Sister Nivedita University

Undergraduate course structure for Physics

As per NEP 2020 regulation and according to UGC-CBCS

Course structure for

B.Sc. in Physics

And

B.Sc. Honours in Physics/ B.Sc. Honours with Research in Physics

Category definition with credit breakup

Semester	Credits										Credits /Semester
	MC/ME	ME		NON -MAJOR		MDC	AEC	SEC	VAC	INT	
		COURSE	PROJECT	NM	NV						
I	4+4			4(FROM DEPARTMENT)	1(*d)+1 (*e)		2(*c)	3(*b)	2(*a)		21
II	4+4				1+1	3	2	3	2		20
III	5+5			4	1+1	3	2				21
IV	5+5			4	1+1	3	2				21
V	5+5+4				1+1			3	2		21
VI	4+4+4			4	1+1					3	21
VII	4+4+4+4			4							20
VIII		8/20	12/0								20
Credits / Course	98			32		9	8	9	6	3	
	Total Credit										165

MC- Major Core Courses; N**M/NV** - Non-major subject minor and vocational education and training; **MDC** – Multidisciplinary courses; **AEC** – Ability Enhancement Courses; **SEC** – Skill Enhancement Courses; **VAC** – Value Added Courses; **INT** – Internship; Project – Project.

Category	Course name	Credit	Teaching Scheme		
			L	T	P
	Semester I				
MC 1	Classical Mechanics	3	3		
	Classical Mechanics Lab	1			2
MC2	Mathematical Methods	4	4		
NM1	Analytical Techniques of Physics	4	4		
NV1	Vocational - EAA I (Yoga/ Sports/ NCC/ NSS)	1			2
NV2	Vocational – Soft Skill Development I	1	1		
AEC 1	Communicative English I	2	2		
VAC1	Environmental Science I	2	2		
SEC1	Computer Application	3	3		
	Total Credit = 21		Teaching Hour = 23		
	Semester II				
MC 3	Electrodynamics	3	3		
	Electrodynamics Lab	1			2
MC 4	Photonics	3	3		
	Photonics Lab	1			2
NV3	Vocational - EAA II (Yoga/ Sports/ NCC/ NSS)	1			2
NV4	Vocational – Soft Skill Development II	1	1		
MDC 1	Selected by the candidate (Elective)	3	3		
AEC 2	Communicative English II	2	2		
VAC 2	Environmental Science II	2	2		
SEC2	Computer Application II	3	3		
	Total Credit = 20		Teaching Hour = 23		
	Semester III				
MC5	Statistical Mechanics and Thermodynamics	4	4		
	Statistical Mechanics and Thermodynamics Lab	1			2
MC6	Quantum Mechanics	5	6		
NV5	Vocational - Mentored Seminar I	1	1		
NV6	Vocational – Soft Skill Development III	1	1		
NM2	Selected by the candidate	4	4		
MDC2	Selected by the candidate (Elective)	3	3		
AEC3	Logical Ability I / Foreign Language I	2	2		
	Total Credit = 21		Teaching Hour = 23		
	Semester IV				
MC7	Basic Electronics	4	4		
	Basic Electronics Lab	1			2
MC8	Special Theory of Relativity	5	5		
NV7	Vocational - Mentored Seminar II	1	1		
NV8	Vocational – Soft Skill Development IV	1	1		
MDC3	Selected by the candidate (Elective)	3	3		
AEC4	Logical Ability II / Foreign Language II	2	2		
NM3	Selected by the candidate	4	4		
	Total Credit = 21		Teaching Hour = 22		

Category	Course name	Credit	Teaching Scheme		
			L	T	P
	Semester V				
MC9	Solid State Physics	4	4		
	Solid State Physics Lab	1			2
MC10	Materials Science	5	6		
MC11	Elective I (Medical Physics/Engineering Physics)	4	5		
NV9	Vocational - Mentored Seminar III	1	1		
NV10	Vocational – Soft Skill Development V	1	1		
SEC3	Selected by the candidate	3	3		
VAC3	Ethics Study and IPR	2	2		
	Total Credit = 21		Teaching Hour = 24		
	Semester VI				
MC12	Atomic, Molecular, Particle Physics	4	5		
MC13	Solid State Devices	4	5		
MC14	Nanotechnology	4	5		
NV11	Vocational - Mentored Seminar IV	1	1		
NV12	Vocational – Soft Skill Development VI	1	1		
NM4	Selected by the candidate	4	4		
INT1	Internship	3			6
	Total Credit = 21		Teaching Hour = 27		
	Semester VII				
MC15	Astrophysics	4	5		
MC16	Spectroscopic Techniques	4	5		
MC17	Quantum Computation	4	4		
MC18	Engineering Physics/ Medical Physics	4	5		
NM5	Selected by the candidate	4	4		
	Total Credit = 20		Teaching Hour = 23		
	Semester VIII				
MC19	Space Physics	4	4		
MC20	Computational Physics	4	4		
ME Project / Courses	Project / (Plasma Physics, Astrophysics 2, Condensed Matter Physics)	12/ (4+4+4)	0/9		24/6
	Total Credit = 20		Teaching Hour = 32/23		

Detailed Syllabus

MC1: Classical Mechanics (Credit 3+1)

Component : Theory (Credit 3)

Unit 1: Fundamentals of Dynamics
Reference frames. Inertial frames; Galilean transformations; Galilean invariance. Review of Newton's Laws of Motion. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. Momentum of variable-mass system: motion of rocket.

Unit 2: Collisions
Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames.

Unit 3: Rotational Dynamics
Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

Unit 4: Gravitation and Central Force Motion
Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). Physiological effects on astronauts.

Unit 5: Non-Inertial Systems
Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.

Unit 6: Classical Mechanics of Point Particles
Generalized coordinates and velocities. Hamilton's Principle, Lagrangian and Euler-Lagrange equations. Applications to simple systems such as coupled oscillators. Canonical momenta & Hamiltonian. Hamilton's equations of motion. Applications: Hamiltonian for a harmonic oscillator, particle in a central force field. Poisson brackets. Canonical transformations.

References

- Evolution of Physics by Einstein and Infeld
- Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
- An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw- Hill
- Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
- Classical Mechanics and General Properties of Matter. S.N. Maiti and D.P. Raychaudhuri, New Age
- Introduction to Classical Mechanics, R. G. Takwale and P.S.Puranik, Tata McGraw-Hill Publishing Company Ltd.
- Theory and Problems of Theoretical Mechanics, M. R. Spiegel, Mc Grow Hill Education
- Classical Mechanics , R.D. Gregory, 2006, Cambridge University Press
- Introduction to Classical Mechanics With Problems and Solutions , D. Morin, Cambridge University Press

Component: Practical (Credit 1)

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the height of a building using a Sextant.
4. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
5. To determine the Moment of Inertia of Flywheel.
6. To determine the Young's Modulus of a Wire by Optical Lever Method.

7. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
8. To determine the value of g using Bar Pendulum.

Course learning outcome:

Upon completion of this course, students will be able to,

- **CO1:** Demonstrate the Galilean invariance of Newton's laws of motion.
- **CO2**: Understand translational and rotational dynamics of a system of particles.
- **CO3:** Illustrate elasticity and fluid motion
- **CO4**: Apply Kepler's laws to describe the motion of planets and satellite in circular orbit.
- **CO5**: Explain and analyze central force motion and relate with problems
- **CO6**: Elaborate Lagrangian, Hamiltonian and solve equation of motion for various problems
- **CO7**: In the laboratory part of the course, the students will learn to use various instruments, estimate the error for every experiment performed and report the result of experiment along with the uncertainty in the result up to correct significant figures.

MC2: Mathematical Methods (Credit 4)

Component : Theory (Credit 4)

Unit 1: Vector Calculus

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations.Vector product, Scalar triple product and their interpretation in terms of area and volume respectively.Scalar and Vector fields.

Vector Differentiation: Directional derivatives and normal derivative.Gradient of a scalar field and its geometrical interpretation.Divergence and curl of a vector field.Del and Laplacian operators.Vector identities, Gradient, divergence, curl and Laplacian in spherical and cylindrical coordinates.

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian.Notion of infinitesimal line, surface and volume elements.Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs).

Unit 2: Vector space: Definition, linear independence , bases, dimensionality, inner product; Gram-Schmidt orthogonalisation ; **Space of Complex numbers as a vector space and the ,triangle and Schwarz inequalities.**
Matrices: Representation of linear transformations and change of base; Eigenvalues and eigenvectors; Functions of a matrix; Cayley-Hamilton theorem; Commuting matrices with degenerate eigenvalues ;Orthonormalityof eigenvectors.

Unit 3: Matrices

Unit 4: Calculus

Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions.Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). First Order Differential Equations and Integrating Factor.

References

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.

Non-Major Minor (NM1)
Analytical Techniques for Physics (Credit 4)

Unit 1: Second Order Differential equations: Homogeneous Equations with constant coefficients. Wronskian and general solution.Statement of existence and Uniqueness Theorem for Initial Value Problems.Particular Integral. Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration.Constrained Maximization using Lagrange Multipliers.

Unit 2:Frobenius Method and Special Functions
Singular Points of Second Order Linear Differential Equations and their importance.Frobenius method and its applications to differential equations.Basic ideas on Legendre, Bessel, Hermite and Laguerre Differential Equations.

Unit 3:Some Special Integrals
Beta and Gamma Functions and Relation between them.Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).

Unit 4: Integral Transforms

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples.Fourier transform of trigonometric, Gaussian, finite wave train & other functions.Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations.
Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits.

References

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.

Course learning outcome:
After completing this course, student will be able to,
• **CO1:** Draw and interpret graphs of various elementary functions. Solve and apply first and second order differential equations for physics problems. Understand the functions of more than one variable and concept of partial derivatives.
• **CO2:** Understand the vector quantities as entities with Cartesian components. Use index notation to write the product of vectors for easy application in computational work. Explain the concept of scalar field, vector field, conservative field, scalar potential, gradient of scalar fields and the divergence and rotation of vector field.
• **CO3:** Elaborate the Dirac delta function and its properties, which have applications in various branches of Physics, especially quantum mechanics.
• **CO4:** Solve practical problems using the integral theorems of vector field. Elucidate and describe the skills that are involved in computational thinking. Build up programming, analytical and logical thinking abilities.

- **CO5:** Represent a periodic function by a sum of harmonics using Fourier series. Solve differential equations with initial conditions using Laplace transform. Evaluate the Fourier transform of a continuous function and be familiar with its basic properties.
- **CO6:** Solve basic ordinary and partial differential equations using analytical techniques.
- **CO7:** Solve improper integrals using beta, gamma functions.

MC3: Electrodynamics (Credit 3+1)

Component : Theory (Credit 3)

Unit 1: Maxwell Equations

Review of Maxwell's equations.

Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry.
Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole.
Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.

Magnetic force between current elements and definition of Magnetic Field B. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of B: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field.
Magnetization vector (M). Magnetic Intensity(H). Magnetic Susceptibility and permeability. Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis.
Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current.

Unit 2: Vector and Scalar Potentials.
Displacement Current. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density.

Unit 3: EM Wave Propagation in Unbounded Media
Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.

Unit 4: EM Wave in Bounded Media
Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence)

Unit 5: Wave Guides:
Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission.

References

- Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
- Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
- Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press
- Electricity and Magnetism, D.Chattopadhyay and P.C.Rakshit, New Central Book Agency, 2011
- Fundamentals of Electricity and Magnetism, B. Ghosh, Books and Allied (P) Ltd., 4th edition, 2015

Component: Practical (Credit 1)

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De'Sauty's bridge.
6. Measurement of field strength B and its variation in a solenoid (determine dB/dx)

MC4: Photonics (Credit 3+1)

Unit 1: Photometry and Radiometry- quantities and units, Colourimetry- chromaticity coordinates, UCSchromaticity coordinates, UCS diagrams, RGB colour mixing and colour purity , colour temperature, CCT, Visual basis of colourimetry, Human eye and colour deficiency ,colour vision model

Unit 2: Modern optics (24 hours) Multiple beam interference-Fabry-Perot interferometer- theory of multilayer films antireflection films and high reflectance films -Fresnel- Kirchoff integral theorem and formula- Fraunhofer and Fresnel diffraction patterns and theory-applications of Fourier transforms to diffraction acoustic- optic modulation- basic ideas of Raman-Nath diffraction and Bragg diffraction holography as wavefront reconstruction-propagation of light in crystals-optical activity and Faraday rotation

Unit 3: Birefringence-Birefringent crystals, polarisers, polarization beam splitters, Wave plates (half-wave, Full-wave and quarter-wave), Compensators and Variable retarders, Circular polarizers Optical activity - Dextro and levorotatory substances, optical activity in liquids, Half-shade plate, Laurrentshalf-shade polarimeter Optical anisotropy-Index ellipsoid, Stress birefringence – Photoelasticity

Analysis of Polarization- Mathematical description of polarization, states of polarization, polarizationellipse, special forms, Elliptical parameters, Stokes polarization parameters, Stokes vectors, Stokesparameters for polarized and unpolarized light, Stokes Intensity formula Jones and Mueller matrixcalculus- Matrices for polarizer, retarder, and rotator in both representations, Neutral densityfilter, Mueller matrix for Depolarizer Poincare sphere, Representation of polarization states

Unit 4: Optical waveguides, numerical aperture, Modes in planar waveguides, Goos-Hanchen effect, evanescent field. Cylindrical fibres. Step index and graded index fibres, single mode and multimodefibres, cut of wavelengths, Integrated Optics, channel waveguides, electro optic waveguides, i/pando/p couplers, e-o and m -o modulators applications of integrated optics - lenses, grating, spectrumanalysers.

Unit 5: Transmission characteristics of optical fibre, attenuation, absorption and scattering losses, nonlinear losses, wavelengths for communication, bend losses, dispersion effects in optical fibres- material , waveguide dispersions, modal birefringence and polarization maintaining fibres. Nonlinear effects inoptical fibres - Self phase modulation, cross phase modulation, stimulated Raman scattering, stimulated Brillouin scattering.

Unit 6: Optical fibre measurements – Attenuation, loss dispersion band width, refractive index profile. OTDR. Testing of optical fibre systems, eye pattern techniques. Fabrication and characterization of silica, polymer fibres and photonic crystal fibres. Erbium doped fibres. Fibre components – couplers, connectors, Packaging, Splicers, Cable, Fiber joints, fiber polishing, Industrial, medical andtechnological applications of optical fibre. Module 4

Fibre optic sensors – advantages of fibre optic sensors. Intensity modulation and interference typesensors, intrinsic: and extrinsic fibre sensors. Wavelength modulated sensors. Fibre Bragg gratingandfibre long period grating sensors. Distributed fibre optic sensors. Polarisation modulationtypesensors. Sagnac and fibre gyro, temperature, pressure, force and chemical sensors.

Unit 7: Non-linear optics (12 hours) Harmonic generation- second harmonic generation- phase matching- third harmonic generation optical mixing- paramagnetization of light- self focusing- multiquantum photoelectric effect two photon process and theory- multiphoton processes- three photon processes- second Unit II harmonic generation- parametric generation of light.

Unit 8: Conditions for producing a Laser : Absorption and gain of homogeneously broadened radiativetransition, gain coefficient and stimulated emission cross section for homogeneous andinhomogeneous broadening. Necessary and sufficient conditions for laser action: Population inversion (necessary condition), saturation intensity (sufficient condition), Development and growth of a laser beam, shapeor geometry of amplifying medium, exponential growth factor (gain), threshold requirements for a laser with and without cavity. Laser Oscillation above threshold: Laser gain saturation, Laser beam growth beyond the saturationintensity, Optimization of laser output power, laser output fluctuations- laser spiking, relaxationoscillations. Laser amplifiers (Elementary ideas only).

Unit 9: Q-switching: Theory, giant pulses, methods of producing Q-switching within a laser cavity, gainswitching. Mode locking : Theory, picosecond optical pulses, techniques for producing mode-locking, Pulse shortening techniques: Generation of ultrashort optical pulses, Self phase modulation, pulsecompression (shortening) with gratings or prisms, femtosecond optical pulses and techniques tocharacterize femtosecond pulses. Properties of laser beams and techniques to characterize laser beam, Semi classical theory of lasers, polarization in the medium, first order theory

References

1. Handbook of Applied Photometry - C De Cusatis, AIP. (1997)
2. Introduction to Soild State Lighting - Zukauskas, Shur, Caska, Wiley (2001)
3. Optics - Eugene Hecht (3rd Edition), Addison Weseli Long inc (1998)
4. Polarized light – Edward Collet, Marcel Decker (1992)
5. Introduction to Optoelectronics- Wilson and Hawkes, PHI, (1996)
6. Wave optics and Applications - R. S. Sirohi, Orient Longmann (2001)
7. Optical Electronics - Thyagarajan and Ghatak, Cambridge University Press (1997)
8. Polarization of light - S. Huard, John Wileyand Sons (1997)
9. Light emitting diodes- E Fred Scheubert, Cambridge University Press (2003)
10. Optics- Ajoy Ghatak, McGraw Hill (2010)
11. Laser fundamentals- W. T .Silfvast, 2 nd edition, Cambridge University Press (2008) (Text).
12. Lasers: Fundamentals and Applications, K. Thyagarajan and Ajoy Ghatak, Springer, 2 nd edition (2011) 13. Principles of Lasers, Orazio Svelto and David C. Hanna, Springer, Fifth Edition (2010)
14. Lasers, A. E. Siegman, Univ Science Books; Revised ed. edition (1986)
15. Laser Physics, Peter W. Milonni, Joseph H. Eberly , Wiley (2010)

Component: Practical (Credit 1)

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2 –T law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous Figures.
4. Familiarization with: Schuster`s focusing; determination of angle of prism.
5. To determine refractive index of the Material of a prism using sodium source.
6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
7. To determine the wavelength of sodium source using Michelson's interferometer.
8. To determine wavelength of sodium light using Fresnel Biprism.
9. To determine wavelength of sodium light using Newton's Rings.
10. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.

11. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
12. To determine dispersive power and resolving power of a plane diffraction grating

MC5: Statistical Mechanics and Thermodynamics(Credit 4+1)

Unit 1: Classical Statistics (8)

Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy

Unit 2: Theory of Radiation (8)

Properties of Thermal Radiation. Blackbody Radiation. Kirchhoff's law. Stefan-Boltzmann law, Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Rayleigh-Jean's Law. Ultraviolet Catastrophe. Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law.

Unit 4: Bose-Einstein Statistics (10)

B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.

Unit 5: Fermi-Dirac Statistics (10)

Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.

Unit 6: Thermodynamics (10)

Statistical mechanics and Thermodynamics, Thermodynamic Functions of an Ideal Gas, Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy. Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Carnot's Cycle, Carnot engine & efficiency

Unit 7: Second Law of Thermodynamics, Entropy and Thermodynamic functions (14)

2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Third Law of Thermodynamics. Unattainability of Absolute Zero. Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Derivations and applications of Maxwell's Relations.

References

• Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
• Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
• Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
• A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press

Component: Practical (Credit 1)

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.

4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
7. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.

MC6: Quantum Mechanics (Credit 4+1)

Unit 1: Foundations of quantum mechanics

Basic postulates if quantum mechanics- Hilberts space- observables- Hermitian operators general statistical interpretation-Uncertainty principle-minimum uncertainty wave packet energy time uncertainty principle-Dirac notation-Matrix representation of state vectors and operators-change of representations- eigenvalue problem in matrix mechanics-energy and momentum representations-unitary transformations involving Heisenberg and interaction pictures.

Unit 2: Exactly solvable problems in quantum mechanics

Time- Schrodinger, One dimensional eigen value problems-square well potential-potential barrier-alpha particle emission-Bloch waves in periodic potential-linear harmonic oscillator problem using wave mechanics and operator methods-free particle wave functions and solutions-three dimensional eigen value problems-particle moving in spherical symmetric potential-rigid rotator-hydrogen atom problem-three dimensional potential well- Deuteron

Unit 3: Variation method (6 hours)

The variational principle-Rayleigh Ritz method-variation method for excited states ground state of Helium and Deutron.

Unit 4: WKB approximation (8 hours)

WKB method-connection formulas-barrier potential-penetration-alpha particle emission bound states in a potential well

Unit 5: Time dependent and time-independent perturbation theory (22 hours)

Time independent perturbation- basic concepts- non-degenerate energy levels- anharmonic oscillator-ground state of helium- effect of electric field on the ground state of hydrogen- degenerate energy levels-effect of electric field on the n=2 state of hydrogen- spin-orbit interaction. Time dependent perturbation-first order, harmonic, transition to continuous states, absorption and emission of radiation- Einstein's coefficients- selection rules.

References:

1. B.K. Agarwal and HariPrakash, Quantum Mechanics, Prentice Hall of India (2002) (2005)
2. S. Devanarayanan, Quanrtum Mechanics, Sci Tech Publications (India) Pvt Ltd (2005)
3. D.J. Griffiths, Introduction to Quantum Mechanics, Second Edition, Pearson Education Inc (G. Aruldas, Quantum Mechanics, Second Edition, PHI learning Pvt Ltd (2009).
4. J. J Sakurai , Modern Quantum Mechanics, Second edition, Pearson (2010).
5. N. Zettili, Quantum Mechanics concepts and Applications, Second edition, Wiley (2009).
6. P.M. Mathews and K.Venkitesan, A Text Book of Quantum Mechanics, Tata Mc Graw Hill Publishers (2004).
7. A. Ghatak and S. Lokanathan ,Quantum Mechanics Theory and Applications, Kluewer Academic
8. V.K. Thankappan, Quantum Mechanics, Second Edition, New Age International Pvt Ltd (2003).

MC7: Basic Electronics (Credit 4+1)

Unit I Selections from electronic circuits (10 hours) Frequency response of an amplifier circuits-power and voltage gain- impedance matchingBode plots- Miller effects- rise time bandwidth relations-frequency analysis of BJT and FET amplifier stages Operational amplifier and its applications (18 hours)

Unit 2: Opamp - frequency response, poles and zeroes, transfer functions (derivation not required), expression for phase angle- Active filters-first order and second order Butterworth transfer function-first order and second order active filters- low pass, high pass and band pass filters- comparators-OP Amp as a voltage comparator-zero crossing detectors-Schmitt trigger-voltage regulators- square, triangular and saw tooth wave form generators-Weinberg oscillator- monostable and astable multivibrator circuits using IC 555 timer- Phase Locked Loop circuits (PLL) Microwave solid state electronic devices (8 hours)

Unit 3:Tunnel diode-varacter diode-IMPATT diode- QWITT diode- TRAPATT diode- Gunn diode

Unit 4: Digital electronics

Arithmetic and data processing digital circuits (16 hours) Binary adder and subtractor- arithmetic logic unit- binary multiplication and divisionarithmetic circuits using HDL- multiplexers- demultiplexers-BCD to decimal decoder- seven segment decoder- parity generators and checkers- magnitude comparator- programmable logic arrays Sequential digital circuits (20 hours)

Flip flops- edge triggered- SR flip flops- JK flip flop- D- flip flop- JK master-slave flip flop- different types of registers (SISO, SIPO, PISO, PIPO)- universal shift registersapplications- counter asynchronous and synchronous electronic counters- decade countersdigital clock

Unit 5: Electronic measurements and instruments-comparison between analog and digital instruments-performance and dynamic characteristics-ideas of errors and measurement standards- voltmeters-ammeters- CRO- Block diagram, CRT, CRT circuits, vertical deflection system- delay line, multiple trace, horizontal deflection system, oscilloscope probes and transducers, oscilloscope techniques, storage oscilloscope, digital storage oscilloscope- classification of transducers-active and passive transducers-force and displacement transducers-strain gauges- temperature measurements-thermistorsthermocouples-flow measurements.

References:

1. A. Malvino and D.J.Bates, Electrinics Prinicples,7th Edition,Tata McGraw Hill (2007)
2. 2. R.A. Gayakwad, Operational Amplifiers and Linear integrated Circuits, Prentice Hall of India (2000) 3. M.S. Tyagi, Introduction to semiconductior materials and devices, Wiley India (2005)
3. B.G. Streetman, S.K. Banerjee, Solid state electronic devices. Pearsoninc (2010)
4. J. Millman, C. Halkias and C.D. Parikh, Integrated Electronics, Tata McGraw Hill (2010)
5. D.P. Leach,A.P. Malvino, and G. Saha ,Digital principles and applications,Tata Mc Graw Hill (2011)
7. G.Keiser, Optical Fibre Communication,3rd edition,McGraw Pub (2000)
8. Lal Kishore, Electronic measurements and Instrumentation, Dorling Kindersley (India) Pvt Ltd (2010)
9. W.D. Cooper, A.O. Helfrik and H. Albert, Electronic Instrumentation and measurement Techniques, PHI (1997)
9. Electronic Devices and Circuits Theory, Robert L. Boylestad, Louis Nashelsky, Pearson 10th edition (2009).

Component: Practical (credit 1)

1. To study the reverse characteristics of Zener diode and study the load and line regulation.
2. To study the static characteristics of BJT in CE Conguration.
3. To design and study the frequency response of the BJT amplifier in CE mode.

4. Construction of a series regulated power supply from an unregulated power supply.
5. To study OPAMP: inverting amplifer, non inverting amplier, adder, substractor, comparator, Schmitt trigger,
Integrator, differentiator, relaxation oscillator.
6. To design a Wien bridge oscillator for given frequency using an op-amp.

Reference Books

1. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill
2. Advanced Practical Physics (volume II), B. Ghosh , Shreedhar Publication
3. An Advanced Course in Practical Physics, D. Chattopadhyay, P.C. Rakshit, New Central Book Agency (P) Ltd
4. Laboratory Manual for Operational Amplifiers and Linear ICs, David A. Bell, Prentice Hall of India Pvt Ltd.

MC8: **SPECIAL THEORY OF RELATIVITY (Credit 5)**

Unit 1: (8)

Newtonian Relativity, Galilean Transformation, Electromagnetism and Newtonian Relativity, Attempts to locate absolute frame, the Michaelson-Morley Experiment, Foundation of special theory of relativity, Postulates of special theory of relativity

Unit 2: (14)

The relativity of simultaneity, Lorentz transformation equations, Derivation and Consequences of Lorentz transformation, Time dilation, Length contraction, Synchronization of clocks, Twin paradox. Lorentz transformation in arbitrary direction. Paradox with muons. Doppler effect

Unit 3: (14)

Relativistic dynamics, Mechanics and Relativity, The need to redefine momentum, Relativistic momentum, Relativistic mass, Relativistic energy, kinetic energy and rest mass energy, relativistic force law and dynamics of a single particle, equivalence of mass and energy. Relativistic collisions

Unit 4: (14)

Geometric representation of space-time, Minkowski space. the invariant interval, light cone and world lines. Space-time diagrams. Four-vectors: space-like, time-like & light-like. Four-velocity and acceleration.
Metric and alternating tensors. Four-momentum and energy-momentum relation. Doppler effect from a four vector perspective. Concept of four-force. Conservation of four-momentum. 4-vectors, Tensors, Transformation properties, Metric tensor, Raising and lowering of indices, Contraction, Symmetric and antisymmetric tensors; 4-dimensional velocity and acceleration; 4-momentum and 4-force

Unit 5: (10)

Relativity and electromagnetism The Electromagnetic field tensor and its transformation under Lorentz transformations: relation to known transformation properties of E and B. Electric and magnetic fields due to a uniformly moving charge. Equation of motion of charged particle & Maxwell's equations in tensor form. Motion of charged particles in external electric and magnetic fields. Invariance of Maxwell’s equations.

References

- Introduction to Special Relativity, R. Resnick, 2010, John Wiley and Sons
- The Special Theory of Relativity, Banerji and Banerjee 2nd Ed., PHI Learning Private Ltd.
- Concepts of Modern Physics, Arthur Beiser, 2013, McGrawhill

MC9: SOLID STATE PHYSICS (Credit 4+1)

Unit 1: Crystal Structure: Solids

Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor. Brief introduction to defects in crystals.

Unit 2: Elementary Lattice Dynamics

Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law

Unit 3: Magnetic Properties of Matter

Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.

Unit 4: Dielectric Properties of Materials

Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes.

Unit 5: Ferroelectric Properties of Materials

Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.

Unit 6: Elementary band theory

Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient.

Unit 7: Superconductivity

Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)

References

• Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
• Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning

Component: Practical (Credit 1)

1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. To determine the refractive index of a dielectric layer using SPR
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 ^{o}C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

MC10:Materials Science

Unit 1: Introduction to Materials: Classification, Properties and Requirements (10)

Introduction, Classification of Engineering Materials, Metals, Alloys, ceramics, Polymers and Semiconducting materials. Crystalline and Non-crystalline Solids, Classification of Bonds, Ionic Bond or

Electrovalent Bond, Covalent Homopolar Bonds, Metallic Bonds, Molecular Bonds, Hydrogen Bond, van der Walls bond (Inter-molecular and Intra-molecular bonds).

Unit 2: Properties of Materials (10)

Introduction, Classification of Optical Materials, Interaction of light with matter, Absorption in Metals, Insulators and Semiconductors, Reflection, Refraction, Transmission and Scattering, Traps, Excitons, Colour Centers, Tauc and Lambert-Beer laws, Optical properties of Photonic material.

Unit 3: Materials characterization using microscopy, diffraction, and spectroscopy (20)

Electron beam instruments: Transmission electron and scanning electron microscopes, Auger electron spectroscope, x-ray spectrometers, electron microprobe, electron spectrometers. Interpretation of diffraction information: selected area and convergent beam Electron diffraction patterns. Analysis of micrographs in TEM, SEM, and HRTEM: Theories of diffraction contrast in TEM, analysis of images in TEM and SEM

Bulk averaging techniques: Optical spectroscopy: Atomic absorption spectroscopy, infrared spectroscopy and Raman spectroscopy, Atomic Force Microscopy. Electrical Characterization, I-V, C-V, Hall effect, Low and High-temperature effect.

Unit 4: Materials for Energy (20)

Photovoltaics: Solar energy and energy conversion, Fundamentals of semiconductor physics and photovoltaic cells, Current status of silicon-based solar cells, Advancement in photovoltaic research and design of new generation solar cells (hybrid, quantum dot, dye-sensitized and perovskite solar cells)

Batteries & Supercapacitors: Basic concepts of Batteries, Supercapacitors and Fuel cells, Thermodynamics and kinetics involved in electrochemical reactions, Primary and rechargible batteries, Li-ion Battery, Components and processes in batteries (Battery operations), Components of supercapacitors, Elecetrochemical properties (Charging/discharging cycles, Cyclic Voltametry and impedance spectroscop, lifetime stability), Different applications.

Thermoelectric Materials: Fundamentals of thermoelectricity (Seebeck, Peltier and Thomson effects), Thermoelectric Effects and Transport Properties, Basics of Thermoelectric devices, Heat Conduction in Bulk Thermoelectric Materials (Heat Conduction by Phonons, Heat Conduction by Electrons), Progress in Thermoelectric Materials (Bulk Thermoelectric Materials, Nanostructured Thermoelectric Materials), Reduction of Thermal Conductivities in Bulk and Nanostructured Materials), Thermoelectric Devices.

Reference Books:

1. Materials Science : V. Rajendran, A. Marikani, Tata MC Graw Hill
2. Materials Science & Engineering: Raghavan, Tata MC Graw Hill
3. Materials Science: Arumugam
4. Materials Science & Metallurgy : O. P. Khanna
5. Materials Science and Engineering: Callister S.
6. TEXT BOOKS 1. Anke Krueger, “Carbon Materials and Nanotechnology”, Wiley-VCH , 2010. 2. Yury Gogotsi, “Carbon Nanomaterials”, Taylor and Francis, 2006.

MC11: Medical Physics I(A) **(Credit 4)**

UNIT 1: REVIEW OF NONIONISING RADIATIONPHYSICS IN MEDICINE

Different sources of Non Ionising radiation-their physical; properties-first law of photochemistry-Law of reciprocity- - Electrical Impedance and Biological Impedance - Principle and theory of thermography - applications –

UNIT 2: TISSUE OPTICS

Various types of optical radiations - UV, visible and IR sources - Lasers: Theory and mechanism- Laser Surgical Systems-Measurement of fluence from optical sources - Optical properties of tissues – theory and experimental techniques-interaction of laser radiation with tissues – photothermal -photochemical – photoablation – electromechanical effect

UNIT 3: MEDIPHOTONICS

Lasers in dermatology, oncology and cell biology - Application of ultrafast pulsed lasers in medicine and biology - Lasers in blood flow measurement -- Fiber optics in medicine - microscopy in medicine - birefringence - Fluorescence microscope - confocal microscope - Hazards of lasers and their safety measures.

UNIT 4: MEDICAL ULTRASOUND

Production, properties and propagation of ultrasonic waves - Bioacoustics - Acoustical characteristics of human body- Ultrasonic Dosimetry - Destructive and nondestructive tests - Cavitation - Piezo electric receivers, thermoelectric probe – Lithotropy - - High power ultrasound in theraphy

UNIT 5: RADIO FREQUENCY AND MICROWAVE

Production and properties - interaction mechanism of RF and mirocwaves with biological systems: Thermal and non-thermal effects on whole body, lens and cardiovascular systems -tissue characterization and Hyperthermia and other applications-Biomagnetism - Effects – application

References:

1. S. S. Martellucci and A. N. Chester, Laser Photobiology and Photomedicine, Plenum Press, New York, 1985.
2. Markolf H. Neimz, Laser-Tissue Interactions, Springer Verlag, Germany, 1996
3. J. P. Woodcock, Ultrasonic, Medical Physics Handbook series 1, Adam Hilger, Bristol, 2002. 2. J. R. Greening, Medical Physics, North Holland Publishing Co., New York, 1999.
4. R. Pratesi and C. A. Sacchi, Lasers in Photomedicine and Photobiology, Springer Verlag, West Germany, 1980.
5. Harry Moseley, Hospital Physicists' Association, Non-ionising radiation: microwaves, ultraviolet, and laser radiation, A. Hilger, in collaboration with the Hospital Physicists' Association, 1988

MC11: ENGINEERING PHYSICS I (B) **(Credit 4)**

Unit 1: ELECTRICAL TECHNOLOGY

Circuit Analysis Techniques, Circuit elements, Simple RL and RC Circuits, Kirchoff's law, Nodal Analysis, Mesh Analysis, Linearity and Superposition, Source Transformations, Thevnin's and Norton's Theorems, Time Domain Response of RC, RL and RLC circuits, Sinusoidal Forcing Function, Phasor Relationship for R, L and C, Impedance and Admittance. Semiconductor Diode, Zener Diode, Rectifier Circuits, Clipper, Clamper, Bipolar Junction Transistors, Transistor Biasing, Transistor Small Signal Analysis, Transistor Amplifier, Operational Amplifiers, Op-amp Equivalent Circuit, Practical Op-amp Circuits, DC Offset, Constant Gain Multiplier, Voltage Summing, Voltage Buffer, Controlled Sources, Instrumentation Circuits, Active Filters and Oscillators. Number Systems, Logic Gates, Boolean Theorem, Algebraic Simplification, K-map, Combinatorial Circuits, Encoder, Decoder, Combinatorial Circuit Design, Introduction to Sequential Circuits. Magnetic Circuits, Mutually Coupled Circuits, Transformers, Equivalent Circuit and Performance, Analysis of Three-Phase Circuits, Electromechanical Energy Conversion, Introduction to Rotating Machines.

UNIT 2: ENGINEERING MECHANICS

1. Rigid body statics: Equivalent force system. Equations of equilibrium, Freebodydiagram, Reaction, Static indeterminacy.
2. Structures: 2D truss, Method of joints, Method of section. Beam, Frame, types ofloading and supports, axial force, Bending moment, Shear force and TorqueDiagrams for a member:
3. Friction: Dry friction (static and kinetic), wedge friction, disk friction (thrustbearing), belt friction, square threaded screw, journal bearings, Wheel friction, Rolling resistance.

4. Centroid and Moment of Inertia
5. Virtual work and Energy method: Virtual Displacement, principle of virtual work,mechanical efficiency, work of a force/couple (springs etc.), PotentialEnergyandequilibrium, stability.
6. Introduction to stress and strain: Definition of Stress, Normal and shear Stress.Relation between stress and strain, Cauchy formula.
7. Stress in an axially loaded member,
8. Stresses due to pure bending,
9. Complementary shear stress,
10. Stresses due to torsion in axi-symmetric sections:
11. Two-dimension state of stress, Mohr's circle representation, Principal stresses

References:

1. C. K. Alexander and M. N. O. Sadiku, Fundamentals of Electric Circuits, 3rd Edition, McGraw-Hill, 2008.
2. W. H. Hayt and J. E. Kemmerly, Engineering Circuit Analysis, McGraw-Hill, 1993.
3. Donald A Neamen, Electronic Circuits; analysis and Design, 3rd Edition, Tata McGraw-Hill Publishing Company Limited.
4. Adel S. Sedra, Kenneth C. Smith, Microelectronic Circuits, 5th Edition, Oxford University Press, 2004.
5. R. L. Boylestad and L. Nashelsky, Electronic Devices and Circuit Theory, 6th Edition, PHI, 2001.
6. M. M. Mano, M. D. Ciletti, Digital Design, 4th Edition, Pearson Education, 2008.
7. Floyd and Jain, Digital Fundamentals, 8th Edition, Pearson.
8. A. E. Fitzgerald, C. Kingsley Jr. and S. D. Umans, Electric Machinery, 6th Edition, Tata McGraw-Hill, 2003.
9. D. P. Kothari and I. J. Nagrath, Electric Machines, 3rd Edition, McGraw-Hill, 2004.
10. I. H. Shames, Engineering Mechanics: Statics and dynamics, 4th Ed, PHI, 2002.
11. F. P. Beer and E. R. Johnston, Vector Mechanics for Engineers, Vol I - Statics, 3rd Ed, TataMcGraw Hill, 2000.
12. J. L. Meriam and L. G. Kraige, Engineering Mechanics, Vol I - Statics, 5th Ed, John Wiley, 2002. 4. E.P. Popov, Engineering Mechanics of Solids, 2nd Ed, PHI, 1998. 5. F. P. Beer and E. R. Johnston, J.T. Dewolf, and D.F. Mazurek, Mechanics of Materials, 6th Ed, McGraw Hill Education (India) Pvt. Ltd., 2012.

MC12: Atomic, Molecular and Particle physics (Credit 4)

Unit 1: Atomic Spectroscopy
Spectra of Atoms - Spectroscopic terms– selection rules– exchange symmetry of wave functions Pauli's exclusion principle. Many electron atoms- Building principle- the spectra of Li and hydrogen like elements, The L-S and j-j coupling schemes- total angular momentum – term symbols- The spectra of Helium-Zeeman effect – The magnetic moment of atom, Lande's g factor- The normal Zeeman effect- Emitted frequencies in anomalous Zeeman transitions- Nuclear spin and Hyperfine structure, Stark Effect, Paschen Bach effect

Unit 2: Molecular symmetry
Symmetry operations-symmetry elements-algebra of symmetry operations-multiplication tables-matrix representation of symmetry operators-molecular point groups-reducible and irreducible representations-great orthogonality theorem-character tables for C2V and C3V point groups, symmetry species of point groups-IR and Raman activity

Unit 3: Photoelectron and Photo-acoustic spectroscopy
Photoelectron spectroscopy-experimental methods-photoelectron spectra and their interpretation-Auger electron and X ray Fluorescence spectroscopy-Photo-acoustic effect-basic theory-experimental arrangement-applications.

Unit 4: Molecular rotational spectroscopy
Classification of molecules-rotational spectra of diatomic molecules-isotope effect and intensity of rotational lines-non rigid rotator-linear polyatomic molecules-symmetric and asymmetric top molecules-microwave spectrometer-analysis of rotational spectra.

Unit 5: IR spectroscopy
Vibrational spectra of diatomic molecules-characteristic IR spectra-vibrations of polyatomic molecules-anharmonicity- Fermi resonance-hydrogen bonding-normal modes of vibration in a crystal- interpretation

of vibrational spectra- IR spectrometer- Fourier transform IR spectroscopy

Unit 6: Electronic spectra of molecules
Vibrational coarse structure and analysis of bound systems- Deslanders table-Frank Condon principle-vibrational electronic spectra-rotational fine structure- Fortrat parabola electronic angular momentum in diatomic molecules

Unit 7: Raman spectroscopy
Theory of Raman scattering-rotational and vibrational Raman spectra-Raman spectrometer structure determination using Raman and IR spectroscopy-nonlinear Raman effects-Hyper Raman effect stimulated Raman scattering- coherent anti-stokes Raman scattering

Unit 8: Elementary particle physics
Elementary particle interactions-symmetries and conservation laws-quark model of elementary particles-colored quarks and gluons-ideas of charm, beauty and truth-quark dynamics-ideas of grand unified theories of fundamental forces

References:

1. J.M. Hollas, Modern Spectroscopy, Fourth Edition, John Wiley &Sons (2004)
2. G. Aruldas, Molecular Structure and Spectroscopy, PHI learning Pvt Ltd (2007)
3. Suresh Chandra, Molecular Spectroscopy, Narosa Publishing Co (2009)
4. H E White, Introduction to Atomic Spectroscopy McGraw-Hill Inc. 1st Edition.
5. C.N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy, Fourth edition, Tata McGraw Hill (1995).
6. D.N. Satyanarayana, Vibrational spectroscopy-Theory and applications, New Age International Pvt Ltd (2004)
7. J.L.McHale, Molecular Spectroscopy, Pearson education Inc (2008).

MC13: Solid State Devices (Credit 4)

Unit 1: Crystal Properties and Growth of Semiconductors

Semiconductor materials- Periodic Structures- Crystal Lattices- Cubic lattices –
Planes and Directions-The Diamond lattice- Bulk Crystal Growth-Starting Materials-Growth of Single Crystal lngots-Wafers-Doping- Epitaxial Growth –Lattice Matching in Epitaxial Growth –Vapor –Phase Epitaxy-Atoms and Electrons

Unit 2:
Elemental and compound semiconductors, Intrinsic and Extrinsic semiconductors, the concept of effective mass, Fermions-Fermi Dirac distribution, Fermi level, Doping and Energy band diagram, Equilibrium and steady-state conditions, Density of states and Effective density of states, the Equilibrium concentration of electrons and holes.Excess carriers in semiconductors: Generation and recombination mechanisms of excess carriers, quasi-Fermi levels.

Unit 2:
Carrier transport in semiconductors, drift, conductivity and mobility, a variation of mobility with temperature and doping, Hall Effect. Diffusion, Einstein relations, Poisson equations, Continuity equations, Current flow equations, Diffusion length, Gradient of the quasi-Fermi level.

UNIT 3: JUNCTIONS

Fabrication of P-N Junctions-Thermal Oxidation-Diffusion –Rapid Thermal Processing-Ion Implantation-Chemical Vapor Deposition Photolithography-Etching –Metallization-Equilibrium

Conditions-The Contact Potential-Equilibrium Fermi Levels –Space Charge at a Junction-Forward –and Reverse –Biased Junctions; -Steady state conditions-Qualitative Description Of current flow at a junction-Carrier Injection-Reverse Bias-Reverse –Bias Breakdown-Zener Breakdown –Avalanche Breakdown-Rectifiers-The Breakdown Diode-Transient and AC Conditions –Time variation of stored charge-Reverse Recovery Transient –Switching Diodes –Capacitance of P-N Junctions-The Varactor Diode-Deviations from the Simple Theory-Effects of contact Potential on carrier injection-Recombination and Generation in the Transition Region-Ohmic Losses –Graded Junctions-Metal –Semiconductor Junctions-Schottky Barriers-Rectifying contacts-Ohmic Contacts-Typical Schottky Barriers-HetrojunctionsPN junctions : Contact potential, Electrical Field, Potential and Charge distribution at the junction, Biasing and Energy band diagrams, Ideal diode equation. Metal Semiconductor contacts, Electron affinity and work function, Ohmic and Rectifying Contacts, current voltage characteristics. Bipolar junction transistor, current components, Transistor action, Base width modulation.

Unit 4:

Ideal MOS capacitor, band diagrams at equilibrium, accumulation, depletion and inversion, threshold voltage, body effect, MOSFET-structure, types, Drain current equation (derive)- linear and saturation region, Drain characteristics, transfer characteristics

Unit 5:

MOSFET scaling – need for scaling, constant voltage scaling and constant field scaling.Sub threshold conduction in MOS. Short channel effects- Channel length modulation, Drain Induced Barrier Lowering, Velocity Saturation, Threshold Voltage Variations and Hot Carrier Effects. Non-Planar MOSFETs: Fin FET –Structure, operation and advantages.

References:

1. Ben G. Streetman and Sanjay Kumar Banerjee, Solid State Electronic Devices, Pearson 6/e, 2010

2. Sung Mo Kang, CMOS Digital Integrated Circuits: Analysis and Design, McGraw-Hill, Third Ed., 2002

MC14: NANOTECHNOLOGY (Credit 3+1)

Unit 1: **Nanoscale Systems**

Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation: Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.

Unit 2: Synthesis of Nanostructure Materials (Basic idea)

(a) Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation.
(b) Vacuum deposition
• Physical vapor deposition (PVD)
• Thermal evaporation
– Electron beam evaporation
– Pulsed Laser deposition
• Chemical vapor deposition (CVD)
• MBE growth of quantum dots
(c) Chemical Synthesis
• Chemical bath deposition
• Electro deposition
• Spray pyrolysis

• Hydrothermal synthesis
• Sol-Gel synthesis

Unit 3: Characterization

(a) X-Ray Diffraction. Optical Microscopy. UV-Vis spectroscopy, Scanning Electron Microscopy (SEM). Transmission Electron Microscopy (TEM). Atomic Force Microscopy (AFM). Scanning Tunneling Microscopy (STM).

Unit 4: Applications

(a) Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (Diodes, Photodetector, LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots -magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).

Component: Tutorial
Tutorial: In tutorial section, problems in the theory classes should be discussed. Problems and solutions regarding the theory course may be discussed.

References:

1. Introduction to Nanotechnology (Wiley India Pvt. Ltd.), C.P. Poole, Jr. Frank J. Owens
2. Nanotechnology: Principles & Practices, S.K. Kulkarni, (Capital Publishing Company)
3. Introduction to Nanoscience and Technology, K.K. Chattopadhyay and A. N. Banerjee, (PHI Learning Private Limited)
4. Nanotechnology, Richard Booker, Earl Boysen, (John Wiley and Sons)
5. Nanoparticle Technology Handbook (Elsevier, 2007), M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama
6. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press
7. Handbook of Nanotechnology, Bharat Bhushan, Springer (Springer-Verlag, Berlin, 2004)

MC15: Astrophysics (Credit 4)

Unit1: Introduction

Size and Time Scales, Historical Astronomy

Unit 2: Astronomical Instrumentation

Unit 3: Stars

Spectra, Classification, Stellar Structure Equations and Survey of Stellar Evolution, Stellar Oscillations, Degenerate and Collapsed Stars, Radio Pulsars

Unit 4: Interacting Binary Systems

Accretion Disks, X-ray Sources, Gravitational Lenses, Dark Matter

Unit 5: Interstellar Medium

HII Regions, Supernova Remnants, Molecular Clouds, Dust, Radiative Transfer, Jeans' Mass, Star Formation

Unit 6: High-energy Astrophysics

Compton Scattering, Bremsstrahlung, Synchrotron Radiation, Cosmic Rays

References:

1. Hansen, Carl J., Steven D. Kawaler, and Virginia Trimble. *Stellar Interiors: Physical Principles, Structure and Evolution*. New York, NY: Springer, 2004. ISBN: 9780387200897.
2. Carroll, Bradley W., and Dale A. Ostlie. *An Introduction to Modern Astrophysics*. Reading, MA: Addison-Wesley Pub., 1995. ISBN: 9780201547306.
3. Kippenhahn, Rudolf, and Alfred Weigert. *Stellar Structure and Evolution*. New York, NY: Springer-Verlag, 1990. ISBN: 9780387502113.
4. Shapiro, Stuart L., and Saul A. Teukolsky. *Black Holes, White Dwarfs, and Neutron Stars*. New York, NY: Wiley, 1983. ISBN: 9780471873167.

MC16: Spectroscopic Techniques (Credit 4)

Unit 1: NMR Spectroscopy

Introduction to NMR; isotope ratios, nuclear spin; chemical shifts, coupling constants and integration; Fourier transform technique. Chemical shifts, coupling constants and correlation with structure and stereochemistry. Long range coupling; magnetic and chemical shift equivalence; first and second order spectra; dynamic process; simplification of spectra by shift reagents and decoupling experiments; stereochemistry by NOE measurements

Nuclear Spin states and Larmor precession, spin-spin and spin-lattice relaxations Selection rules and relative intensities of lines Treatment of Chemical Shift and spin-spin coupling in AX, AMX and AB proton NMR, Multinuclei NMR with special reference to C-13 and relative abundances and intensities, Spin-decoupling methods, Origin of NMR chemical shift, and spin-spin coupling. Factors Affection Chemical Shifts, Chemical exchange, Pulsed FT-NMR- Time and Frequency Domain Spectra

Unit 2: ESR Spectroscopy

Electron Spin and its Characteristics, Treatment of ESR of hydrogen atom with spin levels, gvalue and hyperfine interaction in hydrogen atom and free radicals, Mechanism of proton splitting in organic molecules; McConnel Equation. Basic introduction to anisotropic g- and Atensors from transition ions, Energy levels in many electron spin systems and zero-field splitting

Unit 3: Basic Principles of Mossbauer spectroscopy

Mossbauer effect and Mossbauer Spectroscopy and Mossbauer energy levels with isomer shift, Qudrupole splitting and hyperfine interaction with special reference to Fe57, and Sn119.

Unit 4: Mass Spectrometry

Introduction, ion production-EI, CI, FD and FAB, factors affecting fragmentation , ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement. Nitrogen rule, example of Mass fragmentation of organic compounds with respect to their structure determination. Problems based on spectroscopic techniques.

Mass spectral fragmentation of organic compounds with common functional groups; molecular ion peak; metastable peaks, Mc Lafferty rearrangement; nitrogen rule. High resolution mass spectrometry –

ESIMS and MALDI-TOF. Examples of mass spectral fragmentation of organic compounds.

Unit 5: Raman Spectroscopy

Unit 6: Angle resolved UV photoemissio spectroscopy

Unit 7: Vibrational spectroscopy,

Unit 8: Photon correlation spectroscopy

References:

1. Practical NMR Spectroscopy, M. L. Martin. J. J. Deepish and G. J. Martin, Heyden.

2. Spectrometric Identification of Organic Compounds, R. M. Silverstein, G. C. Bassler and T. C. Morrill, John Wiley.

3. Introduction to NMR spectroscopy, R. J. Abraham, J. Fisher and P. Loftus, Wiley.

4. Application of Spectroscopy of Organic Compounds, J. R. Dyer Prentice Hall.

5. Spectroscopic Methods in Organic Chemistry D. H. Williams, I. Fleming, Tata McGrawHill.

6. W. Kemp, Organic Spectroscopy, 3rd edition, Wiley, 1995.

7. Introduction to Spectroscopy: Donald L. Pavia, Thompson, 2009.

8. Modern NMR techniques for Chemistry Research, A. E. Derome, Pergamon.

9. Physical Methods in Chemistry, R. S. Drago, Saunders College. 10. Chemical Applications of Group Theory, F. A. Cotton

MC17:<u>Quantum Computation (Credi4)</u>

Unit 1 : The Meaning of Computation ; Classical Gates

Unit 2 : The Qubit

Classical bit ; Quantum bit or Qubit ; quantum states and qubits; Bloch Sphere representation of a qubit ; computational basis with examples

Unit 3: Quantum Gates

Fundamental difference between classical gates and quantum gates ; Single qubit gates ; Multiple qubit gates; Hadamard gate ; Phase shift gate ; Controlled NOT (CNOT) gate; Universality of quantum gates ; Quantum Networks ; Quantum Circuits ; Measurements in bases other than the computational basis ; No Cloning theorem

Unit 4 : Quantum Algorithms

Classical computations on a quantum computer ; Quantum parallelism ; Deutsch's algorithm ;The Deutsch–Jozsa algorithm ; Grover Search ; Phase Estimationand Quantum Fourier Transform

Unit 5: Quantum Information

The Stern–Gerlach experiment ; Prospects for practical quantum information processing ; Quantum information theory: example problems ; Quantum information in a wider context

Unit 6 : The Problem of Measurement

State space ; Evolution ; Quantum measurement; Distinguishing quantum states ; Projective measurements;

POVM measurements ; Phase ; Composite systems ; Superdense coding

Unit 7:   Entanglement
Meaning of entanglement ; Bell states ; Bell states as an orthogonal basis ; Teleportation

Unit 8 : The Density Operator
The density operator; Ensembles of quantum states; General properties of the density operator ; The reduced density operator ; The Schmidt decomposition and purifications ; EPR and the Bell inequality

Unit 9: Quantum computation

Single qubit operations ; Controlled operations ; Measurement ; Universal quantum gates ; Universality: Two-level unitary gates; Single qubit and CNOT gates ;
Quantum computational complexity ; Simulation of quantum systems ; Quantum simulation algorithm

Unit 10 : The quantum Fourier transform and its applications 216
The quantum Fourier transform ; Phase estimation ; order-finding and factoring ;

Unit : 11 Quantum search algorithms
The oracle ; Quantum search as a quantum simulation ; Quantum counting

Unit 12 : Physical Realisation of Quantum Computers
Ion traps ; Nuclear magnetic resonance; Cavity quantum electrodynamics

Unit 13 : Quantum Information Theory
Classical noise Markov Processes; Quantum noise and quantum opearations;
Distance measures for quantum information ; Quantum Error correction ;
Shor code ; Shannon entropy ; Von Neumann entropy ;
Using Entanglement to transmit information ; Quantum Cryptography

MC18: Medical Physics II (A) **(Credit 4)**

MEDICAL INSTRUMENTATION

UNIT 1: BIOPOTENTIAL ELECTRODES AND TRANSDUCERS

Cell structure-nature of cancer cells - Transport of ions through cell membrane - Resting and action potential - half cell potential - bioelectric potential - design and co;mponents of medical insturments - electrodes - surface, needle, depth electrodes - electrical circuits.

UNIT 2: BIOELECTRIC SIGNAL RECORDING

Introduction - characterstics of recording systems - Electrodcardiography (ECG) - Electroencephalograph (EEG)- Electromyograph (EMG)- Electroneurograph (ENG) - recoring units.

UNIT 3: PHYSIOLOGICAL ASSIST DEVICES

Cardiac pacemakers - natural and artificial pacemakers - pacemaker batteries - defibrillator - A. C./D. C. synchronized defibrillator - stimulators - bladder stimulators - Heart lung machine - Various types of oxygenators - kidney machine - hemodialysing units - peritoneal dialysis.

UNIT 4: CLINICAL AND OPERATION THEATER EQUIPMENTS

Flame Photometer - Spectroflurometer - pH meters - Audiometer - endoscopes - Electromagnetic and laser blood flow meters - ventilators - diathermy units - ultrasonic, microwave and short wave diathermy – Types and their applications – Surgical diathermy.

UNIT 5: BIOTELEMETRY AND SAFETY INSTRUMENTATION

Principles of a biotelemetry system: radiotelemetry with subcarrier - multiple channel telemetry systems - problems in implant telemetry - uses of biotelemetry - physiological effects of 50Hz current - microshock and macroshock - electrical accidents in hospitals - devices to protect against electrical hazards.

UNIT 6: IMAGING TECHNIQUES

MRI, ECG, EEG

References:

1. M. Arumugam, Biomedical Instrumentation, Anuradha Publishing Co., Kumbakkonam, Tamilnadu, 2004.

2. Jacobson and Webster, Medicine and clinical Engineering, Prentice Hall of India, New Delhi, 1979.

3. R. S. Khandpur, Handbook of Biomedical Instrumentation, Tata McGraw Hill, New Delhi, 1990.

4. Richad Aston, Principles of Biomedical Instrumentation and measurement, Merrill Publishing Co., London, 1990. 3. Marvin D. Weiss, Biomedical instrumentation, Chilton Book Co., 1973

5. Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, Biomedical Instrumentation and Measurements, Prentice-Hall, 1980

MC18: ENGINEERING PHYSICS II(B) **(Credit 4)**

UNIT 1: THERMAL PHYSICS

Kinetic Theory of Gases, Maxwell-Boltzmann distribution, effusion, collision, equation of state, ideal gas, Equipartition of energy, real gas; Thermal Diffusion Equation; Laws of Thermodynamics, Temperature, Internal Energy, Entropy; Equivalence of Kelvin-Planck and Clausius Statements; Carnot Efficiency, Various thermodynamic cycles;Free energies, Path and State Functions, Gibb's-Duhem relations, Maxwell Relations, Clausius-Clapeyron Equation; Chemical Potential, Chemical Equilibrium, Phase Diagram, Gibb's Phase Rule, Phase Transitions, Stable and Metastable States, Phase Co-existence, Maxwell's Construction; Various modes of heat transfer;Saha-Ionization; Speed of Sound in Fluids, Shock Waves, RankineHugoniot Conditions. Engineering applications -Heat Engines, Refrigeration, Heating-Ventilation and Air-conditioning (HVAC), Information Theory

UNIT 2: VACUUM SCIENCE AND TECHNIQUES

Fundamentals of vacuum, units of pressure measurements, Gas Laws (Boyles, Charles), load-lock chamber pressures, Partial and Vapor Pressures, Gas flow, Mean free path, Conductance, Gauges, Capacitance Manometer, Thermal Gauges, Thermocouple, Pirani Gauge, Penning Gauge, High Vacuum Gauges, Leak Detection, Helium Leak Detection, Cold Cathode Gauge, Roughing (Mechanical) Pumps, Pressure ranges, High Vacuum Pumps: Oil Diffusion Pump, Tolerable fore line pressure System configuration, Oils, Traps Crossover pressure calculations, Pump usage and procedures, Turbomolecular pump, Cryopumps, Pump usages, Out gassing and Leak Testing. Introduction to Deposition, Anti Reflection (AR) Coatings, Mono-dimensionally modulated (MDM) Filters, Vacuum Coatings, High reflectors, e-beam deposition systems, Film Stoichiometry, Sputtering, Itching and Lithography, Chemical Vapour deposition and Pulse Laser deposition, Mass Flow control, Reactive sputtering, Film growth control.

.References:

1. Stephen J. Blundell and Katherine M. Blundell, Concepts in Thermal Physics, 3rd Ed, Oxford University Press, 2014.

2. R. H. Dittman and M. W. Zemansky, Heat and Thermodynamics, McGraw-Hill College; Subsequent Ed, 1996. Reference Books:

3. M. N. Saha and B. N. Srivastava, Treatise on Heat, 3rd Edition, The Indian Press, Allahabad, 1950.

4. R.Baierlein, Thermal Physics, Cambridge University Press, 2005.

5. M.Ohring, Materials Science of Thin Films, Second Edition, Academic Press, 2001.

6. K.L. Chopra and S.R. Das, Thin Film Solar Cells, Springer, 1983.

7. N. Yoshimura, Vacuum Technology: Practice for Scientific Instruments, Springer, 2008.

8. A. Roth, Vacuum Technology, North Holland, 1990.

9. D. Smith, Thin-Film Deposition: Principles and Practice, McGraw-Hill Professional, 1995.

10. K.Shesan, Handbook of Thin Film Deposition, William Andrew, 2002.

MC19: Space Physics (Credit 4)

Unit 1: Introduction to Plasma

What is a plasma?, Gaseous plasma Quasi-neutrality, Collisions of charged particles ,Plasma oscillations , Non-classical plasmas, Dynamics of a charged particle: The key role of the magnetic field, Basic charge motion in constant and uniform fields , Non-uniform magnetic field, Adiabatic invariants Elements of plasma kinetics: The Vlasov Model, Heuristic Derivation of the Vlasov Equation, Properties of the Vlasov Equation, Relation between the Vlasov Equation and Fluid Models, Mobility and Drift Velocity, Stochastic processes in a plasma: The velocity distributions, moments of distribution functions, Collisions and Transport, Electrical Conductivity, Diffusion, Motion in Magnetic Fields in the presence of collisions Elements of magnetohydrodynamics (7 hours) Introduction to magnetohydrodynamics, Magnetic Pressure, Diamagnetic Drift, The Generalized Ohm's Law, Diffusion of a Magnetic Field, The Frozen-in Magnetic Flux, Alfvén Waves Plasma Waves and Dusty Plasma (8 hours) Maxwell's Equations and the Wave Equation: Basic Concepts , Phase Velocity, Wave Packet and Group Velocity , Refractive Index, The General Dispersion Relation, Plasma instabilities, Dusty Plasma: Introduction to Dusty Plasma, Presence of plasma in nature, Generation of plasma, application and modeling

UNIT 2 Sun and space environment

The Sun the primary driver of solar system and life on earth, Basic solar properties, historical understanding, Source of Sun's energy, Nuclear reactions in the solar core, Black Body Radiation and the solar spectrum, Transport of Energy from core and Modelling the solar interior: Convective instability, Convective energy transfer, The quiet photosphere, Around the Sun: The solar disc & Sunspots, magnetic fields, Solar rotation and the solar cycle chromosphere and corona

Unit 3: Solar magnetism

Elements of dynamo theory & Solar kinematic dynamos, Concentrating and expelling the magnetic field, Lorentz force restriction on dynamo action, Basic physics of magnetic flux tubes, Surface magnetic field & Basic large-scale magnetic field, Parker's spiral & Basic heliospheric current sheet, Observed large-scale structure, Connecting the Sun and the solar wind: Origin of solar wind, Magnetic field effects on the wind, Three-dimensional structure & Warped heliospheric current sheet, Various sources of fast and slow winds

Unit 4: Solar observations and methods

Observations of Sun and it's interior from ground, Satellite based observations of Sun, Challenges and Technology, Modeling of Sun and Community models for solar processes.

Unit 5: Terrestrial Upper Atmosphere & Sun –Earth Interactions

Geomagnetism and Terrestrial Upper atmosphere (8 hours) Introduction to Earth's magnetic Field, Elements of earth's magnetic field, Difference between geographic and geomagnetic coordinates , The Terrestrial Upper Atmosphere: Diffusion, Molecular Diffusion, Eddy Diffusion, Diffusive Equilibrium, Maximum Diffusion Velocities, Thermal Structure, Thermosphere, The Exosphere , Modeling Thermosphere through MSIS, Community Models

Unit 6: The Ionosphere

Solar radiation and production of ionization, Ionization Profile, Ion Composition and Chemistry, The D Region, The E Region, The F Region, Gyration-Dominated Plasma Transport, Ambipolar Electric Field and Diffusion, Diffusive Equilibrium in the F2 Region, Sq Current and the Equatorial Electro]et , Modeling ionosphere using IRI, Bent, and Ionospheric conductivity and density models, Some Concepts of Atmospheric Chemistry :Thermodynamics, Chemical Kinetics, Atmospheric Composition and Chemistry, Mesosphere , Thermosphere and Ionosphere

Unit 7: The Terrestrial Magnetosphere

Interaction of the Solar Wind with the Terrestrial Magnetic Field, The Bow Shock and the Magnetopause, The Magnetospheric Cavity, Magnetospheric Current Systems, The Ring Current , Field-Aligned Currents, Plasma Convection in the Magnetosphere, The Axford-Hines and the Dungey Models, Magnetic Diffusion & Magnetic Reconnection, Convection Electric Field & High-Latitude Electrodynamics, Polar Cap Convection for Southward IMF and Ionospheric Convection Velocities, Aurorae, Space Weather, Magnetic Activity and Substorms, Magnetic Storms, Geomagnetic Activity Indices, Importance and applications of Space Weather.

References:

1. Chen, F. F., Introduction of Plasma Physics and Controlled Fusion, Plenum Press, 1984

2. Gombosi, T. I., Physics of the Space Environment, Cambridge University Press, 1998

3. Kellenrode, M-B, Space Physics, An Introduction to Plasmas and Particles in the Heliosphere and Magnetospheres, Springer, 2000.

4. Walker, A. D. M., Magnetohydrodynamic Waves in Space, Institute of Physics Publishing,2005.

5. Fundamentals of solar astronomy by Arvind Bhatnagar, William Livingston (World Scientific Series in Astronomy Astrophysics, Vol-6)

6. Nature's Third Cycle by Arnab Rai Chowdhury, Oxford University Press.

7. Solar and stellar magnetic activity by C . J . Schrijver and C . Zwaan, Cambridge University press

8 Gombosi, T. I., Physics of the Space Environment, Cambridge University Press, 1998

9.Kellenrode, M-B, Space Physics, An Introduction to Plasmas and Particles in the Heliosphere and Magnetospheres, Springer, 2000.

10.M. G. Kivelson and C. T. Russle, Introduction to Space Physics, Cambridge University Press

11.M. C. Kelley, The Earth's Ionosphere, Plasma Physics and Electrodynamics, Elsevier Press

12.Vladislav Yu. Khomich·Anatoly I. Semenov, Nikolay N. Shefov, Airglow as an Indicator of Upper Atmospheric Structure and Dynamics, Springer

13.Henry Rishbeth, Owen K. Garriott, Introduction to Ionospheric Physics (International Geophysics)

14.J. K. Hargreaves, Upper Atmosphere and Solar-terrestrial Relations: Introduction to the Aerospace Environment, Cambridge Press

MC20: COMPUTATIONAL PHYSICS

UNIT 1: Recapitulation of numerical techniques and errors of computation (rounding, truncation);

Preliminaries of Computing; Roots of Non Linear Equations and solution of system of Linear Equations:- Fixed-point iteration, Bisection, Secant, Regula-falsi method, Newton Raphson method, Gauss Elimination method by pivoting, Gauss – Jordan method, Gauss – Seidel method, Relaxation method, Convergence of iteration methods, LU and Choleskydecomposition.

UNIT 2: Interpolation and approximations:-

Lagrange and Newton interpolation, Spline interpolation, Rational approximations, Least square approximations.

UNIT 3: Numerical Integration:-

Newton-Cote's rule, Gaussian quadrature. Numerical Optimisation:- Newton's method, Golden section search, Conjugate gradient method.Numerical Solution of Ordinary and Partial Differential Equations:- Taylor series method, Runge-Kutta methods, Crank-Nicolson method, Split operator technique; Eigen value problems:- Jacobi transformation Fourier Transform:- Discrete Fourier Transform and Fast Fourier Transform in two or more dimensions; Engineering applications

UNIT 4: Classical molecular dynamics simulations,

Verlet algorithm, predictor corrector method, Continuous systems, hydrodynamic equations, particle in a cell and lattice Boltzmann methods; Schrodinger equation in a basis: numerical implementation of Numerov method, matrix methods and variational techniques; applications of basis functions for atomic, molecular, solid-state and nuclear calculations;

UNIT 5: Elements of Density functional theories; Monte Carlo simulations, Metropolis, critical slowing down and block algorithms with applications to classical and quantum lattice models;

UNIT 6: Tractable and intractable problems;

P, NP and NP complete problems with examples; Shor and Grover algorithms; Quantum parallelism;

References:

1. W. H. Press, S. A. Teukolsky, W T. Vetterling and B. P. Flannery, Numerical Recipes in C: The Art of Scientific Programming, 2nd Ed, Cambridge University Press, 1997

2. C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Pearson Education India; 7 Ed, 2007.

3. S. S. Sastry, Introductory Methods of Numerical Analysis, PHI learning Pvt. Ltd., 5th Ed, 2012.

4. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Edition, New Age International (P) Ltd., 2014. Reference Books:

5. E. Kreyszig, Advanced Engineering Mathematics, 9th Edition, Wiley, 2005.

6. B. S. Grewal, Higher Engineering Mathematics, 43rd Edition, Khanna Publishers, 2014.

7. Y. Kanetkar, Let us C, 13th edition, BPB publication 2013.

8. Programming in ANSI C, Tata McGraw-Hill Education, 2008.

9. Programming with C (Schaum's Outlines Series), McGraw Hill Education (India) Private Limited; 3rdEd, 2010.

10. T. Pang, An Introduction to Computationl Physics, Cambridge University Press, 2nd Ed, 2006.

11. S. E. Kooning and D. C. Meredith, Computational Physics, Westview Press, 1990. Reference Books:

12. J. M. Thijssen, Computational Physics, Cambridge University Press, 2nd Ed, 2007.

13. R. H. Landau, M. J. PáezMejía and C. C. Bordeianu, A Survey of Computational Physics: Introductory Computational Science, Vol1, Princeton University Press, 2008

ME: Projects/ Courses (Credit 12)

Course1: Plasma Physics

Unit 1: Introduction:

What is Plasma- Fourth State of Matter, Universal abundance, Saha Ionization equation, Characteristics- Debye Shielding, Quasineutrality, Collective property, Plasma oscillations, Plasma confinement techniques, Magnetic bottle, Tokamak plasma, Applications

Unit 2: Kinetic theory of plasma:

Distribution function, Vlasov equation, Moments of fluid equation

Unit 3: Fluid theory of plasma:

Single fluid theory, Two fluid theory, Basic fluid equations, Linear dispersion relations, Electrostatic modes in Plasma: Langmuir wave, Ion acoustic wave, Upper Hybrid and Lower Hybrid wave

Unit 4: Nonlinear phenomena: Landau damping, Solitary waves in Plasma- KdV equation, Wave instabilities

Unit 5: Plasma modelling:

Tools to study plasma,Perturbation techniques, Numerical approaches

References:

1. Introduction to Plasma Physics and Controlled Fusion by F. F. Chen (Plenum Press, 1984)

2. Fundamentals of plasma physics by P.M. Bellan (Cambridge University Press, 2008)

3. Introduction to Plasma Theory by Dwight R. Nicholson (John Wiley and sons, 1983)

4. Introduction to Plasma Physics, R.J. Goldston and P.H. Rutherford (IOP, 1995)

Course2: Condensed Matter Physics

Unit 1: Electron transport

— Semi-classical equations, Bloch electrons in magnetic and electric fields, Hall effect and magneto-resistance, de Haas-van Alphen effect and Fermi surface determination; Semiconductors — Homogeneous semiconductors: carrier density, inhomogeneous semiconductors, carrier densities in a p-n junction, rectification.

Unit 2: Lattice dynamics and Specific heat

Classical theory of lattice vibration under harmonic approximation; Dispersion relations of one dimension lattices: monatomic and diatomic cases, Characteristics of different modes, long wavelength limit, Optical properties of ionic crystal in the infrared region; Inelastic scattering of neutron by phonon; Lattice heat capacity, models of Debye and Einstein, comparison with electronic heat capacity; Anharmonic effects in crystals - thermal expansion.

Unit 3: Dielectric properties

— Screening, Thomas-Fermi and Lindhard expressions for dielectric constants, local field, optical properties, ferroelectrics;

Unit 4: Mean field theory of ferromagnetic and antiferromagnetic transitions — Heisenberg model, spin waves;

Unit 5: Superconductivity

— Persistent current, Meissner effect and critical fields – type I and II superconductors, specific heat, Electron-Phonon interaction and BCS theory, Ginzburg-Landau theory, Superconducting tunneling-Josephson effect, high-temperature superconductivity – brief discussion.

References:

1. N.W.Ashcroft and N.D.Mermin: Solid State Physics
2. J.R.Christman: Fundamentals of Solid State Physics
3. A.J.Dekker: Solid State Physics
4. C.Kittel: Introduction to Solid State Physics
5. J.P.McKelvey: Solid State and Semiconductor Physics
6. P.M.Chaikin and T.C.Lubensky, Principles of Condensed Matter Physics
7. M.Tinkham: Group Theory and Quantum Mechanics
8. M.Sachs: Solid State Theory
9. A.O.E.Animalu: Intermediate Quantum Theory of Crystalline Solids
10. J.M. Ziman: Principles of the Theory of Solids
11. C.Kittel: Introduction to Solid State Physics

Course3: Astrophysics (Credit 4)

Astrophysics :

Celestial Sphere and observational astronomy
Sky coordinates and motions: Earth Rotation , Sky coordinates and seasons
Phases of the Moon, the Moon's orbit and eclipses ; timekeeping (sidereal vs synodic period); Planetary motions; Kepler's Laws - Gravity; Light & Energy - Telescopes - Optics - Detectors; present list of planets ; Planets and the Solar System ; types of planet ; planet atmospheres ; extrasolar planets ;

Stars ; Measuring stellar characteristics (temperature, distance, luminosity, mass, size) ; Hertzsprung Russell diagram; Stellar structure (equilibrium, nuclear reactions, energy transport) ; birth , evolution and final fate of a star ; types of stars ; Galaxies; Our Milky Way ; Galactic structure ; Galactic rotation ; Galaxy types ; Galaxy formation

Cosmology:
The expansion of the universe, Spacetime geometry, Comoving coordinates, Friedmann-Roberson-Walker (FRW) metric, Proper distances, Dynamics of a photon moving in FRW background, particle and event horizons. The cosmological redshift. Hubble's law, Luminosity distances ; Einstein field equations, Friedmann equation, Critical density, Matter dominated and radiation dominated expansion. Galaxy Rotation curves, Indirect evidence for dark-matter, Discovery of accelerated expansion. Dynamics of dark energy, consmological constant. The Cosmic Mircrowave Background Radiation (CMBR), The equilibrium era, recombination and last scattering, the dipole aniotropy, The Synyaev Zel'dovich effect, Primary fluctuations in CMBR, Scahs-Wolfe effect, Harrison – Zel'dovich spectrum, Doppler fluctuations, Intrinsic temperature fluctuations, Integrated Scahs – Wolfe effect. Thermal History of early universe, Cosmological nucleosynthesis, Baryosysthesis and Leptosynthesis, cold dark matter. Comic inflation: flatness, horizon, monopole problem, Slow-roll inflation, Reheating ; Comological perturbation theory, Origin of large scale structure.