M.Sc. Physics

Structure of the Curriculum (2017)

Parts of the curriculum	No. of Courses	Credits
Core	10	50
Elective	4	20
Project	1	4
NMEC	1	2
VLO	1	2
Major Practicals	4	12
Total	21	90

M.Sc Physics

For the Candidates admitted from 2017 onwards

Sem.	Course	Course Title	Course Code	Hours / week	Credits	Marks		
						CIA	ESE	Total
I	Core I	Mathematical Physics - I	P16PH101	6	5	25	75	100
	Core II	Classical Dynamics	P16PH102	6	5	25	75	100
	Core III	Statistical Mechanics	P17PH103	6	5	25	75	100
	Core Prac. I	**Major Practical - I**	**P16PH1P1**	**6**	3	40	60	100
	Elective I	Analog and Digital Electronics/ Modern Communication System	P17PH1:1/ P16PH1:2	6	5	25	75	100
II	Core IV	Mathematical Physics - II	P16PH204	6	5	25	75	100
	Core V	Electromagnetic Theory	P16PH205	6	5	25	75	100
	Core Prac. II	**Major Practical - II**	**P16PH2P2**	**6**	3	40	60	100

	Elective II	Atomic and Molecular Physics	P16PH2:1	6	5	25	75	100
	NMEC	Virtual Labs	P16PHPE1	4	**2**	40	60	100
	VLO	RI / MI	P17VL2:1/ P17VL2:2	2	2	25	75	100
III	Core VI	Quantum Mechanics - I	P16PH306	6	**5**	25	75	100
	Core VII	Solid State Physics - I	P16PH307	6	5	25	75	100
	Core VIII	Microprocessor and Microcontroller	P16PH308	6	5	25	75	100
	Core Prac. III	**Major Practical - III**	**P16PH3P3**	**6**	**3**	**40**	**60**	**100**
	Elective III	Nuclear Physics	P16PH3:1	6	5	25	75	100
IV	Core IX	Quantum Mechanics - II	P16PH409	6	**5**	25	75	100
	Core X	Solid State Physics - II	P16PH410	6	5	25	75	100
	Core Prac. IV	**Major Practical - IV**	**P16PH4P4**	**6**	**3**	**40**	**60**	**100**
	Elective IV	Crystal Growth ,Thin Film and Nano Science	P16PH4:1	6	5	25	75	100
	Core Project	Project	P16PH4PJ	6	4	--	--	100

Total Credits : 90

Core Theory : 10	Core Project : 1	Elective :4	Value Education : 1	Total	21
Core Practical : 4	NMEC :1				

NMEC offered by the Department : Virtual Labs - P16PHPE1

Programme : M. Sc. Physics

Sem.	Course	Course Title	Course Code	Hours Per Week	Credits	Marks		
						CIA	ESE	Total
I	Core I	Mathematical Physics – I	P16PH101	6	5	25	75	100
	Core II	Classical Dynamics	P16PH102	6	5	25	75	100
	Core III	Statistical Mechanics	P16PH103	6	5	25	75	100
	Core Prac.I	**Major Practical – I**	**P16PH1P1**	**6**	**3**	**40**	**60**	**100**
	Elective I	Analog and Digital Electronics / Modern Communication System	P16PH1:1/ P16PH1:2	6	5	25	75	100
II	Core IV	Mathematical Physics – II	P16PH204	6	6	25	75	100
	Core V	Electromagnetic Theory	P16PH205	6	5	25	75	100
	Core Prac. II	**Major Practical – II**	**P16PH2P2**	**6**	**3**	**40**	**60**	**100**
	Elective II	Atomic and Molecular Physics	P16PH2:1	6	5	25	75	100
	VLO	RI / MI	P15VL2:1/ P15VL2:2	2	2	25	75	100
	NMEC	Virtual Labs	P16PHPE1	4	4	25	75	100
III	Core VI	Quantum Mechanics – I	P16PH306	6	6	25	75	100
	Core VII	Solid State Physics – I	P16PH307	6	5	25	75	100
	Core VIII	Microprocessor and Microcontroller	P16PH308	6	5	25	75	100
	Core Prac. III	**Major Practicals – III**	**P16PH3P3**	**6**	**3**	**40**	**60**	**100**
	Elective III	Nuclear Physics	P16PH3:1	6	5	25	75	100
IV	Core IX	Quantum Mechanics – II	P16PH409	6	6	25	75	100
	Core X	Solid State Physics – II	P16PH410	6	5	25	75	100
	Core Prac. IV	**Major Practical – IV**	**P16PH4P4**	**6**	**3**	**40**	**60**	**100**
	Elective IV	Crystal Growth, Thin Film And Nano Science	P16PH4:1	6	5	25	75	100
	Core Project	Project	P16PH4PJ	6	4	-	-	100

Total Credits: 92

Core Theory: 10 Core Practicals: 4 Core Project: 1 Value Education: 1 Total Course: 21
Elective: 4 ED Course: 1
ED Course offered by the Department : Virtual Labs - P16PHPE1

CORE I: MATHEMATICAL PHYSICS - I

SEMESTER: I **CODE: P16PH101**

NO. OF HOURS: 6 **CREDITS: 5**

Objectives:

- To acquire mathematical knowledge and apply it to various physical problems.
- To develop problem solving ability related to physical problems.

Unit 1: Vector Fields and Vector Spaces

Gauss theorem, Green's Theorem, Stroke's Theorem and applications – Orthogonal curvilinear coordinates – Expressions for gradient, divergence, curl and Laplacian in cylindrical and spherical co–ordinates.

Definitions – Linear dependence and linear independence of vectors – Bilinear and quadratic forms– change of Basis – Schmidt's orthogonalisation process– Schwartz inequality.

Unit 2: Tensors

Occurrence of tensors in physics – Notation and conventions – Contravariant vector – Covariant vector – Tensors of second rank – Equality and null tensor –Addition and Subtraction – Outer Product of tensors – Inner product of tensors –Contraction of a tensor – Symmetric and antisymmetric Tensors – The Kronecker Delta – The Fully antisymmetric tensor – Quotient law – Examples of quotient law – Conjugate symmetric tensors of second rank – The Metric tensor – Associated tensor.

Unit 3: Differential Equations

Linear ordinary differential equations – Elementary methods – Linear second order differential equations with variable coefficients – Sturm – Liouville differential equation – Linear partial differential equations – Separation of variables – Examples: the wave equation, Laplace equation and diffusion equation.

Unit 4: Curve fitting, Numerical integration and differentiation

The method of least squares – curve fitting - straight line, non–linear equations – Numerical integration – Trapezoidal rule – Simpson's (1/3 and 3/8) rule Numerical solution of ordinary differential equations – Taylor's series method –Euler's method – Improved Euler's method – Modified Euler's method – Runge–Kutta (II and IV order) methods.

Unit 5: Transcendental and Algebraic Equations

Solution of Algebraic and Transcendental equations – Important properties of equations – Successive approximation method – Bisection method – The Newton–Raphson method – The method of false position – Horner's method – Solutions of linear Algebraic equations – Gauss elimination method – Gauss-Jordan method – Gauss–Seidal method.

Books for Study:

1. Sathyaprakash, Mathematical Physics, Sultan Chand and sons, 6th revised edition, New Delhi, 2014
2. H. K. Dass, Mathematical Physics, S. Chand and Co., New Delhi, 2003.
3. A.W.Joshi, Matrices and Tensors in Physics, Wiley Eastern Ltd., New Delhi, 1975.
4. G.Arfken and H.J Weber, Mathematical Methods for Physicists, Prism Books, Bangalore, 1995.
5. N.Vedamurthy, N.Ch.S.N.Iyengar, Numerical Methods, Vikas Publishing House Pvt. Ltd, New Delhi, 2003.

Books for References:

1. E.Kreyszig, Advanced Engineering Mathematics, Wiley, New York, 1999.
2. M.K.Venkatraman, Numerical Methods in Science and Engineering, The National Publishing Company, Madras, 1999.
3. S.S.Sastry, Introductory Numerical Methods, Prentice Hall of India, New Delhi, 2006.
4. R. Bronson, Differential Equations, Schaum's outline series McGraw Hill, New York, 1973.

CORE II: CLASSICAL DYNAMICS

SEMESTER : I ***CODE: P16PH102***

NO. OF HRS: 6 ***CREDITS: 5***

Objectives:

- To introduce different formulations of classical dynamics with their applications.
- To give exposure to the frontier topic of Nonlinear dynamics.
- To enhance the understanding in the theory of Relativity.

Unit 1: Fundamental Principles and Lagrangian Formulation

Mechanics of a particle and system of particles – Conservation theorems – Constraints – Generalized co–ordinates – D'Alembert's principle and Lagrange's equation – Derivation of Lagrange's equation using Hamilton's principle – Application to Simple pendulum, Atwood's machine – Conservation laws and symmetry properties – Central force motion: General features – The Kepler problem – Scattering in a central force field.

Unit 2: Rigid body dynamics and theory of small oscillations

a) Rigid Body Dynamics: Coordinates of rigid bodies – Orthogonal transformations (basics) - The Euler angles – connection between rate change of a vector in body set of axes and in space set of axes - Moments and products of inertia – Euler's equations of motion – The heavy Symmetrical top with one point fixed.

b) Oscillatory Motion: Wave motion – Wave equation- Phase velocity, Group velocity - Dispersion Theory of small oscillations – Normal modes and frequencies – Linear triatomic molecule.

Unit 3: Hamilton's Formulation

Hamilton's canonical equations from variational principle – Principle of Least action – Cyclic coordinates - Canonical transformations – Poisson bracket – Hamilton–Jacobi equation – Hamilton's principal function – Linear Harmonic oscillator – Hamilton's characteristic function - action - angle variables – Application to Kepler's problem.

Unit 4: Nonlinear Dynamics

Dynamical Systems: Linear and nonlinear forces – linear and nonlinear oscillators - Phase trajectories – Classification of Fixed points - limit cycles – Period doubling phenomena and onset of chaos in logistic map.

Solitons: Linear and nonlinear waves – Solitary waves — Fermi Pasta Ulam experiment - Numerical experiments of Kruskal and Zabusky – Solitons- KdV equation (no derivation) one soliton solution by Hirota's direct method.

Unit 5: Relativistic Mechanics

Review of basic ideas of special theory of relativity – Energy and momentum four vector – Minkowski's four dimensional space – Lorentz transformations as rotation in Minkowski's space – Invariance of Maxwell's equations under Lorentz transformation.

Books for Study

1. H. Goldstein, C. Poole, J. Safko, Classical Mechanics, Addison Wesley, New Delhi, 2002.
2. M.Lakshmanan and S.Rajasekar, "Nonlinear Dynamics: Integrability Chaos and Pattern", Springer Verlag, Berlin, 2003.

Books for Reference:

1. N.C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw Hill, New Delhi, 1991.
2. P.G. Drazin and R.S. Johnson, Solitons: An Introduction, Cambridge University Press, New York, 1989.
3. M. Lakshmanan and K.Murali, Chaos in Nonlinear oscillators, World Scientific Co., Singapore, 1996.
4. K.N. SrinivasaRao, Classical Mechanics, University Press,2003.

CORE III: STATISTICAL MECHANICS

SEMESTER: I **CODE: P17PH103**

NO. OF HOURS: 6 **CREDITS: 5**

Objectives:

- To study the consequences of laws of thermodynamics.
- To study principles and application of classical and quantum statistical mechanics.
- To understand the basic concepts in phase transition

Unit 1: Laws of Thermodynamics and their Consequences

Consequences of first law – T and V independent, T and P independent, P and V independent - Entropy and consequences of second law of thermodynamics – consequences of combined first and second law - T and V independent, T and P independent, P and V independent TdS equations – Thermodynamic potential and the reciprocity relations – Clausius – Clapeyron equation – Gibb's – Helmholtz relations – Thermodynamic equilibria – Nernst heat theorem – Consequences of third law – chemical potential.

Unit 2: Classical Statistical Mechanics

Macro and micro states – Statistical equilibrium – phase space and ensembles – Micro canonical ensemble – Liouville's theorem – Maxwell Boltzmann distribution law – Distribution of energy and velocity – Principles of equipartition of energy – Partition function – Relation between partition function and thermodynamic quantities.

Unit 3: Quantum Statistical Mechanics

Basic concepts – Quantum ideal gas – Bose Einstein and Fermi–Dirac statistics – Distribution laws – Partition function for a harmonic oscillator – Specific heat of solids – Einstein's theory – Debye's theory.

Unit 4: Applications of Quantum Statistical Mechanics

Black body and Planck radiation law – Ideal Bose gas: Energy, pressure and thermal properties –Bose Einstein condensation – Liquid Helium and its properties. Ideal Fermi gas: Properties – Degeneracy – Electron gas.

Unit 5: Phase Transitions and Phase Diagrams

Phase equilibria – first and second-order phase transitions –differences and examples – Ising model – diffusion equation – random walk and Brownian motion – Introduction to non-equilibrium processes.

Binary phase diagram –Types- Phase rule – Lever rule – Iron – Carbon diagram – Phase transition characterization - Calorimetry & microstructural techniques (Overview only)

Books for Study:

1. B.R.Agarwal and N.Eisner, Statistical Mechanics, New Age International Pvt. Ltd., New Delhi, 2005.
2. N.Sears and L.Salinger, Thermodynamics Kinetic Theory and Statistical Mechanics, Narosa Publishing House, New Delhi. 1998. (unit1)
3. S.I. Gupta and V. Kumar, Statistical Mechanics, Pragati Prakashan Publishing Ltd., 24th Edition, Meerut, 2011. (unit 2,3&4)
4. Physical Metallurgy – Principles and Practice, V. Raghavan, Prentice Hall of India Private Ltd., New Delhi (unit 5)

Books for Reference:

1. F.Reif, Statistical and Thermal Physics, McGraw Hill, International Edition, Singapore. 1979.
2. R.Huang, Statistical Mechanics, Wiley Eastern Ltd., New Delhi. 2009.
3. SathyaPrakash and Agarwal, Statistical Mechanics, KedarNath Ram Nath and Co., Meerut, 2003.
4. R.K. Pathria and P.D. Beale, Statistical Mechanics, Academic Press, 3rd Edition, 2011.

ELECTIVE I: ANALOG AND DIGITAL ELECTRONICS

SEMESTER: I ***CODE: P17PH1:1***

NO OF HOURS: 6 ***CREDITS: 5***

Objectives:

- To introduce some important solid state devices and their characteristics
- To introduce the basic ideas about communications through optic fiber cables.

Unit 1: Semiconductor Devices and Thyristor:

FET – Characteristics – Parameters – MOSFET – Depletion mode MOSFET – Enhancement mode MOSFET – V_MOSFET.

SCR operation – SCR characteristics – Parameters - 90˚ phase control – TRIAC operation and Characteristics – TRIAC Phase control circuit – SUS – SBS – UJT operation – UJT characteristics – Parameters – Relaxation Oscillator – PUT.

Unit 2: Opto Electronic Devices

LED – Photo conductive cells – Photo diodes – solar cells – Photo transistors – Opto couplers – Photo multiplier tube - Voltage variable capacitor diodes- Thermistors – Tunnel diodes – shoctkly, PIN and Current limiting diodes.

Unit 3: Operational Amplifier

Basic operational Amplifier – parameter of Op- Amp comparator – window comparator – Precision rectifiers – logarithmic – Antilogarithmic amplifiers – Clippers – clampers.

Active filters butter worth – low pass – High pass – band ass – band reject filters. Solution to simultaneous equations and differential equations.

IC 555 timer block diagram – Pulse generator – Square wave generator – voltage control oscillator.

Unit 4: Sequential Circuit Components

Introduction to sequential circuits - Latches and Flip Flop: SR latch - Timing problems and clocked SR latches - JK latch - Master slave latch - Delay Flip Flop - T Flip Flop - Flip Flop excitation requirements - Registers: Serial load

shift registers - Parallel load shift register - Parallel to serial conversion -Universal shift registers.

Unit 5: Microwave Technique and Dielectric Measurement

Reflex Klystron: Introduction- Basic Theory of Operation- Transit time and mode number – Power frequency Characteristics-Output Frequency. Gunn Oscillator: Gunn Oscillator. Directional Coupler: Characteristics of Directional coupler- Directivity and Coupling of a Directional Coupler. Waveguide E-And H-plane Tees: Waveguide H-Plane Tee -Waveguide E-Plane Tee – Characteristics of Parameters. Attenuation Measurement: Attenuators – Attenuator Characteristics – Attenuation Measurement. Dielectric Measurement: Heston and Symth method for Low-Loss Methods.

Books for Study:

1. Floyd, L., Electronic Devices, Pearson Education, New York, 2004. (Units 1,2)
2. David A. Bell, Electronic Devices and Circuits, Oxford university press, New Delhi, 2008. (Units 1,2)
3. Floyd, L., Digital Fundamentals, 10e, Pearson Education, New York, 2004. (Unit 4)
4. David A. Bell, Operational Amplifiers & Linear ICs, Oxford university press, New Delhi, 2011. (Units 3)
5. M.L.Sisodia, G.S.Raghuvanshi, Basic Microwave Techniques and Laboratory Manual, New Age International (P) Limited, New Delhi, 2009. (Units 5).

Books for References:

1. Millman and Halkias, Integrated Electronics, Tata McGraw Hill Ltd., New Delhi, 1987.
2. Malvino, Electronic Principles, Tata McGraw Hill Ltd., New Delhi, 1985.

ELECTIVE I: MODERN COMMUNICATION SYSTEMS

SEMESTER: I **CODE: P16PH1:2**

NO. OF HOURS: 6 **CREDITS: 5**

Objectives:

- To study the consequences of laws of thermodynamics.
- To study principles and application of classical and quantum statistical mechanics.
- To understand the basic concepts in phase transition

Unit 1: Modulation

Introduction – Amplitude modulation (Theory and Mathematical Analysis) – Power in an Am Wave – Vector representation – Block diagram of an Am transmitter – Collector modulation – Double side band modulator – single Side Bank suppressed carrier (SSB/SC) – Vestigial Side Band System (VSM) Frequency modulation (Theory and Mathematical Analysis) – Frequency Spectrum of FM – Vector representation – Narrow Bank FM – Wide Bank FM – Varactor diode FM Modulator – Transistor Reactance FM Modulator Phase Modulation (Theory and mathematical Analysis) – Vector

Representation – Armstrong phase Modulator – Pulse Width Modulation (PWM) – Theory and Pulse Position Modulation

Unit 2: Demodulation and Noise

Detectors – Practical Diode Am Detector – VSB Demodulator – Synchronous Detector – Phase – Licked Loop (PLL) – FM Discriminator Foster – Seeky FM Discriminator – Ration Detector Demodulation of PM. Noise in Communication system: Noise in Am System: Noise in FM system – Noise in Phase Modulated system – Noise in Pulse Modulated System.

Unit 3: Digital communication

Introduction to Digital Communication system _ Amplitude shift Keying (ASK) – Bank width and Spectrum frequency of ASK – Binary ASK Modulator – Coherent ASK Detector – Non Coherent ASK Detector – Frequency shift keying (FSK) – Bandwidth of binary FSK – detection of FSK using PLL – Phase shift keying (PSK) Generation of Binary PSK wave – Detection of Differential phase shift keying (DPSK) – DPSK

Transmitter Generator – DPSK Demodulator – Advantage and disadvantage of Digital Communication.

Unit 4: Broad band and satellite Communication

Time Division Multiplexing (TDM) – Frequency Division Multiplexing (FDM) – Computer communication – Microwave Service Digital Network (ISDN) – Broadband ISDN (BISDN) – Local Area network (LAN) – Bus topology – Star Topology – ring Topology – Hybrid Topology – Private Branch Exchange (PBX) – MODEMS. Communication Satellite Systematic Basic Components of Satellite Communication System – Telemetry, Tracking and Communication System (Block Diagram) – Satellite Links – Uplink and Down Link – Commonly Used Frequency in Satellite Communication – Multiple Access – Error Detection.

Unit 5: Mobile communication

Evaluation and fundamentals – cellular structure and planning – frequency allocations – propagation problems – Base station antennas and mobile antennas – type of mobile system – access methods – TDMA, FDMA and CDMA – DIGITAL Cellular Radio.

Books for Study:

1. SK. Venkatraman – Digital Communication, S. Chand
2. Arokh Singh and A.K. Chhabra – Principles of Communication Engineering – S. chand
3. Subir Kumar Sarkar – Optical Fibres and Fibre Optic Communication system – S. chand.
4. Wireless Communication Principles & Practice – TS. Rapport
5. BL. Theraja – Basic Electronics – S. chand

Books for Reference:

1. George Kennedy – Electronic Communication systems – Mac Graw Hill International 3 ed.
2. Roddy and Coolen – Communication electronics – PHI
3. B.P. Lathi – Communication System – Wiley Eastern
4. K. Samshanmugam, John Wiley – Digital and Analog Communication System
5. Robert M. Gaghardi – Satellite Communication – CBS Publication

CORE IV: MATHEMATICAL PHYSICS – II

SEMESTER : II ***CODE: P16PH204***

NO. OF HOURS: 6 ***CREDITS: 5***

Objectives:

- To acquire basic knowledge in complex variables.
- To enhance the understanding in Fourier integrals and Laplace transform.
- To give detailed exposure to special functions
- To introduce the basic concepts of group theory.

Unit 1: Complex Variables

Functions of complex variables – differentiability – Cauchy – Riemann conditions – integrals of complex functions – Cauchy's integral theorem and integral formula – Taylor's and Laurent's series – residues and singularities – Cauchy's residue theorem – liouville's theorem – evaluation of definite integrals – integration of trigonometric functions around a unit circle.

Unit 2: Fourier series and Transforms

Definition of Fourier series (odd and even functions)– Dirchlet's theorem –complex form of Fourier series – properties of Fourier series – Fourier integral (odd and even functions) – complex form of Fourier integral - Fourier transform –infinite and finite Fourier sine and cosine transforms - properties – solving linear partial differential equations.

Unit 3: Laplace Transform and Green's Functions

Laplace transform – properties of Laplace transforms – solution of second order ordinary differential equations – convolution theorem – green's functions – properties – methods of solutions in one dimension – applications.

Unit 4: Special Functions

Bessel, Legendre, Hermite and Laguerre differential equations – their series solutions – generating function - orthogonal relations - recursion relations – gamma and beta functions.

Unit 5: Group Theory

Basic definitions – multiplication table – sub–groups, co–sets and classes – direct product groups – point groups and space groups - elementary ideas of rotation groups. – Representation theory – homomorphism and isomorphism – reducible and irreducible representations – Schur's lemma – no derivation - the great orthogonality theorem – character tables – c_{2v} ,c_{3v}.

Books for study:

1. Sathyaprakash, Mathematical Physics, Sultan Chand and Sons, 6th Revised Edition, New Delhi, 2014
2. H.K.Dass, Mathematical Physics, S.Chand And Co., Ltd, New Delhi,2003
3. A.W.Joshi, Elements Of Group Theory For Physicists, New Age International Pvt. Ltd, New Delhi, 2005.
4. G.Arfken And H.J Weber, Mathematical Methods For Physicists, Prism Books, Bangalore, 1995.

Books for reference:

1. L.A.Pipes And Harvill, Applied Mathematics For Engineers And Physicists, International Students Edition, Edition, Mcgraw Hill. Ltd., Singapore, 1970.
2. A.K.Ghatak, I.C.Goyal And A.J.Ghua. Mathematical Physics, Macmillan, New Delhi, 1995.
3. E.Kreyszig, Advanced Engineering Mathematics, Wiley New York, 1999.

CORE V: ELECTROMAGNETIC THEORY

SEMESTER : II ***CODE: P16PH205***

NO. OF HOURS: 6 ***CREDITS: 5***

Objectives:

- To learn and understand the laws and their applications associated with electrostatics and magnetostatics.
- To study the laws associated with electromagnetism and its applications.
- To study the nature of electromagnetic wave propagation in different medium.
- To study the production of electromagnetic waves.

Unit 1: Electrostatics

Coloumb's law – The electric field – Continuous charge distribution – Gauss's law – Differential form – Proof – The curl of E – The electrical potential – Electrostatic boundary conditions – Multipole expansion – Energy density of an electrostatic field - Method of images– Applications – Point charge near a grounded conducting plane – A conducting sphere when it is grounded, insulated, insulated and has a total charge Q and when the sphere is maintained at a constant potential.

Unit 2: Magnetostatics

Magnetic fields – Magnetic forces – Biot–Savart law: The magnetic field due to steady straight current – The Divergence and Curl of B – Application of Ampere's Force law – Magnetic Vector Potential – Magnetostatics boundary conditions – Multipole expansion of vector potential – Magnetisation – Magnetic Materials – Magnetic susceptibility and permeability – Measurement of susceptibility – Quincke's Method – Gouy's Method.

Unit 3: Electromagnetism

Faraday's law of electromagnetic induction – Energy in the magnetic field – Maxwell's displacement current – Derivation of Maxwell's Equations - Vector and Scalar potentials – Gauge transformations – Lorentz gauge – Coulomb gauge – Green function for the wave function – Poynting's theorem – Conservation of energy and momentum for a system of charged particles and electromagnetic fields.

Unit 4: Plane Electromagnetic Waves and Wave Propagation

Plane electromagnetic waves in free space, isotropic and anisotropic non conducting media – Conducting Medium (dissipative medium) – Boundary conditions at the surface of discontinuity - Reflection and refraction of electromagnetic waves at a plane interface between dielectrics – Polarization by reflection and total internal reflection – Super position of waves – Polarization - Stokes Parameters.

Unit 5: Wave guides and Simple Radiating Systems

Wave guides – TE waves in a rectangular wave guide – the coaxial transmission lines - Retarded potentials – Radiation and fields due to an oscillating dipole – Electric dipole and quadrapole radiation and Fields - Center fed linear antenna – Fields and Radiation from a linear half wave antenna.

Books for Study:

1. David J. Griffiths, Introduction to Electrodynamics, Pearson Education Ltd., New Delhi, 2015.
2. J.D.Jackson, Classical Electrodynamics, Wiley India, New Delhi, 2007.
3. Chopra and Agarwal, Electromagnetic theory, Kadernath and Ramnath& Co. Meerut.
4. SathyaPrakash, Electromagnetic Theory and Electrodynamics, KadernathRamnath& Co., Meerut, 2007.

Books for Reference:

1. B.B.Laud, Electromagnetics, New Age International Pvt., Ltd., New Delhi, 2005.
2. K.G. Balmain, Electromagnetic Waves and Radiating System, Prentice Hall of India, 1995.
3. John R. Reitz, Fredric, J. Milford and Robert W. Christy, Foundations of Electromagnetic Theory, Narosa Publishing House, Pvt., Ltd.
4. Paul Lorrain, Dale R.Corson, Francois Lorrain, Electromagnetic fields and waves. CBS Publishers.

ELECTIVE II: ATOMIC AND MOLECULAR PHYSICS

SEMESTER: II **CODE: P16PH2:1**

NO OF HOURS: 6 **CREDITS: 5**

Objectives:

- To understand the atomic spectra and Quantum Chemistry of molecules.
- To study the principles of Microwave, Infrared, Raman and Resonance spectroscopy and its application.

Unit 1: Atomic Spectra

Quantum states of electrons in atoms – Electron spin – Stern – Gerlach experiment – results - spin orbit interaction – LS–JJ coupling schemes – Fine structure – spectroscopic terms and selection rules – Hyperfine structure. – Pauli's exclusion principle – Alkali type spectra – Equivalent electrons – Hund's rule - Quantum theory of Zeeman effect, Paschen Back effect of one & two electron system – Linear Stark effect.

Unit 2: Quantum theory of molecules

Born – Oppenheimer approximation – Molecular Orbital theory (LCAO approximation) – Hydrogen Molecule ion – Bonding and antibonding Molecular Orbital – Hydrogen Molecule – MO method – Valence Bond method – Directed Valance – Hybridization – Huckel molecular approximation – Application to Butadine and Benzene.

Unit 3: Microwave and IR spectroscopy

Rotational spectra of diatomic molecules – intensity of spectral lines – Effect of isotopic substitution – The non– rigid rotator – Rotational spectra of poly–atomic molecules – Linear, symmetric top and asymmetric top molecules – experimental techniques – Vibrating diatomic molecule – Diatomic vibrating rotator – linear and symmetric top molecule – Analysis by infrared techniques – Characteristic and group frequencies.

Unit 4: Raman spectroscopy and Electronic spectroscopy of molecules

Raman effect – Polarizability theory – Pure rotational Raman spectrum – Vibrational Raman spectrum of diatomic molecules – structure determination from Raman and IR spectroscopy– Experimental techniques - Electronic spectra of diatomic molecules – intensity of spectral lines – the Frank Condon principle – Dissociation energy and dissociation products – Rotational fine structure of electronic vibration transitions – pre dissociation.

Unit 5: Resonance Spectroscopy

Larmor's precision –NMR – Basic Principles – Classical and quantum mechanical description – Spin – Spin and spin lattice relaxation time – NMR – chemical shift – coupling constant – coupling between nucleus – chemical analysis by NMR – NMR instrumentation – high resolution method – ESR spectroscopy – ESR – Basic Principles – ESR spectrometer – Nuclear interaction and hyperfine structure – Relaxation effects – g factor – radical studies.

Books for Study:

1. G.Aruldhas, Molecular structure and Spectroscopy, (2nd Edition) Prentice Hall of India , New Delhi, 2007. (Unit-1)
2. A.K.Chandra, Introductory Quantum Chemistry, (4th Edition) Tata McGraw Hill Co., New Delhi, 2008. (Unit-2)
3. C. N. Banwell, Fundamentals of Molecular Spectroscopy, (4th Edition) McGraw Hill, New Delhi, 2008. (Unit-3,4,5)

Books for Reference:

1. B. P. Straughan and S. Walker Spectroscopy Vol.III. Chapman and Hall, London, 1976.
2. R. P. Feynman et al. The Feynman Lectures on Physics Vol. III. Narosa Publishing House, New Delhi, 2008.
3. H. S. Mani and G. K. Mehta, Introduction to Modern Physics, Affiliated East West Pvt. Ltd., New Delhi, 2000.
4. Ira N. Levine, Quantum Chemistry, (5th Edition) Prentice-Hall of India, New Delhi, 2006.
5. Hobart Hurd Willard, Instrumental methods of analysis, Van Nostrand, 1981.
6. ManasChanda, Atomic Structure and Chemical Bond, Tata McGraw Hill, New Delhi, 1991.

NMEC: VIRTUAL LABS

SEMESTER : II **_CODE: P16PHPE1_**

NO. OF HOURS: 4 **_CREDITS: 2_**

Objectives:

- To provide remote-access to Labs in various areas related to Physics.
- To create interest among students to conduct experiments by arousing their curiosity.
- To provide a complete Learning Management System around the Virtual Labs where the students can avail the various tools for learning, including additional web-resources, video-lectures, animated demonstrations and self-evaluation.

Unit 1: Basic Electronics

V-I characteristics of Diode – V-I characteristics of Zener Diode - Ohm's law – half wave rectification – full wave rectification – common base characteristics – common emitter characteristics – common emitter amplifier

Unit 2: Digital Logic Circuit Design

Adder – Multiplexer – Decoder with 7-segment display – ALU with function – Comparator – Latch and flip-flops – Register – Counters

Unit 3: Mobile Robotics

Sensor Modeling – Velocity Modeling – Localization – Grid based Navigation – Forward Kinematics – Scan matching – Exploration – Monte Carlo Localization

Unit 4: Artificial Neural Networks

Parallel and distributed processing – I: Interactive activation and competition models – Parallel and distributed processing – II: Constrain satisfaction neural network models – Perception learning – Multilayer feed forward neural networks – Solution to travelling salesman problem using self-Organizing maps

Unit 5: Real Time Embedded Systems

Traffic control for highways - medical systems for radiation therapy - manufacturing systems with robots – Communication - telephone, radio and satellite - household systems for monitoring and controlling appliances.

References:

1. www.vlab.co.in
2. www.amrita.vlab.co.in

(Note: Sufficient references and e-books are available in the above websites)

CORE VI: QUANTUM MECHANICS – I

SEMESTER : III ***CODE: P16PH306***

NO. OF HOURS: 6 ***CREDITS: 5***

Objectives:

- To make the students to understand the fundamental concepts of quantum mechanics.
- To make them familiar with different methods for studying quantum mechanical systems.

Unit 1: The Schrödinger Equation and Stationary States

Introduction – operators: Hermitian operators – properties – Heisenberg's Uncertainty Principle -Schrödinger equation – Physical interpretation and conditions on the wave function–postulates – Expectation values and Ehrenfest's theorem – stationary states and energy spectra – Linear harmonic oscillator.

Unit 2: Exactly Solvable Problems

Particle in a square well potential – bound states – Eigen functions by solving one dimensional Schrödinger equation — Three dimensional harmonic Oscillator – Components of angular momentum and Eigen value spectra of L^2 and L_z – Rigid Rotator – Hydrogen atom.

Unit 3: Time – Independent Perturbation

Time Independent problems – Non–degenerate – First and second order Perturbation– Degenerate case – Zeeman Effect – Stark effect – Variational method – WKB Approximation – Application to tunneling problem and quantization rule.

Unit 4: Time –Dependent Perturbation

Time dependent problems – Time dependent perturbation theory – First order perturbation – Harmonic perturbation – Transition probability – Fermi's golden rule – Adiabatic approximation – Sudden approximation – Application: Semi classical theory of radiation.

Unit 5: Quantum Theory of Scattering

The Scattering cross section – Scattering amplitude - Born approximation – Green's function approach - Condition for validity of Born approximation – Scattering by a screened Coulomb potential – Rutherford's scattering formula–partial wave analysis – Scattering in hard sphere.

Books for Study:

1. P.M.Mathews and K.Venkatesan, A Text Book of Quantum Mechanics, Tata McGraw Hill, New Delhi, 2007. (Unit 1-5)
2. V.K.Thankappan, Quantum Mechanics, New Age Internationl (P) Ltd., New Delhi, 2003.
3. L.Schiff, Quantum Mechanics, (3rd Edition) Tata McGraw Hill, New Delhi, 2010. (Unit-4)

Books for Reference:

1. Richard L.Liboff, Introductory Quantum Mechanics, Addison– Wesley, New York, 1998.
2. Jaspirit Singh, Quantum Mechanics: Fundamentals and Applications to Technology, John Wiley, New York, 1997.
3. Amit Goswami, Quantum Mechanics, Waveland Press Inc., 1992.
4. Dr.V.Devanathan, Quantum Mechanics, Narosa Publishing House,NewDelhi, 2005.
5. AjoyGhatak&S.Loganathan,Quantum Mechanics: Theory And Applications
6. S.Rajasekar, R.Velusamy The Fundamentals of Quantum Mechanics, CRC Press, 2015.
7. **https://www.youtube.com/watch?v=aNOkZZjUKoM**

CORE VII: SOLID STATE PHYSICS – I

SEMESTER : III — ***CODE: P16PH307***

NO OF HOURS: 6 — **CREDITS: 5**

Objectives:

- To infer the basic ideas of crystals, its periodic structure and its defects.
- To explain the properties that result from the distribution of electrons in metals, semiconductors and insulators.
- To impart the concepts of defects and dislocations in crystals and its consequences.

Unit 1: Crystal Structure, Wave Diffraction & Reciprocal Lattice

Periodic arrays of atoms – lattice translation vectors – Basis – Crystal structure – Primitive lattice cell – Types of lattice – 2D, 3D lattices – Simple crystal structures – NaCl, CsCl, hcp, Diamond, Cubic ZnS – Diffraction – Bragg law – Scattered Wave Amplitude – Fourier analysis – Reciprocal lattice vectors – Diffraction conditions – Laue equations – Brillouin zones – Reciprocal lattice to sc, bcc and fcc lattice – Fourier analysis of the basis – Structure factor of the bcc and fcc lattice – Atomic form factor.

Unit 2: Crystal Vibrations and Thermal properties

Vibrations of crystals with mono-atomic basis – Two atoms per primitive basis – Quantization of elastic waves – Phonon momentum – Inelastic scattering by phonons – Phonon heat capacity – Planck distribution – Normal mode – Density of states in 1D and 3D – Debye model – Einstein model – Thermal conductivity: Thermal resistivity – Umklapp processes – Imperfections.

Unit 3: Free Electron Fermi Gas and Energy Bands

Energy levels in 1D – Effect of temperature on the Fermi-Dirac distribution – Free electron gas in 3D –Heat Capacity of the electron gas – Electrical conductivity and Ohm's law– Motion in magnetic fields– Thermal conductivity of metals– Nearly free electron model – Bloch functions – Kronig-Penney model – Wave equation of electron in a periodic potential.

Unit 4: Semiconductor Crystals, Fermi Surfaces and Metals

Band gap – Equations of motion –Intrinsic carrier concentration – Impurity conductivity – Thermoelectric effects – Construction of Fermi surfaces – Electron orbits, hole orbits and open orbits – Calculation of energy bands – Tight binding method – Experimental methods in Fermi surface studies – DeHass-van Alphen effect.

Unit 5: Point Defects and Dislocations

Lattice vacancies– Diffusion –Colour centers –Shear strength of single crystals – Dislocations – Burgers vectors – Stress fields of dislocations – Low-angle grain boundaries –Dislocation densities – Dislocation multiplication – Slip.

Books for Study:

1. Introduction to Solid State Physics*(8ed)* by Charles Kittel, John Wiley & Sons Inc., NJ, USA, 2005.
   [Unit-1: Chapters 1 & 2; Unit-2: Chapters 4 & 5; Unit-3: Chapters 6 & 7; Unit-4: Chapters 8 & 9; Unit-5: Chapters 20 & 21] {Equivalent Indian Edition: Introduction to Solid State Physics (8ed, Paperback) by Charles Kittel, Wiley India Pvt. Ltd., New Delhi, 2012.}
2. Solid State Physics by S.L. Gupta and V. Kumar, K. Nath& Co., Meerut, 2013.

Books for Reference:

1. Solid State Physics (*Paperback*) by R.L.Singhal, Kedar Nath Ram Nath& Co., Meerut, 2012.
2. Basic Solid State Physics (*Hardcover - Import*) by Neil W.Ashcroft & N. David Mermin, Brooks/Cole Publishing Company, CA, USA, 1976.
3. Elementary Solid State Physics (*Paperback - Import*) by M. Ali Omar, Addison-Wesley Publishing Company Inc., USA, 1993
4. Solid State Physics (2nd edition, Paperback - Import) by J. S. Blakemore, Cambridge University Press, Cambridge, UK, 1985.
5. Basic Solid State Physics (*Paperback - Import*) by A. Roy chaudhuri, Sarat Book House, Kolkatta, 2014.

CORE VIII: MICROPROCESSOR AND MICROCONTROLLER

SEMESTER : III ***CODE: P16PH308***

NO. OF HOURS: 6 ***CREDITS: 5***

Objectives:

- Study the Architecture of 8086 microprocessor.
- Learn the design aspects of I/O and Memory Interfacing circuits.
- Study about communication and bus interfacing.
- Study the Architecture of 8051 microcontroller.

Unit 1: The 8086 microprocessor

Introduction to 8086 – Microprocessor architecture – Addressing modes - Instruction set and assembler directives – Assembly language programming – Modular Programming - Linking and Relocation - Stacks - Procedures – Macros – Interrupts and interrupt service routines – byte and String Manipulation.

Unit 2: 8086 system bus structure

8086 signals – Basic configurations – System bus timing –System design using 8086 – IO programming – Introduction to Multiprogramming – System Bus Structure Multiprocessor configurations – Coprocessor, closely coupled and loosely Coupled configurations – Introduction to advanced processors.

Unit 3: I/O Interfacing

Memory Interfacing and I/O interfacing - D/A and A/D Interface - Timer – Interrupt controller – DMA controller – Traffic Light control, LED display, Stepper Motor.

Unit 4: Microcontroller

Introduction to Microcontroller – Comparison of Microcontrollers and Microprocessor – overview of 8051– Pin description of 8051 – Registers – Program counters – ROM & RAM space – Stack and PSW - Addressing modes – Instruction set.

UNIT 5: On-Chip Peripherals of 8051 and Programme

Counters/Timers – Basics of serial communication – RS232 and MAX 232 IC connection – Serial communication registers – Serial communication – Interrupts – addition- Multiplication - Decimal to Hexadecimal Conversion - Ascending and Descending order- Largest Number in an array – Matrix Keyboard Interfacing – LCD Interfacing.

Books for study:

1. Yu-Cheng Liu, Glenn A.Gibson, "Microcomputer Systems: The 8086 / 8088 Family - Architecture, Programming and Design", Second Edition, Prentice Hall of India, 2007.
2. Mohamed Ali Mazidi, Janice Gillispie Mazidi, Rolin McKinlay, "The 8051 Microcontroller and Embedded Systems: Using Assembly and C", Second Edition, Pearson Education, 2011

Books for reference:

1. Doughlas V.Hall, "Microprocessors and Interfacing, Programming and Hardware, TMH, 2012.

ELECTIVE III: NUCLEAR PHYSICS

SEMESTER : III ***CODE : P16PH3:1***

NO. OF HOURS: 6 **CREDITS: 5**

Objectives:

- To educate about the fundamental characteristics of nucleus, nuclear reactions and radioactive decays
- To impart knowledge about various classification of elementary particles

Unit 1: Elementary Particles

Types of interactions and classification of elementary particles – Quantum numbers (charge, spin, parity, iso spin, strangeness, hypercharge) – Gell–Mann–Nishijima formula – Baryons – Leptons–Invariance principle and symmetries. Invariance under charge, parity, time reversal (CPT) – CP violation in neutral K–meson decay – Quark model – SU(3) and SU(5) symmetry —Types of quarks and their quantum numbers – Gell -Mann and Okubo mass formula.

Unit 2: Nuclear Structure

Basic nuclear properties: size, shape, charge distribution, mass, spin, parityand magnetic moment– Binding energy – Semi empirical mass formula – Nuclear shell model – Liquid drop model – optical model – collective model. Nuclear force – Exchange force – Yukawa's meson theory – Ground state of deuteron – Scattering ideas – Low energy n–p scattering: phase shift, scattering length – spin dependence and charge independence of nuclear forces.

Unit 3: Radioactive Decays

Alpha decay – Gamow's theory – Geiger-Nuttal law – Neutrino hypothesis – Fermi's theory of beta decay – Non–conservation of parity in beta decay – Gamma decay – Internal Conversion – Nuclear isomerism. Basic principles of particle detectors – Ionization chamber - Proportional counter – Geiger–Muller Counter – BF_3 counter – Scintillation Counter – Solid state detector – junction diode detectors - nuclear radiation hazards – safe limits – disposal of nuclear wastes.

Unit 4: Nuclear Reaction

Types of Nuclear reactions - Energetics of reactions – Q equation – Nuclear reaction cross section – Partial wave analysis – Level width – Compound nucleus model – Breit–Wigner one level formula– Direct reactions – Theory of Stripping and pick-up reactions

Unit 5: Nuclear Fission and Fusion

Characteristics of fission – Mass and energy distribution of nuclear fragments – Nuclear chain reaction – Four factor formula – Bohr Wheeler's theory – Atom bomb - Fission reactor – power and breeder reactors – Fusion processes – Solar fusion – controlled thermonuclear reactions – stellar energy – evolution and life cycle of a star

Books for Study:

1. D.C Tayal, Nuclear physics , Himalaya Publishing House, NewDelhi, 2004.(Unit 1-5)
2. V. Devanathan, Nuclear physics, Narosa publishing house, NewDelhi, 2008.
3. R. R.Roy and B.P.Nigam, Nuclear Physics theory and experiment, New Age International, 1991.
4. K. S. Krane, Introductory Nuclear Physics, John-Wiley, New York 1987.

Books for Reference:

1. S. B. Patel, Nuclear Physics: An Introduction, Wiley-Eastern Limited, New Delhi 1991.
2. B.L.Cohen, Concepts of Nuclear Physics, Tata McGraw Hill, New Delhi 1983.
3. S.N.Ghoshal, Nuclear Physics, S. Chand and Co., NewDelhi, 2003.
4. ArtherBeiser, Concepts of Modern Physics, 5th Edition, Mc.GrawHill, Inc. New York (1995).

CORE IX : QUANTUM MECHANICS – II

SEMESTER : IV **CODE: P16PH409**

NO. OF HOURS: 6 **CREDITS: 5**

Objectives:

- To understand the matrix formulation of Quantum Mechanics and the concept of angular momentum.
- To study the concept of relativistic Quantum Mechanics and Quantum field theory.

Unit 1: Matrix Formulation

Matrix representation – Schrödinger, Heisenberg and interaction pictures – symmetry – space and time displacements – Unitary displacement operator – Dirac's Bra and Ket notations – Hilbert space – Operators as matrices – Matrix form of wave functions – Hermitian operators and their properties – Linear harmonic oscillator (Abstract operator method).

Unit 2: Angular Momentum

The Eigen value spectrum – matrix representation of J – Spin angular momentum – Pauli's spin matrices – Spin ½ and 1 – Total wave function – Addition of angular momentum - Clebsch Gordon (CG) co–efficient – calculation of CG co–efficient for $J_1=1/2$ and $J_2=1/2$ - Recursion relation of CG co–efficient.

Unit 3: Identical Particles and Spin

System of identical particles - Distinguishability of identical particles – symmetric and antisymmetric wave functions – relation between symmetry and statistics - Exchange degeneracy – Pauli's exclusion principle.

Many electron system – Central field approximation – Thomas Fermi statistical model – Hartee'sself consistent field.

Unit 4: Relativistic Wave Mechanics

Schrödinger relativistic wave equation – free particle – Electromagnetic potentials – Separation of the equation – Energy levels in a coulomb field– Dirac's relativistic equation – free particle solutions – charge and current densities – Electromagnetic potentials – Dirac's equation for a central field – Spin angular momentum – Spin orbit coupling – Negative energy states.

Unit 5: Quantization of Fields

Lagrangian formulation: Euler – Lagrange equations – Hamilton’s formulation – Second quantization – Creation and annihilation operators – Quantization of real scalar field – the Klein-Gordon field - Complex scalar field – Nonrelativistic Schrödinger equation – Quantization of Dirac field.

Books for Study:

1. P.M.Mathews and K.Venkatesan, A Text Book of Quantum Mechanics, (2nd Edition)TataMcGrawHill, New Delhi, 2010. (Units I, II & IV)
2. L.Schiff, Quantum Mechanics, (3rd Edition) Tata McGraw Hill, New Delhi, 2010. (Units III & V)
3. V.K.Thankappan, Quantum Mechanics, (2nd Edition) Wiley–Eastern, New Delhi 2003. Units III & V.

Books for Reference:

1. Richard L. Liboff, Introductory Quantum Mechanics, (4th Edition) Addison-Wesley, New York, 2003.
2. Jasprit Singh, Quantum Mechanics: Fundamentals and Applications to Technology, John Wiley, New York, 2004.
3. Amit Goswami, Quantum Mechanics, (2nd Edition) Waveland Press, 2003.
4. Amitabha Lahiri,and P.B. Pall, A First Book of Quantum Field Theory, Narosa Book Distributors Pvt.Ltd., New Delhi, 2005.
5. V.Devanathan, Quantum mechanics, Narosa Publishing House, 2005.
6. S.Rajasekar, R.Velusamy, Advanced Topics in Quantum Mechanics, CRC Press, 2015.

CORE X: SOLID STATE PHYSICS–II

SEMESTER : IV **CODE: P16PH410**

NO. OF HOURS: 6 ***CREDITS: 5***

Objectives:

- To understand the basic theories available to explain the behavior of various materials like dielectric, ferroelectric, dia, para, ferro and ferri magnetic materials.
- To acquire knowledge about superconductivity and the various optical properties of materials.

Unit 1: Dielectrics and Ferroelectrics

Macroscopic electric field – Local electric field in an atom–Dielectric constant and polarizability – ClausiusMossotti equation – Response and relaxation phenomenon – Ferro elastic crystals Polarization catastrophe – Landau theory of phase transition – Ferro electric domains – Antiferro electricity – Piezo electricity – crystal elasticity – Pyro electricity.

Unit 2: Diamagnetism and Paramagnetism

Langevin's diamagnetism theory – Langevin's Paramagnetism theory – Quantum theory of diamagnetism – Weiss theory – quantum theory of Paramagnetism – Rare earth ions – Hund's rule – Iron earth ions – crystal field splitting – cooling by isentropic demagnetization – paramagnetic susceptibility of conduction electrons – Kondo effect.

Unit 3: Ferromagnetism, Antiferromagnetism and Ferrimagnetism

Ferromagnetism – Curie point - Weiss theory of ferromagnetism - Temperature dependence of saturation magnetization – Hysteresis and ferromagnetic domain – Antiferromagnetism – Molecular field theory of antiferromgnetism - Susceptibility of antiferromagnetism below the Neel temperature – Ferrimagnetism – Magnons –

Ferromagnetic magnons - Antiferromagnetic Magnons – Introduction to Magnetoresistance (GMR, CMR)

Unit 4: Superconductivity

Occurrence of Superconductivity – properties- Meissner Effect – Energy gap – Isotope effect –Thermodynamics of superconducting transition – Type I & Type II Superconductors – Vortex state -London equation – BCS theory –Coherence Length - Flux quantization in a ring — single particle tunneling – Josephson Superconductor tunneling, AC and DC effect –Application of Superconductors- Superconducting Quantum Interference Device (SQUID) – Development of High T_c Superconductors.

Unit 5: *Optical Properties of Materials*

Photoluminescence-types-ExcitationMechanism-Materials-Luminescence Measurement System-Excitation and emission spectra.
Harmonic Generation-Fundamental harmonic of Polarisation-inversion symmetry-Struture of Centrosymmetric and Noncentrosymmetric Materials-Second Harmonic Generation-Frequency doubler - Phase Matching.

Books for Study:

1. C. Kittel, Introduction to Solid State Physics, Wiley India Pvt. Ltd., New Delhi, 2008. (Unit 1,2 & 3)
2. Gupta & Kumar, Solid state physics, K Nath&Co, Meerut,2011. (Unit 4)
3. Jai Singh,Optical properties of condensed matter& applications, John Willey,England,2006.(Unit 5)
4. B.B. Laud, Lasers and Nonlinear Optics, New Age International Publishers

Book for Reference:

1. M. Ali Omar, Elementary Solid state physics: Principle and applications, Pearson Education Asia, (2002).
2. S.L.Kakani and C.Hemarajani, Solid state physics, Sultan Chand & sons, New Delhi, 1990.
3. Measurement of Photoluminesence, Franc C.Grum, K.D. Mielenz, Academic Press(1982)
4. Introduction to non-linear optical effects in molecules & Polymers, Paras N.Prasad and David J.Williams, John Willey& sons, Newyork.

5. Materials Science &Engineering,V.Raghavan, Printice Hall, India (2007)

ELECTIVE IV: CRYSTAL GROWTH, THIN FILM AND NANO SCIENCE

SEMESTER: IV **CODE: P16PH4:1**

NO OF HOURS: 6 **CREDITS: 5**

Objectives:

- This paper will serve as an eye opener for student's keen in research activities particularly in experimental physics.
- To provide a qualitative idea on the fundamentals of growing crystals, coating thin films, Synthesis of Nano materials and characterizing the prepared samples.

Unit 1: Basics of Crystal Growth and Thin Film

Nucleation – Different kinds of nucleation – Formation of crystal nucleus – Energy formation of a nucleus – Classical theory of nucleation - Gibbs Thomson equations for vapour and solution- spherical and cylindrical nucleus – Thin films –Thermodynamics of nucleation - Growth kinetics of Thin film – Crystal growth process in thin films - Epitaxial growth of thin films (basic concept only)

Unit 2: Crystal Growth Techniques

Classification of crystal growth methods -Growth from low temperature solutions: Meir's solubility diagram – Growth by restricted evaporation of solvent, slow cooling of solution and temperature gradient methods - Basics of melt growth – Czochralski pulling method – Vernueil flame fusion method – Hydrothermal growth method. Growth by chemical vapour transport reaction: Transporting agents, Sealed capsule method, Open flow systems.

Unit 3: Thin Film Preparation Techniques

Thin films – Introduction to vacuum technology – Deposition techniques - Physical methods – Resistance heating – Electron beam method - Sputtering – Reactive sputtering – RF sputtering - DC planar magnetron sputtering - Pulsed laser deposition – Chemical methods – Chemical bath deposition – Electrodeposition – Electro plating and Electroless plating – Deposition mechanisms - Spin and Dip coating –Spray pyrolysis deposition.

Unit 4: Synthesis of Nanomaterials

Top Down Approach, Grinding, Ball Milling, Melt mixing, Photolithography. Bottom Up Approach, Wet Chemical Synthesis Methods, Micro emulsion Approach, Synthesis of metal & semiconductor nano particles by colloidal route, Langmuir-Blodgett method, Sol Gel Methods, Sono chemical Approach, Microwave and Automization, Gas phase Production Methods: Chemical Vapour Depositions.

Unit 5: Characterization Techniques

Characterization using X-ray powder method - Single Crystal methods -Spectroscopic methods: FTIR, Raman, SEM, EDAX, U.V. Visible - Band gap energy calculation. Thermal properties: Thermogrametric analysis (TGA), Differential thermogram (DTA) and Differential Scanning Calorimetry (DSC) – Vicker micro hardness - Thin Film thickness measurement – Microbalance method – Optical interference method, four probe method to determine film resistivity- Hall effect.

Books for study

1. P.Santhana Raghavan & P.Ramasamy, Crystal Growth Processes and methods, KRV Publication, Kumbakonam, 2000
2. A.Goswami, Thin film fundamentals, New age international (P) Ltd., New Delhi, 2006
3. Poole & Owners, Introduction to Nanotechnology, Wiley India Pvt Ltd, 2007.
4. Chattopadhyay and Banerjee, Introduction to Nanoscience and Nanotechnology, PHI Learning Pvt. Ltd., 2009.
5. H.H. Willard, L.L. Merritt, J.A. Dean, F.A. Settle, Instrumental Methods of Analysis, 7 th edition, CBS publishers and Distributors, New Delhi, 1986.

Books for references:

1. LI Maissel and R Clang, Hand book of Thin Films Technology, McGraw Hill, New York, 1970

2. K L Chopra, Thin film Phenomena, McGraw Hill, New York, 1990
3. A.W.Vere, 'Crystal Growth: Principles and Progress' Plenum Press, New York, 1987
4. M. S. Ramachandra Rao, S. Singh, Nanoscience and Nanotechnology, Fundamentals to Frontiers: Wiley, 2013.
5. C.N.R.Rao, A.Muller, A.K.Cheetham (Eds), The chemistry of nanomaterials: Synthesis, properties and applications, Wiley VCH VerlagGmbh&Co, Weinheim, 2004.

MAJOR PRACTICAL – I

SEMESTER: I **CODE: P16PH1P1**

NO. OF HOURS: 6 **CREDITS: 3**

General Experiments

1. Four Probe method – Determination of resistivity of powdered sample.
2. Determination of carrier concentration and Hall coefficients in semiconductors.
3. Determination of magnetic susceptibility of liquid by Guoy method.
4. Determination of magnetic susceptibility of a solid in the form of a thin rod by Guoy method.
5. Determination of magnetic susceptibility of liquid by Quincke's method.
6. Determination of dielectric constant of a liquid by RF oscillator method.
7. Determination of wavelength by using Michelson's interferometer.
8. Determination of wavelength of monochromatic source using biprism.
9. Determination of refractive index of liquids using biprism (by scale & telescope method).
10. Rydberg's constant using spectrometer.
11. Determination of coefficient of coupling of AC bridge method.
12. Forbe's method of determining thermal conductivity.
13. "g" factor determining by using ESR spectrometer.
14. Determination of thickness of a film using Michelson's interferometer.
15. Polarisation of liquid – Hollow prism.
16. Optical fiber – Determination of numerical aperture, acceptance angle and power loss.
17. Determination of wavelength of the laser source - Michelson Interferometer.
18. Determination of thickness of glass plate - Michelson Interferometer.

MAJOR PRACTICAL – II

SEMESTER: II **CODE: P16PH2P2**

NO. OF HOURS: 6 **CREDITS: 3**

Basic Practical (General and Electronics)

General Experiments

1. Determination of q, n, σ by elliptical fringes method.
2. Determination of q, n, σ by hyperbolic fringes method.
3. Determination of Stefan's constant.
4. BH loop – Energy loss of a magnetic material – Anchor ring using B.G.
5. Determination of e/m of an electron by magnetron method.
6. Determination of e/m of an electron by Thomson's method.
7. Photoelectric effect - determination of Planck's constant.

Electronics Experiments

8. Study of feedback amplifier – Determination of bandwidth, input and output impedances.
9. Design and study of monostable multivibrator.
10. Design and study of phase shift oscillator (Transistor).
11. Characteristics of UJT and UJT relaxation oscillator.
12. FET oscillator.
13. Darlington pair amplifier.
14. Characteristics of LDR.
15. Characteristics of SCR.
16. Characteristics of DIAC.
17. Characteristics of TRIAC.
18. Frequency divider using IC 555.

MAJOR PRACTICAL – III

SEMESTER: III **CODE: P16PH3P3**

NO. OF HOURS: 6 **CREDITS: 3**

Analog and Digital Experiments

Digital Electronics

1. Multiplexer – Demultiplexer.
2. Study of 7490 (0-9 and 0-99).
3. One shot multivibrator – Using ICs, determination of pulse width.
4. Digital comparator using EXOR and NAND gates.
5. Study of 7-segment display decoder – IC 7447.
6. Study of FLIP FLOP, Synchronous UP and Down counter.
7. Shift register using FLIP FLOPS.
8. Study of memory circuits – RAM, ROM, EPROM, PROM.
9. Half adder, Half Subtractor and Full adder, Full Subtractor circuits using NAND Gates.
10. Simplification of Boolean expression by Karnaugh Map method and verification.

Analog Experiments

11. Characteristics of Op-amp, open loop differential gain, output resistance, CMRR and frequency response.
12. Op-amp low pass, high pass, band pass and active filters.
13. Op-amp Integrator and differentiator.
14. Op-amp sine, square, triangular and ramp wave generator.
15. Op-amp Log and antilog and second order transfer function amplifier.
16. Op-amp solving simultaneous equations.
17. D/A Conversion R-2R and weighted resistor network – to determine the resolution, linearity and accuracy.
18. Modulation – demodulation.
19. Characteristics of Chua diode. Chaotic dynamics of Chua diode.
20. Nonlinear exhibited by Collpits oscillator and Wein bridge oscillator.

MAJOR PRACTICAL – IV

SEMESTER: IV **CODE: P16PH4P4**
NO. OF HOURS: 6 **CREDITS: 3**

Microcontroller Practicals

1. a. 8 bit addition, multiplication, multibyte addition, subtraction, division and multibyte subtraction.
   b. 16 bit addition Subtraction by 1's complement and 2's complement.
2. Conversion from decimal to octal and hexa systems, octal and hexa to decimal systems
3. Study of DAC interfacing (DAC 0800)
4. Study of ADC interfacing (ADC 0809)
5. Traffic Control System using microprocessor
6. Generation of square, triangular, sawtooth, staircase and sine waves using DAC 0800
7. Control of stepper motor using microprocessor.

Computer Practicals (C Language)

8. Solving equations by Newton – Raphson method
9. Numerical differentiation by Runge Kutta Method (II and IV Order)
10. Plotting, merging and editing the data using Origin.

Material Science Lab

11. Linear Optical studies – UV – Visible Studies (absorbance and optical bandgap)
12. Dielectric studies using microwave– parameters of a liquid.
13. Dielectric studies using microwave – parameters of a solid.
14. Thin film preparation by dip coating – measurement of thickness.
15. Electrical properties of thin film – Calculation of activation energy by Resistance variation with temperature. (two probe).
16. X-ray diffraction analysis – D, ε, N and δ.
17. Gas sensing properties of a thin film.
18. Susceptibility of a material by Hysteresis.
19. Zeeman effect.