SYLLABI
OF
PG / Ph. D. COURSES
(DEPARTMENT OF PHYSICS)

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

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

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

M.Sc. Physics

COURSE STRUCTURE

SEMESTER	COURSE CODE	COURSE TITLE	L	T	P	Cr
I	PH7101	Classical Mechanics	3	1	0	4
	PH7102	Mathematical Physics	3	1	0	4
	PH7103	Computational Physics & Programming	3	1	0	4
	PH7104	Quantum Mechanics-I	3	1	0	4
	PH7151	General Physics Laboratory-I	0	0	6	3
	PH7152	Computer Laboratory	0	0	6	3
			12	**4**	**12**	**22**
II	PH7201	Electrodynamics	3	1	0	4
	PH7202	Statistical Mechanics	3	1	0	4
	PH7203	Elementary Condensed Matter Physics	3	1	0	4
	PH7204	Quantum Mechanics-II	3	1	0	4
	PH7251	General Physics Laboratory-II	0	0	6	3
	PH7252	Condensed Matter Physics Laboratory	0	0	9	5
			12	**4**	**15**	**24**
III	PH8101	Atomic and Molecular Physics	3	1	0	4
	PH8102	Electronics	3	1	0	4
	PH8103	Nuclear Physics	3	1	0	4
	PH810*	Special Paper I	3	1	0	4
	PH8151	Optics & Nuclear Physics Laboratory	0	0	6	3
	PH8152	Electronics Laboratory	0	0	9	5
			12	**4**	**17**	**24**
IV	PH8201	Group Theory and Applications	3	1	2	5
	PH820*	Special Paper II	3	1	0	4
	PH825*	Special Paper Laboratory	0	0	6	3
	PH80**	Elective	3	0	0	3
	PH8299	Project	0	0	16	8
			9	**2**	**16**	**23**

Total Credits 93

***Each specialization will consist of two theory courses and one laboratory course in the fourth semester.**

PH7101 : Classical Mechanics **3 1 0 4**

UNIT-I	**Introductory concepts and Lagrange's equation:** Degree of freedom, constraints in configuration space: holonomic and non-holonomic constraints, generalized coordinates, principle of virtual work, D'Alembert's principle and Lagrange's equations, generalized force, Lagrange's equations for non-holonomic constraints, the two-body central force problem, virial theorem. **Variational principles**: Hamilton's principle, derivation of Lagrange's equation from Hamilton's principle, extension of Hamilton's principle to non-holonomic systems, conservation theorems and symmetry properties, the principle of least action.	10 lectures
UNIT-II	**Hamilton's equations and canonical transformations:** Legendre transformation and the Hamilton equations of motion, cyclic coordinates and conservation theorems, Routh's procedure. The equations of canonical transformation, Poisson brackets and other canonical invariants; equations of motion, Liouville's theorem.	9 lectures
UNIT-III	**Hamilton-Jacobi theory:** The Hamilton-Jacobi equation for Hamilton's principal function, example : the harmonic oscillator ; the Hamilton- Jacobi equation for Hamilton's characteristic function ; separation of variables in the Hamilton-Jacobi equation ; action-angle variables in systems of one degree of freedom, action-angle variables for completely separable systems ; the Kepler problem in action angle variables; analogy between Hamilton – Jacobi equation and Schrödinger equation.	10 lectures
UNIT-IV	**The rigid body:**The kinematics of rigid body motion: the Euler angles, Euler's theorem on the motion of a rigid body, finite rotations, infinitesimal rotations, rate of change of a vector; the rigid body equations of motion: angular momentum and kinetic energy of motion about a point, the inertia tensor and the moment of inertia, the principal axis transformation, the Euler equations of motion.	10 lectures
UNIT-V	**Small oscillations:** Formulation of the problem, principal axis transformation, frequencies of free vibrations and normal coordinators, forced vibrations and the effect of dissipative forces**.**	3 lectures

Recommended Books:

1. Classical Mechanics,Herbert Goldstein, 2nd Edition
2. Classical Mechanics, N.C. Rana and P.S. Joag,
3. Classical Mechanics, G. Aruldhas,

PH7102: Mathematical Physics **3 1 0 4**

UNIT-I	**Elementary differential geometry:** Topological space, continuous mappings, homeomorphism, differential manifolds, diffeomorphisms, connected and simply connected space.	4 lectures
UNIT-II	**Functions of complex variables:**Complex variables, calculus of residues, conformal maps and their applications, branch cut.	10 lectures
UNIT-III	**Integral and discrete transforms:** Fourier, Hilbert and Laplace transforms, dispersion relations, convolution.	4 lectures
UNIT-IV	**Linear operators and matrices:** Vectors and matrices, eigenvalue problem, properties of eigenvectors and eigenvalues, normal modes, tensors.	10 lectures
UNIT-V	**Differential equations:** Separation of variables, boundary value problem, Sturm-Liouville's problem, Green's function for ODEs and PDEs, ill posed boundary value problems.	10 lectures
UNIT-VI	**Differential equations of physics:** PDEs of Laplace, Poisson, Helmholtz, Klein-Gordon, Shrodinger and Maxwell; wave, scalar potential and diffusion equations.	4 lectures

Recommended Books:

1. Mathematical Methods for Physicists, G. Arfken, H.Weber and F.E. Harris, 7th Edition (Academic Press, 2012)
2. Advanced Engineering Mathematics, E. Kreyszig (Dover, 1998)
3. Mathematical Physics, Mathews & Walker, 2nd Edition (Pearson, 1971)
4. Differential Geometry, E. Kreyszig (Dover, 2003)

PH7103 : Computational Physics & Programming **3 1 0 4**

UNIT-I	**Numerical Analysis:** Methods for determination of zeroes of linear and non-linear algebraic equations and transcendental equations, solutions of simultaneous linear equations, Iterative method, Matrix inversion.	10 lectures
UNIT-II	**Linear fitting and interpolation**: Interpolation with equally spaced and unevenly spaced points, curve fitting, polynomial, least square and cubic spline fitting.	8 lectures
UNIT-III	**Numerical differentiation and integration**: Newton-cotes formulae, Error estimates, Gauss'method. Numerical solution of ordinary differential equation: Euler and Runge-Kutta methods.	8 lectures
UNIT-IV	**Random variate**: Monte-Carlo evaluation of integrals and error analysis, methods of importance sampling, Random walk, rejection Method, Metropolis algorithm.	6 lectures
UNIT-V	**Programming:** Elements of Computer programming with C ++.	10 lectures

Recommended Books:

1. Computational Methods in Physics & Engineering, SamuelS. M.Wong, World Scientific
2. Introductory Methods of Numerical Analysis, S. S. Sastry, Prentice Hall of India
3. Programming in C^{++}, E. Balagurusamy, Tata McGraw Hill

PH7104 : Quantum Mechanics-I **3 1 0 4**

UNIT-I	**(i) Recapituations:** Chronological evolution of quantum mechanics, wave particle dualism, uncertainty principle, wave packets in space and time. **(ii) Formalism of quantum mechanics:** development of the wave equation, the Schrodinger wave equation, statistical interpretation of the wave function, probability density and probability current density, Ehrenfest's theorem, stationary states, energy eigenfunctions, one dimensional square wave potential, parity. **(iii) Some bound state problems:** Linear harmonic oscillator, spherically symmetric potential, the hydrogen atom, particle in a spherical cavity.	14 lectures
UNIT-II	**Operator algebra:** Eigenfunctions and eigenvalues, expectation values, Dirac bra-kets, completeness and closure property, Hilbert space of state vectors, minimum uncertainty product, form of minimum packet, coordinate and momentum representation, unitary transformations.	12 lectures
UNIT-III	**Pictures of representations:** Schrodinger, Heisenberg and interaction pictures, matrix theory of harmonic oscillator, derivation of Hamiltonian of atomic electron in an em-field, equation of election in uniform magnetic field.	8 lectures
UNIT-IV	**Approximation methods for bound states:** Stationary perturbation theory- non-degenerate and degenerate states, Stark effect, variation method, WKB approximation.	8 lectures

Recommended Books:

1. Quantum Physics, Stephen Gasiorowicz, 3rd Edition(Wiley)
2. Quantum Mechanics: Theory and Applications, A. K. Ghatak and S. Lokanathan(Springer)
3. Quantum Mechanics, Cohen and Tannoudji, 1st Edition(Wiley)
4. Quantum Mechanics, G. Aruldhas, 2nd Edition(Prentice Hall of India)

PH 7201: Electrodynamics **3 1 0 4**

UNIT-I	**Introduction to vectors and tensors:** Vectors, tensors, vector calculus, curvilinear coordinates, Dirac delta function. **Electrostatics and magnetostatics:** Multipole expansion for localized charge distribution, static electric and magnetic fields in material media, Maxwell's equations, electrostatic and magnetic boundary conditions, boundary value problems using Laplace's equation in Cartesian and spherical coordinates, method of images.	14 lectures
UNIT-II	**Maxwell's equations and electromagnetic waves:** Maxwell's equations for time varying fields, the continuity equation, Poynting theorem, polarization and conductivity, plane wave in dielectric and conducting media.	6 lectures
UNIT-III	**Special theory of relativity:** Postulates of STR, homogenous Lorentz transformation,kinematics and dynamics in Minkowski space, Lorentz covariance of Maxwell's equations, Lorentz transformation of E and B, momentum 4-vector, continuity equation.	8 lectures
UNIT-IV	**Communication in different channels:** Wave propagation in plasmas, critical reflection, surface waves and medium frequency communication, wave guides, transmission lines, dipole antenna and antenna array.	6 lectures
UNIT-V	**Radiation from accelerated charges:** Scalar and vector potentials, Coulomb and Lorentz gauge, retarded potentials, Lienard-Wiechert potentials, radiation from accelerated charges, applications to communication and RADAR.	8 lectures

Recommended Books:

1. Classical Electricity & Magnetism, Panofsky and Phillips, 2nd Edition(Dover)
2. Electromagnetic Fields & Waves, P. Lorrain, D. R. Corsion and F. Lorrain, 3 rd Edition (Freeman) 1987)
3. Foundations of Electromagnetic theory, J. R. Reitz & F.J. Millford, 4 th Edition(Pearson)
4. Introduction to Electrodynamics, D.J. Griffiths, 4th Edition(Pearson)

PH7202 : Statistical Mechanics **3 1 0 4**

UNIT-I	**Introduction to Statistical Methods**: Random walk, binomial distribution, Gaussian and Poisson distributions, elements of ensemble theory-micro canonical, canonical and grand canonical ensembles, partition function, thermodynamic functions.	12 lectures
UNIT-II	**Formulation of quantum statistics:** Postulates of quantum statistical mechanics, density matrix, harmonic oscillator, an electron in magnetic field, Wigner's function.	8 lectures
UNIT-III	**Ideal Bose systems:** Thermodynamicbehavior of an ideal Bose gas, phonons, liquid helium & superfluidity.	6 lectures
UNIT-IV	**Ideal Fermi systems:** Thermodynamic behaviour of an ideal Fermi gas, magnetic behavior of an ideal Fermi gas, Pauli paramagnetism and Landau diamagnetism.	6 lectures
UNIT-V	**Statistical mechanics of interacting systems:** Cluster expansion for a classical gas, virial expansion of the equation of state, quantum cluster expansion, thermodynamics of phase transition in a van der Waaal system, Ehrenfest criterion, statistical mechanics of magnetic phase transition, Landau theory of 1st & 2nd order phase transition.	10 lectures

Recommended Books:

1. Statistical Mechanics, K. Huang (Wiley)
2. Statistical Mechanics, R.K. Pathria and P.D. Beale (Academic Press)
3. Statistical Physics, L.D. Landau and E.M. Lifshitz, 3rd Edition (Butterworth-Heinamann)
4. Statistical Mechanics, F. Mandl, 2nd Edition (Wiley-Backwell)

PH7203: Elementary Condensed Matter Physics 3 1 0 4

UNIT-I	**Crystal lattices and symmetry:** Crystalline Periodicity, amorphous structures, elements of crystallography, concept of point and space groups, Bragg scattering, atomic form factor, structure factor, reciprocal lattice, and Brillouin zone, Ewald sphere, electron and neutron diffraction.	12 lectures
UNIT-II	**Specific heat and lattice vibrations:** vibrational modes of a linear lattice, phonons and quantization, normal modes, acoustic and optical modes, vibrational modes of a di-atomic linear lattice, Einstein and Debye model of specific heat.	8 lectures
UNIT-III	**Free electron theory of solids:** energy levels and density of states in one, two and three- dimensions. electrical conductivity, thermal conductivity and Wiedemann – Franz ratio, specific heat contribution.	8 lectures
UNIT-IV	**Electronic properties of solids**: Bloch theorem in a periodic structure, origin of energy bands, Kronig-Penney model, nearly free electron model, tight binding model, effective mass, overlapping of energy bands.	6 lectures
UNIT-V	**Semiconductors:** intrinsic and extrinsic semiconductors, carrier density in intrinsic and extrinsic semiconductors, expression for Fermi levels, recombination process, pho-toconductivity, Hall effect in metals and semiconductors, band structure of Ge and Si.	8 lectures

Recommended Books:

1. Solid State Physics, A.J. Dekker (MacMillan)
2. Introductory Solid State Physics: H.P. Myers, 2nd Edition (CRC Press)
3. Introduction to Solid State Physics, C. Kittel, 8th Edition (Wiley)
4. Crystallography Applied to Solid State Physics : A.R. Verma and O.N. Srivastava (New Age)

PH7204 : Quantum-Mechanics-II 3 1 0 4

UNIT-I	**Angular momentum matrices:** spin matrices and eigenfuntions, addition of angular momentum, CG coefficients.	8 lectures
UNIT-II	**System of identical particles:** permutation symmetry, symmetric and anti-symmetric wave functions, Pauli exclusion principle, spin functions for two and three electron atoms, helium atom (ground state and first excited state).	8 lectures
UNIT-III	**Time dependent perturbation:** semi-classical treatment of radiation, intensity ratio of transitions in alkali atoms.	6 lectures
UNIT-IV	**Quantum theory of scattering:** cross sections, partial wave analysis, phase shifts, optical theorem, Schrodinger'sequation as an integral equation, Green's function, Lippman-Schwinger equation, Born approximation, Coulomb scattering.	8 lectures
UNIT-V	**Relativistic wave mechanics:** Klein-Gordon equation for a free particle, solution of the Klein-Gordon equation, a spin zero particle in Coulomb field, fine structure, Dirac equation for a free particle, anti-commuting relations of the Dirac matrices, spin of Dirac particle, Dirac equation, Dirac equation in Coulomb field.	12 lectures

Recommended Books:

1. Quantum Mechanics, L.I. Schiff (McGraw-Hill Book, New York).
2. Quantum Mechanics: Theory and Applications, A. K. Ghatak and S. Lokanathan (Macmillan India Ltd.).
3. Quantum Mechanics, Cohen and Tannoudji.
4. Quantum Mechanics, Ahruldhas.

PH 8101 : Atomic, Molecular And LASER Physics 3 1 0 4

UNIT-I	**Atomic physics:** Central field approximation, Hartree and Hartree-Fock approximation, Thomas-Fermi statistical rule, hydrogen atom spectrum, electron spin, Stern-Gerlach experiment, spin-orbit interaction, two electron systems, LS-JJ coupling schemes, fine structure, spectroscopic terms and selection rules, hyperfine structure, exchange symmetry of wave functions, Pauli's exclusion principle, periodic table, alkali type spectra, equivalent electrons, Hund's rule, Zeeman and Paschen-Back effect of one and two electron systems-selection rules-Stark effect.	12 lectures
UNIT-II	**Molecular physics**: Covalent, ionic and van der Waals interactions, Born-Oppenheimer approximation, Heitler-London and molecular orbital theories of H2, bonding and anti-bonding MOs, Huckel's molecular approximation-applications, vibrational structure and vibrational analysis, rotational Raman spectra and influence of nuclear spin, Franck-Condon principle, dissociation energy.	10 lectures
UNIT-III	**Vibration of polyatomic molecules:**Symmetry of molecules, symmetry elements and point groups, proper and improper rotations and their matrix representation, normal co-ordinates and normal modes of vibrations, infrared absorption and Raman scattering from molecular vibrations and rotations and selection rules.	8 lectures
UNIT-IV	**Lasers:**Basic elements of a laser, threshold condition, four-level laser system, CW operation of laser, critical pumping rate, population inversion and photon number in the cavity around the threshold, output coupling of laser power, role of plane and conical cavity resonators, longitudinal and transverse cavity modes, mode selection, switching and mode locking, ultra short pulses.	12 lectures

Recommended Books:

1. Introduction to Atomic Spectra, H.E. White (McGraw Hill)
2. LASERS-Theory and Application, K. Thyagrajan and A.K. Ghatak (Plenum Press)
3. Physics of Atoms and Molecules, Bransden and Joachan.
4. Vibrational Spectroscopy Theory & Application, D. N. Sathyanarayan.

PH8102 : Electronics 3 1 0 4

UNIT-I	**Devices and circuits:** Semiconductor devices (diodes, BJT, FET)-structure, device characteristics, opto-electronics (solar cells, photo-detectors, LEDs), zener diode as voltage regulator, application of diode as clamper, clipper, voltage multiplier, transistor biasing, operating point and load line, single stage amplifier, feedback and oscillators.	16 lectures
UNIT-II	**Differential amplifier:** Introduction to operational amplifiers, inverting, non-inverting and differential mode, uses of opamp as inverting amplifiers, adder, subtractor, integrator and differentiator.	6 lectures
UNIT-III	**Digital electronics:** Elementary ideas of binary numbers, hexadecimal and octal and interconversion, logic gates (AND, OR, NOT). Universal gates – NAND, NOR, logic families, De Morgan's theorem, laws of Boolean algebra, S-O-P and P-O-S representation, Karnaugh map.	10 lectures
UNIT-IV	**Arithmetic circuits:** Half adder, full adder, half subtractor and full subtractor, decoder/ demultiplexer, data selector/multiplexer and encoder. **Sequential digital systems:** flip-flops, shift registers and counters. **Digital applications:** Schmitt trigger, multivibrators.	10 lectures
UNIT-V	**Modulation and Demodulation:**Need of modulation, types of modulation, analysis of AM, demodulation, diode detector.	4 lectures

Recommended Books:

1. Electronic Devices and Circuits, J. Millman, C. Halkias and S Jit, 3rd Edition (McGraw Hill)
2. Opamps and Linear Integrated Circuits, R.A. Gayakwad, 4th Edition (Prentice Hall of India)
3. Digital Fundamentals, T. L. Floyd, 11 th Edition (Peasron)
4. Electronic Principles, A.P. Malvino, 6 th Edition (McGraw Hill)

PH 8103 : Nuclear Physics **3 1 0 4**

UNIT- I	**Basic properties of nuclei and their stability**: Nuclear Radius, Nuclear Excited states, Nuclear angular momentum, and parity, Nuclear magnetic Dipole and electric quadrupole moments, Nuclear masses and Binding Energy, Semi-empirical mass formula (Liquid drop mode & Beta(E)-stability. **Two body problem and nuclear forces**: The deuteron, experimental data, normalization of deuteron wavefunctions and its root-mean square radius, Properties of Nuclear Forces, Exchange Character of Nuclear Forces (Yukawa theory).	9 lectures
UNIT - II	**Nuclear models**: The Nuclear model (single particle)- magic Numbers, Spin-orbit coupling, consequence of shell model, predictions of magnetic-dipole and electric-quadrupole moments, angular momenta of nuclear ground-state, failures of the shell model. The collective Nuclear Model, rotational and Vibrational states.	7 lectures
UNIT-III	**Nuclear reactions**: Types of Nuclear reactions and conservation Laws, reaction dynamics and Q-equation, Cross-sections, partial wave analysis of reaction cross-sections, optical model,compound Nucleus reactions, Direct reactions, resonance reactions-Briet-Wigner formula. **Nuclear Decays:** **(i) Alpha decay:** Occurrence of D-decay, Gamow's theory, barrier penetration, decay constant for D-decay, Angular momentum and parity in D-decay . **(ii) Beta decay**: Modes of E-decay, Energy release and neutrino hypothesis, Fermi theory of E-decay, Curie Plots, comparative half-life, allowed and forbidden transitions, selection rules, parity violation in E-decay processes. **(iii) Gamma transitions**: Energetic of J-decay, excited states and decay constant, angular momentum and parity selection rules, Life-time for J-emission, internal conversion.	12 lectures
UNIT-IV	**Nuclear fission and fusion:** Fission process, characteristics of fission, energy released in fission, types of fission reactor, basic fusion process, characteristics of fusion, thermonuclear fusion, solar fusion.	6 lectures
UNIT-V	**Elementary particle physics:** Basic interactions in nature, classification of elementary particles, the eight fold way, conservation laws- Baryons, Leptons, muon numbers, strangeness and hypercharge, Gellmann-Nishijima formula, quark model.	8 lectures

Recommended Books:

1. Quarks and Leptons: An introductory course in Modern Particle Physics, F. Halzen and A. D. Martin
2. Concepts of Nuclear Physics, B.L. Cohen (McGraw Hill)
3. An Introduction to Nuclear Physics, W.N. Cottingham and D.A. Greenwood, 2nd Edition (Cambridge University Press)
4. Introductory Nuclear Physics, K.S. Krane, 3rd Edition (Wiley).

PH8104 :Condensed Matter Physics (Special Paper-I) **3 1 0 4**

UNIT-I	**Optical properties:** Transverse plasma frequency & propagation of electromagnetic wave in a material, Longitudinal plasma frequency & Plasmon, Electrostatic screening, Thomas-Fermi dielectric function, Polariton & LST relation, Polaron, Exciton, Raman effect in crystal, Kramers-Kronig relation.	12 lectures
UNIT-II	**Properties of ferroelectric materials:** Review of optical and dielectric properties of solids, Dielectric classification andproperties of representative ferroelectrics, the dipole theory of ferro-electricity, objections against the dipole theory, ionic displacements and the behavior of $BaTiO_3$ above the Curie temperature, the theory of spontaneous polarization of $BaTiO_3$,Thermodynamics of ferroelectric transitions, ferroelectric domains.	12 lectures
UNIT-III	**Magnetic properties of solids:** Quantization of orbit in a magnetic field {Landau levels}, DeHaas Van Alphen Effect, Magnetic breakdown, magnetoresistance, quantum theory of dia,paramagnetism, transition and rare-earth elements, Ferromagnetic, anti-ferromagnetic andFerri-magnetic order, molecular fields, direct and indirect exchange interaction, Heisenbergand Ising model, domain theory, Bloch wall, spin waves, magnons.	10 lectures
UNIT-IV	**Superconductivity:** Superconductivity, Meissner effect, Thermodynamics of superconducting state, London equations, coherence length, idea of BCS theory, flux quantization, Ginzberg-Landau theory, Josephson tunnelling, SQUIDs,Introduction to high temperature superconductivity.	8 lectures

Recommended Books:

1. Solid State Physics, A.J. Dekker (MacMillan)
2. Introductory Solid State Physics: H.P. Meyers and H.P. Myers, 2 nd Edition (CRC Press)
3. Introduction to Solid State Physics, C. Kittel, 8th Edition (Wiley)
4. Crystallography Applied to Solid State Physics : A.R. Verma and O.N. Srivastava (New Age)

PH 8201 :Group Theory and Applications **3 1 2 5**

UNIT- I	**Groups and their representations**: introduction, invariant subspaces and reducible representations, the Schur's lemmas, orthogonality theorem and its interpretation, characters of a representation, C_{4v}, the regular representation, symmetrized basis functions for irreducible representations, other reducible representations, direct product of representations.	12 lectures
UNIT-II	**Lie Groups and Lie algebras:** Lie groups, axial rotation groups SO(2), SO(3), Lorentz group, special unitary groups SU(2) and SU(3), generators of U(n) and SU(n), Lie algebra and representations of a Lie group.	12 lectures
UNIT-III	**Group theory in quantum mechanics:** Hilbert spaces in quantum mechanics, transformations of a function, space and time displacements, symmetry of Hamiltonian, reduction due to symmetry, matrix element theorem and selection rules, dynamical symmetry, time reversal and space inversion symmetries, atomic symmetries, irreducible tensor operators, matrix elements of tensor operators.	12 lectures
UNIT-IV	**Crystallographic and molecular symmetries:** Crystallographic point groups, translation group and space group, molecular point groups, irreducible representations of point groups,double groups,crystal field splitting of atomic levels.	10 lectures
UNIT-V	**Group theory in solid state physics:** problem of the electronic structure of crystals, translation group and reciprocal lattice, irreducible representation of a space group, free electron energy bands (one-, two-, three-dimensional lattices), energy bands of real crystals.	10 lectures

Recommended Books:

1. Elements of Group Theory for Physicists, A.W. Joshi (Wiley Eastern)
2. Chemical Applications of Group Theory, F.A. Cotton, 3 rd Edition (Wiley-Blackwell)
3. Mathematical Methods for Physicists, G. B. Arfken and H. J. Weber (Academic Press)
4. Molecular Symmetry and Group Theory, R.L. Carter, 3 rd Edition (Wiley-Blackwell)

PH 8202 : Condensed Matter Physics (Special Paper -II) **3 1 0 4**

UNIT- I	**Lattice defects:** Lattice defects and configuration entropy, the number of vacancies and interstitials as a function of temperature, formation of lattice defects in metals, interstitial diffusion in metals, self-diffusion in metals, elastic constants of metals, the interpretation of slip, dislocations: edge and screw dislocations, estimates of dislocation densities.	8 lectures
UNIT-II	**Quantum structures**: Heterojunctions, quantum confinement in one, two and three dimensions, e.g., super lattices, quantum wires and quantum dots, nanoparticles.	6 lectures
UNIT-III	**Soft condensed matter physics:** Intermolecular forces in liquids, dispersion, colloids, interaction in colloids, association colloids. **Liquid crystals**: definition, types of liquid crystals, classification of the mesophases, liquid crystals of rod like molecules (N, Ch and smectic phases).	8 lectures
UNIT-IV	**Materials preparationtechniques**: various methods of crystal growth, preparation of amorphous materials, thin film preparation (polycrystalline & amorphous), galss and glass transition, synthesis of low dimensional materials, lithography, arc discharge, thermal evaporation, sputtering, chemical vapour deposition, pulsed laser deposition, molecular beam epitaxy, electrodeposition and sol-gel technique.	8 lectures
UNIT-V	**Material characterization and instrumentation**: Material characterization :X-ray diffraction (XRD), XPS, Introduction to microscopy: advantages and disadvantages of optical microscopy over electron microscopy, scanning electron microscopy, transmission electron microscopy, scanning tunneling microscopy, atomic force microscopy, Introduction to thermal analysis: phase changes, crystalline and amorphous fractions-DSC thermo-gravimetric methods-TGA, DTA, Energy dispersive analysis: X-ray (EDX), neutron scattering and neutron diffraction, ESR and NMR, Different optical measurements: optical absorption and transmission study by UV-Vis spectrophotometer, photo-luminescence (PL), FTIR and Raman spectroscopy, electrical measurements.	12 lectures

Recommended Books:

1. Solid State Physics, A.J. Dekker (MacMillan)
2. Introductory Solid State Physics: H.P. Meyers and H.P. Myers, 2 nd Edition (CRC Press)
3. Introduction to Solid State Physics, C. Kittel, 8th Edition (Wiley)
4. Crystallography Applied to Solid State Physics : A.R. Verma and O.N. Srivastava (New Age)

PH 8001:Plasma Physics (Elective) **3 0 0 3**

UNIT- I	**Introduction:** definition and occurrence of plasma, Saha equation, concept of plasma temperature, Debye shielding, plasma applications, plasma frequency, motion of charged particle in electromagnetic field, parallel acceleration and magnetic mirror effect, plasma applications.	12 lectures
UNIT-II	**Plasma as a fluid:** equation of motion, plasma approximation, plasma oscillations, electron and ion plasma waves- their dispersion relations and properties, electromagnetic waves in plasma, plasma diffusion, and resistivity, single fluid MHD equation, plasma instability: two stream instability.	10 lectures
UNIT-III	**Kinetic theory of plasma and its applications:**Velocity distribution function, kinetic equation, Landau dumping, relation to hydrodynamics.	6 lectures
UNIT-IV	**Non-linear effects of plasma:** nonlinear phenomena in plasma, linear and non-linear waves in plasma, concept of pseudo potential (Sagdeev potential), theory of plasma sheath and its relation to nonlinear waves (soliton), Bohm sheath criteria and Mech number.	8 lectures
UNIT-V	**Plasma in controlled thermonuclear reactor:** introduction to thermonuclear fusion, magnetic confinement, tokamak, ITER.	6 lectures

Recommended Books:

1. Introduction to Plasma Physics and Controlled Fusion, Vol 1: Plasma physics, F. F. Chen (Springer)
2. Plasma Physics: Basic Theory with Fusion Applications, K. Nishikawa and M. Wakatani (Springer)
3. Fundamentals of Plasma Physics, JA Bittencourt, 3rd Edition (Springer)
4. Physics of Partially Ionised Plasmas, V. Krishan (Cambridge University Press)

PH 8002: Molecular Biophysics (Elective) **3 0 0 3**

UNIT-I	**Basic concepts:** biological polymers: nucleic acids, nucleosides and nuclestides, three dimentional DNA structure, RNA, nucleic acid conformation, proteins : primary secondary, tertiary and quaternary structures, noncovalent forces.	12 lectures
UNIT-II	**Determining protein structure:** dispersion forces, electrostatic interaction, van der Waals potentials, hydrogen bonds, entropic forces, DNA and protein folding, conformational energy, calculation, theoretical quantum chemical methods, enzyme catalysis, enzyme-controlled modifications, denaturation, replication, mutation, intercalation, neurotransmitters, membranes.	10 lectures
UNIT-III	**Functional role of DNA and protein**.: Biomolecular Recognition, Drug Design, Interaction of Proteins with other Macromolecules, Forces Stabilizing DNA and Protein Structure, Charge Transport Through DNA, Non-Linear Excitations and Their Propagation.	10 lectures
UNIT-IV	**Experimental Techniques:** Absorption and Fluorescence Spectroscopy, FTIR and UV Spectroscopy, Nuclear Magnetic Resonance, X-ray Diffraction and Molecular Structure, Atomic Force Microscopy, Molecular Dynamics, Potential Energy Contour Tracing, Photodimenrization	10 lectures

Recommended Books:

1. Biophysics, An Introduction, R. Cotterill (Wiley)
2. Principles of Protein Structure, G.E. Schulz & R.H. Shirmer (Springer)
3. Essentials of Biophysics, P. Narayanan (New Age International)
4. Fundamental Techniques of Biophysics and Molecular Biology, P. Kumar (Path Finder)

PH 8003: Laser Physics (Elective**)** **3 0 0 3**

UNIT-I	**Basic concepts:** Laser idea, characteristic properties of lasers, idea of negative temperature and population inversion, amplification in the medium, line broadening mechanism, homogeneous and inhomogeneous line broadening, inhomogeneously broadened transitions, hole burning, optical pumping, efficiency of pumping, rate of pumping, electrical pumping.	14 lectures
UNIT-II	**Basic principle and laser types:** laser threshold conditions, rate equations for three level lasers and four level lasers, continuous wave laser behavior, pumping power requirements, output power from three level and four level lasers for steady state operation, Ruby laser, Argon ion laser, Nd-YAG lasers, diode lasers, CO_2 laser, dye lasers.	12 lectures
UNIT-III	**Nonlinear processes:** Propagation of electromagnetic waves in nonlinear medium, self focusing, phase matching condition, fibre lasers, stimulated Raman scattering and Raman lasers, CARS.	8 lectures
UNIT-IV	**Laser applications:** Cooling and trapping of atoms, evaporative cooling and Bose-Einstein condensation, SERS, TERS, Spectroscopy in nanomaterials and biomolecules.	8 lectures

Recommended Books:

1. Principles of Lasers, O. Svelto, 4th Edition (Plenum Press)
2. Laser Cooling and Trapping, H.J. Metcalf and P. Straten (Springer)
3. Lasers and Nonlinear Optics, B.B Laud (Wiley)
4. Laser Physics, P. W. Milonni and J. H. Eberly (Wiley-Backwell)

PH 8004 : Liquid Crystals (Elective**)** **3 0 0 3**

UNIT-I	**Liquid Crystals:** definition, classification of the mesophases: liquid crystals of rod like molecules (N, Ch and Smectic phases), liquid crystals of disk like molecules, polymer liquid crystals, polymer dispersed liquid crystals, ferroelectric liquid crystals, lyotropic liquid crystals, polymorphism in thermotropic liquid crystals.	12 lectures
UNIT-II	**Statistical theories of nematic order:** definition of long range orientation order parameter, Maier-Saupe theory and its applications, the mean field approximation, evaluation of the order parameter.	6 lectures

UNIT-III	**Liquid crystal models:** Short range order effects in isotropic phase, the Landau – de Gennes model, Leboh1-Lasher model, magnetic and electric birefringence, extension of Maier- Saupe theory to semectic A : McMillan's model, continuum theory of smectic A.	10 lectures
UNIT-IV	**Thermal properties of liquid crystals:** Isotropic-nematic and nematic- smectic A phase transitions, structural studies of liquid crystals using X-ray diffraction, electrical properties.	6 lectures
UNIT-V	**Applications of liquid crystals:** nematics, cholesterics, ferroelectric liquid crystals, polymeric liquid crystals and polymer dispersed liquid crystals, introduction to liquid crystal displays: twisted nematic display device.	8 lectures

Recommended Books:

1. Liquid Crystals, S. Chandrasekhar, 2nd Edition (Cambridge University Press)
2. The Physics of Liquid Crystals, P. G. de Gennes and J. Prost, 2nd Edition (Clarendon Press)
3. Liquid Crystals and Polymers, G. D. Arora (Swarup & Sons)
4. The Molecular Dynamics of Liquid Crystals, Edited by G. R. Luckhurst and C.A. Veracini (Kluwer Academic)

PH 8005 :Basic Vacuum Science & Cryogenic (Elective) **3 0 0 3**

UNIT-I	**Vacuum Science:** Basics of vacuum science, Different types of pumps: rotary, diffusion, ion,turbo molecular and cryogenic pumps, Application of vacuum in research and Industry.	10 lectures
UNIT-II	**Measurement of Vacuum**: Classification of gauges, Vacuum gauges: McLeod, pirant,penning, hot cathode Ionization gauge.	12 lectures
UNIT-III	**Low Temperature Physics:** Production of low temperature, Liquefaction of nitrogen andHelium, Cryogenic storage and insulation, design of cryostat, Safety considerations.	10 lectures
UNIT-IV	**Cryogenic thermometry**: Gas and vapour pressure thermometers, thermocouple, resistance,and semiconductor diode and capacitance thermometers.	10 lectures

Recommended Books:

1. G.K. White; Experimental techniques in Low temperature physics
2. Ramdall F. Barron; Cryogenic systems
3. V.V. Rao, T.B. Ghosh and K.L. Chopra ; Vacuum Science & Technology

PH8006 : Particle Physics (Elective) **3 0 0 3**

UNIT-I	**Introduction:** Classification of elementary particles,photon, anti-particles, neutrinos, strange particles, the eightfold way classification, Gellman-Nishijima formula, properties and types of quarks, the quark model, the standard model.	10 lectures
UNIT-II	**Elementary particle dynamics:** the four fundamental forces, quantum electrodynamics, quantum chromodynamics, asymptotic freedom, weak interactions, decays and conservation laws.	10 lectures
UNIT-III	**Symmetries:** Groups and conservation laws, spin and orbital angular momentum, addition of angular momenta, spin ½, parity, charge conjugation, CP violation, time reversal and CPT theorem.	12 lectures
UNIT-IV	**Electrodynamics of quarks and hadrons:** electron-quark interactions, hadron production in e^+e^- scattering, elastic and inelastic electron-proton scattering, parton and Bjorken scaling, quark distribution functions.	10 lectures

Recommended Books:

1. Introduction to Elementary Particles, D. Griffiths (Wiley India)
2. Quarks and Leptons: An Introductory Course in Modern Particle Physics, F. Halzen and A. D. Martin (W iley India)
3. An Introduction to Quarks and Partons, F. E. Close (Academic Press)

M.Sc. (Physics) Practicals

FIRST SEMESTER:

PH7151: General Physics Laboratory I **0 – 0 – 6 – 3**

1. To measure the magnetic field for circular conductor loop.
2. To verify the existence of discrete atomic energy levels and to evaluate the quantum of energy transfer from electron beam to atoms by Frank Hertz experiment.
3. To find the value of Planks constant (h) using a photo cell.
4. To determine the electronic charge by using rectifier equation in case point contact Germanium rectifier.
5. To analyze waves (Square, Triangular, clipped sine wave) using Fourier analysis kit.
6. Determine Boltzmann constant by P–N junction diode and hence find the value of η of LED.
7. Determination of stopping potential of the material of photo cell & determination of maximum kinetic energy of the photoelectron.
8. Study the elastic and plastic extension of material wires.

PH7152: Computer Laboratory **0 – 0 – 6 – 3**

1. To find the roots of an equation using Bisection method.
2. To find the roots (or Zeros) of a real valued function using Newton – Raphson method.
3. To find the least square linear regression of data.
4. To find the numerical approximation of definite integrals using Simpson's rule.
5. To find the approximate solutions of ordinary differential equations using Runge – Kutta method.
6. To solve a system of linear equation using Gauss elimination method and inverse matrix method.

SECOND SEMESTER:

PH7251: General Physics Laboratory II **0 – 0 – 6 – 3**

1. To determine the Stefan's constant using Stefan's constant kit.
2. Determination of photo conductivity.
3. Determination of capacitance.
4. Determination of Rydberg constant for hydrogen.
5. Determination of refractive index by Abbe refractometer.
6. Verification of de Broglie wave.
7. To Study the Zeeman effect.

PH7252: Condensed Matter Physics Laboratory **0 – 0 – 9– 5**

1. Determination of g factor by ESR.
2. Determination of specific heat capacity of solid (Ag,Al).
3. Determination of energy band gap of semiconductor.
4. Study of Hysteresis loss of given sample.
5. Study of lattice parameters.
6. Determination of specific heat capacity of solid (Ag,Cu).
7. Study of Hall Effect.
8. Determination of Curie temperature of given sample during cooling.
9. Determination of Curie temperature of given sample during heating.

THIRD SEMESTER:

PH8151: Nuclear Physics Laboratory **0 – 0 – 6 – 3**

1. Study of characteristics of GM tube and determination of its operating voltage, platue length and slope.
2. Verification of inverse square law using J rays.
3. Estimation of efficiency of GM tube.
4. Determination of short half life.
5. Determination of linear absorption co-efficient (μ) and the mass absorption co-efficient of the absorbing materials.

6. Study of energy resolution characteristics of scintillation spectrometer as a function of applied voltage and determination of best operating voltage.
7. Study of Cs-137 spectrum and calculation of FWHM and resolution of given scintillation detector.
8. Study of Co-60 spectrum and calculation of resolution of detector in terms of energy.
9. Energy calibration of J rays spectrum (study of linearity).

Optics Laboratory

1. Determination of wave length of LASER light by Michelson interferometer.
2. Determination of wave length of light by Febry Perot interferometer.
3. Determination of wave length of sodium light by Michelson interferometer.
4. Determination refractive index of transparent slice by interference method.
5. Line Spacing of gating by Bragg's diffraction condition.
6. Wave length of light used by single/double slit diffraction method.

PH8152: Electronics Laboratory **0 – 0 – 9– 5**

1. Design and verification of half and full wave rectifier with and without filters.
2. Design and verification of diode clipping circuits both biased and unbiased.
3. Design and verification of clamping circuit with and without reference.
4. Design and verification of astable and bistable multivibrators.
5. Design and verification of adder circuit using OP-AMP.
6. Design and verification of subtractor circuit using OP-AMP.
7. Design and verification of differentiator circuit using OP-AMP.
8. Design and verification of integrator circuit using OP-AMP.
9. Design and verification of AND, OR and NOT gate using universal gate.
10. Design and verification of Half adder logic circuit.
11. Design and verification half subtractor logic circuit.
12. Design and verification of SR flip flop.
13. Design and verification of clocked SR flip flop.
14. Design and verification of edge triggered JK flip flop.
15. Design and verification of shift register using JK flip flop.
16. Design and verification of 8 MOD counter.

FOURTH SEMESTER:

PH 825* Special Paper Laboratory **0 – 0 – 6 – 3**

1. Determination of ultrasonic velocity by ultrasonic interferometer.
2. Determination of g factor by ESR.
3. Determination of thermal conductivity of aluminum.
4. Study of Hall effect.
5. Study of dielectric constant.
6. Determination of thermal conductivity.
7. Verification of susceptibility of given liquid.
8. Study of thermo luminescence of alkali halide crystals.