1. Introduction to Matrix Analysis of Structures, S. K. Mallick and K. S. Rangaswami, Khanna Publishers, Delhi, 1971.
2. Structural Analysis- a Matrix Approach, G. S. Pandit & S. P. Gupta, Tata McGraw Hill, New Delhi, 1981.
3. Elementary Structural Analysis, S. Utku, C. H. Norris and J. B. Wilbur, McGraw Hill Inc., Singapore, 1991.
4. Matrix Method of Analysis of Structures, M. B. Kanchi, New Age International, New Delhi, 1993.
5. Matrix Analysis of Structures, H. I. Laursen, McGraw Hill, New York, 1966.
6. Basic Structural Analysis, C. S. Reddy, Tata McGraw Hill, New Delhi, 2017.
7. Structural Analysis, A. Ghali & A. M. Neville, Chapman and Hall, London, 2018.

CE24013	Theory of Elasticity (3-0-0)	
Unit I	Analysis of stress and strain in 3D, stress-strain relationships; Differential equation of equilibrium compatibility of strains.	10 lectures
Unit II	Plane stress and plane strain problem, two-dimensional problems in rectangular and polar co-ordinates.	8 lectures
Unit III	General theorems in elasticity and their applications, principle of superposition.	8 lectures
Unit IV	Strain energy; Energy principles; Virtual work; Castigliano's theorem, principle of least work.	8 lectures
Unit V	Problems of torsion and bending of bars.	8 lectures

Books:

1. Theory of Elasticity, S. Timoshenko & J. N. Goodier, Mc Graw Hill International, NY, 1982.
2. Applied Elasticity, Zhilun Xu, Wiley Eastern Ltd., New Delhi, 1992.
3. Introduction to Solid Mechanics, Irving H. Shames, Prentice Hall of India, New Delhi, 1989.
4. A Treatise on the Mathematical Theory of Elasticity, A.E.H. Love, Dover, New York, 1927.

CE24014	Finite Element Methods (3-0-0)	
Unit I	Basic concepts of FEM, matrix techniques, vibrational methods, concept of an element, displacement models, iso-parametric elements, formulation of element stiffness based on direct, vibrational and weighted residual techniques, mixed and hybrid models.	10 lectures
Unit II	Discretization of a body or structure, co-ordinates and shape functions, interconnection at nodes, construction of stiffness matrix and loads for assemblage by different approaches, Boundary condition, solution to one dimensional problems.	8 lectures
Unit III	Beams and frames: truss and beam elements, finite element formulations, load vector, boundary conditions, shear force and bending moment, beams on elastic support, plane frames.	8 lectures
Unit IV	Two dimensional problems: constant strain triangles, triangular, rectangular and iso-parametric elements, finite element modelling, boundary conditions, numerical integration, axisymmetric problems.	8 lectures
Unit V	Three dimensional problems: tetrahedral and prismatic elements, degenerate forms, finite element formulation, stress calculations, solution to three dimensional problems.	8 lectures

Books:

1. Introduction to the Finite Element Method, C.S. Desai and J.F. Abel, Affiliated East-West Press, New Delhi, 1977.
2. The Finite Element Method, O.C. Zienkiewicz Tata Mc Graw Hill, New Delhi, 1979.
3. Introduction to Finite Elements in Engineering, T.R. Chandrapatla and Ashok D. Belegwndn, Prentice Hall of India, New Delhi, 1991.
4. Finite Element Procedures in Engineering Analysis, Klans-Jiirgen Bathe, Prentice Hall of India, New Delhi, 1990.
5. Energy and Finite Element Methods in Structural Mechanics, Irving H. Shames and Clive L. Dym, Wiley Eastern Ltd., New Delhi, 1995.

CE24015	**Advanced Mechanics of Solids (3-0-0)**	
Unit I	State of stress in 3D; Equations of equilibrium in Cartesian and polar co-ordinates; Analysis of strains.	10 lectures
Unit II	Theories of failures and their significance, Unsymmetrical bending of beams.	8 lectures
Unit III	Curved beams of small and large curvatures, crane hooks, rings and chain links; Shear center.	8 lectures
Unit IV	Thin and thick cylinders, Introduction to shells, Membrane analysis of cylindrical shells.	10 lectures
Unit V	Stress concentration; Introduction to experimental stress analysis - mechanical and electrical strain gauges and strain rosettes, analysis.	6 lectures

Books:

1. Advanced Mechanics of Solids, 3rd Edition, L.S. Srinath, Tata McGraw Hill, New Delhi, 2009.
2. Advanced Mechanics of Materials, 6th Edition, Aurther P Boresi and Richard J Schmidt, John Wiley and Sons, Inc, New York, 2003.
3. Advanced Strength and Applied Stress Analysis, 2nd Edition, Richard G Budynas, McGraw Hill International, New York, 1999.
4. Engineering Solid Mechanics Fundamentals and Applications, Abdel-Rahman Ragab and Saleh Eldain Bayoumi, CRC Press, Boca Raton, Florida, 1999.
5. Strength of Material, G.H. Ryder, MacMillan India ltd, New Delhi, 2001 reprint.
6. Engineering Mechanics of Solids, Egor P Popov, Prentice Hall of India, New Delhi, 1990.
7. Introduction to Solid Mechanics, 2nd Edition, Irving H Shames, Prentice Hall of India, New Delhi, 1990.
8. Fundamentals of Structural Mechanics, 2nd Edition, Keith D Hjelmstad, Springer (India) Pvt. Ltd., New Delhi, 2005.
9. Mechanics of Materials, Vol I & II, E J Hearn, Butterworth-Hrinemann (Elsevier), Reed Elsevier (India) Pvt. Ltd., New Delhi, 2008.
10. Advanced Mechanics of Solids, Otto T Bruhns, Springer-Verlog, Springer (India) Private Ltd, New Delhi, 2008.
11. Design and Construction of Concrete Shell Roofs, G.S. Ramaswamy, Tata McGraw Hill, New Delhi, 1971.
12. Theory of Elasticity, Timoshenko and Goodier, McGraw Hill, New York, 1982.
13. Experimental Stress Analysis, L.S. Srinath et al., Tata McGraw Hill, New Delhi, 1984.

CE24016	**Structural Dynamics (3-0-0)**	
Unit I	Single degree of freedom systems - free vibration: introduction to dynamics of structures and their modelling, springs in series and parallel; Equation of motion and response, free vibration, damping, amplitude, natural frequency and logarithmic decrement.	7 lectures
Unit II	Single degree of freedom system - forced vibration under harmonic loading; Undamped and damped harmonic excitation; resonance; Half power method for damping; transmissibility, vibration isolation, seismic instruments; Introduction to Duhamel Integral, response to unit impulse, infinite duration step force, rectangular pulse force, linearly increasing force concept of response spectrum.	10 lectures
Unit III	Multi degree of freedom system: Equation of motion, two degrees of freedom system, natural vibration, frequency and modes, orthogonality and normalisation of modes.	7 lectures

Unit IV	Solution of equation of motion: eigen vlalue problem, estimating fundamental frequency by Rayleigh's method; Holzer's and stodola method and other matrix method. Modal analysis: modal equation, modal expansion of displacement, modal displacement super position, response, element forces.	12 lectures
Unit V	Continuous systems: un-damped equation of motion, natural vibration frequencies and modes of uniform simply supported and cantilever beams, modal orthogenality.	6 lectures

Books:

1. Structural Dynamics: Theory & Computations, Mario Paz, Springer International Edition, Indian Reprint, 2004.
2. Dynamics of Structures, Anil K. Chopra, Prentice Hall of India, New Delhi, 2000.
3. Dynamics of Structures, Clough and Penzien, McGraw Hill International, New York, 1993.
4. Structural Dynamics, Craig Jr., John Wiley and Sons, New York, 1981.
5. Theory of Vibrations with Applications, W. T. Thomson, CBS, New Delhi, 1988.
6. Vibrations, Dynamics & Structural Systems, M. Mukhopadhay, Oxford and IBH, New Delhi, 1989.

CE24021	**Advanced Design of RCC Structures (3-0-0)**	
Unit I	Design of combined footings, rafts, and piles.	10 lectures
Unit II	Design of cantilever and counter fort retaining walls .	8 lectures
Unit III	Design of Water Retaining Structures; Design of staircases; Design of columns under biaxial bending.	12 lectures
Unit IV	Analysis and design of frames under gravity and lateral loads by approximate and exact methods, Substitute Frame method.	6 lectures
Unit V	Introduction to pre-stressed concrete structures: methods, losses.	6 lectures

Books:

1. Advanced Reinforced Concrete Design, P. C. Varghese, PHI, New Delhi, 2006.
2. Advanced Reinforced Concrete Design, N. Krishna Raju, CBS, New Delhi, 1988.
3. Design of Reinforced Concrete Structures, N Subramanian, Oxford University Press, New Delhi, 2013.
4. Comprehensive RCC Designs, B. C. Punamia, Ashok K Jain, and Arun K. Jain, Laxmi Publications, New Delhi, 1998.
5. Reinforced Concrete: Limit State Design, A K Jain, Nem Chand & Broders, Roorkee, India, 1997.
6. Plain and Reinforced Concrete, Vol. I & II, Jai Krishna & O. P. Jain, Nem Chand & Broders, Roorkee, India, 1981.
7. Reinforced Concrete Structural Elements: Behaviour, Analysis & Design, P. Purushothaman, Tata McGraw-Hill, New Delhi, 1984.
8. Reinforced Concrete Design, S. N. Sinha, Tata McGraw-Hill, New Delhi, 1988.
9. Limit State Design of Concrete Structures, Ramachandra, Standard Book House, Delhi, 1990.
10. IS: 456-2000, BIS Publication.
11. IRC: 112-2011, Code of Practice for Concrete Road Bridges, IRC, New Delhi.

CE24022	**Bridge Engineering (3-0-0)**	
Unit I	Site selection; Economic spans, bridge components; Types of bridges and selection of suitable type, IRC specifications and standard loading.	7 lectures
Unit II	Foundations: water way scour depths, types of bridge foundations and considerations in their design.	7 lectures
Unit III	Pier, pier caps, abutments; Approaches and bearings and considerations in their design.	7 lectures
Unit IV	Analysis and Behaviour of T-beams with diaphragm, culverts, Box girder bridges, cable stayed and suspension bridges. Courbon's method for assessment of load distribution, Pigeud's method of slab design.	14 lectures
Unit V	Design of RC culvert, T-beams and cantilever type bridges; Construction procedures of foundation and super structures.	7 lectures

Books:

1. Bridge Engineering, S. Ponnuswami, Tata McGraw Hill, New Delhi, 1986.
2. Essentials of Bridge Engineering, J Victor, Oxford and IBH, New Delhi, 1991.
3. Comprehensive RCC design, B C Punamia, Ashok K Jain and Arun K Jain, Laxmi Publications, New Delhi, 1999.
4. Design of Concrete Bridges, M. G. Ashwani, V. N. Vazrani and M. M. Ratwani, Khanna Publications, New Delhi, 1981.
5. Design of Bridges, N K Raju, Oxford & IBH, New Delhi, 1998.
6. Principles and Practice of Bridge Engineering, S P Bindra, Dhanpat Rai & Sons, Delhi, 1987.

CE24023	**Elements of Earthquake Engineering (3-0-0)**	
Unit I	Introduction, origin, propagation, intensity, magnitude and measurement of earthquake size, seismic zoning, risks and consequences.	8 lectures
Unit II	Overview of free and forced vibrations of SDOF; Base isolation; Response spectra.	10 lectures
Unit III	Multi-degree of Freedom System (MDOF); Vibration absorber, modal analysis for displacement and element forces.	8 lectures
Unit IV	Codal provisions for aseismic design of multistory buildings and water towers.	8 lectures
Unit V	Codal provisions for aseismic design of dams, stack like structures- chimneys, bridges; Ductility, demand and ductility capacity.	8 lectures

Books:

1. Elements of Earthquake Engineering, Jai Krishna and A. R. Chandrasekaran, Nem Chand & Brothers, 1990.
2. Structural Dynamics: Theory and Computations, Mario Paz, Springer International Edition, Indian Reprint, 2004.
3. Dynamics of Structures, Anil K. Chopra, Prentice Hall of India, New Delhi, 2000.
4. Dynamics of Structure, Clough and Penzien, McGraw Hill International, New York, 1993.
5. An Introduction to the Theory of Seisomology, K. E. Bullen and B. A. Bolt, Cambridge Universitry Press, Cambridge, 1985.
6. Eartquake Resistant Design of Masonry Buildings, M Tomazevic, Imperial College Press, London, 1999.
7. Relevant BIS Codes (latest revision); IS: 1893, IS: 4326, IS: 13920.

CE24024	**Earthquake Resistant Structures (3-0-0)**	
Unit I	Philosophy of Earthquake Resistant Design, General effects of Earthquake Loading on Structures, Architectural Planning for Earthquake Resistance, Strong Column-Weak Beam philosophy, Soft Storey phenomenon, Short Column problem. Response of Structures to Earthquakes: Elastic Response Spectra and Elastic Design Spectra, Introduction to Performance Based Design.	10 lectures
Unit II	Modal Analysis of MDF systems: Modal expansion of displacement and exciting force, Modal mass, Modal height, Mode participation factor.	8 lectures
Unit III	IS Codal recommendations: Detailed study of IS-1893-2016 (part-I), IS 1893-1984 (Excluding buildings), IS 13920-1993, Reinforcement detailing for imparting ductility; Salient features of IS 4326-1993.	8 lectures
Unit IV	Seismic coefficient and Response Spectrum loading of shear buildings, Analysis of Torsional shear, Example design of Multistoreyed buildings; Ductile detailing of beams and columns.	10 lectures
Unit V	Introduction to nonlinear analysis of buildings, Introduction to useful/Free codes viz. OpenSees, Seismostruct etc.	6 lectures

Books:

1. IS 1893 (Part-I)-2002, IS Criteria for Earthquake Resistant Design, BIS, New Delhi.
2. IS 4326-1993, IS COP for Earthquake Resistant Design and Construction of Buildings, BIS, New Delhi.
3. IS-13920-1993, IS COP-Ductile Detailing of RC structures Subjected to Seismic Forces, BIS, New Delhi.
4. Dynamics of Structures, (3e) Chopra, A. K. PHI, EEE, New Delhi, 2007.
5. Seismic Analysis of Structures, Dutta, T. K. (2011) John Wiley & Sons (Asia) Pvt Ltd, Singapore.
6. Proposed Draft Provisions and Commentary on Indian Seismic Code IS 1893 (Part-I), Jain, S. K. and Murty, C. V. R. (2005), Document No. IITK-GSDMA-EQ05-V-5.0 and IITK-GSDMA-EQ-15-V-1.0; http://www.nicee.org.

7. Design Example of a Six Storey Building, Shah, H. J. and Jain, S. K. (2005), Document No. IITK-GSDMA-EQ26-V-1.0; http://www.nicee.org.
8. Selective resources from http://opensees.berkeley.edu.

CE24025	Design of Offshore and Coastal Structures (3-0-0)	
Unit I	Types of offshore structures and conceptual development - Analytical models for jacket structures - Materials and their behaviour under static and dynamic loads - Statutory regulations - Allowable stresses - Various design methods and Code Provisions - Design specification of API, DNV, Lloyd's and other classification societies - Construction of jacket and gravity platforms.	8 lectures
Unit II	Operational loads - Environmental loads due to wind, wave, current and buoyancy - Morison's Equation - Maximum wave force on offshore structure - Concept of Return waves - Principles of Static and dynamic analyses of fixed platforms - Use of approximate methods - Design of structural elements.	10 lectures
Unit III	Waves in shallow waters - shoaling, refraction, diffraction and breaking - Interaction currents and waves Sediment characteristics - Initiation of sediment motion under waves - Wave run-up and overtopping Radiation stress-wave set-up and wave setdown Mechanics of Coastal Sediment transport - Limits for littoral drift.	8 lectures
Unit IV	Breakwaters- Classification, Design and application in coastal protection and harbor planning Distribution of long shore currents and Sediment transport rates in Surf zone - Stability of tidal inlets Wave forces on coastal structures.	8 lectures
Unit V	Coastal Features - Beach Features - Beach cycles - Beach Stability - Beach profiles Coastal erosion, Planning and methods of coast protection works - Design of shore defense structures Case studies on coastal erosion and protection.	8 lectures

Books:

1. Hydrodynamics of Offshore Structures by S.K. Chakrabarti, Springer-Verlag.
2. Handbook of Offshore Engineering by S.K. Chakrabarti, Elseviers, 2005.
3. Offshore pipelines by B. Gou, S. Song, J. Chacko and A. Ghalambor, GPP Publishers, 2006.
4. Structural Stability - Theory and Implementation by W.F. Chen and E.M. Lui by Elsevier.
5. Reeve, D., Chadwick, A. and Fleming, C. Coastal Engineering-Processes, theory and design practice, Spon Press, Taylor & Francis Group, London & Paris, 2004.
6. Silvester, R. and Hsu, J.R.C. Coastal Stabilisation, Advances on Ocean Engineering, Volume 14, World Scientific, 1997.
7. Kamphius, J.W. Introduction to coastal Engineering and Management, Advances on Ocean Engineering, Volume 16, World Scientific, 2002.

CE24026	Prefabricated Structures (3-0-0)	
Unit I	Need for prefabrication, types of prefabrication, principles, materials, modular coordination, standardization.	8 lectures
Unit II	Systems production, transportation, prefabrication of load carrying members, disuniting of structures, design of cross section of load carrying members, handling and erection stresses.	10 lectures
Unit III	Application of prestressing of roof members, floor systems, wall panels, hipped plate and shell structures, large panel constructions, columns, shear walls.	8 lectures
Unit IV	Joints for different structural connections, beam to column, beam to beam, column to column, column to foundation, connections between wall panels, connections between floor panels.	8 lectures
Unit V	Design of expansion joints, jointing materials, production, transportation and erection - shuttering and mould design, dimensional tolerances, design and detailing of prefabricated units.	8 lectures

Books:

1. Precast Concrete Design and Applications, A. M. Hass, Applied Science Publishers, 1991.
2. Design and Erection of Reinforced Concrete Structures, V. Promyslolw, MIR Publishers Moscow, 1980.
3. Knowledge Based Process Planning 76 for Construction and Manufacturing, C. Z. Gerostiza, C. Hendrikson and D. R. Rehat, Academic Press Inc., 1980.
4. Bauverlag, GMBH, 1971.
5. Precast Concrete Connection Details, Structural Design Manual, Society for the Studies in the Use of Precast Concrete, Netherland Betor Verlag, 1978.
6. Precast Concrete Material, Manufacture, Properties and Usage, M. Levitt, Applied Science Publishers Ltd., 1982.
7. Prefabrication with concrete, A.S.G. Bruggeling and G.F. Huyghe, Netherlands: A.A. Balkema Publishers, 1991.

CE24031	**Advanced Soil Mechanics and Foundations (3-0-0)**	
Unit I	3D Consolidation, Skempton's pore pressure parameters, stress paths and invariants, constitutive relations. Earth pressures.	12 lectures
Unit II	Methods of stability analysis of earth and rock-fill dams.	8 lectures
Unit III	Ultimate bearing capacity of shallow foundation by limit equilibrium method, limit analysis and method of characteristics.	8 lectures
Unit IV	Settlement response of pile foundations.	7 lectures
Unit V	Critical state soil mechanics, soil-structure interaction; Reinforced earth.	7 lectures

Books:

1. Elementary Mechanics of Soil Behavior: Saturated Remolded Soils, Biarez, Jean, and Hicher, Pierre-Yves, Balkema Publishers, 1994.
2. Limit Analysis in Soil Mechanics (Developments in Geotechnical Engineering, Vol. 52), Liu, X. L. and Chen, Wal-Fah, Elsevier Science Ltd, 1991.
3. Limit Equilibrium, Plasticity and Generalized Stress-Strain in Geotechnical Engineering, American Society of Safety Engineers Staff, American Society of Civil Engineers, NY 1981.
4. Soils and Foundations, Evett, Jack, and Liu, Cheng, Prentice Hall Inc, N.J, 1997.
5. Soil Mechanics: Concepts and Applications, Powrie, William, E & F N Spon, London, 1997.

CE24032	**Machine Foundations (3-0-0)**	
Unit I	Theory of vibration: free and forced vibration, damping.	8 lectures
Unit II	Natural frequency of foundation- soil systems, amplitude and settlement, damping characteristics, dynamic soil properties, in-situ measurements.	8 lectures
Unit III	Design of machine foundations.	10 lectures
Unit IV	Wave propagation through soil, effects of pile driving and blasting on adjacent structures, vibration isolation.	8 lectures
Unit V	Seismic design of foundations, beneficiary aspects of vibrations in soil engineering practice.	8 lectures

Books:

1. Dynamics of Bases and Foundations, D.D. Barken, Mc Graw Hill, NY, 1962.
2. Vibrations of Soils and Foundations, Richart F.E. et al., Prentice Hall Inc, NJ, 1970.
3. Theory of Vibration with Aplications, W.T. Thomson, CBS, New Delhi, 1988.
4. Soil Dynamics, Shamsher Prakash, McGraw Hill International, New York, 1961.
5. Soil Dynamics and Machine Foundations, Swami Saran, Galgotia Publications, New Delhi, 1999.

CE24033	**Earth and Earth Retaining Structures (3-0-0)**	
Unit I	Lateral earth pressure; Rankine's and Coulomb's theories of active and passive earth pressures.	6 lectures
Unit II	Effect of wall shape, wall friction, backfill and surcharge; Methods of computing active and passive earth pressure.	6 lectures

Unit III	Graphical constructions for computing active and passive earth pressures; Stability of retaining walls; Anchored bulk heads.	10 lectures
Unit IV	Arching in soil; Tunnels and shafts; Earth pressure on temporary supports in cuts; Relaxation and creep effects on earth pressure.	8 lectures
Unit V	Earth and rock fill dams; Selection of sites; Material and dam cross-section; Design of dams; Stability; Slope stability; Construction and performance.	12 lectures

Books:

1. Soil Mechanics, Craig, R. F., Routledge, 1997.
2. Engineering Properties of Soil and Rock, Bell, F. G., Blackwell Science Inc., London, 1999.
3. Elements of Soil Mechanics, Smith, G. N., Blackwell Science Inc., London, 1998.
4. Soils in Construction, Schroeder, W. L. and Dickenson, S. E., Prentice Hall Inc, NJ, 1995.
5. Basic Soil Mechanics, Whitlow, R., Addison-Wesley Pub. Co, NY, 1995.
6. Geotechnical Engineering of Embankment Dams, Fell, R., Mac Gregor, P. and Stapledon, D., Balkema Publishers, 1992.
7. Design of Small Dams, United States Department of the Interior, Oxford & IBH, New Delhi, 1974.

CE24034	**Principles and Practices in Geotechnical Engineering (3-0-0)**	
Unit I	Lateral earth pressure; Rankine's and Coulomb's theories of active and passive earth pressures.	6 lectures
Unit II	Effect of wall shape, wall friction, backfill and surcharge; Methods of computing active and passive earth pressure.	6 lectures
Unit III	Graphical constructions for computing active and passive earth pressures; Stability of retaining walls; Anchored bulk heads.	10 lectures
Unit IV	Arching in soil; Tunnels and shafts; Earth pressure on temporary supports in cuts; Relaxation and creep effects on earth pressure.	8 lectures
Unit V	Earth and rock fill dams; Selection of sites; Material and dam cross-section; Design of dams; Stability; Slope stability; Construction and performance.	12 lectures

Books:

1. Geotechnical and Foundation Engineering: Design and Construction, Day, Robert W., McGraw Hill., NY, 1999.
2. Principles of Soil Mechanics and Foundation Engineering, Murthy, V.N.S., UBSPD, New Delhi, 2001.
3. Soil Engineering Part-I: Fundamentals and General Principles, Singh, Alam and Chowdhary, G.R., CBS, New Delhi, 1994.
4. Geotechnical Engineering: Principles and Practices, Coduto, Donald P., Prentice Hall Inc, NJ, 1998.
5. Principles of Foundation Engineering, Das, B. M., PWS & ITP Publications, London, 1999.
6. Geotechnical Engineering: Soil Mechanics and Foundation Design Set, Cernica, John N., John Wiley & Sons, NY, 1996.
7. Solving Problems in Soil Mechanics, Sutton, B. H. C., Addison – Wesley Pub. Co, NY, 1993.
8. Manual of Soil Laboratory Testing, Vol. I, II, & III, Head, K. H., John Wiley & Sons, NJ, 1996.

CE24035	**Ground Improvement Techniques (3-0-0)**	
Unit I	Principles of ground improvement; Strengthening of rocks by pressure grouting, rock reinforcement, and rock freezing.	8 lectures
Unit II	Compaction of soils: theories, factors affecting compaction, field compaction control, shallow and deep compaction methods, vibro-flotation and dynamic compaction.	8 lectures
Unit III	Admixture stabilization: stabilization mechanisms, lime, cement and bitumen stabilization, geotechnical applications.	8 lectures
Unit IV	Construction in problematic soils: requirements, incremental or stage construction, renewal of soils by excavation, light weight structural fills, displacement by loading and replacement- micropiles, sand compaction piles, stone columns; Strengthening by in-situ mixing, deep lime column method, slurry injection and jet grouting, jet pile method.	12 lectures

Unit V	Reinforced earth, principles and applications; Geotextiles: principles and applications.	6 lectures

Books:

1. Method of Treatment of Unstable Grounds, Bell, Butternorth, London, 1975.
2. Soil Improvement - History, Capabilities and Outlook, ASCE publication, 1978
3. Soil Engineering in Theory and Practice Vol. III: Special Topics, Ed: Alam Singh, Asia Publishing House, New Delhi, 1997.
4. Reinforced Earth, T S Ingold, Thomas Telford Ltd., London, 1982.

CE24036	**Reinforced Earth and Geotextiles (3-0-0)**	
Unit I	Reinforced Earth, mechanisms of the reinforced earth techniques, design principles, materials used for construction, advantages of reinforced earth, reinforced earth construction techniques.	8 lectures
Unit II	An overview of Geosynthetics, Description of Geotextiles, Geogrids, Geonets, Geomembranes, Geocomposites, Geocells, Designing with Geotextiles, Geotextile properties and test methods, Functions of Geotextile, Design methods for separation, stabilization, filtration. drainage.	10 lectures
Unit III	Designing with geogrids, geogrid properties and test methods, designing with geonets, geonet properties and test methods, designing with geomembranes, geomembrane properties and test methods, construction practices with geotextiles, geogrids, geonets, geomembranes.	8 lectures
Unit IV	Design of liquid contaminant liners, liquid contaminant liners, covers for reservoirs, water conveyance (Canal liners), solid material liners, underground storage tanks, design of pavements, geo composites as liquid /vapour barriers, improvement in bearing capacity, erosion control for water ways	8 lectures
Unit V	Geo synthetics: recent research and developments, control of improvement, field instrumentation, design and analysis for bearing capacity and settlement of improved deposits	8 lectures

Books:

1. Designing with Geosynthetics, Robert M. Koerner, Prentice Hall, 1989.
2. Engineering with Geosynthetics, Rao, G. V. and Suryanarayana Raju, G. V. S., Tata Mc Graw Hill Publishing Co. New Delhi, 1990.
3. Geosynthetics and their Applications, Shukla, S. K., Thomas Telford, London, 2002.
4. Reinforced Soil and its Engineering Applications, Swami Saran, I.K. International, 2010.

CE22121	**Forest Survey and Engineering: 3 Credits (2-0-2)**	
Unit I	Forest survey, scope and types of surveying, types and instruments used; Traversing, triangulation, survey stations, base line check and tie, lines; ranging of survey lines; offsets and their types; chain of sloppy grounds, chaining across obstacles; cross staff surveying; Areas of irregularly bounded fields, different methods, Simpson's and trapezoidal rule.	6 lectures
Unit II	Compass traversing, magnetic and true bearing, prismatic compass, local attraction; Computation of interior angles and balancing of closed traverse.	6 lectures
Unit III	Plane table surveying: plane table and its accessories, methods of plane table surveying	5 lectures
Unit IV	Levelling: terms used types of level; Theodolite and its uses. Contour surveying.	6 lectures
Unit V	Building materials: types, strength and characteristics, site selection for building construction, forest roads-alignment, construction and drainage, retaining walls, breast wall, water ways and culverts Bridges-types, selection of site, simple wooden beam bridge; Check dams, spurs, farm ponds, earth dams.	6 lectures

Books:

1. Kanetkar, T.P. and Kulkarni, S.V. (1989). Surveying and Leveling. Vidyarthi Griha Prakashan, Pune.
2. Punmia, B.C. (1987). Surveying Vol. I and II. Laxmi Publisher, New Delhi.
3. Parkash, R. (1983). Forest Surveying, International Book Distributor.
4. Murthy, V.V.N. (1958). Land and Water Management Engineering. Kalyani Publishers, New Delhi.
5. Garg, S.K. Water Resources Engineering- Irrigation Engineering and Hydraulic Structures – Vol. II. Khanna Publisher.
6. Duggal, S.K. Building Materials. New Age International Publisher.
7. Sushil Kumar (1983). Engineering Materials, Metropolitan Publishers, New Delhi.
8. Punmia, B.C. (1998). Building Construction, Laxmi Publication, Delhi.
9. Mackey B. and Orient, W. (1993). Building Construction, Vol. I to IV, Longman, Mumbai.
10. Khanna S.K. and Justo, C.E.G. (1990). Highway Engineering, Nem Chand and Borthers, Roorkee, India.

ES21277	**Environment Science: 0 Credits (2-0-0)**	
Unit I	Basic Concept of Environment and Ecology: Introduction, types of environments, components of environment, environmental studies, need for public awareness, Introduction to ecosystem, classification of ecosystem, structure of ecosystems, functioning of ecosystems, balance of ecosystems.	6 lectures
Unit II	Environmental Impact of Human Activities: Impact of industrialization, modern agriculture, housing, mining, and transportation on environment.	4 lectures
Unit III	Natural Resources: Classification of natural resources, water resources, mineral resources, forest resources, material cycles, energy resources, electromagnetic radiation.	6 lectures
Unit IV	Environmental Pollution: Types of environmental pollution, water pollution, waterborne diseases, land pollution, noise pollution, air pollution, automobile pollution, effects of environmental pollution, public health aspects, solid waste management.	6 lectures
Unit V	Current Environmental Issues: Population growth, global warming, climate change, urbanization, acid rain, ozone layer depletion, animal husbandry. Environmental Protection: Role of Government, Legal aspects, initiatives by NGOs, environmental education, women's education.	6 lectures

Books:

1. Textbook of Environment & Ecology – Dave, D. and Katewa, S. S., Cenage Learning India Pvt. Ltd, Delhi. 2010.
2. Textbook of Environmental Studies – Bharucha, E., Universities Press (India) Pvt. Ltd., Hyderabad. 2010.
3. Environmental Studies: From Crisis to Cure – Rajgopalan, R., Oxford University Press, New Delhi. 2008.
4. Fundamentals of Ecology – Dash, M. C. and Dash, S. P., Tata McGraw Hill Education Private Limited, New Delhi. 2009.
5. Principles of Environmental Science & Engineering – Rao, P. V., PHI Learning Pvt. Ltd., New Delhi. 2009.
6. Elements of Environmental Science & Engineering – Meenakshi, P., PHI Learning Pvt. Ltd., New Delhi. 2009.
7. Environmental Science & Engineering – Debi, A. University Press (India) Pvt. Ltd. Hyderabad. 2008.

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

Year I Semester I						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	PH21103	Quantum Mechanics for Engineers	4	0	2	05
2.	MA21101	Mathematics – I	3	1	0	04
3.	ES21100	Basic Electrical Engineering	3	1	2	05
4.	ES21151	Engineering Graphics and Design	0	0	6	03
5.	FR21121	Biology for Engineers	2	1	0	03
Total						**20**

Year I Semester II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CY21201	Engineering Chemistry – A	3	1	2	05
2.	MA21201	Mathematics – II	3	1	0	04
3.	ES21200	Programming for Problem Solving	3	0	2	04
4.	ES21251	Workshop Practice	0	0	6	03
5.	HS21201	Communication Skills	2	0	2	03
6.	ES21277	Environmental Science (Audit)	2	0	0	00
Total						**19**

Year II Semester III						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	MA22101	Mathematics – III	3	1	0	04
2.	ES22100	Engineering Mechanics	3	1	0	04
3.	ES22101	Basic Electronics Engineering	3	0	2	04
4.	CS22100	Digital Logic Design	3	0	2	04
5.	CS22101	Data Structure and Algorithms	3	0	4	05
6.	CS22102	Programming Tools and Techniques	2	0	4	04
Total						**25**

Year II Semester IV						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS22201	Entrepreneurship and Startups	3	0	0	03
2.	HS22277	Indian Constitution (Audit)	2	0	0	00
3.	CS22200	Discrete Mathematics	3	1	0	04
4.	CS22201	Computer Organization and Architecture	3	1	2	05
5.	CS22202	Programming in Java	2	0	4	04
6.	CS22203	Design and Analysis of Algorithms	3	0	4	05
Total						**21**

Year III Semester V						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS23101	Principles of Economics	3	0	0	03
2.	HS23177	Essence of Indian Knowledge and Tradition (Audit)	2	0	0	00
3.	EC23121	Signals and Systems	2	1	0	03
4.	CS23100	Database Management Systems	3	1	2	05
5.	CS23101	Formal Language and Automata Theory	3	0	0	03
6.	CS23102	Operating Systems	3	1	2	05

7.	CS23103	Microprocessors	3	0	2	04
8.	CS23166	Study Tour (Audit)	0	0	0	00
Total						**23**

Year III Semester VI						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS23201	Organizational Behaviour	3	0	0	03
2.	MO230**	Open Elective – I (From MOOC)	3	0	0	03
3.	CS230**	Programme Elective – I	3	0	0	03
4.	CS230**	Programme Elective – II	3	0	0	03
5.	CS23200	Compiler Design	3	1	2	05
6.	CS23201	Computer Networks	3	1	2	05
7.	CS23289	Seminar	0	0	2	01
Total						**23**

Year IV Semester VII						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	**240**	Open Elective – II	*	*	*	03
2.	CS240**	Programme Elective – III	3	0	0	03
3.	CS240**	Programme Elective – IV	3	0	0	03
4.	CS24199	Project – I	0	0	6	03
5.	CS24179	Industrial Training	0	0	0	03
Total						**15**

Year IV Semester VIII						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	MO240**	Open Elective – III (From MOOC)	3	0	0	03
2.	**240**	Open Elective – IV	*	*	*	03
3.	CS240**	Programme Elective – V	3	0	0	03
4.	CS240**	Programme Elective – VI	3	0	0	03
5.	CS24299	Project – II	0	0	12	06
6.	ED24288	Extra-Curricular Activities and Discipline	0	0	0	02
Total						**20**

List of Electives

Programme Electives – I & II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CS23001	Speech Processing	3	0	0	03
2.	CS23002	Graphics Design and Modelling	3	0	0	03
3.	CS23003	Computer Oriented Numerical Techniques	3	0	0	03
4.	CS23004	Software Engineering	3	0	0	03
5.	CS23005	Principles of Programming Languages	3	0	0	03
6.	CS23006	IOS Application Development	3	0	0	03
7.	CS23007	Computer Graphics	3	0	0	03
8.	CS23008	Data Communication	3	0	0	03

Programme Electives – III & IV						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CS24001	Soft Computing	3	0	0	03
2.	CS24002	Graph Theory	3	0	0	03
3.	CS24003	Real Time Systems	3	0	0	03
4.	CS24004	Information Security	3	0	0	03
5.	CS24005	Artificial Intelligence	3	0	0	03
6.	CS24006	Combinatorial Design Theory for Computer Science	3	0	0	03
7.	CS24007	Data Warehousing and Data Mining	3	0	0	03
8.	CS24008	Machine Learning	3	0	0	03

Programme Electives – V & VI						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CS24011	Grid Computing	3	0	0	03
2.	CS24012	Microprocessors and Micro-Controllers	3	0	0	03
3.	CS24013	Neural Imaging and Signal Systems	3	0	0	03
4.	CS24014	Wireless Communication	3	0	0	03
5.	CS24015	Distributed Algorithms	3	0	0	03
6.	CS24016	Operations Research	3	0	0	03
7.	CS24017	Mobile Application Development	3	0	0	03
8.	CS24018	Image Processing	3	0	0	03
9.	CS24019	Big Data Analytics	3	0	0	03
10.	CS24020	Human Computer Interaction	3	0	0	03

Open Elective – II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CS24041	Software Engineering Methodologies	3	0	0	03

Open Elective – IV						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CS24042	Soft Computing for Engineers	3	0	0	03

Course Content

ES21200	Programming for Problem Solving: 4 Credits (3-0-2)	
Unit I	Overviews of C; Procedural vs. Object Oriented Programming (OOP); Characteristics of OOP; Variables, constants, operators in C++; Functions: Function Prototyping, Call by Reference, Call by Value, Return by Reference, Inline Function, Constant Arguments, Function Overloading.	6 lectures
Unit II	Classes and Objects, Arrays within a Class, Memory Allocation for Objects, Static Data Members, Static Member Functions, Arrays of Objects, Object as Function Arguments, Friend Functions, friend classes, Returning Objects, Constant member functions, Pointer to members, Constructor :Parameterized Constructor, Multiple Constructor in a Class, Constructors with Default Arguments, Dynamic Initialization of Objects, Copy Constructor, Dynamic constructor, Destructor and its uses.	8 lectures
Unit III	Operator Overloading: Defining operator Overloading, Overloading Unary, binary Operators, Overloading Binary Operator Using Friends, Manipulating of String Using Operators; Type Conversion details; Inheritance: Single, Multilevel, Hierarchical, Multiple, Hybrid Inheritance, Virtual Base Classes, Abstract Classes, Constructor in Derived Classes, Nesting of Classes.	10 lectures
Unit IV	Pointers, Pointer to Object, This pointer, Pointer to Derived Class, Virtual Function, Pure Virtual Function, Polymorphism implementations. Working with files, Command Line Arguments.	10 lectures
Unit V	Templates; Exception handling; Introduction to standard library; Namespace.	8 lectures

Books:

1. Objected Oriented Programming with C++, E. Balaguruswamy, 6th Edition, TMH, 2013.
2. Mastering C++, R. Venugopal, Rajkumar, T. Ravishankar, 2nd Edition, McGraw Hill Education, 2013.
3. C++ Primer, S. B. Lippman & J. Lajoie, 5th Edition, Addison Wesley, 2012.
4. Object Oriented Programming using C++, R. Lafore, BPB Publications, 2004.

CS22100	Digital Logic Design: 4 Credits (3-0-2)	
Unit I	Number systems, base conversion methods, complement of numbers, binary Codes, binary arithmetic, Binary Coded Decimal and its Properties, Gray Code, Error Detecting and Correcting Codes, Hamming Code. Logic design, logic gates, properties of XOR gate, universal logic gates, multilevel NAND/NOR realizations.	8 lectures
Unit II	Boolean algebra, basic theorems and properties, Boolean functions, truth tables and Boolean expressions, canonical and standard forms, Simplification/minimization of Boolean functions, algebraic method, Karnaugh map method and Quine Mc Cluskey tabular method.	8 lectures
Unit III	Combinational Circuits design, adders, subtractors, multiplier, comparator, decoders, BCD-to-seven-segment display decoder, encoders, decimal-to-BCD encoder, multiplexers, de-multiplexers, code converters, logic design using ROMs, PLAs and FPGAs.	8 lectures
Unit IV	Sequential circuits, basic architectural distinctions between combinational and Sequential circuits, flip flop, S-R flip flop, J-K flip flop, clocked flip flops, master-slave J-K flip flop, D and T flip flops, design of a clocked flip-flop, conversion from one type of flip-flop to another, registers and counters, shift registers, design and operation of ring and twisted ring Counters, operation of asynchronous and synchronous counters.	8 lectures
Unit V	State diagram, analysis of synchronous sequential circuits, approaches to the design of synchronous sequential Finite State Machines, synthesis of synchronous sequential circuits, design aspects, state reduction, design steps, realization using flip-flops, design of single mode counters, ripple counter, ring	10 lectures

	counter, shift register, Asynchronous Sequential Circuits, Analysis and synthesis, static and dynamic hazards and elimination of hazards.	

Books:

1. Digital Logic and Computer Design, Morris Mano, PHI, 2002.
2. Digital Computer Electronics, Tata McGraw Hill, Malvino, 3rd Edition, 1993.
3. Switching Theory and Logic Design, A. Anand Kumar, 3rd Edition, PHI, 2016.
4. Switching and Finite Automata Theory, Zvi Kohavi & Niraj K. Jha, 3rd Edition, Cambridge, 2010.

CS22101	**Data Structure and Algorithms: 5 Credits (3-0-4)**	
Unit I	Introduction to Data Structures, Various ways of representation of array elements: Row Major and Column Major order, handing multi-dimensional array and their representation.	6 lectures
Unit II	Arrays: Dynamic memory allocation, one-dimensional arrays, multidimensional arrays, operations on arrays, storage – Row major order, Column major order. Linked lists: types of linked lists – singly, doubly and circularly linked lists, operations on linked lists.	9 lectures
Unit III	Stacks: Implementation of stacks– array and linked list, operations on stacks, Applications of Stacks, Notations – infix, prefix and postfix, Conversion and evaluation of arithmetic expressions using Stacks. Queues: Implementation of queues– array and linked list, operations on queues, Types of queues – queue, double ended queue and priority queue.	9 lectures
Unit IV	Trees: Binary tree, Binary search tree, Threaded binary tree, Height balanced trees, Tries, Heaps, Hash tables. Graph traversals: Breadth First Search, Depth First Search, Shortest path: Depth first search in directed and undirected graphs. Union-find data structure and applications. Directed acyclic graphs; topological sort.	9 lectures
Unit V	Searching: Linear search, Binary search and Hashing. Algorithms and data structures for sorting: Insertion Sort, Bubble sort, Selection Sort, Merge sort, Quick Sort, Heap sort, Radix sort, Bucket sort, Shell sort. Algorithm design techniques: Divide and conquer, Greedy approach, dynamic programming.	9 lectures

Books:

1. Fundamentals of Data Structures, E. Horowitz, Sartaj Sahani, 2nd Edition, Galgotia Publication, 2008.
2. Algorithms, Data Structures, and Problem Solving with C++, Mark Allen Weiss, Addison-Wesley Publishing Company, 1995.
3. Data Structures using C and C++, Y. Langsam, M.J. Augenstein, AM. Tanenbaum, 2nd Edition, PHI, 2007.
4. Data structure and program design in C, R.L. Kruse, B.P. Leary, C.L. Tondo, 5th Edition, PHI, 2009.

CS22102	**Programming Tools and Techniques: 4 Credits (2-0-4)**	
Unit I	Vim, Emacs, HTML; Report and presentation software: latex; Drawing software (e.g., inkscape, xfig); Office suite: openOffice/ libreoffice.	4 lectures
Unit II	Unix (Linux) basics: shell, file system, permissions; Unix (Linux) commands; Bash Shell Scripting.	8 lectures
Unit III	Unix tools: e.g., awk, sed, grep, find, tar, sort, ls, diff, etc; I/O redirection, pipes; AWK scripting.	6 lectures
Unit IV	Python programming: Basic data types - numbers (floating point, complex, and unlimited-length long integers), strings (both ASCII and Unicode), lists, and dictionaries.	6 lectures
Unit V	Advanced topics in Python: matrix operations, matplotlib, etc.; Graph plotting software (e.g., gnuplot).	4 lectures

Books:

1. Beginning Linux Programming, Neil Matthew and Richard Stones, 4th edition, Wiley publication, 2007.

2. Latex - A document preparation system, Leslie Lamport, 2nd Edition, Addison-Wesley, 1994.
3. Learn Python 3 the Hard way, Zed A. Shaw, Pearson, 2018.
4. Python for Data Analytics, Wes McKinney, O' Reilly, 2015.
5. The Python Tutorial Online Book (http://docs.python.org/3/tutorial/index.html).

CS22200	Discrete Mathematics: 4 Credits (3-1-0)	
Unit I	Basic operation on sets, Cartesian product, Relation, Types of relations, composition and inverse of relation, Types of functions and their composition.	6 lectures
Unit II	Algebraic structure, group theory with emphasis to finding groups: subgroups and group homomorphism, lagrange's theorem, rings, ideals, finite fields and the elementary properties.	10 lectures
Unit III	Basic counting principle arrangements, multinomial theorem, partitions and allocations, pigeon-hole principle, cardinality and countability, inclusion-exclusion principle, recurrence relation, generating functions.	10 lectures
Unit IV	Posets, chain, well order sets, lattices, cardinal and ordinal number. Graph and their basic properties, degree, path and trees.	8 lectures
Unit V	Formal logic, propositional logic, predicate logic, syntax and semantics, rules of inference, derivation.	8 lectures

Books:

1. Discrete Mathematics with applications to computer science, J.P. Tremblay and R. P. Manohar, McGraw Hill, 1997.
2. Discrete Mathematics & its Applications, K. H. Rosen, 6th Edition, Tata McGraw-Hill, 2007.
3. Introductory Discrete Mathematics, V. K. Balakrishnan, Dover, 1996.
4. Discrete Mathematics, Seymour Lipschutz, Marc Laras Lipson and Varsha H. Patil, Schaum's Outline, 2017.
5. Discrete Mathematics and Graph Theory, B. Satyanarayana and K. S. Prasad, PHI, 2009.

CS22201	Computer Organization and Architecture: 5 Credits (3-1-2)	
Unit I	Introduction: Digital computer generation, computer types and classifications. Data Representation: Binary numbers, binary codes, fixed point representation, floating point representation, error detection codes. Functional units and their interconnections, buses, bus architecture, types of buses and bus arbitration. Register, bus and memory transfer. Arithmetic microoperations, logic microoperations, shift microoperations, Arithmetic Logic shift Unit.	8 lectures
Unit II	Fundamental concepts of the processing Unit: Addition and subtraction of signed numbers, look ahead carry adders. Multiplication: Signed operand multiplication, Booths algorithm. Division and logic operations. Floating point arithmetic operation. Processor organization, general register organization, stack organization and addressing modes.	8 lectures
Unit III	Control Unit: Instruction types, formats, instruction cycles and subcycles (fetch and execute etc.), micro-operations, execution of a complete instruction. Hardwired and microprogrammed control: microprogramme sequencing. Basic concepts of pipelining: Instruction Queue, branching, data dependency.	9 lectures
Unit IV	Memory: Basic concept and hierarchy, semiconductor RAM memories, ROM memories. Cache memories: concept and design issues (performance, address mapping and replacement) Auxiliary memories: magnetic disk, magnetic tape and optical disks. Virtual memory: concept and implementation.	9 lectures
Unit V	Input / Output: Peripheral devices, I/O interface, I/O ports, Interrupts: interrupt hardware, types of interrupts and exceptions. Modes of Data Transfer: Programmed I/O, interrupt initiated I/O and Direct Memory Access. I/O channels and processors. Serial Communication: Synchronous & asynchronous communication, standard communication interfaces.	8 lectures

Books:

1. Computer System and Architecture, Mano. M, (3rd edition) PHI, 1994.
2. Computer Organization & Architecture Stallings. W, 9th Edition, PHI, 2012.
3. Computer Organization, V. Carl Hamacher, Z.G. Vranesic and Zaky, 5th Edition McGraw Hill.
4. Troubleshooting, Maintaining and Repairing PCs, S. Bigelow, 5th Edition, TMH, 2001.
5. Computer Organization and Design, P. Pal Choudhury, 3rd Edition, PHI, 2012.

CS22202	**Programming in Java: 4 Credits (2-0-4)**	
Unit I	OOP Principles, Overview of Java, data types, variables, dynamic initialization, arrays, operators, control statements, type conversion and casting.	4 lectures
Unit II	Concepts of classes and objects, Methods, constructors, this key word, garbage collection, overloading methods and constructors, parameter passing techniques, recursion, nested classes and inner classes, exploring the String class; Inheritance: member access rules, forms of inheritance, method overriding, abstract classes, dynamic method dispatch, using final with inheritance.	7 lectures
Unit III	Package, importing packages, differences between classes and interfaces, defining an interface, implementing interface, variables in interface and extending interfaces.	5 lectures
Unit IV	Exception handling: types of exceptions, Built-in exceptions, creating own exception sub classes; Multithreading: differences between process and thread, thread life cycle, creating multiple threads using Thread class, Runnable interface, Synchronization, thread priorities, inter thread communication, daemon threads, deadlocks, thread groups. Java Library: String handling, java.util, java.io and java.net packages.	7 lectures
Unit V	Introduction SWING: SWING classes, window fundamentals, working with frame windows, working with graphics, colors, fonts; Networking programming TCP/IP sockets, Datagram, URL connection.	5 lectures

Books:

1. Core Java 2, Cay. S. Horstmann and Gary Cornell, Vol 1, 9th Edition, PHI, 2013.
2. Core Java 2, Vol 2, Cay. S. Horstmann and Gary Cornell, 9th Edition, PHI, 2013.
3. The Complete Reference Java J2SE, Herbert Schildt, 7th Edition, TMH, 2007.

CS22203	**Design and Analysis of Algorithms: 5 Credits (3-0-4)**	
Unit I	Asymptotic notations and their significance, introduction to RAM model of computation, complexity analysis of algorithms, comparison based sorting - quick sort, heap sort, merge sort: worst and average case analysis. Divide and conquer methods for solving problems, recursion-tree method for solving recurrences, Master theorem.	9 lectures
Unit II	Greedy methodology: fractional knapsack, Job Scheduling, Interval Scheduling, Graph algorithms: minimum spanning trees, shortest paths - single source.	10 lectures
Unit III	Dynamic programming methodology: optimal substructure, memorization, 0/1 Knapsack, TSP, Fibonacii calculation, longest common subsequence, longest increasing subsequence, shortest paths – all pairs.	9 lectures
Unit IV	Backtracking methodology: n-queen problem, Hamiltonian circuit, subset problem, m-coloring.	6 lectures
Unit V	Branch bound approach: Assignment problem, 0/1 knapsack; NP-Complete Theory: P and NP, NP hard and NP-complete problems, intractability, approximation algorithms.	8 lectures

Books:

1. Introduction to algorithms, T.H. Cormen, C.E. Leiserson, R.L. Rivest, C. Stein, 3rd Edition, PHI, 2009.
2. Fundamentals of Algorithm, Horowitz & Sahani, 2nd Edition, Universities Press.

3. Algorithms, Berman, Cengage Learning, 2008.
4. Algorithms, Sanjoy Dasgupta, Umesh Vazirani, 1st Edition, McGraw-Hill Education, 2006.
5. Algorithm Design, Goodrich, Tamassia, Wiley India, 2001.

CS23100	Database Management Systems: 5 Credits (3-1-2)	
Unit I	Introduction to DBMS- evolution, File-Processing System Versus a DBMS, Advantages, DBMS architecture, Data Models, Schemas and Instances, and Data independence, Data modelling using Entity Relationship model, Specialization, Generalization, Aggregation, Relational database design using ER to Relational Mapping.	8 lectures
Unit II	Relational Query Languages: Relational Algebra, Tuple Relational Calculus and Domain Relational Calculus, SQL, Views, Assertions and Triggers. Relational Database Design: Functional dependencies, Normal forms - INF, 2NF, 3NF, BCNF, Multivalued Dependencies and 4NF, Join dependencies and Fifth Normal Forms.	10 lectures
Unit III	Storage strategies: Indexes, Hashing, B-trees and B+ trees. Stable storage: RAID technology. Query processing and optimization.	7 lectures
Unit IV	Transaction Processing: Transaction support in SQL, Concurrency control, Locking and Timestamp based techniques for Concurrency control, Multiversion Concurrency control scheme, Recovery, Log-based and Shadow paging Recovery techniques.	9 lectures
Unit V	Security and Authorization- Access control, Direct access control and Mandatory access control, Overview of Object-oriented and Object Relational Databases, Distributed databases, Introduction to Big Data, No SQL.	8 lectures

Books:

1. Fundamentals of Database systems, Elmasri, Navathe, Somayajulu, Gupta, 6th Edition, Pearson Education, 2011.
2. Database Systems Concepts, A. Silberschatz, Korth and S. Sudarshan, 6th Edition, Mc. Graw Hill. International, New York, 2010.
3. Database Management Systems, Raghu Ramakrishnan, Johannes Gehrke, 3rd Edition, McGraw Hill, 2003.

CS23101	Formal Language and Automata Theory: 3 Credits (3-0-0)	
Unit I	Introduction to theory of Automata, language theory, tokens, alphabets, NDFA and DFA, Minimization of FA. Expressions, regular sets and regular grammar.	8 lectures
Unit II	Formal languages, grammar, production rules, sentences, concepts of type 0, type 1, type 2 and type 3 languages, properties of various types of grammars and operations on them.	9 lectures
Unit III	Context free languages, Derivation trees, simplification of CFG, methods for null and unit product elimination, context free grammar.	7 lectures
Unit IV	Basic definition of Pushdown Automata (PDA), Acceptance by PDA, PDA and CFL, constructing PDAs for given CFG and vice-versa.	9 lectures
Unit V	Turing machine computability and Church's hypothesis, halting, problem and undecidability, Universal Turing machine, Recursive functions.	9 lectures

Books:

1. Theory of Computer Science: Automata, Languages and Computation, Mishra K.L.P, & N. Chandrasekaran, PHI, 2006.
2. Introduction to Automata Theory, Languages and Computation, Hopcroft, & Ullman, AWL, New York, 2000.
3. An Introduction to Formal Languages and Automata, Peter Linz, 6th Edition, Jones and Bartlett Student Edition.
4. Introduction to Languages and Theory of Computation, J.C. Martin, Tata McGraw Hill, New Delhi, 2001.

CS23102	Operating Systems: 5 Credits (3-1-2)	
Unit I	Operating system and functions, Classification of Operating systems - Batch, Interactive, Time sharing, Real Time System, Multiprocessor Systems, Multiuser Systems, Multiprocessor Systems, Multithreaded Systems, Personal Computer Systems, Computer System Operation, System calls, System Programs.	8 lectures
Unit II	Process Concept, Principle of Concurrency, Producer / Consumer Problem, Mutual Exclusion, Critical Section Problem, Dekker's solution, Peterson's solution, Semaphores, Classical Problems in Concurrency- Dining Philosopher Problem, Sleeping Barber Problem; Inter Process Communication models and Schemes, Process generation.	8 lectures
Unit III	CPU Scheduling: Scheduling Concepts, Performance Criteria, Process States, Process Transition Diagram, Schedulers, Process Control Block (PCB), Process address space, Process identification information, Threads and their management, Scheduling Algorithms, Multiprocessor Scheduling. Deadlock: System model, Deadlock characterization, Prevention, Avoidance and detection, Recovery from deadlock.	8 lectures
Unit IV	Memory Management: Basic bare machine, Resident monitor, Multiprogramming with fixed partitions, Multiprogramming with variable partitions, Protection schemes, Paging, Segmentation, Paged segmentation, Virtual memory concepts, Demand paging, Performance of demand paging, Page replacement algorithms, Thrashing, Cache memory organization, Locality of reference.	9 lectures
Unit V	I/O Management and Disk Scheduling: I/O devices, and I/O subsystems, I/O buffering, Disk storage and disk scheduling. File System: File concept, File organization and access mechanism, File directories, and File sharing, Filesystem implementation issues, File system protection and security. Case studies: DOS, UNIX and Windows Operating systems.	9 lectures
Books: 1. Modern Operating Systems, Andrew S. Tanenbaum, and Herbert Bos, 4th Edition, Pearson Education, 2014. 2. Operating Systems: A Design Oriented Approach, Crowley, 1st Edition, Tata McGraw Hill, New Delhi, 2017. 3. Operating Systems Concepts, Sibershatz, Galvin, and Gagne, 10th Edition, John Wiley and Sons, 2018.		

CS23103	Microprocessors: 4 Credits (3-0-2)	
Unit I	History and evolution of microprocessors, 8085/8085A microprocessor, pin description, internal architecture, bus organization, registers, ALU, instruction set of 8085, instruction format, addressing modes, types of instructions.	8 lectures
Unit II	Assembly language programming, macros, labels and directives, simple examples, microprocessor timings, instruction cycle, Machine cycles, T states, state transition diagrams, Timing diagram for different machine cycles.	8 lectures
Unit III	Assembly programming with additional instruction; looping, counting, indexing, additional data transfer and 16-bit arithmetic instructions, logic operations, rotate and compare, counters and time delays, illustrative programs: hexadecimal counter, zero-to-nine modulo counter, Pulse Timing for Flashing.	8 lectures
Unit IV	Code conversions programs: BCD to binary code conversion, binary to BCD conversion, BCD to seven-segment LED code conversion, BCD addition and subtraction, introduction to advanced instruction and applications, multiplication and subtraction with carry.	9 lectures
Unit V	Basic interfacing concept, interfacing I/O devices like keyboard, LED display; 8085 interrupt, D/A and A-D converters, 8255A programmable peripheral interface, 8253 programmable interval timer, basic concept of serial I/O, software-controlled asynchronous serial I/O, SID, SOD, hardware -controlled serial I/O using Programmable chips.	9 lectures

Books:

1. Programming and Applications with 8085/8080A, R. S. Gaonkar, Microprocessor Architecture, 6th Edition, Penram International Publishing, 2013.
2. Introduction to Microprocessors, A.P. Mathur, 3rd Edition, Tata McGraw Hill, 2017.
3. Microprocessors & Interfacing, Douglas V Hall, McGraw-Hill.
4. Microprocessor System, Architecture Programming & Design, YU-Cheng Liu & Glenn A Gibson, 2nd Edition, Pearson Education, 2015.

CS23200	**Compiler Design: 5 Credits (3-1-2)**	
Unit I	Introduction to Compilers: The structure of a compiler; Definitions of programming languages: The role of Lexical Analyser, Regular Expressions, Finite automata, NFA, DFA, LEX, Implementation of a lexical analyzer.	9 lectures
Unit II	Context sensitive and Context free grammars, Derivation and Parse trees; Parsers, Shift- reduce parsing, Operator - precedence parsing, Top-down and bottom-up parsing techniques, Predictive parsing, LR parsers, Canonical collection of LR (0) items, Constructing SLR parsing tables.	10 lectures
Unit III	Syntax directed translation schemes, implementation of syntax directed translators; Intermediate Code, Postfix notation, Syntax trees, Three address code, Quadruples, Triples, Translation of assignment statements, Boolean expressions, Translation with a top-down parser, Symbol tables, Contents and Data structure representing scope information.	8 lectures
Unit IV	Errors and recovery in compiling, Lexical and Syntactic phase errors, Semantic errors. Principal sources of optimization, Loop optimization, The DAG representation of basic blocks, Global data flow analysis, Loop invariant computations, Inductions, variable elimination, Some other loop optimization.	8 lectures
Unit V	Code generation: Object programs, problems in code generation, A machine model, an example of a simple code generator, Register allocation and assignment, Code generation from DAG, Study of a practical compiler.	7 lectures

Books:

1. Compilers: Principles, Techniques and Tools, Aho, Ullman and Sethi, 2nd Edition, AWL Publication, New York, 2006.
2. Compiler Construction, N. Wirth, AWL Publication, New York, 2000.
3. Compiler Design in C, Holub, Prentice Hall of India, New Delhi, 2001.

CS23201	**Computer Networks: 5 Credits (3-1-2)**	
Unit I	Computer networks and the Internet: Internet and protocol, the network edge, network core, access networks and physical media, ISPs and Internet backbones, delay and loss in packet switched networks, protocol layers and their service models, history of computer networking and the internet. OSI Model, layers in the OSI Model, TCP/IP protocol suites, Addressing. Application Layer: principles of network applications, the web and the HTTP, FTP, electronic mail in the internet, SMTP, MIME, DNS, P2P file sharing, socket programming with TCP, socket programming with UDP, web server and its functions.	9 lectures
Unit II	Transport Layer: transport layer services, multiplexing and demultiplexing, connectionless transport (UDP), principles of reliable data transfer, connection-oriented transport (TCP), principles of congestion control, TCP congestion control. Network Layer: forwarding and routing, network service models, virtual circuit and datagram networks, the inside of a router, forwarding and addressing in the internet, routing algorithms, routing in the internet, broadcast and multicast routing.	9 lectures
Unit III	The link layer and local area networks: link layer services, error detection and correction techniques, multiple access protocols, link layer addressing, the Ethernet, interconnections (hubs and switches), point-to-point protocol, link virtualization, ATM networks, MPLS.	8 lectures

Unit IV	Wireless and Mobile networks: wireless links and network characteristics, CDMA, Wi-Fi, 802.11 wireless LANs, cellular internet access, mobility management principles, mobile IP, managing mobility in cellular networks, impact of wireless and mobility on higher layer protocols.	8 lectures
Unit V	Multimedia Networking: applications, streaming stored audio and video, RTSP, protocols for real-time interactive applications, RTP, RTCP, SIP, H.323, distributing multimedia, content distribution networks, scheduling and policing mechanisms, integrated services and differentiated services, RSVP.	8 lectures

Books:

1. Computer Network, A.S. Tanenbaum, 5th Edition, PHI, 2013.
2. Data and computer Communications, Stallings, 10th Edition, Pearson Education, 2013.
3. An Engineering Approach to computer Networking, Keshav, 1st Edition, Pearson Education, 2002.
4. Network Security Essentials, Stallings, 6th Edition, Pearson Education India, 2017.

CS23001	**Speech Processing: 3 Credits (3-0-0)**	
Unit I	Speech production mechanism, classification of speech sounds, nature of speech signal, models of speech production, Review of speech signal processing, purpose of speech processing and digital processing of speech signals.	8 lectures
Unit II	Time domain parameters of speech, methods for extracting the parameters, zero crossings, energy, power, auto correlation function, pitch estimation, Short time Fourier analysis and filter bank analysis. Spectrographic analysis, formant extraction, pitch extraction, formulation of linear prediction problem in time domain, interpretation of linear prediction in autocorrelation and spectral domain.	9 lectures
Unit III	Pattern comparison techniques, speech distortion measures– mathematical and perceptual – log–spectral distance, cepstral distances, weighted cepstral distances and filtering, likelihood distortions, spectral distortion using a warped frequency scale, LPC, PLP and MFCC Coefficients and Dynamic Time Warpi.	9 lectures
Unit IV	Speech modeling, markov processes, hidden markov models (HMM), evaluation, optimal state sequence, viterbi search, baum-welch parameter re-estimation and implementation issues.	8 lectures
Unit V	Approaches to speech recognition, large vocabulary continuous speech recognition, Architecture of a large vocabulary continuous speech recognition system – acoustics and language models – ngrams, context dependent sub-word units, speaker recognition, speech synthesis, text-to-speech synthesis, applications and present status.	8 lectures

Books:

1. Speech and Language Processing – An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition, Daniel Jurafsky and James H Martin, Pearson Education, 2000.
2. Speech Signal Processing, T.E. Quatieri, Pearson LPE, 2002.
3. Speech and Language Processing, Daniel Jurafsay, Tames H. Mrtian, Pearson, 2008.
4. Fundamentals of Speech Recognition, Lawrence R. Rabiner, Juang, Prentice Hall, 1994.

CS23002	**Graphics Design and Modelling: 3 Credits (3-0-0)**	
Unit I	Graphics basics, introduction, Graphics output device, Raster scan Graphics, Graphics programming and Open GL.	6 lectures
Unit II	Modeling Transformation, Clipping, Hidden line/surface elimination, Hierarchical modeling, Viewing, scan conversion, Computer-aided drafting, Parametric drafting, Projections, Viewing Cameras, Projection Matrices, Parallel Projections, Perspective Projections.	10 lectures
Unit III	Modeling, Polygonal meshes, Curves & Surfaces, Models Other Material Hierarchical Models, Language Models, Physical Models, Particle Systems, Web Based Models, Solid Modeling, Constructive Solid Geometry (CSG).	10 lectures

Unit IV	Rendering, Rendering basics, Hidden surface removal, Illumination and shading, Texture mapping.	8 lectures
Unit V	Animation, Animation basics, Key-frame animation, Graphics Standards: 2D and 3D standards, Graphics portability.	8 lectures

Books:

1. Interactive Computer Graphics: A Top-Down Approch using OpenGL, E. Angel, 4th Edition, Addison-Wesley, 2006.
2. Computer Graphics with OpenGL, D. Hearn and M. Baker, 3rd Edition, Prentice Hall, 2003.
3. Computer Graphics: Principles and Practice, J. Foley, A. Van Dam, S. Feiner, J. Hughes and R. Phillips, Addison-Wesley, 1995.

CS23003	**Computer Oriented Numerical Techniques: 3 Credits (3-0-0)**	
Unit I	Introduction, numbers and Significant figures, Floating point number representation of number and normalization. Errors in numbers. Absolute, and Relative errors measures, Relation between Relative and Absolute error measures. Errors and their Computation, The general formula of errors, Error in a series approximation.	6 lectures
Unit II	Solution of Transcendental equation by method of Bisection, False Position, Newton's method of tangents, Newton Raphson method, complex roots, Muller's method, Secant method. Rate of convergence of Iterative methods. Solution of Polynomial Equations. Solution of simultaneous nonlinear equation, Solution of linear equation by creamers rule, Gaussian elimination, Gauss-Seidel iterative method, Factorization method Jecobi's method.	9 lectures
Unit III	Interpolation and extrapolation: Finite Differences, Difference tables Polynomial Interpolation: Newton's forward and backward formula, Central Difference Formulae: Gauss forward and backward formula, Sterling's, Bessel's, Everett's formula. Interpolation with unequal intervals: Langrange's Interpolation, Newton Divided difference formula, Hermite's Interpolation.	8 lectures
Unit IV	Numerical Integration and Differentiation: Introduction, Newtons-Cotes Closed quadrate, A general quadrate formula of equidistant ordinates, Trapezoidal rule, Simpson's 1/3 and 3/8 rule, Boole's rule, Waddle's rule, Gass- Languor quadrate. Go firefight quadrate.	7 lectures
Unit V	Solution of differential Equations: Picard's Method, Euler's Method, Taylor's Method, Runge-Kutta Methods, Predictor Corrector Methods. Statistical Computation: Frequency chart, Curve fitting by method of least squares, fitting of straight lines, polynomials, exponential curves etc, Data fitting with Cubic Splines, Regression Analysis, Linear and Non-linear Regression, Multiple regression, Statistical Quality Control methods.	12 lectures

Books:

1. Computer Oriented Numerical Methods, Rajaraman V, Pearson Education, 1993.
2. Applied Numerical Analyses, Gerald and Whealey, 7th Edition, Pearson Education, 2003.
3. Numerical Methods for Scientific and Engineering Computations, Jain, Iyengar and Jain, New Age Int.
4. Introductory Methods of Numerical Analysis, Sastry S. S., PHI, 2012.

CS23004	**Software Engineering: 3 Credits (3-0-0)**	
Unit I	Concept of systems, its characteristics, The product, The process, Methods, Tools, Software process modules, Process technology, Project management concepts: People, the problem, the process and the project.	8 lectures
Unit II	Software process and project metrics, Software measurement, Software project planning: Observation on estimating, project planning objectives, software scope, resources, project estimation, decomposition techniques.	8 lectures
Unit III	Project scheduling, basic concepts, Relationship between people and effort, Defining task set, Refinement of major task, Software quality assurance: Quality concepts, Software reviews, Software reliability.	8 lectures

Unit IV	Software project analysis, analysis concepts, requirements analysis, analysis methods, analysis modelling, elements, data modelling, data flow diagrams, The mechanics of structures analysis, Design concepts .and principles.	8 lectures
Unit V	Software testing methods, Testing fundamentals, Test case design, Software Testing strategies, Strategic issues, Unit testing, Integration testing, Validation testing, system testing. Object-oriented Paradigm, concepts, elements of an object model, Management of Object oriented software projects. Object-oriented analysis concepts.	10 lectures

Books:

1. Software Engineering: A Practitioner's Approach, Roger S. Pressman, 7th Edition, Tata McGraw Hill, New Delhi, 2009.
2. Software Engineering Concepts, Richard Fairley, Tata McGraw Hill, New Delhi, 2004.
3. Classical and Object Oriented Software Engineering with UML and Java, S.R. Schach, 4th Edition, McGraw Hill International, New York, 1999.

CS23005	**Principles of Programming Languages: 3 Credits (3-0-0)**	
Unit I	Introduction, Brief history of programming language, Criteria for programming language design, Evolution of major Programming languages Concept of low level languages, mid level language, high level languages, Programming environment.	8 lectures
Unit II	Syntax and semantics of programming languages, language translation, Context-free grammars, Parse trees, BNF, EBNF, Variables expressions.	10 lectures
Unit III	Scope rules, Binding – statics and dynamic binding, type checking procedures, sub programs and functions.	8 lectures
Unit IV	Data abstraction, information hiding, Encapsulation, Inheritance, Concurrency polymorphism, Exception handling.	8 lectures
Unit V	Basic concept of functional programming language, Object oriented programming languages, Logical programming languages.	8 lectures

Books:

1. Programming Language Pragmatics, Michael L. Scott, Morgan Kaufmann, 4th Edition, 2015.
2. Essentials of Programming Languages, Friedman, Wand and Haynes, 3rd Edition, MIT Press, 2008.
3. Principles of Programming Languages-Tennant. PHI, 1981.

CS23006	**IOS Application Development: 3 Credits (3-0-0)**	
Unit I	Introduction: iPhone and iPad Device Anatomy, iOS Architecture and SDK Frameworks, iOS and SDK Version Compatibility, Apple iOS Developer Program.	8 lectures
Unit II	Xcode: Tour of the XcodeIDE, Use XcodeIDE for building iPhone applications, Templates, Projects, and Workspaces, Creating a New Project, LLVM and LLDB, Debug Gauges, Asset Management, XCTest Testing Framework, Continuous Integration and Bots, Automatic Configuration.	8 lectures
Unit III	Views and Windows: The View Hierarchy, Containers, Controls, Text and Web Views, Navigation View and Tab Bars, Alert Views and Action Sheets, Controlling Rotation Behavior, View Autosizing, Autolayout, Storyboards, Adding Scenes, Segues, Transitions, Using in a Tab Bar Application.	8 lectures
Unit IV	Application Patterns and Architecture: Model View Controller (MVC), IBOutlets and IBActions, Subclassing and Delegation. Table Views: Static and Dynamic Table Views, Delegates and DataSources, Table View Styles, Custom Cells. Navigation Based Applications: Adding the Root View Controller, Creating the Navigation Controller, Controlling the Stack Navigation Programmatically.	9 lectures
Unit V	Working with Data: SQLite Integration, Using SQLite Directly, Overview of Core Data, Managed Objects, Persistent Store Coordinator, Entity Descriptions, Retrieving and Modifying Data, Multitouch, Taps, and Gestures, The Responder Chain, Touch Notification Methods, Enabling Multitouch on the View, Gesture Motions, Gesture Recognizers.	9 lectures

Books:

1. Beginning iPhone Development with Swift 5 - Exploring the iOS SDK, Wallace Wang, Apress, 2019.
2. Xcode Treasures: Master the Tools to Design, Build, and Distribute Great Apps, Chris Adamson, 1st edition, Pragmatic Bookshelf (November 1, 2018).
3. Complete iOS 12 Development Guide- Become a Professional iOS developer by mastering Swift, Xcode 10, ARKit, and Core ML, Craig Clayton, Donny Wals, Packt Publishing, 2019.

CS23007	**Computer Graphics: 3 Credits (3-0-0)**	
Unit I	Fundamental of computer graphics, Interactive graphics display, Display devices, Point plotting techniques: Co-ordinate systems, incremental methods, Line drawing algorithms, Circle generators, 2 Dimensional transformations; Transformation Principles: Concatenation and matrix representation.	8 lectures
Unit II	Clipping and Windowing: A line clipping algorithm, Midpoint subdivision, Clipping other graphic entities, polygon clipping, viewing transformations, the windowing transformation.	8 lectures
Unit III	Rules for Graphics software design, Graphic primitives, Windowing functions, Example of a graph plotting program; Segments: Posting and Unposting a segment; Basics of Geometric modeling, Symbols and instances; Picture structure: Symbols by procedure, Display procedures; Principles of event handling.	9 lectures
Unit IV	Raster graphics fundamentals: Generating a raster image, representing a Raster image; Geometric representation of Areas, the Y -X algorithm, Scan-conversion algorithm, Moving parts of an image, Raster manipulation functions.	8 lectures
Unit V	Three Dimensional (3D) Graphics; Techniques for achieving realism, modeling 3-D scenes, 3-D curves and surfaces, Bezier methods, B-spline methods, Displaying 3D curves, 3D transformations, 3-D clipping, 3-D Graphics packages, Hidden-surface elimination concepts; Shading model, Special effects concepts, Animation.	9 lectures

Books:

1. Principles of Interactive Computer Graphics, Newman & Sproull, 2nd Edition, McGraw Hill International, New York, 2001.
2. Computer Graphics, Hearn and Baker, 2nd Edition, Prentice Hall of India, New Delhi, 2001.
3. Computer Graphics: Principles and Practice (in C), J.D. Foley, A. VanDam, SK Feiner, & J.F. Hughes, 2nd Edition, AWL Publication, New York, 2000.

CS23008	**Data Communication: 3 Credits (3-0-0)**	
Unit I	Analog and Digital data and signals, periodic and non-periodic signals; periodic analog signal: sin wave, phase, wavelength, time and frequency domain, composite signal, bandwidth, Digital signal: bit rate and bit length, signal representation and systems.	7 lectures
Unit II	Transmission of digital signal, transmission impairment, attenuation, distortion, noise; data rate limit; Nyquist bit rate, Shannon capacity; performance: bandwidth, throughput, latency, Digital to digital communication, analog to digital communication, PCM DM; transmission mode: serial parallel, synchronous, asynchronous, simplex, duplex, half duplex, full duplex.	8 lectures
Unit III	Digital to analog conversion: ASK, FSK, PSK, QAM, analog to analog conversion, AM, FM, PM.	7 lectures
Unit IV	Multiplexing: FDM, WDM, synchronous DDM, statistical TDM: Spread spectrum: FHSS, DSSS.	7 lectures
Unit V	Circuit switching network, circuit switching technology in telephone networks, data gram networks in the internet; virtual circuit network: Structure of circuit switch and packet switch.	7 lectures

Books:

1. Data Communication and Networking, Behrouz A. Forouzan, 4th Edition, Tata McGraw-Hill, 2017.
2. Computer Networking, Tanenbaum, 5th Edition, Pearson, 2013.
3. Data and computer communications, W. Stallings, 10th Edition, PHI, 2013.

CS24001	**Soft Computing: 3 Credits (3-0-0)**	
Unit I	Fundamentals of Neural Network, model of an artificial neuron, NN Architectures, learning rules; Back propagation networks (BPN): Architecture, working principle, learning effect of the BPN, variation of standard back propagation algorithm.	6 lectures
Unit II	Associative memory: Auto correlators, Kosko's discrete BAM, exponential BAM, Associative memory for real-coded pattern pairs; Adaptive resonance theory: ART1, ART2, Hopfield Networks, recurrent networks, Kohonen self organzing map (SoM), Autoencoders, Boltzman Machine, Deep Nueral network and CNN, Deep Belief Networks.	13 lectures
Unit III	Fuzzy set theory, fuzzy sets, crisp sets, crisp relation, fuzzy relation, fuzzy system, crisp logic, predicate logic, fuzzy logic, fuzzy rule based system, defuzzification methods.	7 lectures
Unit IV	Fundamental of Genetic algorithm, encoding techniques, fitness functions, and reproduction: selection methods, Cross over, Mutation operators, Bitwise operators and its use in GA, convergence of GA, Multi objective GA and NSGA-II, applications.	8 lectures
Unit V	Hybrid systems: NN Fuzzy logic, GA hybrids; GA based Back propagation network, GA based weight determination applications, fuzzy based back propagation, fuzzy associative memory, GA in fuzzy logic controller design, applications.	8 lectures

Books:

1. Fuzzy Logic with Engineering applications, T.J. Ross, 3rd ed., TMH, 2010.
2. Neural Networks and Learning Machines, S. Haykin, 3rd ed, Pearson/PHI, 2008.
3. Genetic Algorithms, D.E. Goldberg, Addison-Wesley, 2005.
4. Neural Network, Fuzzy Logic & Genetic algorithm: Synthesis and application, S. Rajasekharan, G.A, Vijaylaxshmi Pai, PHI, 2013.
5. Neuro fuzzy and Soft Computing, J.S.R. Jang, C.T. Scan, E. Mitzumi, PHI, 2005.
6. Fuzzy sets and fuzzy logic: Theory and Applications, Klir & Yuan, PHI, 2002.

CS24002	**Graph Theory: 3 Credits (3-0-0)**	
Unit I	Graphs and subgraphs, isomorphism, walks, path and circuit, traveling salesman problem, trees, spanning trees, cut sets, connectivity and seperability, network flows.	10 lectures
Unit II	Combinatorial and geometric graphs, planar graphs, geometric dual, thickness and crossings, vectors and vector spaces, circuit and cut set subspaces, orthogonal vectors and spaces, matrix representation of graphs.	9 lectures
Unit III	Chromatic number, chromatic partitioning, matching and coverings, vertex cover and set cover, Bipartite graphs, diagraphs, enumeration of graphs.	7 lectures
Unit IV	Basic graph algorithms: connectedness, components, spanning tree, shortest path, performance of graph-theoretic algorithms, planarity testing, isomorphism testing.	9 lectures
Unit V	Graph theory applications: contact networks, switching networks, computer networks and routing, game theory, operation research, flow problems.	7 lectures

Books:

1. Introduction to Graph Theory, Douglas West, 2nd Edition, Pearson, 2015.
2. Graph theory with applications to engineering and computer science, N. Deo, PHI, India, 1979.

CS24003	Real Time Systems: 3 Credits (3-0-0)	
Unit I	Introduction: Application of Real Time Systems, Basic Model of a Real Time System, Characteristics of Real Time Systems, Issues in Real Time Computing, Task classes, Timing Constraints, Modeling Timing Constraints, Safety and reliability.	6 lectures
Unit II	Real time task scheduling: Classical Uniprocessor Scheduling Algorithms, Handling Resource Sharing and Dependencies among Real Time Tasks, Scheduling Real Time Tasks in Multiprocessor and Distributed Systems; Task Allocation, Fault Tolerant Scheduling and Clock Synchronization.	12 lectures
Unit III	Real time communication: Example of Real Time Communication, Communication Media, Network Topologies, Soft and Hard Real Time Communication in a LAN, Protocols, Fault Tolerant Routing.	8 lectures
Unit IV	Real time databases: Applications of Real Time Databases, basic definition, real time vs. general purpose databases, main memory databases, transaction priorities, transaction aborts, concurrency control issues and protocols, two phase approach to improve predictability, maintaining serialization consistency.	10 lectures
Unit V	Real time operating systems (RTOS): Features of Real Time operating System, Types of Real Time Operating systems, Operating System Designs, RTOS for Safety Critical Systems, Case Studies - UNIX and Windows as RTOS.	6 lectures
Books: 1. Real-Time Systems: Theory and Practice, Rajib Mall, Pearson, 2009. 2. Real-Time Systems, Krishna and Shin, Tata McGraw Hill. 1999. 3. Hardware-dependent Software: Principles and Practice, W. Ecker, W. Muller and R. Domer, Springer, 2009.		

CS24004	Information Security: 3 Credits (3-0-0)	
Unit I	Information Security Vulnerabilities: Overview, vulnerabilities in software, System administration, Complex Network Architectures, Open Access to Organizational Data, Weak Authentication, Unprotected Broadband communications, Poor Cyber Security Awareness. Cyber Security Safeguards - Overview, Access control, Audit, Authentication, Biometrics, Cryptography, Deception, Denial of Service Filters, Ethical Hacking, Firewalls, Intrusion Detection Systems, Response, Scanning, Security policy, Threat Management.	8 lectures
Unit II	Securing Web Application, Services and Servers: Introduction, Basic security for HTTP Applications and Services, Basic Security for SOAP Services, Identity Management and Web Services, Authorization Patterns, Security Considerations, Challenges.	8 lectures
Unit III	Intrusion Detection and Prevention: Intrusion, Physical Theft, Abuse of Privileges, Unauthorized Access by Outsider, Malware infection, Intrusion detection and Prevention Techniques, Anti-Malware software, Network based Intrusion detection Systems, Network based Intrusion Prevention Systems, Host based Intrusion prevention Systems, Security Information Management, Network Session Analysis, System Integrity Validation.	8 lectures
Unit IV	Introduction to Cryptography: Symmetric key Cryptography, Asymmetric key Cryptography, Message Authentication, Digital Signatures, Applications of Cryptography.	9 lectures
Unit V	Firewalls: Types of Firewalls, User Management, VPN Security Security Protocols - security at the Application Layer - PGP and S/MIME, Security at Transport Layer - SSL and TLS, Security at Network Layer-IPSec.	9 lectures
Books: 1. Information Security: Principles and Practice, Mark Stamp, 2nd Edition, Willey, 2011. 2. The InfoSec Handbook: An Introduction to Information Security, Umesh Hodeghatta Rao, Umesha Nayak, 1st Edition, Apress, 2014. 3. Cryptography and Network Security: Principles and Practice, William Stallings, 6th Edition, Pearson, 2013.		

CS24005	Artificial Intelligence: 3 Credits (3-0-0)	
Unit I	Concept of AI, history, current status, scope, agents, environments, Problem Formulations, Review of tree and graph structures, State space representation, Depth first and Breadth first search, Heuristic search, Best first search, A* algorithm, Game Search: optimal decisions in games and Alpha–Beta Pruning.	9 lectures
Unit II	Forward chaining, backward chaining and resolution in propositional and predicate logic; fuzzy logic, overview of different forms of learning, Learning Decision Trees, Neural Networks.	6 lectures
Unit III	Probabilistic Reasoning: Probability, conditional probability, Bayes Rule, Bayesian Networks - representation, construction and inference, temporal model, hidden Markov model.	10 lectures
Unit IV	Markov Decision process: MDP formulation, utility theory, utility functions, value iteration, policy iteration and partially observable MDPs.	8 lectures
Unit V	Passive reinforcement learning, direct utility estimation, adaptive dynamic programming, temporal difference learning, active reinforcement learning - Q learning. AI application in natural language processing and Robotics.	9 lectures

Books:

1. Artificial Intelligence – A Modern Approach, Stuart Russell, Peter Norvig, 3rd Edition, Pearson Education / Prentice Hall of India, 2015.
2. Artificial Intelligence, Elaine Rich and Kevin Knight, 3rd Edition, Tata McGraw-Hill, 2017.
3. Artificial Intelligence: A new Synthesis, Nils J. Nilsson, Harcourt Asia Pvt. Ltd., 2000.
4. Artificial Intelligence-Structures and Strategies for Complex Problem Solving, George F. Luger, Pearson Education/ PHI, 2002.
5. Artificial Intelligence, Saroj Kaushik, Cengage Learning India, 2011.

CS24006	Combinatorial Design Theory for Computer Science: 3 Credits (3-0-0)	
Unit I	Introduction to Design Theory, Balanced Incomplete Block Designs, Incidence Matrices, Isomorphisms and Automorphisms, Constructing BIBDs with Specified Automorphisms, NewBIBDs from Old, Fisher's Inequality, Symmetric BIBDs, Intersection Property, Residual and Derived BIBDs, Projective Planes and Geometries, The Bruck-Ryser-Chowla Theorem.	8 lectures
Unit II	Difference Sets and Automorphisms, Quadratic Residue Difference Sets, Singer Difference Sets, The Multiplier Theorem, Hadamard Matrices and Designs, Equivalence Between Hadamard Matrices and BIBDs, Conference Matrices and Hadamard Matrices, A Product Construction, Williamson's Method, Regular Hadamard Matrices, Excess of Hadamard Matrices, Bent Functions.	9 lectures
Unit III	Latin Squaresand Quasi groups, Steiner Triple Systems, The Bose Construction, The Skolem Construction, Orthogonal Latin Squares, Mutually Orthogonal Latin Squares, MOLS and Affine Planes, MacNeish's Theorem, Orthogonal Arrays, Orthogonal Arrays and MOLS, Some Constructions for Orthogonal Arrays, TransversalDesigns, Wilson's Construction, Disproof of the Euler Conjecture.	8 lectures
Unit IV	Pairwise Balanced Designs, Definitions and Basic Results, Necessary Conditions and PBD-Closure, Steiner Triple Systems, (v, 4, 1)-BIBDs, Kirkman Triple Systems, The Stanton-Kalbfleisch Bound, The Erd¨os-de Bruijn Theorem, Improved Bounds, Minimal PBDs and Projective Planes, Minimal PBDs with $\lambda > 1$, t-Designs and t-wise Balanced Designs, Basic Definitions and Properties of t-Designs, Some Constructions for t-Designs with $t \geq 3$, Inversive Planes, Some 5-Designs, t-wise Balanced Designs, Holes and Subdesigns.	9 lectures
Unit V	Applications of Combinatorial Designs, Authentication Codes, A Construction from Orthogonal Arrays, Threshold Schemes, A Construction from Orthogonal Arrays, Anonymous Threshold Schemes, Group Testing Algorithms, Two-Point Sampling, Monte Carlo Algorithms, Orthogonal Arrays and Two-Point Sampling.	8 lectures

Books:

1. Combinatorial Designs Constructions and Analysis, Douglas R. Stinson, Spinger publishing 2003.
2. Introductory Combinatorics, Richard A. Brualdi, 4th Edition, Pearson Education, 2004.
3. Discrete and Combinatorial Mathematics, Ralph P. Grimaldi, 5th Edition, Pearson Education, 2004.
4. Graph Theory and Combinatorics, D.S. Chandrasekharaiah, Prism, 2005.
5. Discrete Mathematics and Its Applications with Combinatorics and Graph Theory, Kenneth H. Rosen, 7th Edition, McGraw Hill Education, 2008.

CS24007	**Data Warehousing and Data Mining: 3 Credits (3-0-0)**	
Unit I	Data Warehousing: Overview, Definition, Data Warehousing Components, Building a Data Warehouse, Warehouse Database, Mapping the Data Warehouse to a Multiprocessor Architecture, Difference between Database System and Data Warehouse, Multi-Dimensional Data Model, Data Cubes, Stars, Snow Flakes, Fact Constellations, Concept hierarchy, Process Architecture, 3-Tier Architecture, Data Marting.	8 lectures
Unit II	Data Warehouse Process and Technology: Warehousing Strategy, Warehouse management and Support Processes, Warehouse Planning and Implementation, Hardware and Operating Systems for Data Warehousing, Client/Server Computing Model & Data Warehousing. Parallel Processors & Cluster Systems, Distributed DBMS implementations, Warehousing Software, Warehouse Schema Design, Data Extraction, Cleanup & Transformation Tools, Warehouse Metadata.	8 lectures
Unit III	Data Mining: Overview, Motivation, Definition & Functionalities, Data8 Processing, Form of Data Preprocessing, Data Cleaning: Missing Values, Noisy Data, (Binning, Clustering, Regression, Computer and Human inspection), Inconsistent Data, Data Integration and Transformation. Data Reduction - Data Cube Aggregation, Dimensionality reduction, Data Compression, Numerosity Reduction, Discretization and Concept hierarchy generation, Decision Tree.	9 lectures
Unit IV	Classification: Definition, Data Generalization, Analytical Characterization, Analysis of attribute relevance, Mining Class comparisons, Statistical measures in large Databases, Statistical-Based Algorithms, Distance-Based Algorithms, Decision Tree-Based Algorithms. Clustering: Introduction, Similarity and Distance Measures, Hierarchical and Partitional Algorithms. Hierarchical Clustering- CURE and Chameleon. Density Based Methods - DBSCAN, OPTICS. Grid Based Methods - STING, CLIQUE. Model Based Method - Statistical Approach, Association rules: Introduction, Large Itemsets, Basic Algorithms, Parallel and Distributed Algorithms, Neural Network approach.	9 lectures
Unit V	Data Visualization and Overall Perspective: Aggregation, Historical information, Query Facility, OLAP function and Tools. OLAP Servers, ROLAP, MOLAP, HOLAP, Data Mining interface, Security, Backup and Recovery, Tuning Data Warehouse, Testing Data Warehouse. Warehousing applications and Recent Trends: Types of Warehousing Applications, Web Mining, Spatial Mining and Temporal Mining.	8 lectures

Books:

1. Data Warehousing, Data-Mining & OLAP, Alex Berson, Stephen J. Smith, TMH, 2017.
2. Data Warehousing: Architecture and Implementation, Mark Humphries, Michael W. Hawkins, Michelle C. Dy, Pearson, 1999.
3. Data Mining: Introductory and Advanced Topics, Margaret H. Dunham, S. Sridhar, Pearson Education, 2006.

CS24008	Machine Learning: 3 Credits (3-0-0)	
Unit I	Overview of Machine learning concepts – Over fitting and train/test splits, bias vs. variance, types of learning – Supervised, Unsupervised, Reinforced learning, Linear Regression- model assumptions, regularization (lasso, ridge, elastic net).	7 lectures
Unit II	Supervised learning: Naïve Bayes, K-Nearest Neighbors, logistic regression, support vector machines (SVM), decision trees, random forest, bagging, boosting, cross validation methods, performance metrics: confusion matrix, RoC curve, MSE, RMSE, etc.	12 lectures
Unit III	Unsupervised Learning: K-means clustering, Hierarchical clustering, Self-organizing map. Dimension Reduction: principal component analysis (PCA), independent component analysis (ICA), Reinforcement learning: Q-learning.	7 lectures
Unit IV	Bayesian learning: deep belief networks, EM algorithm, Neural Networks Learning: perceptron, multilayer perceptron, Radial basis functions and network, outlier detection algorithms, hidden markov models.	10 lectures
Unit V	Deep learning: overview, convolutional neural network (CNN), LSTM recurrent neural network and analysis of time series data, deep auto encoders.	6 lectures
Books: 1. Machine Learning: An algorithmic perspective, S. Marsland, 2nd Edition, CRC Press, 2015. 2. An Introduction to Statistical Learning, Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, Springer, 2013. 3. Machine Learning, Tom Mitchell, McGraw Hill, 1997.		

CS24011	Grid Computing: 3 Credits (3-0-0)	
Unit I	Introduction: the grid, past, present and future, applications of grid computing, organizations and their roles.	6 lectures
Unit II	Grid computing anatomy, next generation of grid computing initiatives, merging the grid services architecture with web service architecture.	8 lectures
Unit III	Grid computing technologies: OGSA, sample use cases that drive the OGSA platform components, OGSI and WSRF, OGSA basic services, security standards for grid computing.	10 lectures
Unit IV	Grid computing tool kit: Globus toolkit, versions, architecture, GT programming model, a sample grid service implementation.	9 lectures
Unit V	High level grid services: OGSI.NET middleware solution, mobile OGSI.NET for grid computing on mobile devices.	9 lectures
Books: 1. Grid Computing, Joshy Joseph, Craig Fellenstein, Pearson/PHI PTR-2004. 2. Grid Computing: A Practical Guide to Technology and Applications, Ahmar Abbas, Charles River Media, 2004.		

CS24012	Microprocessors and Micro-Controllers: 3 Credits (3-0-0)	
Unit I	Microprocessor concepts: Serial and parallel input/output, interrupts, ALU, Timers, registers. Introduction to Intel 8086 and other Intel processors. Comparison of microprocessor and microcontroller.	8 lectures
Unit II	Design issues of RISC and CISC processors; Architecture of 80286, 80386, 80486 and Pentium processors.	7 lectures
Unit III	Embedded Systems, Embedded Microcontrollers, 8051 Architecture - Registers, Pin diagram, I/O ports functions, Internal Memory organization. External Memory (ROM & RAM) interfacing. 8051 Instruction Set: Addressing Modes, Data Transfer instructions, Arithmetic instructions, Logical instructions, Branch instructions, Bit manipulation instructions. Simple Assembly language program examples to use these instructions.	10 lectures

Unit IV	Architecture of 8051: display interface, keyboard interface, serial interface and parallel interface and timers in 8051; working with local mode and remote mode, idea regarding LCD routines, keyboard routines and other system subroutines, communication using 8051 microcontrollers.	10 lectures
Unit V	Superscalar embedded processors, comparison and evaluation of popular 32-bit Microcontrollers, Microcontroller/ Microprocessor based industrial control systems.	7 lectures

Books:

1. Intel Microprocessors, B.B. Brey, PHI, 2006.
2. Advanced Microprocessors and Peripherals, Ray & Bhurchandi, TMH, 2004.
3. 8051 Microcontroller, Majdi & Majdi, PHI, 2002.
4. Microcontrollers, D. Tabak, TMH, 2001.

CS24013	**Neural Imaging and Signal Systems: 3 Credits (3-0-0)**	
Unit I	Fundamentals of Image Processing, Filters, Transformations, Registration and segmentation.	6 lectures
Unit II	Signal processing: Basics of Bio-signals, analog to digital conversion (ADC), Sampling and aliasing in time and frequency, Digital Filtering, FIR and IIR filters, basic properties of discrete-time systems, convolution, DFT: The discrete Fourier transform and its properties, the fast Fourier transform (FFT), spectral analysis.	10 lectures
Unit III	Brain anatomy, Survey of major neuro-imaging modalities: CT, MRI, PET, and SPECT and their physics, sMRI vs fMRI. Feature extraction techniques and analysis.	10 lectures
Unit IV	Volume based morphometry (VBM), surface based morphometry (SBM), Neuro-imaging analysis tools: SPM, FSL, FreeSurfer.	8 lectures
Unit V	Basics of EEG, pre-processing of EEG necessary for advanced data analysis, Time, Frequency and Time-Frequency Domains Analyses, Event-Related Potentials (ERP).	8 lectures

Books:

1. Signals and Systems, Alan S. Willsky and Alan V. Oppenheim, Pearson, 2013.
2. Bio-signal and medical image processing, John L. Semmlow, Benjamin Griffel, 3rd Edition, CRC Press, 2014.
3. Neuroscience, Claudia Krebs, Elizabeth Akesson, Joanne Weinberg, Lippincott Williams & Wilkins, 2012.
4. Analyzing Neural Time Series Data, Mike X Cohen, MIT Press, 2014.

CS24014	**Wireless Communication: 3 Credits (3-0-0)**	
Unit I	Applications of mobile communications; antennas, signal propagation; multiplexing – space division multiplexing, frequency division multiplexing, time division multiplexing, code division multiplexing; modulation – ASK, FSK, PSK, Advanced FSK, Advanced PSK; multi-carrier modulation; spread spectrum; multiplexing in cellular systems.	10 lectures
Unit II	Hidden and exposed terminals problem, near and far terminals problem; medium access control – FDMA, TDMA, CDMA; cellular systems – GSM, DECT, UMTS, IMT-2000.	10 lectures
Unit III	Satellite systems – routing, localization and handoff issues; wireless LAN – Infrastructure and ad-hoc network, IEEE 802.11, bluetooth.	6 lectures
Unit IV	Mobile network layer – mobile IP, mobile ad-hoc networks (MANETs); MANET routing – AODV, DSDV, DSR, hierarchical routing, location based routing.	10 lectures
Unit V	Mobile transport layer – Indirect TCP, Snooping TCP, Mobile TCP; wireless application protocol; wireless network security	6 lectures

Books:

1. Mobile Communication, Jochen Schiller, 2nd Ed., Pearson Education, 2003.
2. Wireless Communication and Networks, William Stallings, 2nd Edition, Pearson Education, 2009.
3. Wireless Communications Principles and Practice, T.S. Rappaport, 2nd Edition, PHI, 2001.

CS24015	**Distributed Algorithms: 3 Credits (3-0-0)**	
Unit I	Introduction, Characteristics of Distributed systems, Model and System architectures, Inter-process communications.	8 lectures
Unit II	Concept of clock in Distributed System, Synchronization of process - traditional synchronization, lock free, clocks (vector clocks), barrier synchronization, readers/writers, local-spin algorithms, wait-free and lock-free synchronization.	8 lectures
Unit III	Consistency, Distributed Mutual Exclusion, Distributed deadlock detection techniques, Agreement protocol, deadlock detection, termination detection, diffusing computations, distributed snapshots.	10 lectures
Unit IV	Recovery in distributes system and Fault tolerance - Byzantine agreement (algorithms and impossibility results), distributed consensus (algorithms and impossibility results), atomic commit protocols, broadcast and multicast algorithms, active and passive replication, self-stabilizing systems, two- and three-phase commit, check pointing, Distributed Algorithms.	8 lectures
Unit V	Distributed Security - typical security architectures, including multi-level security systems, Mechanism-threats, control mechanisms, security issues and solutions, including authentication, key distribution, firewalls, and network security protocols, Kerberos, Auditing and intrusion detection.	8 lectures

Books:

1. Distributed Systems: Principles and Paradigms, Andrew S. Tanenbaum, Maarten van Steen, 2nd Edition, Pearson, 2006.
2. Distributed System: Concept and Design, Georage Colounis, J. Dollimore, Tim Kindberg, 5th Edition, Pearson, 2011.
3. Concurent Systems, Sape Mullender, 2nd Edition, AWL Publications, New York, 2000.

CS24016	**Operations Research: 3 Credits (3-0-0)**	
Unit I	Basic Temrinologies, Different Phases of an Operational Research Study, Scope and Limitations of Operational Research, Mathematical Modeling of Real Life Problems. Linear Programming Problem Formulation, solution by Graphical Method, Theory of Simplex Method, Simplex Algorithm, Two phase Method, Charnes-M Method, Degeneracy, Theory of Duality, Dual-simplex method.	9 lectures
Unit II	Transportation Model: Iterative Computations of the Transportation Algorithm, Simplex Method Explanation of the Method of Multipliers, Assignment problem: The Hungarian Method, Simplex Explanation of the Hungarian Method.	8 lectures
Unit III	Network Models: Maximum flow problem and algorithms, CPM computations, construction of time schedule, Linear Programming formulation of CPM, PERT Networks	8 lectures
Unit IV	Decision Making Under Certainty—Analytic Hierarchy Process (AHP), Decision Making Under Risk, Decision Under Uncertainty, Optimal Solution of Two-Person Zero-Sum Games, Solution of Mixed Strategy Games.	9 lectures
Unit V	Inventory Modelling: Inventory Metric in Supply Chains, Elements of the Inventory Optimization Model, Static Economic-Order-Quantity Models, Dynamic EOQ Models; Various Queuing models.	8 lectures

Books:

1. Operations Research, H.A. Taha, 10th Edition, Pearson, 2017.
2. Introduction to Operations Research - Concepts and Cases, F.S. Hillier. G.J. Lieberman, 9th Edition, Tata Mc-Graw Hill, 2010.
3. Operations Research - Principles and Practice, A. Ravindran, D. T. Phillips and James J. Solberg, John Wiley & Sons, 2005.

CS24017	Mobile Application Development: 3 Credits (3-0-0)	
Unit I	Introduction to Mobile Application development, Characteristics of mobile applications, History of mobile application frameworks, Android Development Environment, Factors in Developing Mobile Applications, Mobile Software Engineering, Frameworks and Tools, Generic UI Development.	8 lectures
Unit II	User-interface design for mobile applications, Android UIs, VUIs and Mobile Apps, Designing the Right UI, Multichannel and Multi-model UIs, Intents and Services, Android Intents and Services, Characteristics of Mobile Applications, Successful Mobile Development.	9 lectures
Unit III	Managing application data, Storing and Retrieving Data, Synchronization and Replication of Mobile Data Getting the Model Right, Working with a Content Provider, Communications ViaNetwork and the Web, State Machine, Correct Communications Model, Deciding Scope of an App, Wireless Connectivity and Mobile Apps.	8 lectures
Unit IV	Integrating with cloud services, Integrating networking, the OS and hardware into mobile, Memory Management, Android Notifications and Alarms, Graphics Performance and Multithreading, Graphics and UI Performance, Android Graphics and Multimedia, Mobile Agents and Peer-to-Peer Architecture.	9 lectures
Unit V	Addressing enterprise requirements in mobile applications: performance, scalability, modifiability, availability and security, Android Multimedia, Location, Mobility and Location. Based Services, Packaging and Deploying, Performance Best Practices, Android Field Service App, Security and Hacking, Active Transactions, Applications testing, Testing methodologies for mobile applications, publishing, deployment, maintenance, and management.	8 lectures
Books: 1. Mobile Applications: Architecture, Design, and Development, Valentino Lee, Heather Schneider, and Robbie Schell, Prentice Hall, 2004. 2. Android SDK 3 for Dummies, Rajiv Ramnath, Roger Crawfis, and Paolo Sivilotti, Wiley, 2011. 3. Professional Mobile Application Development, Jeff McWherter, Scott Gowell, Wrox Press, 2012.		

CS24018	Image Processing: 3 Credits (3-0-0)	
Unit I	Introduction: Fundamentals concepts of digital image representation, fundamental steps in image processing; elements of digital image processing systems: image acquisition, storage, processing, communication and display. Fundamentals elements of visual perception, simple image model, sampling and quantization, some basic relationships between pixels.	9 lectures
Unit II	Image Enhancement in the spatial domain: Basic gray level transformations-histogram processing-Enhancement using arithmetic/logic operations-Basics of spatial filtering- comparison between smoothing and sharpening spatial filters.	8 lectures
Unit III	Image Enhancement in the frequency domain: 1D Fourier transform-2D Fourier transform and its Inverse. Smoothing & sharpening frequency domain filters (Ideal, Butterworth, Gaussian)-Homomorphic filtering.	8 lectures
Unit IV	Color Image processing: Colour fundamentals, Colour models, Pseudo Colour image processing, colour image processing, Image restoration / degradation process, Noise Models, Image segmentation.	8 lectures
Unit V	Fundamentals of Image compression, Image compression models, Error-free compression, lossless predictive coding-source and channel encoding/decoding. Lossy compression: lossy predictive coding; DCT, DWT, JPEG.	9 lectures
Books: 1. Digital Image Processing Using Java, Efford, AWL Publication, New York, 2000. 2. Digital Image Processing, Woods & Gonglez, 4th Edition, Pearson Education, 2018. 3. The Computer Image, AWatt, F. Policarpo, AWL Publication, 1999.		

CS24019	Big Data Analytics: 3 Credits (3-0-0)	
Unit I	Introduction to big data and hadoop: Types of Digital Data, Introduction to Big Data, Big Data Analytics, History of Hadoop, Apache Hadoop, Analysing Data with Unix tools, Analysing Data with Hadoop, Hadoop Streaming, Hadoop Echo System, IBM Big Data Strategy, Introduction to Infosphere BigInsights and Big Sheets.	8 lectures
Unit II	HDFS (Hadoop Distributed File System): The Design of HDFS, HDFS Concepts, Command Line Interface, Hadoop file system interfaces, Data flow, Data Ingest with Flume and Scoop and Hadoop archives, Hadoop I/O: Compression, Serialization, Avro and File-Based Data structures.	8 lectures
Unit III	Map Reduce: Anatomy of a Map Reduce Job Run, Failures, Job Scheduling, Shuffle and Sort, Task Execution, Map Reduce Types and Formats, Map Reduce Features.	8 lectures
Unit IV	Hadoop Eco System: Pig: Introduction to PIG, Execution Modes of Pig, Comparison of Pig with Databases, Grunt, Pig Latin, User Defined Functions, Data Processing operators. Hive: Hive Shell, Hive Services, Hive Metastore, Comparison with Traditional Databases, HiveQL, Tables, Querying Data and User Defined Functions. Hbase: HBasics, Concepts, Clients, Example, Hbase Versus RDBMS. Big SQL: Introduction.	10 lectures
Unit V	Data Analytics with R: Machine Learning: Introduction, Supervised Learning, Unsupervised Learning, Collaborative Filtering. Big Data Analytics with BigR.	8 lectures

Books:

1. Hadoop: The Definitive Guide, Tom White, 3rd ed, O'reily Media, 2012.
2. Big Data Analytics, Seema Acharya, Subhasini Chellappan, Wiley 2015.
3. Intelligent Data Analysis, Michael Berthold, David J. Hand, Springer, 2007.
4. Big Data and Business Analytics, Jay Liebowitz, Auerbach Publications, CRC press (2013).
5. Using R to Unlock the Value of Big Data: Big Data Analytics with Oracle R Enterprise and Oracle R Connector for Hadoop, Tom Plunkett, Mark Hornick, McGraw-Hill/Osborne Media (2013), Oracle press.
6. Mining of Massive Datasets, Anand Rajaraman and Jef rey David Ulman, Cambridge University Press, 2012.

CS24020	Human Computer Interaction: 3 Credits (3-0-0)	
Unit I	Introduction: Importance of user Interface – definition, importance of good design. Benefits of good design. A brief history of Screen design. The graphical user interface – popularity of graphics, the concept of direct manipulation, graphical system, Characteristics, Web user – Interface popularity, characteristics- Principles of user interface.	8 lectures
Unit II	Design process – Human interaction with computers, importance of human characteristics human consideration, Human interaction speeds, understanding business junctions.	8 lectures
Unit III	Screen Designing: Design goals, Screen planning and purpose, organizing screen elements, ordering of screen data and content – screen navigation and flow – Visually pleasing composition – amount of information – focus and emphasis – presentation information simply and meaningfully – information retrieval on web – statistical graphics – Technological consideration in interface design.	9 lectures
Unit IV	Windows – New and Navigation schemes selection of window, selection of devices based and screen based controls. Components – text and messages, Icons and increases – Multimedia, colors, uses problems, choosing colors.	9 lectures
Unit V	Software tools – Specification methods, interface – Building Tools. Interaction Devices – Keyboard and function keys – pointing devices – speech recognition digitization and generation – image and video displays – drivers.	8 lectures

Books:

1. Human Computer Interaction, Alan Dix, Janet Finlay, Gregory Abowd, Russell Beale, 3rdEdition Prentice Hall, 2004.
2. Research Methods in HumanComputer Interaction, Jonathan Lazar Jinjuan Heidi Feng, Harry Hochheiser, Wiley, 2010.

3. Ben Shneiderman and Catherine Plaisant Designing the User Interface: Strategies for Effective Human-Computer Interaction (5th Edition, pp. 672, ISBN 0-321-53735-1, March 2009), Reading, MA: Addison-Wesley Publishing Co.

CS24041	**Software Engineering Methodologies: 3 (3-0-0)**	
Unit I	Concept of systems, its characteristics, The product, The process, Methods, Tools, Software process modules, Process technology, Project management concepts: People, The problem, the process and the project.	8 lectures
Unit II	Software process and project metrics, Software measurement, Software project planning: Observation on estimating, project planning objectives, software scope, resources, project estimation, decomposition techniques.	8 lectures
Unit III	Project scheduling, basic concepts, Relationship between people and effort, Defining task set, Refinement of major task, Software quality assurance: Quality concepts, Software reviews, Software reliability.	8 lectures
Unit IV	Software project analysis, analysis concepts, requirements analysis, analysis methods, analysis modelling, elements, data modelling, data flow diagrams, The mechanics of structures analysis, Design concepts and principles.	8 lectures
Unit V	Software testing methods, Testing fundamentals, Test case design, Software Testing strategies, Strategic issues, Unit testing, Integration testing, Validation testing, system testing. Object-oriented Paradigm, concepts, elements of an object model, Management of Object oriented software projects. Object-oriented analysis concepts.	10 lectures

Books:

1. Software Engineering: A Practitioner's Approach, Roger S. Pressman, 7th Edition, Tata McGraw Hill, New Delhi, 2009
2. Software Engineering Concepts, Richard Fairley, Tata McGraw Hill, New Delhi, 2004.
3. Classical and Object Oriented Software Engineering with UML and Java, S.R. Schach, 4th Edition, McGraw Hill International, New York, 1999.

CS24042	**Soft Computing for Engineers: 3 Credits (3-0-0)**	
Unit I	Fundamentals of Neural Network, model of an artificial neuron, NN Architectures, learning rules; Back propagation networks (BPN): Architecture, working principle, learning effect of the BPN, variation of standard back propagation algorithm.	6 lectures
Unit II	Associative memory: Auto correlators, Kosko's discrete BAM, exponential BAM, Associative memory for real-coded pattern pairs; Adaptive resonance theory: ART1, ART2, Hopfield Networks, recurrent networks, Kohonen self organzing map (SoM), Autoencoders, Boltzman Machine, Deep Nueral network and CNN, Deep Belief Networks.	13 lectures
Unit III	Fuzzy set theory, fuzzy sets, crisp sets, crisp relation, fuzzy relation, fuzzy system, crisp logic, predicate logic, fuzzy logic, fuzzy rule based system, defuzzification methods.	7 lectures
Unit IV	Fundamental of Genetic algorithm, encoding techniques, fitness functions, and reproduction: selection methods, Cross over, Mutation operators, Bitwise operators and its use in GA, convergence of GA, Multi objective GA and NSGA-II, applications.	8 lectures
Unit V	Hybrid systems: NN Fuzzy logic, GA hybrids; GA based Back propagation network, GA based weight determination applications, fuzzy based back propagation, fuzzy associative memory, GA in fuzzy logic controller design, applications.	8 lectures

Books:

1. Fuzzy Logic with Engineering applications, T.J. Ross, 3rd ed., TMH, 2010.
2. Neural Networks and Learning Machines, S. Haykin, 3rd ed, Pearson/PHI, 2008.
3. Genetic Algorithms, D.E. Goldberg, Addison-Wesley, 2005.

4. Neural Network, Fuzzy Logic & Genetic algorithm: Synthesis and application, S. Rajasekharan, G.A, Vijaylaxshmi Pai, PHI, 2013.
5. Neuro fuzzy and Soft Computing, J.S.R. Jang, C.T. Scan, E. Mitzumi, PHI, 2005.
6. Fuzzy sets and fuzzy logic: Theory and Applications, Klir & Yuan, PHI, 2002.

CS21101	**Information and Communication Technology: 3 Credits (2-0-2)**	
Unit I	Introduction to computers, hardware and software, basic works of computer, operating systems. DOS, WINDOWS commands for managing files. Windows component like icons, desktop, My Computer, recycle bin, My Documents, task bar, start menu options.	6 lectures
Unit II	Familiarizing with MS OFFICE (MS Excel, MS Word, and MS Power Point). Introductions to FOSS for OS and for work related to word processing, spreadsheet and presentation.	6 lectures
Unit III	Introduction to intra and internet and its application. Introduction to statistical packages and image processing software.	5 lectures
Unit IV	Audio visual aids - definition, advantages, classification and choice of AV aids. Cone of experience and criteria for selection and evaluation of AV aids. Video conferencing.	6 lectures
Unit V	Communication process, Berlo's model, feedback and barriers to communication.	5 lectures

Books:

1. Norton, Peter, "DOS Guide", Prentice Hall of India.
2. Norton, Peter, "Introduction to Computers", TMH.
3. Rajaraman, V. "Fundamentals of Computers", PIH.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Year I Semester I						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	PH21104	Oscillations, Waves and Optics	4	0	2	05
2.	MA21101	Mathematics – I	3	1	0	04
3.	ES21100	Basic Electrical Engineering	3	1	2	05
4.	ES21151	Engineering Graphics and Design	0	0	6	03
5.	FR21121	Biology for Engineers	2	1	0	03
Total						**20**

Year I Semester II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CY21201	Engineering Chemistry – A	3	1	2	05
2.	MA21201	Mathematics – II	3	1	0	04
3.	ES21200	Programming for Problem Solving	3	0	2	04
4.	ES21251	Workshop Practice	0	0	6	03
5.	HS21201	Communication Skills	2	0	2	03
6.	ES21277	Environmental Science (Audit)	2	0	0	00
Total						**19**

Year II Semester III						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	MA22101	Mathematics – III	3	1	0	04
2.	ES22100	Engineering Mechanics	3	1	0	04
3.	ES22101	Basic Electronics Engineering	3	0	2	04
4.	EC22101	Electronic Instrumentation and Measurements	3	0	2	04
5.	EC22102	Digital Electronics	2	1	2	04
6.	EC22103	Signals and Systems	2	1	0	03
Total						**23**

Year II Semester IV						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS22201	Entrepreneurship and Startups	3	0	0	03
2.	HS22277	Indian Constitution (Audit)	2	0	0	00
3.	EC22201	Microprocessors and Applications	3	0	2	04
4.	EC22202	Analog Communication Systems	3	0	0	03
5.	EC22203	Linear Integrated Circuits	2	1	2	04
6.	EC22204	Circuits and Devices	2	1	2	04
7.	EE22221	Power Electronics	3	0	0	03
Total						**21**

Year III Semester V						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS23101	Principles of Economics	3	0	0	03
2.	HS23177	Essence of Indian Knowledge and Tradition (Audit)	2	0	0	00
3.	MA23101	Applied Probability and Statistics	3	0	0	03
4.	EC23101	Digital Design using HDL	2	1	2	04
5.	EC23102	Digital Signal Processing	3	0	2	04

6.	EC23103	Electromagnetic Theory	3	0	0	03
7.	EC23104	Control Systems	3	0	0	03
8.	EC23166	Study Tour (Audit)	0	0	0	00
Total						**20**

Year III Semester VI						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS23201	Organizational Behaviour	3	0	0	03
2.	MO230**	Open Elective – I (From MOOC)	3	0	0	03
3.	EC230**	Programme Elective – I	3	0	0	03
4.	EC230**	Programme Elective – II	3	0	0	03
5.	EC23289	Seminar	0	0	2	01
6.	EC23201	Digital Communications	3	0	2	04
7.	EC23202	Microwave Engineering	3	0	2	04
8.	EC23203	Microelectronics	3	0	0	03
Total						**24**

Year IV Semester VII						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	**240**	Open Elective – II	*	*	*	03
2.	EC240**	Programme Elective – III	3	0	0	03
3.	EC240**	Programme Elective – IV	3	0	0	03
4.	EC24101	Antenna and Radar Engineering	3	0	2	04
5.	EC24102	VLSI Designs	3	0	2	04
6.	EC24199	Project – I	0	0	6	03
7.	EC24179	Industrial Training	0	0	0	03
Total						**23**

Year IV Semester VIII						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
	MO242**	Open Elective – III (From MOOC)	3	0	0	03
	240	Open Elective – IV	*	*	*	03
	EC240**	Programme Elective – V	3	0	0	03
	EC240**	Programme Elective – VI	3	0	0	03
	EC24299	Project – II	0	0	12	06
	ED24288	Extra-Curricular Activities and Discipline	0	0	0	02
Total						**20**

List of Electives

Programme Elective – I						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	EC23001	Network Analysis and Synthesis	3	0	0	3
2.	EC23002	Video and Advanced TV Engineering	3	0	0	3
3.	EC23003	Modern Control Engineering	3	0	0	3
4.	EC23004	Information Theory and Coding	3	0	0	3
5.	EC23005	Medical Electronics	3	0	0	3
6.	EC23006	Speech Processing	3	0	0	3

Programme Elective – II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	EC23011	Microcontrollers and Applications	3	0	0	3
2.	EC23012	Computer Organization	3	0	0	3
3.	EC23013	Introduction to Plasmonics	3	0	0	3
4.	EC23014	Embedded Systems	3	0	0	3
5.	EC23015	Transducers and Signal Conditioning	3	0	0	3
6.	EC23016	Digital Image Processing	3	0	0	3

Programme Elective – III						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	EC24001	Multimedia Communication and Networking	3	0	0	3
2.	EC24002	Telecommunication Switching	3	0	0	3
3.	EC24003	Optical Fiber Communication	3	0	0	3
4.	EC24004	Wireless Communication	3	0	0	3
5.	EC24005	Instrumentation and Process Control	3	0	0	3
6.	EC24006	Artificial Intelligence and Machine Learning	3	0	0	3

Programme Elective – IV						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	EC24011	Advanced Digital System Design	3	0	0	3
2.	EC24012	Semiconductor Device Modelling	3	0	0	3
3.	EC24013	Advanced Computer Architecture	3	0	0	3
4.	EC24014	Nano-electronics	3	0	0	3
5.	EC24015	Low Power VLSI Design	3	0	0	3
6.	EC24016	Advanced Digital Signal Processing	3	0	0	3

Programme Elective – V						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	EC24021	Artificial Neural Network and its Applications	3	0	0	3
2.	EC24022	Modern Digital Communication Techniques	3	0	0	3
3.	EC24023	Satellite Communication	3	0	0	3
4.	EC24024	Computer Communication and Network	3	0	0	3
5.	EC24025	Wireless Sensor Networks	3	0	0	3
6.	EC24026	Radio Frequency Components and Circuits	3	0	0	3

Programme Elective – VI						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	EC24031	Analog Integrated Circuits	3	0	0	3
2.	EC24032	Digital Integrated Circuits	3	0	0	3
3.	EC24033	Computer Aided Design of VLSI Circuits	3	0	0	3
4.	EC24034	VLSI Digital Signal Processing Systems	3	0	0	3
5.	EC24035	CMOS Mixed Signal Circuits	3	0	0	3
6.	EC24036	VLSI implementation of DSP architecture	3	0	0	3
7.	EC24037	System and Data Security	3	0	0	3
8.	EC24038	Data Analytics	3	0	0	3

Open Elective – II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	EC24041	Electronic Circuits and Devices	3	0	0	3
2.	EC24042	Instrumentation and Measurements	3	0	0	3

Open Elective – IV						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	EC24043	Electronic Engineering Materials	3	0	0	3

ES22101	**Basic Electronics Engineering: 4 Credits (3-0-2)**	
Unit I	Semiconductors and diode**:** Conduction in solids. Pure and doped semiconductor, Concept of holes, Electron and hole mobility, Band Diagram.	6 lectures
Unit II	Diode: p-n junction diode, diode mechanism & I-V characteristics, Equivalent circuits of diodes, Avalanche and Zener effect, Zener diode, LED, Schottky diode. Application: Half wave and Full wave rectifier circuits, clipping and clamping circuits, zener voltage regulator circuit.	8 lectures
Unit III	Bipolar Junction Transistors: Operation of N-P-N and P-N-P transistors in active, saturation and cut-off modes. I-V characteristics, current and voltage gain in CE, CB and CC configuration. Transistor biasing circuits, and stability, ac dc load line concept.	10 lectures
Unit IV	Transistor AC Analysis: Low frequency and high frequency models for BJT, BJT Amplifiers, h parameters /r-parameter model, high frequency π model. Miller's theorem.	10 lectures
Unit V	Voltage regulators and Power Amplifiers: Series and Shunt voltage regulators. Introduction to Power amplifiers – Class A, B, AB, C, Push pull and Tuned amplifier.	8 lectures

Books:

1. Physics of Semiconductor Devices, (S M Sze and Kwok K. Ng, 3rd Edition), Wiley-Interscience.
2. Solid State Electronic devices, Streetmann and Banerjee (7th Edition), Prentice Hall, 2014.
3. Millman & Halkias, “Integrated Electronics” (3rd Edition), Tata McGraw Hill.
4. Semiconductor Physics & Devices: Basic Principle, Donald A. Neaman, (3rd Edition), Tata McGraw Hill, New Delhi.
5. Electronic Devices and Circuit Theory, Robert L. Boylestad, Louis Nashelsky, 10th Edition, Pearson.
6. Electronics Principles By: A. P. Malvino, Tata McGraw Hill.

EC22101	**Electronic Instrumentation and Measurements: 4 Credits (3-0-2)**	
Unit I	Generalized Measurement system: Accuracy, Precision, Fidelity, speed of response, static & dynamic performance characteristics, dynamic - step response, ramp response of first and second order instruments. Classifications of errors, error analysis of measurement.	8 lectures

Unit II	Analog and Digital instruments: PMMC Galvanometer, Analog multimeter, range extension of voltmeter and ammeter, Series and shunt ohmmeter. Digital multimeter.	8 lectures
Unit III	Signal generator and Function generator. Cathode Ray Oscilloscope, basic of CRO circuit and components. Uses of CRO for different measurement. Lissajous pattern.	8 lectures
Unit IV	AC and DC Bridges: Introduction to DC and AC bridges for measurement of voltage/ current/ resistance/ capacitance and inductance.	10 lectures
Unit V	Definition of transducer, classification, resistive, capacitive, inductive, magnetic, optical, piezoelectric, pneumatic.	8 lectures

Books:

1. Principles of Electronics instrumentation and measurements. Berlyn and Getz, McMillan Pub. Co.
2. A Course in Electrical Electronics Measurements and instrumentation. A.K. Sawhney, Dhanpat Roy & Co.
3. Modern Electronics Instrumentation and Measurement Techniques. Albert D. Heltrick, W. D. Cooper. PHI.
4. Transducers & Instrumentation, Murthy DVS, PHI, ND, 1995.
5. Elements of Electronic Instrumentation and Measurement. Joseph J. Carr, Pearson Education.
6. PC-Based Instrumentation Concept and Practice. N. Mathivanan, PHI.

EC22102	**Digital Electronics: 4 Credits (2-1-2)**	
Unit I	Number System and Boolean Algebra: Binary Numbers. Hexadecimal number, r's complement & (r-1)'s complement, binary addition, subtraction, binary multiplication and Division. Codes and their conversions: BCD, Octal, Hexadecimal, ASCII, Gray, Excess 3. Boolean Algebra: Boolean identities, De Morgan's theorems. SOP, POS. Concepts of min term and max terms. AND-OR networks. Algebraic Simplification. Karnaugh Map, MEV technique and Quine-McClusky method.	7 lectures
Unit II	Combinational Circuit: Basic logic gates and universal Gate. Design of Combinational logic circuit. Half Adder, Full adder, Ripple Carry adder, the carry look-ahead adders. Half- Subtractor, Full Subtractor, code converter, decoder, multiplexer, de-multiplexer parity generator and checker.	6 lectures
Unit III	Logic Families: Different Logic families- TTL, ECL, MOS and CMOS, their operation Circuits for INVERTER, NAND, NOR. Transfer Characteristics, noise margin, propagation delay, fan in fan out, power dissipation consideration.	5 lectures
Unit IV	Data Processing Circuits MSI CHIPS: Multiplexer, Decoder, Decoder driver, 7 segment display decoder driver, Encoders Octal to Binary, Decimal to BCD encoders, Priority encoders. Implementation of combinational circuit by MSI chip.	5 lectures
Unit V	Introduction to sequential circuits: Latch, R-S, J-K, D flip flops, Master Slave arrangement, Edge triggered flip flops, shift registers, asynchronous and synchronous counters.	5 lectures

Books:

1.Digital Systems: Principles and Applications, Ronald J. Tocci, 6th Ed, PHI.
2. Digital Principles and Applications, A.P. Malvino, D.P. Leach, 4th Ed, TMH.
3. Fundamentals of Logic Design, C.A. Roth, Jr., Jaico, 4th Ed, Publishing House.
4. Digital Design, Morris Mano, 4th Ed. PHI, 2008.
5. Fundamentals of Digital Circuits, A. Anand Kumar, 4th Ed. PHI, 2016.
6. Digital Integrated Electronics, H. Taub and D. Shilling, 1st Ed. MGraw Hill.
7. Modern Digital Electronics, R.P Jain, 4th Ed. TMH, 2010.
8. Digital Fundamentals, T. L. Floyd (9th Edition), Prentice Hall.

EC22103	**Signals and Systems: 3 Credits (2-1-0)**	
Unit I	Continuous and discrete time signals: Classification of Signals, Transformation of independent variable of signals, Basic continuous-time and discrete-time signals. Energy and power signals. Unit Impulse, Unit Step Functions and Ramp Function. Periodic and aperiodic signals, Orthogonal signal.	6 lectures

Unit II	Basic system properties: Analysis of Continuous-time and Discrete-time LTI Systems and their properties. Linear constant co-efficient differential equations and difference equations.	5 lectures
Unit III	Fourier-series and Fourier Transform representation of Continuous-time Signals and their properties. Discrete-Time Fourier-series and Discrete-Time Fourier Transform representation of discrete-time Signals and their properties.	5 lectures
Unit IV	Laplace Transform and its properties. Unilateral Laplace Transform. Analysis of LTI systems using Laplace-transform. Z-transform and its properties. Unilateral Z-Transform. Analysis of LTI systems using Z - transform.	7 lectures
Unit V	State-space analysis and multi-input, multi-output representation. The state-transition matrix and its role. The Sampling Theorem and its implications-Spectra of sampled signals. Reconstruction: ideal interpolator, zero-order hold, first-order hold. Aliasing and its effects. Relation between continuous and discrete time systems.	5 lectures

Books:

1. Signals & Systems, Alan V. Oppenheim, Alan S. Willsky, S. Hamid Nawab, 2nd Ed., Pearson Education, 2013.
2. Signals and Systems, S. Haykin and B. Van Veen, 2nd Ed., Wiley, 2007.
3. Principles of Linear Systems and Signals, B.P. Lathi, 2nd Ed., Oxford, 2009.
4. Signal Processing and Linear Systems, B.P. Lathi, Oxford University Press.
5. Introduction to Signals and Systems, Douglas K. Lindner, McGraw Hill.

EC22201	**Microprocessors and Applications: 4 Credits (3-0-2)**	
Unit I	Microprocessors: Evolution of microprocessor, Architecture of Intel 8085A microprocessor. Register organization, pin description. Instruction sets, operand addressing modes, instruction cycle, machine cycle, Timing diagram, Mapping of I/O to microprocessor.	8 lectures
Unit II	Programming: Concept of Micro and Macro programming, arithmetic and logical computations, block of data moving looping, counting, time delaying operations. Stack and subroutines, Concept of stack memory.	8 lectures
Unit III	Interrupts and Peripherals: Vectored interrupts, maskable and unmaskable interrupts. Intel 8085 software and hardware interrupts and their working mechanism. Usage of RIM, and SIM instructions.	8 lectures
Unit IV	Peripherals: Introduction to I/O addressing. Study of peripherals like Intel 8255, 8257, 8254 and 8251. Interfacing of I/O to microprocessor.	8 lectures
Unit V	Evolution of 16-bit microprocessors from the 8 bit 8085: Introduction to Intel 8086/8088 microprocessor architecture, Architecture, Addressing Modes, Data Movement, Arithmetic and Logic operations, Concept of segmentation and computation of physical addresses. The maximum and minimum mode of operation of 8086 processor.	10 lectures

Books:

1. Microprocessor Architecture Programming Application with the 8085/8080A, R.S. Gaonkar, 6th Ed. Prentice Hall of India, 2013.
2. Intel Corp: The 8085/8085A. Microprocessor Book–Intel marketing communication, Wiley interscience publications, 1980.
3. Intel Corp. Micro Controller Handbook–Intel Publications,1994.
4. Microprocessors and Interfacing, Douglas V. Hall, McGraw Hill International Ed.
5. Assembly Language Programming the IBMPC, Alan R. Miller, SubexInc, 1987.
6. Bary B. Brey, “The Intel Microprocessors: 8086/8088, 80186, 80286, 80386 & 80486” Prentice Hall, India.
7. Introduction to Microprocessors, A.P. Mathur, 3rd Ed. Tata McGraw Hill, 2001.
8. Fundamental of Microprocessor and Microcomputers, B. Ram, 1st Ed. Dhanpat Rai.

EC22202	Analog Communication Systems: 3 Credits (3-0-0)	
Unit I	Introduction to various types of signals used in communication engineering and their Mathematical representations. Review of Fourier series, Fourier Transform.	8 lectures
Unit II	Study and analysis of AM, FM and PM and their respectiveDemodulation Techniques, Advantages of FM over AM. AM Limiters. Pre-emphasis and De-emphasis. Transmitters for AM, FM, SSB, ISB systems.	10 lectures
Unit III	Introduction to Pulse Modulation techniques- PAM, PPM, PDM and PCM systems. TDM and FDM systems and their comparison.	6 lectures
Unit IV	Review of random signals and noise, signal to noise ratio in amplitude and angle modulated systems. Thermal and shot noise, White noise and filtered noise, AWGN Properties, Noise equivalent bandwidth concept. Discrete probability theory, Continuous random variables, Statistically independent random variables, Probability density functions of sums, Transformation of density functions, Ergodic functions, Auto correlation and Cross Correlation process, Spectral density.	10 lectures
Unit V	TRF and super heterodyne receiver, AGC, FM receiver, sensitivity, selectivity, image frequency rejection measurements, communication receiver and its special features, PLL, Power Line Carriers & Interfacing with power line.	8 lectures

Books:

1. Introduction to Analog and Digital Communication, Simon Haykin, Wiley, 2009.
2. Electronic Communication Systems, G. Kenedy & Bermard, 4th Ed., TMH, 1999.
3. Electronics Communication, Roody & J. Coolen, 4th Ed., Prentice Hall, 1977.
4. Principles of Communication System, H Taub and D. L. Schilling, "(2nd Edition), McGraw Hill.
5. Communication System, Carlson, (4th Edition), Tata McGrawHill, New Delhi.
6. Modern Digital and Analog Communication Systems, B P Lathi and Zhi Ding, Oxford University Press.
7. Digital and Analog Communication System, L. W. Couch Li, (6th Edition), Pearson Education, Pvt. Ltd.
8. Signal Processing, Modulation and Noise, J A Betts, Hodder & Stoughton Ltd., 1974.
9. Communication Systems, Siman Haykin, (4th Edition), John Wiley.
10. Fundamental of Communication Systems, John G. Proakis and M Salehi, Pearson Education.

EC22203	Linear Integrated Circuits: 4 Credits (2-1-2)	
Unit I	Differential Amplifiers (DA): Single ended and fully differential output topology, voltage gain, CMRR, PSRR and ICMR and output swing of BJT-based DA., active loads, IC biasing, current source and sink, current mirrors, level translators' circuits.	6 lectures
Unit II	OPAMP: Block-level and internal circuit level working of op-amp, ideal characteristics, open loop gain, negative feedback configurations with closed loop gain, various linear applications adder, subtractor, averager, precision rectifiers.	5 lectures
Unit III	Integrator, differentiator, log and antilog amplifiers, absolute value detectors, voltage limiters, instrumentation amplifier etc., non-linear applications such as comparators, zero crossing detector, analog multipliers, etc.	5 lectures
Unit IV	OSCILLATORS: Classification, Barkhausen Criterion, frequency stability, inverting and non-inverting Schmitt triggers, integrator, square wave and triangular wave oscillators, Phase Shift Oscillator, Wein Bridge Oscillator, voltage-controlled oscillator (VCO) circuit design using OP-AMP, PLL.	6 lectures
Unit V	ACTIVE FILTERS and CONVERTERS: classification and characterization of filters, Various types of active RC-filters of first order and second order and their design. State variable Biquadratic filters. Converters: Various types of Analog to Digital and Digital to Analog Converter, working principle, characteristics.	6 lectures

Books:

1. Op-Amps and Linear Integrated Circuits, 4 Edition, Ramakant A. Gayakwad, PHI Learning, 2009.
2. Linear Integrator Circuits, D.R. Chaudhury and S.B. Jain, New Age International Publishers, Fourth Edition.
3. Operational Amplifiers with Linear Integrated Circuits, 4th Edition, William D. Stanley, Pearson, 2004.
4. Electronics Principles, A. P. Malvino, Tata McGraw Hill.
5. Integrated Electronic Circuits, J. Millman and C.C. Halkias, TMH.
6. Electronic Devices and Circuits, Fourth Edition, David A. Bell, PHI.
7. Electronics Circuits, D. Shilling, Tata McGraw Hill.

EC22204	**Circuits and Devices: 4 Credits (2-1-2)**	
Unit I	FET and MOSFET: Operation and Structure of FETs, Junction field effect transistor (JFET), MOS Capacitor, MOSFET types, biasing, Small signal parameters. Common Drain, Common source and common gate amplifiers, CMOS.	6 lectures
Unit II	Feedback amplifier: Feedback concept, characteristics of negative and positive feedback. Four feedback topologies, effect of negative and positive feedback on input impedance, output impedance, voltage gain, band width, noise frequency, de-sensitivity factor and stability.	6 lectures
Unit III	Oscillators: Review of the basic concept, Barkhausen criterion, RC oscillators (phase shift, Wien bridge etc.), LC oscillators (Hartley, Colpitt, Clapp etc.), non-sinusoidal oscillators.	6 lectures
Unit IV	Multistage amplifier: Need, Gain expression, types - RC coupled, transformer coupled, direct coupled, and their frequency response and Bandwidth.	5 lectures
Unit V	Cascode amplifiers Tuned Amplifiers: Need for tuned circuits, Single, Double tuned and Synchronously tuned amplifiers.	5 lectures

Books:

1. Fundamentals of Microelectronics, Behzad Razavi, John Wiley & Sons.
2. Electronic Devices and Circuits, Fourth Edition, David A. Bell, PHI, 1st Ed.
3. Electronics Principles, A. P. Malvino, TMH, 2nd Ed., 2008.
4. Microelectronic, Adel S. Sedra and C Smith, Oxford University Press, 4th Ed.
5. Integrated Electronic Circuits, J. Millman and C.C. Halkias, 4th Ed. TMH.
6. Electronics Circuits, D. Shilling, 3rd Ed., Tata McGraw Hill, 2002.
7. Microelectronics, J. Millman and A. Grabel, 2nd edition, McGraw Hill, 1988.
8. Semiconductor Physics & Devices: Basic Principle, Donald A. Neaman, 3rd Edition, Tata McGraw Hill, New Delhi.

EC23101	**Digital Design using HDL: 4 Credits (2-1-2)**	
Unit I	Introduction to sequential circuits: Latch, R-S, J-K, D flip flops, Master Slave arrangement, Edge triggered flip flops, Conversion of flip flop, shift registers, asynchronous and synchronous counters.	5 lectures
Unit II	Design tools: Introduction to HDL Basic features of HDL. Simulation and synthesis. Basic HDL modelling techniques. Algorithmic level design. Register Level Design. HDL-based design techniques. Modelling for synthesis.	6 lectures
Unit III	Synchronous sequential finite state machines: Synchronous analysis process, design approaches, state reduction, design of next state decoder and output decoder, design of counters and decoders, code sequence detector, sequential code generators.	6 lectures
Unit IV	Algorithmic State Machine (ASM): ASM Chart, ASM block, Design using FFs, Design using multiplexers and PLAs.	5 lectures
Unit V	Asynchronous Sequential finite state machines: Need for asynchronous circuit analysis, cycles and races, Hazards, map entered variable Approaches to asynchronous design.	6 lectures

Books:

1. An Engineering approach to Digital Design, William J. Fletcher, PHI.
2. VHDL Primer, J. Bhaskar.
3. Verilog HDL Synthesis, A Practical Primer, J. Bhaskar.
4. Digital Design: Principles and Practices, John F. Wakerly, PHI.
5. Fundamentals of Digital Circuits, A. Anand Kumar, PHI.
6. Digital Design, Morris Mano, PHI.
7. Digital Principles and Design, Donald D. Givone, TMH.

EC23102	**Digital Signal Processing: 4 Credits (3-0-2)**	
Unit I	Review of Discrete-time Fourier Transform, Frequency response of discrete time systems, All pass inverse and minimum phase systems.	5 lectures
Unit II	DFT, Relationship of DFT to other transforms, FFT, DIT and DIF algorithms, Linear filtering using DFT and FFT.	8 lectures
Unit III	Frequency response of FIR filter, Design of FIR Digital filters, Window method, Park-McClellan's method, Frequency Sampling Method, Design of IIR Digital Filters, Butterworth, Chebyshev and Elliptic Approximations, Lowpass, Bandpass, Bandstop and High pass filters, Mapping formulas, Frequency transformations.	11 lectures
Unit IV	Direct form realization of FIR and IIR systems, Lattice structure for FIR and IIR systems, Finite-word length effects. Limit cycle oscillations.	8 lectures
Unit V	Multirate signal processing – Sampling rate conversion – applications of multirate signal processing. Parametric and non-parametric spectral estimation. Application of DSP.	10 lectures

Books:

1. Digital Signal Processing, Algorithms and Applications, Proakis and Manolakis, 3rd edition, Prentice Hall of India, New Delhi.
2. Discrete-time Signal processing, Alan V Oppenheim and Ronald W Schafer, 3rd edition, Pearson.
3. The Scientist & Engineer's Guide to Digital Signal Processing, Steven W Smith.
4. Understanding Digital Signal Processing, Richard G Lyons, Pearson.
5. Digital Signal Processing: A Practical Approach, Emmanual C Ifeachor et al., Pearson Education, 2nd edition.

EC23103	**Electromagnetic Theory: 3 Credits (3-0-0)**	
Unit I	Review of vector Algebra, Rectangular, Cylindrical, spherical Coordinate systems and transformation, Vector Calculus – Gradient, Divergence and curl, Green's and Stroke theorems.	8 lectures
Unit II	Electrostatics, Coulomb's law. Gauss's law and applications. Electric potential. Poisson's and Laplace equations. Method of images. Electrostatic fields in matter. Dielectrics and dielectric polarization. Capacitors with dielectric substrates.	10 lectures
Unit III	Magnetostatics, Biot-Savart's Law, Ampere Circuits Law, Applications of Ampere's Law, Maxwell Equations of static fields, Magnetic Scalar and Vector Potentials, Magnetic Force - charge particle, current elements, Magnetic field inMaterial space, Magnetization, Magnetic Boundary Conditions, Inductor, Inductances, Magnetic Energy.	10 lectures
Unit IV	Time-varying Fields, Faraday's Law, Transformer and Motional Electromotive Forces, Displacement current, Maxwell Equations, Time Varying Harmonic Fields.	7 lectures
Unit V	Electromagnetic waves, General wave Equations, waves in lossy dielectrics, Plane wave in lossless dielectrics, free space, good conductors, Wave polarization, Poynting vector and reflection of waves.	7 lectures

Books:

1. Elements of Electromagnetics 4th Edition – M. N. O. Sadiku, Oxford.
2. Electromagnetic waves and radiating systems, 2nd edition, E. Jordan and K. Balmin, Prentice Hall of India, New Delhi, 2001.
3. Advanced Engineering Electromagnetics, C.A. Balanis, John Willy and Sons, New York, 2001.
4. Electromagnetics, 4th edition, J.D. Kraus, Tata McGrawhill, New Delhi, 1991.

EC23104	**Control Systems: 3 Credits (3-0-0)**	
Unit I	Elementary control concepts: Open loop and close loop control system. Transfer function, impulse response, modeling of electrical and mechanical (translational and rotational) systems, DC motor block diagramsimplification, and signal flow graphs.	8 lectures
Unit II	Transient response analysis of I and II order system: Type of systems andits effect on error function, stability, steady state error.	6 lectures
Unit III	Stability concept: Routh Hurwitz criterion of stability, Root locustechniques: Root-Loci and complementary root loci rules for root locusplots.	8 lectures
Unit IV	Frequency Response Analysis: Nyquist plot and Bode plot. Gain and phasemargins, compensation typical examples. Compensators and controllers: lead, lag and lag-lead compensators, proportional, PI and PID controllers.	10 lectures
Unit V	State Space Analysis: State Variables and State Model, State TransitionMatrix and its properties, Concept of Controllability and Observability. Digital Control System: Sampled Data Control System, Step Response (First & Second Order Systems), Introduction to Digital PID Controller, block schematic of PLC and addressing.	10 lectures

Books:

1. Control Systems Engineering, Nagaratha and Gopal.
2. Discrete-Time Control Systems, K. Ogata, Pearson Education/PHI, 2 Edition.
3. Modern Control Engg, K. Ogata, 2nd ed., PHI, 1995.
4. Automatic Control Systems, B.C. Kuo, 7th ed., PHI, 1995.

EC23201	**Digital Communications: 3 Credits (3-0-2)**	
Unit I	Review of Sampling theorem, Pulse-Amplitude Modulation, Channel bandwidth. Natural and Flat top sampling. Quantization of signals, Quantization error, Pulse-code modulation (PCM), Electrical representation of binary digits, PCM system, Companding, Multiplexing. Differential PCM, Delta modulation, Adaptive delta modulation, Vocoders, Channel Vocoder, Linear Predictive coder.	10 lectures
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).	10 lectures
Unit III	Data Transmission: Baseband signal receiver, Probability of error. Matched Filter, Probability of error in Matched filter, Coherent reception of PSK and FSK, Non-Coherent reception of FSK, PSK and QPSK. Error probability of BPSK, BFSK and QPSK.	6 lectures
Unit IV	Bit-by-bit encoding versus Symbol-by-Symbol encoding, Relationship between Bit error rate and Symbol Error rate, comparison of modulation systems.	6 lectures
Unit V	Information Theory and Coding: Discrete messages, information, Entropy, Information rate, coding to increase average information per bit. Shannon's theorem, Capacity of Gaussian channel, Bandwidth-S/N trade off, use of orthogonal signals to attain Shannon's limit, Efficiency of orthogonal signal transmission, Coding: Parity check bit coding, error detection and error correction coding, Block codes, Convolution codes, Comparison of error rates in coded and uncoded transmission.	10 lectures

Books:

1. Electronic Communications Systems, Wayne Tomasi, Pearson Education.
2. Principles of Communication Systems, Taub and Schilling TMH.
3. Digital Communication, S. Haykin, Wiley.
4. Analog and Digital Communication, S. Haykin, Wiley.

EC23202	**Microwave Engineering: 4 Credits (3-0-2)**	
Unit I	Introduction to Microwave frequencies, systems and measurements, review of Maxwell equations, waves and reflection of waves.	8 lectures
Unit II	Microwave Transmission lines - Transmission line Equations and Solutions, Reflection and transmission Co-efficient, standing waves and SWR, Line impedance and Admittance, Impedance matching using Smith chart.	8 lectures
Unit III	Microwave wave guides, Study of Rectangular and Circular Wave guides. Microwave components-rectangular, Circular cavity resonators. Slow wave structures, Sparameters. Wave guide Tees, Directional Couplers, Circulators and Isolators, Hybrid couplers.	10 lectures
Unit IV	Microwave Sources - Klystrons, Reflex klystrons, TWTs, Hybrid amplifier, BWO. Magnetrons, Forward wave cross-field amplifiers.	8 lectures
Unit V	Microwave solid state devices - Transistors, Tunnel Diodes, Gunn LSA, InP. Avalanche transit time devices, IMPATT, TRAPATT, and BARITT Diodes, Electron motion in EM field.	8 lectures

Books:

1. Foundations of Microwave Engineering, 2nd Ed, R. E. Collin, McGraw Hill
2. Microwave Devices and Circuits, 3rd Ed, Samuel Y. Lio, Prentice Hall of India, New Delhi, 1995.
3. Microwave Engineering 2^{nd} Edition, David M. Pozar, Wiley.

EC23203	**Microelectronics: 3 Credits (3-0-0)**	
Unit I	Fundamentals of Semiconductors: Crystal Plane. Valence Band Model of Semiconductor. Fermi Dirac probability distribution function. Carrier Concentration in Intrinsic and Extrinsic semiconductors at equilibrium, compensated semiconductor. Carrier transport phenomena- Drift, Diffusion. Excess carriers in semiconductors- Carrier Generation and Recombination. Continuity equation. E-K Diagram. Direct and Indirect semiconductors. Hall Effect.	10 lectures
Unit II	PN Junction: Energy Band Diagram. Equilibrium state analysis of p-n junction, Forward and Reverse Bias. Forward bias Diode current (minority and majority carrier current). Generation and recombination current.	6 lectures
Unit III	Small signal model of the p-n junction. Metal semiconductor junctions. Light emitting diodes- generation of light, internal quantum efficiency, external quantum efficiency.	6 lectures
Unit IV	Bipolar junction transistors: Principle of Operation. Minority Carrier Distribution Profiles in a Bipolar Junction Transistor. Current Components and Current Gain. Bias modes and operation of bipolar transistor. Non-ideal effects, Base width modulation, High injection effects, emitter ban gap narrowing and emitter current crowding. Breakdown mechanisms in BJTs. BJT small signal equivalent circuit models. Frequency limitations-Time delay Factors, transistor cut-off frequency.	10 lectures
Unit V	MOS Fundamentals- Electrostatics of ideal and non-ideal MOS Capacitors. HF and LF capacitance of MOS Capacitors. Theory of operation of MOSFET- Threshold Voltage, I_D-V_D relationship, square-law theory, bulk charge theory. Small-signal equivalent circuits, cut-off frequency. Short channel effects in MOSFETs. JFET introduction and theory of operation. I_D-V_D relationship.	10 lectures

Books:

1. Solid-State Electronic Devices, B. Streetman and S. K. Banerjee, PHI
2. Semiconductor Physics and Devices, Donald A. Neaman, Tata McGraw-Hill.
3. Semiconductor Device Fundamentals, R. Pierret, Pearson.
4. Physics of Semiconductor Devices, S.M. Sze, Wiley Eastern Ltd.

EC24101	Antenna and Radar Engineering: 4 Credits (3-0-2)	
Unit I	Antenna fundamentals-Antenna parameters, point source electric doublet, Instantaneous and short dipoles, Quarter and Half wavelength Dipoles.	7 lectures
Unit II	Antenna far –field approximations, Monopoles, Antenna above perfect electric conductor.	7 lectures
Unit III	Antenna arrays, Loop Antennas.	10 lectures
Unit IV	Introduction of Broadband, Frequency independent antennas- Spiral antennas, log periodic antennas. Aperture antennas, Horn antennas, Microstrip antennas and its analysis.	12 lectures
Unit V	Rader fundamentals, Range equation, Different types of radar with practical applications.	6 lectures

Books:

1. Antennas, J.D. Kraus, McGraw Hill, 1988.
2. Antenna Theory - Analysis and Design, John Wiley, 1982.
3. R.E. Collin, Antennas and Radio Wave Propagation, C.A. Balanis, McGraw Hill, 1985.
4. Antenna Engineering Handbook, R.C. Johnson and H. Jasik, Mc-Graw Hill, 1984.
5. Micro Strip Antennas, I.J. Bahl and P. Bhartia, Artech House, 1980.
6. Electromagnetic Waves, R.K. Shevgaonkar, Tata McGraw Hill, 2005.
7. Adaptive Antennas, R.E. Crompton, John Wiley. 2016.

EC24102	VLSI Designs: 4 Credits (3-0-2)	
Unit I	VLSI design flow Design; MOS Transistor; DC Transfer Characteristics: Static CMOS; Inverter DC Characteristics.	10 lectures
Unit II	CMOS Processing Technology: Layout design rules, CMOS Process enhancements; Stick Diagrams; Technology-Related CAD Issues, Manufacturing Issues.	6 lectures
Unit III	Delay: Delay Models; Logical Efforts of Paths, Timing Analysis of Delay Models; Power: Dynamic Power and Static Power.	6 lectures
Unit IV	Combinational Circuit Design: CMOS Logic Gates, The Compound Gates, Pass Transistors and Transmission Gates, Tristate buffer, Multiplexers; Circuit Families: Static CMOS, Ratioed Circuits, Cascode Voltage Switch Logic, Dynamic Circuits, Pass-Transistor Circuits. Subthreshold Circuit Design.	10 lectures
Unit V	Sequential MOS logic circuitry: Behavioral of Bistable element, Flip-Flop. Sequencing Static Circuits; Circuit Design of Latches and Flip-Flops; Memory: SRAM; DRAM; Semiconductor memories: Introduction, Read-Only Memory circuits, SRAM circuits, DRAM circuits.	10 lectures

Books:

1. “CMOS VLSI Design”, Pearson Education, Neil H.E. Weste, David Harris, Ayan Banerjee, 3rd Edition.
2. “CMOS digital Integrated Circuits, Analysis and Design”, Sung-Mo Kang and Yusuf Leblebici, Tata McGraw-Hill Publishing Company Limited, New Delhi.
3. “Basic VLSI Design”, Douglas A. Pucknell, Kamaran Eshraghian, PHI, 3rd Edition, 2016.
4. “Introduction to VLSI Circuits and Systems”, John P. Uyemura, Wiley India Edition, 2016.

EC23001	Network Analysis and Synthesis: 3 Credits (3-0-0)	
Unit I	Review of Network Theorems, Formulations of network equations: First –order systems, Natural response, Initial conditions, complete response of First- order systems, zero state and zero input responses. Second order system, Natural response, Overdamped, Underdamped and critically damped case. Geometry of plane, unit-step and unit impulse response, linear system with sinusoidal inputs, impedance and admittance, power, concept of Complex frequency.	10 lectures

Unit II	Transform Impedances Network functions of one port and two port networks, concept of poles and zeros, properties of driving point and transfer functions, time response and stability from pole zero plot, frequency response.	6 lectures
Unit III	Characterization of LTI two port networks ZY, ABCD and h-parameters, reciprocity and symmetry. Inter relationships between the parameters, interconnections of two port networks. Transient analysis of different electrical circuits with and without initial conditions.	6 lectures
Unit IV	Positive real function; definition and properties; properties of LC, RC and RL driving point functions, synthesis of LC, RC and RL driving point immittance functions using Foster and Cauer first and second forms.	11 lectures
Unit V	Graph of a Network, definitions, tree, co tree, link, basic loop and basic cut set, Incidence matrix, cut set matrix, Tie set matrix Duality, Loop and Node methods of analysis.	9 lectures

Books:

1. "Network Analysis", M.E. Van Valkenburg, Prentice Hall of India.
2. "An Introduction to Circuit analysis: A System Approach", Donald E. Scott, McGraw Hill Book Company.
3. "Circuit Theory", A. Chakrabarti, Dhanpat Rai and Co.
4. "Networks and Systems", D. Roy Choudhary, Wiley Eastern Ltd, 2012.

EC23002	**Video and Advanced TV Engineering: 3 Credits (3-0-0)**	
Unit I	Fundamentals of Television: Geometry form and Aspect Ratio, Image Continuity, Number of scanning lines, Camera tubes, Image orthicon - Vidicon-plumbicon-silicon diode array, Monochrome picture tubes, Composition- vertical sync, Picture signal transmission: Positive and negative modulation, VSB transmission, Sound signal transmission, Standard channel bandwidth.	8 lectures
Unit II	Monochrome Television Transmitter and Receiver: TV transmitter, TV transmission Antennas, Monochrome TV receiver, RF tuner, UHF, VHF tuner, Digital tuning techniques: AFT-IF subsystems, Video and sound inter carrier detection, Video amplifier circuits, Deflection current waveform, Deflection Oscillators - Frame deflection circuits, EHT generation - Receiver Antennas.	8 lectures
Unit III	Essentials of Colour Television: Compatibility, Colour perception, Three colour theory, Colour television cameras, Colour television display tubes, Colour picture tubes, Pincushion correction techniques: Automatic degaussing circuit, Grey scale tracking, Colour signal transmission, Weighting factors, Formation of chrominance signal.	8 lectures
Unit IV	Colour Television Systems: NTSC colour TV system, PAL colour TV system: Cancellation of phase errors, PAL -D colour system, PAL coder, Colour burst separation, burst phase Discriminator, Reference Oscillator, Ident and colour killer circuits, Merits and demerits of the PAL system, SECAM system: Merits and demerits of SECAM system.	8 lectures
Unit V	Advanced Television Systems: Satellite TV technology, Cable TV, Tele Text broadcast receiver, Digital television: Transmission and reception, Projection Television: Flat panel display TV receiver, Sterio sound in TV, 3D TV, EDTV, Digital equipment for TV studios.	10 lectures

Books:

1. Monochrome Television Practice, Principles, Technology and servicing, R.R. Gulati, Second edition, New age International Publishes, 2004.
2. Monochrome and colour television, R.R. Gulati, New age Internationl Publisher.
3. Television and Video Engineering, A.M. Dhake, Second edition, TMH, 2003.
4. Colour Television, Theory and Practice, S.P. Bali, TMH, 1994.

EC23003	Modern Control Engineering: 3 Credits (3-0-0)	
Unit I	Review of Z-Transforms, State Space Representation of discrete time systems, State transition matrix and its Properties, Discretization of continuous timestate-space equations, Controllability and Observability, Duality between Controllability and Observability, Controllability and Observability conditions for Pulse Transfer Function.	10 lectures
Unit II	Stability Analysis, Mapping between the S-Plane and the Z-Plane, Primary strips and Complementary Strips, Constant frequency loci, Constant damping ratio loci.	6 lectures
Unit III	Stability Analysis of closed loop systems in the Z-Plane, Jury stability test, Stability Analysis by use of the Bilinear Transformation and Routh Stability criterion.	6 lectures
Unit IV	Design of Discrete Time Control System, Transient and steady-State response Analysis, Design based on the frequency response method, bilinear Transformation and Design procedure in the w-plane, Lead, Lag and Lead-Lag compensators and digital PID controllers.	10 lectures
Unit V	State Feedback Controllers and Observers, Design of state feedback controller through pole placement, Ackerman's formula, State Observers.	10 lectures

Books:

1. Discrete Time Control Systems, K. Ogata, Pearson Education/PHI, 2 Edition.
2. Digital Control Systems, V. I. George, C. P. Kurian, Cengage Learning.
3. Digital Control Systems, Kuo, Oxford University Press, 2 Edition, 2003.
4. Digital Control and State Variable Methods, M. Gopal, TMH.

EC23004	Information Theory and Coding: 3 Credits (3-0-0)	
Unit I	Entropy: Entropy, Joint Entropy and Conditional Entropy, Relative Entropy andMutual Information, Relationship Between Entropy and Mutual Information, Chain Rules for Entropy, Relative Entropy, and Mutual Information, Jensen's Inequality and its Consequences, log sum inequality and its Applications, Data-Processing Inequality, Sufficient Statistics, Fano's Inequality.	8 lectures
Unit II	Asymptotic equipartition Property: Asymptotic equipartition Property Theorem, Consequences of the AEP: Data Compression, High-Probability Sets and the TypicalSet Data Compression: Examples of Codes, Kraft Inequality, Optimal Codes, boundson the optimal code length, kraft inequality for Uniquely Decodable Codes, Huffman Codes, Some Comments on Huffman Codes, Optimality of Huffman Codes, Shannon–Fano–Elias Coding.	9 lectures
Unit III	Channel capacity: Examples of channel capacity, 7.2 Symmetric Channels, Properties of Channel Capacity, Preview of the Channel Coding Theorem, Definitions, Jointly Typical Sequences, Channel Coding Theorem.	8 lectures
Unit IV	Block Codes Digital communication channel, Introduction to block codes, Single-parity check codes, Product codes, Repetition codes, hamming codes, Minimumdistance of block codes, Soft-decision decoding, Automatic-repeat-request schemesLinear Codes Definition of linear codes, Generator matrices, Standard array, Parity-check matrices, Error syndromes, Error detection and correction, Shortened and extended linear codes.	9 lectures
Unit V	Convolution codes: Encoding convolutional codes, Generator matrices for convolutional codes, Generator polynomials for convolutional codes, Graphical representation of convolutional codes, Viterbi decoder.	8 lectures

Books:

1. Joy A. Thomas, Thomas M. Cover, "Elements of information theory", Wiley.
2. S. Gravano, "Introduction to Error Control Codes", OUP Oxford.
3. Robert B. Ash, "Information Theory", Dover Publications.
4. Error Correction Coding: Mathematical Methods and Algorithms, Todd K Moon, Wiley, 2005.
5. T. S. Rappaport, "Wireless Communication - Principles and Practice", Pearson Publications, Second Edition.

EC23005	Medical Electronics: 3 Credits (3-0-0)	
Unit I	Introduction: General measurement and diagnostic system, classification, Biomedical signal acquisition, difficulties in signal acquisition. ECG: signal origin, parameters-QRS detection different techniques, ST segment analysis, Arrhythmia, Arrhythmia analysis, Arrhythmia monitoring system.	8 lectures
Unit II	ECG Data Reduction, compression: Turning Point, AZTEC, Cortes, FAN, Transformation, Karhunen - Loeve Transform, DPCM, Huffman coding, Datacompression. Signal averaging: Basics, Signal averaging as a digital filter, A typical averager, Software and limitations.	10 lectures
Unit III	Frequency Domain Analysis, Spectral analysis, linear filtering, cepstral analysis and homomorphic filtering. Removal of high frequency noise, motion artefacts and power line interference in ECG, Time Series Analysis: AR models, Estimation of AR parameters, ARMA models. Spectral modelling and analysis of PCG signals.	8 lectures
Unit IV	Spectral Estimation, Evaluation of prosthetic heart valves using PSD techniques. Comparison of the PSD estimationmethods. Event Detection and waveformanalysis: Identification of heart sounds, Morphological analysis of ECG waves and Activity.	8 lectures
Unit V	Adaptive Filtering: Introduction, General structure, LMS, adaptivenoise cancellation in ECG, cancellation of ECG from EMG signal, Cancellation ofmaternal ECG in fetal ECG. EEG: EEG signal characteristics, Sleep EEG classification and epilepsy.	8 lectures

Books:

1. Biomedical Signal Analysis - A case study approach, Rangaraj M Rangayyan, JohnWiley 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.

EC23006	Speech Processing: 3 Credits (3-0-0)	
Unit I	Introduction to fundamentals of digital speech processing: Speech signal, storage, synthesis, speaker verification, identification and recognition, Discrete timessystems, sampling, FIR and IIR Digital Filters.	8 lectures
Unit II	Models of the speech signals: Speech production, acoustic theory, digital modelsof speech signals, Vocal tract, time dependent processing of speech, pitch, speechand silence discrimination.	8 lectures
Unit III	Digital representation of speech waveform: Sampling speech signal, statisticalspeech models, instantaneous, quantization, adaptive quantization, differentialquantization, delta modulation, differential PCM and Direct digital codeconversion.	8 lectures
Unit IV	Short Term Fourier Analysis, digital filter banks, spectrographic displays, pitchdetection, analysis by synthesis system, Homomorphic Speech Processing, Homomorphic systems for convolution, Complex Speech Spectrum, Pitchdetection and formant estimation, homomorphic vocoder.	9 lectures
Unit V	Linear Predictive coding of speech: Linear predictive analysis, Gain computation, Prediction error signal, Frequency domain interpretation, Applications of LPC parameters and speech synthesis.	9 lectures

Books:

1. "Digital Processing of Speech Signals", Lawrence Rabiner, Ronald W. Schafer, Macmillan Publishing, 1993.
2. "The Scientist and Engineer's Guide to Digital Signal Processing", Steven W. Smith, California Technical Publishing, 1997.
3. "Discrete-Time Speech Signal Processing – Principles and Practice", Thomas F Quatieri, Pearson Education, 2004.

4. “Speech Recognition”, Claudio Becchetti and Lucio PrinaRicotti, John Wiley and Sons, 1999.
5. “Speech and Audio Signal Processing, Processing and Perception of Speech and Music”, Ben Gold and Nelson Morgan, Wiley- India Edition, 2006.

EC23011	**Microcontrollers and Applications: 3 Credits (3-0-0)**	
Unit I	The 8051 microcontroller: Evolution of microcontrollers, overview of the 8051 family.	8 lectures
Unit II	Assembly language programming: Arithmetic, logical, jump, loop, call instructions. Input/Output port programming: pin descriptions of the 8051, I/O programming; bit manipulation.	8 lectures
Unit III	Addressing modes: Immediate and register addressing modes; memory accessing. Timer/Counter programming.	8 lectures
Unit IV	Serial communication: basics, connection to RS232 and programming. Interrupts: different types and their programming.	9 lectures
Unit V	Real world interfacing: LCD, ADC, Sensors, stepper motors, keyboards.	9 lectures

Books:

1. The 8051 Microcontroller and Embedded Systems, M. A. Mazidi, and J.G. Mazidi, Pearson Education.
2. Microcontroller Projects in C for 8051, D. Ibrahim, Newnes, Elsevier.

EC23012	**Computer Organization: 3 Credits (3-0-0)**	
Unit I	Concepts and Terminology: Digital computer concepts; Von-Neumann concept; Hardware and Software and their nature; structure and functions of a computer system, Role of operating system Evolution of computer architectures, different generations, CISC and RISC characteristics.	8 lectures
Unit II	Memory Unit: Memory classification, characteristics; static memories, dynamic memories; Organization of RAM, address decoding ROM/PROM/EEPROM; Concept of memory map, memory hierarchy, Associative memory organization; Cache introduction, Replacement algorithms. On chip caches. Performance consideration interleaving. Hit rate, miss penalty. Concept of virtual memory and paging.	10 lectures
Unit III	Processor organization: The ALU–ALU organization, Integer representation, 1s and 2s complement arithmetic; Serial and Parallel Adder; implementation of high-speed Adder Carry Look Ahead and carry Save Adder; Multiplication of signed binary numbers-Booth’s algorithm; Divide Algorithms-Restoring and Non-Restoring.	7 lectures
Unit IV	Control Design, Instruction sequencing, Interpretation, Hard wired control-Design methods, and CPU control unit. Microprogrammed Control- Basic concepts, minimizing microinstruction size, multiplier control unit.	7 lectures
Unit V	System organization: Input-Output systems, Interrupt, DMA, Standard I/O interfaces Concept of parallel processing, Pipelining, Forms of parallel processing, interconnect network. Introduction to Flynn’s classification – SISD, SIMD, MISD, MIMD architectures.	10 lectures

Books:

1. V. Carl Hammacher, “Computer Organisation”, Fifth Edition.
2. A.S. Tanenbum, “Structured Computer Organisation”, PHI, Third edition.
3. Y. Chu, “Computer Organization and Microprogramming”, II, Englewood Chiffs, N.J., Prentice Hall Edition.
4. M.M. Mano, “Computer System Architecture”, Edition.
5. C.W. Gear, “Computer Organization and Programming”, McGraw Hill, N.V. Edition.
6. Hayes J.P, “Computer Architecture and Organization”, PHI, 2nd edition.

EC23013	Introduction to Plasmonics: 3 Credits (3-0-0)	
Unit I	ELECTROMAGNETICS OF METALS: Maxwell's Equations and Electromagnetic Wave Propagation, the Dielectric Function of the Free Electron Gas, The Dispersion of the Free Electron Gas and Volume Plasmons, Real Metals and Interband Transitions the Energy of the Electromagnetic Field in Metals.	8 lectures
Unit II	SURFACE PLASMON POLARITONS AT METAL/ INSULATOR INTERFACES: The Wave Equation, Surface Plasmon Polaritons at a Single Interface, Multilayer Systems, Energy Confinement and the Effective Mode Length.	8 lectures
Unit III	EXCITATION OF SURFACE PLASMON POLARITONS AT PLANAR INTERFACES: Excitation upon Charged Particle Impact, Prism Coupling, Grating Coupling, Excitation Using Highly Focused Optical Beams, Near-Field Excitation, Coupling Schemes Suitable for Integration with Conventional Photonic Elements.	8 lectures
Unit IV	ELECTROMAGNETIC SURFACE MODES AT LOW FREQUENCIES: Surface Plasmon Polaritons at THz Frequencies, Designer Surface Plasmon Polaritonson Corrugated Surfaces, Surface Phonon Polaritons.	8 lectures
Unit V	PLASMON WAVEGUIDES: Planar Elements for Surface Plasmon Polariton Propagation, Surface Plasmon PolaritonBand Gap Structures, Surface Plasmon Polariton Propagation Along Metal Stripes, Metal Nanowires and Conical Tapers for High-Confinement Guiding and Focusing Localized Modes in Gaps and Grooves.	10 lectures

Books:

1. S. A. Maier, Plasmonics: Fundamentals and Applications.
2. Heinz Raether, Surface Plasmons on Smooth and Rough Surfaces and on Gratings.

EC23014	Embedded Systems: 3 Credits (3-0-0)	
Unit I	Introduction to Real Time Embedded Systems: Embedded Systems Components, Digital Signal Processors, General Purpose Processors, Embedded Processors and Memory-Interfacing.	10 lectures
Unit II	Embedded Systems I/O: Interfacing bus, Protocols, Timers, Interrupts, DMA, USB and IrDA, AD and DA Converters, Analog Interfacing.	10 lectures
Unit III	Design of Embedded Processors: Field Programmable Gate Arrays and Applications with HDL, Embedded Communications: Serial, Parallel, Network, Wireless Communication.	10 lectures
Unit IV	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.	6 lectures
Unit V	Introduction to Software Engineering, Requirements Analysis and Specification, Modelling Timing Constraints, Software Design.	6 lectures

Books:

1. Real Time Systems, Rajib Mall, PHI, New Delhi.
2. Embedded Systems Architecture - A Comprehensive Guide for Engineers and Programmers, Tammy Noergaard, Newnes, Elsevier.
3. An Embedded System Primer, Simon, PHI.
4. Embedded Systems-Architecture, Programming and Design, Raj Kamal, TMH.
5. Embedded System Design: A Unified Hardware/Software Introduction, Frank Vahid, Tony D. Givargis, Wiley Publishers.

EC23015	Transducers and Signal Conditioning: 3 Credits (3-0-0)	
Unit I	Introduction: Measurement systems, Basic electronic measuring system, Transduction principles, Classification of transducers, General transducers characteristics, Criteria for transducer selection. Resistive Transducers: Potentiometers, strain gauges, (metallic and semi-conductor type), Resistance Thermometer, Thermistors.	8 lectures
Unit II	Inductive Transducers, variable Inductive Transducers, LVDT (Linear variable differential transformer). Capacitive Transducers, Types of capacitive transducer. Elastic Transducers: Spring bellows, diaphragm, bourdon tube – their special features and application.	9 lectures
Unit III	Active Transducers: Principle of operation, construction, theory, advantages and disadvantages and applications of following transducers: Thermocouple, Piezo-electric transducer, Magneto-strictive transducer, Hall effect transducer, Photo-voltaic transducer and Electrochemical transducer.	8 lectures
Unit IV	Other Transducers: Optical transducers: photo-emissive, photo-conductive and Photo-voltaic cells, Digital Transducers: Optical encoder, Shaft encoder. Feedback fundamentals, introduction to Inverse transducer.	8 lectures
Unit V	Signal Conditioning: Concept of signal conditioning, Introduction to AC/DC Bridges. Op-amp circuits used in instrumentation, Instrumentation amplifiers, analogue-digital sampling, introduction to A/D and D/A conversion, signal filtering, averaging, correlation, Interference, grounding, and shielding.	9 lectures

Books:

1. Murty D. V. S., “Transducers & Instrumentation”, PHI, New Delhi, 2000.
2. Sawhney A. K., “Electrical and Electronics Measurements and Instrumentation”, Dhanpat Rai and Sons, New Delhi, 2000.
3. Kalsi H S, “Electronic Instrumentation”, Tata McGraw Hill, New Delhi, 4th Ed., 2001.
4. Patranabis D., “Sensors and Transducers”, PHI, New Delhi, 2003.
5. Doebelin Ernest O., “Measurement Systems: Application and Design”, Tata McGraw Hill Ltd., New Delhi, 2004.

EC23016	Digital Image Processing: 3 Credits (3-0-0)	
Unit I	Fundamental concepts of digital geometry, Digital image representation, Fundamental steps, Image Processing systems, Image acquisitions, Storage, Communication, Display fundamentals. Visual perception, Simple image model, Sampling and quantization, Basic relationships between pixels neighbour of pixels, Connectivity’s, Relation, Equivalence and transitive clause, Distance measures, Arithmetic/logic operations.	8 lectures
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, properties, 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.	10 lectures
Unit III	Image enhancement: Spatial domain methods, Frequency domain method, Enhancement by point processing, Simple intensity transforms, Histogram processing, 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.	8 lectures
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 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.	8 lectures

Books:

1. Digital Image Processing Using Java, Efford, AWL, NY, 2000.
2. The Computer Image, A Watt and F. Policarpo AWL, NY, 1999.
3. Fundamentals of Image Processing by A.K. Jain, PHI.

EC24001	**Multimedia Communication and Networking: 3 Credits (3-0-0)**	
Unit I	Basics of analog and digital video: colour video formation and specification, analog TV system, video raster, digital video formats. Frequency domain analysis of video signals, spatial and temporal frequency response of the human visual system.	8 lectures
Unit II	Scene, camera, and motion modelling, 3D motion and projected 2D motion, models for typical camera/object motions.	8 lectures
Unit III	2D motion estimation: optical flow equation, different motion estimation methods (pel-based, block-based, mesh-based, global motion estimation, multi-resolution approach), Basic compression techniques: information bounds for lossless and lossy source coding, binary encoding, scalar/vector quantization.	10 lectures
Unit IV	Waveform-based coding: transform coding, predictive coding including motion compensated prediction and interpolation, block-based hybrid video coding, scalable video coding.	8 lectures
Unit V	Video compression standards (H.261 and H.263, MPEG1, MPEG2, MPEG4, MPEG7). Error control in video communications. Video transport over the Internet and wireless networks.	8 lectures

Books:

1. JPEG2000: Image Compression Fundamentals, Standards, and Practice," D. Taubman and M. Marcellin, Kluwer, 2001. ISBN: 079237519X.
2. "H.264 and MPEG-4 Video Compression," Iain E G Richardson, John Wiley & Sons, September 2003, ISBN 0-470-84837-5.
3. "Video Coding for Mobile Communications: Efficiency, Complexity and Resilience", M. E. Al-Mualla, C. N. Canagarajah and D. R. Bull, Elsevier Science, Academic Press, 2002. ISBN: 0120530791.
4. "Digital Video Processing," A. Murat Tekalp, Prentice Hall, Englewood Cliffs, NJ.
5. "Introduction to Data Compression," Khalid Sayood, 2nd ed., Morgan Kaufmann.
6. "Digital Compression for Multimedia: Principles & Standards," Jerry Gibson, Toby Berger, Tom Lookabaugh, Rich Baker and David Lindbergh, Morgan Kaufmann, 1998. ISBN 1-55860-369-7.
7. "Digital Pictures – Representation, Compression and Standards," A. N. Netravali and B. G. Haskell, 2nd ed. Plenum Press, 1995.

EC24002	**Telecommunication Switching: 3 Credits (3-0-0)**	
Unit I	Telecommunications Transmission- Four-wire circuits, TDM, PCM, Differential coding, Pulse Transmission, Line Coding, Binary N – Zero Substitution, Digital Bi-phase. SONET/SDH: SONET Frame Formats, Operations, Administration and Maintenance, Payload Framing and Frequency Justification, Virtual Tributaries, DS3 & E4 Payload Mapping, SONET Optical Standards, Networks, SONET Rings.	10 lectures
Unit II	Evolution of switching system, Switching Networks, Digital Switching - Switching Functions, Space Division Switching, Time Division Switching, two-dimensional switching: STS Switching, TST Switching, Signaling techniques - In channel, Common channel signaling, SS7 signaling.	8 lectures

Unit III	Network Synchronization Control and Management Timing: Timing Recovery, Phase-Locked Loop, Clock Instability, Jitter Measurements, Systematic Jitter. Timing Inaccuracies: Slips, Asynchronous Multiplexing, Network Synchronization, Network Control, Network Management.	8 lectures
Unit IV	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.	8 lectures
Unit V	Digital Subscriber Access: ISDN, High-Data-Rate Digital Subscriber Loops, VDSL, Digital Loop Carrier Systems, Fiber in the Loop, Hybrid Fiber Coax Systems, and Voice band Modems, Local microwave Distribution Service, Digital Satellite Services.	8 lectures

Books:

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

EC24003	**Optical Fiber Communication: 3 Credits (3-0-0)**	
Unit I	Introduction: Advantage over other communication system. Optical wave guides-Ray theory of transmission, Total internal reflection, acceptance angle, Numerical aperture, skews rays.	8 lectures
Unit II	EM theory of optical propagation. Setup and graded index fibers, Modes and their coupling, single mode fiber, mode field diameter, spot size. Transmission characteristics of optical fiber - Intrinsic and Extrinsic absorption, Linear scattering, Fiber band loss, Material and waveguide dispersion, Intermodal dispersion, Modified single mode fiber.	8 lectures
Unit III	Optical sources-LASERS: Absorption and emission of radiation, Einstein relation, Population inversion, Optical feedback and threshold condition for laser oscillation. Optical emission from semiconductors - PN Junction, Spontaneous and stimulated emission and lasing. Heterojunctions, semiconductor injection laser, efficiency, Laser modes, Single mode operations, Injection Laser characteristics. LED structure - surface and edge emitters. LED characteristics - Optical output power, output spectrum, Modulation BW.	10 lectures
Unit IV	Optical detectors-Principles, Direct and Indirect absorption, Group 3 to 5 alloy. Quantum efficiency, p-n-p-n, Avalanche and p-i-n photodiode. Receiver structure-Low and high impedance front end.	8 lectures
Unit V	Optical amplification-Semiconductor Laser and fiber amplifier. Optical TDM, WDM. Transmission link analysis, Point to point links, System considerations, Link power budget, Rise time budget. Fiber attenuation measurements-Opticaltime domainreflecto-meter. Fiber fault location, Dispersion measurements.	8 lectures

Books:

1. Optical Fiber Communication: Principles and Practice, 2nd Ed. John Senior, Prentice Hall of India, New Delhi., 1992.
2. Optical Fiber Communication, 3rd Ed., G. Keiser, McGraw Hill International, New York, 2000.

EC24004	**Wireless Communication: 3 Credits (3-0-0)**	
Unit I	Wireless Communication Systems: evolution of mobile radio communications. Radio communication systems: paging systems, cordless telephone systems, cellular telephone systems; comparison of common wireless communications, generations of cellular mobile communication networks. Radio wave propagation, free space propagation model.	7 lectures

Unit II	Mobile communication: Limitations of conventional mobile system. Cellular communication: introduction, 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.	11 lectures
Unit III	Mobile Radio Propagation: Large Scale Path Loss, Free Space Propagation Model, Reflection, Two-Ray model, Fresnel Zone Geometry, Knife edge Diffraction Model, Scattering. Small Scale Fading: Factors, types of small scale fading, Rayleigh and Ricean Distribution.	12 lectures
Unit IV	Equalization and Diversity: Equalization Fundamentals, Linear and Non Linear Equalizers, Algorithms for Adaptive Equalizers. Diversity techniques: Selection Diversity, Maximal Ratio Combining.	6 lectures
Unit V	Polarization Diversity, Frequency Diversity and Time Diversity. RAKE Receiver.	6 lectures

Books:

1. Wireless Communication Principles and Practice, Theodore S Rapaport, Pearson Education.
2. Wireless Communication, Andrea Goldsmith, Cambridge.

EC24005	**Instrumentation and Process Control: 3 Credits (3-0-0)**	
Unit I	Introduction of Process Control: Steady state system, Process control, Feedback control, Transient response, Proportional control, Integral control, Block diagram, Parts of control system, Laplace Transforms.	6 lectures
Unit II	Response of First Order Systems: Mercury thermometer, Transient response of step functions, Sinusoidal input, Impulse functions. Physical Examples of First Order Systems: Liquid level, Mixing process, RC circuit, linearization. First Order System in Series: Non-interacting system of liquid level, Generalization of several non-interacting systems in series, Interacting systems. Second Order Systems, Development of transfer functions, Damped vibrator, Liquid manometer, Thermometer in thermos- pocket, Step response & impulse response.	9 lectures
Unit III	The Control Systems Block diagram, Negative and positive feedback, Servo problem v/s regulator problems, Process measuring element, Controller, Final control element. Closed Loop Transfer Functions: Overall transfer function for single loop system, change in load, multi loop control system, Controllers and Final Control Elements, Actual v/s Ideal controller, Pneumatic controller mechanism of proportional control, Proportional integral (PI) control, Proportional derivative (PD) control, Proportional integral derivative (PID) control. Control valve, Control valve characteristics.	10 lectures
Unit IV	Transfer functions of P, On-off, PI, PD, and PID control Transfer functions of P, On-off, PI, PD, and PID control, Motivation for addition of integral and derivative modes, Block diagram of chemical reactor control system. Transient Response of Control Systems, Method of Root Locus for stability analysis, Nyquist stability criterion.	9 lectures
Unit V	Frequency Response analysis: Fortunate circumstances, Transportation lag, Bode diagrams, First order system, First order system in series, Graphical rules for Bode diagrams.	8 lectures

Books:

1. Stephanopoulos, G. (1984). "Chemical process control: an introduction to theory and practice", Prentice-Hall, New Delhi.
2. Seborg, D.E., Edgar, T.F. and Mellichamp, D.A. (2003). "Process dynamics and control", Wiley, New York.
3. Smith, C.A. and Corripio, A.B. (1997). "Principles and practice of automatic process control", Wiley, New York.
4. Johnson, C.D. (2006). "Process control instrumentation technology", PHI.

EC24006	Artificial Intelligence and Machine Learning: 3 Credits (3-0-0)	
Unit I	Introduction to artificial intelligence and machine learning, machine learning examples, well defined machine learning problem, decision tree learning, overfitting, random variables and probabilities, python introduction and essentials, Sklearn tool, keras tool.	7 lectures
Unit II	Bayes rule, maximum likelihood estimation, maximum a priori estimation, conditional independence, naïve Bayes: why and how, gaussian naïve Bayes classifiers, document classification, brain image classification, decision trees. Uniformed search, A* search and heuristics, constrained satisfaction problems, Game trees, adversarial search, expectimax and utilities. DFS and BFS, Alpha-Beta pruning, D-separation, elimination of one variable and variable elimination.	10 lectures
Unit III	Markov decision processes. Logistic regression: maximizing conditional likelihood, gradient ascent as a general learning/optimization problem. Generative/discriminative models, minimizing squared error and maximizing data likelihood, regularization, bias-variance decomposition. Learning theory, graphical models, EM and clustering.	10 lectures
Unit IV	Reinforcement learning, markov models, Hidden Markov Models, (HMM) applications of HMMs/speech, sampling, Laplace smoothing. Geometric margins and perceptrons. Kernels, SVM. Partial clustering, hierarchical clustering, learning representations, dimensionality reduction.	8 lectures
Unit V	Neural networks, Deep learning concepts, natural language processing, games, robotic cars, computer vision and robotics.	7 lectures

Books:

1. Artificial Intelligence: A Modern Approach, S. Russell and P. Norvig, Prentice Hall, ISBN0-13-080302-2.
2. Learning From Data, Yaser S. Abu-Mostafa, Malik Magdon-Ismail, Hsuan-Tien-Lin, AMLBook, ISBN-10: 1600490069.
3. Machine Learning, Tom Mitchell, McGraw Hill, ISBN 0070428077.

EC24011	Advanced Digital System Design: 3 Credits (3-0-0)	
Unit I	Revision of basic Digital systems: Combinational Circuits, Sequential Circuits, Timing, Electrical Characteristics., Power Dissipation.	6 lectures
Unit II	VHDL for Synthesis: Introduction, Behavioral, Data flow, Structural Models, Simulation, Cycles, Process, Concurrent Statements, Sequential Statements, Loops, Delay Models, Sequential Circuits, FSM Coding, Library, Packages, Functions, Procedures, Operator Inferencing, Test bench.	9 lectures
Unit III	Digital system Design: Top-down Approach to Design, Case study, Data Path, Control Path, Controller behavior and Design, Case study Mealy and Moore Machines, Timing of sequential circuits, Pipelining, Resource sharing, FSM issues.	10 lectures
Unit IV	Programmable Logic Devices: Introduction, Evolution: PROM, PLA, PAL, Architecture of PAL's, Applications, Programming PLD's, Design Flow, Programmable Interconnections, Complex PLD's (MAX - 7000, APEX), Architecture, Resources, Applications.	9 lectures
Unit V	FPGA's: Introduction, Logic Block Architecture, Routing Architecture, Programmable, Interconnections, Design Flow, Xilinx Virtex-II (Architecture), Boundary Scan, Programming FPGA's, Constraint Editor, Static Timing, Analysis, One hot encoding, Applications, Tools, Case Study, Xilinx Virtex II Pro, Embedded System on Programmable Chip, Hardware-software co-simulation, Bus function models, BFM Simulation, Debugging FPGA Design, Chip scope Pro.	8 lectures

Books:

1. Digital Design: Principles and Practices, Jon F Wakerly, Prentice Hall.
2. VHDL for programmable logic, Kevin Skahil, Addison Wesley.
3. VHD: analysis and modelling of digital systems, ZainalabedinNavabi, Me Graw-Hill.
4. PLD, FPGA data sheet.

EC24012	**Semiconductor Devices Modelling: 3 Credits (3-0-0)**	
Unit I	Energy bands in 3D crystals, Density of States, Fermi-Dirac Statistics, Doping, Equilibrium Statistics, Equilibrium Concentration. Recombination-Generation, Bulk Recombination, Surface Recombination/Generation.	8 lectures
Unit II	Carrier Transport, Hall effect, Drift, Diffusion, Continuity Equation, Numerical Solution of Transport Equation.	8 lectures
Unit III	Electrostatics of P-N Junction Diodes, P-N Diode I-V Characteristics, Fermi Level Differences for Metals and Semiconductors, Schottky Diode I, Schottky Diode II, Non-ideal Effects, ac response, large signal response.	10 lectures
Unit IV	Introduction to Bipolar Junction Transistor, BJT design, Heterojunction BJT.	8 lectures
Unit V	MOSFET Electrostatics, MOS capacitor frequency response, MOSFET IV characteristics, Non-ideal effects in MOSFET, Modern MOSFET. Reliability of MOSFET.	8 lectures

Books:

1. "Advanced Semiconductor Fundamentals", Robert F Pierret, Pearson Education, Volume VI Modular Series on Semiconductor Devices.
2. "Semiconductor Device Fundamentals", Robert F Pierret, Pearson Education, Volume I Modular Series on Semiconductor Devices.
3. "Operation and Modeling of the MOS Transistor", Tsividis, Y, Oxford University Press.
4. Fundamentals of Modern VLSI Devices, Taur and Ning, Cambridge Press, 1999.
5. "Physics of Semiconductor Devices", S. M. Sze and K. K. Ng, 3rd Edition, Wiley-Interscience.
6. Introduction to Solid State Physics, C. Kittle, 7th Edition, Wiley.Compound Semiconductor Device Physics, S S. Tiwari, Academic Press, 1991.

EC24013	**Advanced Computer Architecture: 3 Credits (3-0-0)**	
Unit I	Introduction: review of basic computer architecture, quantitative techniques in computer design, measuring and reporting performance. Evolution of computer architectures, different generations. CISC and RISC processors, Flynn's Classification.	8 lectures
Unit II	CPU Design: ALU organization, Serial and Parallel Adder, implementation of high speed Adder Carry Look Ahead and carry Save Adder; Multiplication of signed binary numbers-Booth's algorithm, Divide algorithms- Restoring and Non-Restoring, Floating point number arithmetic, Hardwired control, Micro-programmed control, practical aspects of circuit implementations.	10 lectures
Unit III	Hierarchical memory technology: Inclusion, Coherence and locality properties. Cache memoryorganizations, Techniques for reducing cache misses, Virtual memory organization, mapping and management techniques, memory replacement policies.	8 lectures
Unit IV	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.	8 lectures
Unit V	Instruction-level parallelism: basic concepts, techniques for increasing ILP, superscalar, super pipelined and VLIW processor architectures, Array and Vector processors.	8 lectures

Books:

1. Computer Organization, Carl Hamacher, ZvonkoVranesic, SafwatZaky, Mc Graw Hill International.
2. Computer Architecture and Organization, J.P. Hayes, Mc Graw Hill International.
3. Advanced Computer Architecture, Kai Hwang, McGraw Hill International.
4. Computer Organization and Architecture, William Stallings, Macmillan Publishing Company.
5. Designing Efficient Algorithms for Parallel Computers, M.J. Quinn, McGraw Hill International.

EC24014	**Nano-electronics: 3 Credits (3-0-0)**	
Unit I	Challenges going to sub-100 nm MOSFETs - Oxide layer thickness, tunnelling, power density, non-uniform dopant concentration, threshold voltage scaling, lithography, hot electron effects, subthreshold current, velocity saturation, interconnect issues, fundamental limits for MOS operation. High-K gate dielectrics, effects of high-K gate dielectrics on MOSFET performance.	8 lectures
Unit II	Novel MOS-based devices – Multiple gate MOSFETs, Silicon-on-nothing, Silicon-on-insulator devices, FD SOI, PD SOI, Fin-FETs, vertical MOSFETs, strained Si devices.	8 lectures
Unit III	Hetero structure-based devices – Type I, II and III Heterojunction, Si-Ge hetero-structure, hetero structures of III-V and II-VI compounds -resonant tunnelling devices, MODFET/HEM.	8 lectures
Unit IV	Carbon nanotubes-based devices – CNFET, characteristics, Spin-based devices – spin FET, characteristics.	8 lectures
Unit V	Quantum structures – quantum wells, quantum wires and quantum dots, Single electron devices – charge quantization, energy quantization, Coulomb blockade, Coulomb staircase, Bloch oscillations.	10 lectures

Books:

1. Nanoelectronics – Principles & devices, Mircea Dragoman and Daniela Dragoman.
2. Nanoelectronics and Nano systems, Karl Goser.
3. Nanoscale Transistors, Device Physics, Modelling and Simulation: Mark Lundstrom and Jing Guo.
4. Physics of Quantum Well Devices, Springer 2002, B.R. Nag.

EC24015	**Low Power VLSI Design: 3 Credits (3-0-0)**	
Unit I	Introduction: Introduction to low power VLSI design - Need for low power - CMOS leakage current - static current - Basic principles of low power design.	6 lectures
Unit II	probabilistic power analysis - random logic signal - probability and frequency - power analysis techniques - signal entropy.	6 lectures
Unit III	Circuit level and logic level design: Circuit - transistor and gate sizing; pin ordering, network restructuring and reorganization, adjustable threshold voltages; logic-signal gating; logic encoding.	10 lectures
Unit IV	Special low power VLSI design techniques: Power reduction in clock networks – CMOS floating node - low power bus - delay balancing, Low power technique for SRAM, Adiabatic computation, Pass transistor.	10 lectures
Unit V	Architecture and System: Power and performance management, Switching activity reduction, Parallel architecture with voltage reduction.	10 lectures

Books:

1. Practical Low Power Digital VLSI Design, Gary Yeap, Springer US, Kluwer Academic Publishers.
2. Low power CMOS VLSI circuit design, Kaushik Roy, Sharat C. Prasad, Wiley.
3. Low Voltage Low Power VLSI Subsystems, Kiat-Seng Yeo, Kaushik Roy, Tata Mc-Graw Hill.
4. Basic VLSI Design, Douglas A. Pucknell, Kamran Eshraghian, 3 rd edition, PHI.
5. Digital Integrated circuits, J. Rabaey, PHI.

EC24016	Advanced Digital Signal Processing: 3 Credits (3-0-0)	
Unit I	Review: Discrete-Time Signals and Systems, Sampling, Z-transform, DFT, Filter design techniques - FIR, IIR.	8 lectures
Unit II	Discrete Hilbert transforms: Real and Imaginary Part, sufficiency of the FT for causal Sequences, Sufficiency Theorems for Finite length Sequences, Relationship between Magnitude and Phase, HT Relation for complex sequences.	8 lectures
Unit III	Cepstrum analysis and Homomorphic Deconvolution: Definition of complex cepstrum Homomorphic Deconvolution, Properties of complex Logarithm, Alternative expression for complex cepstrum, The complex cepstrum of exponential sequences, Realization of the Characteristic system, Examples of Homomorphic Filtering, Application to speech processing.	8 lectures
Unit IV	Multirate DSP: The basic sample rate Alteration device Filters in sampler rate Alteration System, Multistage Design of Decimator and interpolator. The polyphase Decomposition, Arbitrary rate sampler rate converter, Digital filter banks, Nyquist filters, two channel quadrature mirror filter bank, L channel QMF banks, Cosine modulated L channel filter banks, Multilevel filter bank, STFT, Wavelet transform, DCT.	10 lectures
Unit V	Adaptive filters: Introduction, Examples of Adaptive filtering, The minimum mean Square Error Criterion, The windrow LMS algorithm, Recursive Least Square Algorithm, Forward and Backward Lattice method, Gradient adaptive Lattice method.	8 lectures

Books:

1. Digital Signal Processing: A Practical approach, Emmanual C. Ifeachor et. Al., Pearson Education, 2nd edition.
2. Digital Signal Processing, Algorithms and Applications 3rd edition, Proakis and Manolakis, Prentice Hall of India, New Delhi, 1999.
3. Digital Signal Processing, A Computer based Approach, 2nd edition, S.K. Mitra, Tata McGraw Hill, New Delhi, 2001.
4. Theory and Application of Digital Signal Processing., L.R. Rabiner and B. Gold, PHI.
5. Adaptive Filters, Simon Haykin, PHI.

EC24021	Artificial Neural Network and its Applications: 3 Credits (3-0-0)	
Unit I	Introduction: Biological Neuron – Artificial Neural Model – Types of activation functions – Architecture: Feedforward and Feedback, Convex Sets, Convex Hull and Linear Separability, Non-Linear Separable Problem. XOR Problem, Multilayer Networks.	8 lectures
Unit II	Support Vector Machines and Radial Basis Function: Learning from Examples, Statistical Learning Theory, Support Vector Machines, SVM application to Image Classification, Radial Basis Function Regularization theory, Generalized RBF Networks, Learning in RBFNs, RBF application to face recognition.	8 lectures
Unit III	Attractor Neural Networks: Associative Learning Attractor Associative Memory, Linear Associative memory.	8 lectures
Unit IV	Hopfield Network, application of Hopfield Network, Brain State in a Box neural Network, Simulated Annealing, Boltzmann Machine, Bidirectional Associative Memory.	8 lectures
Unit V	Self-organization Feature Map: Maximal Eigenvector Filtering, Extracting Principal Components, Generalized Learning Laws, Vector Quantization, Self-organization Feature Maps, Application of SOM, Growing Neural Gas.	10 lectures

Books:

1. Neural Networks A Classroom Approach, Satish Kumar, McGraw Hill Education (India) Pvt. Ltd, Second Edition.
2. Introduction to Artificial Neural Systems, J.M. Zurada, Jaico Publications.
3. Artificial Neural Networks, B. Yegnanarayana, PHI, New Delhi 1998.

EC24022	Modern Digital Communication Techniques: 3 Credits (3-0-0)	
Unit I	Review of sampling theorem, PAM, PPM, PDM and PCM System, TDM and FDM systems and their comparison. Cross talk andguard times. Practical sampling and aliasing. Baseband digital transmission: digital PAM signals, transmission limitations. Power spectra and digital PAM, spectral shaping by precoding. Signal coding Techniques, PCM Generation andReconstruction, Quantization Noise, Non uniform Quantization and companding. DPCM, DM, ADM and ADPCM; Linear Predictive Coding. Transmission ofbase band signal over Band Limited system - RZ and NRZ format.	10 lectures
Unit II	Matched filter, Error rate due to Noise, ISI, Nyquist criteria for distortionless baseband binary transmission, Optimum Linear Receiver, Adaptive Equalization.	8 lectures
Unit III	Geometric representation of signals - Gram-Schmidt Orthogonalisationprocedure, Vector Noise Channel, Likelihood functions, Maximum Likelihooddecoding, Correlation receiver, Probability of Error, Frame patterns, Bit andFrame synchronization carrier recovery.	8 lectures
Unit IV	Introduction to Information Theory-Definition of information, Self and Mutual information, Entropy and Information rate. Discrete memoryless source andcoding, Discrete channel capacity, Shannon-Hartley equation for channelcapacity, Markov chains. Principles of Error Detection and Correction methods, Channel Coding - Linear Block Codes, Cyclic Codes, Convolution Coding, Automatic request for retransmission systems.	8 lectures
Unit V	Digital CW Modulation-Principles, Block schematics and Comparative Study of ASK, FSK and PSK systems, Introduction to Quadrature Carrier and M-arysystems, Modems and standards, Modern Digital Communication Technologies - ISDN, BISDN, etc. Cellular digital Radio, Spread Spectrum techniques andPersonal communication Networks.	8 lectures

Books:

1. Digital Communications, Simon Haykin, John Wiley and Sons.
2. Digital Communications, Proakis, McGraw Hill.
3. Communication Systems, A. B. Carlson, McGraw Hill.

EC24023	Satellite Communication: 3 Credits (3-0-0)	
Unit I	Orbital mechanics: Orbital perturbations, Azimuth & elevation angle calculations, limits of visibility, eclipse, sun-transit outage, launches and launch vehicle.	8 lectures
Unit II	Spacecraft systems: Attitude and Orbit control system, Telemetry, tracking and command (TT&C), communications subsystems, Transponders, Spacecraft antennas.	8 lectures
Unit III	Earth Segments: Earth station antennas, Amplifiers, Converters, Reliability, Basic transmission theory of satellite link, noise figure and noise temperature, satellite uplink and down link analysis, Propagation on Satellite - Earth Paths and its Influence.	10 lectures
Unit IV	Satellite Access and Applications: Analog telephone transmission, FM theory, FM Detector theory, analog TV transmission.	8 lectures
Unit V	Digital transmission: Base band and band pass transmission of digital data, BPSK, QPSK, PCM, Access techniques: FDMA, TDMA, CDMA, Encoding & FEC for Digital satellite links.	8 lectures

Books:

1. Satellite communication, Timothy Pratt, Charles W. Bostian, John Wiley & sons, Publication, 2003.
2. Digital Satellite Communications, Tri T. Ha, 2nd Edition, Tata McGraw Hill.
3. Satellite Communication, Dennis Roddy, 4th Edition, Mc Graw Hill International, 2006.
4. Satellite Communication Systems Engineering, Wilbur L. Pritchard, Hendri G. Suyderhoud, Robert A. Nelson, Prentice Hall/Pearson, 2007.
5. The Satellite Communication Applications, Bruce R. Elbert, Hand Book, Artech House Bostan London, 1997.

EC24024	Computer Communication and Network: 3 Credits (3-0-0)	
Unit I	Review of data communication techniques, basic networking concepts, layered network and protocol concepts, quality of service, Network structure, protocol Hierarchies, The OSI reference model, Service Primitives, Example Networks: ARPANET, SNA etc.	8 lectures
Unit II	The Physical Layer: Transmission Media, Transmission and Switching, Terminal, The medium Access sub layer, The ALOHA protocols, LAN Protocols, Ethernet, Token bus, Token ring.	8 lectures
Unit III	The Data link layer: Design issues, Error control, Sliding Window Protocols, protocols performance. The Network layer: Design issues, Routing algorithms, congestion control Algorithms, Internet working.	10 lectures
Unit IV	The Transport layer: Design issues, connection management. The Session layer: Design issues, Remote procedure call.	8 lectures
Unit V	The Presentation layer: Design issues, data compression techniques concepts, Introduction to Cryptography. The Application layer: Design issues, File transfer, Access and management, Virtual terminals.	8 lectures

Books:

1. Computer networks, 3rd Ed., A.S Tanenbaum, Prentice Hall of India, New Delhi, 2001.
2. Data communications, Computer Networks, and Open Systems, 4th Ed, Fred Halsall, Addison Wesely Longman, Singapore, 1995.
3. Data and Computer communications, 5th Ed, W. Stallings, Prentice Hall of India, New Delhi, 2001.
4. Forouzen, “Data Communication and Networking”, TMH.

EC24025	Wireless Sensor Networks: 3 Credits (3-0-0)	
Unit I	Introduction: Challenges for wireless sensor networks, Comparison of sensor network with ad hoc network, Single node architecture, Hardware components, Energy consumption of sensor nodes, Network architecture, Sensor network scenarios, Design principles. Physical Layer: Introduction, wireless channel and communication fundamentals, physical layer and transceiver design consideration in wireless sensor networks, Example physical Layers Bluetooth, IEEE 802.11b, WINS, µAMPS.	10 lectures
Unit II	Data Link Layer: MAC protocols –fundamentals of wireless MAC protocols, low duty cycle protocols and wakeup concepts, contention-based protocols, Schedule-based protocols, LEACH, Link Layer protocols, Error control, Framing.	8 lectures
Unit III	Network Layer: Gossiping and agent-based unicast forwarding, Energy-efficient unicast, Broadcast and multicast, geographic routing, mobile nodes, Data centric and content-based networking, Data aggregation.	8 lectures
Unit IV	Applications: Target detection tracking, Habitat monitoring, Military battlefield awareness Environmental disaster monitoring, Underwater Acoustic and Deep space networks, Wireless Body Area Networks (WBAN) for health-monitoring, Open issues and Design challenges.	8 lectures
Unit V	Case Study: Security in Sensor networks, Localization, IEEE 802.15.4 low rate WPAN, Practical implementation issues, Sensor Node Hardware- Node-level software platforms, Node-level simulators.	8 lectures

Books:

1. Protocol and Architecture for Wireless Sensor Networks, Holger Karl, Andreas willig, John wiley publication, Oct 2007.
2. Wireless Sensor Networks: an information processing approach, Feng Zhao, Leonidas Guibas, Elsivierpublication, 2004.
3. Wireless Sensor Networks: Architecture and Protocol, Edgar H Callaway, CRC press, 2003, First Edition.
4. Wireless Sensor Networks, CS Raghavendra Krishna, M Sivalingam and TaribZnati, Springer publication, 2006.

EC24026	Radio Frequency Components and Circuits: 3 Credits (3-0-0)	
Unit I	Transmission lines, Waveguides, Microstrip line, Smith chart.	8 lectures
Unit II	Network analysis using S-matrix, Signal Flow graph, RF components: coupler, divider etc. Resonators.	10 lectures
Unit III	RF Filters: Filter design Transformation, Implementations.	8 lectures
Unit IV	Microwave Amplifier and Oscillators: Two-Port Power Gains, Amplifier Stability, Amplifier Design.	8 lectures
Unit V	Broadband Amplifier Design One Port negative resistance oscillators, Two Ports negative resistance oscillators, Oscillator configurations.	8 lectures

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.

EC24031	Analog Integrated Circuits: 3 Credits (3-0-0)	
Unit I	Basic MOS Device Physics; MOS device models; Single State Amplifier: Common Source Stage; Source Follower; Common Gate Stage; Cascode Stage.	8 lectures
Unit II	Differential Amplifier: Basic Differential Pair; Common-Mode Response; Differential Pair with MOS Loads; Gilbert Cell; Passive and Active Current Mirrors: Cascode Current Mirrors; Current sink and current source design, Active Current Mirror; Signal Analysis; Frequency Response of Amplifier.	10 lectures
Unit III	Operational Amplifier: Single-stage and Two stage OTA and Op-amp; Stability and Frequency Compensation; Voltage and Current references, Bandgap References; Introduction to Switched-Capacitor Circuits; Nonlinear and Mismatch.	8 lectures
Unit IV	Noise: Statistical Characteristics of Noise; Types of Noise; Thermal and Flicker noise in CMOS, Representation of Noise in Circuits; Noise in Single-stage Amplifier. Noise analysis of Current Mirror load OTA.	8 lectures
Unit V	Oscillators: Ring, LC, VCO. Phase-Lock Loop: Charge-Pump PLL, Non-ideal effect in PLL; Delay Locked Loops. Short-Channel effects and Device Models.	8 lectures

Books:

1. Design of Analog CMOS Integrated Circuits, B. Razavi, McGraw-Hill Science.
2. Analysis and Design of Analog Integrated Circuits, P. Gray, P.Hurst, S.Lewis, and R.Meyer, 5th Edition, Wiley.
3. Analog Integrated Circuit Design, T. Carusone, D. Johns and K. Martin, 4th Edition, Wiley.
4. CMOS Analog Circuit Design, Phillip E. Allen, Douglas R. Holberg, Oxford.
5. Design of CMOS Operational Amplifiers, Rasoul Dehghani, Artech House, Norwood, 2013.

EC24032	Digital Integrated Circuits: 3 Credits (3-0-0)	
Unit I	Challenges in Digital IC Design, MOS device model with Sub-micron effects, VTC parameters DC characteristics.	8 lectures
Unit II	CMOS INVERTER: CMOS Propagation Delay, Parasitic Capacitance Estimation, Layout of an Inverter, Supply and Threshold Voltage Scaling, Components of Energy and Power Switching, Short-Circuit and Leakage Components SPICE Simulation Techniques.	8 lectures
Unit III	COMBINATIONAL LOGIC: Pass Transistor/ Transmission Gate Logic DCVSL, Introduction to Dynamic Logic, Dynamic Logic Design Considerations Power Dissipation in CMOS, Leakage Power Dissipation, Logical Effort Sizing – Performance Optimization of Digital Circuits ARITHMETIC STRUCTURES: Adders, Multipliers, Shifters, Design Methodology, Layout Techniques and Mapping.	10 lectures

Unit IV	SEQUENTIAL CIRCUIT: Classification/ Parameters Static Latches and Register, Race Condition, Dynamic Latches and Registers, Two Phase vs. Single Phase, Pulse Based Registers, Latch vs. Register Systems, Metastability.	8 lectures
Unit V	INTERCONNECT: Capacitance Estimation, Buffer Chains, Low Swing Drivers, Power Distribution, Issues in Timing - Impact of Clock Skew and Jitter CLOCK DISTRIBUTION: Origins of Clock Skew/ Jitter and Impact on Performance, Clock Distribution Techniques, Self-timed Circuits.	8 lectures

Books:

1. Digital Integrated Circuits - A Design Perspective, Jan M Rabaey, Prentice Hall.
2. CMOS Digital Integrated Circuits - Analysis & Design, Sung-Mo Kang & Yusuf Leblebici, Mc Graw Hill.
3. CMOS Dircuit Design, Layout, and Simulation, R.J. Baker, H.W. Li, and D.E. Boyce, Wiley-IEEE Press, 2007.
4. Analysis and Design of Digital Integrated Circuits, David A. Hodges, Horace G. Jackson, and Resve A. Saleh, Mc Graw-Hill.

EC24033	**Computer Aided Design of VLSI Circuits: 3 Credits (3-0-0)**	
Unit I	Introduction to VLSI Methodologies - VLSI Physical Design Automation - Design and Fabrication of VLSI Devices - Fabrication process and its impact on Physical Design.	8 lectures
Unit II	A Quick Tour of VLSI Design Automation Tools - Data structures and Basic Alogrithms– Algorithmic Graph theory and computational complexity - Tractable and Intractable problems.	8 lectures
Unit III	General purpose methods for combinational optimization, partitioning, floor planning and pin assignment, placement and routing.	8 lectures
Unit IV	Simulation: Gate-level modelling and simulation; Switch-level modeling and simulation, Combinational Logic Synthesis: Binary Decision Diagrams, Two Level Logic Synthesis.	8 lectures
Unit V	Physical Design Automation of FPGAs, MCMS, High level Synthesis: Hardware models, Internal representation, Allocation, assignment and scheduling, Simple scheduling algorithm, Assignment problem, High level transformations.	10 lectures

Books:

1. Algorithms for VLSI Design Automation, S.H. Gerez, John Wiley & Sons, 2002.
2. Algorithms for VLSI Physical Design Automation, N.A. Sherwani, Kluwer Academic Publishers, 2002.
3. VLSI Physical Design automation: Theory and Practice, Sadiq M. Sait, Habib Youssef, Worldscientific, 1999.
4. Computer Aids for VLSI Design, Steven M. Rubin, Addison Wesley Publishing 1987.

EC24034	**VLSI Digital Signal Processing Systems: 3 Credits (3-0-0)**	
Unit I	Algorithms for fast convolution, Algorithmic strength reduction in filters and transforms: Parallel FIR Filters, DCT and inverse DCT, Parallel Architectures for Rank-Order Filters.	8 lectures
Unit II	Scaling and Round off Noise – State variable description of digital filters, Scaling and Round off Noise computation, round off Noise in Pipelined IIR Filters, Round off Noise Computation using state variable description, Slow-down, Retiming and Pipelining.	8 lectures
Unit III	Bit level arithmetic Architectures – parallel multipliers, interleaved floor-plan and bit-plane-based digital filters, Bit serial multipliers, Bit serial filter design and implementation, Canonic signed digit arithmetic, Distributed arithmetic.	9 lectures
Unit IV	Redundant arithmetic-Redundant number representations carry free radix-2 addition and subtraction, Hybrid radix-4 addition, radix-2 hybrid redundant multiplication architectures, data format conversion, Redundant to Non-redundant converter.	9 lectures
Unit V	Numerical Strength Reduction – Subexpression Multiplication, Subexpression Sharing in Digital Filters, Additive and Multiplicative Number Splitting.	8 lectures

Books:

1. "VLSI Digital Signal Processing Systems", K.K. Parhi, John-Wiley.
2. Digital Signal Processing with FPGAs, U. Meyer-Baese, Springer.
3. Digital signal processing in VLSI, Richard J. Higgins.
4. VLSI Design Methodologies for Digital Signal Processing, Magdy A. Bayoumi.
5. VLSI and modern signal processing, Sun Yuan Kung, Harper J. Whitehouse.

EC24035	**CMOS Mixed Signal Circuits: 3 Credits (3-0-0)**	
Unit I	Analog and discrete-time signal processing, introduction to sampling theory; S.N.R. derivation, Analog continuous-time RC-filters: State variable biquadratic filters, Basics of analog discrete-time filters and Z-transforms.	8 lectures
Unit II	Switched-capacitor (SC) filters - Nonidealities in switched-capacitor filters; Stray-capacitance insensitive SC-networks, Switched-capacitor filter architectures; Switched-capacitor filter applications.	8 lectures
Unit III	Basics of Data Converters; Nyquist rate converters, Successive approximation ADCs, Dual slope ADCs, Flash ADCs, Pipeline ADCs, Hybrid ADC structures, High-resolution ADCs, DACs, Charge scaling DACs, Pipeline DACs.	9 lectures
Unit IV	Mixed-signal layout, Oversampling Converters: O.S.R., Zeroth and multiple-order Noise shaping modulators, Decimating filters and interpolating filters, Higher order modulators, Delta sigma modulators with multi-bit quantizers, Delta sigma D/A converter.	9 lectures
Unit V	Introduction to frequency synthesizers and synchronization; Basics of PLL, Analog PLLs; Digital PLLs; DLLs.	8 lectures

Books:

1. CMOS mixed-signal circuit design, R. Jacob Baker, Wiley India, IEEE press, reprint 2008.
2. Design of analog CMOS integrated circuits, Behzad Razavi, McGraw-Hill, 2003.
3. CMOS circuit design, layout and simulation, R. Jacob Baker Revised second edition, IEEE press, 2008.
4. CMOS Integrated ADCs and DACs, Rudy V. dePlassche, Springer, Indian edition, 2005.
5. Electronic Filter Design Handbook, Arthur B. Williams, McGraw-Hill, 1981.
6. Design of analog filters by, R. Schauman, Prentice-Hall, 1990 (or newer additions).
7. An introduction to mixed-signal IC test and measurement, M. Burns et al., Oxford university press, first Indian edition, 2008.

EC24036	**VLSI Implementation of DSP Structures: 3 Credits (3-0-0)**	
Unit I	An overview of DSP concepts, Representations of DSP algorithms. Loop bound and iteration bound.	8 lectures
Unit II	Transformation Techniques: Retiming, Folding and Unfolding.	8 lectures
Unit III	Pipelining of FIR filters. Parallel processing of FIR filters. Pipelining and parallel processing for low power, Combining Pipelining and Parallel Processing. Systolic Architecture Design.	10 lectures
Unit IV	Pipeline interleaving in digital filters. Pipelining and parallel processing for IIR filters. Low power IIR filter design using pipelining and parallel processing, Pipelined adaptive digital filters.	8 lectures
Unit V	Synchronous pipelining and clocking styles, clock skew and clock distribution in bit level pipelined VLSI designs. Wave pipelining, constraint space diagram and degree of wave pipelining, Implementation of wave- pipelined systems, Asynchronous pipelining.	8 lectures

Books:

1. "VLSI Digital Signal Processing Systems", K. K. Parhi, John-Wiley.
2. "Digital Signal Processing with FPGAs", U. Meyer-Baese, Springer.
3. "VLSI Signal Processing", W. Burleson, K. Konstantinides, T.H. Meng.
4. "Digital signal processing in VLSI", R.J. Higgins.
5. "VLSI and modern signal processing", S.Y. Kung, H.J. Whitehouse.

EC24037	System and Data Security: 3 Credits (3-0-0)	
Unit I	Introduction and security trends. General security concepts and introduction to what is an "infosphere". Inside the security mind. Operational security and people's role in information security.	7 lectures
Unit II	Cryptography, internet standards and physical security. Network security and infrastructure. Authentication and wireless. Intrusion Detection Systems and Security Baselines. Attacks and E-mail. Web security and software security. Disaster planning and risk management. Change and privilege management.	8 lectures
Unit III	Information security for client devices. Integrity of data, hash function, digital signature, public key certificate and public key infrastructure, denial-of-service, traceback, DoS defence, network monitoring, fundamental NIDS issues, evaluating detectors, the threat of worms, worm detection/defence, scanning, inferring activity, forensics.	11 lectures
Unit IV	Securing protocols, authentication, identity, anonymity, censorship, surveillance, legality and ethics, architecture, botnets, spam, cybercrime. Memory safety, privilege separation, capabilities, sandboxing.	8 lectures
Unit V	Security problems with TCP/IP, Kerberos, SUNDR, CryptDB, Merkle trees, Bitcoin, secure messaging, differential privacy introduction.	8 lectures

Books:

1. Security Engineering, Ross Anderson, John Wiley & Sons, 2001.
2. Introduction to Modern Cryptography, Jonathan Katz and Yehuda Lindell, CRC Press, 2007.
3. Cryptography Engineering, Niels Ferguson, Bruce Schneier, and Tadayoshi Kohno, Wiley, 2010.
4. Information Security: Principles and Practice, Mark Stamp, John Wiley & Sons, 2006.
5. Applied Cryptography, Bruce Schneier, 2nd Edition, John Wiley & Sons, 1996.
6. Network Security: Private Communication in a Public World, Charlie Kaufman, Radia Perlman, Mike Speciner, 2nd Edition, Prentice Hall, 2002.

EC24038	Data Analytics: 3 Credits (3-0-0)	
Unit I	Elements, variables, and data categorization. Levels of measurement, data management and indexing. Introduction to statistical learning and R-programming.	8 lectures
Unit II	Measures of central tendency, measures of location of dispersions, practice and analysis with R.	8 lectures
Unit III	Basic analysis techniques, statistical hypothesis generation and testing, Chi-square test, t-test, analysis of variance, correlation analysis, maximum likelihood test, practice and analysis with R.	10 lectures
Unit IV	Regression analysis, classification techniques, clustering, association rules analysis, practice and analysis with R.	8 lectures
Unit V	Understanding business scenarios, feature engineering and visualization, scalable and parallel computing with Hadoop and Map-Reduce, sensitivity analysis.	8 lectures

Books:

1. The Elements of Statistical Learning, Data Mining, Inference, and Prediction (2nd Ed.), Trevor Hastie, Robert Tibshirani, Jerome Friedman, Springer, 2014.
2. An Introduction to Statistical Learning with Applications in R, G James, D. Witten, T. Hastie, and R. Tibshirani, Springer, 2013.

EC23121	Signals and Systems: 3 Credits (2-1-0)	
Unit I	Continuous and discrete time signals: Classification of Signals, Transformation of independent variable of signals, Basic continuous-time and discrete-time signals. Energy and power signals. Unit Impulse, Unit Step Functions and Ramp Function. Periodic and aperiodic signals, Orthogonal signal.	6 lectures

Unit II	Basic system properties: Analysis of Continuous-time and Discrete-time LTI Systems and their properties. Linear constant co-efficient differential equations and difference equations.	5 lectures
Unit III	Fourier-series and Fourier Transform representation of Continuous-time Signals and their properties. Discrete-Time Fourier-series and Discrete-Time Fourier Transform representation of discrete-time Signals and their properties.	5 lectures
Unit IV	Laplace Transform and its properties. Unilateral Laplace Transform. Analysis of LTI systems using Laplace-transform. Z-transform and its properties. Unilateral Z-transform. Analysis of LTI systems using Z-transform.	7 lectures
Unit V	State-space analysis and multi-input, multi-output representation. The state-transition matrix and its role. The Sampling Theorem and its implications-Spectra of sampled signals. Reconstruction: ideal interpolator, zero-order hold, first-order hold. Aliasing and its effects. Relation between continuous and discrete time systems.	5 lectures

Books:

1. Signals & Systems, Alan V. Oppenheim, Alan S. Willsky, S.Hamid Nawab, 2nd Ed., Pearson Education, 2013.
2. Signals and Systems, S. Haykin and B. Van Veen, 2nd Ed., Wiley, 2007.
3. Principles of Linear Systems and Signals, B.P. Lathi, 2nd Ed., Oxford, 2009.
4. Signal Processing and Linear Systems, B.P. Lathi, Oxford University Press.
5. Introduction to Signals and Systems, Douglas K. Lindner, McGraw Hill.

EC24041	**Electronic Circuits and Devices: 3 Credits (3-0-0)**	
Unit I	Operational Amplifier: Introduction to op-amp, offset voltage/currents, CMRR, Feedback amplifier, Linear and Nonlinear application, active filters, performance comparison of typical op-amp (741C, LM411, LM118, LM108, QD611).	8 lectures
Unit II	Regulated Power Supply: Regulated power supply design, capacitive (CRC) filterbased power supply, Linear series regulators, single op-amp regulator, three terminal regulators, adjustable power supply.	8 lectures
Unit III	Linear ICs such as LM78XX, LM79XX, LM317, LM 337, Switched capacitor conversion (LM-7660). Switching power supply, Basic principles, Buck regulator, and Boost regulator.	8 lectures
Unit IV	Tuned Amplifiers: Single tuned circuit, FET and BJT amplifier, FET tuned amplifier, tuned transistor amplifier with tuned load, narrow band approximation and tuning (Synchronous and Stagger), cascade tuned IF amplifier, Design of tuned amplifier, oscillator possibility and sensitivity. Oscillators: Wein bridge, phase shift, twin T and crystal oscillators.	10 lectures
Unit V	Power Switches and ICs: Introductory idea and use of SCR, Diac, Triac and UJT circuits. Integrated Circuits: Introduction to IC, familiarization with popular IC NE/SE-555, 7400 7402, 7406, Audio and Video amplifiers.	8 lectures

Books:

1. Basic Electronics and Linear Circuits, 6th Ed., N.N. Bhargav, D.C. Kulshreshta, S.C. Gupta, Tata McGraw Hill, New Delhi, 2001.
2. Electronics Principles, 6th Ed., A.P. Malvino, Tata McGraw Hill, New Delhi, 1999.
3. Micro Electronics, 2nd Ed., J. Millman, Arvin Grabel, Tata McGraw Hill, New Delhi,1999.
4. Integrated Electronics, J. Millman, C.C. Halkias, Tata McGraw Hill, New Delhi, 1999.

EC24042	**Instrumentation and Measurements: 3 Credits (3-0-0)**	
Unit I	Generalized Measurement system: Accuracy, Precision, Fidelity, speed of response, static & dynamic performance characteristics, dynamic- step response, ramp response of first order instrument. Classifications of errors, error analysis of measurement.	10 lectures
Unit II	Introduction to DC and AC bridges for measurement of voltage / current / resistance /capacitance and inductance.	8 lectures

Unit III	Principle and working of voltmeter, ammeter and ohmmeter, Introduction to DVM, Electronic multimeter. Cathode Ray Oscilloscope- Introduction, cathode ray tube, electron gun.	7 lectures
Unit IV	Deflection plates, basic CRO circuit, Lissajous pattern. Digital multimeter, Signal generator and Function generator using multi op-amp and crystal.	7 lectures
Unit V	Definition of transducer, classification, resistive, capacitive, inductive, magnetic, optical, piezoelectric, pneumatic.	10 lectures

Books:

1. Principles of Electronics instrumentation and measurements, Berlyn and Getz, McMillan Pub. Co.
2. A Course in Electrical Electronics Measurements and instrumentation. A.K.Sawhney, Dhanpat Roy & Co.
3. Modern Electronics Instrumentation and Measurement Techniques, Albert D. Heltrick, W. D. Cooper, PHI.
4. Murthy DVS – Transducers & Instrumentation, PHI, ND, 1995.
5. Elements of Electronic Instrumentation and Measurement, Joseph J. Carr, Pearson Education.
6. PC-Based Instrumentation Concept and Practice, N. Mathivanan, PHI.

EC24043	**Electronic Engineering Materials: 3 Credits (3-0-0)**	
Unit I	Electronic Engineering Materials: Conducting materials – Effect of temperature on resistivity of different conducting materials, Metal and alloys for fuses, Properties and specifications of wire, cable and antenna material. Semiconducting materials – Element and compound semiconductors and their properties, Carrier concentration in semiconductors, Variation of fermi level and carrier concentration with temperature, Hall effect.	10 lectures
Unit II	Magnetic materials – Different types of magnetic materials and their properties, Diamagnetism, Paramagnetism, ferromagnetism, anti ferromagnetism and ferrimagnetism.	6 lectures
Unit III	Hard and Soft magnetic materials, Magnetic materials used at high frequencies. Frequency dependence of dielectric constant; Ferroelectricity and Piezoelectricity in materials.	6 lectures
Unit IV	Optical properties of materials: metals, insulators and semiconductors, Phosphorescence and fluorescence, Different phosphors used in CRO screens, Liquid crystal as display, materials for LEDs, Photoconductivity and photo conducting materials. Light interaction with solids; Absorption, Transmission and Reflection; Luminescence; Photoconductivity; Lasers.	10 lectures
Unit V	Insulating materials – Atomic interpretation of dielectric material of mono atomic gases and poly atomic molecules, general feature of static dielectric constant of solids, piezo electricity and piezoelectric materials, Dielectric properties in alternating fields: Frequency dependence of electronic and ionic polarizability, complex dielectric constant, dielectric relaxation and losses, temperature dependence, superconductors.	10 lectures

Books:

1. Electronics Engineering Materials and Devices, John Allyson, 1st Ed., Tata McGraw Hills, 1973.
2. Introduction to Materials Science for Engineers, James Shakelfolk, 6th Ed., Macmillan Publishing Co., 2007.
3. Materials Science and Engineering, V. Raghavan, 2nd Ed., Prentice Hall of India, 2015.
4. Electrical Engineering Materials, A.J. Dekker, 3rd Ed., Prentice Hall of India, New Delhi, 2007.

DEPARTMENT OF ELECTRICAL ENGINEERING

Year I Semester I						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	PH21105	Introduction to Electromagnetic Theory	4	0	2	05
2.	MA21101	Mathematics – I	3	1	0	04
3.	ES21100	Basic Electrical Engineering	3	1	2	05
4.	ES21151	Engineering Graphics and Design	0	0	6	03
5.	FR21121	Biology for Engineers	2	1	0	03
Total						**20**

Year I Semester II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	CY21201	Engineering Chemistry – A	3	1	2	5
2.	MA21201	Mathematics – II	3	1	0	4
3.	ES21200	Programming for Problem Solving	3	0	2	4
4.	ES21251	Workshop Practices	0	0	6	3
5.	HS21201	Communication Skills	2	0	2	3
6.	ES21277	Environmental Science (Audit)	2	0	0	0
Total						**19**

Year II Semester III						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	MA22101	Mathematics – III	3	1	0	4
2.	ES22100	Engineering Mechanics	3	1	0	4
3.	ES22101	Basic Electronics Engineering	3	0	2	4
4.	EE22101	Analog Electronic Circuits	3	0	2	4
5.	EE22102	Electrical Circuit Analysis	3	1	0	4
6.	EE22103	Electrical Machines – I	3	0	2	4
Total						**24**

Year II Semester IV						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	EE22201	Microprocessors and its Applications	3	0	2	4
2.	EE22202	Power Systems – I	3	0	2	4
3.	EE22203	Electrical Machines – II	3	0	2	4
4.	EE22204	Power Electronics	3	0	2	4
5.	HS22201	Entrepreneurship and Startups	3	0	0	3
6.	HS22277	Indian Constitution (Audit)	2	0	0	0
Total						**19**

Year III Semester V						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	EE23101	Digital Electronics	3	0	2	4
2.	EE23102	Control Systems	3	0	2	4
3.	EE23103	Electromagnetic Fields	3	1	0	4
4.	EE23104	Power Systems – II	3	0	2	4
5.	EE23105	Signals and Systems	2	1	0	3
6.	HS23101	Principles of Economics	3	0	0	3
7.	HS23177	Essence of Indian Knowledge and Tradition (Audit)	2	0	0	0
8.	EE23166	Study Tour (Audit)	0	0	0	0
Total						**22**

Year III Semester VI						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS23201	Organizational Behavior	3	0	0	3
2.	EE23201	Switchgear and Protection	3	0	2	4
3	EE23202	Electrical Measurements and Instrumentation	3	0	2	4
4.	EE230**	Programme Elective – I	3	0	0	3
5.	EE230**	Programme Elective – II	3	0	0	3
6.	MO230**	Open Elective – I (from MOOC)	3	0	0	3
7.	EE23289	Seminar	0	0	2	1
Total						**21**

Year IV Semester VII						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	EE24101	Modern Control Engineering	3	0	0	3
2.	EE240**	Programme Elective – III	3	0	0	3
3.	EE240**	Programme Elective – IV	3	0	0	3
4.	**240**	Open Elective – II	*	*	*	3
5.	EE24199	Project – I	0	0	6	3
6.	EE24179	Industrial Training	0	0	0	3
Total						**18**

Year IV Semester VIII						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	EE240**	Programme Elective – V	3	0	0	3
2.	EE240**	Programme Elective – VI	3	0	0	3
3.	MO240**	Open Elective – III (from MOOC)	3	0	0	3
4.	**240**	Open Elective – IV	*	*	*	3
5.	EE24299	Project – II	0	0	12	6
6.	EE24288	Extra-curricular Activities and Discipline	0	0	0	2
Total						**20**

List of Electives

Programme Electives – I & II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	EE23001	Advanced Power Electronics	3	0	0	3
2.	EE23002	Electrical Energy Management	3	0	0	3
3.	EE23003	Power System Stability	3	0	0	3
4.	EE23004	Computer Aided Design of Electrical Machines	3	0	0	3
5.	EE23005	Power System Economics	3	0	0	3
6.	EE23006	Extra HVDC/HVAC Transmission	3	0	0	3
7.	EE23007	Optimization Techniques and Engineering	3	0	0	3
8.	EE23008	Computer Application in Power Systems	3	0	0	3
9.	EE23009	Flexible AC Transmission Systems	3	0	0	3

Programme Electives – III & IV						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	EE24001	High Voltage Engineering	3	0	0	3
2.	EE24002	Advanced Artificial Intelligence	3	0	0	3
3.	EE24003	Distributed Generations	3	0	0	3
4.	EE24004	Advanced Microprocessors and its Applications	3	0	0	3
5.	EE24005	Power System Instrumentation and Control	3	0	0	3
6.	EE24006	Special Electromechanical Systems	3	0	0	3
7.	EE24007	Power Electronics based Industrial Drives	3	0	0	3
8.	EE24008	Bio-Medical Instrumentation	3	0	0	3
9.	EE24009	Safety and Reliability Engineering	3	0	0	3
10.	EE24010	Network Synthesis	3	0	0	3

Programme Electives – V & VI						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	EE24021	Time Series Analysis and Forecasting	3	0	0	3
2.	EE24022	Power System Reliability	3	0	0	3
3.	EE24023	CMOS VLSI Design	3	0	0	3
4.	EE24024	Microprocessor based Industrial Drives	3	0	0	3
5.	EE24025	Arduino Programing	3	0	0	3
6.	EE24026	Electric Vehicles	3	0	0	3
7.	EE24027	Energy Systems	3	0	0	3
8.	EE24028	Electrical Power Utilization and Illumination Engineering	3	0	0	3

Open Elective – II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	EE24041	Renewable Energy and Applications	3	0	0	3

Open Elective – IV						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	EE24042	Introduction to Nano-Biotechnology	3	0	0	3

Course Content

ES21100	Basic Electrical Engineering: 5 Credits (3-1-2)	
Unit I	DC Circuits: Electrical circuit elements (R, L and C), voltage and current sources, Kirchhoff's current and voltage laws, analysis of simple circuits with dc excitation. Nodal and Mesh Analysis, Superposition, Thevenin's and Norton's theorem. Time-domain analysis of first-order R-L and R-C circuits.	10 lectures
Unit II	AC Circuits: Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), resonance. Three-phase balanced circuits, voltage and current relations in star and delta connections.	10 lectures
Unit III	Transformers: Magnetic materials, BH characteristics, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency. Auto-transformer and three-phase transformer connections.	7 lectures
Unit IV	Electrical Machines: Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, Significance of torque-slip characteristic. Loss components and efficiency, starting and speed control of induction motor. Single-phase induction motor. Construction, working, torque-speed characteristic and speed control of DC motors. Construction and working of synchronous generators.	8 lectures
Unit V	Introduction to Semi-Conductor Devices and its Applications.	7 lectures

Books:

1. Basics of Electrical Engineering, by Fitzgerald, TMH.
2. A Text Book of Electrical Technology, by Theraja & Theraja.
3. Electrical Machines by S. K. Bhattacharya

EE22101	Analog Electronic Circuits: 4 Credits (3-0-2)	
Unit I	Diode Circuits: P-N junction diode, I-V characteristics of a diode, review of half-wave and full-wave rectifiers, Zener diodes, clamping and clipping circuits. BJT Circuits: Structure and I-V characteristics of a BJT; BJT as a switch. BJT as an amplifier: small-signal model, biasing circuits, current mirror, common-emitter, common-base and common-collector amplifiers; Small signal equivalent circuits, high-frequency equivalent circuits.	10 lectures
Unit II	MOSFET Circuits: MOSFET structure and I-V characteristics. MOSFET as a switch. MOSFET as an amplifier: small-signal model and biasing circuits, common-source, common-gate and common-drain amplifiers; small signal equivalent circuits - gain, input and output impedances, trans-conductance, high frequency equivalent circuit.	9 lectures
Unit III	Differential, Multi-Stage and Operational Amplifiers: Differential amplifier; power amplifier; direct coupled multi-stage amplifier; internal structure of an operational amplifier, ideal op-amp, non-idealities in an op-amp (Output offset voltage, input bias current, input offset current, slew rate, gain bandwidth product).	8 lectures
Unit IV	Linear Applications of Op-Amp: Idealized analysis of op-amp circuits. Inverting and non-inverting amplifier, differential amplifier, instrumentation amplifier, integrator, active filter, P, PI and PID controllers and lead/lag compensator using an op-amp, voltage regulator, oscillators (Wein bridge and phase shift), Analog to Digital Conversion.	8 lectures
Unit V	Nonlinear Applications of Op-Amp: Hysteretic Comparator, Zero Crossing Detector, Square-wave and triangular-wave generators. Precision rectifier, peak detector. Monoshot.	7 lectures

Books:

1. A. S. Sedra and K. C. Smith, “Microelectronic Circuits”, New York, Oxford University Press, 1998.
2. J. V. Wait, L. P. Huelsman and G.A. Korn, “Introduction to Operational Amplifier theory and applications”, McGraw Hill U. S., 1992.
3. J. Millman and A. Grabel, “Microelectronics”, McGraw Hill Education, 1988.
4. P. Horowitz and W. Hill, “The Art of Electronics”, Cambridge University Press, 1989.
5. P.R. Gray, R.G. Meyer and S. Lewis, “Analysis and Design of Analog Integrated Circuits”, John Wiley & Sons, 2001.

EE22102	**Electrical Circuit Analysis: 4 Credits (3-1-0)**	
Unit I	Network Theorems: Basic concepts & Circuit Elements, Node and Mesh Analysis, Superposition, Thevenin’s, Norton’s, Maximum power transfer, Reciprocity, and Compensation theorems.	10 lectures
Unit II	First and Second Order Networks: Solution of first and second order differential equations for Series and parallel R-L, R-C, R-L-C circuits, initial and final conditions in network elements, forced and free response, time constants, steady state and transient state response.	8 lectures
Unit III	Sinusoidal Steady State Analysis: Representation of sine function as rotating phasor, phasor diagrams, impedances and admittances, AC circuit analysis, effective or RMS values, average power and complex power. Three-phase circuits. Mutual coupled circuits, Dot Convention in coupled circuits, Ideal Transformer.	8 lectures
Unit IV	Circuit Analysis using Laplace Transforms: Review of Laplace Transform, Analysis of electrical circuits using Laplace Transform for standard inputs, convolution integral, inverse Laplace transform, transformed network with initial conditions. Transfer function representation. Poles and Zeros. Frequency response (magnitude and phase plots), series and parallel resonances.	8 lectures
Unit V	Network Functions and Network Parameters: Two Port Networks, terminal pairs, relationship of two port variables, impedance parameters, admittance parameters, transmission parameters and hybrid parameters, interconnections of two port networks.	8 lectures

Books:

1. M. E. Van Valkenburg, “Network Analysis”, Prentice Hall, 2006.
2. D. Roy Choudhury, “Networks and Systems”, New Age International Publications, 1998.
3. W. H. Hayt and J. E. Kemmerly, “Engineering Circuit Analysis”, McGraw Hill Education, 2013.
4. C. K. Alexander and M. N. O. Sadiku, “Electric Circuits”, McGraw Hill Education, 2004.
5. K. V. V. Murthy and M. S. Kamath, “Basic Circuit Analysis”, Jaico Publishers, 1999.

EE22103	**Electrical Machines – I: 4 Credits (3-0-2)**	
Unit I	Magnetic Fields and Magnetic Circuits: Concepts of magnetic circuits: magnetic materials, types of magnetic materials, properties of magnetic materials, permeability, relative permeability and magnetization curves, Magneto-motive force, magnetic field, flux density, reluctance, flux linkage, inductance, magnetic field intensity, B-H curve and hysteresis loop of magnetic materials, hysteresis losses energy stored in the magnetic circuit, analogies between electric and magnetic circuits.	6 lectures
Unit II	Electromechanical Energy conversions: Elementary concepts of electrical machines, classifications, its common feature, basic principle of generator and motor, torque due to non-alignment of two magnetic fields, elementary two-pole motor, electromechanically induced EMF in magnetic field (generator action), speed voltage and BLV rule, elementary two-pole generator, magnetic force and torque in magnetic systems, magnitude of mechanical force exerted on current carrying conductor situated in magnetic fields (BIL rule) and interaction of magnetic fields (Motor action), eddy current and eddy current losses.	9 lectures

Unit III	Basic Concept of DC Machines: Constructional features of DC machines, working principle of DC machines as a generator and a motor. Types of DC machines, EMF equation of DC Generator, building up of an EMF, relation between induced EMF and the terminal voltage enumerating the brush drop, concept of armature reaction, inter poles, Back EMF and its significance. Magnetic field produced by the field winding excitation with armature winding open, air gap flux density distribution, flux per pole, induced EMF in an armature coil. Armature winding and commutation - Elementary armature coil and commutator, Lap and wave windings, commutator.	8 lectures
Unit IV	DC Machines – DC Generator and DC motors: Armature circuit equation for motoring and generation, Types of field excitations – separately excited, shunt and series. Open circuit characteristic of separately excited DC generator, back EMF with armature reaction, voltage build-up in a shunt generator, critical field resistance and critical speed. Types of DC motors, V-I characteristics and torque-speed characteristics of separately excited, shunt and series motors. Methods of Speed control DC motors, starting of DC motor and DC motor starters.	7 lectures
Unit V	Transformers: Introduction to transformers, constructional details and Principle of single phase transformer, emf equations, phasor diagrams equivalent circuit, phasor diagrams, equivalent circuit diagram, losses, efficiency and condition for maximum efficiency, rating of transformer, voltage regulation, open circuit test and short circuit tests, polarity test, Three-phase transformer-construction, types of connection and their comparative features and Parallel operation of single-phase transformers, three-phase transformers, phase sequence and Parallel operation of three-phase transformers, different parts three phase transformer and their functions, Autotransformers and instruments transformer.	12 lectures

Books:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education, 2013.
2. A. E. Clayton and N. N. Hancock, "Performance and design of DC machines", CBS Publishers, 2004.
3. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
4. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
5. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.
6. Charles I. Hubert, "Electric Machines-Theory, Operation, adjustment and control", Pearson.

EE22201	**Microprocessors and its Applications: 4 Credits (3-0-2)**	
Unit I	Review of Basic Computer Organization: Basic computer organization, evolution of computers and microprocessors, concepts on bus organization, memory organization. Concept of microcomputer, microprocessor, microcontroller.	4 lectures
Unit II	Architecture of Intel 8085 Microprocessor: Description of Architecture and pin out diagram of Intel 8085A, de-multiplexing of buses, control signals and flags, Instruction sets of Intel 8085A, classification, format and addressing modes of instructions. Instruction cycle, machine cycle, timing diagram.	10 lectures
Unit III	Programming in 8085: Description of instructions for Data transfer, Arithmetic, logic and branch operations, Rotate and Compare operations, stack operations, Assembly language program for addition, subtraction, multiplication, division for decimal and hexadecimal one byte and multi-byte numbers, one's and two's complement, largest and smallest among the data array, Block of data moving, looping, counting and time delay subroutines.	9 lectures
Unit IV	Interrupts of Intel 8085: Software and hardware interrupts and their working mechanisms, Concept of vectored interrupts, maskable and non-maskable interrupts, interrupts priorities, usage of RIM and SIM instructions. Stack and subroutines, concept of stack memory and calling subroutines.	9 lectures

Unit V	Interfacing Concepts: Basic interfacing concepts, memory mapped and peripheral mapped I/O addressing, Interrupt controlled I/O. Study of peripheral devices such as 8255, 8257, 8253 and 8251 and their applications.	10 lectures

Books:

1. Microprocessor Architecture Programming and Applications, R.S. Gaonkar, New Age International, 1993.
2. Microprocessor 8085- Architecture, Programming and Interfacing, Sunil Mathur, PHI.
3. Microprocessor Interfacing and Applications, R. singh and B. P. Singh.
4. Fundamentals of Microprocessors and Microcomputers, B. Ram, Dhanpat Rai and Sons.
5. Microprocessor and Peripherals, S. P. Chowdhury and Sunetra Chowdhury, Scitech Pub, 2014.

EE22202	**Power Systems – I: 4 Credits (3-0-2)**	
Unit I	Overview of different conventional generation systems. Renewable power generation systems. Hybrid power generation systems. Economic analysis of renewable and hybrid generation systems. Cogeneration systems. AC and DC transmission and distribution systems. Different types of conductors.	9 lectures
Unit II	Mechanical designs of overhead lines including sag. Line insulators. Underground cables. Complex power. PU systems.	5 lectures
Unit III	Line parameters: Resistance, capacitance and inductance of short, medium and long transmission lines. Skin effect, Ferranti effect, Corona effect. Performance of short, medium and long transmission lines. Efficiency and voltage regulation of short, medium and long transmission lines.	9 lectures
Unit IV	Load Flow Analysis.	12 lectures
Unit V	Generation and absorption of reactive power in the transmission systems. Line compensation. Economic operation of power systems. Unit power commitment.	7 lectures

Books:

1. C. L. Wadhwa, “Generation, distribution and utilization of electrical energy”, New Age International.
2. B. R. Gupta, “Electrical power systems”, Wheeler Publishers.
3. Stevenson, “Electrical power systems”.

EE22203	**Electrical Machines – II: 4 Credits (3-0-2)**	
Unit I	Three phase Induction Motors: Construction, Types (squirrel cage and slip-ring), principle of operation, production of rotating magnetic field and mmf phasors, rotor frequency, rotor emf, current and power; losses and efficiency, phasor diagram, equivalent circuit, Torque Slip Characteristics, operating characteristics of induction motors, Starting and Maximum Torque, Effect of parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency). Methods of starting, braking and speed control for induction motors. Generator operation. Self-excitation. Doubly-Fed Induction Machines.	12 lectures
Unit II	Induction Generator: Working principle, equivalent circuits, types of excitations, single phase and three phase operation and applications.	6 lectures
Unit III	Single-Phase Induction Motors: Constructional features, production of pulsating magnetic field and mmf phasors, working principle, double revolving field theory, equivalent circuit, determination of parameters. Split-phase starting methods and applications.	6 lectures
Unit IV	Three phase Synchronous Generators: Constructional features and excitation, types of synchronous generators, three phase windings, concentrated windings and distributed windings, distribution factor and pitch factor, types of rotors, synchronous generator on No-load, synchronous generator on load, synchronous speed and frequency, EMF equation, equivalent circuit and phasor diagram, armature reaction, synchronous impedance, voltage regulation, power transfer equation, parallel operation of	10 lectures

	alternators, infinite bus bar, synchronizations, load sharing, machine floats on the busbar, Operating characteristics of synchronous machines, V-curves, power angle characteristics..	
Unit V	Synchronous Motors: working principle, hunting, effect of change of excitation of a synchronous motor driving a constant load, synchronous condenser, starting of synchronous motors, applications.	8 lectures

Books:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", McGraw Hill Education, 2013.
2. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
3. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
4. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.
5. A. S. Langsdorf, "Alternating current machines", McGraw Hill Education, 1984.
6. P. C. Sen, "Principles of Electric Machines and Power Electronics", John Wiley & Sons, 2007.

EE22204	**Power Electronics: 4 Credits (3-0-2)**	
Unit I	Power Switching Devices: Diode, Thyristor, MOSFET, IGBT: I-V Characteristics; Firing circuit for thyristor; Voltage and current commutation of a thyristor; Gate drive circuits for MOSFET and IGBT.	8 lectures
Unit II	Thyristor Rectifiers: Single-phase half-wave and full-wave rectifiers, Single-phase full-bridge thyristor rectifier with R-load and highly inductive load; Three-phase full-bridge thyristor rectifier with R-load and highly inductive load; Input current wave shape and power factor.	9 lectures
Unit III	Choppers (DC–DC Converters): Classification, applications, principle of operation, control strategies of chopper, Types of Chopper circuits, Step-up chopper, Steady state time domain analysis of Type-A and Type-B Chopper, concept of switched mode power supply.	10 lectures
Unit IV	Inverters (DC–AC Converters): Classification and industrial applications, Voltage Source Inverters: Single phase VSI circuits, 3-Φ VSI circuits, PWM based Inverters; Current Source Inverter – 1-Φ and 3-Φ CSI circuits.	8 lectures
Unit V	AC Voltage Controller (ACVC) and Cylco-Converter: Classification and industrial applications of ACVC, Single phase half wave and full wave ACVCs, Sequence Control of ACVC; Cyclo-converters: classification and industrial applications, 1- phase to 1- phase Step-up and Step down Cyclo-converters.	7 lectures

Books:

1. M. H. Rashid, "Power electronics: circuits, devices, and applications", Pearson Education India, 2009.
2. N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
3. R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, 2007.
4. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2009.
5. Power Electronics, P. S. Bimbhra, Khanna Publishers., New Delhi, 1999.
6. Power Electronics, M. D. Singh, K. B. Khanchandani, Tata McGraw Hill, New Delhi, 2007.
7. Dubey, G.K., Doradlla, S.R., "Thyristerised Power Controllers", Wiley Eastern, 1987.

EE23101	**Digital Electronics: 4 Credits (3-0-2)**	
Unit I	Fundamentals of Digital Systems and Logic Families: Digital signals, digital circuits, AND, OR, NOT, NAND, NOR and Exclusive-OR operations, Boolean algebra, examples of IC gates, number systems-binary, signed binary, octal hexadecimal number, binary arithmetic, one's and two's complements arithmetic, codes, error detecting and correcting codes, characteristics of digital lCs, digital logic families, TTL, Schottky TTL and CMOS logic, interfacing CMOS and TTL, Tri-state logic.	9 lectures
Unit II	Combinational Digital Circuits: Standard representation for logic functions, K-map representation, simplification of logic functions using K-map, minimization of logical functions. Don't care conditions, Multiplexer, De-Multiplexer/Decoders, Adders, Subtractors, BCD arithmetic, carry look ahead	8 lectures

	adder, serialadder, ALU, elementary ALU design, popular MSI chips, digital comparator, paritychecker/generator, code converters, priority encoders, decoders/drivers for display devices, Q-M method of function realization.	
Unit III	Sequential circuits and systems: A 1-bit memory, the circuit properties of Bi-stable latch, the clocked SR flip flop, J-K-T and D- types flip-flops, applications of flip-flops, shift registers, applications of shifter registers, serial to parallel converter, parallel to serial converter, ring counter, sequence generator, ripple (Asynchronous) counters, synchronous counters, counters design using flip-flops, special counter IC's, asynchronous sequential counters, applications of counters.	8 lectures
Unit IV	A/D and D/A Converters: Digital to analog converters: weighted resistor/converter, R-2R Ladder D/Aconverter, specifications for D/A converters, examples of D/A converter lCs, sample and hold circuit, analog to digital converters: quantization and encoding, parallel comparator A/D converter, successive approximation A/D converter, counting A/D converter, dual slope A/D converter, A/D converter using voltage to frequency and voltage to time conversion, specifications of A/D converters, example of A/D converter ICs.	9 lectures
Unit V	Semiconductor Memories and Programmable Cogic Devices: Memory organization and operation, expanding memory size, classification and characteristics of memories, sequential memory, read only memory (ROM), read and write memory (RAM), content addressable memory (CAM), charge de coupled device memory (CCD), commonly used memory chips, ROM as a PLD, Programmable logic array, Programmable array logic, complexProgrammable logic devices (CPLDS), Field Programmable Gate Array (FPGA).	8 lectures

Books:

1. R. P. Jain, "Modern Digital Electronics", McGraw Hill Education, 2009.
2. M. M. Mano, "Digital logic and Computer design", Pearson Education India, 2016.
3. A. Kumar, "Fundamentals of Digital Circuits", Prentice Hall India, 2016.

EE23102	**Control Systems: 4 Credits (3-0-2)**	
Unit I	Introduction to Control Problems: Industrial control examples. Mathematical models of physical systems. Control hardware and their models. Transfer function models of linear time-invariant systems. Feedback Control: Open-Loop and Closed-loop systems. Benefits of Feedback. Block diagram algebra. Signal-flow graph, Mason's gain formula.	5 lectures
Unit II	Time Response Analysis: Standard test signals. Time response of first and second order systems for standard test inputs. Application of initial and final value theorem. Design specifications for second-order systems based on the time-response. Concept of Stability. Routh-Hurwitz Criteria. Relative Stability analysis. Root-Locus technique. Construction of Root-loci.	10 lectures
Unit III	Frequency-Response Analysis: Relationship between time and frequency response, Polar plots, Bode plots. Nyquist stability criterion. Relative stability using Nyquist criterion – gain and phase margin. Closed-loop frequency response.	6 lectures
Unit IV	Introduction to Controller Design: Stability, steady-state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness of control systems. Root-loci method of feedback controller design. Design specifications in frequency-domain. Frequency-domain methods of design. Application of Proportional, Integral and Derivative Controllers, Lead and Lag compensation in designs. Analog and Digital implementation of controllers.	10 lectures
Unit V	State Variable Analysis: Concepts of state variables. State space model. Diagonalization of state matrix. Solution of state equations. Eigenvalues and Stability Analysis. Concept of controllability and observability. Pole-placement by state feedback. Discrete-time systems. Difference Equations. State-space models of linear discrete-time systems. Stability of linear discrete-time systems. Introduction to Optimal Control and Nonlinear Control: Performance Indices. Regulator problem, Tracking Problem. Nonlinear system–Basic concepts and analysis.	11 lectures

Books:

1. M. Gopal, “Control Systems: Principles and Design”, McGraw Hill Education, 1997.
2. B. C. Kuo, “Automatic Control System”, Prentice Hall, 1995.
3. K. Ogata, “Modern Control Engineering”, Prentice Hall, 1991.
4. I. J. Nagrath and M. Gopal, “Control Systems Engineering”, New Age International, 2009.
5. Franklin, Powel and Naeini, “Feedback Control of Dynamic System”, Pearson, 2009.

EE23103	**Electromagnetic Fields: 4 Credits (3-1-0)**	
Unit I	Review of Vector Calculus: Vector algebra – addition, subtraction, scalar and vector multiplications, components of vectors, three orthogonal coordinate systems (rectangular, circular cylindrical and spherical coordinates), conversion of vector from one coordinate system to another. Vector calculus – vector operator del, Gradient, Divergence and Curl.	6 lectures
Unit II	Static Electric Fields: Coulomb’s law and electric field intensity, Electric flux, Electric flux density, Gauss’s law and Divergence theorem, potential and potential difference, potential gradient, potential and field intensity due to a Dipole, energy stored in an electrostatic field and energy density.	6 lectures
Unit III	Conductors, Dielectric and Capacitance: Current and current density, Ohm’s law in point form, continuity of current, boundary conditions for perfect dielectric materials. Permittivity of dielectric materials, capacitance, capacitance of two wire line, Poission’s and Laplace’s equations, solutions of Laplace/Poisson’s equations and its applications.	9 lectures
Unit IV	Steady magnetic field: Biot-Savart law, Amperes’s law, Stoke’s theorem, magnetic flux and flux density. Scalar and vector magnetic potentials, dteady magnetic fields produced by current carrying conductors. Force on a moving charge, force on a differential current element, and nature of magnetic materials, inductance, mutual inductances and magnetic boundary conditions.	9 lectures
Unit V	Time Varying Fields and Maxwell’s Equations: Faraday’s law of electromagnetic induction, Displacement current, Maxwell’s equation in point and integral forms, motional electromotive forces, boundary conditions. Electromagnetic Waves: Derivation of wave equation, uniform plane waves, Maxwell’s equation in phasor form, wave equation in phasor form, plane waves in free space and in a homogeneous material. Wave equation for conducting medium, plane waves in lossy dielectrics, propagation in good conductors, Poynting theorem.	12 lectures

Books:

1. Engineering Electromagnetics, W. H. Hayat, TMH, 2012.
2. Elements of Electromagnetics, M. N. O. Sadiku, Oxford University Press, 2014.
3. Electromagnetic Field Theory: A Problem Solving Approach, MARKUS ZAHN, Massachusetts Institute of Technology, Cambridge, MA 01239.
4. Problems of Electromagnetics, S. A. Nasar, Schaum Series, MGH.
5. Electromagnetism – Theory and Applications, A. Pramanik, PHI Learning Pvt. Ltd., New Delhi, 2009.
6. Electromagnetism – Problems with Solution, A. Pramanik, PHI, 2012.
7. Electricity and Magnetism, W. J. Duffin, McGaw Hill Publication, 1980.

EE23104	**Power Systems – II: 4 Credits (3-0-2)**	
Unit I	Surge Phenomena and Symmetrical Short Circuits.	9 lectures
Unit II	Symmetrical Fault Analysis for small and large power system network.	9 lectures
Unit III	Unsymmetrical Fault Analysis for small and large power system network.	7 lectures
Unit IV	System stability: Stability problem; swing equation; power angle equation; equal area criterion of stability; multi-machine stability studies; step by step solution of swing equation; solution for transient stability; factors affecting steady state; transient and dynamic stability.	8 lectures
Unit V	Automatic generation and voltage control: Load frequency control; Economic dispatch control; Single area and multi area frequency control; Optimal load	9 lectures

	frequency control; Automatic voltage control; Load frequency control using GRC speed governor; Digital LF controller; Decentralized controller.	

Books:

1. P. Kundur, “Power system stability and control”, Tata McGraw Hill Publishers.
2. I.J. Nagrath, D.P. Kothari, “Power system engineering”, Tata McGraw Hill Publishers.
3. Hadi Saddat, “Power system analysis”, Tata McGraw Hill Publishers.

EE23105	**Signals and Systems: 3 Credits (2-1-0)**	
Unit I	Introduction to Signals and Systems: Signals and systems as seen in everyday life, and in various branches of engineering and science. Signal properties: periodicity, absolute integrability, determinism and stochastic character. Some special signals of importance: the unit step, the unit impulse, the sinusoid, the complex exponential, some special time-limited signals; continuous and discrete time signals, continuous and discrete amplitude signals. System properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, realizability.	3 lectures
Unit II	Behavior of continuous and discrete-time LTI systems: Impulse response and step response, convolution, input-output behavior with aperiodic convergent inputs, cascade interconnections. Characterization of causality and stability of LTI systems. System representation through differential equations and difference equations. State-space Representation of systems. State-Space Analysis, Multi-input, multi-output representation. State Transition Matrix and its Role. Periodic inputs to an LTI system, the notion of a frequency response and its relation to the impulse response.	7 lectures
Unit III	Fourier, Laplace and z-Transforms: Fourier series representation of periodic signals, Waveform Symmetries, Calculation of Fourier Coefficients. Fourier Transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response, Fourier domain duality. The Discrete-Time Fourier Transform (DTFT) and the Discrete Fourier Transform (DFT). Parseval's Theorem.	8 lectures
Unit IV	Review of the Laplace Transform for continuous time signals and systems, system functions, poles and zeros of system functions and signals, Laplace domain analysis, solution to differential equations and system behavior. The z-Transform for discrete time signals and systems, system functions, poles and zeros of systems and sequences, z-domain analysis.	7 lectures
Unit V	Sampling and Reconstruction: The Sampling Theorem and its implications. Spectra of sampled signals. Reconstruction: ideal interpolator, zero-order hold, first-order hold. Aliasing and its effects. Relation between continuous and discrete time systems. Introduction to the applications of signal and system theory: modulation for communication, filtering, feedback control systems.	3 lectures

Books:

1. Signals and System by Openheim, Willlsky PHI.
2. Signals and Sytems by Chen, Oxford University Press.
3. Linear System theory by chen. Oxford University Press.

EE23201	**Switchgear and Protection: 4 Credits (3-0-2)**	
Unit I	Various types of electromechanical relays, construction and principle of operation and characteristic, applications and limitations; Over and under current, directional, differential, distance and other types of relays; Concept of static relays; Protection system and properties; Introduction to numerical relays.	8 lectures
Unit II	Protection of transmission lines using overcurrent, differential, directional-overcurrent and distance relays, back-up protection, carrier relaying; Bus-bar protection.	7 lectures

Unit III	Protection of transformers against internal faults such as short circuit and turn-to-turn fault using differential and overcurrent relays, protection for other abnormal conditions. Protection of generators against short circuit and turn-to-turn fault, stator ground fault, field ground fault, loss of excitation, loss of synchronism using different types of relays.	11 lectures
Unit IV	Switchgear, arc and interruption theory, application in different conditions, ratings and selection, principle of operation of air break, oil filled, air blast, vacuum and SF6 circuit breakers, elementary idea of testing methods.	10 lectures
Unit V	Neutral Grounding-definition and difference from equipment grounding, disadvantages of neutral ungrounded system, types of neutral grounding, criterion for neutral grounding practice, Earthing Transformer.	6 lectures

Books:

1. Switchgear and Protection in power system, by Sunil S. Rao, Khanna publishers, Delhi.
2. Power System Protection and Switchgear, by B. Ravindranath and M. Chander, NAI, New Delhi.
3. Power System Protection and Switchgear', by Badri Ram and Vishwakarma, D.N., TMH, 1995.
4. The Art and Science of Protective Relaying, by C Russel Mason, Wiley Eastern Ltd., New Delhi.
5. Power System Protection by P.M. Anderson IEEE Press. 1999.
6. Power System Relaying by S. H. Horowitz and A. G. Phadke, 4th Edition, Wiley. 2014
7. Protective Relaying: Principles & Applications by J. L. Blackburn and T. J. Domin, 4th Edition, CRC Press 2014.
8. Computer Relaying for Power Systems A. G. Phadke and J.S. Thorpe 2nd Edition, Wiley India. 2012.
9. Protective Relays - Theory and Practice by Van A. R. and Warrington C Vol. I and II, 3rd Ed. Chapman and Hall. 1982.
10. Fundamentals of Power System Protection by Paithankar Y. G. and Bhide S. R. Prentice Hall of India Private Limited. 2007.

EE23202	**Electrical Measurements and Instrumentation: 4 Credits (3-0-2)**	
Unit I	Introduction to measurement system: Introduction, Types of measurement and instruments, Static and dynamic characteristics of instruments. Different types of operating forces for indicating instruments. Different types of damping and control systems; Errors in measurement, Type of errors and its corrections.	6 lectures
Unit II	Analog Electromechanical Instruments: Classification of analog instruments; construction, working principle, torque equation, extension of range, errors and compensation in permanent magnet moving coil, moving iron, dynamometer type, induction type, electrostatic type ammeters and voltmeters instruments.	8 lectures
Unit III	Measurement of Power and Energy: construction, working principle, torque equation, errors in Electrodynamometer type wattmeter, LPF wattmeter, three phase wattmeter; measurement of reactive power; construction, working principle, torque equation, errors and testing of induction type energy meter, Digital Multi-meter, True RMS meters, Clamp-on meters, Digital Storage Oscilloscope.	8 lectures
Unit IV	Measurement of resistance: Type of resistances, methods of measurement of these resistances, Wheatstone Bridge and its Sensitivity, Kelvin double bridge, Direct deflection methods as series and shunt type ohmmeter, Meggers, Loss of charge method, Measurement of Earth resistance and insulation resistance. AC Bridges and Potentiometer: Measurement of self inductance by Maxwell's bridge, Hay's bridge, Anderson's bridge and Owen's bridge; Measurement of mutual inductance by heavyside's bridge, Compbell's bridge, Careyforster's bridge.	10 lectures
Unit V	Measurement of capacitance by De-Sauty's bridge, Schering Bridge, Measurement of frequency by Wein's Bridge. Basic Potentiometer circuit, Types of Potentiometers, Crompton type, Standardization of Calibration and	10 lectures

	application. Measurement of Frequency and Power Factor: types of frequency meter, electrical and mechanical resonance type, Weston frequency meter. Single-phase Electro dynamometer type power factor meter 3-phase Electrodynamometer type PF meter.	

Books:

1. A course in Electrical and Electronics Meas. and Instrumentation, by A.K. Sawhney, Dhanpat Rai and Sons.
2. Advanced Electrical Technology by H. Cotton, Wheeler Publication.
3. A Course in Electronic and Electrical Measurements and Instrumentation by J.B. Gupta, S.K. Kataria & Sons, Delhi, 2003.
3. Electrical Measurements & Measuring Instruments by E.W. Golding and F.C. Widdis, A. H. Wheeler & Co, 1994.
4. Modern Electronic Instru. and Meas. Techniques by A. D. Helfrick and W.D. Cooper, PHI.
5. Electrical and Electronic Measurements by G. K. Banerjee, PHI Learning Pvt. Ltd., 2e, 2016.
6. Electrical Measuring Instruments and Measurements by S. C. Bhargava, BS Publications, 2012.
7. Electronic and Instrumentation and Measurements by H. S. Kalsi. 4e, MGH.

EE24101	**Modern Control Engineering: 3 Credits (3-0-0)**	
Unit I	Discrete Time Systems: Introduction to discrete-time systems and its essential elements, z-transform, solution of difference equations by z-transformation methods, Inverse z-transform, pulse transfer function, Theorems on z-transform & response between sampling instants.	8 lectures
Unit II	Stability Analysis: Definitions, relation between s-plane and z-plane, Stability analysis using Jury's criterion and bilinear transformation.	7 lectures
Unit III	Root Loci for digital control systems, Design of digital control systems via root loci.	7 lectures
Unit IV	State Space Analysis: State-space representations of continuous and discrete time systems, relation between state equation & transfer function, state transition matrix, solution of state equations. Controllability and observability, eigenvalues and eigenvectors.	8 lectures
Unit V	Pole placement design by state feedback, design of full and reduced order observer and Deadbeat control design. Introduction to non-linear systems: Stability in the sense of Lyapunov, Describing functions and Phase plane analysis.	12 lectures

Books:

1. Digital Control Systems, B. C. Kuo, Oxford University Press, 1992.
2. Discrete-Time Control Systems, K. Ogata, Pearson Education, 1995 (Reprint-2001).
3. Digital Control & State Variable Methods (2/e), M. Gopal, PHI, 2007.
4. Control Theory: Multivariable & Nonlinear Methods, T. Glad & L. Ljung, Taylor & Francis, 2002.
5. Analog & Digital Control System Design, C. T. Chen, 1993.
6. Modern Control Engineering., K. Ogata, Pearson Education, 2002

EE23001	**Advanced Power Electronics: 3 Credits (3-0-0)**	
Unit I	Review: Thyristor, MOSFET, IGBT with their characteristics, Concept of Solid state controlled electric Drive, elements and salient features of power converter for drive, General representation of closed loop control of electric drives and performance parameters, speed and current sensors.	8 lectures
Unit II	Thyristors based Control of D.C. separately and series excited motor drives using single phase and three phase ac source, chopper based control, static Ward-Leonard control scheme, solid state electric braking schemes, Modelling of closed loop control of DC drives.	9 lectures
Unit III	Operation of induction and synchronous motor drives from voltage source and current source inverters using thyristor, pump drives using AC line controllers, self-controlled synchronous motor derives, brushless DC motor drive.	10 lectures
Unit IV	Function of microprocessor in electric drive control, salient features of microprocessor control microprocessor based control scheme for D.C., induction and synchronous motor drives, applications.	8 lectures

Unit V	Modeling and Simulation of thyristor/MOSFET based single and three phase controlled rectifier and inverters. Space vector representation. Pulse-width modulation methods for voltage control. Waveform control. Modelling and Simulation of inverter based drives.	7 lectures

Books:

1. Sivanagaraju, M. Balasubba Reddy and A. M. Prasad, Power Semiconductor Drives S, Prentice Hall of India, 2009.
2. G. K. Dubey, Fundamental of Electric Drives, Alpha Scinece, 2001.
3. M. Rashid, Power Electronics- Circuits, Devices and Applications, 3rd Ed., Prentice Hall, 2004.
4. B. K. Bose, Modern Power Electronics and AC Drives, Pearson Education, 2003.
5. A. M. Trzynadlowski, Introduction to Modern Power Electronics, John Wiley & Sons, 1998.
6. M. Rashid, Power Electronics Handbook, Academic Press-Elsevier, 2001.
7. G. K. Dubey, Thyristorised Power Controllers, Wiley Eastern Ltd., 2005.
8. M. B. Patil, V. Ramnarayanan, V. T. Ranganathan, Simulation of Power Electronic Converters, 1st ed., Narosa Publishers, 2010

EE23002	**Electrical Energy Management: 3 Credits (3-0-0)**	
Unit I	Feasibility of non-conventional resources in present industrial scenario. Case studies from industries about use of non-conventional resource.	8 lectures
Unit II	Energy Conservation in Industrial Infrastructure: Energy loads in buildings. Reduction in plant energy usage, conservation in lighting load with case studies. Energy conservation trough Demand Side Management with case studies. Maximum Demand control in industries with case studies. Fuel conservation through optimal loading of synchronized generators. Energy conservation through power factor improvement with case studies. Energy conservation by changing manufacturing sequence.	10 lectures
Unit III	Energy Conservation in Electrical Drives: Introduction of industrial drives, controlling methods of different drives. Losses in electrical drive systems. Methods of energy savings in industrial drives with case studies. Quality of utility power and its effect in industries. Harmonic analysis of industrial power.	9 lectures
Unit IV	Industrial Energy Use Profiles: The concept of cogeneration, cogeneration alternatives. Improvement of efficiency in captive plants using auxiliary devices. Potential of energy savings in foods industry, sugar industry, primary metals industry, paper industry, cement industry and any other industries.	9 lectures
Unit V	Energy Audit: The energy audit concept. Elements of energy audit. Presentation of energy audit report. Analysis of energy audit report of different industries.	6 lectures

Books:

1. Energy Management by P. W. Callaghan, McGraw Hill International.
2. Renewable Energy Sources: J. W. Twidell, ELBS Publishing Company.
3. Energy conservation and utilization by S.C. Tripathy, S. Chand and Co.

EE23003	**Power System Stability: 3 Credits (3-0-0)**	
Unit I	Steady state power transmission stability limit, Line compensation, Dynamic and transient limits, Stability criteria.	9 lectures
Unit II	Representation of system and machines in different frames of reference, Prime movers and excitation control system.	6 lectures
Unit III	Application of state variable method and Lyapunov functions	9 lectures
Unit IV	System disturbances, System's response in fault recovery.	9 lectures
Unit V	System performances and techniques of improving it.	9 lectures

Books:

1. Stability of Large Electrical Power System by Byerly R.T. and Kimbark E.W., IEEE Press.
2. Power System Control and Stability by Anderson and Foud, Iowa State University Press.
3. Power System Analysis by Hadi Sadaat, McGraw Hill.

EE23004	**Computer Aided Design of Electrical Machines: 3 Credits (3-0-0)**	
Unit I	Base problem in modern power equipment, Basic design methodology and engineering considerations.	7 lectures
Unit II	Computerization of design procedures.	9 lectures
Unit III	Optimization Techniques and their application to design problems.	9 lectures
Unit IV	Transformer Design, DC machine design.	9 lectures
Unit V	AC machine design.	8 lectures

Books:

1. A Course in Electrical Machine Design by A.K. Sawhney, Dhanpat Rai & Sons.
2. Computer Aided Design of Electrical Equipment by M. Ramamurthy, Affiliated East West Press Pvt. Ltd.
3. Performance and Design of Electrical Machines by M.G. Say, ELBS Publishers.
4. Electrical Machine Design Data Book by G. Gangadhara, R. Pallani.

EE23005	**Power System Economics: 3 Credits (3-0-0)**	
Unit I	Economics of power plants: Load curves, tariffs, power factor improvements.	6 lectures
Unit II	Economic operation: Incremental cost, generators allocation, Krichmayer's loss formula.	10 lectures
Unit III	Active and reactive power control, Economics Economic operation of steam plants.	10 lectures
Unit IV	Methods of loading of turbo generators Economic loading with/without co-ordination equations, optimum economy of mix-plant systems, Generator schedule.	10 lectures
Unit V	Automatic load Dispatching.	6 lectures

Books:

1. Power System Analysis by Hadi Sadaat, Mc Graw Hill.
2. Economic Operation of Power Systems by Kirchmayer L.K., John Wiley & Sons.
3. Power Systems Analysis and Design by B.R. Gupta, Wheeler Publication.

EE23006	**Extra HVDC/HVAC Transmission: 3 Credits (3-0-0)**	
Unit I	Problem, Advantages, Disadvantages of EHV transmission on Human, Animals and plants.	4 lectures
Unit II	Zero-sequence impedance, single and double circuit lines, equivalent circuit of 2-winding transformers.	8 lectures
Unit III	E.H.V.A.C. tower configuration, transmission line characteristics: its thermal rating, line compensation, tuned lines, and high-phase order transmission.	10 lectures
Unit IV	HVDC transmission: Relative advantages w.r.t. AC lines. Bridges circuit KVAR requirements; General aspects and converter circuits, characteristics of converter, HVAC and HVDC links, comparison, reliability Combined, choice for best circuit for HVDC converters, Bridge converters: analysis and control, power reversal, desired features of control, actual control characteristics.	14 lectures
Unit V	Corona and its effects, Corona in Bundled-conductors, power loss, audible noise and radio interference and its measurements.	6 lectures

Books:

1. EHV-AC and HVDC Transmission Engg. and Practice by S. Rao; Khana Publishers.
2. EHV-AC Transmission by R.D. Begmudra, New Age International.
3. HVDC Power Transmission System; Technology and Systems Interaction by K.R. Padiyar, New Age International.
4. High Voltage Direct Current Transmission by J. Arrilaga, Peter Prengninver Ltd, London, U.K., 1983.

EE23007	Optimization Techniques and Engineering Applications: 3 Credits (3-0-0)	
Unit I	Introduction: Introduction, Engineering application of optimization, statement of an optimization, problem, classification of optimization problems.	6 lectures
Unit II	Classification optimization techniques: Single variable and multivariable optimization with and without constraints.	9 lectures
Unit III	Linear programming: Single and multi-variable optimization, Graphical interpretation. Pivot reduction of general systems of equations. Simplex method.	10 lectures
Unit IV	Non-linear programming: Unimodel function, quadratic interpolation method. Unconstrained optimization Techniques: Direct search method, random search method, univariate method and pattern search method. Basic idea of Hooks & Jeaves, Simplex Powell and Newton methods.	9 lectures
Unit V	Constrained optimization: Characteristics of constrained problem. The complex method, method of feasible directions; transformation techniques, interior penalty function and exterior penalty function method.	8 lectures

Books:

1. Operation Research an Introduction, H.A. Taha, Macmillan Co.
2. Optimization Theory and Application, S.S. Rao, Wiley Eastern Ltd.
3. Optimization Techniques an introduction, L.R. Foulds.
4. Optimization Methods for Engineering Design, A L Fox, Addison Wesley, 1972.

EE23008	Computer Application in Power System: 3 Credits (3-0-0)	
Unit I	Representation of power system elements for digital computer studies.	6 lectures
Unit II	Data preparation, Load flow studies, Gauss-Seidel and Newton-Raphson methods, Fast-coupled Method.	9 lectures
Unit III	Active and reactive power control, Economic operation of steam plants.	9 lectures
Unit IV	Simulation of power system transients, Steady state and Transient stability study by Computers.	9 lectures
Unit V	Programming on Economic Operation Systems, Automatic Load dispatching.	9 lectures

Books:

1. Power System Analysis by Hadi Saadat, McGraw Hill.
2. Computing Modeling of Electrical Power System by Arrilago. I.J., Arnold C.P. and Harker B.J., John Wiley.
3. Computer Analysis Methods for Power System by Heydt, Macmillan.
4. Computer Aided Power System Analysis by Kusic, PHI.

EE23009	Flexible AC Transmission Systems: 3 Credits (3-0-0)	
Unit I	Introduction of the facts devices and its importance in transmission Network. Introduction to basic types of facts controller, comparison of HVDC and facts.	6 lectures
Unit II	Static Shunt Compensator: SVC And STATCOM objectives of the shunt compensation, method of controller Var generator, transfer function dynamics, performance of SVC and STATCOM, VAR reserve control, comparison between STATCOM, SVC and STATIC VAR System.	12 lectures
Unit III	Static Series Compensator: GCSC, TSSC, TCSC AND SSSC Objectives of the series compensation, series capacitive compensation, power oscillation damping, variable Impedance type series compensation switching converter type series compensators characteristics of series compensator.	12 lectures
Unit IV	Static Voltage Regulation, TCVR: Objective of voltage regulators approach to Thyristor – controlled voltage regulator; switching converter based voltage regulators.	6 lectures
Unit V	Static Phase Angle Regulation, TCPAR: Objective of phase angle regulators approach to Thyristor – controlled phase angle regulator; switching converter based phase angle regulators.	6 lectures

Books:

1. Understanding FACTS – Concept and Technology of Flexible AC Transmission Systems. By N.G. Hingorani, L. Gawky, Standard Publishers & Distributors.
2. Static Reactive Power Compensation. By T.J.E. Miller, John Wiley & Sons New York.

EE24001	**High Voltage Engineering: 4 Credits (3-0-2)**	
Unit I	Breakdown in Gases: Ionization processes and de-ionization processes, Types of Discharge, Gases as insulating materials, Breakdown in Uniform gap, non-uniform gaps, Townsend's theory, Streamer mechanism, Corona Discharge.	8 lectures
Unit II	Breakdown in Liquid and Solid Insulating Materials: Breakdown in pure and commercial liquids, Solid dielectrics and composite dielectrics, intrinsic breakdown, electromechanical breakdown and thermal breakdown, Partial discharge, applications of insulating materials.	9 lectures
Unit III	Measurements of High Voltages and Currents: Peak voltage, impulse voltage and high direct current measurement method, cathode ray oscillographs for impulse voltage and current measurement, measurement of dielectric constant and loss factor, partial discharge measurements.	9 lectures
Unit IV	Lightning and Switching Over-voltages: Charge formation in clouds, Stepped leader, Dart leader, Lightning Surges. Switching over-voltages, Protection against over-voltages, Surge diverters, and Surge modifiers.	8 lectures
Unit V	High Voltage Testing of Electrical Apparatus and High Voltage Laboratories: Various standards for HV Testing of electrical apparatus, IS, IEC standards, Testing of insulators and bushings, testing of isolators and circuit breakers, testing of cables, power transformers and some high voltage equipment, High voltage laboratory layout, indoor and outdoor laboratories, testing facility requirements, safety precautions in H. V. Labs.	8 lectures

Books:

1. M. S. Naidu and V. Kamaraju, "High Voltage Engineering", McGraw Hill Education, 2013.
2. C. L. Wadhwa, "High Voltage Engineering", New Age International Publishers, 2007.
3. D. V. Razevig (Translated by Dr. M. P. Chourasia), "High Voltage Engineering Fundamentals", Khanna Publishers, 1993.
4. E. Kuffel, W. S. Zaengl and J. Kuffel, "High Voltage Engineering Fundamentals", Newnes Publication, 2000.
5. R. Arora and W. Mosch "High Voltage and Electrical Insulation Engineering", John Wiley & Sons, 2011.
6. Various IS standards for HV Laboratory Techniques and Testing.

EE24002	**Advanced Artificial Intelligence: 3 Credits (3-0-0)**	
Unit I	Introduction problem solving methods, knowledge representation, natural language processing, AI languages.	6 lectures
Unit II	Expert Systems: Components, production rules, inference mechanism, knowledge engineering, Expert System Shells and Tool kits.	12 lectures
Unit III	Artificial Neural Networks: Biological concepts, neuron model, transfer functions and network architectures.	6 lectures
Unit IV	Artificial Neural Networks learning methods and design procedure.	6 lectures
Unit V	Fuzzy logic: Fuzzy set theory, fuzzy logic systems, Membership functions, fuzzy interference, uncertainty in information, fuzziness in expert system and neural networks, Genetic Algorithms, Case studies.	12 lectures

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. Artificial Intelligence by Patrick Henry Winson, AWL.

EE24003	Distributed Generation: 3 Credits (3-0-0)	
Unit I	Introduction: Conventional power generation: advantages and disadvantages, Energy crises, Nonconventional energy (NCE) resources: basics of Solar PV, Wind Energy systems, Fuel Cells, micro turbines, biomass, and tidal sources.	10 lectures
Unit II	Distributed Generations (DG): Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547.	7 lectures
Unit III	Energy storage elements in DG: Batteries, ultra-capacitors, flywheels and Superconducting magnetic energy storage.	5 lectures
Unit IV	Microgrids: Concept and definition of microgrid, microgrid drivers and benefits, review of sources of Microgrids, typical structure and configuration of a Microgrid, AC and DC Microgrids, Power Electronic interfaces in DC and AC Microgrids.	10 lectures
Unit V	Impact of Grid Integration: Requirements for grid interconnection, limits on operational parameters: voltage, frequency, THD Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.	10 lectures

Books:

1. D. N. Gaonkar, Distributed Generation, In-Tech publications Electrical design, estimating & costing, K.B. Raina, S. K Bhattacharjee, New Age International, New Delhi, 2003.
2. Magdi S. Mahmoud, Fouad M. AL-Sunni, Control and Optimization of Distributed Generation Systems, Springer International Publishing.

EE24004	Advanced Microprocessors and its Applications: 3 Credits (3-0-0)	
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.	10 lectures
Unit II	Coprocessor, its internal architecture, its handshaking signals for main processor, Data formats, stack registers, coprocessor instruction set.	6 lectures
Unit III	Bus interface: ISA bus, the extended ISA and CESA local bus, PCI bus, Parallel Printer Interface (LPT), Universal Serial Bus (USB), Accelerated Graphics Port (AGP). Asynchronous and synchronous data format and transfer, modems and interfacing.	10 lectures
Unit IV	Microprocessor based control: temperature/pressure/flow/speed control-a case study.	6 lectures
Unit V	32-bit processor (80386 and higher processor), architecture, memory management unit, real address mode and virtual address mode, protected mode of operation, 32 bit processor flags, privilege levels, paging mode of operation Pentium processor, its 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.	10 lectures

Books:

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.

EE24005	Power System Instrumentation and Control: 3 Credits (3-0-0)	
Unit I	Introduction to power generating systems. Thermal power station, Description of process, measuring devices and systems monitoring, combustion and steam generation. Instrumentation for automated boiler control and operation.	9 lectures
Unit II	Turbine-room instrumentation, Special instrumentation schemes for performance testing, safety and essential auxiliary services, Instrumentation for automated boiler control and operation. Turbine room instrumentation.	9 lectures
Unit III	Special instrumentation schemes for performance testing, safety and essential auxiliary services, Instrumentation system applicable to diesel, gas turbine and hydroelectric plants.	9 lectures
Unit IV	Introduction to nuclear power generation, description of the processes, and instrumentation for nuclear reactor control, Safety instrumentation for plant and operating personnel, Summation metering.	9 lectures
Unit V	Law-out of instrumentation systems in the central control room for data display and control signal generation, Instrumentation systems in regional and central control rooms.	6 lectures

Books:

1. Digital Protection by L.P. Singh, New Age International.
2. Modern Electronic Instrumentation & Measurement Technique of Cooper. PHI.
3. Modern Power Station Practice Vol-F (Control and Instrumentation) by H.B., Asian Books Pvt. Ltd.

EE24006	Special Electromechanical Systems: 3 Credits (3-0-0)	
Unit I	Electromechanical Conversion Techniques.	6 lectures
Unit II	Different Types of F.H.P. motors used in domestic and industrial applications, Linear induction motors and actuators.	9 lectures
Unit III	Permanent magnet motors, Stepper motors, Brush and brush less motor.	9 lectures
Unit IV	High performance energy efficient machines.	9 lectures
Unit V	Special induction generators associated with wind, solar, tidal biogas and other.	9 lectures

Books:

1. Fractional and Sub Fractional Horsepower Electric Motors by Veunott, McGraw Hill.
2. Fractional Horsepower Electrical Machines by Armensky and Falk, MIR Publishers.
3. Stepper Motors & Their Microprocessor Control by Kenjo, Calarendon Press Oxford.
4. Permanent Magnet and Brushless de Motors by Kenjo and Naganori, Clarendon Press Oxford.

EE24007	Power Electronics based Industrial Drives: 3 Credits (3-0-0)	
Unit I	D.C. motor drives: Mathematical model, Line commutated converted control.	12 lectures
Unit II	Three phase induction motor drives: Mathematical model and equivalent circuit, A.C. voltage controller drive, VSI drives, CSI drive.	8 lectures
Unit III	Three phase induction motor drives: Cyclo-converter drive, Slip power recovery.	6 lectures
Unit IV	Three phase synchronous, motor drives, Mathematical model & equivalent circuit, VSI drives, CSI drives, Cyclo-converter.	10 lectures
Unit V	Microprocessor Application in Drive Control.	6 lectures

Books:

1. Power Semiconductor Drives by Dewan, Selmon & Straughen, Jojn Wiley& Sons.
2. Power Electronics and Motor Control by Shepherd, Holley and Liang, Cambridge Univ. Press.
3. Power Electronic Control of A.C. motors by Murphy and Tuurnbull, Pergamon Press.

EE24008	Bio-Medical Instrumentation: 3 Credits (3-0-0)	
Unit I	Introduction to Biomedical instrumentation: man-instrument system and its components, Physiological system of human body. Basic transducer principles, sources of bioelectric potentials, electrodes.	13 lectures
Unit II	Cardiovascular, respiratory and nervous systems measurement: Heart and cardiovascular system, cardiovascular measurement.	6 lectures
Unit III	Respiratory system measurements, measurements from the nervous system.	5 lectures
Unit IV	Instrumentation for sensory measurements: physiological measurements, patient care monitoring instruments, Non-invasive diagnostic instrumentation.	9 lectures
Unit V	Microprocessor and Computer application in biomedical instruments.	9 lectures

Books:

1. Biomedical Instrumentation and Measurements by L.Cromwell, F.J. Weibell and E.A. Pfeiffer (2e), PHI.
2. Text book of Biomedical Instrumentation by K. N. Scott and A. K Mathur, CBS.
3. Handbook of Biomedical Instrumentation by R. S. Khandpur, TMH.
4. Introduction to Biomedical equipment and Technology by J.J. Carr, J. M. Brown, Pearson Education.

EE24009	Safety and Reliability Engineering: 3 Credits (3-0-0)	
Unit I	Reliability, Quality and Safety: definitions, Reliability Functions, Relationship among hazard rate, failure density function and reliability, Elementary analysis and Estimation techniques for reliability. Risk factor, Different Hazard functions, Bath tub curve, MTTF, MTBF, prospective measures, Safety measurement.	8 lectures
Unit II	System reliability Modeling: different techniques for reliability evaluation for simple and complex systems Reliability logic Diagram, reliability evaluation of redundant systems and multi-states system, Preliminary hazard analysis, Subsystem fault hazard analysis, Common mode failures.	10 lectures
Unit III	Availability and reliability Modeling: Repairable and non-repairable system, Maintainability, mean up and mean down time, Relationship between MTBF, hazard rate, failure rate, reliability, Steady state and Point availability, Markov method for evaluation of availability, reliability and MTTF for single unit system, Availability, reliability and MTTF evaluation for two similar, standby and dissimilar unit system with joint servicing, without joint servicing and single repairman facility. Stress-strength approach to reliability design.	9 lectures
Unit IV	Fault Tree Analysis: definitions, symbols used in fault tree, qualitative and quantitative analysis, system reliability and safety evaluation by using fault tree technique.	6 lectures
Unit V	Code and standards for reliability and safety Distributions. Case studies for reliability evaluation of Electrical, Nuclear, Chemical and Process Engineering systems.	9 lectures

Books:

1. Reliability Analysis and Prediction – A Methodology Oriented Treatment by K.B. Mishra, Elservier Publishers.
2. Probabilistic Reliability – An Engineering Approach by Martin L Shooman, Mc. Graw Hill.
3. Reliability Evaluation of Engineering Systems by Roy Billington and Ronald Allan, Springer.
4. Reliability Engineering by E. Balagurusamy, TMH.
5. Concept of Reliability Engineering by L.S. Srinath, EWP Ltd.
6. Electrical Safety by Cadick, MGH.
7. Electrical Safety, Fire Safety Engineering and Management by H. L. Saluja and S. Rao, Khanna Pub.

EE24010	Network Synthesis: 3 Credits (3-0-0)	
Unit I	Positive real function-synthesis of 2-port, R-L-C networks, cascading and interconnection, Bisection theorem, synthesis of R-L and R-C filters Butterworth.	12 lectures
Unit II	Chebyshev and Bessel type frequency transformations.	6 lectures
Unit III	Active networks find synthesis techniques.	6 lectures
Unit IV	Synthesis of R-L-C low-pass, band pass and band reject filters.	12 lectures
Unit V	Biquad and simulation of physical systems and active networks.	6 lectures

Books:

1. Network and Synthesis by D. Roy Chaudhury, New Age International.
2. Network and Synthesis by Kuo, Franklin F., John Wiley and Sons.
3. Network Synthesis by M.E. Van Valkenburg, PHI.

EE24021	Time Series Analysis and Forecasting: 3 Credits (3-0-0)	
Unit I	The method of least squares, Linear and non-linear regression test for linearity, Regression coefficients.	6 lectures
Unit II	Correlation theory, Multiple linear regressions, Partial and multiple correlations, rank and Inter-class correlation and their applications.	9 lectures
Unit III	Forecasting auto/regressive processes, auto correlation, Moving average method of forecasting.	9 lectures
Unit IV	Exponential smoothing, Cyclic forecasting.	9 lectures
Unit V	Box-Jenkins Predictor, Non-parametric methods.	9 lectures

Books:

1. Basic Statistics by B.L., Agarwal, New Age International.
2. Forecasting: Methods and Applications by W. Wheel and S. Markdakis, John Wiley & Sons.
3. Probability and Stochastic Process for Engineers by Helstrom, Maxwell Press.

EE24022	Power System Reliability: 3 Credits (3-0-0)	
Unit I	Basic Probability Theory: Review of probability concepts. Probability distributions. Application of binomial distribution to engineering problems. Probability distribution in reliability evaluation. Network modeling and evaluation of simple and complex systems. System reliability evaluation using probability distributions.	10 lectures
Unit II	Outage definition: Loss of load probability methods. Loss of energy probability method. Load forecast, System Design and planning, Strategies for generation, Transmission & Distribution networks. Transmission system reliability evaluation – Average interruption rate method. The frequency and duration method.	10 lectures
Unit III	Transmission System Reliability Evaluation: Evaluation of the LOLP and E (DNS) indices for an isolated transmission system.	8 lectures
Unit IV	Interconnected system: Generating capacity reliability evaluation introduction. The loss of load approach, reliability evaluation in two and more than two interconnected systems, Interconnection benefits.	8 lectures
Unit V	Distribution System Reliability Evaluation: Reliability analysis of radial systems with perfect and imperfect switching.	6 lectures

Books:

1. Reliability Evaluation of Power System by Roy Billinton and R. N. Allan, Springer.
2. Electric Power Distribution Reliability by Richard E.Brown, 2nd Edition, CRC Press Taylor & Francis Group.
3. Reliability Evaluation of Power System, Volume – II, Roy Billinton and Ronald N. Allan.
4. Reliability Modeling in Electric Power System, J. Endreny.
5. Electric Power Distribution, A. S. Pabla.

EE24023	CMOS VLSI Design: 3 Credits (3-0-0)	
Unit I	Introduction to CMOS technology and layout: integrated circuit technology, basic MOS transistors, CMOS fabrication.	3 lectures
Unit II	Basic electrical properties of MOS circuits: drain-to-source current versus voltage relationships, aspects of MOS threshold voltage, pass transistor, NMOS and CMOS inverter, MOS circuit model, Latch-up in CMOS.	10 lectures
Unit III	MOS circuit design processes: MOS layers, Stick diagrams, scaleable CMOS design rules, symbolic diagrams.	3 lectures
Unit IV	Circuit characterization and performance estimation: delay estimation, logical effort and transistor sizing, power dissipation, design margin; circuit simulation: Spice introduction, device models, device characterization, circuit characterization.	13 lectures
Unit V	Computational and sequential circuit design: circuit families, low power logic design, sequential static circuits, Latch and Flip design; datapath design: adder and multiplier.	13 lectures

Books:

1. CMOS VLSI Design: A Circuits and Systems Perspective, 3rd ed, Addison Wesley, 2005 by Weste and Harris.
2. Digital Design, 3rd edition by M. Morris Mano.
3. Principles of CMOS VLSI design by N H E Weste and K Eshraghian.
4. Modern VLSI Design: System on Silicon by Wayne Wolf.

EE24024	Microprocessor based Industrial Drives: 3 Credits (3-0-0)	
Unit I	Description of microprocessor architecture, Peripherals, Sensors, Actuators and Isolators.	9 lectures
Unit II	Data Transmission techniques, Different control techniques.	6 lectures
Unit III	Multiprocessor control, Microprocessor based DC drives Control, Microprocessor-based PWM inverter.	9 lectures
Unit IV	Microprocessor-based control of stator fed and doubly fed induction motor.	9 lectures
Unit V	Application of modern control strategies, application of Microcontrollers for drive control, Case studies.	9 lectures

Books:

1. Microprocessor Architecture Programming and Application by Ramesh S. Gaonkar, New Asian Publisher.
2. Power Electronics and Motor Control by Sherpherd, Mulley, Liang, Cambridge.
3. Thyristorized Power Controlled by G.K. Dubey, S, R. Doradla, A. Joshi and RKM Sinha, New Asian Age.
4. Microprocessors by A. Pal.
5. Power Semiconductor Controlled Drives by G. K. Dubey, PHI.
6. Electric Drive by Leonard.

EE24025	Arduino Programming: 3 Credits (3-0-0)	
Unit I	Introduction to Arduino, Pin configuration and architecture, Device and platform features, Concept of digital and analog ports, Familiarizing with Arduino Interfacing Board, Introduction to Embedded C and Arduino platform.	10 lectures
Unit II	Arduino data types, Variables and constants, Operators, Control Statements, Arrays Functions.	10 lectures
Unit III	Pins Configured as INPUT, Pull-up Resistors, Pins Configured as OUTPUT, pin Mode Function, digital Write Function, analog Read function Arduino Interrupts.	10 lectures
Unit IV	Incorporating Arduino time, delay function, delay Microseconds function, millis function and micros function.	7 lectures
Unit V	Arduino Sensors, arduino secondary integration, giving input to the controller, arduino communications.	5 lectures

Books:

1. Massimo Banzi, Michael Shiloh, “Getting Started with Arduino” published by Shroff Publishers and Distributors Pvt. Ltd.
2. Kimmo Karvinen, Tero Karvinen, “Make: Getting Started with Sensors - Measure the World with Electronics, Arduino, and Raspberry Pi” Shroff Publishers and Distributors Pvt. Ltd.
3. Cuno Pfister, “Getting Started with the Internet of Things (Make: Projects)” Shroff Publishers and Distributors Pvt. Ltd.
4. Dr. K. Bikshalu, “Basics of Arduino Programming” Educreation Publishing.

EE24026	**Electric Vehicles: 3 Credits (3-0-0)**	
Unit I	Electric Vehicles (EV) and Hybrid Electric Vehicles (HEV) Developments: History of EV developments, Recent technologies, State of art EVs and HEVs,	6 lectures
Unit II	EV architecture and configurations, Parameters affecting the EV performance, HEV configurations, Power flow control system.	7 lectures
Unit III	Electric Propulsion: Different types of Power converter based DC motor drives, induction motor drives, permanent magnet motor drives, Switched reluctance motor drives.	9 lectures
Unit IV	Energy Sources: Basics- Parameters-Capacity, Discharge rate, State of charge, state of Discharge of Batteries, Fuel cells, Ultra-capacitors, Fly-wheels.	10 lectures
Unit V	EV auxiliaries: Battery characteristics and chargers, Battery indication and management, Temperature control units, Power steering units, Auxiliary power supplies, Navigation systems, Regenerative Braking systems.	10 lectures

Books:

1. C. C. Chan, K. T. Chau, “Modern Electric Vehicle Technology”, Oxford University Press.
2. Rodrego Garcia-valle, J. A. P Lopes “Electric Vehicle Integration into Modern Power Networks”, Springer.
3. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 2004.
4. Chris Mi, M. AbulMasrur, David Wenzhong Gao, “Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives”, John Wiley Ltd. Publication.

EE24027	**Energy Systems: 3 Credits (3-0-0)**	
Unit I	Energy Resources in general, present scenario, Energy consumption and acts, Environmental aspects of Thermal, Nuclear and hydroelectric power generation, types of emission from various sectors, co-relation between emission & pollution. Kyoto protocol, and carbon credit etc. Energy audit: primary and detail auditing.	10 lectures
Unit II	Energy management: Demand side management (DSM) and Supply side management (SSM), Supply side management through energy price control, Smart Grid – functions, features and technologies. The role of Reactive power management.	8 lectures
Unit III	Distributed generation (DG) and Microgrids: - features of distributed generations, technical issues of DG connection at distribution voltage level. Composition of Microgrid.	6 lectures
Unit IV	Renewable energy resources: Solar- solar thermal, solar PV, wind energy- prospects and status in national and global context, principles of wind energy conversion, wind monitoring system, VAWT and HAWT, selection of site for WTGS. Geothermal, Tidal, Bioenergy- Biomass and bio gas with gasifiers etc. fuel cell. Mini and micro hydel power plant, micro turbine.	10 lectures
Unit V	Energy storage and conservation: Types and methods of energy storage, Energy storage setups like Chemical, Thermal, Magnetic, fly wheel storage etc. Energy conservation - Concept of co-generation, combined heat and power (CHP).	8 lectures

Books:

1. Energy Management Handbook (6th ed. 2007), Wayne C. Turner, Steve Doty, Fairmont Press, Inc.
2. Guide to energy management, 6 th Ed., Barney L. Capehart, Wayne C. Turner, William J. Kennedy, The Fairmont Press, Inc.
3. Power Station Engineering and Economics, Skortzki, B. G. A., Vopat W. A., McGraw Hill, New York.
4. Solar Energy Engineering, Sayigh A. A. M, Academic Press.

EE24028	**Electrical Power Utilization and Illumination Engineering: 3 Credits (3-0-0)**	
Unit I	Electric heating: advantages, classification, resistance heating, design of heating element, types of electrodes, induction heating, dielectric heating, and dielectric loss calculation; electric welding: types of resistance welding, arc welding.	8 lectures
Unit II	Electric traction: ac and dc systems, low frequency and high frequency systems, composite system and kando system.	8 lectures
Unit III	Illumination: nature of light, eye sensitivity, definition, laws of illumination, evaluation of different light sources, polar curve, Rousseau diagram, luminous efficacy, types of lamps, lighting schemes & its design. Life of the lamps and their mechanism of breakdown. Energy efficient illumination systems, case studies on efficient illumination systems; fundamentals of light efficient buildings.	9 lectures
Unit IV	Electrochemical process: laws of electrolyte, electric deposition, application of electrolysis, factors affecting electro chemical process.	8 lectures
Unit V	Refrigeration cycle, refrigeration systems, domestic Refrigerator, water cooler, desert cooler, air conditioning, industrial air conditioning, heating of buildings, calculation of rating of electrical equipments, related numerical problems.	9 lectures

Text/Reference Books:

1. Art and Science of Utilisation of Electrical Energy, H. Pratap, Dhanpat Rai & Sons, Delhi, 1987.
2. Generation, Distribution & Utilisation of Electrical Energy, C.L. Wadhawa, New Age Inter.
3. Electric Power Utilisation, Taylor, Prient Longman, Bombay, 1996.
4. Utilization of Electrical Energy, R.K. Rajput, Laxmi Publications Limited.

EE22221	**Power Electronics: 3 Credits (3-0-0)**	
Unit I	Power Switching Devices: Diode, Thyristor, MOSFET, IGBT: I-V Characteristics; Firing circuit for thyristor; Voltage and current commutation of a thyristor; Gate drive circuits for MOSFET and IGBT.	8 lectures
Unit II	Thyristor Rectifiers: Single-phase half-wave and full-wave rectifiers, Single-phase full-bridge thyristor rectifier with R-load and highly inductive load; Three-phase full-bridge thyristor rectifier with R-load and highly inductive load; Input current wave shape and power factor.	9 lectures
Unit III	Choppers (DC–DC Converters): Classification, applications, principle of operation, control strategies of chopper, Types of Chopper circuits, Step-up chopper, Steady state time domain analysis of Type-A and Type-B Chopper, concept of switched mode power supply.	10 lectures
Unit IV	Inverters (DC–AC Converters): Classification and industrial applications, Voltage Source Inverters: Single phase VSI circuits, 3-Φ VSI circuits, PWM based Inverters; Current Source Inverter – 1-Φ and 3-Φ CSI circuits.	8 lectures
Unit V	AC Voltage Controller (ACVC) & Cylco-Converter: Classification and industrial applications of ACVC, Single phase half wave and full wave ACVCs, Sequence Control of ACVC; Cyclo-converters: classification and industrial applications, 1-phase to 1-phase Step-up and Step down Cyclo-converters.	7 lectures

Books:

1. M. H. Rashid, “Power electronics: circuits, devices, and applications”, Pearson Education India, 2009.
2. N. Mohan and T. M. Undeland, “Power Electronics: Converters, Applications and Design”, John Wiley & Sons, 2007.

3. R. W. Erickson and D. Maksimovic, “Fundamentals of Power Electronics”, Springer Science & Business Media, 2007.
4. L. Umanand, “Power Electronics: Essentials and Applications”, Wiley India, 2009.
5. Power Electronics, P. S. Bimbhra, Khanna Publishers., New Delhi, 1999.
6. Power Electronics, M. D. Singh, K. B. Khanchandani, Tata McGraw Hill, New Delhi, 2007.
7. Dubey, G.K., Doradlla, S.R., “Thyristerised Power Controllers”, Wiley Eastern, 1987.

EE24041	**Renewable Energy and Applications: 3 Credits (3-0-0)**	
Unit I	Basics, design, analysis and application of micro-hydro power generation systems. Case-studies, Economic analysis.	8 lectures
Unit II	Basics, design, analysis and application of Solar-PV based power generation systems. Case-studies, Economic analysis.	9 lectures
Unit III	Basics, design, analysis and application of Wind-Turbine based power generation systems. Case-studies, Economic analysis.	9 lectures
Unit IV	Basics, design, analysis and application of Hybrid renewable power generation systems. Case-studies, Economic analysis.	8 lectures
Unit V	Rural electrification through renewable energy, design aspects, regulations, Government’s flagship programs for rural electrifications, micro-grids and applications, distributed generation, energy co-operatives, smart-metering etc.	8 lectures

EE24042	**Introduction to Nano-Biotechnology: 3 Credits (3-0-0)**	
Unit I	Introduction to Nano-technology: Nanoscale dimension, Nanoscale forces, Nanoscale paradigm. Nanostructures and nanomaterials: Carbon structures and materials, Carbon nanotubes (CNT and MWNT), Organometallic comounpds, Silicon structures materials - Semiconduction, Metals and high performance alloys, Glasses and and ceramics. Materials characterization tools: Atomic Force microscopy, Fluorescence microscopy, Electron Microscopy.	10 lectures
Unit II	Semiconductor and Nano-electronics devices: overview, Moore's Law and silicon devices, Molecular computing, Quantum effects/ tunneling, Quantum devices and computing.	8 lectures
Unit III	Nano Fabrication Techniques: Bottom-up and top-down approaches, MEMS fabrication and integration, Self-assembly, DNA arrays and templating.	6 lectures
Unit IV	Nano Biotechnology: Nano-Bio convergence, Applications of DNA micro arrays GeneChip, SNP, and protein arrays; Application of Self-assembly-Protein assembly, DNA assembly/ templating; Digital cells - Insilico devices, Genetic circuits. DNA computing, Synthetic Biology, Bioelectronic circuits & sensors.	12 lectures
Unit V	Application: Virus Detection, Radiation/Chemotherapy, Neurological functions of the brain, Biomedical engineering research.	6 lectures

Books:

1. Nanotechnology: A Gentle Introduction to the Next Big Idea. Mark Ratner, Daniel Ratner, Pearson Education, Inc., 2003.
2. Nano Technology: Basic Science to Emerging Technology by Shalini Suri, Aph Publishing Corporation, 2006.
3. Nano-Biotechnology: Bio-Inspired Devices and Materials of The Future by Oded Shoseyov, Ilan Levy, Humana Press, 2007.

DEPARTMENT OF MECHANICAL ENGINEERING

Year I						
S. N.	**Course**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	PH21102	Introduction to Mechanics	4	0	2	5
2.	MA21101	Mathematics – I	3	1	0	4
3.	ES21100	Basic Electrical Engineering	3	1	2	5
4.	ES21151	Engineering Graphics and Design	0	0	6	3
5.	FR21121	Biology for Engineers	2	1	0	3
Total						**20**

Year I						
S. N.	**Course**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS21201	Communication Skills	2	0	2	3
2.	MA21201	Mathematics – II	3	1	0	4
3.	CY21202	Engineering Chemistry – B	3	1	2	5
4.	ES21200	Programming for Problem Solving	3	0	2	4
5.	ES21251	Workshop Practice	0	0	6	3
6.	ES21277	Environmental Science (Audit)	2	0	0	0
Total						**19**

Year II						
S. N.	**Course**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	MA22101	Mathematics – III	3	1	0	4
2.	ES22100	Engineering Mechanics	3	1	0	4
3.	ES22101	Basic Electronics Engineering	3	0	2	4
4.	ME22101	Engineering Metallurgy	3	0	0	3
5.	ME22102	Thermodynamics	3	1	0	4
6.	ME22151	Machine Drawing	0	0	6	3
Total						**22**

Year II						
S. N.	**Course**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS22201	Entrepreneurship and Startups	3	0	0	3
2.	HS22277	Indian Constitution (Audit)	2	0	0	0
3.	ME22201	Applied Thermodynamics	3	1	0	4
4.	ME22202	Fluid Mechanics and Machines	3	1	2	5
5.	ME22203	Strength of Materials	3	0	2	4
6.	ME22204	Theory of Machines	3	0	2	4
Total						**20**

Year III						
S. N.	**Course**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS23101	Principles of Economics	3	0	0	3
2.	HS23177	Essence of Indian Knowledge and Tradition	2	0	0	0

3.	ME23101	Heat Transfer	3	0	2	4
4.	ME23102	Mechanics of Solids	3	0	0	3
5.	ME23103	Manufacturing Processes	4	0	2	5
6.	ME23104	Design of Machine Elements	3	0	2	4
7.	ME23105	Instrumentation and Control	3	0	2	4
8.	ME23166	Study Tour (Audit)	0	0	0	0
Total						**23**

Year III						
S. N.	**Course**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS23201	Organizational Behaviour	3	0	0	3
2.	ME23201	Manufacturing Technology	4	0	2	5
3.	ME23202	Machine Design	3	0	2	4
4.	ME230**	Programme Elective – I	3	0	0	3
5.	ME230**	Programme Elective – II	3	0	0	3
6.	MO230**	Open Elective – I (From MOOC)	3	0	0	3
7.	ME23289	Seminar	0	0	2	1
Total						**22**

Year IV						
S. N.	**Course**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	ME24101	Automation in Manufacturing	3	0	0	3
2.	ME24102	Mechanical Vibrations	3	0	0	3
3.	ME240**	Programme Elective – III	3	0	0	3
4.	ME240**	Programme Elective – IV	3	0	0	3
5.	**240**	Open Elective – II	*	*	*	3
6.	24179	Industrial Training	0	0	0	3
7.	24199	Project – I	0	0	6	3
Total						**21**

Year IV						
S. N.	**Course**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	ME24201	Energy Conversion Techniques	3	0	0	3
2.	ME240**	Programme Elective – V	3	0	0	3
3.	ME240**	Programme Elective – VI	3	0	0	3
4.	MO240**	Open Elective – III (From MOOC)	3	0	0	3
5.	**240**	Open Elective – IV	*	*	*	3
6.	ME24299	Project – II	0	0	1	6
7.	ED24288	Extra-Curricular Activities and Discipline	0	0	0	2
Total						**23**

List of Electives

Programme Elective – I						
S. N.	**Course**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	ME23001	Power Plant Engineering	3	0	0	3
2.	ME23002	Two Phase Flow and Heat Transfer	3	0	0	3

3.	ME23003	Boundary Layer Theory	3	0	0	3
4.	ME23004	Fluid Power Control Systems	3	0	0	3
5.	ME23005	Refrigeration and Air-conditioning	3	0	0	3

Programme Elective – II						
S. N.	**Course**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	ME23011	Non-Conventional Machining	3	0	0	3
2.	ME23012	Industrial Robotics	3	0	0	3
3.	ME23013	Composite Materials	3	0	0	3
4.	ME23014	Production Planning and Control	3	0	0	3

Programme Elective – III						
S. N.	**Course**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	ME24001	Internal Combustion Engines	3	0	0	3
2.	ME24002	Combustion Engineering	3	0	0	3
3.	ME24003	Compressible Flow	3	0	0	3
4.	ME24004	Heat Exchanger Design	3	0	0	3
5.	ME24005	Energy Management	3	0	0	3

Programme Elective – IV						
S. N.	**Course**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	ME24011	Numerical Control and CAM	3	0	0	3
2.	ME24012	Management of Production Systems	3	0	0	3
3.	ME24013	Total Quality Management	3	0	0	3
4.	ME24014	Intelligent Manufacturing Systems	3	0	0	3

Programme Elective – V						
S. N.	**Course**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	ME24021	Numerical Analysis	3	0	0	3
2.	ME24022	Principles of Tribology	3	0	0	3
3.	ME24023	Engineering Materials	3	0	0	3
4.	ME24024	Computer Aided Design and Graphics	3	0	0	3

Programme Elective – VI						
S. N.	**Course**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	ME24031	Finite Element Methods	3	0	0	3
2.	ME24032	Fracture Mechanics	3	0	0	3
3.	ME24033	Theory of Elasticity	3	0	0	3
4.	ME24034	Rotor Dynamics	3	0	0	3

Open Elective – II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	ME24041	Non-Conventional Energy Source	3	0	0	3
2.	ME24042	Operations Research	3	0	0	3

Open Elective – IV						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	ME24043	Mechatronics Systems	3	0	0	3
2.	ME24044	Wind and Solar Energy Systems	3	0	0	3

Course Content

ES21251	Workshop Practice: 3 Credits (0-0-6)
Unit I	Carpentry Shop: Introduction to carpentry and safety aspects; use of different tools (functions, types and specifications) types of woods, Practice on simple carpentry joints. Demonstration of wood working machines.
Unit II	Machine Shop: Introduction to machine shop; safety aspects; Practices on lathe work: plain turning/ step turning/ chamfering/ knurling/ drilling; practice on drilling, shaping and milling. Demonstration of milling/lathe attachments, copying mechanism, etc.
Unit III	Fitting shop: Introduction to fitting practice and safety aspects; use of different tools (functions, types and specifications); Practice on filing, hack sawing, drilling and tapping; Fitting practices. Electrical workshop practices.
Unit IV	Welding: Introduction welding hand tools (functions, types and specifications) and safety aspects; arc welding process: practice on welding joints. Demonstration of casting work. Electronic workshop practices.
Unit V	Smithy Shop: Introduction smithy practice: hand tools used (functions, types and specifications) and safety aspects; Practice on smithy work - Making simple components.

Books:

1. Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., Elements of Workshop Technology - Vol. I & II, Media promoters and publishers private limited, 2010.
2. Kalpakjian S. And Steven S. Schmid, Manufacturing Engineering and Technology, Pearson Education India Edition, 4th Ed., 2002.
3. Gowri P. Hariharan and A. Suresh Babu, Manufacturing Technology – I, Pearson Education, 2008.
4. Roy A. Lindberg, Processes and Materials of Manufacture, Prentice Hall India, 4th Ed., 1998.
5. Rao P.N., Manufacturing Technology Vol. I & II, Tata McGraw Hill House, 2017.

ES22100	Engineering Mechanics: 4 Credits (3-1-0)	
Unit I	Introduction to Engineering Mechanics covering, Force Systems-Basic concepts, Particle equilibrium; Rigid Body equilibrium; System of Forces, Coplanar Concurrent Forces, Components in Space – Resultant- Moment of Forces and its Application; Couples and Resultant of Force System, Equilibrium of System of Forces, Free body diagrams, Equations of Equilibrium of Coplanar Systems and Spatial Systems; Static Indeterminacy.	7 lectures
Unit II	Friction covering, Types of friction, Limiting friction, Laws of Friction, Static and Dynamic Friction; Motion of Bodies, wedge friction, screw jack and differential screw jack. Basic Structural Analysis covering: Equilibrium in three dimensions; Method of Sections; Method of Joints; How to determine if a member is in tension or compression; Simple Trusses; Zero force members; Beams & types of beams; Frames & Machines.	7 lectures
Unit III	Centroid and Centre of Gravity covering, Centroid of simple figures from first principle, centroid of composite sections; Centre of Gravity and its implications; Area moment of inertia- Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Mass moment inertia of circular plate, Cylinder, Cone, Sphere, Hook.	7 lectures
Unit IV	Virtual Work and Energy Method - Virtual displacements, principle of virtual work for particle and ideal system of rigid bodies, degrees of freedom. Active force diagram, systems with friction, mechanical efficiency. Conservative forces and potential energy (elastic and gravitational), energy equation for equilibrium. Applications of energy method for equilibrium. Stability of equilibrium. Introduction to Kinetics of Rigid Bodies covering, Basic terms, general principles in dynamics; Types of motion, Instantaneous centre of	10 lectures

	rotation in plane motion and simple problems.	
Unit V	Review of particle dynamics - Rectilinear motion; Plane curvilinear motion (rectangular, path, and polar coordinates). Relative and constrained motion; Newton's 2nd law (rectangular, path, and polar coordinates). Work-kinetic energy, power, potential energy. Impulse-momentum (linear, angular); Impact (Direct and oblique). D'Alembert's principle and its applications in plane motion and connected bodies; Work energy principle and its application in plane motion of connected bodies; Kinetics of rigid body rotation.	11 lectures

Books:

1. Shames, I.H., Engineering Mechanics, Prentice Hall, 4th Edition, 2006.
2. Beer, F.P. and Johnston, E.R., Vector Mechanics for Engineers, Vol. I - Statics, Vol. II – Dynamics, Tata McGraw Hill, 9th Ed., 2011.
3. Hibbler, R.C., Engineering Mechanics: Principles of Statics and Dynamics, Pearson Press, 2006.
4. Shames I.H. and Rao, G.K.M., Engineering Mechanics Statics and Dynamics, Pearson Education, 2006.
5. Hibler and Gupta, Engineering Mechanics (Statics, Dynamics), Pearson Education, 2010.
6. Reddy, V.K. and Suresh Kumar, K.S., Mechanics, Singer's Engineering, 2010.
7. Bansal, R.K., A Text Book of Engineering Mechanics, Laxmi Publications, 2010.

ME22101	**Engineering Metallurgy: 3 Credits (3-0-0)**	
Unit I	Crystal Structure: Unit cells, Metallic crystal structures, Ceramics. Imperfection in solids: Point, line, interfacial and volume defects; dislocation strengthening mechanisms and slip systems, critically resolved shear stress.	6 lectures
Unit II	Mechanical Property measurement: Tensile, compression and torsion tests; Young's modulus, relations between true and engineering stress-strain curves, generalized Hooke's law, yielding and yield strength, ductility, resilience, toughness and elastic recovery; Hardness: Rockwell, Brinell and Vickers and their relation to strength, Impact test.	7 lectures
Unit III	Static failure theories: Ductile and brittle failure mechanisms, Tresca, Von-mises, Maximum normal stress, Mohr-Coulomb and Modified Mohr-Coulomb; Fracture mechanics: Introduction to Stress-intensity factor approach and Griffith criterion. Fatigue failure: High cycle fatigue, Stress-life approach, SN curve, endurance and fatigue limits, effects of mean stress using the Modified Goodman diagram; Fracture with fatigue, Introduction to nondestructive testing (NDT).	8 lectures
Unit IV	Alloys, substitutional and interstitial solid solutions- Phase diagrams: Interpretation of binary phase diagrams and microstructure development; eutectic, peritectic, peritectoid and monotectic reactions. Iron Iron-carbide phase diagram and microstrctural aspects of ledeburite, austenite, ferrite and cementite, cast iron; Alloying of steel, properties of stainless steel and tool steels, maraging steels- cast irons; grey, white, malleable and spheroidal cast irons- copper and copper alloys; brass, bronze and cupro-nickel.	11 lectures
Unit V	Heat treatment of Steel: Annealing, tempering, normalising and spheroidising, isothermal transformation diagrams for Fe-C alloys and microstructure development. Continuous cooling curves and interpretation of final microstructures and properties- austempering, martempering, case hardening, carburizing, nitriding, cyaniding, carbo-nitriding, flame and induction hardening, vacuum and plasma hardening; Aluminium and Al-Cu – Mg alloys – Nickel based super alloys and Titanium alloys.	11 lectures

Books:

1. W.D. Callister, Materials Science and Engineering – An Introduction, Wiley India, 6th Edition**,** 2006.
2. Metallurgy for non metallurgists, Harry Chander, ASM International, 1998.
3. Budinski, K.G. and Budinski, M.K., Engineering Materials, Prentice Hall of India Private Limited, 4th Indian Reprint, 2002.
4. Raghavan, V., Material Science and Engineering – A first course, Prentice Hall of India Private Limited, 5th Edition, 2004.
5. Jindal, U.C., Engineering Materials and Metallurgy, Pearson, 2011.

ME22102	**Thermodynamics: 4 Credits (3-1-0)**	
Unit I	Fundamentals - System and Control volume; Property, State and Process; Exact and Inexact differentials; Work Thermo dynamic definition of work; examples; Displacement work; Path dependence of displacement work and illustrations for simple processes; electrical, magnetic, gravitational, spring and shaft work.	7 lectures
Unit II	Definition of Pure substance, Ideal Gases and ideal gas mixtures, Real gases and real gas mixtures, Compressibility charts - Properties of two phase systems - Const. temperature and Const. pressure heating of water; Definitions of saturated states; P-v-T surface; Use of steam tables and R134a tables; Saturation tables; Super heated tables; Identification of states and determination of properties, Mollier's chart.	8 lectures
Unit III	First Law for Flow Processes - Derivation of general energy equation for a control volume; Steady state steady flow processes including throttling; Examples of steady flow devices; Unsteady processes; examples of steady and unsteady I law applications for system and control volume. Second law - Definitions of direct and reverse heat engines; Definitions of thermal efficiency and COP; Kelvin-Planck and Clausius statements; Definition of reversible process; Internal and external irreversibility; Carnot cycle; Absolute temperature scale.	10 lectures
Unit IV	Clausius inequality; Definition of entropy S; Demonstration that entropy is a property; Evaluation of S for solids, liquids, ideal gases and ideal gas mixtures undergoing various processes; Determination of T-s from steam tables Principle of increase of entropy; Illustration of processes in T-s coordinates; Definition of Isentropic efficiency or compressors, turbines and nozzles - Irreversibility and Availability, Availability function for systems and Control volumes undergoing different processes, Lost work. Second law analysis for a control volume. Energy balance equation and Exergy analysis.	10 lectures
Unit V	Thermodynamic cycles: Basic Rankine cycle; Basic Brayton cycle; Basic vapor compression cycle and comparison with Carnot cycle.	7 lectures

Books:

1. Sonntag, R.E., Borgnakke, C., and Van Wylen, G.J., Fundamentals of Thermodynamics, John Wiley and Sons., 6th Edition, 2003.
2. Jones, J.B. and Duggan, R.E., Engineering Thermodynamics, Prentice-Hall of India, 1996.
3. Moran, M.J. and Shapiro, H.N., Fundamentals of Engineering Thermodynamics, John Wiley and Sons, 1999.
4. Nag, P.K., Engineering Thermodynamics, Tata McGraw-Hill Publishing Co., 5th Edition, 2005.
5. Cengel, Y.A. and Boles, M.A., Thermodynamics: An Engineering Approach, McGraw Hill Education, 2006.
6. Estop, T.D. and McConkey, A., Applied Thermodynamics for Engineering Technologists, Pearson Education India, 5th Edition, 2002.
7. Rogers, F.C.G. and Mayhew, Y.R., Engineering Thermodynamics: Work and Heat Transfer, Longman Scientific & Technical, 4th Edition, 1992.

ME22151	Machine Drawing: 3 Credits (0-0-6)
Unit I	Machine Drawing Conventions: Introduction to IS conventions, conventional representation of materials, common m/c elements and parts (screw, nut, bolts, keys, gear, webs, ribs), method of dimensioning, general rules for size and placement of dimensions for holes, centers, curved and tapered features.
Unit II	Drawing of m/c elements and parts: section views, additional views for the following m/c elements and parts: popular form of screw threads, bolts, nuts, stud bolts, tap bolts, set screws.
Unit III	Types of keys, cotter joint, knuckle joint, riveted joint for plates, flanged and protected flanged joint. Shaft coupling, spigot and socket pipe joint, journal and foot step bearings.
Unit IV	Assembly Drawing: Drawing of assembled views for the part drawings of the following engine parts- Stuffing box, Cross heads, Eccentrics, Petrol engine connecting rod, piston assembly. Other m/c parts: screw jack, machine vice, single tool post, Valves: steam stop vale, feed check valve, non-return valve.
Unit V	Computerized Drafting Techniques: Using drafting or solid modeling package (any of Autocad/Creo/CATIA) for drawing m/c element and parts with sectional views, simple dimensioning, etc, 3D dimensional drawings.

Books:

1. Bhatt, N.D., Engineering Drawing, Charotar Publishing House, 53rd Edition., 2014.
2. Narayana, K.L., Machine Drawing, New Age International, 4th Edition., 2013.
3. Narayana, K.L., Production Drawing, New Age International, 2009.
4. AutoCAD/Creo/CATIA Manual.

ME22201	Applied Thermodynamics: 4 Credits (3-1-0)	
Unit I	Introduction to solid, liquid and gaseous fuels Stoichiometry, exhaust gas analysis - First law analysis of combustion reactions - Heat calculations using enthalpy tables - Adiabatic flame temperature - Chemical equilibrium and equilibrium composition calculations use free energy.	8 lectures
Unit II	Vapor power cycles Rankine cycle with superheat, reheat and regeneration, exergy analysis. Super-critical and ultra super-critical Rankine cycle - Gas power cycles, Air standard Otto, Diesel and Dual cycles - Air standard Brayton cycle, effect of reheat, regeneration and intercooling - Combined gas and vapor power cycles - Vapor compression refrigeration cycles, refrigerants and their properties.	10 lectures
Unit III	Properties of dry and wet air, use of pschyrometric chart, processes involving heating/cooling and humidification/dehumidification, dew point.	4 lectures
Unit IV	Basics of compressible flow. Stagnation properties, Isentropic flow of a perfect gas through a nozzle, choked flow, subsonic and supersonic flows - normal shocks - use of ideal gas tables for isentropic flow and normal shock flow - Flow of steam and refrigerant through nozzle, super saturation - compressible flow in diffusers, efficiency of nozzle and diffuser.	8 lectures
Unit V	Reciprocating compressors, staging of reciprocating compressors, optimal stage pressure ratio, effect of inter cooling, minimum work for multistage reciprocating compressors. Analysis of steam turbines, velocity and pressure compounding of steam turbines	12 lectures

Books:

1. Sonntag, R.E, Borgnakke, C., and Van Wylen, G.J., Fundamentals of Thermodynamics, John Wiley and Sons. 6th Edition, 2003.
2. Jones, J.B. and Duggan, R.E., Engineering Thermodynamics, Prentice-Hall of India, 1996.
3. Moran, M.J. and Shapiro, H.N., Fundamentals of Engineering Thermodynamics, John Wiley and Sons., 1999.

4. Nag, P.K., Engineering Thermodynamics, Tata McGraw-Hill Publishing Co. Ltd., 5th Edition, 2005.
5. Nag, P.K., Basic and Applied Thermodynamics, Tata McGraw Hill Education Private Limited, 2009.
6. Estop, T.D. and McConkey, A., Applied Thermodynamics for Engineering Technologists, Pearson Education India, 5th Edition, 2002.
7. Rogers, F.C.G. and Mayhew, Y.R., Engineering Thermodynamics: Work and Heat Transfer, Longman Scientific & Technical, 4th Edition, 1992.

ME22202	**Fluid Mechanics and Machines: 5 Credits (3-1-2)**	
Unit I	Definition of fluid, Newton's law of viscosity, Units and dimensions – Properties of fluids, mass density, specific volume, specific gravity, viscosity, compressibility and surface tension, Control volume – application of continuity equation and momentum equation, Bernoulli's equation and its applications, viz., venturimeter and orifice meter.	9 lectures
Unit II	Exact flow solutions in channels and ducts, Couette and Poisuielle flow, laminar flow through circular conduits and circular annuli – Darcy Weisbach equation, friction factor, Moody's diagram.	9 lectures
Unit III	Need for dimensional analysis – methods of dimension analysis – Rayleigh's method – Similitude – types of similitude Dimensionless parameters – application of dimensionless parameters.	8 lectures
Unit IV	Euler's equation – theory of Rotodynamic machines – various efficiencies, velocity triangles – Centrifugal pumps, working principle, work done by the impeller, Cavitation in pumps- Reciprocating pump – working principle & analysis.	8 lectures
Unit V	Classification of water turbines, heads and efficiencies, velocity triangles – Axial, radial and mixed flow turbines – Pelton wheel, Francis turbine and Kaplan turbines, working principles – draft tube – Specific speed, unit quantities.	8 lectures

Books:

1. Massey, V., Thornes, Y.N., Mechanics of fluids, Pearson, 2001.
2. Rajput, R.K., Fluid Mechanics and Hydraulic Machines, S. Chand Publishers, 1998.
3. Douglas, J.F., Gasiorek, J.M., Swaffield, J.A., and Jack, L.B., Fluid Mechanics, Pearson Education, 2008.
4. Som, S.K. and Biswas, G., Fluid Mechanics and Fluid Machines, McGraw Hill Education, 3rd Edition, 2012.
5. Dixon, S.L., Fluid Mechanics and Thermodynamics of Turbo machinery, Elsevier, 5th Ed, 1998.
6. Jagadishlal, J., Fluid Mechanics and Hydraulics, Metropolitan New Delhi, 9th Ed., 1991.

ME22203	**Strength of Materials: 4 Credits (3-0-2)**	
Unit I	Stresses and strains, elasticity, Hooke's law, Poisson's ratio, volumetric strain, elastic constants, constitutive relations, material properties for isotropic materials and their relations, stresses in composite bars, strain energy impact and suddenly applied loads, thermal stresses, Torsion of shafts and springs.	10 lectures
Unit II	Principal stresses and their planes, plane of maximum shear, Mohr's circle of stresses, theories of failures for isotropic materials.	08 lectures
Unit III	Shear force and bending moment diagrams for beams subjected to different types of loads.	07 lectures
Unit IV	Bending of beams: Theory of simple bending and assumptions, stresses due to pure bending, transverse shear stress distribution, combined stresses due to bending, torsion and axially loading with eccentricity, combined bending and torsion, failure of columns.	10 lectures
Unit V	Deflection of beams: Double integration method, the moment area method, Macaulay's method, superposition (statically determinate beams only), Castigliano's theorem.	07 lectures

Books:

1. Ryder, G.H., Strength of Materials, McMillan Publishers India Limited, 2002.
2. Timoshenko, S. and Gere, M.J., Mechanics of Materials, C.B.S, Publishers, 1980.
3. Punmia, B.C., Strength of Materials, Firewall Media, 2002.
4. Popov, E.P., Engineering Mechanics of Solids, PHI, New Delhi, 2nd Edition, 2012.
5. Bansal, R.K., A Text Book Strength of Material, Laxmi Publication, 6th Edition, New Delhi, 2018.

ME22204	**Theory of Machines: 4 Credits (3-0-2)**	
Unit I	Introduction: purpose, kinematics and kinetics, machines, structures, mechanisms and their inversions, elements of kinematic chain, kinematics fundamental, degree of freedom and its determination, lower pairs and higher pairs, types of motions, links, joints and kinematics chains, Grasshoff's law.	6 lectures
Unit II	Velocity and Acceleration Analysis: Graphical solution of velocity and acceleration of rigid mechanisms, velocity and acceleration analysis with instantaneous centres, Coriolis acceleration.	8 lectures
Unit III	Force Analysis: Static and Dynamic force analysis of slider crank and four bar mechanism with graphical/analytical, concept of dynamically equivalent link (slider crank mechanism). Turning moment Diagram and Flywheel analysis. Gear and gear trains.	10 lectures
Unit IV	Balancing of Machineries: Static and Dynamic Balancing of rotating and reciprocating masses.	6 lectures
Unit V	Gyroscope and Governors: Gyroscopic couple and its effects in ship/aircraft/vehicles, Different governors and its characteristics. Cams analysis and design.	12 lectures

Books:

1. Rattan, S.S., Theory of Machines, Tata McGraw Hill Publishing Co. Ltd., 4th Edition, 2014.
2. Nortan, R.L., Design of Machinery, Tata McGraw Hill Publishing Co. Ltd., 4th Edition, 2008.
3. Shigley, J.E., Theory of Machines and Mechanism, McGraw Hill, 3rd Edition, 2009.
4. Beven, T., Theory of Machines, CBS Publications, 3rd Edition, 2005.
5. Ghosh and Mallik, Theory of Mechanisms and Machines, East West Press, 3rd Edition, 2008.

ME23101	**Heat Transfer: 4 Credits (3-0-2)**	
Unit I	Introduction to three modes of heat transfer, Derivation of heat balance equation - Steadyone dimensional solution for conduction heat transfer in Cartesian, cylindrical and spherical geometry, concept of conduction and film resistances, critical insulation thickness, lumped system approximation and Biot number, heat transfer through pin fins - Two dimensional conduction solutions for both steady and unsteady heat transfer - approximate solution to unsteady conduction heat transfer by the use of Heissler charts.	11 lectures
Unit II	Heat convection, basic equations, boundary layers - Forced convection, external and internal flows - Natural convective heat transfer - Dimensionless parameters for forced and free convection heat transfer - Correlations for forced and free convection - Approximate solutions to laminar boundary layer equations (momentum and energy) for both internal and external flow - Estimating heat transfer rate in laminar and turbulent flow situation using appropriate correlations for free and forced convection.	11 lectures
Unit III	Interaction of radiation with materials, definitions of radiative properties, Stefan Boltzmann's law, black and gray body radiation, Calculation of radiation heat transfer between surfaces using radiative properties, view factors and the radiosity method.	8 lectures

Unit IV	Types of heat exchangers, Analysis and design of heat exchangers using both LMTD and - NTU methods.	6 lectures
Unit V	Boiling and Condensation heat transfer, Pool boiling curve. Introduction Mass transfer, Similarity between heat and mass transfer.	6 lectures

Books:

1. Bejan, A., Heat Transfer, Wiley India Pvt. Ltd., 2011.
2. Holman, J. P., Bhattacharyya, S., Heat Transfer, McGraw Hill Education, 10th Edition, 2017.
3. Bergman, T. L., Lavine, A. S., Incropera, F. P., Dewitt, D. P., Fundamentals of Heat and Mass Transfer, John Wiley, 8th Edition, 2017.
4. Kaviany, M., Principles of Heat Transfer, John Wiley, 2002.
5. Cengel, Y. A., Ghajar, A. J., Heat and Mass Transfer: Fundamentals and Applications, McGraw Hill Education, 5th Edition. 2017.

ME23102	**Mechanics of Solids: 3 Credits (3-0-0)**	
Unit I	Analysis of stresses: 3D state of stress at a point, principal stresses, invariants, 3D Mohr's circle, octahedral stresses, hydrostatic and pure shear stresses, differential equations of equilibrium in rectangular and polar coordinates, boundary conditions.	8 lectures
Unit II	Analysis of strains: 3D strain components in rectangular and polar coordinates, state of strain at a point, principal strains, strain deviators and invariants, compatibility conditions in rectangular and polar coordinates, constitutive relations.	8 lectures
Unit III	2D problems in rectangular and polar coordinates and axi-symmetric problems: Cantilever beam with end load, uniformly loaded beam, thick and thin wall cylinders, rotating discs and cylinders, and curved beams.	8 lectures
Unit IV	Stresses due to torsion of non-circular bars, thin and thick pressure vessels. Unsymmetrical bending: Shear center and shear flow. Energy methods: Principle of virtual work, minimum potential energy.	12 lectures
Unit V	Statically indeterminate systems, method of superposition, theorem of three moments. Yield and Fracture criteria: Failure theories, stress space and strain space, yield surfaces. Introduction to plasticity.	6 lectures

Books:

1. Srinath, L.S., Advanced Mechanics of Solids, Tata McGraw Hill, 3rd Edition, 2008.
2. Timoshenko, S.P. and Goodier, J.N., Theory of Elasticity, McGraw Hill International, 3rd Edition., 1984.
3. Sadd, M.H., Elasticity: Theory, Applications and Numerics, Elsevier, 2nd Edition, 2009.
4. Hosford, W., Solid Mechanics, Cambridge University Press, 3rd Edition, 2010.
5. Shames, H. and Pitarresi, J.M., Introduction to Solid Mechanics, Pearson, 3rd Edition, 1999.
6. Crandall, S.H., Dahl, N.C., and Lardner, T.J., An Introduction to The Mechanics of Solids, Tata McGraw Hill, 2nd Edition, 2008.

ME23103	**Manufacturing Processes: 5 Credits (4-0-2)**	
Unit I	Casting and moulding: Metal casting processes and equipment, Heat transfer and solidification, shrinkage, riser design, casting defects and residual stresses.	10 lectures
Unit II	Introduction to bulk and sheet metal forming, plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk forming (forging, rolling, extrusion, drawing) and sheet forming (shearing, deep drawing, bending) principles of powder metallurgy.	10 lectures
Unit III	Metal cutting: Single and multi-point cutting; Orthogonal cutting, various force components: Chip formation, Tool wear and tool life, Surface finish and integrity, Machinability, Cutting tool materials, Cutting fluids, Coating; Turning, Drilling, Milling and finishing processes, Introduction to CNC machining.	14 lectures

Unit IV	Joining/fastening processes: Physics of welding, brazing and soldering; design considerations in welding, Solid and liquid state joining processes; Adhesive bonding. Additive manufacturing: Rapid prototyping and rapid tooling**.**	10 lectures
Unit V	Abrasive Jet Machining, Water Jet Machining, Abrasive Water Jet Machining, Ultrasonic Machining, principles and process parameters. Laser Beam Machining (LBM), Plasma Arc Machining (PAM) and Electron Beam Machining. Electrical Discharge Machining, principle and processes parameters, MRR, surface finish, tool wear, dielectric, power and control circuits, wire EDM; Electro-chemical machining (ECM), etchant & maskant, process parameters, MRR and surface finish.	12 lectures

Books:

1. Kalpakjian and Schmid, Manufacturing Processes for Engineering Materials, Pearson India, 7th Edition, 2018.
2. Groover, M.P., Fundamentals of Modern Manufacturing: Materials, Processes, and Systems. Wiley, 7th Ed., 2019.
3. Black, J.T., Kohser, R.A., Degarmo's Materials and Processes in Manufacturing, Wiley, 2017.
4. Ghosh and Mallik, Manufacturing Science, East-West Press Pvt. Ltd, 2nd Edition, 2010.
5. Rao, P.N., Manufacturing Technology (Vol. I & II), TMH, 5th Edition, 2018.
6. Ravi B, Metal Casting - Computer Aided Design and Analysis, PHI Pvt. Ltd., 2005.

ME23104	**Design of Machine Elements: 4 Credits (3-0-2)**	
Unit I	Introduction to design and its classification, basic design procedure, standards and codes, engineering materials and its classification, stress – strain diagram, selection of failure theories, design of simple machine parts.	6 lectures
Unit II	Design of power screws, Belt drives.	8 lectures
Unit III	Design of joints: riveted, bolted and welded joints, knuckle and cotter joints.	8 lectures
Unit IV	Design of shafts, keys and couplings.	10 lectures
Unit V	Design of helical and leaf springs	10 lectures

Books:

1. Bhandari, V.B., Design of Machine Elements, Tata McGraw Hill, 2nd Edition, 2007.
2. Spotts, M.F., Shoup, T.E., Hornberger, L.E. Jayram, S.R., and Venkatesh, C.V., Design of Machine Elements, Pearson Education, 8th Edition, 2006.
3. Juvinall, R.C. and Marshek K.M., Fundamentals of Machine Component Design, Wiley, 3rd Edition, 2007.

ME23105	**Instrumentation and Control: 4 Credits (3-0-2)**	
Unit I	Measurement systems and performance (accuracy, range, resolution, error sources). Instrumentation system elements: sensors for common engineering measurements; Signal processing and conditioning.	6 lectures
Unit II	Laplace and Inverse Laplace Transformations, Convolution Theorem, Linearization, Control systems: basic elements, open/closed loop.	6 lectures
Unit III	Mathematical modelling of different systems (electrical, mechanical, thermal, fluid, etc.), Block diagram, Signal flow diagram, Mason's rule, Modelling of control system elements (pneumatic, hydraulic, electric motors, etc.). State space modelling.	10 lectures
Unit IV	Time domain response analysis of std test signals, Representation of systems, First and Second order system response with steady state errors and different control actions (P, PD, PI, PID). Routh-Hurwitz stability criterion.	12 lectures
Unit V	Root locus analysis of the systems, Frequency domain response, Nyquist stability criterion, Bode/polar plots.	8 lectures

Books:

1. Ogata, K., Modern Control Engineering, Pearson Education Asia, 4th Edition, 2002.
2. Kuo, B.C. and Golnaraghi, F., Automatic Control Systems, John Wiley, 8th Edition, 2002.

3. Bolton, W., Instrumentation and Control Systems, Newnes, 2nd Edition, 2015.
4. McMillan, G.K., Process/Industrial Instruments and Controls Handbook, McGraw-Hill: NewYork, 5th Edition, 1999.
5. Beckwith, T.G., Marangoni, R.D., Mechanical Measurements, John H., Lienhard V, Pearson Education India, 6th Edition, 2007.

ME 23201	**Manufacturing Technology: 5 Credits (4-0-2)**	
Unit I	Tooling for conventional and non-conventional machining processes: Mould and die design, Press tools, Cutting tools; Holding tools: Jigs and fixtures, principles, applications and design; press tools – configuration, design of die and punch; principles of forging die design.	12 lectures
Unit II	Metrology: Dimensions, forms and surface measurements, Limits, fits and tolerances; linear and angular measurements; comparators; gauge design; interferometry; Metrology in tool wear and part quality including surface integrity, alignment and testing methods; tolerance analysis in manufacturing and assembly. Process metrology for emerging machining processes such as micro-scale machining, Inspection and workpiece quality.	16 lectures
Unit III	Assembly practices: Manufacturing and assembly, process planning, selective assembly, Material handling and devices.	8 lectures
Unit IV	Linear programming, objective function and constraints, graphical method, Simplex and duplex algorithms, transportation assignment, Travelling Salesman problem; Network models: shortest route, minimal spanning tree, maximum flow model.	10 lectures
Unit V	Project networks: CPM and PERT, critical path scheduling; Production planning& control: Forecasting models, aggregate production planning, materials requirement planning. Inventory Models: Economic Order Quantity, quantity discount models, stochastic inventory models, practical inventory control models, JIT. Simple queuing theory models.	10 lectures

Books:

1. Kalpakjian and Schmid, Manufacturing processes for engineering materials, Pearson India, 5th Edition, 2014.
2. Jain, R.K., Engineering Metrology, Khanna Publishers, 2005.
3. Taha, H.A., Operations Research, Prentice Hall of India, 6th Edition, 2003.
4. Shenoy, G.V. and Shrivastava, U.K., Operations Research for Management, Wiley Eastern, 1994.
5. Gupta P.K. and Hira, D.S., Operation Research, S. Chand & Co. Ltd., 5th Edition, 2008.

ME23202	**Machine Design: 4 Credits (3-0-2)**	
Unit I	Attributes of design, design philosophy and design process, design evaluation methods, linear weighting scale method, AHP model, and failure theories. Design under fatigue loading: Stress concentration, reduction of stress concentration effects, fluctuating stresses, fatigue failures, endurance limit, notch sensitivity, SN diagrams, reverse unit stress design in fatigue, Soderberg and Goodman diagram, fatigue design under combined loading.	12 lectures
Unit II	Design of spur, helical, bevel, rack & pinion and worm gears. Standard system of gears, Lewis equation, design of gear tooth based on strength and wear.	10 lectures
Unit III	Sliding contact bearing and lubrication: Basic module of lubrication, Petroff's law, stable lubrication, thick film lubrication, hydrodynamic lubrication theory, design consideration of hydrostatic and hydrodynamic bearings.	8 lectures
Unit IV	Rolling element bearings: Bearing life, bearing load, selection of ball, straight roller and taper roller bearings, lubrication.	8 lectures

Unit V	Systems approach to design: decision making/simulation of mechanical systems using CAD tools, sensitivity analysis of design parameters, overview of design optimization.	4 lectures

Books:

1. Sheigley, J.E., Mechanical Engineering Design, McGraw Hill, 5th Edition, 1988.
2. Bhandari, V.B., Design of Machine Elements, Tata Mcgraw Hill, 2nd Edition, 2007.
3. Spotts, M.F., Shoup, T.E., Hornberger, L.E., Jayram, S.R., and Venkatesh, C.V., Design of Machine Elements, Pearson Education, 8th Edition, 2006.
4. Juvinall, R.C. and Marshek, K.M., Fundamentals of Machine Component Design, Wiley Student Edition, 5th Edition, 2007.
5. Design Data Book of Engineers, PSG College of Technology, Publisher K. Achchagam, Coimbataore, 2009.

ME24101	**Automation in Manufacturing: 3 Credits (3-0-0)**	
Unit I	Introduction: Why automation, Current trends, CAD, CAM, CIM; Rigid automation: Part handling, Machine tools. Flexible automation: Computer control of Machine Tools and Machining Centers, NC part programming.	6 lectures
Unit II	Assembly system and line balancing: line balancing methods, Automated Material handling and storage system: AGV, SGV, AS/RS etc, Assembly automation, Flexible fixturing.	6 lectures
Unit III	Computer Aided Design: Fundamentals of CAD - Hardware in CAD - Computer Graphics Software and Data Base, Geometric modeling for downstream applications and analysis methods; Computer Aided Manufacturing: CNC technology, PLC, Micro controllers, CNC - Adaptive Control.	12 lectures
Unit IV	Low cost automation: Mechanical and Electro mechanical Systems, Pneumatics and Hydraulics, PLC controlled systems vs. Hard wired ladder logic system, Illustrative Examples and case studies.	10 lectures
Unit V	Introduction to Modeling and Simulation: Product design, process route modeling, Optimization techniques, Case studies and industrial applications.	8 lectures

Books:

1. Groover, M.P., Automation, Production Systems and Computer-Integrated Manufacturing, Pearson Education, 4th Edition, 2016.
2. Kalpakjian, S. and Schmid, S.R., Manufacturing–Engineering and Technology, Pearson, 7th Ed., 2018.
3. Yoram, K., Computer Control of Manufacturing Systems, McGraw Hill Education, 1st edition, 2017.
4. Zeid, I. and Sivasubramanian, R., CAD/CAM: Theory and Practice, McGraw Hill Education, 2nd edition, 2009.
5. David W.P., Industrial Automation-Circuit Design and Components, Willy India Pvt. Ltd., 2011.

ME24102	**Mechanical Vibrations: 3 Credits (3-0-0)**	
Unit I	Generalized coordinates, constraints, virtual work, Hamilton's principle, Lagrange's equations, discrete and continuous system.	9 lectures
Unit II	Response of discrete systems, SDOF & MDOF: free vibration, periodic excitation and Fourier series, impulse and step response, convolution integral, vibration absorbers and vibration isolation.	9 lectures
Unit III	Modal analysis: un-damped and damped non-gyroscopic, un-damped gyroscopic, and general dynamical systems, effect of damping.	8 lectures
Unit IV	Continuous systems: free and forced vibrations of strings, bar and beams using analytically, and approximate method (AMM/FEM).	10 lectures
Unit V	Vibration measurement techniques.	6 lectures

Books:

1. Thomson, W.T., Theory of Vibration with Applications, Prentice Hall, 4th Ed., 1993.
2. Meirovitch, L., Principles and Techniques of Vibrations, Prentice Hall International (PHI), 1997.
3. Tse, F.S., Morse, I.E., and Hinkle, R.T., Mechanical Vibrations, CBS Publ., 1983.
4. Dukkipati, R.V. and Srinivas, J., Mechanical Vibration, PHI, 2nd Ed., 2012.
5. Rao, J.S. and Gupta, K., Theory and Practice of Mechanical Vibrations, New Age Publication, 2nd Ed., 1995.

ME24201	**Energy Conversions Techniques: 3 Credits (3-0-0)**	
Unit I	Steam power systems, steam generator, introduction draught - natural draught, induced draught, forced draught and balance draught, calculation of chimney height, and chimney diameter, condition for maximum discharge through the chimney, steam jet draught, chimney efficiency, evaporation rate, performance, boiler efficiency, factor affecting boiler efficiency, boiler trial, heat balance.	8 lectures
Unit II	Introduction and classification of steam nozzles, isentropic flow in nozzle, velocity of steam leaving the nozzle, p-V, h-s and T-S diagram, classification of steam turbine, impulse turbine& reaction turbine, pressure compounded impulse turbine, velocity compounded impulse turbine, impulse-reaction turbine, velocity diagrams.	8 lectures
Unit III	Performance of steam turbine, diagram efficiency, energy converted to heat by friction, stage efficiency, velocity diagram for parsons' reaction turbine, degree of reaction of turbines. Regenerative cycles, reheat factor, governing of steam turbine, methods of governing, back pressure and pass out turbines.	10 lectures
Unit IV	Steam condenser, classification of steam condenser, jet and surface condenser, types of surface condenser, comparison of jet and surface condenser, mass of circulating water required in condenser, air removal methods, vacuum efficiency.	6 lectures
Unit V	Introduction to the non-conventional energy sources, energy conversion principles, new energy conversion methods, biomass, wind, solar, photovoltaic, biogas, biodiesel, fuel cells and MHD.	10 lectures

Books:

1. Culp, A.W., Principles of Energy Conversion, McGraw-Hill, 1991.
2. Kadambi, V. and Prasad, M., Energy Conversion (Vol. II & III), New Age International Private Limited, 2011.
3. Nag, P.K., Power Plant Engineering, McGraw Hill Education, 4th Edition, 2017.
4. Kearton, W.J., Theory and Practice of Steam Turbines, CBS Publishers & Distributers, 7th Edition, 2004.
5. El-Wakil M.M., Power Plant Technology, McGraw Hill Education, 2017.

ME23001	**Power Plant Engineering: 3 Credits (3-0-0)**	
Unit I	Coal based thermal power plants, basic Rankine cycle and its modifications, layout of modern coal power plant, super critical boilers, FBC boilers, turbines, condensers, steam and heating rates, subsystems of thermal power plants, fuel and ash handling, draught system, feed water treatment, binary cycles and cogeneration systems.	10 lectures
Unit II	Gas turbine and combined cycle power plants, Brayton cycle analysis and optimization, components of gas turbine power plants, combined cycle power plants, Integrated Gasifier based Combined Cycle (IGCC) systems.	8 lectures
Unit III	Basics of nuclear energy conversion, Layout and subsystems of nuclear power plants, Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANDU Reactor, Pressurized Heavy Water Reactor (PHWR), Fast Breeder Reactors (FBR), gas cooled and liquid metal cooled reactors, safety measures for nuclear power plants.	8 lectures

Unit IV	Hydroelectric power plants, classification, typical layout and components, principles of wind, tidal, solar PV and solar thermal, geothermal, biogas and fuel cell power systems.	8 lectures
Unit V	Energy, economic and environmental issues, power tariffs, load distribution parameters, load curve, capital and operating cost of different power plants, pollution control technologies including waste disposal options for coal and nuclear plants.	8 lectures

Books:

1. Nag, P.K., Power Plant Engineering, Tata McGraw Hill, 3rd Edition., 2008.
2. Wakil, M.M., Power Plant Technology, Tata McGraw Hill, 2010.
3. Elliot, T.C., Chen, K., and Swanekamp., R.C., Power Plant Engineering, McGraw Hill, 2nd Edition, 1998.
4. Rajput, R.K., Power Plant Engineering, Laxmi Publishers, 4th Edition, 2007.
5. Black, V. and Veatch, B., Power Plant Engineering, CBS Publishers & Distributers Pvt. Ltd., 1st Ed., 2005.

ME23002	**Two Phase Flow and Heat Transfer: 3 Credits (3-0-0)**	
Unit I	Definitions, properties of mixtures, review of one-dimension conservation equations in single phase flows, governing equations for homogeneous, separated and drift-flux models.	7 lectures
Unit II	Flow pattern maps for horizontal and vertical system, material handling, solid-liquid and solid-gas system, particle distribution, pressure variation.	7 lectures
Unit III	Simplified treatment of stratified, bubbly, slug and annular flows.	7 lectures
Unit IV	Thermodynamics of boiling, pool boiling – onset of nucleation, heat transfer coefficient, critical heat flux, effect of sub-cooling, flow boiling-onset of nucleation, heat transfer coefficients. Condensation-film and drop wise condensation.	14 lectures
Unit V	Fluidized bed heat transfer.	7 lectures

Books:

1. Wallis, G.B., One-Dimensional Two-Phase Flow, Tata McGraw-Hill, 1969.
2. Collier, J.G. and Thome, J.R., Convective Boiling and Condensation, Oxford University Press, 3rd Edition, 1996.
3. Holman, J.P. and Bhattacharyya, S., Heat Transfer, McGraw Hill Education, 10th Edition, 2017.
4. Kleinstreuer, C., Two-Phase Flow, Theory and Applications, Taylor & Francis, 2003.
5. Whalley, P.B., Boiling, Condensation and Gas-Liquid Flow, Oxford University Press, 1987.
6. Tong, L.S. and Tang, Y.S., Boiling Heat Transfer and Two-Phase Flow, Taylor & Francis, 2nd Edition, 1997.
7. Ishii, M. and Hibiki, T., Thermo-Fluid Dynamics of Two-Phase Flow, Springer, 2nd Edition, 2011.

ME23003	**Boundary Layer Theory: 3 Credits (3-0-0)**	
Unit I	Outline of fluid motion with friction, real and perfect fluids, viscosity and compressibility, similarity principles, comparison between theoretical experimental and numerical study of flow. concept of boundary layer, boundary layer separation and vortex formation.	4 lectures
Unit II	Navier-Stoke's equation, fundamental equation of motion and continuity applied to fluid flows, Stokes hypothesis and N-S equation.	8 lectures
Unit III	Simplification of N-S equation, normalization of N-S equation, order of magnitude and simplification of N-S equation, Prandtl's boundary layer theory & boundary layer equation.	6 lectures
Unit IV	Laminar boundary layer, boundary layer equation for 2–D incompressible flow, separation & control of boundary layer, momentum integral equation for boundary layer, some exact solutions, steady state boundary layer equation, flow past a wedge, flow in a convergent channel, flow past a cylinder. Introduction to thermal boundary layer, heat conduction equation from boundary layer equation, general properties of thermal boundary	14 lectures

	layers, forced and natural flows, adiabatic walls.	
Unit V	Approximate methods, approximate solution for flow over flat plate at zero incidence, flow past a circular cylinder, fundamentals of turbulent boundary layer, Reynolds equation, Prandtl's mixing length.	10 lectures

Books:

1. White, F.M., Viscous Fluid Flow, McGraw-Hill, 1991.
2. Duncan, W.J., Thom, A., and Young, A., Mechanics of Fluid, Arnold Publications, 1970.
3. Massey, B. and Smith, J.W., Mechanics of Fluids, Nelson Thornes Publications, 2001.
4. Schlichting, H. and Gersten, K., Boundary Layer Theory, Springer-Verlag, 2000.

ME23004	**Fluid Power Control Systems: 3 Credits (3-0-0)**	
Unit I	Introduction to fluid Power, hydraulics vs. pneumatics, properties of fluid, energy and power in hydraulic systems, distribution system, source of hydraulic power, positive displacement pumps, types, classifications, construction and operation of gear, vane (constant, variable delivery and pressure compensated and piston pumps (in-line and radial type), efficiency calculation, pump selection, pump performance.	8 lectures
Unit II	Fluid power actuators: Linear, single acting, double acting and telescopic, cylinder force, velocity and power, cylinder cushioning devices, cylinder mountings. Rotary or hydraulic motors, types – gear, vane and piston types, torque, power, flow rate and efficiencies, hydrostatic transmissions; Control components in hydraulic system valves, flow control valves, needle, pressure and temperature compensated valves, pressure control valves, relief – direct, compound &pilot operated, pressure - reducing, sequence valve, direction control valve: 3/2, 4/2, 4/3, 5/2 and check valve, center flow path configuration of 3 position d.c. valves: open centre, closed centre, tandem centre; cartridge valves, manually operated - solenoid operated valves, servo valves, proportional control valves.	10 lectures
Unit III	Symbols for hydraulic and pneumatic circuits. Hydraulic circuit design and analysis, speed control circuits such as meter-in, meter-out, bleed-off, and regenerative circuits, unloading circuit, counter balance circuit, cylinder synchronization, accumulator circuits, and failsafe circuits, trouble shooting of hydraulic circuits.	10 lectures
Unit IV	Pneumatic– air preparation and components, Basic pneumatic circuits – single & double acting, air pilot control, two step speed, two hand safety circuits, Cascade design of pneumatic circuits.	7 lectures
Unit V	Electric control of fluid power circuits, electrical components, electrical ladder diagram. Application of pneumatics in low cost automation, dual cylinder circuits, regenerative circuit, box-sorting system, programmable logic controllers (PLCs), PLC control of hydraulic/pneumatic cylinder and its ladder diagram, fluid power maintenance and safety, experiments on hydraulic and pneumatic circuits.	7 lectures

Books:

1. Esposito, A., Fluid Power with Applications, Pearson Education, 5th Edition, 2003.
2. Pipenger, J.J., Industrial Hydraulics, Tata McGraw Hill, 2000.
3. Majumdhar, S.R., Oil Hydraulics (Principles and Maintenance), Tata McGraw Hill Publishing Co., 2002.
4. Frankline, Y., Hydraulic and Pneumatic Power and Control, Tata McGraw Hill Publishing Co., 1966.
5. Goodwin, A.B., Fluid Power System, Palgrave Macmillan, 1976.
6. Manual on Pneumatic Principle and its Applications, Festo's Report, 2005.

ME23005	Refrigeration and Air Conditioning: 3 Credits (3-0-0)	
Unit I	Introduction, concept of heat engine, heat pump and refrigeration, efficiency and COP, Ideal refrigeration cycle, Reverse Carnot cycle, unit of refrigeration, refrigeration effect, different types of refrigeration systems, air refrigeration system, Bell Coleman cycle, Reverse Brayton cycle, ideal and actual cycle analysis, air cycles for aircraft, simple system, bootstrap system. regenerative system, reduced ambient system, concept of dry air rated temperature.	9 lectures
Unit II	Vapor compression refrigeration system, limitation of reversed Carnot cycle with vapor as a refrigerant, *P-V*, *T-s*, *P-h* diagram, actual vapour compression cycle and deviation from ideal conditions and their effects on cycle performance, use of tables and charts for solving problems, production of low temperature - compound vapor compression and cascade systems.	9 lectures
Unit III	Vapour absorption refrigeration systems, principles, different refrigerants absorbent combination, ideal and actual systems, ideal COP of absorption refrigeration systems, solar refrigeration.	4 lectures
Unit IV	Refrigerant types: Designation of refrigerants, their properties, desirable properties of an ideal refrigerants, selection of refrigerants, impact of refrigerants on global warming and ozone depletion, global warming potential and ozone depletion potential, environmentally friendly refrigerants, secondary refrigerants and its applications.	4 lectures
Unit V	Air Conditioning: Working substance in air conditioning, psychometric properties, wet bulb temperature, dry bulb temperature, thermodynamic wet temperature, relative humidity and humid specific heat, use of Psychometric chart, air conditioning processes, sensible and latent heating, humidification and dehumidification, SHF, BF, ADP, mixing of air streams, Comfort conditions, thermal exchange of body with environment, Factors affecting human comfort, effective temperature and comfort chart, principles of cooling load calculations, summer and winter air-conditioning, industrial air-conditioning. Introduction to steam jet refrigeration, thermoelectric refrigeration, vortex tube refrigeration and pulse tube refrigeration.	16 lectures

Books:

1. Arora and Domkundwar, Refrigeration and Air Conditioning, DhanpatRai and Sons, 2016.
2. Prasad, M., Refrigeration and Air Conditioning, New Age International Pvt. Ltd., 3rd Edition, 2015.
3. Ananthanarayanan, P.N., Basic Refrigeration and Air Conditioning, McGraw Hill Education, 4th Edition, 2013.
4. Dossat, R., Principles of Refrigeration, Pearson Education, 5th Edition, 2001.
5. Arora, C.P., Refrigeration and Air Conditioning, Tata McGraw-Hill, 3rd Ed., 2008.

ME23011	Non-Conventional Machining: 3 Credits (3-0-0)	
Unit I	Introduction of conventional and nontraditional machining (NTM), classification of NTM and need for NTM. EDM and ECM: Working principle, material removal mechanism, process parameters, characteristics and application.	9 lectures
Unit II	AJM: Mechanism of material removal and working principle, process parameters, machining characteristics, effect of process parameters on material removal rate (MRR), applications and limitations. USM: mechanism of material removal, process parameters, machining characteristics, effect of process parameters on material removal rate (MRR), applications and limitations.	8 lectures
Unit III	LBM and EBM: Basic mechanism of material removal, process parameters, applications and limitations.	8 lectures
Unit IV	Water jet machining, elevated temperature machining and cold temperature machining: material removal mechanism, applications and limitations.	8 lectures

Unit V	Basic mechanism of material removal and applications of chemical milling, chemical blanking, chemical engraving, electroforming.	9 lectures

Books:

1. Pandey, P.C. and Shah, H.S., Modern Machining Processes, McGraw Hill Education, 2017.
2. Jain, V.K., Advanced Machining Processes, Allied Publishers, 2007
3. Bhattacharyya, B. and Doloi, B., Modern Machining Technology: Advanced, Hybrid, Micro Machining and Super Finishing Technology, Academic Press, 2019.
4. Misra, P.K., Non-Conventional Machining, Narosa Publishers, 2007.
5. Ghosh, A. and Mallik, A.K., Manufacturing Science, East-West Press Pvt. Ltd., 2nd Edition, 2010.

ME23012	**Industrial Robotics: 3 Credits (3-0-0)**	
Unit I	Introduction to robotics, classification of robots and manipulators, industrial application of robots.	8 lectures
Unit II	Design criteria for end effectors and Problems related to design of grippers and robot models.	10 lectures
Unit III	Kinematics and dynamics of linkage with special emphasis to the open loop controls.	8 lectures
Unit IV	Actuators and drive elements, robot sensors and machine vision.	8 lectures
Unit V	Control of robots and manipulators, robot languages and programming.	8 lectures

Books:

1. Mittal, R.K. and Nagrath, I.J., Robotics and Control, McGraw Hill Publishing Co. Ltd., 2003.
2. Fu, K.S., Gonzalez, R.C., and Lee, C.S.G., Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill, 2008.
3. Craig, J.J., Introduction to Robotics, Addision Wesley, 2005.
4. Niku, S.B., Introduction to Robotics: Analysis, Control, Applications, Wiley Publication, 2nd Edition, 2010.
5. Koren, Y., Robotics for Engineers, McGraw Hill, 1985.
6. Horn, B.K.P., Robot Vision, MIT Press, Cambridge, 1986.

ME23013	**Composite Materials: 3 Credits (3-0-0)**	
Unit I	Introduction, materials, fiber reinforcement, matrix materials.	8 lectures
Unit II	Manufacturing processes, hand lay-up, bag molding, autoclave processing, compression molding, resin transfer molding, pultrusion, filament winding.	8 lectures
Unit III	Micro-mechanics: Strength of materials approach, continuum approach, Ply mechanics, co-ordinate systems, off-axis stiffness.	8 lectures
Unit IV	Macro-mechanics: Description of laminates, laminate moduli, computation of stresses in laminates.	8 lectures
Unit V	Types of joints, Mechanics of joints, Damages in joints, Failure criteria, (Strength of materials approaches & Fracture mechanics approach).	10 lectures

Books:

1. Jones, R.M., Mechanics of Composite Materials, Taylor & Francis, 1999.
2. Tsai, S.W. and Hahn, H.T., Mechanics of Composite Materials, Technomic Publishing Company, 1980.
3. Kaw, A.K., Mechanics of Composite Materials, CRC Press, 2006.
4. Zyong, K., Introduction of Composites Materials and Fibres, CRC Press, 2000.
5. Chawla, K.K., Composite Materials: Science and Engineering, Springer Science & Business Media, 2013.

ME23014	**Production Planning and Control: 3 Credits (3-0-0)**	
Unit I	Forecasting and methods of forecasting, forecasting errors, Delphi technological forecasting.	7 lectures
Unit II	Product design and development, optimisation in design, product design for environment, Eco indicators, new product development and life cycle assessment.	7 lectures
Unit III	Product planning and process planning, product anatomy, capacity planning, master production schedule, process and equipment selection,	7 lectures

	line balancing, manpower planning.	
Unit IV	Loading and scheduling of production systems, Dispatching and different types of dispatching for PPC, scheduling methods, Shortest Processing Time, Longest Processing Time, critical Ratio, Red tag method. Job loading on machines.	11 lectures
Unit V	Production control methods, systems concepts in PPC, dispatching, progressing, priority sequencing, functions of production control, material control, Johnsons algorithm for n jobs and m machines, assignment problems.	10 lectures

Books:

1. Eilon, S., Elements of Production Planning and Control, Universal Book Co., 1985.
2. King, J.R., Production Planning and Control, Pergamon Press, 1975.
3. Mukhopadhya S.K., Production Planning and Control -Text and Cases, PHI Ltd., 2010.
4. Plossi and Wight, Production and Inventory Control, Prentice Hall, 1967.
5. Arora, K.C., Production and Operations Management, Laxmi Publications, 2016.
6. Mukhopadhyay, S.K., Production Planning and Control, PHI Learning Pvt. Ltd., 3rd Edition, 2015.
7. Chapman, S.N., Fundamentals of Production Planning and Control, Pearson Education India, 2008.

ME 24001	**Internal Combustion Engines: 3 Credits (3-0-0)**	
Unit I	Review of basics of IC Engines, basic components and nomenclature, classification of IC engines, SI and CI engine, 2-stroke and 4-stroke engine, Engine performance parameters such as various efficiencies, average piston speed, specific fuel consumptions.	5 lectures
Unit II	Fuel-air cycle and their analysis, significance of cycle, comparison with air standard cycle, basis of cycle analysis, variable specific heat, Actual cycles and their analysis, time loss factor, heat loss factor, exhaust blow down, Fuels, classification, properties, characteristics and rating, Alternate fuels.	9 lectures
Unit III	Air and fuel induction, Carburetion – factors affecting carburetion, air-fuel mixture and requirements at different load and speeds, principle of carburetion, and essential parts of carburetor, calculation of air-fuel ratio, compensating devices, types of carburetors. Injection systems – functional requirement, classification, components of injection system, electronic injection systems.	8 lectures
Unit IV	Fluid motions in combustion chamber, turbulence, swirl, tumble, squish, cerevic flow, blow, combustion in SI Engine, stages of combustion, factors influencing flame speed, rate of pressure rise, abnormal combustion pre ignition, detonation, factors causing abnormal combustion, combustion chamber for SI Engines Combustion in CI Engine, stages of combustion, factors influencing delay period, knocking in CI engine, factors causing abnormal combustion, combustion chamber for CI Engines, comparison of knock in SI and CI engine.	10 lectures
Unit V	Engine heat transfer, variation of gas temperature, piston and cylinder temperature distribution, heat transfer, parameters affecting engine heat transfer, need for cooling systems, types of cooling system, fundamentals of engine friction and lubrication. Engine operating characteristics, heat balance, supercharged and turbo charged engine, Engine emission and their control.	10 lectures

Books:

1. Ganesan, V., Internal Combustion Engines, McGraw Hill Education, 4th Edition, 2012.
2. Heisler, H., Advanced Engine Technology, Edward Arnold, 1995.
3. Heywood, J.B, Internal Combustion Engine Fundamentals, McGraw Hill Book Co., NY, 1989.
4. Pulkrabek, W.W., Engineering Fundamentals of the Internal Combustion Engine, Pearson, 2nd Edition, 2015.
5. Stockel, M.W., Stockel, M.T., Johanson, C., Auto Fundamentals, Goodheart-Willcox, 12th Edition, 2020.

ME24002	Combustion Engineering: 3 Credits (3-0-0)	
Unit I	Energy sources, energy scenario, review of general fuel properties and their resources in Indian context, solid, liquid and gaseous fuels. Various refining methods of fossil fuels and nuclear fuels, synthetic and other fuels, hydro-carbon fuel testing, bio fuels, fuel cells, fuel preparation for combustion.	10 lectures
Unit II	Theories of combustion, burners and combustors for solid, liquid and gaseous fuels, fuel chemistry, thermodynamics of combustion, calculation of temperature and equilibrium flame gas composition for constant pressure and constant volume combustion.	8 lectures
Unit III	Premixed flames, theories of flame propagation, factors affecting propagation velocity, effects of turbulence, diffusion flames.	8 lectures
Unit IV	Burning rates of solid and liquid fuels, combustion of liquid, droplet and fuel sprays, combustion of coal and pulverized particles in air, combustion in engines.	8 lectures
Unit V	Gas turbine combustion system, stoichiometric and combustion reactions, flue gas analysis.	8 lectures

Books:

1. Sharma, S.P. and Mohan, C., Fuels and Combustion, Tata McGraw Hill, 1987.
2. Kanury, A.M., Introduction to Combustion Phenomena, Gordon & Beach Science Pub., 1977.
3. Francis, W., Fuels and Fuel Technology (Vol. I & II), Pergamon Press, 1982.
4. Brame, J.S.S. and King, J.G., Fuels – Solid, Liquid and Gaseous, Edward Arnold, 1956.
5. Mukunda, H.S., Understanding Combustion, Macmillan, 1992.
6. Kuo, K.K., Principles of Combustion, Wiley, 2nd Ed., 2005.
7. Turns, S.R., An Introduction to Combustion, Tata McGraw Hill, 2nd Ed., 2000.

ME24003	Compressible Flow: 3 Credits (3-0-0)	
Unit I	Review of fluid dynamics and thermodynamics principles and concepts, generalized energy equation, energy equation for compressible flow, compressibility correction factor, stagnation and critical state parameters.	6 lectures
Unit II	Isentropic flow with variable area, subsonic, supersonic nozzle and diffuser. Nozzle operation, nozzle choking, over expansion and under expansion.	7 lectures
Unit III	Normal shock analysis, hugoniot equation, oblique shock-tangential velocity superposition on normal shock, oblique shock analysis, shock strength, weak and strong shocks, attached and detached shocks, pressure and entropy changes across a Mach wave.	10 lectures
Unit IV	Isentropic turn of supersonic flow, Prandtl meyer flow, expansion fans and compression waves.	7 lectures
Unit V	Effects of friction on compressible flow (Fanno flow), effect of heat transfer (Rayleigh flow), flow choking. combined effect of friction and heat transfer, compressible flow measurement, supersonic wind tunnels. Flight speed measurement, optical techniques – schlieren technique and interferometer, computational methods in compressible flow.	12 lectures

Books:

1. Zucker, R.D., Fundamentals of Gas Dynamics, John & Wiley, 2002.
2. Rathakrishnan, E., Gas Dynamics, PHI, 2012.
3. Shapiro, A., The Dynamics and Thermodynamics of Compressible Flow, The Ronald Press Co., 1954.
4. Zuckrow, J. and Hoffman, J., Gas Dynamics (Vol. I & II), Wiley International, 1976.
5. Anderson, J.D., Modern Compressible Flow, Tata McGraw Hill, 1989.

ME24004	Heat Exchanger Design: 3 Credits (3-0-0)	
Unit I	Introduction to heat exchanger, types and constructional details, baffles design criteria, selection of material and type for typical application, use of hand book, and tables, charts.	7 lectures
Unit II	Design of various types of exchangers such as double pipe counter flow exchanger, double pipe series, parallel exchangers.	7 lectures
Unit III	Tubular exchangers, tubular gas after cooler, tubular gas inter cooler, atmospheric cooler, electric resistance heater.	7 lectures
Unit IV	Condenser; Horizontal and vertical, surface condenser, Shell and tube condenser, plate condenser, air cooled condenser, direct contact condenser, condenser for refrigeration and air-conditioning, thermal design of shell and tube condenser.	7 lectures
Unit V	Evaporators: Raw water evaporators, power plant, make up evaporator, saltwater distiller, thermo compression cane sugar evaporator, thermal analysis of evaporator, standards for evaporators and condensers. Vaporizing exchanger, kettle reboiler, thermo syphon reboiler, extended surfaces, fix heat exchanger, direct contact transfer equipment.	14 lectures

Books:

1. Kern, D.Q., Process Heat Transfer, McGraw Hill, 1950.
2. Kern, D.Q., Extended Surface Heat Transfer, McGraw Hill, 1972.
3. Shah R.K. and Sekulic, D.P., Fundamentals of Heat Exchanger Design, John Wiley & Sons, 2003.
4. Cengel, Y.A., Heat Transfer: A Practical Approach, McGraw Hill Pulblising Co. Ltd., 2002.
5. Hewitt, G.F., Shires, G.L., and Bott, T.R., Process Heat Transfer, CRC Press, 1994.
6. Das, S.K., Process Heat Transfer, Narosa Publishing House, 2005.

ME24005	Energy Management: 3 Credits (3-0-0)	
Unit I	Energy classification, Sources, utilization. Energy conversion principles of steam power plants, gas turbine, internal combustion engines, hydraulic turbines, wind turbines, fuel cells, etc. Solar energy: Sources, reserves and technologies, photovoltaic devices, design of solar energy operated systems.	10 lectures
Unit II	Introduction to energy management, need for energy management, energy management program, organizational structure, energy policy, planning of energy management program, energy accounting, monitoring and reporting.	8 lectures
Unit III	Energy Audit: The energy audit concept. Elements of energy audit. Presentation of energy audit report. Analysis of energy audit report of resident, different industries, etc.	8 lectures
Unit IV	World energy scenario, Indian energy scenario, concept of energy conservation, energy conservation objectives, approaches to energy conservation, barriers to energy conservation, measurement of energy conservation. Energy conservation technologies such as cogeneration, waste heat recovery, combined cycle power generation, etc.	8 lectures
Unit V	Conventional and non-conventional energy applications: case studies.	8 lectures

Books:

1. Culp, A.W., Principles of Energy Conversion, McGraw Hill, 2nd Edition, 1991.
2. Capehart, B.L., Turner, W.C., Kennedy, W.J., Guide to Energy Management, The Fairmont Press, Inc., 8th Edition, 2016.
3. Callaghan, P.O., Energy Management, McGraw Hill Professional, 1993.
4. Kaiser, V., Industrial Energy Management, Technip Publications, 1993.
5. Diwan, P. and Yaqoot, M., Energy Management, Pentagon Energy Press, 2010.
6. Goswami, D.Y. and Kreith, F., Energy Conversion, CRC Press, 2nd Edition, 2017.
7. Doty, S., Turner, Wayne, C., Energy Management Handbook**,** The Fairmont Press, Inc., 8th Edition, 2012.

ME24011	Numerical Control and CAM: 3 Credits (3-0-0)	
Unit I	Introduction to NC; Advantages and application; NC Classifications: PTP, Straight cut, Contouring; Structure of NC machine tools; Punched tape formats.	8 lectures
Unit II	Introduction to Computer Numerical Control (CNC); Open and closed loop control; Designation of axes, drives & actuation systems, feedback devices, CNC tooling, automatic tool changers & work holding devices. DNC; Communication systems; PLC; LAN in manufacturing.	9 lectures
Unit III	CNC Programming: Manual part programming: PTP drilling, Milling and Turning; APT Programming, Geometric and motion commands, Post processor commands; Programming of components; Computer aided part programming of PTP, Continuous path machining.	9 lectures
Unit IV	Introduction to group technology (GT); Part classification & coding: OPTIZ system; GT cell formation; Introduction to Computer Aided Process Planning (CAPP); Variant and Generative approaches, advantages of CAPP; CAD/CAM and CIM.	8 lectures
Unit V	Introduction to FMS, AGVS, Automated material handling and storage systems: AGV, AS/RS, etc.; Introduction to robotics; Shop floor control.	8 lectures

Books:

1. Koren, Y., Computer Control of Manufacturing System, Tata Mc-Graw Hills, New Delhi, 2006.
2. Kundra, T.K., Rao, P.N., and Tiwari, N.K., Numerical Control and Computer aided manufacturing, Tata Mc-Graw Hill Publishing Company Limited, New Delhi, 2001.
3. Groover, M.P., Automation, Production system & Computer Integrated Manufacturing System, Pearson Education Asia, 2008.
4. Valentino, J.V. and Goldenberg, J., Introduction to Computer Numerical Control, Prentice Hall, Englewood Cliff, New Jersey, 5th Edition, 2012.
5. Suh Suk-Hwan, Kang Seong-Kyoon, Chung Dae-Hyuk, Stroud Ian, Theory and Design of CNC Systems, Springer-Verlag London Limited, 2008.
6. Groover, M.P. and Zimmers, E.W., CAD/CAM: Computer Aided Design and Manufacturing, Pearson Education India, 2006.

ME24012	Management of Production Systems: 3 Credits (3-0-0)	
Unit I	Job, Batch, Mass, cellular production systems, automation in production systems, MLT and itsmathematical models, material handling.	7 lectures
Unit II	AGVS, TTW, productivity engineering, and methods of improvement, cost analysis, marketing and sales, inventory, production planning and control.	7 lectures
Unit III	Automated layout and flow analysis, systems concepts in production systems CAD, CAM &CIM, Future factories and MAP, group technology and FMS.	12 lectures
Unit IV	Shop-floor management techniques, Job card design, work centers, work study, time study applications.	7 lectures
Unit V	Quality circles, productivity quality teams, TQM, ISO 9000, work force planning.	9 lectures

Books:

1. Chary, S.N., Production and Operations Management, Tata Mc-Graw Hill Publishing Company Limited, New Delhi, 6th Edition, 2019.
2. Buffa, E.S., Modern Production and Management, Wiley, 8th Edition, 2007.
3. Mukhopadhyay, S.K., Production Planning and Control, PHI Learning Pvt. Ltd., 3rd Edition, 2015.
4. Telsang, M.T., Industrial Engineering and Production Management, S Chand & Co., 3rd Edition, 2018.
5. David W.P., Industrial Automation - Circuit Design and Automation, Wiley India Pvt. Ltd., 2011.

ME24013	Total Quality Management: 3 Credits (3-0-0)	
Unit I	Introduction, need for quality, evolution of quality; Definitions of quality, product quality and service quality; Basic concepts of TQM, TQM framework, contributions of Deming, Juran and Crosby. Barriers to TQM; Quality statements, customer focus, customer orientation & satisfaction, customer complaints, customer retention; costs to quality.	10 lectures
Unit II	TQM principles; leadership, strategic quality planning; Quality councils - employee involvement, motivation; Empowerment; Team and Teamwork; Quality circles, recognition and reward, performance appraisal; Continuous process improvement; PDCE cycle, 5S, Kaizen; Supplier partnership, Partnering, Supplier rating and selection.	8 lectures
Unit III	The seven traditional tools of quality; New management tools; Six sigma - concepts, methodology, applications to manufacturing, service sector including IT, Bench marking process; FMEA - stages, types.	8 lectures
Unit IV	TQM tools and techniques, control charts, process capability, concepts of six sigma, Quality Function Development (QFD), Taguchi quality loss function; TPM - concepts, improvement needs, performance measures.	6 lectures
Unit V	Quality systems, need for ISO 9000, ISO 9001-9008; Quality system - elements, documentation; Qualityauditing, QS9000, ISO14000 - concepts, requirements and benefits; TQM implementation in manufacturing and service sectors.	10 lectures

Books:

1. Besterfield, D.H. et al., Total Quality Management, 3rd ed., Pearson Education Asia, 2006.
2. Evans, J.R. and Lindsay, W.M., The Management and Control of Quality, Cengage Learning, 8th Edition, 2012.
3. Janakiraman, B. and Gopal, R.K., Total Quality Management, Prentice Hall India, 1st Ed., 2006.
4. Suganthi, L. and Samuel, A., Total Quality Management, Prentice Hall India, 2006.
5. Mukherjee, P.N., Total Quality Management, PHI Learning Pvt. Ltd., 2006.

ME24014	Intelligent Manufacturing Systems: 3 Credits (3-0-0)	
Unit I	Introduction to manufacturing and intelligent systems, historical of developments, their applications to manufacturing, types of intelligence - biological, computational and artificial, basic concepts of artificial intelligence, neural networks, fuzzy logic, genetic algorithm and expert systems.	8 lectures
Unit II	Taxonomy of Knowledge and Knowledge based systems - knowledge representation - knowledge acquisition and optimization, Case studies for manufacturing. Knowledge based system for material selection - Intelligent process planning system.	10 lectures
Unit III	Intelligent system for equipment selection - Intelligent system for projects management and factory monitoring, Machine intelligence and its sub-systems, methods of machine intelligence measurement and machine intelligence quotient (MIQ).	8 lectures
Unit IV	The role of Artificial Intelligence In the factory of future - Intelligent systems, Industry 4.0 and its application domains, cyber physical systems and communication systems.	8 lectures
Unit V	Manufacturing scheduling the shop floor - Diagnosis & trouble shooting, Computer based scheduling, Robotics and Programmable logic controllers.	8 lectures

Books:

1. David W. Pessen, Industrial Automation: Circuit Design and Automation, Willy India Pvt. Ltd., 2011.
2. Mohammad H. Hassoun, Fundamentals of Artificial Neural Networks, PHI Pvt. Ltd., 2007.
3. Geoge J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy logic Theory and Applications, PHI Pvt. Ltd., 2007.
4. Elaine A. Rich, Artificial Intelligence in Theory and Practice, third edition, Tata McGraw Hill, 2017.
5. Mohammed Jamshidi, Design and Implementation of Intelligent Manufacturing Systems, Pearson Education India, 2008.
6. L. Underwood, Intelligent Manufacturing, Universities Press, 2008.
7. Kusiak, A., Intelligent Manufacturing Systems, Prentice-Hall International, 1990.

ME24021	Numerical Analysis: 3 Credits (3-0-0)	
Unit I	Mathematical Preliminaries: Continuity of a Function and Intermediate Value Theorem; Mean Value Theorem for Differentiation and Integration; Taylor's Theorem (1 and 2 dimensions). Floating-Point Approximation of a Number; Loss of Significance and Error Propagation; Stability in Numerical Computation.	8 lectures
Unit II	Linear Systems: Gaussian Elimination; Pivoting Strategy; LU factorization; Residual Corrector Method; Solution by Iteration; Conjugate Gradient Method; Ill-Conditioned Matrices, Matrix Norms; Eigenvalue problem - Power Method; Gershgorin's Theorem.	8 lectures
Unit III	Nonlinear Equations: Bisection Method; Fixed-Point Iteration Method; Secant Method; Newton Method; Rate of Convergences; Solution of a System of Nonlinear Equations; Unconstrained Optimization.	6 lectures
Unit IV	Interpolation by Polynomials: Lagrange Interpolation; Newton Interpolation and Divided Differences; Hermite Interpolation; Error of the Interpolating Polynomials; Piecewise Linear and Cubic Spline Interpolation; Trigonometric Interpolation; Data Fitting and Least-Squares Approximation Problem.	8 lectures
Unit V	Differentiation and Integration: Difference formulae; Some Basic Rules of Integration; Adaptive Quadratures; Gaussian Rules; Composite Rules; Error Formulae. Differential Equations: Euler Method; Runge-Kutta Methods; Multi-Step Formulae; Predictor-Corrector Methods; Stability and Convergence; Two Point Boundary Value Problems.	12 lectures

Books:

1. Hamming, R.W., Numerical Methods for Scientists and Engineers, Dover Publications, New York, 2nd Edition, 2012.
2. Isaacson, E. and Keller, H.B., Analysis of Numerical Methods, Courier Corporation, 2012.
3. Cheney.W. and Kincaid, D., Numerical Mathematics and Computing, 3rd Edition, Brooks/Cole Publishing, 1994.
4. Atkinson, K., An Introduction to Numerical Analysis, John Wiley & Sons, 2nd Edition, 1989.
5. Shastry, S.S., Introductory Methods of Numerical Analysis, PHI, 5th Edition, 1984.
6. Epperson, J.F., An Introduction to Numerical Methods and Analysis, Wiley, 2nd Edition, 2013.
7. Rice, J.R., Numerical Methods, Software, and Analysis, McGraw-Hill, 1983.

ME24022	Principles of Tribology: 3 Credits (3-0-0)	
Unit I	Introduction to Tribology: Surfaces - Nature of metal surfaces, surface properties, surface parameters and measurements, Fundamental of Contact between Solids, Surface Treatment and coatings. Measurements - ASTM standards related to Tribo tests, Pin on Disc test for wear and friction measurement, Tests for fretting and Galling, Surface roughness and topography measurements, Surface profilometry, Atomic Force Microscopy.	10 lectures
Unit II	Lubricants: Physical Properties, Viscosity measurements, Viscosity Pressure Relationships. Lubricant classification, Thermal and Optical Properties. Additives in Lubricants and its composition. Interpretation of various acronyms printed on commercial lubricants pack.	8 lectures
Unit III	Friction: Introduction to friction, theories of friction, adhesion and ploughing friction. Types of wear, wear mechanisms, factors affecting wear, material selection for different wear situation, Anti wear coatings with particular emphasis to cutting tools.	8 lectures
Unit IV	Lubrication: Theory of hydrodynamic lubrication, Reynolds equation, assumptions and simplifications, variable density and compressibility, hydrodynamic journal bearings, pressure equation for short and finite bearings, journal bearing parameters, friction in journal bearings.	8 lectures

Unit V	Industrial Tribology: Industrial lubrication, Gear Oils, Hydraulic Oils, Grease, Solid and Special lubricants, Bearing failures, Bearing Maintenance, Diagnostics, Preventive measures in tribologicalcomponents. Basics of Elasto-hydrodynamic Lubrication, Boundary and Extreme pressure lubrication.	8 lectures

Books:

1. Majumdar, B.C., Introduction to Tribology, Wheeler Publishing, 2000.
2. PrasantaSahoo, Engineering Tribology, PHI Learning Pvt. Ltd., New Delhi, 2011.
3. Bhushan, B., Principles and Applications of Tribology, John Wiley & Sons, 2013.
4. Stachowiak, G. and Batchelo, A., Engineering Tribology, Butterfly-Heinemann, 4th Ed., 2013.
5. Szeri, A.Z., Fluid Film Lubrication, Cambridge University Press, 2nd Edition, 2010.
6. Wen, S. and Huang, P., Principles of Tribology, John Wiley & Sons, 2017.
7. Majumder, B.C., Introduction of Tribology for Bearing, S. Chand & Company, 2nd Edition, 2008.

ME24023	**Engineering Materials: 3 Credits (3-0-0)**	
Unit I	Structure of solids: Classification of engineering materials, Structure-property relationship in engineering materials, Crystalline and non-crystalline materials, Miller Indices, Crystal planes and directions, Determination of crystal structure using X-rays, Inorganic solids, Silicate structures and their applications. Defects; Point, line and surface defects.	7 lectures
Unit II	Mechanical properties of materials: Elastic, Anelastic and Viscoelastic behaviour, Engineering stress and engineering strain relationship, True stress - true strain relationship, review of mechanical properties, Plastic deformation by twinning and slip, Movement of dislocations, Critical shear stress, Strengthening mechanism, and Creep.	7 lectures
Unit III	Equilibrium diagram& Materials selection: Solids solutions and alloys, Gibbs phase rule, Unary and binary eutectic phase diagram, Examples and applications of phase diagrams like Iron - Iron carbide phase diagram; Overview of properties of engineering materials, Selection of materials for different engineering applications.	10 lectures
Unit IV	Electrical and magnetic materials: Conducting and resistor materials, and their engineering application; Semi conducting materials, their properties and applications; Magnetic materials, Soft and hard magnetic materials and applications; Superconductors; Dielectric materials, their properties and applications. Smart materials: Sensors and actuators, piezoelectric, magnetostrictive and electrostrictive materials.	9 lectures
Unit V	Surface Protection and New Generation Materials: Corrosion, Cause of corrosion, Types of corrosion, Protection against corrosion, Surface treatment process in industry, automotive and consumer durable painting and powder coating; Composites, Smart Materials and Nano Materials.	9 lectures

Books:

1. Callister, W.D., Materials Science and Engineering, John Wiley & Sons, Singapore, 2002.
2. Smith, W.F., Principles of Materials Science and Engineering: An Introduction, Tata Mc-Graw Hill, 2008.
3. Budinski, Engineering Materials – Properties and Selection, Pearson Education India, Ninth Edition, 2016.

ME24024	**Computer Aided Design and Graphics: 3 Credits (3-0-0)**	
Unit I	Introduction: A typical product cycle, CAD tools for the design process of product cycle, CAD / CAM system evaluation criteria, Input / Output devices; Graphics Displays Systems (Refresh display, DVST, Raster display, pixel value and lookup table), estimation of graphical memory, LCD, LED fundamentals.	4 lectures
Unit II	Concept of Coordinate Systems, Line and Curve generation algorithm: DDA, Bresenham's algorithms. Graphics exchange standards and Database management systems. Geometric Transformations: Homogeneous representation; Translation, Scaling, Reflection, Rotation, Shearing in 2D and 3D; Orthographic and perspective projections. Window to View-port transformation.	14 lectures

Unit III	Design of Curves and Surfaces: Parametric representation of lines: Locating a point on a line, parallel lines, perpendicular lines, distance of a point, Intersection of lines. Parametric representation of circle, Ellipse, parabola and hyperbola. Synthetic Curves: Concept of continuity, Cubic Spline: equation, properties and blending. Bezier Curve: equations, properties; Properties and advantages of B-Splines and NURBS. Various types of surfaces along with their typical applications.	12 lectures
Unit IV	Mathematical representation of solids: Geometry and Topology, Comparison of wireframe, surface and solid models, Properties of solid model, properties of representation schemes, Concept of Half-spaces, Boolean operations. Schemes: B-rep, CSG, Sweep representation, ASM, Primitive instancing, Cell Decomposition and Octree encoding.	7 lectures
Unit V	Finite Element Analysis: Using FEM based package, solve (1-D problems, trusses and beam problems and higher order problems (CST, etc.)	5 lectures

Books:

1. Zied, I., CAD/ CAM: Theory and Practice, McGraw-Hill, 2009.
2. Hearn, D and Baker, M.P., Computer Graphics, Prentice-Hall, 1994.
3. Dixit, U.S., Finite Element Methods for Engineers, Cengage Learning, 2009.
4. Sarcar, M.M.M., Rao K.M., Narayan, K.L., Computer Aided Design and Manufacturing, PHI Learning Pvt. Ltd., 2008.
5. Groover, M.P., CAD/CAM: Computer-Aided Design and Manufacturing, Pearson Education India, 2006.

ME24031	**Finite Element Methods: 3 Credits (3-0-0)**	
Unit I	Introduction: historical background, basic concept of the finite element method, comparison with finite difference method, directs FEM formulations. variational methods: calculus of variation, the Rayleigh-Ritz and Galerkin methods.	10 lectures
Unit II	Finite element analysis of 1-D problems: formulation by different approaches (direct, potential energy and Galerkin), derivation of elemental equations and their assembly, solution and its post-processing.	8 lectures
Unit III	FEM application: Heat transfer and solid mechanics problems (rod, beam, truss and frame), eign value and time dependent problems, discussion about preprocessors, postprocessors and finite element packages.	8 lectures
Unit IV	Finite element analysis of 2-D problems: finite element modeling of single variable problems, triangular and rectangular elements, applications in heat transfer, and solid mechanics.	6 lectures
Unit V	Numerical considerations: numerical integration, error analysis, mesh refinement. Plane stress, plane strain problems and bending of plates.	10 lectures

Books:

1. Dixit, U.S., Finite Element Methods for Engineers, Cengage Learning India Pvt. Ltd., 1st Edition, 2009.
2. Reddy, J.N., An introduction to the Finite Element Method, McGraw-Hill, New York, 3rd Edition, 2005.
3. Cook, R.D., Malkus, D.S., and Plesha, M.E., Concepts and Applications of Finite Element Analysis, John Wiley, New York, 3rd Ed., 1989.
4. Bathe, K.J., Finite Element Procedures in Engineering Analysis, Prentice-Hall, Englewood Cliffs, NJ, 1st Ed., 1996.
5. Zienkiewicz, O.C. and Taylor, R.L., The Finite Element Method, McGraw-Hill, 3rd Edition, 1989.

ME24032	**Fracture Mechanics: 3 Credits (3-0-0)**	
Unit I	Introduction and historical review: Sources of micro and macro cracks, Stress concentration due to elliptical hole, Ideal Strength of materials, Griffith's energy balance approach. Fracture mechanics approach to design, NDT and Various NDT methods used in fracture mechanics, The Airy stress function. Effect of finite crack size. Numerical problems.	8 lectures

Unit II	Stress Analysis of Members with Cracks: Linear elastic fracture mechanics, Crack tip stress and deformations, Relation between stress intensity factor and fracture toughness, Stress intensity based solutions. Crack tip plastic zone estimation, Plane stress and plane strain concepts. The Dugdale approach, the thickness effect.	8 lectures
Unit III	Elastic – Plastic Fracture Mechanics: Introduction, Elasto–plastic factor criteria, crack resistance curve, J-integral, Crack opening displacement, crack tip opening displacement. Importance of R-curve in fracture mechanics, experimental determination of J-integral.	8 lectures
Unit IV	Fatigue and Fatigue Crack Growth Rate and Resistance: Introduction, the dynamic stress intensity and elastic energy release rate, crack branching, the principles of crack arrest, the dynamic fracture toughness. Fatigue loading, various stages of crack propagation, the load spectrum, approximation of the stress spectrum, the crack growth integration, fatigue crack growth laws. Fracture criteria, fatigue cracking criteria, effect of alloying and second phase particles, effect of processing and anisotropy, effect of temperature.	8 lectures
Unit V	Computational Fracture Mechanics and Testing: Overview of numerical methods, traditional methods in computational fracture mechanics – stress and displacement marching, elemental crack advance, virtual crack extension, the energy domain integral, finite element implementation. Limitations of numerical fracture analysis. Specimen size requirements, various test procedures, effects of temperature, loading rate and plate thickness on fracture toughness. Fracture testing in shear modes, fatigue testing.	10 lectures

Books:

1. Prasant Kumar, Fracture Mechanics, McGraw Hill, 2005.
2. Rolfe, S.T. and Barson, J.M., Fracture and fatigue control in structures, Prentice-Hall Incorporated, 1977.
3. Broek, D., Elementary Engineering Fracture Mechanics, 4th Revised Edition, Springer, 2012.
4. Hartzberg, R.W., Deformation and Plastic Deformation of Engineering Materials, Willey Publishers, 1989.
5. Parton, V.Z., Elastic Plastic Fracture Mechanics, Taylor and Francis, 1992.

ME24033	**Theory of Elasticity: 3 Credits (3-0-0)**	
Unit I	Surface and body forces, stress tensor and transformation laws, Lagrangian and Eulerian description, strain tensor, equations of elasticity (equilibrium, constitutive law and compatibility, boundary conditions), uniqueness and St. Venant's principle, strain energy functions.	8 lectures
Unit II	Two-dimensional problems: In rectangular coordinates (polynomial solution, bending of beam, Fourier series solution). In polar coordinates (axi-symmetric problems – rotating discs, wall cylinders, plate with a hole, infinite plate with point load, curved beams).	8 lectures
Unit III	Two-dimensional problems in curvilinear coordinates: stress functions in terms of harmonic and complex functions, complex potential function, elliptic coordinates, and plate with elliptic holes.	6 lectures
Unit IV	Three-dimensional problems (extension of bar under its body weight, pure bending of bars and plates, twist of circular shafts).	8 lectures
Unit V	Torsion (circular and non-circular cross section, membrane analogy, thin wall members, hydrodynamic analogy). Bending of bars with circular, elliptic and rectangular cross section and shear center.	12 lectures

Books:

1. Timoshenko, S.P. and Goodier, J.N., Theory of Elasticity, McGraw-Hill, 3rd Edition, 1970.
2. Sokolnikoff, S., Mathematical Theory of Elasticity, McGraw-Hill, 2nd Edition, 1957.
3. Fung, Y.C., Foundation of Solid Mechanics, Prentice Hall, 1965.
4. Zhilun, X., Applied Elasticity, Willey Eastern Ltd., 1992.

ME24034	Rotor Dynamics: 3 Credits (3-0-0)	
Unit I	Introduction to Vibration and the Laval-Jeffcott Rotor Model: Co-ordinate systems, Steady state rotor motion, Elliptical motion, Single degree of freedom systems, Free and forced vibrations. The two degrees of freedom rotor system, Geared systems, Translational motion, Natural frequencies and Natural modes, Steady state response to unbalance, The effect of flexible support, Whirling and Operating deflection curve.	10 lectures
Unit II	Torsional Vibrations: Modeling of rotating machinery shafts, Multi degree of freedom systems, Determination of natural frequencies and mode shapes, Branched systems, Numerical methods for fundamental frequency.	6 lectures
Unit III	Dynamics of Rigid Rotors: Difference between rigid rotor and flexible rotor, Rigid disk equation, Gyroscopic effects, Whirling of an unbalanced simple elastic rotor, Unbalance response, Orbital Analysis and Cascade Plots, Simple shafts with several disks, Effect of axial stiffness, Determination of bending critical speeds, Campbell diagram.	10 lectures
Unit IV	Rotor-bearing interaction: Effect of support stiffness on critical speeds, Stiffness and damping coefficients of journal bearings, Computation and measurements of journal bearing coefficients, Mechanics of Hydrodynamic Instability, Half frequency whirl and Resonance whip, Design configurations of stable journal bearings.	8 lectures
Unit V	Modelling of Rotor system with MATLAB (or GNU Octave) and Balancing of Rotors: Introduction to MATLAB codes for solving ordinary differential equations, Simulink model development, Modelling rotor with Simulink, FFT with MATLAB, Modelling ramp up and coast down of rotors, Hilbert envelope and Hilbert transform. Single plane balancing, Multi-plane balancing, Balancing of rigid rotors, Balancing of flexible rotors, Influence coefficient and modal balancing techniques for flexible rotors.	8 lectures

Books:

1. Rao, J.S., Rotor Dynamics, New Age International Publishers, New Delhi, 3rd Edition, 1996.
2. Genta, Gincarlo, Dynamics of Rotating Systems, Springer Science + Business Media Inc., 233 Spring Street, New York, 2005.
3. Friswell, M., Penny, J., Garvey, S., and Lees, A., Dynamics of Rotating Machines, Cambridge University Press, 32 Avenue of the Americas, New York, 2010.

ME22221	Basics of Mechanical Engineering: 2 Credits (2-0-0)	
Unit I	Introduction to engineering thermodynamics: Thermodynamic systems and surroundings, thermodynamic properties, states, processes and cycles, heat and work transfer, path function and point function, thermodynamic equilibrium, quasi-static processes, flow and non flow processes, thermodynamic laws and their applications.	6 lectures
Unit II	Introductory heat transfer: Conduction, convection & radiation, heat flow through building materials, simple power generating equipments like boiler, turbines and IC engines.	5 lectures
Unit III	Engineering materials: (cast iron, steel and their alloys) properties, various heat treatment and manufacturing processes, fibers and composites, applications of composite materials.	6 lectures
Unit IV	Introduction to the machine tools: Introduction to working principles of Lathe, construction of lathe, drilling, shaping and milling machines, types of cutting tools, selection of cutting speeds, feeds.	5 lectures
Unit V	Introduction to theory of machines: Kinematics and kinetics, mechanism and structures, various mechanisms of practical use, fundamentals of kinematics, degree of freedom and its determination, lower pairs and higher pairs, types of motions, links, joints and kinematic chains, inversions, graphical velocity and acceleration analysis.	6 lectures

Books:

1. Nag, P.K., Engineering Thermodynamics, TMH, 2005.
2. Ballaney, P.L., Thermal Engineering, Khanna Publishers, 3rd Edition, 2009.
3. Choudhary, S.K.H., Choudhary, A.K.H., and Roy, N., Elements of Workshop Technology (Vol. I & II), Media Promoters & Publishers Pvt. Ltd., 2007.
4. Rattan, S.S., Theory of Machines, TMH, New Delhi, 1991.
5. Bawa, H.S., Material and Metallurgy, TMH, 1986.

ME24041	**Non-Conventional Energy Source: 3 Credits (3-0-0)**	
Unit I	Energy sources, classification, importance of non-conventional energy sources, advantages and disadvantages of non-conventional energy sources, environmental aspect of energy, energy storage, necessity of energy storage, energy storage methods.	6 lectures
Unit II	Solar radiation: extraterrestrial radiations and terrestrial radiations, solar radiation geometry, solar time, solar day length, solar radiation measurement on horizontal and inclined surfaces, solar thermal systems, solar collectors, classification, performance indices. Liquid flat plate collector and their components, efficiency, solar thermal system applications, photovoltaic devices.	8 lectures
Unit III	Wind energy: Origin of wind, factor affecting the distribution of wind on the surface of earth, nature of wind, wind turbines, components of wind turbine, wind energy conversion systems, types of wind machines: horizontal and vertical axis wind rotors performance.	8 lectures
Unit IV	Bio-mass: Introduction, photosynthesis process, bio fuels, biomass resources, recycling of agricultural wastes, Biomass conversion technologies, types, digester, urban waste to energy conversion, biomass gasification.	8 lectures
Unit V	MHD, thermoelectric, thermionic, thermo nuclear fusion technology, hydroelectric (mini and macro hydropower), Fuel cell, OTEC, geothermal.	12 lectures

Books:

1. Black and Veatch, Power Plant Engineering, CBS Publishers & Distributers Pvt. Ltd., 1st Ed., 2005.
2. Rai, G.D., Non-Conventional Energy Source, Khanna Publishers, 6th Edition, 1988.
3. Parikh, J., Energy Models: 2000 and Beyond, Tata McGraw Hill, 1997.
4. Ghosh, B., Saha, S.K., and Basu, S., Towards Clean Energy, Tata McGraw Hill, 1998.
5. Goswami, D.Y., Kreith, F., Kreider, J. F., Principles of Solar Engineering, CRC Press, 2nd Edition, 2015.

ME24042	**Operations Research: 3 Credits (3-0-0)**	
Unit I	Introduction to linear programming introduction, feasible solution, equality principle, formulation procedures, Simplex algorithm and its variants, sensitivity analysis, dual simplex method.	9 lectures
Unit II	Application of LP to transportation & assignment problems, Introduction to integer programming, cut plane method.	9 lectures
Unit III	Introduction to dynamic programming, goal programming, game theory, nonlinear programming.	9 lectures
Unit IV	Queuing theory, Poisson's arrival, exponential service times, basic equation, single channel models, simulation, Monte Carlo techniques, use of random numbers, applications in maintenance problems, optimal size of repair crew and queuing.	7 lectures
Unit V	Inventory and product control problem, EOQ, production run, shortage, quantity discount, ABC analysis, replacement models, capital equipment, PV, ARP, IRP, Payoff period, MAPI method.	8 lectures

Books:

1. Iyer, P.S., Operations Research, Tata McGraw Hills, New Delhi, 2009.
2. Rao, S.S., Engineering Optimization, New Age International (P) Limited, 3rd Edition, 2004.
3. Taha, H.A., Operations Research, Pearson Education India, 2008.
4. Sharma, J.K., Operations Research: Theory and Applications, Macmillan, 4th Edition, 2009.
5. Gupta P.K. and Hira, D.S., Operation Research, S. Chand & Co. Ltd., 5th Edition, 2008.

ME24043	**Mechatronics Systems: 3 Credits (3-0-0)**	
Unit I	Introduction: Definition of Mechanical Systems, Mechatronics approach, Types, Open and closed loop system, Mechatronics system components, Various application of mechatronics system, Man-Machine Interface.	6 lectures
Unit II	Digital logic fundamentals: Different logic gates: AND, OR, NOT, NOR, XOR, NAND gates, its Boolean/ truth table representation, wave form representation; Combination gates; Sequential logic gates; Design of logic gates; Flip-flops, Counters, Decoder design, and registers.	8 lectures
Unit III	Sensors & Transducers: LVDT, Strain gauge, bimetallic strip, photo-electric sensors, Opto-electronics-Shaft encoders, proximity sensors, flow sensors, velocity and acceleration sensors; Sensors in robotics; Vision System, etc. Smart materials used in sensors. Drives and Actuators: Electrical Actuators such as servo motor and Stepper motor, Drive circuits, Hydraulic and Pneumatic drives: system components, Circuit design for automation.	12 lectures
Unit IV	Programmable logic controllers: Parts of PLC – PLC programming, Ladder logic diagramming, Electrical relay operation, Timer instructions: On Delay, Off Delay, etc. Applications of PLC – Simple materials handling applications, Automatic control of warehouse door, Automatic Conveyor belt, motor control, Automatic car washing machine, Bottle label detection and process control application, etc. Embedded Systems.	8 lectures
Unit V	Micro mechatronics systems: Micro sensors, Micro actuators; Micro-fabrication techniques LIGA Process: Lithography etching, Micro-joining, etc. Application examples; Case studies Examples of Mechatronics Systems from Robotics Manufacturing, Machine Diagnostics, Road vehicles and Medical Technology.	8 lectures

Books:

1. David G. Alciatore and Michael B. Histand, Introduction to Mechatronics and Measurement Systems, Tata McGraw-Hill Publishing Co. Ltd., 2nd Edition, 2003.
2. Bolton, W., Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Prentice Hall, 2003.
3. Bolton, W, Mechatronics: A Multidisciplinary Approach, Pearson Education, 2014.
4. Bishop, R.H., Mechatronics Systems, Sensors, and Actuators: Fundamentals and Modeling, CRC Press, 2017.
5. HMT, Mechatronics, TMH.

ME24044	**Wind and Solar Energy Systems: 3 Credits (3-0-0)**	
Unit I	Physics of Wind Power: History of wind power, Indian and Global statistics, Wind physics, Betz limit, Tip speed ratio, stall and pitch control, Wind speed statistics - probability distributions, Wind speed and power - cumulative distribution functions.	6 lectures
Unit II	Wind generator topologies: Review of modern wind turbine technologies, Fixed and Variable speed wind turbines, Induction Generators, Doubly-Fed Induction Generators and their characteristics, Permanent-Magnet Synchronous Generators, Power electronics converters. Generator-Converter configurations, Converter Control.	12 lectures

Unit III	The Solar Resource: Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.	6 lectures
Unit IV	Solar photo voltaic: Technologies-Amorphous, mono crystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Power Electronic Converters for Solar Systems, Maximum Power Point Tracking (MPPT) algorithms. Converter Control.	6 lectures
Unit V	Network Integration Issues: Overview of grid code technical requirements. Fault ride-through for wind farms - real and reactive power regulation, voltage and frequency operating limits, solar PV and wind farm behavior during grid disturbances. Power quality issues. Power system interconnection experiences in the world. Hybrid and isolated operations of solar PV and wind systems. Solar thermal power generation: Technologies, Parabolic trough, central receivers, parabolic dish, Fresnel, solar pond, elementary analysis.	12 lectures

Books:

1. Ackermann, T., Wind Power in Power Systems, John Wiley and Sons Ltd., 2nd Edition, 2005.
2. Sukhatme, S.P. and Nayak, J.K., Solar Energy: Principles of Thermal Collection and Storage, McGraw Hill Education, 3rd Edition, 2008.
3. Heier, S. and Waddington, R., Grid Integration of Wind Energy Conversion Systems, John Wiley and Sons Ltd., 2nd Edition, 2006.
4. Tiwari, G.N. and Ghosal, M.K., Renewable Energy Resources: Basic Principles and Applications, Narosa Publishing House, 2004.
5. Duffie, J.A. and Beckman, W.A., Solar Engineering of Thermal Processes, John Wiley & Sons, 4th Edition, 2013.

DEPARTMENT OF CHEMISTRY

CY21101	Plant Biochemistry: 2 Credits (1-0-2)	
Unit I	Chemistry of carbohydrates: classification, mono, di and poly saccharides, anomerism, epimerism, mutarotation, configuration of sugars and inversion.	2 lectures
Unit II	Chemistry of lipids: classification, simple lipids and phospholipids. Fatty acids and fat constants, lipids of chloroplast, membrane lipids.	3 lectures
Unit III	Chemistry of amino acids, peptides and proteins: classification, levels of protein structure. Chemistry of nucleic acids – N bases, sugars; Enzymes – classification, enzyme kinetics, enzyme inhibition, allosteric enzymes, lysozymes, coenzymes.	3 lectures
Unit IV	Metabolism of carbohydrates: glycolysis, TCA cycle, HMPshunt, glyoxylic acid cycle, electron transport chain. Lipids metabolism – beta oxidation and fatty acid biosynthesis.	3 lectures
Unit V	Photosynthesis: light reaction, dark reaction, Hill's reaction, photo respiration, C4 pathway, C3 and C4 plants, CO2 fixation, regulation of photosynthesis. Plant hormones and their mode of action.	3 lectures

Books:

1. Conn, E.E. and Stumpf, P.K. (1989). Outlines of Biochemistry, Wiley Eastern Ltd., New Delhi.
2. Mazur, A. and Harrows, B. (1971). Text book of Biochemistry. W.B. Sanders Publications, New Delhi.
3. Robert, C.B. (1983). Modern Concepts in Biochemistry. Allyn and Bacon Inc., London.
4. William, H.E. and Daphne, C.E. (2005). Biochemistry and Molecular Biology, Oxford University Press.
5. Lehninger, Nelson, D.L. and Michael, M.C. (2004), Principles of Biochemistry, Freeman Publishers.

CY21202	Engineering Chemistry – B: 5 Credits (3-1-2)	
Unit I	Water Technology: Boiler feed water-hardness, its units and determination; scale and sludge formation, boiler corrosion, caustic embrittlement, priming, foaming and their prevention. Conditioning (internal and external): phosphate, carbonate and Calgon conditioning; sodalime, zeolite and ion-exchange processes. Municipal water, water treatment (purification, coagulation, filtration and disinfection) for municipal supply.	10 lectures
Unit II	Metallurgy: General methods of extraction of metals, Extraction of Iron, Aluminium and Germanium. Alloys and their significance: Composition, properties and uses of stainless steel, Invar, Alnico, Tungsten Steel, Brass, Bronze, Gun metal, Duralumin, Magnalium and Soft solders.	10 lectures
Unit III	Corrosion and its prevention: Definition, theories of corrosion (chemical and electrochemical) and their mechanism. Factors affecting the rate of corrosion. Prevention of corrosion.	7 lectures
Unit IV	Macromolecules: Classification, addition and condensation polymers, molecular weight of polymers (M_n, M_w, M_v), glass transition temperature (T_g), structure - property relationship in polymers (Chemical, electrical, optical and mechanical), examples and uses of inorganic polymers, synthesis of some commercially important polymers and their uses (Nylon 66, Nylon 6, PE, PET, PS).	10 lectures
Unit V	Spectroscopy: Fundamentals of spectroscopic techniques, basic principles of electronic and vibrational spectroscopy.	5 lectures

Books:

1. Principles of Physical Chemistry, B. R. Puri, L. R. Sharma and M. S. Pathania, 48th Edition, 2019, Vishal Publishing Co., Jalandhar.
2. Physical Chemistry, P. W. Atkins, 10th Ed., 2014, Oxford University Press, ELBS Ed., London.
3. A Text Book of Engineering Chemistry, S. S. Dara, 2013, S. Chand & Company Ltd., New Delhi.
4. Engineering Chemistry, B. Sivashankar, 2008, Tata McGraw-Hill Publishing Company Limited, New Delhi.
5. Engineering Chemistry, P. C. Jain and Monica Jain, 16th Ed., 2014, Dhanpat Rai and Co. Pvt. Ltd., Delhi.
6. Polymer Science, 1st Ed., 1986, V. R. Gowarikar, N. V. Wishwanathan and J. Sreedhar, Wiley-Eastern Ltd., New Delhi.

7. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, 4th Ed., 2017, Tata McGraw Hill, New Delhi.
8. A Text Book of Engineering Chemistry, Shashi Chawla, 3rd Ed., 2003, Dhanpat Rai and Co. Pvt. Ltd., New Delhi.

CY21201	**Engineering Chemistry – A: 5 Credits (3-1-2)**	
Unit I	Macromolecules: Classification, addition and condensation polymers, molecular weight of polymers (M_n, M_w, M_v), glass transition temperature (T_g), structure - property relationship in polymers (Chemical, electrical, optical, and mechanical), examples and uses of inorganic polymers, synthesis of some commercially important polymers and their uses (Nylon 66, Nylon 6, PE, PET, PS).	10 lectures
Unit II	Chemical Kinetics: Rate of reactions, Factors influencing rate of reactions, Molecularity and order of reaction, Rate expression and examples of first and second order reactions. Kinetics of chain reactions, parallel reactions, side reactions, kinetics of catalytic action (biological catalysis), application of catalyst in industrially important processes (Haber's process, Ostwald process, Bergius process).	8 lectures
Unit III	Corrosion and its prevention: Definition, theories of corrosion (chemical and electrochemical) and their mechanism. Factors affecting the rate of corrosion. Prevention of corrosion.	7 lectures
Unit IV	New Materials: Nanomaterials-Introduction, preparation (Synthesis-top down and bottom-up approaches), properties and applications of nanomaterials. Types, Properties and application of fullerenes, carbon nanotubes and nanowires. Nanoelectronics. Applications of nanomaterials in catalysis, telecommunication and medicine. E-Waste and its Management: E-Waste – Definition, sources of e-waste, hazardous substances in e-waste, effects of e-waste on environment and human health, need for e-waste management, e-waste handling rules, waste minimization techniques for managing e-waste, recycling of e-waste, disposal treatment methods of e- waste, global Scenario of E-waste, E-waste in India – case studies.	12 lectures
Unit V	Spectroscopy: Fundamentals of spectroscopic techniques, basic principles of electronic and vibrational spectroscopy.	5 lectures

Books:

1. Principles of Physical Chemistry, B. R. Puri, L. R. Sharma and M. S. Pathania, 48th Edition, 2019, Vishal Publishing Co., Jalandhar.
2. Physical Chemistry, P. W. Atkins, 10th Ed., 2014, Oxford University Press, ELBS Ed., London.
3. A Text Book of Engineering Chemistry, S. S. Dara, 2013, S. Chand & Company Ltd., New Delhi.
4. Engineering Chemistry, B. Sivashankar, 2008, Tata McGraw-Hill Publishing Company Limited, New Delhi.
5. Engineering Chemistry, P. C. Jain and Monica Jain, 16th Ed., 2014, Dhanpat Rai and Co. Pvt. Ltd., Delhi.
6. Polymer Science, 1st Ed., 1986, V. R. Gowarikar, N. V. Wishwanathan and J. Sreedhar, Wiley-Eastern Ltd., New Delhi.
7. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, 4th Ed., 2017, Tata McGraw Hill, New Delhi.
8. Palanisamy P. N., Manikandan P., Geetha, A., Manjula Rani, K. and Kowshalya V. N., Environmental Science, Revised Edition, Pearson Education, New Delhi, 2019.
9. Ludovico Cadimartiri and Geoffrey A. Ozin, Concepts of Nanochemistry, Wiley-VCH, 2009.
10. C.N.R. Rao, A. Muller and A.K. Cheetham, The Chemistry of Nanomaterials, Wiley – VCH Verlag GmbH & Co., 2004.

DEPARTMENT OF MATHEMATICS

MA21102	**Basic Mathematics: 2 Credits (2-0-0)**	
Unit I	Elementary idea of complex number; Arithmetic progression (AP). Geometric progression (GP): General term and sum of n terms.	5 lectures
Unit II	Elementary idea of permutation and combination; Binomial theorem for positive integral index; Any index and their applications.	5 lectures
Unit III	Trigonometric functions, sum and difference formulae; Sum to product, product to sum formula; Trigonometrical ratios of multiple; sub multiple and compound angle.	5 lectures
Unit IV	Function: algebraic, trigonometrical and exponential functions. Limit: properties of limit. Differentiation: product rule, quotient rule, chain rule, differentiation of trigonometrical function, logarithmic function. Maxima and Minima: simple application of maxima and minima. Integration: Integration of simple functions. Methods of integration and properties.	7 lectures
Unit V	Matrix: Operation of matrix. Determinant: properties of determinant; Solution of simultaneous linear equations by matrix method.	6 lectures

Books:

1. Chatterjee, S.K. (1970). Mathematical Analysis. Oxford & IBH.
2. Frank, A. (1962). Schaum's Outline of Theory and Problems of Matrices. McGraw-Hill.
3. Frank, A. (1967). Theory and Problems of Differential Equations. McGraw-Hill.
4. Gentle, J.E. (2007). Matrix Algebra: Theory, Computations and Applications in Statistics. Springer.
5. Narayan, S. (1953). A Text Book of Matrices. S. Chand and Company.
6. Parameswaran, S. (1976). An introduction to mathematics. Oxford & IBH Publishing Co.
7. Priestley, H.A. (1985). Introduction to Complex Analysis. Clarenton Press.
8. Walter, R. (1976). Principles of Mathematical Analysis. McGraw-Hill.

MA21202	**Statistical Methods and Experimental Designs: 3 Credits (2-0-2)**	
Unit I	Basic concepts: Types and sources of data, classification and tabulation of data. Construction of frequency distribution tables: grathical representation of data, simple, multiple components and percentage, bar diagram, pie diagram, histogram, frequency polygon and frequency curve average and measures of location; mean, median, mode; percentiles and quadrilles for raw and grouped data. Dispersion: Range, standard deviation, variance, coefficient of variation for raw and grouped data.	6 lectures
Unit II	Probability: Basic concept, additive and multiplicative laws. Theoretical distributions, binominal, poisson and normal distributions.	5 lectures
Unit III	Test of significance: basic concepts, tests for equality of means, independent and paired t-tests, Chi square tests for application of attributes and test for goodness to fit.	5 lectures
Unit IV	Correlation: scatter diagram, correlation co-efficient and its properties, regression, fitting of sample linear regression, tests of significance of correlation and regression co-efficient.	6 lectures
Unit V	Introduction to design of experiment, basic principles of experimental design-replication, randomization and local control; Analysis of variance-assumptions-construction of ANOVA table-conclusions based on ANOVA; Comparisons based on means-critical difference, DMRT; Transformations of data square root, logarithmic and angular transformations. Completely randomized design: layout, analysis, advantages and limitations; Randomised block design: layout, analysis, choice of no. of blocks, advantages and limitations. Latin square designs: layout, analysis, applications, advantages and limitations.	6 lectures

Books:

1. Anderson, R.L. and Banercxft, T.A. (1952). Statistical Theory in Research. Mc. Graw Hill Book Co., New Work.
2. Cochran, W.G. and Cox, G.M. (1958). Experimental Designs. Wiley, New York.
3. Das, M.N. and Giri, N.C. (1986). Design and Analysis of Experiments. Wiley Eastern Ltd., New Delhi.
4. Federer, W.T. (1955). Experimental Design. Macmillan, New York.
5. Gomez, K.A. and Gomz A.A. (1984). Statistical Procedures for Agricultural Research. John Wiley and Sons. New York.
6. Kempthorne, O. (1952). The Design and Analysis of Experiments. Wiley, New Work.
7. Nigam, A.K. and Gupta, V.K. (1979). Hand Book on Analysis of Agricultural Experiments. IASRI Publication. New Delhi.
8. Panse, V.G. and Skhatme, P.V. (1967). Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi.
9. Petersen Roger G. (1994). Agricultural Field Experiments: Design and Analysis. Marcel Dekker, New York.

MA21101	**Mathematics – I: 4 Credits (3-1-0)**	
Unit I	Successive differentiation, Leibnitz theorem, L. Hospital's rule, Limit, Continuity and differentiability of functions of two and three variables, partial differentiation, Euler's theorem for homogenous function. Maxima and Minima of function of two variables, Lagrange's multipliers.	10 lectures
Unit II	Infinite series: Comparison test, Ratio test, Cauchy's n^{th} root test, Raabe's test power series, radius of convergence, Taylor's and Maclaurin's series, curvature, curve tracing.	8 lectures
Unit III	Applications of definite integral, area between curves, length of a plane curve, surface area of revolution, volume of solids of revolution, Beta and Gamma functions.	9lectures
Unit IV	Solution of linear, exact differential equations, differential equation of order one but not of first degree, solvable by x, y, p., application of first order ordinary differential equations.	7 lectures
Unit V	Types of matrices, elementary operations; Echelon form; normal form, rank of a matrix, solution of system of linear equations, eigen values and eigen vectors, Cayley-Hamilton theorem, diagonalization.	8 lectures

Books:

1. A Text Book of Engineering Mathematics, N.P. Bali and M. Goyal, Laxmi Publications, 2014.
2. Schaum's Outline of Vector Analysis, M.R. Spiegel, 2009.
3. Engineering Mathematics, K.A. Stroud, Industrial Press Inc., 2013.
4. Calculus and Analytic Geometry, G.B. Thomas and R.L. Finey, Addison Wesley, 1996.
5. Linear Algebra, G. Hadley, Narosa, Reprint 2002.

MA21201	**Mathematics – II: 4 Credits (3-1-0)**	
Unit I	Linear differential equation of higher order with constant and variable coefficients, method of variation of parameters, Cauchy Euler's and Legendre's equations, series solution of ordinary differential equations with special emphasis on Legendre's and Bessel's differential equations; application of linear differential equation of second order.	10 lectures
Unit II	Fourier Series: Periodic function, Fourier series of a function with 2π period and arbitrary period, Fourier series of even and odd functions, half range Fourier sine and cosine series.	8 lectures
Unit III	Laplace transform and its properties; existence theorem; Laplace transform of derivatives, inverse Laplace transform; convolution theorem, use of Laplace transform in solving differential equations.	8 lectures
Unit IV	Fourier integral, Fourier transform, Fourier sine and cosine transforms and their elementary properties, applications of Fourier transforms in boundary value problems.	8 lectures

Unit V	Introduction to Z-transform and its convergence, Properties of Z-transform. Inverse Z-transform by Partial Fraction Method, Power Series Expansion, Convolution theorem.	8 lectures

Books:

1. Advanced Engineering Mathematics, E. Kreyszig, John Wiley & Sons, 1999.
2. Calculus and Analytical Geometry, G.B. Thomas and R.L Finney, Pearson, 2019.
3. Differential equations, S.L. Rose, Wiley.
4. Advanced Engineering Mathematics, R.K. Jain and S.R.K. Iyengar, Narosa Publishing House, 2016.
5. Higher Engineering Mathematics, B.S. Grewal, Khanna Publications, 1965.

MA22101	**Mathematics – III: 3 Credits (3-1-0)**	
Unit I	Introduction to limit, continuity and differentiability of complex function; analytic functions, singularity; Cauchy-Riemann equations, complex integration; Cauchy's integral theorem, Calculus of residues.	10 lectures
Unit II	Multiple integral: double and triple integrals, change of order of integration, change of variables, application of double and triple integrals.	7 lectures
Unit III	Vector Calculus**:** Gradient of a scalar point function, divergence and curl of a vector field, line and surface integrals; Green's theorem, Gauss's theorem; Stoke's theorem.	8 lectures
Unit IV	Introduction to partial differential equations, formation of PDE and solution of first order PDE by Lagrange's method; solution of 2^{nd} order linear partial differential equations by separation of variables, heat, wave and Laplace's equations; application of Fourier transforms in PDE.	9 lectures
Unit V	Random variables; discrete and continuous random variables, probability mass function and probability density function; probability distribution-Binomial, Poisson and normal distributions.	8 lectures

Books:

1. Advanced Engineering Mathematics, E. Kreyszig, John Wiley & Sons, 1999.
2. A Text Book of Engineering Mathematics, N.P. Bali and M. Goyal, Laxmi Publications, 2014.
3. Ordinary and Partial Differential Equations, M.D. Raisinghania, S. Chand & Company, 2005.
4. Higher Engineering Mathematics, B. S. Grewal, Khanna Publishers, Delhi, 2000.

DEPARTMENT OF PHYSICS

PH21101	Engineering Physics: 5 Credits (4-0-2)	
Unit I	Dia, para and ferromagnetism-classification, Langevin theory of dia and paramagnetism, Adiabatic demagnetization, Weiss molecular field theory and ferromagnetism, Curie-Weiss law.	8 lectures
Unit II	Wave particle quality, de-Broglie concept, uncertainty principle, Wave function, Time dependent and time independent Schrodinger wave equation.	8 lectures
Unit III	Qualitative explanation of Zeeman effect, Stark effect and Paschen-Back effect, Raman Spectroscopy.	8 lectures
Unit IV	Statement of Bloch's function, bands in solids, velocity of Bloch's electron and effective mass, Distinction between metals, insulators and semiconductors, Donor and acceptor levels, Superconductivity, critical magnetic field, Meissner effect, Isotope effect, Type-I and II superconductors, Josephson's effect DC and AC, Squids, Introduction to high Tc superconductors.	16 lectures
Unit V	Illumination: laws of illumination, luminous flux, luminous intensity, candle power, brightness, Spontaneous and stimulated emission, Einstein A and B coefficients, Population inversion, He-Ne and Ruby lasers, Ammonia and Ruby masers, Holography-Note, Optical fiber, Physical structure, basic theory, Mode type, input output characteristics of optical fiber and applications.	16 lectures

Books:

1. Text Book of Optics, Brijlal and Subrahmanyam, S. Chand and Co., New Delhi.
2. Optical State Physics and Fiber Optics, Sarkar Subit Kumar, S. Chand and Co., New Delhi.
3. Elements of Spectroscopy, Gupta S.L., Kumar V, Sharma RC, Pragati Prakashan, Meerut.
4. Concept of Physics, H.C. Verma, Volume 2, Bharati Bhawan Publishers.
5. Engineering Physics, D.K. Bhattacharya and T. Poonam, Oxford University Press.

PH21102	Introduction to Mechanics: 5 Credits (4-0-2)	
Unit I	Transformation of scalars and vectors under Rotation transformation; Forces in Nature; Newton's laws and its completeness in describing particle motion; Form invariance of Newton's Second Law; Solving Newton's equations of motion in polar coordinates; Problems including constraints and friction; Extension to cylindrical and spherical coordinates.	12 lectures
Unit II	Potential energy function; E = - Grad V, equipotential surfaces and meaning of gradient; Conservative and non-conservative forces, curl of a force field; Central forces; Conservation of Angular Momentum; Energy equation and energy diagrams; Elliptical, parabolic and hyperbolic orbits; Kepler problem; Application: Satellite manoeuvres.	10 lectures
Unit III	Non-inertial frames of reference; Rotating coordinate system: Five-term acceleration formula. Centripetal and Coriolis accelerations; Applications: Weather systems, Foucault pendulum. Harmonic oscillator, Damped harmonic motion – over-damped, critically damped and lightly-damped oscillators; Forced oscillations and resonance.	10 lectures
Unit IV	Definition and motion of a rigid body in the plane; Rotation in the plane; Kinematics in a coordinate system rotating and translating in the plane; Angular momentum about a point of a rigid body in planar motion; Euler's laws of motion, their independence from Newton's laws, and their necessity in describing rigid body motion; Examples.	10 lectures
Unit V	Introduction to three-dimensional rigid body motion – only need to highlight the distinction from two-dimensional motion in terms of (a) Angular velocity vector, and its rate of change and (b) Moment of inertia tensor; Three-	14 lectures

	dimensional motion of a rigid body wherein all points move in a coplanar manner, e.g., Rod executing conical motion with centre of mass fixed – only need to show that this motion looks two-dimensional but is three-dimensional, and two dimensional formulation fails.	

Books:

1. Engineering Mechanics, M. K. Harbola, Cengage; 2nd ed., 2013.
2. Introduction to Mechanics, M. K. Verma, Universities Press India Private Limited, 2nd ed., 2016.
3. An Introduction to Mechanics, D. Kleppner and R. Kolenkow, Cambridge University Press, 2nd ed., 2013.
4. Mechanics, J. P. Den Hartog, Dover Publications Inc., 2003.
5. Engineering Mechanics – Dynamics, J. L. Meriam, LG Kraige and J.N. Bolton, 8th ed., Wiley, 2018.
6. Mechanical Vibrations, J. P. Den Hartog, Dover Publications Inc., 1985.

PH21103	**Quantum Mechanics for Engineers: 5 Credits (4-0-2)**	
Unit I	Introduction to Quantum mechanics, Wave nature of Particles, Free-particle wave function and wave-packets, Uncertainty principle, Time-dependent and time-independent Schrodinger's equation, Born interpretation, probability current density, Expectation values.	10 lectures
Unit II	Complex numbers, Linear vector spaces, inner product, operators, eigenvalue problems, Hermitian operators, Hermite polynomials, Legendre's equation, spherical harmonics.	8 lectures
Unit III	Solution of stationary-state Schrodinger equation for one-dimensional problems – particle in a box, particle in attractive delta-function potential, square-well potential, linear harmonic oscillator. Numerical solution of stationary-state Schrodinger equation for one-dimensional problems for different potentials. Scattering from a potential barrier and tunnelling; related examples like alpha-decay, field-ionization and scanning tunnelling microscope. Three-dimensional problems: particle in three-dimensional box and related examples, Angular momentum operator, Rigid Rotor, Hydrogen atom ground-state, orbitals, interaction with magnetic field, spin. Numerical solution stationary-state radial Schrodinger equation for spherically symmetric potentials.	18 lectures
Unit IV	Particle in double delta-function potential, Molecules (hydrogen molecule, valence bond and molecular orbitals picture), singlet/triplet states, chemical bonding, hybridization.	10 lectures
Unit V	Free electron theory of metals, Fermi level, density of states, Application to white dwarfs and neutron stars, Bloch's theorem for particles in a periodic potential, Kronig-Penney model and origin of energy bands. Numerical solution for energy in one-dimensional periodic lattice by mixing plane waves.	10 lectures

Books:

1. Quantum Physics, R. Eisberg and R. Resnick, John Wiley & Sons, 2nd ed., 1985.
2. Quantum Mechanics, G. Aruldhas, Prentice Hall India Learning Private Limited, 2nd ed., 2008.
3. Quantum Mechanics:Theory and Applications, A.Ghatak and S.Lokanathan, Macmillan Publisher, 2012.
4. Quantum mechanics, D. J. Griffiths, Cambridge India, 2016.
5. Introduction to Solid State Physics, C. Kittel, Wiley, 8th ed., 2012.

PH21104	**Oscillations, Waves and Optics: 5 Credits (4-0-2)**	
Unit I	Mechanical and electrical simple harmonic oscillators; complex number notation and phasor representation of simple harmonic motion; damped harmonic oscillator-heavy, critical and light damping; energy decay in a damped harmonic oscillator; quality factor, forced mechanical and electrical oscillators, electrical and mechanical impedance, steady state motion of forced damped harmonic oscillator, power absorbed by oscillator.	10 lectures

Unit II	Transverse wave on a string, equation of wave on a string, harmonic waves, reflection and transmission of waves at a boundary, impedance matching, standing waves and their eigenfrequencies, longitudinal waves and wave equation for them, acoustics waves and speed of sound, standing sound waves; waves with dispersion, water waves, superposition of waves and Fourier method, wave groups and group velocity.	10 lectures
Unit III	Fermat's principle of stationary time and its applications, e.g., in explaining mirage effect, laws of reflection and refraction, light as an electromagnetic wave and Fresnel equations, reflectance and transmittance, Brewster's angle, total internal reflection and evanescent wave. Mirrors, lenses and optical instruments based on them, transfer formula of matrix method.	14 lectures
Unit IV	Huygens' principle, superposition of waves and interference of light by wavefront splitting and amplitude splitting, Young's double-slit experiment, Newton's rings, Michelson interferometer, Mach-Zehnder interferometer.	10 lectures
Unit V	Einstein's theory of matter radiation interaction, Einstein A and B coefficients; amplification of light by population inversion, different types of lasers: gas lasers (He-Ne, CO_2), solid-state lasers (Ruby, Neodymium), dye lasers; properties of laser beams: mono-chromaticity, coherence, directionality and brightness, laser speckles, applications of lasers in science, engineering and medicine.	12 lectures

Books:

1. Ian G. Main, Oscillations and Waves in physics, Cambridge University Press, 3rd ed., 1993.
2. H. J. Pain, The physics of vibrations and waves, Wiley, 6th ed., 2006.
3. E. Hecht, Optics, Pearson, 4th ed., 2001.
4. A. Ghatak, Optics, McGraw Hill Education India Private Limited, 6th ed., 2017.
5. O. Svelto, Principles of lasers, Springer, 5th ed., 2010.

PH21105	**Introduction to Electromagnetic Theory: 5 Credits (4-0-2)**	
Unit I	Calculation of electric field and electrostatic potential for a charge distribution; Divergence and curl of electrostatic field; Laplace's and Poisson's equations for electrostatic potential and uniqueness of their solution and connection with steady state diffusion and thermal conduction; Boundary conditions of electric field and electrostatic potential; method of images; energy of a charge distribution and its expression in terms of electric field.	10 lectures
Unit II	Electrostatic field and potential of a dipole. Bound charges due to electric polarization; Electric displacement; boundary conditions on displacement; Solving simple electrostatics problems in presence of dielectrics – Point charge at the centre of a dielectric sphere, charge in front of a dielectric slab.	10 lectures
Unit III	Bio-Savart law, Divergence and curl of static magnetic field; vector potential and calculating it for a given magnetic field using Stokes theorem. Magnetization and associated bound currents; auxiliary magnetic field; Boundary conditions. Solving for magnetic field due to simple magnets like a bar magnet; magnetic susceptibility and ferromagnetic, paramagnetic and diamagnetic materials; Qualitative discussion of magnetic field in presence of magnetic materials.	12 lectures
Unit IV	Faraday's law in terms of EMF produced by changing magnetic flux; equivalence of Faraday's law and motional EMF; Lenz's law; Electromagnetic breaking and its applications; Differential form of Faraday's law expressing curl of electric field in terms of time-derivative of magnetic field; energy stored in a magnetic field.	10 lectures
Unit V	Continuity equation for current densities; Modifying equation for the curl of magnetic field to satisfy continuity equation; Maxwell's equation in vacuum and non-conducting medium; Energy in an electromagnetic field; Flow of energy and Poynting vector with examples. The wave equation; Plane electromagnetic waves in vacuum, their transverse nature and polarization;	14 lectures

	relation between electric and magnetic fields of an electromagnetic wave; energy carried by electromagnetic waves and examples. Momentum carried by electromagnetic waves and resultant pressure.	

Books:

1. Introduction to Electrodynamics, David Griffiths, Cambridge University Press, 4th ed., 2020.
2. Electricity and Magnetism, D.C. Tayal, Himalaya Publishing House, 2014.
3. Physics, D. Halliday, R. Resnick and K. S. Krane**,** Wiley India Pvt. Ltd., 5th ed., 2017.
4. Introduction to Electromagnetic Theory, P. C. Clemmow, Cambridge University Press, 1973.

DEPARTMENT OF HUMANITIES AND SOCIAL SCIENCES

Open Elective – II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	HS24041	Managing Stress	3	0	0	3
2.	HS24042	Human Resource Management	3	0	0	3
3.	HS24043	Project Formulation, Analysis and its Management	3	0	0	3
4.	HS24044	Engineering Ethics	3	0	0	3

HS21101	**Communication Skills and Personality Development: 3 Credits (2-0-2)**	
Unit I	Communication Skills: Structural and functional grammar; meaning and process of communication, verbal and nonverbal communication; listening and note taking, writing skills, oral presentation skills; field diary and lab record; indexing, footnote and bibliographic procedures.	6 lectures
Unit II	Reading and comprehension of general and technical articles, precise writing, summarizing, abstracting; individual and group presentations, impromptu presentation, public speaking; Group discussion. Organizing seminars and conferences, Text – I, Text – II.	6 lectures
Unit III	Applied Grammar: Introduction to Word Classes. Structure of the Verb in English. Uses of Tenses. Study of Voice.	6 lectures
Unit IV	Use of Conjunctions and Prepositions. Sentence Patterns in English. Spoken English: Conversations of Different Situations in Everyday Life.	6 lectures
Unit V	The Concept of Stress, Stress Shift in Words and Sentences. Words with Silent Letters and their Pronunciations. The Basic Intonation Patterns.	4 lectures

Books:

1. Carroll, B.J. (1986). English for college, Macmillan India Ltd. New Delhi.
2. Hahn, “The Internet complete reference”, TMH.
3. Hornby, A.S. (1975). Guide to patterns and usage in English. Oxford University, New Delhi.
4. Qurik, R and Green Baum, S. (2002). A University grammar.

HS23102	**Entrepreneurship Development and Business Management: 2 Credits (2-0-0)**	
Unit I	Entrepreneurship Development: Assessment of business environment; Overview of social, political and economic systems for entrepreneurs in India; Globalization and the emerging business / entrepreneurial environment.	5 lectures
Unit II	Concept of entrepreneurship and characteristics of entrepreneurs; Motivation for entrepreneurship development; Importance of planning, monitoring, evaluation and follow-up for managing competition; entrepreneurship development programs.	6 lectures
Unit III	Government schemes and incentives for promotion of entrepreneurship. Government policy on Small and Medium Enterprises (SMEs)/SSIs. Public-private partnerships. Social Responsibility of Business organizations.	5 lectures
Unit IV	Export and Import Policies relevant to forestry sector. Contract farming and joint ventures; Overview of forestry inputs industry. Characteristics of Indian forestry processing and export industry.	5 lectures
Unit V	SWOT Analysis; Developing leadership skills, developing managerial skills, problem solving skill; Project planning formulation and Project Report preparation; Supply chain management and Total quality management.	7 lectures

Books:

1. Entrepreneurship: Starting a new Business, Anderson, Allied Publishers Ltd., New Delhi, 1991.
2. Entrepreneurship Development, Colombo Plan Staff College for Technician Education, Manila, Tata McGraw Hill, New Delhi, 1998.
3. Maslow, A.H., Motivation and personality, Harper and Row Publishers, New York, 1970.
4. Perelson, B. and Steiner, G., Human behaviour, Harcourt Brace Jovanovich, New York, 1964.

HS23202	Forest Economics and Marketing: 3 Credits (3-0-0)	
Unit I	Meaning of Economics; Divisions of economics; Importance of economics; Forest Economics; Meaning and importance of Goods, service, utility, value, price, wealth, growth and development.	8 lectures
Unit II	Theory of consumption; Utility and Indifference curve theory; Consumer surplus; Demand and supply theory; Types of markets; Market structures; Market equilibrium.	9 lectures
Unit III	Elasticity of demand and supply; Importance of elasticity of demand and supply for pricing of timber and non-timber products; Economics of timber and non-timber forest products; Forest planning–forest policy and development; Production theory and factor rewards of factors of production.	8 lectures
Unit IV	National Income; Concepts of Public finance; Inflation: deflection; Welfare economics; Meaning of Marketing; Marketing Process and its role.	9 lectures
Unit V	Basic guidelines and Techno-economic parameters for preparation of project proposals; SWOT analysis for business venture selection; Preparation of Bankable projects for forest and agri-based products projects; Identification of marketing channels for new products.	8 lectures

Books:

1. Dewett, K. K., Modern Economic Theory, S. Chand, New Delhi, 2005.
2. Dewett, K. K., Verma, Elementary Economic Theory, S. Chand, New Delhi, 2004.
3. Jhingan, M. L., Macro Economic Theory, Vrinda Publishers, New Delhi, 2012.
4. Reddy, S. S., Raghu Ram, P., Neelakanta Sastry, T. V., Bhavani, D.I., Agricultural Economics, Oxford and IBH Publishers, New Delhi, 2004.

HS23203	Marketing of Non-Timber Forest Products: 3 Credits (2-0-2)	
Unit I	Meaning of timber and non-timber forest produce (NTFP); Features and types of timber and non-timber forest produce and their markets; Price determination of timber and non-timber forest produce.	5 lectures
Unit II	Economic features of timber markets in terms of degree and type of competition; Cost and prices of pre-commercial thinning, commercial thinning, harvesting, hauling, sawing, transportation, treatment of wood, carpentry, and other processing activities involved in teakwood, rosewood, matchwood, pulpwood, sandalwood, veneers; Domestic demand and trade in timber and non-timber forest products. International demand and trade in timber and non-timber forest produce.	6 lectures
Unit III	Demand forecasting; Economic features of specialized markets in terms of degree and type of competition for bamboo, canes, lac, gums, resins, hides and skins. Services of saw mill and other intermediate wood processing industries.	6 lectures
Unit IV	Economics of processing pulp to paper/poly fiber; wood to plywood/veneers. Economics of gathering medicinal plants from forests, economics of processing medicinal plants. Role of cooperative societies in marketing of timber and non-timber forest produce.	6 lectures
Unit V	Economic Policy and Regulations of international timber trade. Essentials of World Trade Organization, GATT, Dunkel proposals, Intellectual Property Rights and Patenting. International Timber Trade Organization (ITTO) and timber certification.	5 lectures

Books:

1. Gray, J. W. (1993). Forest resource systems in Developing Countries. Food and agricultural organization. Rome.
2. ITTO. [International Tropical Timber Organisation]. (1993). The economic linkages between international trade in tropical timber and sustainable management of tropical forests. London environmental economic centre, International Institute for Environment and Development, London, UK.
3. ITTO. [International Tropical Timber Organisation]. (2012). Annual review and assessment of the world timber situation, Yogyakarta, Indonesia.

4. Kula, E. (1996). The economics of forestry: Modern theory and practice. Timber Press, Portland, Oregon.
5. Muraleedharan, P. K., Subramanian, K. K., and Pillai, P. P. (1998). Basic readings in Forest Economics. Kerala Forest Research Institute and Ford Foundation, Thrissur, Kerala.
6. Tewari, D. N. (1995). Marketing and trade of forest produce. International Book Distributors (Book Sellers & Publishers), Dehradun, India.

HS21201	**Communication Skills: 3 Credits (2-0-2)**	
Unit I	Applied Grammar and Usage; Parts of Speech, Sentence Construction, Subject-Verb-Agreement in English; Tenses, Voice; Punctuation and Vocabulary; Idioms and Figures of Speech.	6 lectures
Unit II	Communication Skills: Concepts and Types; Language and Communication; Meaning and Process of Communication, Verbal and Non-verbal Communication; Reading Writing and Listening Skills. Accent, Pitch, Pronunciation and Basic Intonation Patterns; Conversation.	6 lectures
Unit III	Reading and Comprehension: Characteristics and types of Essays; Text I (General/Personal/Technical essay) for detailed study.	6 lectures
Unit IV	Reading and Comprehension: Characteristics and types of Short Stories/Fiction; Text II (Short Story/Fiction) for detailed study.	5 lectures
Unit V	Writing Skills: Precís Writing, Summarizing and Abstracting; Field Diary and Laboratory Record; Indexing, Footnote, Endnote, Bibliographic Format and Referencing; Note Taking and Report Writing.	5 lectures

Books:

1. Carroll, B. J. 1986. English for College. Macmillan India Ltd., New Delhi.
2. Hahn, “The Internet complete reference”, TMH.
3. Hornby, A. S. 1975. Guide to Patterns and Usage in English. Oxford University, New Delhi.
4. Qurik, R. and Green baum, S. 2002. A University Grammar. Pearson, New Delhi.

HS22201	**Entrepreneurship and Startups: 3 Credits (3-0-0)**	
Unit I	Definition, Importance of entrepreneurship. Entrepreneurial values and attitudes; Innovativeness, risk-taking and analytical ability. Entrepreneurial motivation, Characteristics of entrepreneurs. Types of entrepreneurs, Rural entrepreneurship and women entrepreneurship.	8 lectures
Unit II	Launching a new Business Venture: Identification of investment opportunities, Project formulation, Project screening, Market analysis and demand Forecasting. Technical, Environmental and Managerial analysis of project proposals.	9 lectures
Unit III	Project Appraisal; Means of financing and working results estimation, Ratio Analysis, Depreciation of Assets, Break-even analysis, Qualitative methods for Project evaluation, Social Cost Benefit Analysis.	8 lectures
Unit IV	Financial Analysis; Pay-back period, Net Present Value Estimation, IRR calculation, Cost-benefit analysis.	9 lectures
Unit V	Definition of Start-up; Features of start-up, Start-up of India Programmes and its importance in Indian economy, Essentials of start-up schemes. SWOT Analysis, External environment of business venture, Socio-economic, political environment for undertaking starting self-employment schemes, Preservation of environment and improvement in the quality of life in rural economy.	8 lectures

Books:

1. Project Preparation, Evaluation & Implementation, P. Chandra, Tata McGraw Hill, New Delhi, 1996.
2. Agri-Business and Entrepreneurship, Rajgopal, Indian Books & Periodicals, New Delhi, 1991.
3. Entrepreneurship: Starting a new Business, Anderson, Allied Publishers Ltd, New Delhi, 1991.
4. Entrepreneurship Development, Colombo Plan Staff College for Technician Education, Manila, Tata McGraw Hill, New Delhi, 1998.

HS22277	Indian Constitution: 0 Credits (2-0-0)	
Unit I	The Constitution – Introduction; The History of the Making of the Indian Constitution; Preamble and the Basic Structure, and its interpretation; Fundamental Rights and Duties and their interpretation; State Policy Principles.	5 lectures
Unit II	Union Government; Structure of the Indian Union; President – Role and Power; Prime Minister and Council of Ministers; Lok Sabha and Rajya Sabha.	6 lectures
Unit III	State Government; Governor – Role and Power; Chief Minister and Council of Ministers; State Secretariat.	6 lectures
Unit IV	Local Administration; District Administration; Municipal Corporation; Zila Panchayat.	6 lectures
Unit V	Election Commission; Role and Functioning; Chief Election Commissioner; State Election Commission.	5 lectures

Books:

1. Ethics and Politics of the Indian Constitution, Rajeev Bhargava Oxford University Press, New Delhi, 2008.
2. The Constitution of India, B. L. Fadia, Sahitya Bhawan, New edition, 2017.
3. Introduction to the Constitution of India, D. D. Basu, Lexis Nexis, Twenty-Third edition, 2018.

Websites:

1. https://www.constitution.org/cons/india/const.html
2. http://www.legislative.gov.in/constitution-of-india
3. https://www.sci.gov.in/constitution
4. https://www.toppr.com/guides/civics/the-indian-constitution/the-constitution-of-india/

HS23101	Principles of Economics: 3 Credits (3-0-0)	
Unit I	Definition, of Economics, Scope of economics, Micro vs. Macroeconomics, Basic Economic problems of the economy, Production Possibility Curve of an Economy, Laws of Supply and Demand. General market equilibrium, Elasticity of demand.	8 lectures
Unit II	Consumers' Behaviour; Utility Analysis. Indifference curve analysis and consumers' equilibrium. Applications of IC Analysis.	8 lectures
Unit III	Theory of production; Laws of Production, Optimal use of Factors of Production, Producer's Equilibrium, Cost concept and types of costs. Cost of production, supply functions, cost and revenue functions.	10 lectures
Unit IV	Price and output determination and Producers' equilibrium under different market situations in short-run and long-run, Price discriminating monopoly.	8 lectures
Unit V	Pricing of Factors of Production; Interest, wage, rent and profit; National Income; Business Cycle; Exchange rate; Inflation & Deflation.	8 lectures

Books:

1. Microeconomic Analysis – R. R. Barthwal, Wiley Eastern Ltd. New Delhi, 1991.
2. Principles of Microeconomics – D. D. Tewari and K. Singh, New Age International, New Delhi, 1996.
3. Microeconomics – Kourtsoyanis, ELBS, McMillan, London, 1985.
4. Principles of Economics – M. L. Seth and L. N. Agrawal, Educational Publication, Agra, 1995.
5. Economics – P. A. Samuelson and W. D. Nordhaus, Tata McGraw Hill Publications, New Delhi, 2002.

HS23177	Essence of Indian Knowledge and Tradition: 0 Credits (2-0-0)	
Unit I	Basic Structure of Indian Knowledge System.	5 lectures
Unit II	Modern Science and Indian Knowledge System.	6 lectures
Unit III	Yoga and Holistic Health care.	6 lectures
Unit IV	Case Studies.	6 lectures
Unit V	Case Studies.	5 lectures

Books:

1. Cultural Heritage of India - Course Material, V. Sivaramakrishna, Bharatiya Vidya Bhavan, Mumbai, 5th Edition, 2014.
2. Modern Physics and Vedant, Swami Jitatmanand, Bharatiya Vidya Bhavan.

3. The wave of Life, Fritzof Capra.
4. Tao of Physics, Fritzof Capra.
5. Tarkasangraha of Annam Bhatta, V. N. Jha, Chinmay Inernational Foundation, Velliarnad, Ernakulam.
6. Science of Consciousness, Psychotherapy and Yoga Practices, R. N. Jha, Vidyanidhi Prakasham, Delhi, 2016.

HS23201	**Organizational Behaviour: 3 Credits (3-0-0)**	
Unit I	Fundamentals of organizations - Nature of people and Organizations, Forces affecting organizational behaviour, Changing work force and employment relations, Impact of globalization and Information technology on organizational behaviour, Organizational climate and culture.	8 lectures
Unit II	Individual dimensions in organizational behaviour-Individual differences; Theories of Personality, Perception - Perceptual process and impression management. Learning-theories of learning and implications for management.	8 lectures
Unit III	Communication- Concept, Process, Barriers and their remedies; Leadership-Theories and Styles. Implications for different stakeholders.	9 lectures
Unit IV	Theories and implications of Motivation, Work place emotions - Job satisfaction, designing effective jobs, Job-rotation enrichment, enlargement and reengineering work process, job related causes of stress, fatigue and its impact on productivity. Employee counselling and other psychological measures to improve productivity and mental health.	9 lectures
Unit V	Groups and group dynamics, group behavior, group dynamics theories and group cohesiveness - group decision making process, understanding work teams, team Vs groups, team development, Ingredients of effective teams, team life cycle, inter-personal skills - Johari Window and transactional analysis.	8 lectures

Books:

1. Organizational Behaviour – Robbins, S. P., Judge, T. A. and Vohra, N., Pearson, India, 2018.
2. Organizational Behaviour – Luthans, Fred, Mc Graw Hill, International Edition, 2013.
3. Organisational Behaviour – Rao, V. S. P, Excel Books, New Delhi, 2012.
4. Developing Managerial skills in Organizational Behaviour – Mainiero, Lisa A. and Tromley, Chery L., Printice Hall India, New Delhi, 2009.
5. Organizations: structures, processes and outcomes – Hall Tolbert, PHI, New Delhi, 2010.
6. Behaviour in organizations: Understanding and managing the human side of work – Jerald Greenderg, Baron, PHI, 2008.

HS24041	**Managing Stress: 3 Credits (3-0-0)**	
Unit I	The stress process: Concept of stress, current and historical status; The nature of the stress response.	8 lectures
Unit II	Common sources of stress - biological, personality, and environmental.	9 lectures
Unit III	Coping styles - defensive behaviour and problem solving.	8 lectures
Unit IV	Consequences of stress - medical, Psychological, and behavioural. The role of social support in mitigating stress.	8 lectures
Unit V	Stress Management Techniques - relaxation, meditation, cognitive restructuring, self-control, bio-feedback, and time management.	9 lectures

Books:

1. Stress and Coping: The Indian Experience, D. M. Pestonjee, Sage Publication, New Delhi, 1999.
2. Controlling Stress and Tension, D. Girdano and G. Everly, Prentice Hall of India, New Delhi, 1996.
3. Adjustment: Applying Psychology in a Complex World, R. S. Feldman, McGraw International, New York, 1989.

HS24042	Human Resources Management: 3 Credits (3-0-0)	
Unit I	HRM, Definition, Scope, HRM vs. Personnel Management, Functions of HRM in changing environment.	9 lectures
Unit II	Human Resource Planning, Recruitment, Selection, Induction and Placement.	8 lectures
Unit III	Training, Executive Development, Career and Succession Planning.	7 lectures
Unit IV	Motivation Job description, enrichment, analysis and Evaluation, Performance Appraisal.	8 lectures
Unit V	Industrial Relations Scenario in India, Trade Unionism, Collective Bargaining, Industrial Conflict Resolution, Industrial democracy and workers participation in Management.	10 lectures

Books:

1. Human Resource Management, DeCenzo, D. A., Robbins S. P., and Verhulst, S. L., Wiley India, New Delhi, 2015.
2. Human Resource Management, Mirza S. Sayadin, Tata McGraw Hill, New Delhi, 2000.
3. Human Resource Management, K. Ashwathappa, McGraw Hill Education, 2017.
4. Personnel Management, C. B. Manoria, Himalayan Publishing House, New Delhi, 1995.

HS24043	Project Formulation, Analysis and its Management: 3 Credits (3-0-0)	
Unit I	Definition of Project, Identification of Investment opportunities, Preliminary report and feasibility report preparation, Project screening and Criteria for selection of a project, Commercial, Technical, Financial and Socio-Economic study of project proposals.	8 lectures
Unit II	Project Evaluation; Time value of money, Non Discounting and Discounting criteria of Project evaluation; Net Present value estimation, Pay-back period, Internal Rate of Return, Benefit-Cost ratio etc.	8 lectures
Unit III	Estimation of working results, Profitability projection, Cash flow statement and analyses, Risk and uncertainty analysis.	8 lectures
Unit IV	Social Cost Benefit Analysis, UNIDO approach. Little Mirlee Approach.	8 lectures
Unit V	Network Technique; Critical Path Method, Programme Evaluation Review Technique, Management of Manpower, Decision making, Auditing of projects etc.	10 lectures

Books:

1. Project Preparation, Evaluation & Implementation, P. Chandra, Tata McGraw Hill, New Delhi, 1996.
2. Agri-Business and Entrepreneurship, Rajgopal, Indian Books & Periodicals, New Delhi, 1991.
3. Entrepreneurship: Starting a new Business, Anderson, Allied Publishers Ltd., New Delhi, 1991.
4. Entrepreneurship Development, Colombo Plan Staff College for Technician Education, Manila, Tata McGraw Hill, New Delhi, 1998.

HS24044	Engineering Ethics: 3 Credits (3-0-0)	
Unit I	Scope and Aims of Engineering Ethics: What is Engineering Ethics? Why study Engineering Ethics? Morality, Mental Health and Executive Success.	8 lectures
Unit II	Moral Moral Reasoning and Ethical Theories: Professional ideas and virtues.	9 lectures
Unit III	Values – the vital core of psychological growth: Values, Self-esteem, and Managerial Effectiveness.	8 lectures
Unit IV	The Ontological Foundation of Ethical management; The Nature of the Personas the basis of human Management.	9 lectures
Unit V	Engineers as Managers, Consultants, and Leaders.	8 lectures

Books:

1. Charles B. Fleddermann, “Engineering Ethics”, Pearson Prentice Hall, New Jersey, 2012.
2. John R. Boatright, “Ethics and the conduct of Business”, Pearson Education, New Delhi, 2012.
3. Ethics in Engineering – M. W. Martin and R. Schinzingler, Tata McGraw Hill, New Delhi, 1997.
4. Managerial Dilemma and Executive Growth – F. V. Manning, Reston Publishing Co.

CENTRE FOR MANAGEMENT STUDIES

Open Elective – II						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	MB24041	Time Series Analysis	3	0	0	3
2.	MB24042	Entrepreneurship in Renewable Energy	3	0	0	3

Open Elective – IV						
S. N.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**
1.	MB24043	Marketing Management	3	0	0	3

MB24041	**Time Series Analysis: 3 (3-0-0)**	
Unit I	Understanding the characteristics of time series data, Stochastic process and its main characteristics: Stochastic process. Time series as a discrete stochastic process. Stationarity. Main characteristics of stochastic processes (means, auto-covariation and autocorrelation functions). Stationary stochastic processes. Stationarity as the main characteristic of stochastic component of time series. Wold decomposition. Lag operator. Exploratory Data Analysis: Trends in time series data, Using smoothing and removing trends when working with time series data. Understanding how periodograms are used with time series data.	9 lectures
Unit II	Autoregressive-moving average models: Understanding moving average models and partial autocorrelation as foundations for analysis of time series data, ARMA (p,q) Moving average models MA(q). Condition of invertability. Autoregressive models AR(p). Yull-Worker equations. Stationarity conditions. Autoregressive-moving average models ARMA (p,q). Coefficient estimation in ARMA (p,q) processes: Box-Jenkins' approach Coefficients estimation in autoregressive models. Coefficient estimation in ARMA (p) processes. Quality of adjustment of time series models. AIC information criterion. BIC information criterion. "Portmonto"-statistics. Box-Jenkins methodology to identification of stationary time series models. Forecasting in the framework of Box-Jenkins model: Forecasting, trend and seasonality in Box-Jenkins model.	9 lectures
Unit III	The unit root problem: The unit root problem. Spurious trends and regressions. Unit root tests (Dickey-Fuller). ADF test and the choice of the number of lags. Other unit root tests. Regressive dynamic models: Regressive dynamic models. Autoregressive models with distributed lags (ADL).	9 lectures
Unit IV	Using ARCH and AR class of models in multivariate time series contexts, Using spectral density estimation and spectral analysis, Using fractional differencing and threshold models with time series data.	6 lectures
Unit V	Vector auto-regression model and co-integration: Time series co-integration. Co-integration regression. Testing of co-integration. Vector autoregression and co-integration. Co-integration and error correction model. Causality in time series: Granger causality. Hypothesis testing on rational expectations. Hypothesis testing on market efficiency.	9 lectures
Books: 1. Applied Time series analysis: Walter Enders, Willey. 2. Econometrics: Greene, PHI.		

MB24042	Entrepreneurship in Renewable Energy: 3 Credits (3-0-0)	
Unit I	Need and importance of Entrepreneurship in Renewable Energy, Energy Conservation Act 2003, Indian Electricity Regulation Act on deregulation, Government schemes and initiatives for the promotion of Renewable Energy.	9 lectures
Unit II	Company incorporation process, Preparation of Journal, Ledger, Bank Reconciliation Statement, Special Ledger, Balance Sheet, Profit and Loss Account, Cost Sheet, Cash Flow.	8 lectures
Unit III	Facility Location, Layout, Optimisation Planning in Renewable Energy, Tools and Techniques: Linear programming, Transportation, Assignment, Scheduling.	9 lectures
Unit IV	Project management in Renewable Energy, Time value of money, impact of Compounding, Critical Path Method (CPM), Program Evaluation and Review Techniques (PERT), Sources of financing.	8 lectures
Unit V	Marketing Mix, Market segmentation, Technology Development Life Cycle, Energy Marketing, Intellectual Property Right, Human Resource Planning, Legal aspects of Human Resource Management.	8 lectures

Books:

1. Entrepreneurship: Rajiv Roy, OUP.
2. Accountancy: Hanif, Mukherjee, TMH.
3. Financial Managment: I.M. Pandey, Vikash Publishing.
4. Production and Operations Management: K. Bedi, OUP.
5. Operations Research: Paneerselvan, PHI.
6. Electricity deregulation: Loi, Lai, Lei, IEEE Press.
7. Websites of Ministry of Power, NABARD, World Bank, etc.

MB24043	Marketing Management: 3 Credits (3-0-0)	
Unit I	Understanding Marketing Management, Marketing in a Developing Economy, Marketing of Services.	9 lectures
Unit II	Marketing Planning and Organisation, Planning Marketing Mix, Market Segmentation, Marketing Organisations, Marketing Research and its applications.	9 lectures
Unit III	Marketing Environment and Consumers, Determinants of Consumer Behaviour, Models of Consumer Behaviour, Indian Consumer Behaviour.	9 lectures
Unit IV	Marketing offerings, Product Decisions and Strategies, Product Lifecycle and New Product Development, Branding and Packaging Decisions, Pricing Policies and practices.	6 lectures
Unit V	Promotion and Distributions, Marketing Communications, Advertising, Publicity, Personal Selling and Sales Promotion, Sales Forecasting, Distribution Strategy, Managing Sales Personnel.	9 lectures

Books:

1. Marketing Management - A South Asian Perspectives – Kotler, Keller, Koshy, Jha, Pearson.