Curriculum and List of Electives

First year (Semester I)

Sl.No.	Course Code	Course Title	L	T	P	C
1	PHD6101	Classical Mechanics and Relativity	4	0	0	4
2	PHD6102	Mathematical Physics	3	1	0	4
3	PHD6103	Solid state Physics	3	0	0	3
4	PHD6104	Physics of semiconductor devices	3	0	0	3
5		Elective – I	2/3	0	2/-	3
6		Elective – II	2/3	0	2/-	3
7	PHD6105	Advanced Optics Lab	0	0	4	2
8	PHD6106	Semiconductor devices and circuits lab	0	0	4	2
		Total				**24**

First year (Semester II)

Sl.No.	Course Code	Course Title	L	T	P	C
1	PHD6201	Quantum Mechanics	3	0	0	3
2	PHD6202	Electromagnetic Theory & Electrodynamics	3	1	0	4
3	PHD6203	Atomic Physics and Molecular Spectroscopy	4	0	0	4
4	GED 6202	Research Methodology	4	0	0	4
5		Elective – III	2/3	0	2/-	3
6		Elective – IV	2/3	0	2/-	3
7	PHD6204	Thermal Physics lab	0	0	4	2
8	PHD6205	Seminar				1
		Total				**24**

Second year (Semester III)

Sl.No.	Course Code	Course Title	L	T	P	C
1	PHD7101	Digital Electronics and Microprocessors	4	0	0	4
2	PHD7102	Thermodynamics and Statistical Physics	4	0	0	4
3	PHD7103	Nuclear and Particle Physics	3	0	0	3
4		Elective –V	2/3	0	2/-	3
5		Elective –VI	2/3	0	2/-	3
6	PHD7104	Advanced Electronics Lab	0	0	4	2
7	PHD7105	Materials Science Lab	0	0	4	2
8	PHD7106	Mini Project/Internship (during summer vacation after II Sem)			2	1
9	PHD7201	Project phase – I				2
		Total				**24**

Second year (Semester IV)

Sl.No.	Course Code	Course Title	L	T	P	C
1	PHD7201	Project Phase – II				10
		Total				**10**

Total number of credits: 82

List of Electives

First year (Semester I)

S.No.	Course Code	Course Name	L	T	P	C
1	PHDY101	Crystal Growth Techniques	2	0	2	3
2	PHDY102	Materials processing	3	0	0	3
3	PHDY103	Materials Characterization	2	0	2	3
4	PHDY104	Smart materials and structures	3	0	0	3
5	PHDY105	Advanced Optics & Laser Technology	3	0	0	3
6	PHDY106	Nonlinear optics	3	0	0	3
7	PHDY107	Optical Fiber communication	2	0	2	3
8	PHDY108	Optical computing	3	0	0	3
9	PHDY109	Density Functional Theory	3	0	0	3

First year (Semester II)

S.No.	Course Code	Course Name	L	T	P	C
1	PHDY201	Electro-Optic materials and devices	3	0	0	3
2	PHDY202	Ferroelectric materials and devices	2	0	2	3
3	PHDY203	Structure and properties of alloys	3	0	0	3
4	PHDY204	Photonic materials and devices	3	0	0	3
5	PHDY205	Numerical methods and programming	3	0	0	3
6	PHDY206	Ultrasonics and Non-Destructive Testing	3	0	0	3
7	PHDY207	Optoelectronic devices	2	0	2	3
8	PHDY208	Biophotonics	3	0	0	3

Second year (Semester III)

S.No.	Course Code	Course Name	L	T	P	C
1	PHDY111	Mathematical methods for nonlinear science	3	0	0	3
2	PHDY112	Measurements and Instrumentation	3	0	0	3
3	PHDY113	Biomedical Instrumentation	3	0	0	3
4	PHDY114	Radiation Physics	3	0	0	3
5	PHDY115	Laser spectroscopy and its applications	3	0	0	3
6	PHDY116	Nanophotonics	3	0	0	3
7	PHDY117	Nanoscience and Technology	3	0	0	3
8	PHDY118	Thin film science and technology	3	0	0	3
9	PHDY119	Corrosion science and technology	3	0	0	3
10	PHDY120	Biomaterials	3	0	0	3

SEMESTER I

PHD6101	CLASSICAL MECHANICS AND RELATIVITY	L	T	P	C
		4	0	0	4

OBJECTIVES:

- To provide the foundations of the advanced level mechanics
- To learn Lagrangian and Hamiltonian mechanics
- To understand rigid body dynamics and small oscillations
- To provide applications to relativistic mechanics
- To understand the nonlinear systems, chaos and solitons

MODULE I FUNDAMENTAL PRINCIPLES AND LAGRANGIAN FORMULATION 12

Mechanics of a particle and a system of particles – Conservation laws – Degrees of freedom – Constraints – Generalised coordinates – Principle of Virtual work – D'Alembert's Principle – Lagrange's equations of motion for conservative and Non-conservative systems – Applications: L-C circuit – Linear harmonic oscillator and Atwood's machine. Central force and motion in a plane – Equation of motion under central force and first integrals – Differential equation for an orbit – Inverse square law of force – Kepler's laws of planetary motion and their deduction –Virial theorem.

MODULE II HAMILTONIAN FORMULATION 12

Hamiltonian function – Physical significance – Hamilton's canonical equations of motion – Applications: Simple pendulum – Motion of a particle in a central force field – Charged particle in an electromagnetic field– Hamilton's variational principle – proof –Derivation of Lagrange's equations-Principle of Least Action – its deduction- Canonical Transformations-Generating function-Poisson bracket – properties – The Hamilton – Jacobi equation – Kepler's problem -solution by Hamilton – Jacobi method - Action and angle variables.

MODULE III RIGID BODY DYNAMICS AND SMALL OSCILLATIONS 12

Independent coordinates – Euler's angles – Components of Angular velocity in terms of Euler's angles –Angular momentum of a rigid body – Moments and products of inertia – Euler's equations of motion for a rigid body. Theory of small oscillations – Frequencies of free vibration and normal coordinates – Two coupled harmonic oscillators – Vibrations of a linear triatomic molecule.

MODULE IV RELATIVISTIC MECHANICS 12

Reviews of basic ideas of special relativity – variation of mass with velocity– Relativistic energy – Mass- energy relation – Force in relativistic mechanics – Minkowski space and Lorentz transformations – four vectors – Elements of general theory of relativity.

MODULE V NONLINEAR DYNAMICS 12

Dynamical systems – Mathematical implications of nonlinearity – definition and effects of nonlinearity – Linear vs Nonlinear oscillators – Classification of equilibrium points – Logistic map – stability analysis – Period doubling phenomenon – definition of chaos – initial conditions – Linear and Nonlinear dispersive waves – KdV equation – solitary waves & solitons : Application in optical fibres.

Total Hours: 60

REFERENCES:

1. Golstein. H, Poole. C and Sofko. J, Classical Mecanics , Pearson Education, New Delhi, 2013.
2. Upadhyaya. J.C., Classical Mechanics, Himalaya Publishing House, 2010.
3. Marion and Thorntron, Classical Dynamics of Particles and Systems, Fifth Edition, Holt Rinehart & Winston, 2012.
4. Panat. P.V, Classical Mechanics, Narosa Publishing Home, New Delhi, 2008.
5. Rana. N.C and Joag.P.S, Classical Mechanics, Tata Mc-Graw Hill Publishing Company Limited, New Delhi, 2004.
6. M.Lakshmanan and S.Rajasekar, Nonlinear dynamics: Integrability, Chaos and Spatio-temporal patterns, Springer-Verlag, 2003.
7. Steven H.Strogatz, Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering (Studies in Nonlinearity) 2nd Edition, 2015.

OUTCOMES:

At the end of the course, the students will have a good understanding of the following topics and their applications

- Advanced level mechanics.
- Description of Lagranges equation and Hamiltons equation for a system of particles
- Discussion on the centre force problem
- Dynamics of rigid body and small oscillations
- Discussion on Relativistic mechanics and Nonlinear systems

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PHD6102 MATHEMATICAL PHYSICS

L	T	P	C
3	1	0	4

OBJECTIVES:

- To provide a strong mathematical foundation in vector calculus, matrices
- To discuss the properties of second order linear differential equations and special functions
- To understand the complex variables
- To learn about Fourier transform and Greens functions
- To provide the basics of Tensor analysis and Group theory

MODULE I VECTORS AND MATRICES 12

Vector analysis: Gradient – Divergence – Curl – vector spaces – linear dependence and independence of vectors - second order derivatives Gauss's theorem - Stoke's theorem - Green's theorem – Curvilinear coordinates-spherical polar-cylindrical coordinates.Matrices: Orthogonal and Unitary Matrices, Matrix diagonalization, Cayley-Hamilton theorem - eigen values and eigen vectors.

MODULE II SECOND ORDER LINEAR DIFFERENTIAL EQUATIONS AND SPECIAL FUNCTIONS 12

Hermite, Legendre, Bessel and Laguerre differential equations –series solutions- generating functions-recurrence relations- Sturm Liouville theorem - Orthogonality of eigen function. Hyper geometric functions – generating functions.

MODULE III COMPLEX VARIABLES 12

Functions of complex variables – single and many valued functions-analytic functions –Cauchy – Riemann equations –conjugate functions – complex line integrals-Cauchy's integral theorem-integral formula – Taylor and Laurent expansions –zeros and singularities – residues –Cauchy's Residue theorem and its applications for evaluation of integrals.

MODULE IV FOURIER TRANSFORM AND GREEN FUNCTIONS 12

Fourier Transform: Fourier transform – sine and cosine transform – properties Faultung's theorem- application in heat conduction and spectroscopy. Laplace transforms – Inverse transforms – Linearity and Shifting theorems. Linear spaces – Basis-change of basis – Inner product space – Schmidt's orthogonalisation procedure – Schwartz's inequality – Hilbert spaces - properties. Green's function: Definition and construction – symmetry properties - expression for Green's functions in terms of Eigen functions - Green's functions for simple and second order operator.

MODULE V TENSORS AND GROUP THEORY 12

Tensor analysis : Cartesian tensors – law of transformation of first and second order tensors- addition, subtraction and multiplication (inner and outer product) of tensors –rank ,covariant, contravariant and mixed tensors- symmetric and antisymmetric tensors-Quotient law. Group Theory: Basic definitions- subgroups- permutation groups-Cyclic groups - cosets - Normal Subgroups-Isomorphism - Homomorphsim-Rotation groups - Reducible – Irreducible representations – Applications.

Total Hours: 60

REFERENCES:

1. G.B. Arfken, H.J.Weber and F.E. Harris, Mathematical Methods for Physicists, Seventh Edition, Academic Press, 2012
2. S.Andrilli and D.Hecker, Elementary Linear Algebra,Academic Press, 2006
3. Chattopadhyay. P.K, Mathematical Physics, 3rd Edition, New Academic Science, 2014.
4. Joshi. A. W, Matrices and Tensors in Physics, 3rd edition, Wiley Eastern Ltd., New Delhi, 1995.
5. Gupta. B. D., Mathematical Physics, 4th edition, Vikas Publishing House Pvt Limited, 2007.
6. Murray Spiegel, Schaum's Outline of Advanced Mathematics for Engineers and Scientists, Schaum's Outline Series, McGraw-Hill, 2009.

OUTCOMES:

At the end of the course, the students will be able to,

- understand the vector, vector fields, matrices and their need in science
- gain knowledge in solving the second order linear differential equations and special functions
- solve the problems in complex variables
- gain knowledge in Fourier Transforms and green's functions
- develop the essential mathematical skills to solve problems in tensors and group theory.

PHD6103 SOLID STATE PHYSICS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To provide the knowledge of crystal structures and bonding in solids
- To know the transport properties and band theory of solids
- To understand the thermal vibrations in solids and thermal properties
- To provide the knowledge of magnetic and dielectric properties of materials
- To learn the superconducting and optical properties of materials

MODULE I CRYSTAL STRUCTURE AND BINDING9

General Description of Crystal Structures – Bravais lattices- Cubic Structures, NaCl, CsCl, Diamond, Zinc blende, HCP structures- Miller Indices- interplanar distance(derivation) - The Reciprocal Lattice - defects and dislocations-Quasi crystals -Force between atoms-cohesive energy – bonding in solids - binding energy of ionic crystals(derivation)-Madelung constant – Born Haber cycle.

MODULE II TRANSPORT PROPERTIES AND BAND THEORY OF SOLIDS 9

Free electron theory (Sommerfeld theory) – electronic specific heat- electrical and thermal conductivity of metals – Wiedemann Franz law (derivation)- Hall effect and Thermoelectric power - Effective mass and concept of hole- electron motion in periodic potential – Bloch's theorem - band theory of solids -construction of Brillouin zone - Fermi surface in metals – characteristics of Fermi surface- De Haas van Alphen effect - Kronig Penney model (derivation).

MODULE III PHONONS : CRYSTAL VIBRATIONS AND THERMAL PROPERTIES 8

Vibrations of crystals with monoatomic lattice(derivation) - Vibrations of crystals with diatomic lattice (derivation)– optical and acoustical modes – number of normal modes of vibrations in a band-Phonon momentum- inelastic scattering of photons by phonons –Debye's theory of lattice specific heat(derivation) - anharmonic effects.

MODULE IV MAGNETIC AND DIELECTRIC PROPERTIES 10

Types of magnetic materials –Diamagnetism – Langevin's theory(derivation)-Paramagnetism – Hund’s rules – rare earth ions-iron group ions-crystal field splitting-Pauli paramagnetism- Ferromagnetism – domain theory- Curie-Weiss law (derivation)-antiferromagnetism-ferrites. Polarization and polarizability- types of polarization (qualitative) and dependence on frequency and temperature-local electric field in an atom- Clausius Mossotti relation(derivation) -Piezo, pyro and ferroelectric properties of crystals.

MODULE V SUPERCONDUCTIVITY AND OPTICAL PROPERTIES 9

Properties of superconductor – critical magnetic field – Meissner effect (derivation) – Type I and Type II super conductors – superfludidty - entropy and heat capacity –energy gap-quantum tunneling - London equations (derivation) – coherence length-BCS theory –RVB - AC and DC Josephson effect – SQUID. Traps – Excitons – coloration of crystals - types of colour centers - Luminescence: fluorescence and phosphorescence– activators - Emission and absorption spectra – Efficiency of phosphor.

Total Hours: 45

REFERENCES:

1. Kittel. C, Introduction to Solid State Physics, 8th edition, Wiley Eastern, New Delhi, 2019.
2. Pillai. S.O, Solid State Physics, New Age International, New Delhi, 2009.
3. Blakemore. J. S, Solid State Physics, 2nd edition, Cambridge University Press, Cambridge, 1985.
4. Philip Hofmann, Solid State Physics, 1st edition, Wiley-VCH Publishers, 2011.
5. Wahab. A, Solid State Physics: Structure and Properties of Materials , Alpha Science International Ltd; 2nd Revised edition,2005

OUTCOMES:

At the end of the course, the students will be able

- to illustrate the concepts on crystal structures and bonding nature of solids
- to analyse the thermal properties on the basis of thermal vibrations
- to explain the thermal properties, electrical properties and electronic band structure of solids
- to elucidate the magnetic and dielectric properties and their applications
- to exemplify the superconducting and optical properties of materials and their applications

PHD6104 PHYSICS OF SEMICONDUCTOR DEVICES

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand the fundamentals of physics of semiconducting materials
- To construct and study the operations of semiconductor devices in the family of diodes and transistors under different operating conditions.
- To expose to circuit design of different types of amplifiers and oscillators.
- To explore the knowledge on various types of oscillators and convertors
- To understand the design and fabrication of Integrated Circuits (ICs) and timer.

MODULE I SEMICONDUCTOR DIODES 9

Semiconductors: N and P type, mass action law - continuity equation – PN junction diode under forward and reverse bias – Band structure – Einstein's diode equation – Zener diode - Varactor diode – Schottky diode – Tunnel diode – Gunn diode – Optoelectronic diodes – LED,LASER diode and photo diode.

MODULE II SPECIAL DEVICES 9

BJT construction and characteristics – biasing circuits – current components - JFET- structure and working –V-I Characteristics – pinch off voltage –Depletion and Enhancement type MOSFFT – UJT – SCR–DIAC, TRIAC - applications.

MODULE III AMPLIFIERS 9

BJT single stage amplifier - FET single stage amplifier – small signal analysis - Operational amplifier - inverting and non-inverting amplifier – instrumentation amplifier – voltage follower –comparator - integrating and differential circuits – log & antilog amplifiers –active filters : lowpass, high pass, band pass & band rejection filters.

MODULE IV OSCILLATORS and CONVERTORS 9

Colpitt's oscillator – Hartley oscillator - Wien bridge, phase shift oscillators - – triangular, sawtooth and square wave generators-Schmitt's trigger – sample and hold circuits –phase locked loops. Basic D to A conversion and A to D conversion.

MODULE V IC FABRICATION AND IC TIMER 9

Basic monolithic ICs – epitaxial growth – masking – etching impurity diffusion fabricating monolithic resistors, diodes, transistors and capacitors – circuit layout – contacts and inter connections – 555 timer – description of the functional diagram – mono stable operation – applications of mono shots – astable operation and pulse generation.

Total Hours: 45

REFERENCES:

1. Floyd L, Electronic Devices, Pearson Education, 10th edition, New York, 2018.
2. Milman.J and Halkias.C.C, Electronic devices and circuits, 4th edition, Tata McGraw Hill, 2015.
3. Roy Choudhary. D, Linear Integrated Circuits, 5th edition, New Academic Science Ltd, 2018.
4. Mottershead, A., Electronic Devices and Circuits - An Introduction, Prentice,1979
5. SM.Sze, Semiconductor devices – Physics and Technology, 2nd Ed, John Wiley 2008.
6. Doneld A Neaman, Semiconductor physics and devices, 4th Ed, Tata McGraw Hill, 2017.
7. S. Salivahanan, N.Suresh Kumar and A.Vallavaraj, Electronic devices and circuits, Tata McGraw Hill, Third Edition, 2012.

OUTCOMES:

At the end of the course, the students will be able to explore the

- fundamentals and working of semiconductor diodes
- working and application of various type of transistors
- principle and working mechanism of various types amplifiers and filters
- characteristics of oscillators and converters
- applications of electronic devices in fabrication of Integrated circuits (ICs) and functioning of timer circuit.

PHD6105 ADVANCED OPTICS LAB

L	T	P	C
0	0	4	2

OBJECTIVES

- To gain in-depth knowledge in the field of optics
- To apply the concepts learnt through laboratory in various applications to meet the epithetical needs of the society.

LIST OF EXPERMENTS
(ANY TEN)

1. Determination of wavelength of light using Michelson interferometer
2. Refractive index of a given liquid using Hollow prism method
3. Air – wedge experiment
4. Numerical aperture and acceptance angle of an optical fibre.
5. Particle size determination of different materials
6. Spectrometer experiment – determination of wavelength of prominent line of mercury spectrum.
7. Determination of Brewster angle using fibre optics
8. Fraunhoffer diffraction experiment
9. Fresnel diffraction experiment
10. Beam divergence of He - Ne laser semiconductor diode laser
11. Single mode fibre characteristics
12. Nonlinear optical studies using Pulsed Nd: YAG Laser
13. Demonstrate the principle of Rayleigh Scattering
14. Polarization experiments using polarimeter

OUTCOMES:

At the end of the course, the student will be able to

- have a thorough knowledge on the different experimental techniques in Advanced optics
- grasp the basic ideas involved in laser experiments
- apply the concepts of physics and do the interpretation on interference, diffraction, polarization experiment results

PHC6106 SEMICONDUCTOR DEVICES AND CIRCUITS LAB

L	T	P	C
0	0	4	2

OBJECTIVES:

- To make the student understand the basics of electronics.
- To enable the student to explore the concepts involved in the oscillators
- To make the student understand the basic concepts in IC's and digital devices
- To make the student to understand the fundamentals of multivibrators

LIST OF EXPERMENTS
(ANY TEN)

1. Characteristics of PN Junction diode and Zener diode. Design of clipper and clamper circuits.
2. Input and Output characteristics of BJT in CB and CE configurations and comparison.
3. Characteristics of JFET and MOSFET
4. UJT and SCR characteristics
5. Characteristics of photodiode and photo transistor.
6. Design of single stage amplifier using BJT and JFET for small signal applications and comparison.
7. Design of Colpitt's and Hartley oscillators using BJT for a given frequency
8. Design of Wien bridge and Phase shift oscillators using OPAMP.
9. Schmitt's trigger: Triangular, sawtooth and square wave generators.
10. Design of Adder, Subtractor, Multiplier, Differentiator and Integrator circuits using OPAMP
11. Construction of Astable, Monostable and Bistable multivibrators using BJT / OPAMP.

12. Construction of Dual power supply.
13. Design of A / D and D / A convertors.
14. Design of modulation and demodulation circuits.

OUTCOMES:

At the end of the course, the student will be able to

- classify the characteristics of semiconductor devices.
- design amplifier, oscillator and other circuits using OP AMP

SEMESTER II

PHD6201 **QUANTUM MECHANICS** **L T P C**
3 0 0 3

OBJECTIVES:

- To understand the basic concepts of quantum mechanics.
- To know certain exactly solvable systems.
- To enable the students to explore the different approximation methods.
- To understand the scattering theory and angular momentum operators.
- To give the applications of relativistic quantum mechanics.

MODULE I BASIC FORMULATION 09

Postulates of quantum mechanics - Schrodinger time independent and dependent equations– physical Interpretation of wave function Ψ - expectation values - Ehrenfest theorem-Basic postulates - Operators: Definition and properties- Eigen values and Eigen functions - self adjoint operators – Parity operator- uncertainty principle. (Statement and Proof) - Quantum pictures: Schroedinger, Heisenberg and Interaction.

MODULE II EXACTLY SOLVABLE SYSTEMS 09

One dimensional linear harmonic oscillator – solutions to a square well potential – rigid rotator -Particle in a central potential – Particle in a periodic potential - Central forces and reduction of two body problem – Particle in a spherical well – Hydrogen atom.

MODULE III APPROXIMATION METHODS 09

Time independent perturbation theory: Equations in various orders of time independent perturbation theory for non- degenerate case: first and second order– Stark effect – Zeeman effect- Application to ground state of Helium atom – Time dependent perturbation theory: harmonic perturbation (Fermi-Golden Rule) - Adiabatic, Sudden Approximation perturbation.

MODULE IV SCATTERING THEORY AND ANGULAR MOMENTUM 09

Scattering theory: Scattering amplitude and cross-section – Green's function approach -- Born approximation and its application to square-well and screened Coulomb potentials. Angular momentum: Components of orbital angular momentum – Properties of L and L^2 – Eigen pairs of L^2 and L_z – Eigen states and Eigen values of of J^2 and J_z – addition of angular momentum – Clebsch Gordan coefficients - spin angular momentum – Pauli's spin matrices.

MODULE V RELATIVISTIC QUANTUM MECHANICS 09

Klein Gordon equation for a free particle and its solution –Dirac's equation for free particle – Dirac matrices - covariant form of Dirac's equation - Spin of Dirac's particle- Charge and current densities – Plane wave solution – Negative energy states – Zitterbewegung – Spin of a Dirac particle – Spin-orbit coupling.

Total Hours: 45

REFERENCES:

1. David J. Griffiths, Introduction to Quantum Mechanics, Pearson Publication, 2nd Edition, 2015.
2. L. Schiff, Quantum Mechanics, Tata McGraw Hill, New Delhi, 2014, 4th edition.
3. Satya Prakash, Quantum Mechanics, Sultan Chand Publishers, New Delhi, 2004.
4. S. Rajasekar, R. Velusamy, Quantum Mechanics I: The Fundamentals, CRC Press, 2014.
5. S L Gupta, V Kumar, H V Sharma, Quantum Mechanics, Jai Prakash Nath Publications, 2015
6. P M Mathews, K.Venkatesan ,Text Book of Quantum Mechanics, 2nd Ed, Tata McGraw-Hill Education, 2017
7. A.K. Ghatak and S. Lokanathan, Quantum Mechanics: Theory & Applications (Macmillan, Chennai, 2004) 5th edition.
8. R. Shankar, Principles of Quantum Mechanics (Springer, New Delhi, 2007).

OUTCOMES:

At the end of the course, the students will be able to

- Comprehend the basics of quantum mechanics and to apply it in different branches of Physics.
- Apply the knowledge gained in the solvable system in the field of harmonic oscillator and hydrogen atom
- Enable the students to explore the different approximation methods used in quantum mechanics.
- Familiarize with the concepts of scattering theory and angular momentum and its importance.
- Understand the applications of relativistic quantum mechanics.

PHD6202	ELECTROMAGNETIC THEORY AND ELECTRODYNAMICS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To know the principles of electrostatics and magnetostatics.
- To familiarize with the Maxwell’s equation and boundary conditions.
- To understand the basic concepts in electromagnetic wave and radiation.
- To study the laws governing the propagation of electromagnetic waves.
- To enable the student to explore the field of electrodynamics

MODULE I ELECTROSTATICS 12

Coulomb's law, Gauss’s law and applications, Electrostatic potential – Laplace and Poisson's equation – Laplace equation in three dimensions - Boundary value problems and uniqueness theorem, Polarization and displacement vectors - Boundary conditions - Dielectric sphere in a uniform field – Molecular polarisability and electrical susceptibility – Electrostatic energy in the presence of dielectric – Multipole expansion.

MODULE II MAGNETOSTATICS 12

Biot-Savart Law and its Applications, Ampere’s circuital Law – Applications – Magnetic vector and scalar potential - Magnetic moment, force and torque on a current distribution in an external field - Magnetostatic energy - Magnetic induction and magnetic field in macroscopic media - Boundary conditions.

MODULE III MAXWELL’S EQUATION 12

Faraday's laws of Induction - Maxwell's displacement current - Maxwell's equations – free space and linear isotropic media – Boundary conditions on the fields at interfaces -Vector and scalar potentials - Gauge invariance - Wave equation in one dimension - Coulomb and Lorentz gauges - Energy and momentum of the field - Poynting's theorem - Lorentz force - Conservation laws for a system of charges and electromagnetic fields.

MODULE IV ELECTROMAGNETIC WAVES & INTERACTION WITH MATTER 12

Electromagnetic waves in free space – Plane waves in non-conducting media - Linear and circular polarization, reflection and refraction at a plane interface- Fresnel’s law, interference, coherence and diffraction – Dynamics of charged particles in static and uniform electromagnetic fields - Waves in a conducting medium - Propagation in linear media – Reflection and transmission at Normal incidence – Reflection and Transmission at Oblique incidence –Laws of incidence and reflectance, Snell’s law, Brewster law – Fresnel’s equations.

MODULE V RELATIVISTIC AND QUANTUM ELECTRODYNAMICS 12

Four vectors - Lorentz transformation – invariance of Maxwell's equations under Lorentz transformation - invariance of D'Alembertian operator – invariance of Maxwell's field equations in terms of four vector – Radiation from moving charges and dipoles and retarded potentials - Quantum Electrodynamics (QED) – Introduction - S-Matrix and its expansion. Ordering theorems, Feynman graph and Feynman rules - Application - Rutherford scattering and Compton scattering.

Total Hours: 60

REFERENCES:

1. David J.Griffith, Introduction to Electrodynamics, 4th Edition, Pearson New International Edition, New Delhi, 2014.
2. John David Jackson, Classical electrodynamics, 3rd edition, Wiley Eastern Ltd. (1999).
3. Zangwill A, Modern Electrodynamics, 1st edition, Cambridge (2013).
4. Reitz, John R.; Milford, Frederick J., Christy., Robert W., Foundations of Electromagnetic Theory 4th ed. Addison Wesley (2008).
5. Gupta, Kumar, Singh, Electrodynamics, Pragati Prakashan (2001).
6. Capri A.Z. and Panat P.V., Introduction to Electrodynamics, Narosa Publishing House, 2010.
7. Satya Prakash, Electromagnetic theory and Electrodynamics, 10th edition, Kedar Nath and co., Meerut, 1999.
8. Matthew N.O, Sadiku, Elements of Electromagnetics, 3rd Ed. 2006

OUTCOMES:

At the end of the program, the students will

- Familiarize with the concepts of electrostatics and magnetostatics.
- Apply Maxwell's equations to circuit theory.
- Acquaint with the boundary conditions.
- Gain knowledge on the propagation of electromagnetic waves.
- Disseminate the principles of Quantum Electrodynamics.

PHD6203 ATOMIC PHYSICS AND MOLECULAR SPECTROSCOPY

L	T	P	C
4	0	0	4

OBJECTIVES:

- To provide basic knowledge of modern atomic and molecular physics
- To understand different spectroscopic studies on matter on the basis of quantum mechanics
- To master the experimental and theoretical methods in atomic and molecular spectroscopy
- To gain knowledge about NMR and ESR spectroscopy
- To obtain understanding on NQR and Mossbauer spectroscopy

MODULE I ATOMIC AND MOLECULAR STRUCTURE 12

Atomic models: Vector atom model – Pauli's exclusion principle – Heisenberg's uncertainty principle – Types of spectra - Equation of motion of matters waves – operators - momentum and energy operators - eigen functions and eigen values –– Many electron atoms – coupling schemes – Spin orbit interaction -energy levels – Spin functions of two and three electrons - Central field approximation: Thomas Fermi statistical model –– Paschen back effect – Covalent bond - Hybridization: sp, sp^2, sp^3 - molecular orbital theory –Heitler London theory of Hydrogen ion and Helium molecule.

MODULE II INFRARED AND MICROWAVE SPECTROSCOPY 12

Characteristic features of pure rotation – vibration – rotation and vibration of a diatomic molecule – theory – evaluation of molecular constants – IR spectra of polyatomic molecules – experimental techniques of IR – Dipole moment studies – molecular structure determination. Microwave spectra of polyatomic molecules – experimental techniques of microwave spectroscopy – inversion spectrum of ammonia – Maser principles – Ammonia Maser– applications of Masers.

MODULE III RAMAN SPECTROSCOPY 12

Semi classical treatment of emission and absorption of radiation – emission and absorption coefficients – spontaneous and induced emission of radiation – polarisability – Rayleigh scattering – Raman effect – basic principles of Raman scattering – vibrational and rotational Raman spectra – Experimental techniques of Raman Spectroscopy- – molecular structure studies – Laser as a Raman source.

MODULE IV NMR AND ESR SPECTROSCOPY 12

NMR spectroscopy Basic principles- classical and quantum mechanical techniques - Bloch equations- spin- spin and spin- lattice relaxation times- experimental technique - single coil and double coil methods- pulse

ESR spectroscopy- basic principles- ESR spectrometer- Nuclear interaction and hyperfine structure- Relaxation effects- ‘g’ factor- biological applications.

MODULE V NQR AND MOSSBAUER SPECTROSCOPY 12

NQR spectroscopy- basic principles- quadrupole Hamiltonian- Nuclear quadrupole energy levels- for axial and non axial symmetry- NQR spectrometer-chemical bonding- molecular structure and molecular symmetry studies. Mossbauer spectroscopy-principle experimental arrangement - chemical shift-quadrupole splitting-applications.

Total Hours: 60

REFERENCES:

1. Sune Svanberg, Atomic and Molecular spectroscopy, 3rd Edition, Springer Publishers, 2012.
2. Jain V. K., Introduction to Atomic And Molecular Spectroscopy, Alpha Science Intl Publishers, 2007.
3. Colin N. Banwell and Elaine M. McCash, Fundamentals of Molecular spectroscopy, McGraw-Hill College, 1994.
4. G.Aruldhas, Molecular structure and Spectrocopy, 2nd Ed., PHI learning Pvt.Ltd. 2014.
5. R.Gopalan, P.S.Subramanian and K.Rengarajan, Elements of Analytical Chemistry,Sultan Chand & sons, 2011
6. Jeanne L. McHale, Molecular spectroscopy, Prentice Hall, 1994.

OUTCOMES:

At the end of the course, the students will be able to

- explain the basic ideas about the various energy levels in matter
- understand the concepts of different spectroscopic studies
- carry out theoretical and experimental studies on molecular spectroscopy
- focus on structure and dynamics of atoms and molecules
- gain knowledge in Mossbauer and NQR spectroscopy towards chemical shift and quadrupole splitting applications

GEC6202 RESEARCH METHODOLOGY

L	T	P	C
4	0	0	4

OBJECTIVES:

The students will be trained to

- Select and Define a research problem
- Describe the Methodology of Research
- Acquire good laboratory practices
- Operate the software for Programming techniques
- Analyze and Interpret the Results
- Demonstrate the Plagiarism check by turtin

MODULE I RESEARCH METHODOLOGY- AN INTRODUCTION 12

Research: Objectives, Motivation and types - Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Research Process, Criteria of Good Research, Problems Encountered by Researchers - Introduction to ethics, scientific conduct and misconduct, Misconduct and why it occurs, Fabrication, Authorship issues, The investigation and punishment of scientific misconduct.

MODULE II GOOD LABORATORY PRACTICES AND SAFETY 12

Introduction: History, definition, Principles, Good Laboratory Practices (GLP) and its application GLP training: Resources, Rules, Characterization, Documentation, quality assurance, Resources, Facilities: building and equipment, Personnel, GLP and FDA, Stepwise implementation of GLP and compliance monitoring. Safety Symbols, Science Safety Rules- Dress Code, First Aid, Heating and Fire Safety

MODULE III PROGRAMMING TECHNIQUES 12

Data analysis using Excel, Origin and Sigma plot Analyzing the chemical data and drawing chemical structures using Chemdraw and Chemsketch. Basics of C and C++ programme – MATLAB – Numerical Methods – Ordinary Differential Equation – Partial Differential Equation – Runge Kutta Method.

MODULE IV INTERPRETATION OF RESULTS AND ANALYSIS 12

Importance and scientific methodology in recording results, importance of negative results, different ways of recording, industrial requirement, artifacts versus true results, types of analysis (analytical, objective, subjective) and cross verification, correlation with published results, discussion, outcome as new idea, hypothesis, concept, theory, model etc.

Conceptions of error of measurement, true score theory and generalisability theory. Measures of central tendency or averages – mean median and mode. Measures of dispersion – range, variance, and standard deviation: The normal distribution and the normal probability curve.

MODULE V **SCIENTIFIC WRITING, TECHNICAL PUBLICATION AND RESEARCH PROPOSAL** **12**

Different types of scientific and technical publications in the area of research, and their specifications, Ways to protect intellectual property – Patents, technical writing skills, definition and importance of impact factor and citation index - assignment in technical writing, The research problem, finding related literature, computer generated references sources and the research project, model research proposal. Plagiarism checking by Turtin –demonstration

Total Hours –60

REFERENCES:

1 Essentials of Research Design and Methodology Geoffrey R. Marczyk, David DeMatteo, David Festinger, 2005 John Wiley & Sons Publishers, Inc
2 Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry, 2nd Edition, Irwin H. Segel, 1976 John Wiley & Sons Publishers, Inc
3 Guide to Publishing a Scientific paper, Ann M. Korner, 2004, Bioscript Press.
4 P Laake, H B Benestad, B R Olsen. Research Methodology in the medical and biological sciences. Academic Press, 2007.
5 R Arora. Encyclopaedia of Research Methodology in Biological Sciences. Anmol Publishing, 2004.
6 Kothari C.R., Research Methodology, Methods and Techniques, Wiley Eastern Ltd., NewDelhi, 1991.
7 Coghill M. and Gardson L.R., The ACS Style Guide Effective Communication of Scientific Information, 3rd Edn., Oxford University Press, 2006.
8 Willa Y. Garner, Maureen S. Barge, James, P, Good Laboratory Practice Standards: Applications for Field and Laboratory Studies (ACS Professional References Book).

OUTCOMES:

At the end of this course, the students should be able to:

- recognize the basic concepts of research and its methodologies
- Identify appropriate research topics
- Select and define appropriate research problem and parameters
- Prepare a project proposal (to undertake a project)
- Organize and conduct research (advanced project) in a more appropriate manner
- Write a research report and thesis

PHD6204 **THERMAL PHYSICS LAB** **L T P C**
0 0 4 2

OBJECTIVES:

- To make the student familiarize with the basics of experimental physics
- To enable the student to explore the concepts involved in the thermodynamics and heat
- To allow the student to apply the fundamentals of instruments involved in thermal process.

LIST OF EXPERMENTS
(ANY TEN)

1. Radiation from a black body: Stefan-Boltzmann Law
2. Thermal conductivity of good conductors by Forbe's method.
3. To determine the Coefficient of Thermal Conductivity of Copper by Searle's and Angstrom's method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee disc method.
5. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
6. Measurement of Planck's constant using black body radiation.
7. Determination of Stefan's constant.
8. Specific heat of liquid – Newtons law of cooling
9. EMF of a thermocouple – Mirror galvanometer – Direct deflection method.
10. Verification of Newton's Law of cooling.
11. Thermal conductivity of a good conductor by Searle's method.
12. Temperature characteristics of thermistor.
13. Specific heat of liquid – Joule's Calorimeter

14. Thermal expansion by Fizeau's method (Coefficient of linear expansion of brass).
15. Determination of co-efficient of thermal conductivity of a single crystal.

OUTCOMES:

At the end of the course, the student will be able to

- have a thorough knowledge on the different experimental techniques in thermal physics.
- grasp the basic ideas involved in thermal experiments
- apply the concepts of physics and do the interpretation and acquire the result

SEMESTER III

PHD7101 DIGITAL ELECTRONIC AND MICROPROCESSORS

L	T	P	C
4	0	0	4

OBJECTIVES:

- To understand the concepts of microprocessors and microcontrollers.
- To comprehend the ideas about the digital electronics
- To get knowledge on 8085 microprocessors
- To perform arithmetic operations using 8085 microprocessor programming
- To study the interfacing technique using 8085 microprocessor

MODULE I LOGIC GATES **12**

Logic gates - block diagram - truth table - XOR gate - equivalent functions - combinational logic - half adder / subtractor - full adder / subtractor – De Morgan's laws-Boolean algebra - Karnaugh maps - max and min terms - encoders and decoders - multiplexers and demultiplexers.

MODULE II COUNTERS **12**

Sequential logic – flip flops – sequential circuit analysis – state diagram – state equation – registers – counters – up down counters – timing sequences – the memory MODULE – Random Access Memory (RAM) – Magnetic core memory.

MODULE III INTRODUCTION TO MICROPROCESSOR **12**

Common microprocessor characteristics - pin diagram and functions for generic microprocessor - microprocessor architecture - the intel 8085 microprocessor - the 8085 pin diagram and functions - 8085 architecture - different addressing modes - 8085 instruction set - arithmetic, logical and branch instructions - the 8085 stack, I/O and control instructions.

MODULE IV 8085 MICROPROCESSOR **12**

Programming the 8085 microprocessor - 8 bit addition, subtraction, multiplication and division - looping programs - sum of data - maximum, minimum values of the given array - ascending / descending - data transfer- 16 bit addition – relay generation – multiple precision arithmetic decimal arithmetic - subroutine programs - ASCII to decimal multiple precision addition subroutine.

MODULE V MICROPROCESSOR INTERFACING **12**

Timing diagram - instruction cycle, machine cycle, R/W cycle – interfacing the microprocessor - interfacing with ROM - interfacing with RAM - I/O interfacing basics.

Total Hours: 60

REFERENCES:

1. Jain R. P, Digital Electronics and Microprocessors, First Edition, Tata – McGraw Hill, 1987.
2. Anokh Singh, A.k.Chhabra, Fundamental of Digital Electronics and Microprocessors, 2nd Edition, S. Chand Limited, 2005.
3. Anokh Singh, Chhabra A.k, Fundamental of Digital Electronics and its application, S. Chand Limited, 2005.
4. Sumit Kumar Singh, Fundamental of Digital Electronics and Microprocessors, Coronet Books Incorporated, 2008.
5. Jain, Modern Digital Electronics, 3rd Edition, Tata McGraw Hill, 2003.

OUTCOMES:

At the end of the course, the students will be able to illustrate

- the working of digital electronic devices.
- the concepts of working model of microprocessors and microcontrollers.
- the basic knowledge on 8085 microprocessor
- to carry out the mathematical analysis such as addition and subtraction programming using 8085 micrprocessor
- to concept of interfacing using 8085 microprocessor

PHD7102 THERMODYNAMICS AND STATISTICAL PHYSICS L T P C
4 0 0 4

OBJECTIVES:

- To understand the concepts of thermodynamics
- To provide the kinetic theory of gases
- To acquire the knowledge of classical statistical mechanics
- To learn about quantum statistical mechanics
- To understand the applications of quantum statistical mechanics

MODULE I REVIEW OF THERMODYNAMICS 12

Energy and first law of thermodynamics – entropy and second law of thermodynamics – Nernst heat theorem and third law of thermodynamics Enthalpy – consequences of Nernst heat theorem – heat capacity and specific heat – Maxwell's thermodynamic relations and potentials - Gibb's- Helmholtz relations - thermodynamic equilibria.

MODULE II KINETIC THEORY 12

Boltzmann transport equation and its validity – Boltzmann's H-theorem – Relation between H-function and entropy – Maxwell-Boltzmann distribution – Mean free path – Conservation laws – Transport phenomena – Viscosity of gases – Thermal conductivity – Diffusion process.

MODULE III CLASSICAL STATISTICAL MECHANICS 12

Review of probability theory – Macro and micro states – Phase space – Statistical ensembles – Density function – Liouville's theorem – Maxwell –Boltzmann distribution law – Micro canonical ensemble – Ideal gas – Entropy – Partition function – Equipartition theorem – Canonical and grand canonical ensembles.

MODULE IV QUANTUM STATISTICAL MECHANICS 12

Basic concepts – Ideal quantum gas – Bose-Einstein statistics – Photon statistics –Fermi-Dirac statistics – Sackur-Tetrode equation – Equation of state – Bose-Einstein condensation – Comparison of classical and quantum statistics.

MODULE V APPLICATIONS OF QUANTUM STATISTICAL MECHANICS 12

Ideal Bose System: Photons – Black body and Planck radiation – Specific heat of solids – Liquid helium. Ideal Fermi System: Properties – Degeneracy – Electron gas – Pauli paramagnetism. Ferromagnetism: Ising and Heisenberg models.

Total Hours: 60

REFERENCES:

1. Frederick Reif, Fundamentals of statistical and thermal physics, McGraw- Hill, 2008.
2. Agarwal B.K. and Eisner M, Statistical Mechanics, 2nd Edition, New Age International, New Delhi, 1998.
3. Sears F.W and Salinger G.L, Thermodynamics, kinetic theory and statistical thermodynamics, Narosa publishing House, 1998.
4. Huang. K, Statistical Mechanics, Wiley Eastern Ltd., 2nd Edition, New Delhi,1987.
5. Bhattacharjee J.K, Statistical Mechanics: An Introductory Text, Allied Publication, New Delhi, 1996.

OUTCOMES:

At the end of the course, the students will be able to explain the

- fundamentals of thermodynamical systems
- the kinetic theory of gases
- ensemble appproach to solve classical and quantum thermodynamic systems
- way to obtain partition function and their applications in calculating thermodynamical quantitites
- classical and quantum statistical mechanics

PHD7103	NUCLEAR AND PARTICLE PHYSICS	L T P C
		3 0 0 3

OBJECTIVES:

- To acquire the knowledge of basic properties of nucleus.
- To have an idea on the nature of nuclear forces.
- To gain the knowledge on elementary particles.
- To introduce the concepts of radioactivity
- To get an insight into nuclear reactions

MODULE I NUCLEAR STRUCTURE 9

Basic properties: nuclear size-nuclear radius-estimation of nuclear size- nuclear structure, Rutherford's formula for alpha particle scattering - magnetic moments - systematics of stable nuclei - semi empirical mass formula of Weizsacker - nuclear stability - mass parabolas- liquid drop model- shell model.

MODULE II NUCLEAR FORCES 9

Ground state of deuteron – Orbitals in deuteron – Non central forces of deuteron - magnetic dipole moment of deuteron-square well potential of deuteron- Neutron-neutron, proton-proton forces - Scattering Processes: The scattering problem- formulation- scattering amplitude- Low energy neutron-proton scattering - phase shifts- scattering length and effective range.

MODULE III RADIOACTIVITY 9

Alpha particle emission- Geiger Nuttal law- Gamow's theory of alpha decay- fine structure of alpha spectra-beta decay- Neutrino hypothesis- Fermi's theory of beta decay-Fermi and G.T.Slection rules- pair production- annihilation - Gamma emission-selections rules- transition probability- internal conversion- nuclear isomerism.

MODULE IV NUCLEAR REACTIONS 9

Energies of Nuclear reaction- level widths - cross sections- compound nucleus model- resonance scattering- Breit- Wigner one level formula- optical model- direct reactions- Stripping and pick- up reactions- Fission and fusion reactions- elementary ideas of fission reaction- theory of fission- elementary ideas of fusion- controlled thermonuclear reactions- ideas of nuclear reactors.

MODULE V ELEMENTARY PARTICLES 9

Classification of fundamental elementary particles- isospin strangeness- Gell Mann Nishijima's formula- symmetry of elementary particles-weight diagrams- quark model- CPT theorem - elementary ideas of gauge theory of strong and weak interactions – Higg's boson particle.

Total Hrs :45

REFERENCES:

1. Tayal D.C., Nuclear Physics, Himalaya Publishing House, 1997.
2. Khanna M.P., Introduction to Particle Physics, Prentice Hall of India, 2004.
3. Williams W. S. C., Nuclear and Particle Physics, Oxford University Press, 1991.
4. Brian Martin, Nuclear and Particle Physics: An Introduction, Wiley Publishers, 2011.
5. I. S. Hughes, Elementary Particles, Cambridge University Press.
6. Roy and Nigam, Nuclear Physics, Wiley.

OUTCOMES:

At the end of the course, the students will be able to

- explore the basic concepts of nucleus and its properties
- explore the basic ideas and comprehend concepts of Nuclear forces
- get an exposure of radioactivity concepts
- apply the concepts of quantum forces in nuclear reactions
- gain knowledge on elementary particles.

PHD7104 **ADVANCED ELECTRONICS LAB** **L T P C**
0 0 4 2

OBJECTIVES:

- To understand basic analog circuit designs
- To know the working of amplifiers
- To study transistor biasing

LIST OF EXPERMENTS
(ANY TEN)

1. Combinational circuit (Half Adder, Hall - Subtractor, Full Adder and Full-Subtractor)
2. Design a BCD to Excess 3 code converter using combinational circuits.
3. Design a combinational circuit whose output is the 2’s complement of the input number.
4. To design and construct of a 4-bit parallel Binary Adder
5. To design and construct multiplexer and demultiplexer
6. To design and verify encoder and decoder
7. To Verification of Flip-Flop (JK, RS,T& D)
8. To verify the operation of a 4 bit shift register using IC 7495
9. To design and construct Synchronous Counter
10. To verify the operation of a ring counter
11. To verify the operation of a decade counter
12. Addition and subtraction of two numbers using 8085 Microprocessor.
13. Multiplication of 2 - 8 numbers using 8085 Microprocessor

OUTCOMES:

- Students can simulate building and test basic analog circuit
- Students can simulate building and test amplifier circuits
- Students can simulate building and test Transistor biasing

PHD7105 **MATERIALS SCIENCE LAB** **L T P C**
0 0 4 2

OBJECTIVES:

- To make the student understand the basics of materials science.
- To enable the student to explore the concepts involved in various instrumentation techniques
- To make the student understand the basic concepts of electronic band structures and some applications
- To allow the student to understand the fundamentals of nonlinear optics.

LIST OF EXPERMENTS
(ANY TEN)

1. Crystal growth – Constant temperature bath
   i. Solubility Test
   ii. Metastable zone width
   iii. Slow evaporation technique
2. Determination of susceptibility of liquid using Quincke's method.
3. Determination of type of semiconductor by Hall Effect method.
4. Determination of Conductivity of a material using four probe method.
5. Determination of dielectric constant of material using LCR meter.
6. Determination of Young's Modulus using Flexural vibration
7. Determination of Band structure and Density of States (DOS)
8. Determination of magnetic properties using density functional theory (DFT).
9. Study of Nonlinear behaviors – Numerical simulation
10. Determination of Velocity and Compressibility of ultrasonic waves in liquid

11. Characteristics of solar cell
12. Comparative study of Compound pendulum and Torsion pendulum
13. Determination of Magnetic moment using materials modelling.
14. Measurement of Line intensities in Iron Arc Spectrum by spectrograph

OUTCOMES:

At the end of the course, the students will be able to

- demonstrate experiments related to Materials Science
- obtain electronic band structure through computational methods and investigate materials properties

ELECTIVES

SEMESTER I

PHDY101	CRYSTAL GROWTH TECHNIQUES	L T P C 2 0 2 3

OBJECTIVES:

- To get the basic understanding on Crystal-Symmetry operations and various defects in crystals
- To understand and compare the various solution-based Crystal Growth techniques.
- To know the principle in the methods involved in the growth of crystal using melt growth process.
- To study the applications of single crystals in non-linear optics

MODULE I CRYSTALLOGRAPHY 7

Symmetry elements, operations - translational symmetries - point groups - space groups - equivalent positions –close packed structures - voids - important crystal structures – defects in crystals, – polymorphism and twinning - polarizing microscope and uses-

MODULE II GROWTH FROM SOLUTIONS 9

Introduction to crystal growth – nucleation - Measurement of super saturation - solution growth methods – low and high temperature solution growth methods – vapour growth – Crystal growth in gel – Growth of biological crystals – Hydrothermal technique – Sol-gel growth – unidirectional growth of crystals from solution. Accelerated crucible rotation technique (ACRT)

MODULE III MELT GROWTH 7

Temperature measurement and control – Starting materials and purification – conservative and non-conservative process – Bridgman method – Czochralski method – Verneuil method – Zone melting – Zone refining- Skull melting

MODULE IV APPLICATIONS OF LINEAR AND NON-LINEAR CRYSTALS 7

Nonlinear Optics in Linear Photonic Crystals - Phase Matching - Nonlinear Photonic Crystal Analysis – Nonlinear photonic crystals – photonic crystal fibers – photonic crystal sensor - Materials: $LiNbO_3$, Chalcogenide Glasses, etc., Wavelength Converters, etc.

Total Hours: T-30, L-15

LIST OF EXPERIMENTS:

1. Growth of crystal by slow evaporation technique
2. Growth of crystals from temperature reduction method.
3. Determination of melting point of given crystal.
4. Solubility test for different materials.
5. Determination of Meta-stable zone width.
6. Hydrothermal method of crystal growth
7. Sol-gel method of growing crystals
8. Characterization of second harmonic crystals
9. Simulation of crystal structures using DFT

REFERENCES:

1. Brice J.C., Crystal Growth Processes, John Wiley and Sons, New York, 1987.
2. Santhana Ragavan P. and Ramasamy P., Crystal Growth Processes and Methods, KRU Publications, Kumbakonam, 2001.
3. Scheel, Hans J. and Fukuda, Crystal Growth Technology, Wiley publishers, 2004.
4. Hans J. Scheel and Peter Capper, Crystal Growth Technology: From Fundamentals and Simulation to Large-scale Production, Wiley publishers, 2008.

OUTCOME:

At the end of the course, the students will be able to

- understand the various techniques involved in Crystal Growth.
- get practical knowledge on various solution-based Crystal Growth techniques
- get practical knowledge on various Crystal Growth process using melt growth techniques.
- study various application of single crystals in non-linear optics

PHDY102 **MATERIALS PROCESSING** **L T P C**
3 0 0 3

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OBJECTIVES:

- To introduce the basic concepts of physics of materials processing
- To provide knowledge of surface treatment processes
- To study about different welding processes
- To discuss various types of mechanical working of metals
- To give the basics of powder metallurgical process

MODULE I BASIC MANUFACTURING PROCESSES **9**

Fundamental analysis of Manufacturing processes, casting, casting processes, forging, methods of forging, extrusion, rolling, spinning, turning, planning and shaping, milling, grinding.

MODULE II SURFACE TREATMENT PROCESSES **9**

Necessity for surface modification, surface cladding, surface alloying, hard facing, shock hardening, conventional methods, carburizing, nitriding, cyaniding, advantages of laser surface treatment over conventional methods, typical laser variables used in surface alloying, laser cladding, experimental set up.

MODULE III WELDING PROCESSES **9**

Various processes of welding, fusion welding, pressure welding, oxyacetylene welding, resistance welding, spot welding, thermite welding, projection welding, seam welding, butt welding, thermal effects of welding, effects on grain size and microstructure, internal stresses effect, corrosion effect, high energy beam welding, laser beam and electron beam welding, key hole effect.

MODULE IV MECHANICAL WORKING OF METALS **9**

Hot working, cold working, normalizing, full annealing, tempering, theory of tempering, effect of tempering temperature on mechanical properties of carbon steels, different tempering process, deformation of metals, elastic deformation, plastic deformation, slip, twinning.

MODULE V POWDER METALLURGICAL PROCESS **9**

Production of powders, powder mixing, compacting, types of presses, sintering, soaking, finishing process, limitations and advantages of powder metallurgy, applications, production of cemented carbide cutting tools, self-lubricating bearings, magnets, cermets, ultrasonic ceramic transducers.

Total Hours: 45

REFERENCES:

1. Rajan T.V, Sharma C.P and Ashok Sharma Heat treatment - Principles and Techniques, Prentice Hall of India Pvt. Ltd. New Delhi, 1995.
2. Muralidhara, M.K., Materials Science and Processes, Dhanpat Rai Publishing Co., New Delhi, 1998.
3. Rykalin, Uglov A, Kokona, A Laser and Electron beam material processing hand book, MIR Publishers, 1987.
4. Gupta, R.B. Materials Science and Processes, Satya Prakashan, New Delhi, 1995.

OUTCOMES:

At the end of the course the students will be able to

- illustrate the manufacturing process, surface treatment process, welding process and mechanical working of metals and powder metallurgical process.
- explain the surface treatment process
- explore various types of welding technology
- explain Various types of mechanical working of metals
- acquire knowledge about various metallurgical process and its application

PHDY103	**MATERIALS CHARACTERIZATION**	**L**	**T**	**P**	**C**
		2	**0**	**2**	**3**

OBJECTIVES:

- To get knowledge on thermal analysis of materials using TGA, DTA and DSC
- To study on microscopic analysis
- To study on electrical analysis of various materials
- To obtain knowledge on spectroscopic analysis

MODULE I THERMAL ANALYSIS 7

Introduction – thermogravimetric analysis (TGA) –instrumentation – determination of weight loss and decomposition products – differential thermal analysis (DTA)- cooling curves - differential scanning calorimetry (DSC) – instrumentation – specific heat capacity measurements.

MODULE II OPTICAL AND ELECTRON MICROSCOPIC METHODS 10

Optical Microscopy: optical microscopy techniques – Bright field optical microscopy – Dark field optical microscopy – phase contrast microscopy - fluorescence microscopy - scanning probe microscopy (STM, AFM) - SEM, EDAX, ESCA, EPMA, TEM: working principle and Instrumentation - Photoluminescence – light–matter interaction – instrumentation – Applications.

MODULE III ELECTRICAL METHODS 7

Two probe and four probe methods- van der Pauw method – Hall probe and measurement – scattering mechanism – C-V characteristics – Schottky barrier capacitance – impurity concentration – electrochemical C-V profiling – limitations.

MODULE IV SPECTROSCOPY 6

Principles and instrumentation for UV-Vis-IR, FTIR spectroscopy, Raman spectroscopy, SIMS-proton induced X-ray Emission spectroscopy (PIXE).

Total Hours: T-30: L-15.

LIST OF EXPERMENTS

1. Determination of the excitation and emission spectra using photoluminescence spectrophotometer.
2. Determination of Conductivity of a material using four probe method.
3. Determination of the absorbance and reflectance using UV-Vis analysis.
4. Determination of inorganic and organic mixtures of compounds using FTIR Spectrophotometer.
5. Surface analysis of grown crystals using optical microscope
6. Determination of spectral resolution of sodium d1 and d2 lines.

REFERENCES:

1. Stradling,R.A; Klipstain, P.C; Growth and Characterization of semiconductors, Adam Hilger, Bristol,1990.

2. Belk, J.A; Electron microscopy and microanalysis of crystalline materials, Applied Science Publishers, London, 1979.

3. Lawrence E.Murr, Electron and Ion microscopy and Microanalysis principles and Applications, Marcel Dekker Inc., New York, 1991

4. D.Kealey&P.J.Haines, Analytical Chemistry, Viva Books Private Limited, New Delhi 2002.
5. Hobart Hurd Willard, Lynne Lionel Merritt, Instrumental Methods of Analysis, 6th ed, CBS Publishers & Distributors, 1986.

OUTCOMES:

At the end of the course, the students will be able to

- interpret data obtained through the characterization techniques
- explain various thermal analysis
- illustrate microscopic analysis using FESEM, TEM and STM
- interpret the electrical analysis of various materials

PHDY104 FUNCTIONAL MATERIALS AND STRUCTURES **L T P C 3 0 0 3**

OBJECTIVES:

- To enable the students understand importance and structure of smart materials
- To gain knowledge on application of function materialsfor sensor applications
- To understand the electro rheological functional materials
- To understand the theory behind piezoelectric materials
- To make the students understand the applications of smart materials towards shape memory alloys

MODULE I INTRODUCTION AND HISTORICAL PERSPECTIVE 9

Classes of materials and their usage – Intelligent /Smart materials – Evaluation of materials Science – Structural material – Functional materials – Poly functional materials – Generation of smart materials – Diverse areas of intelligent materials – Primitive functions of intelligent materials – Intelligent inherent in materials – Examples of intelligent materials, structural materials, Electrical materials, bio-compatible materials etc. – Intelligent biological materials – Biomimetics – Wolff's law – Technological applications of Intelligent materials.

MODULE II FUNCTIONAL MATERIALS AND STRUCTURAL SYSTEMS 9

The principal ingredients of smart materials – Thermal materials – Sensing technologies – Micro sensors – Intelligent systems – Hybrid smart materials – An algorithm for synthesizing a smart material – Passive sensory smart structures–Reactive actuator based smart structures – Active sensing and reactive smart structures – Smart skins – Aero elastic tailoring of airfoils – Synthesis of future smart systems.

MODULE III ELECTRO-RHEOLOGICAL (FLUIDS) FUNCTIONAL MATERIALS 9

Suspensions and electro-rheological fluids – Bingham-body model – Newtonian viscosity and non-Newtonian viscosity – Principal characteristics of electro rheological fluids – The electro-rheological phenomenon – Charge migration mechanism for the dispersed phase – Electro-rheological fluid domain – Electrorheological fluid actuators – Electro-rheological fluid design parameter – Applications of Electrorheological fluids.

MODULE IV PIEZOELECTRIC FUNCTIONAL MATERIALS 9

Background – Electrostriction – Pyro electricity – Piezoelectricity – Industrial piezoelectric materials – PZT – PVDF – PVDF film – Properties of commercial Piezoelectric materials – Properties of piezoelectric film (explanation) – Smart materials featuring piezoelectric elements – Smart composite laminate with embedded piezoelectric actuators – SAW filters.

MODULE V SHAPE – MEMORY (ALLOYS) FUNCTIONAL MATERIALS 9

Background on shape – Memory alloys (SMA) Nickel – Titanium alloy (Nitinol) – Materials characteristics of Nitinol – Martensitic transformations – Austenitic transformations – Thermoelastic martensitic transformations – Cu based SMA, chiral materials – Applications of SMA – Continuum applications of SMA fastners – SMA fibers – reaction vessels, nuclear reactors, chemical plants, etc. – Micro robot actuated by SMA – SMA memorization process (Satellite antenna applications) SMA blood clot filter – Impediments to applications of SMA – SMA plastics – Primary molding – secondary molding – Potential applications of SMA plastics.

Total Hours: 45

REFERENCES:

1. M.V.Gandhi and B.S. Thompson, Smart Materials and Structures Chapman and Hall, London, First Edition, 1992

2. T.W. Deurig, K.N.Melton, D.Stockel and C.M.Wayman, Engineering aspects of Shape Memory alloys, Butterworth –Heinemann, 1990

3. C.A.Rogers, Smart Materials, Structures and Mathematical issues, TechnomicPublising Co., USA, 1989.

OUTCOMES:

At the end of the course the students will be able to

- illustrate structure and properties of smart materials and their applications in Science & Technology
- explore the various application of functional materials towards sensors technology
- explain the concept behind electro rheological functional materials
- get adequate knowledge in theory behind piezoelectric materials
- study the the applications of smart materials towards shape memory alloys

PHDY105 ADVANCED OPTICS AND LASER TECHNOLOGY **L T P C**
3 0 0 3

OBJECTIVES:

- To know the role of advanced optics in laser technology
- To understand the imaging techniques applications
- To understand the various mechanisms involving operation of laser.
- To get knowledge on various switching modes of lasers
- To get practical knowledge towards applications of lasers

MODULE I THEORY OF DIFFRACTION **9**

Kirchoff's theorem – Fresnel – Kirchoff integral formula and its application to diffraction problems - Wave propagation in free space - Fraunhofer and Fresnel diffraction, Fraunhofer diffraction by a single slit, double slit, diffraction grating, circular aperture - Fresnel diffraction, Fresnel zones, Fresnel integrals.

MODULE II FOURIER OPTICS **9**

Concept of spatial Frequencies, Impulse response and transfer functions- Fourier Transform properties of lens - spatial filtering - theory of imaging (Focused and non-focused) - Pupil functions - Abbe's principle.

MODULE III LASER SYSTEMS **9**

Laser systems – General description-Laser structure-excitation mechanism- Different laser systems- He-Ne laser, Argon-ion laser, Nitrogen laser, Carbon-dioxide laser - Excimer laser - X-ray laser - Free electron laser, Nd:YAG; Nd:Glass, Alexandrite laser - Ti-Sapphire laser – Diode pumped solid state laser, Pulsed-CW dye laser.

MODULE IV Q-SWITCHING, MODE LOCKING AND COHERENCE OF LASER **9**

Theory of Q-switching and experimental methods - cavity dumping -Theory of Mode locking and experimental methods - Spatial and Temporal coherence - Methods of detection and measurement of ultrashort pulses.

MODULE V LASER APPLICATIONS **9**

Cooling and Trapping of Atoms, Principles of Doppler and Polarization Gradient Cooling, Qualitative Description of Ion Traps, Optical Traps and Magneto-Optical Traps, Evaporative Cooling and Bose Condensation. Medical applications - laser and tissue interaction – laser instrument of surgery.

Total Hours: 45

REFERENCES:

1. Born and Wolf, Principles of Optics, Cambridge University press, 1999.

2. Saleh and Tiech, Fundamentals of photonics, Wiley-Interscience Publishers, 2007.

3. Guenther. R.D., Modern Optics, John Wiley Publishers, 1990.

4. William T. Silfvast, Laser Fundamentals, Cambridge University press, 1996.

5. Robert Boyd. W, Non Linear Optics, 3rd edition, Academic Press, 2008.

OUTCOMES:

At the end of the course, the students will be able to

- illustrate the characteristics of the laser systems
- explain the imaging techniques using lasers
- elaborate the pumping mechanism of lasers
- explore Q-switching process in lasers and method of detection
- study various applications of laser systems.

PHDY106	NONLINEAR OPTICS	L T P C 3 0 0 3

OBJECTIVES:

- To teach the principles of nonlinear optics and origin of optical nonlinearities.
- To analyze various types of nonlinearities in optics and its applications.
- To study about third order nonlinearities and Kerr effect
- To provide the basics of photorefractive materials and multiphoton processes
- To give the details of different kinds of scattering processes

MODULE I INTRODUCTION TO NONLINEAR OPTICS 9

Wave propagation in an anisotropic crystal – Polarization response of materials to light – Harmonic generation – Second harmonic generation – Sum and difference frequency generation – Phase matching – Third harmonic generation – bistability – self focusing.

MODULE II NONLINEAR PROCESSES 9

Propagation of Electromagnetic Waves in Nonlinear medium, Self Focusing, Phase matching condition, Fiber Lasers, Stimulated Raman Scattering and Raman Lasers, CARS, Saturation and Two photon Absorptions.

MODULE III THIRD ORDER NONLINEARITIES 9

Two photon process – Theory and experiment – Three photon process Parametric generation of light – Oscillator – Amplifier – Stimulated Raman scattering – Intensity dependent refractive index optical Kerr effect – photorefractive, electron optic effects.

MODULE IV MULTIPHOTON PROCESSES 9

Electro-optic effects – Electro-optic modulators - Photorefractive effect - Two beam coupling in Photorefractive materials – Four wave mixing in Photorefractive materials.

MODULE V STIMULATED SCATTERING PROCESSES 9

Stimulated scattering processes – Stimulated Brillouin scattering – Phase conjugation – Spontaneous Raman effect – Stimulated Raman Scattering – Stokes – Anti-Stokes Coupling in SRS – Stimulated Rayleigh - Wing Scattering.

Total Hours: 45

REFERENCES:

1. Robert W. Boyd, “Non-linear Optics”, Academic Press, London, 5th Edition, 2008.
2. A.Yariv, Opto Electronics, Third Edition, John Wiley and Sons, New York,1990.
3. P.N.Butcher and D.Cotter, “The Elements of Nonlinear Optics”, CambridgeUniv. Press, New York, 1990.
4. YVGS Murthi and C. Vijayan, Essentials of Nonlinear Optics, Ane/Athena Books 1st Edition (2014)

OUTCOMES:

At the end of the course the students will able to

- explain the principles of nonlinear optics,
- explore detailed study on different nonlinear phenomena and its applications
- apply the knowledge for third harmonic conversion and evaluate nonlinear susceptibility of materials
- illustrate about multiphonon process and kerr effect
- explore about raman scattering process and its applications

PHDY107 OPTICAL FIBER COMMUNICATION L T P C

2 0 2 3

OBJECTIVES:

- To introduce the principles and classifications of fiber optic communication.
- To introduce the various optical fiber modes, configurations and various signal degradation factors associated with optical fiber.
- To analyze the different types of optical fiber cables and connectors.
- To study about various optical sources and optical detectors and their use in the optical communication system.

MODULE I FIBER OPTICS 6

Introduction to optical fiber – structure of an optical fiber - Total internal reflection - Phase shift & attenuation during total internal reflection - Hybrid modes - cutoff frequencies - meridinal rays & skew rays – Classifications of optical fiber.

MODULE II TRANSMISSION CHARACTERISTICS OF OPTICAL FIBERS 7

Dispersion - Fiber attenuation, absorption loss & scattering loss measurement - Optical Time Domain Reflectometer (OTDR) and its uses - Interferometric method to measure fiber refractive index profile.

MODULE III OPTICAL FIBERS CABLES & CONNECTORS 7

Fiber materials - Fiber fabrication- fiber optic cables design - fiber connectors - fiber splices - Lensing schemes for coupling improvements.

MODULE IV MODULATION, OPTICAL SOURCES, DETECTION AND COMMUNICATION NETWORKS 10

Electrooptic and Acoustooptic modulation - Injection laser - Homojunction and Heterojunction lasers - Injection laser to fiber coupling - Fiber lasers - Surface Emitting, edge emitting and superluminescent LEDs - Optical Detectors - Pin photodiodes - Avalanche photodiodes - Multiplexers - wavelength division multiplexing - Elements of an optical fiber communication system - Coherent optical fiber communication system - Local Area Networks - Bus, ring and star topologies - optical fiber regenerative repeater - optical amplifiers - basic applications - Low speed industrial optical fiber networks

Total Hours – T-30, L- 15

LIST OF EXPERIMENTS:

1. To measure the numerical aperture (NA) of the different optical fiber.
2. Measuring optical power attenuation in plastic optical fiber.
3. Measuring optical power bending loss and coupling loss in plastic optical fiber.

4. To check the VI characteristic of LED.
5. Characteristics of LASER Diode.
6. Characteristics of APD
7. Describe the operational characteristics and parameters of Photodiode used as photo detector in fiber optic system.

REFERENCES:

1. Gerd Keiser, "Optical fiber Communications", McGraw Hill Inc. Company, Tokyo, 5th Edition, 2017.
2. John M. Senior, "Optical Fiber Communications", Prentice Hall International Ltd., London, 3rd Edition, 2010.
3. Govind P. Agrawal, "Fiber Optic Communication Systems", John Wiley & Sons Inc., New York, 3rd Edition, 2007.
4. Allen H. Cherin, "An Introduction to Optical Fibers", Mc Graw Hill Inc., Tokyo, 1995.

OUTCOME:

On completion of this course the student will be able to

- Design optimization of single mode fibers, refractive index profile and cut-off wavelength.
- Know the various optical fiber modes, configurations and various signal degradation factors associated with optical fiber.
- Analyze the different types of optical fiber cables and connectors.
- Understand various optical sources and optical detectors and their use in the optical communication system.

PHDY108 **OPTICAL COMPUTING** **L T P C**
3 0 0 3

OBJECTIVES:

- To introduce the concepts of digital images and optical computation
- To understand the analog based optical computing
- To provide knowledge of advanced digital communications areas.
- To introduce the students to neural networks and
- To gain knowledge on advanced memory techniques such as associative memory and artificial intelligence.

MODULE I DIGITAL IMAGE PROCESSING FUNDAMENTALS 5

Digital Image fundamentals - sampling and Quantization - Image Enhancement – Image Restoration – image filtering

MODULE II ANALOG OPTICAL COMPUTING 7

Optical Computing 4f - fourier system - Spatial filtering - Inverse filtering - Deblurring - Analog Optical Arithmetic - Halftone processing - Non-linearOptical processing - Matched filter - Joint transform correlation - Phase only filter - Amplitude-modulated recognition filters - Generalized correlation filter.

MODULE III DIGITAL LOGIC 14

Number Systems - Number representations - Codes - Arithmetic Operations - Logic elements and Operations - Basic Logic Operations - Logic function formulations - Boolean Algebra - Minimization of function using K-map - Universal Logic gates - Logic functions using Multiplexers - Threshold Logic - Combinational Logic- Binary Adders - Carry-Look Ahead adder - Arithmetic Logic Unit- Decoders and encoders - Sequential Logic -Flip-flops- Synchronous sequential circuits - Counters.

MODULE IV DIGITAL OPTICAL COMPUTING 14

Non-linear devices - Integrated Optics - Threshold Devices - Spatial Light Modulators - Theta Modulation Devices - Shadow casting and Symbolic substitution - Design Algorithm - POSC Logic operations - POSC Multiprocessor Parallel and Sequential ALU using POSC - POSC Image Processing - Symbolic Substitution- Optical Implementation- Limitations and Challenges - Optical Matrix Processing - Multiplication using Convolution - Matrix Operations - Cellular Logic Architecture - Programmable Logic Array.

MODULE V OPTICAL NEURAL NETWORKS 5

Neural Networks - Associative Memory - Optical Implementations - Interconnections - Artificial Intelligence.

Total Hours – 45

REFERENCES:

1. Mohammad A. Karim and Abdul A.S. Awwal, "Optical Computing - An Introduction", John Wiley & Sons, 2003.
2. Alistair D. McAulay, "Optical Computer Architectures", John Wiley & Sons, 1991.
3. Dror G. Fritelson, "Optical Computing", The MIT Press, 1988.
4. B.S. Wherrett and F.A.P. Tooley, "Optical Computing", Heriot-WattUniversity, Edinburgh, 1988..Henri H. Arsenault et al., "Optical Processing and Computing", Academic Press, London, 1989.
5. Morris Mano, "Fundamentals of Digital Logic Circuits", Prentice Hall, 2002.

OUTCOME:

At the end of the course, the student will be able to

- explain digital image fundamentals and various imaging techniques
- explore the analog computing process
- gain knowledge on digital logic operations
- attain knowledge in neural networks
- explain concept related to advanced memory techniques

PHDY 109 DENSITY FUNCTIONAL THEORY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand the Density Functional Theory in Functional and derivatives
- To solve the Many body problems using DFT.
- To understand the Local & semi Local Approximations.
- To solve Kohn-Sham equation
- To understand the applications of DFT

MODULE I INTRODUCTION TO MANY ELECTRON PROBLEMS 9

Hartree Fock (HF) theory- Configuration Interaction (CI) - Practical difficulties in solving many electron problems - The Thomas Fermi model: precursor to modern DFT - Functional and functional derivatives, Euler Lagrange equation - Hohenberg KohnTheorem - N and v represent ability of densities, and non uniqueness of potentials.

MODULE II KOHN SHAM (KS) EQUATION 9

Effective exact single particle method to the many body problems - Exchange and correlation energies - Interpretation of KS Eigen values: Koopman's theorem, Ionization energy, Fermi surface, band gap KS equation for spin polarized systems.

MODULE III APPROXIMATION TO FUNCTIONALS 9

Local approximation: local density approximation (LDA) – Semi local approximation: generalized gradient approximation (GGA) –Hubbard Model- applying GGA+U methods- Non local approximation: hybrid functional - Self interaction correction.

MODULE IV DENSITY FUNCTIONAL THEORIES 9

Introduction - Green's Function and Self-energy Operator - any-Body Perturbation Theory and the *GW* Approximation - Pathologies of the Kohn–Sham xc Functional - The Band Gap Problem - Widely Separated Open Shell Atoms - The Exchange-Correlation Electric Field - Total Energies from Many-Body Theory – Applications - Generalised KS Schemes and Self-energy Models

MODULE V PRACTICAL IMPLEMENTATION OF DFT METHODS 9

General scheme for solving Kohn Sham equation - Full potential and pseudo potential methods - Basis functions: Gaussian, LAPW, Numerical – Application of DFT methods for molecules and solids- vibrational frequencies, enthalpy, and Gibbs free energy of molecules.

Total Hours: 45

REFERENCES:

1. DensityFunctional Theory of Atoms and Molecules by Robert G. Parr and Yang Weitao, Publisher: Oxford University Press (1994).
2. Density Functional Theory: An Advanced Course by Eberhard Engel and Reiner M. Dreizle, Publisher: Springer, 2011 edition.
3. Electronic Structure: Basic Theory and Practical Methods by Richard M.Martin, Publisher: Cambridge University Press; 1 edition (2008).
4. Density Functional Theory: A Practical Introduction by David Sholl and Janice A Stecke, Publisher: WileyInterscience; 1 edition (2009)

OUTCOMES:

At the end of the course, the students will be able to

- Identify the difference between Hartree and Hartree Fock theorems.
- explain the basic concepts in many body problems.
- understand the basics of Kohn-Sham equations.
- interpret the various exchange-correlation schemes.
- apply theorems relating to the DFT to real problems.

PHDY201 ELECTRO-OPTIC MATERIALS AND DEVICES **L T P C**
3 0 0 3

OBJECTIVE:

- To make the students to understand the various electro optic materials and devices.
- To study the optical activity of crystals
- To understand the electro optic effect and its types
- To understand the acousto optic and elasto optic effect
- To study the application of non-linear optical materials

MODULE I PHYSICS OF LASER 9

Laser beam characteristics, Spontaneous and stimulated emission - Population inversion - Threshold condition - Gain profile – super-radiance Laser - Rate equation for 3 level and 4 level systems - conditions for CW and pulsed laser action. Methods of detection and measurement of ultrashort pulses.

MODULE II OPTICAL ACTIVITY OF CRYSTALS 9

Anisotropic media - index ellipsoid, propagation in uniaxial crystals, Birefringence, wave plates and compensators, optical activity.

MODULE III ELECTRO-OPTIC EFFECT 9

E-O effect in KDP E-O retardation, E-O modulation - longitudinal and transverse E-O effect in cubic crystals, E-O Q- switching (Experimental) Beam deflectors.

MODULE IV ACOUSTO-OPTIC AND ELASTO-OPTIC EFFECTS 9

Materials and devices based on these effects – modulators - SHG, mode locking and frequency mixing - materials and devices.

MODULE V NON LINEAR OPTICAL MATERIALS AND DEVICES 9

Origin of optical nonlinearities – second and third order optical non-linearities-Optical switching devices employing optical non-linearities - Photorefractive effect - Two beam coupling in Photorefractive materials – Four wave mixing in Photorefractive materials.

Total Hours: 45

REFERENCES:

1. Munn R W and Ironsid C N, "Non - Linear Optical Materials", Blackie Academic & Professional, Glassgow, 1993.
2. Kochner W, "Solid State Laser Engineering", Springer-Verlag, New York, 1976.
3. Yariv A, "Quantum Electronics", John Wiley & Sons, 1975.

4. Ivan P Kaminov, " Introduction to Electro-Optic Devices", Academic press, New York, 1974.

OUTCOMES:

At the end of the course the students will be able to explain

- theory of lasers
- optical activity of crystals
- electrooptic effect and Acoustooptic effect
- electro optics and Acousto-Optics devices.
- non linear optical materials and devices

M.Sc. Physics

PHDY202 FERROELECTRIC MATERIALS AND DEVICES

L	T	P	C
2	0	2	3

OBJECTIVES:

- To enable the students understand the principles behind ferroelectric materials.
- To make the students understand materials, devices and applications.
- To understand the concept of dielectric materials
- To get knowledge on application of ferroelectric materials towards fabrication of piezoelectric devices

MODULE I INTRODUCTION 8

Maxwell equations – Polarization – Macroscopic electric field – Local electric field at an atom – Dielectric constant and polarizability – Structural phase transitions – Displacive transitions – Soft optical phonons – Landau theory of the phase transition – Second order transition – First order transition – Antiferroelectricity – Ferroelectric domains – Optical ceramics.

MODULE II THEORY OF FERROELECTRICS 8

Ferroelectricity, piezoelectricity and pyroelectricity – definitions – classification of ferroelectrics – oxygen octahedral and order – disorder ferroelectronics. Characteristics of typical ferroelectrics, barium titanate, potassium dihydrogen phosphate and triglycine sulphate – applications of ferroelectrics. Theories of ferroelectrics – dipole theory of ferroelectrics– first order and second order transitions – ferroelectric domains.

MODULE III HIGH PERMITTIVITY DIELECTRICS 7

Ceramic capacitors. Chip capacitors. Hybrid substrate– High permittivity – Diffuse phase transition – Dielectric relaxation -IK dielectric materials. Ferroelectric memory devices: DRAM – Ferroelectric DRAM Pyroelectric devices: Pyroelectric materials – pyroelectric effect – responsivity – figures of merit. Temperature / infrared light sensors.

MODULE IV PIEZOELECTRIC DEVICES 7

Piezoelectric materials and properties – Figures of Merit. – Single crystal – polycrystalline materials - relaxer ferroelectrics polymers – composites thin films. Pressure sensors, accelerometers, gyroscopes. Piezoelectric vibrators – ultrasonic transducers – Resonators/filters. Piezoelectric transformers, Piezoelectric actuators.

Total Hours:T-30, L-15 hrs

LIST OF EXPERMENTS

1. Determination of transition temperature of a ferroelectric material by hysteresis.
2. Determination of dielectric constant of ferroelectric material..
3. Modelling of Crystal structure of a ferroelectric material using DFT.
4. Determination of Band structure and Density of States of ferroelectric material
5. Determination of Curie constant of a ferroelectric material.

REFERENCES:

1. Kenji Uchino, “Ferroelectric Devices”, Marcel Dekker, INC, 2000.
2. Gerhard R, "Electrets", Vol 2, Laplacian Press, 2000.
3. Moulson A L and Herberh J M, "Electroceramics – Materials properties and Applications", Chapman & Hall, 2000.
4. Lines M E and Glass A M, "Principles and Applications of Ferroelectrics and Related Materials", Clarendon Press, 1977.
5. Jack C Burfoot, "Ferroelectrics – Introduction to the Physical Principles", D Van Nostrand Co., 1967.

OUTCOMES:

At the end of the course the students will be able to understand

- the principles of ferroelectric materials.
- Basic theory behind the concept of ferroelectricity
- the concept of dielectric materials and its application
- ferroelectric materials, devices and applications

PHDY203 STRUCTURE AND PROPERTIES OF ALLOYS **L T P C**
3 0 0 3

OBJECTIVES:

- To enable the students understand importance of phase diagrams and their relationship with properties of alloys
- To make the students understand the basic structure and property relationship of the alloy
- To make students to learn the application of the alloys with respect to their phase diagram and properties
- To study the characteristics of copper-zinc alloy
- To study the characteristics of iron –carbon alloy

MODULE I SOLID SOLUTIONS 9

Concept of solid solution - Solid solutions of Copper and Iron - Cu-Ni phase diagram - cast cupro nickel microstructures - Properties of annealed copper solid solution alloys - Soft magnetic alloys - Stainless steels.

MODULE II EUTECTIC ALLOYS 9

Pb-Sb phase diagram and microstructure - Pb-Sn phase diagram - Cu:O system - Ternary Pb-Sn-Sb phase diagram - Characteristic properties of eutectic system alloys - Applications of Pb-Sn and Pb-Sn-Sb alloys.

MODULE III CAST AND WROUGHT ALLOYS 9

Al-Si phase diagram - Al-Cu phase diagram -coherency theory of age hardneing - Microstructures – Cast aluminium alloy -properties-residual stresses and relaxation.

MODULE IV TWO PHASE ALLOYS 9

Cu-Zn phase diagram – Cu-Zn alloy structure - Cu-Sn and Cu-Al alloy systems and their microstructures - Properties of brasses, tin brasses and aluminium bronzes.

MODULE V IRON-CARBON ALLOYS 9

Fe-Fe3C phase diagram - Solubility of carbon in austenite and ferrite-terminology-Equilibrium and non equilibrium - Microstructures-properties of normalized steels - Grain size of steels - Engineering applications of low carbon steels and low alloy high strength steels.

Total Hours: 45

REFERENCES:

1. Structure and Properties of Alloys, R.M.Brick and Arthur Philips, MCGraw Hill Book Co. inc, New york, 1985.
2. Solid State Physics - Structure and properties of materials, M.A.Wahab, Narosa publishing house, New Delhi, 2015
3. Heat Treatment - Principle and Techniques, T.V.Rajan, C.P.Sharma and Ashok Sharma, Prentice Hall of India pvt. Ltd., New Delhi, 1995.
4. Materials Science and Processes, M.K.Muralidhara, Dhanpat Rai publishing company, New Delhi, 1998.
5. Charlie Brooks, R,Heat Treatment, Structure and properties of non ferrous alloys, American Society for Metals, U.S.A, 1984.
6. William F Smith, "Structure and Properties of Engineering Alloys", McGraw – Hill, 2nd Edition,1993
7. William D. Callister, David G. Rethwisch,"Materials Science and Engineering : AN Introduction" Wiley Publishing, 9th Edition, 2013.

OUTCOMES:

At the end of the course the students will be able to explain

- importance of phase diagrams and their relationship with properties of alloys
- basic structure and property relationship of the alloys
- applications of phase diagram and their importance
- the application and characteristics of Cu-Zn alloy
- the characteristics of iron-carbon alloy

M.Sc. Physics

PHDY204 **PHOTONIC MATERIALS AND DEVICES** **L T P C**
3 0 0 3

OBJECTIVE:

- To impart knowledge on photonic devices by going over the fundamentals of semiconductor physics and optical processes in semiconductors.
- To study about various optical process in semiconductors
- To explore device fabrication techniques using semiconductor materials
- To gain knowledge on characteristics of photonic devices
- To gain knowledge on photonic devices instruments

MODULE I SEMICONDUCTING MATERIALS 7

Band gaps - density of states – materials - optical and electronic properties - carrier generation and recombination - mobility and diffusion - low dimensional structures - quantum wells - wires and dots - heterostructures.

MODULE II OPTICAL PROCESSES IN SEMICONDUCTORS 10

Electron-Hole formation and recombination – absorption in semiconductors – effect of electric field on absorption – absorption in quantum wells and the quantum-confined Stark effect – Kramer-Kroning relations – radiation in semiconductors – deep level transitions – auger recombination – Luminescence from quantum wells – measurement of absorption and luminescence spectra – time resolved photoluminescence.

MODULE III SEMICONDUCTOR DEVICE FABRICATION 10

Types of photonic materials –III-V compound-II-VI compounds-Wafer preparation- interface quality- interdiffusion and doping. Quantum wells and bandgap engineering (examples of structures).Post-growth processing-Photolithography-different methodologies – patterning - fabrication of semiconductor devices.

MODULE IV PHOTONIC DEVICES 10

Photodiodes: current-voltage equation – operation-spectral response of Ge and Si – quantum efficiency – response time – diffusion time – drift – capacitance of diodes, measurement - device configuration and efficiency – device performance.

MODULE V INSTRUMENTATION OF PHOTONIC MATERIALS 8

Measurements using lenses, monochromators, spectrometers, grating, mirrors, lock-in amplifiers – characterization of photodiodes, LEDs and laser diodes – modulation of lasers – rate equations.

Total Hours: 45

REFERENCES:

1. P. Bhattacharya, “Semiconductor optoelectronic devices”, Prentice-Hall India, New Delhi, 2003.
2. B.E.A. Saleh and M.C. Teich., “Fundamentals of photonics”, John Wiley., New York, 1991.
3. J. Singh, “Optoelectronics: An introduction to materials and devices”, Mc-Graw-Hill Co., New York, 1996.
4. S.O. Kasap, “Optoelectronics and photonics: Principles and practices”,Prentice-Hall, New York, 2001.
5. T.P. Pearsall, “Photonics essentials: An introduction to experiments”, Mc-Graw-Hill Professional, New York, 2002.
6. Ajoy Ghatak and K Thyagarajan, “An Introduction on Fibre Optics”, Cambridge University Press, 2012.

OUTCOMES:

At the end of the course, the students would be able to,

- Optical processes in semiconductors
- understand the properties of a photonic materials.
- understand the photonic devices and its characterization techniques.
- explore about the characteristics of photonic devices
- explain the instruments fabricated using photonic matetials

M.Sc. .Physics

PHDY205 NUMERICAL METHODS AND PROGRAMMING **L T P C**
3 0 0 3

OBJECTIVES:

- To understand the basic errors occurring in numerical methods.
- To have an idea about Algebraic and Transcendental Equations.
- To know about the interpolation concepts.
- To familiarize the numerical differentiation and integration equations.
- To learn about the C programming and its applications in the research areas.

MODULE I ERRORS AND THE MEASUREMENTS **9**

Errors and their computations – General formula for errors – Errors of observation and measurement – Round of errors and Computer Arithmetic – Empirical formula – Graphical method – method of averages – Least square fitting – curve fitting – parabola, exponential – Algorithms and convergence.

MODULE II NUMERICAL SOLUTION OF ALGEBRAIC AND TRANSCENDENTAL EQUATIONS **9**

The iteration method – the bisection method – the method of false position – Newton – Raphson method.SimultaneousLinear algebraic equations: Direct methods – Gauss elimination method – Gauss – Jordan method – Iterative method – Jacobi's method – Gauss Seidel iterative method.

MODULE III INTERPOLATION **9**

Finite differences – Interpolation – Gregory – Newton forward interpolation of Newton's formula – Backward differences – Newton's Backward interpolation formula – central differences – Gauss's forward and backward formula – Stirling's formula – Divided differences – Newton's divided difference formula
– Lagrange's interpolation formula.

MODULE IV NUMERICAL DIFFERENTIATION AND INTEGRATION **9**

Introduction – Numerical differentiation – Errors in numerical differentiation – The cubic spline method – Maximum and Minimum values of a tabulated function – Numerical integration – Trapezoidal rule – Simpson's rule – Extended Simpson's rule – Use of cubic splines – Romberg integration – Newton – Cotes Integration formulae – Euler – Maclaurin formula – Adaptive quadrature method – Gaussian integration.

MODULE V PROGRAMMING WITH C **9**

Introduction to C programming-program control-logical compares-functions, variables and prototypes-C preprocessor- strings, arrays-pointers- standard input & output-structures, Unions-bitwise operators.

Total Hours: 45

REFERENCES:

1. Sastry, S.S., Introduction of Numerical Analysis, Fifth Edition, Prentice Hall of India, New Delhi, 2012.
2. Gerald C.F., Wheatley P.O., Applied Numerical Analysis, Seventh Edition, Addison – Wesley, Singapore, 2003.
3. Kandasamy, P., Thilakavthy, K and Gunavathy K., Numerical Methods, S.Chand and Co., New Delhi, 2006.
4. Grewal B.S., Grewal J.S., Numerical Methods in Engineering and Science, Khanna Publishers, New Delhi, 2015.
5. Balagurusamy. E, Programming in Ansi C, 7^{th} Edition, Tata McGraw Hill, 2017.

OUTCOME:

At the end of the course, the students will be able to,

- Indentify the errors occurring in the numerical methods.
- Numerically solve the algebraic and transcendental equations.
- Understand the interpolation concepts.
- Numerically solve the differentiation and integration equations.
- Wright the numerical programme using C.

PHDY206 ULTRASONIC AND NON-DESTRUCTIVE TESTING **L T P C**
3 0 0 3

OBJECTIVES:

- To introduce students with the recent advances in the field of ultrasonics
- To equip them with the knowledge of different inspection methods.
- To introduce the other NDT techniques like LPI to equip the students to understand the evaluation method
- To understand the theory of wave guides and applications
- To study the detection mechanism of ultrasonic sounds

MODULE I FUNDAMENTALS OF ULTRASONIC WAVES 9

Nature of sound waves, wave propagation in metals– modes of sound wave generation – longitudinal waves, transverse waves, surface waves, lamb waves –Velocity, frequency and wavelength of ultrasonic waves – Ultrasonic pressure, intensity and impedance – Attenuation of ultrasonic waves – reflection, refraction and mode convection – Snell's law and critical angles – Fresnel and Fraunhofer effects – ultrasonic beam split – wave propagation in other engineering materials

MODULE II ULTRASONIC INSPECTION METHODS AND EQUIPMENT 9

Principle of pulse echo method, through transmission method, resonance method – Advantages, limitations – contact testing, immersion testing, couplants – Data presentation A, B and C scan displays, comparison of contact and immersion method. Pulse Echo instrumentation, controls and circuits, pulse generation, signal detection, display and recording methods, gates, alarms and attenuators, detectability of defects

MODULE III ULTRASONIC GUIDED WAVES 9

Types of guided waves – Generation of guided waves – Plate theory – Rayleigh-Lamb Equation, Guided waves in Plates, Pipes and rods – Wave structure analysis – Dispersion curves –Modes in guided waves – Air coupled ultrasonic guided waves – advantages and limitations – Applications, few case studies. Electro Magnetic Acoustic Transducer (EMAT)-Basic principles – types of coil and design – Generation and defect detection of guided waves using EMATS- - advantages and limitations – Applications- case studies

MODULE IV OPTICAL METHODS IN ULTRASONICS 9

Laser Ultrasonics – Laser fundamentals – types of lasers – bulk wave and lamb wave generation mechanisms – optical detection of ultrasound – measurement of in plane displacement and velocity – holographic NDT – recording and reconstruction of a hologram – Two wave mixing interferometry – Laser shearography – Applications (Laser ultrasonics for flaw detection and material characterization) – Case studies.

MODULE V LIQUID PENETRANT TESTING 9

Principles – types and properties of liquid penetrants – developers – advantages and limitations of various methods - Preparation of test materials – Application of penetrants to parts, removal of excess penetrants, post cleaning – Control and measurement of penetrant process variables – selection of penetrant method – solvent removable, water washable, post emulsifiable – Units and lighting for penetrant testing – Interpretation and evaluation of test results - dye penetrant process, applicable codes and standards.

Total Hours: 45

Reference Books:

1. J. Krautkramer and H. Krautkramer, Ultrasonic Testing of Materials, Springer, 4 th edition (1990).
2. B. Raj, C.V. Subramanian and T. Jayakumar, Non Destructive Testing of Welds, Woodhead Publishing, 1st edition (2000).
3. L. Schmerr and J. Song, Fundamentals of Ultrasonic Nondestructive Evaluation, Springer, 1998.
4. P. J. Shull, Nondestructive Evaluation: Theory, Techniques, and Applications, CRC Press, 1st edition (2002).
5. C.V.Subramanian, Practical Ultrasonics, Alpha Science International, (2006).
6. A.S. Birks and R.E. Green, Ultrasonic Testing, Nondestructive Handbook, Vol. 7, American Society for Nondestructive Testing, 2nd edition (1991).

OUTCOMES:

After successful completion of this course the student will be able to

- have a basic knowledge of ultrasonic
- learn testing and NDT methods to enable them to perform inspection of samples.
- Understand applications of ultrasonic guided waves in instrumentation.
- differentiate various defect types and select the appropriate NDT methods for the specimen.
- Understand different processes involved in the LPT.

PHDY207	OPTO ELECTRONIC DEVICES	L	T	P	C
		2	0	0	3

OBJECTIVES:

- To make the students learn about the fundamentals of Photo-luminous- semiconductors, Optoelectronic devices, Optical modulators/detectors
- To make them understand the technology behind latest Display devices like LCD, Plasma and LED Panels.
- To make students understand the various types of optical modulators and detectors
- To get knowledge on photonic devices such as solar cells and photoconductors

MODULE I INTRODUCTION TO OPTOELECTRONIC MATERIALS 8

Energy bands in solids, Electrical conductivity, Semiconductors, carrier concentrations, Work function, Excess carrier in semiconductors, Junctions, , Metal-semiconductor junctions - semiconductor junctions: energy-band relation, surface states and depletion layer, Schottky-effect current transport process – thermo ionic emission, tunneling, device structures.

MODULE II OPTOELECTRONIC DEVICES **7**

Light-Emitting Diodes, Semiconductor Lasers, Optical processes in semiconductor lasers - power and efficiency - double hetero LED - LED structure - LED characteristics - White LED – Applications.

MODULE III OPTICAL MODULATORS & DETECTORS 8

Modulation of light – birefringence - electro optic effect - EO materials - Kerr modulators - scanning and switching - self electro optic devices - MO devices, AO devices - AO modulators-Photo detectors - thermal detectors – photoconductors – detectors - photon devices - PMT- photodiodes - photo transistors - noise characteristics - PIN diode- APD characteristics - APD design of detector arrays – CCD

MODULE IV PHOTONIC DEVICES 7

Photoconductors – Solar cells – basic principles, spectral response, efficiency, materials and cascaded solar cells, thin film solar cells, manufacturing and design characteristics.

LIST OF EXPERMENTS

1. Characteristics of LEDs
2. Characteristics of LASER diode
3. Characteristics of Photodiodes
4. Characteristics of Solar cells
5. Determination of electro-optic coefficient using KERR modulator.

Characteristics of Diodes

Total Hours – T-30, L-15

TEXT BOOKS:

REFERENCES:

1. Wilson & J.F.B. Hawkes, "Optoelectronics – An Introduction", Prentice Hall, India, 1998.
2. Bhattacharya, "Semiconductor optoelectronic devices", Second Edn Pearson Education, Singapore, 2002.
3. J. M. Senior, "Optical fiber communication", Prentice-Hall India, 2009.
4. J. Gowar, "Optical fiber communication systems", Prentice–Hall, 1995.
5. J .Palais, "Introduction to optical electronics", Prentice–Hall, 1988.
6. Jasprit Singh, "Semiconductor optoelectronics", McGraw–Hill, Inc, 1995.R. P.
7. Khare, "Fiber optics and Optoelectronics", Oxford University Press, 2004.

OUTCOME:

On completion of this course the student will explore

- The fundamental concept and theory on semiconductor devices
- The concepts of light emitting diodes (LEDs) and Laser drive circuits.
- The modulation of light, birefringence, MO devices, the working of optical detectors and various optical devices.
- The working mechanism of solar cells, efficiency calculation and large scale solar cells manufacturing technology

PHDY208 **BIOPHOTONICS** **L T P C**
3 0 0 3

OBJECTIVES:

- To know the role of light and its interaction in the cells and tissues.
- To understand the different imaging techniques for the biological systems.
- To know the concepts of spectroscopy in biological applications.
- To understand the optical force spectroscopy.
- To understand the role of Biophotonic materials in applications.

MODULE I INTERACTION OF LIGHT WITH BIOLOGICAL SYSTEMS 9

Interaction of light with cells, tissues, nonlinear optical processes with intense laser beams, photo-induced effects in biological systems.

MODULE II IMAGING TECHNIQUES 9

Imaging techniques: Light microscopy, wide-field, laser scanning - confocal, multiphoton, fluorescence lifetime imaging, FRET imaging - Frequency-Domain lifetime imaging. Cellular Imaging - Imaging of soft and hard tissues and other biological structures.

MODULE III SINGLE MOLECULE SPECTROSCOPY 9

Single molecule spectroscopy: UV-VIS spectroscopy of biological systems, single molecule spectra and characteristics – IR and Raman spectroscopy and Surface Enhanced Raman Spectroscopy for single molecule applications.

MODULE IV OPTICAL FORCE SPECTROSCOPY 9

Optical Force Spectroscopy: Generation optical forces – Optical trapping and manipulation of single molecules and cells in optical confinement - Laser trapping and dissection for biological systems - single molecule biophysics, DNA protein interactions.

MODULE V BIOSENSORS 9

Biosensors, Principles- DNA based biosensors – Protein based biosensors – materials for biosensor applications- fabrication of biosensors.

Total Hours: 45

REFERENCES:

1. Prasad. P.N., Introduction to Biophotonics, John Wiley & Sons, 2003
2. Michael P. Sheetz, Laser Tweezers in Cell Biology (Methods in Cell Biology), Vol.55, Academic Press Publishers, 1997.
3. Ranier .W, Nanoelectronics and Information Technology, Wiley Publishers, 2012.
4. Drexler. K.E., Nanosystems: Molecular Machinery, Manufacturing, and Computation, Wiley Publishers, 1992.

OUTCOMES:

At the end of the course, the students will be able to illustrate

- The application of light interaction with biological systems.
- different imaging techniques.
- The various spectroscopic techniques used in biological system.
- The usage of the optical force spectroscopy.
- the importance of use of spectroscopy in design of biophotonic devices.

M.Sc. Physics		**SEMESTER-III**	
PHDY111	**MATHEMA**	**MATHEMATICAL METHODS FOR NONLINEAR SCIENCE**	**L T P C** **3 0 0 3**

OBJECTIVES:

- To understand the basic concepts of different mathematical methods useful for nonlinear sciences.
- To provide the basics of nonlinear ordinary and partial differential equations
- To study discrete Fourier transform method to solve nonlinear systems
- To have a comprehensive idea on KdV and NLS soliton equations.
- To understand the Inverse scattering, Backlund transformations and Hirota's method to solve the integrable systems.

MODULE I FOURIER ANALYSIS AND OPTICS 8

Fourier series – Harmonic analysis – Fourier Transform and applications – Convolution Theorem – Sampling Theorem and applications – Fourier Optics – Holographic filters.

MODULE II DISCRETE FOURIER TRANSFORM 7

Discrete time signals – Discrete Fourier Transform – Butterfly algorithm – Fast Fourier Transform.

MODULE III DIFFERENTIAL EQUATIONS 10

Ordinary differential equations (ODEs) – Partial differential equations (PDEs) – Nonlinear ordinary differential equations – Nonlinear partial differential equations.

MODULE IV SOLITON EQUATIONS 10

Korteweg de Vries (K-dV) type equations – modified K-dV equation (MK-dV) – sine-Gordon m-Nonlinear Schrodinger type equations – Burger's equations.

MODULE V COHERENT STRUCTURES 10

Solitons – Generating soliton equations (AKNS method) – Inverse scattering method – Backlund transformation – Hirota bilinearization method – Painleve Analysis – Lax pair.

Total Hours: 45

REFERENCES:

1. L.A.Pipes, Applied mathematics for Engineers and Physicists, McGraw Hill book Co., 1980.
2. A.V.Oppenheim and R.W.Schafer, Digital Signal Processing, Printice Hall of India, 1995.
3. M.J.Ablowitz and H.Segur, Solitons and Inverse scattering Transform, Philadelphia, 1981.
4. J.M.T. Thomson and H.B.Stewart, Nonlinear Dynamics and Chaos, John Wiley and Sons, 1986.
5. M.Lakshmanan and S.Rajasekar, Nonlinear dynamics: Integrability, Chaos and Spatio-temporal patterns, Springer-Verlag, 2003.
6. Steven H.Strogatz, Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering (Studies in Nonlinearity) 2nd Edition, 2015.

OUTCOMES:

At the end of the course, the students will be able to

- use different mathematical methods to study problems in nonlinear sciences.
- Use discrete Fourier transform method to solve nonlinear systems
- apply various methods to solve ordinary differential equations and partial differential equations
- understand the concepts and applications of solitons.
- Solve the integrable systems and study about solitons.

PHDY112 MEASUREMENT AND INSTRUMENTATION L T P C
3 0 0 3

OBJECTIVES:

- To enable the students understand the importance of measurements.
- To make the students understand the principle behind the transducers
- To understand different types of bridges and recorders used in instrumentation techniques.
- To understand different types of electronic devices used in instrumentation techniques.
- To learn about the different advanced measuring instruments.

MODULE I PHYSICAL MEASUREMENT 7

Measurement – result of a measurement – uncertainty and experimental error– systematic error – random error – repeated measurements – data distribution functions; mathematical description, derivation and properties – propagation error – analysis of data – multi parameter experiments.

MODULE II TRANSDUCERS 10

Classification of Transducers - Principle, construction and working of Thermistor - LVDT, Electrical strain gauges and capacitive transducers, Photoelectric transducer, Piezoelectric transducer - Measurement of non-electrical quantities - Strain, Displacement, temperature, Pressure, Magnetic fields, vibration, optical and particle detectors.

MODULE III BRIDGES AND RECORDERS 10

DC bridges - Wheatstone's bridge – Kelvin's bridge – double bridge –AC bridges – bridges for capacitance and inductance comparison – Wien bridge – Schering bridge – Maxwell's inductance bridge – Maxwell – Wein bridge - Hay bridge – Anderson bridge – De sauty bridge – Owen bridge - resonance bridge – types of detectors– strip chart recorders – X-Y recorders – digital data recording – recorder specifications.

MODULE IV INSTRUMENTATION ELECTRONICS 8

Op-amps – instrumentation amplifier – signal conditioning – filters – analog signal processing – high speed A/D conversion – D/A conversion – digital logic levels –digital instrumentation – frequency measurements – FFT –sampling time and analyzing – IEEE 488 interface bus – LabView (basics).

MODULE V ADVANCED MEASUREMENTS 10

Spectroscopic instrumentation –UV – Vis spectrometer IR spectroscopy – spectrometer design – refraction and diffraction — dispersive elements – lasers – fiber optics – X-ray fluorescence: line spectra and fine structure – absorption and emission processes – X-ray production – X-ray crystallography –neutron diffraction – TEM – SEM – atomic force and tunneling scanning microscope.

Total Hours: 45

REFERENCES:

1. M. Sayer and A. Mansingh, "Measurement, instrumentation and experiment design in physics and engineering", Prentice-Hall India Pvt. Ltd., New Delhi,2000.
2. H.S. Kalsi, 'Electronic instrumentation', (2nd Edition), Tata McGraw Hill Publication Co.Ltd., New Delhi, 2004.
3. R.F. Coughlin and F.F. Driscoll, "Operational amplifiers and linear integrated circuits", Pearson Education, New Delhi, 2001.
4. E.O. Doebelin, "Measurement systems: Applications and design", McGraw-Hill, New York, 2002.
5. Rangan Sharma and Mani, "Instrumentation devices and systems", Tata McGraw-Hill, New Delhi, 2000.

OUTCOMES:

At the end of the course, the students will be able to,

- acquire the knowledge about the different errors and principle behind the instrumentation for measurement.
- Identify the various transducers involved in measurement.
- gain knowledge about bridges and recorders used in instrumentation techniques.
- Apply the knowledge gained in electronic devices for instrumentation techniques.
- Identify the different advanced measuring instruments for practical applications.

PHDY113 **BIOMEDICAL INSTRUMENTATION** **L T P C**
3 0 0 3

OBJECTIVES:

- To understand the human physiological systems.
- To know the different aspects of biosignal acquisition.
- To understand the basics in biopotential recorders.
- To know the importance methods, instruments available for biomedical field.
- To analyze the special biomedical instrumentation systems.

MODULE I HUMAN PHYSIOLOGICAL SYSTEMS 9

Cells and their structure – Nature of Cancer cells – Transport of ions through the cell membrane – Resting and action potentials – Bio-electric potentials – Nerve tissues and organs – Different systems of human body. Biopotential Electrodes and Transducers Design of Medical instruments – components of the biomedical instrument system – Electrodes – Transducers.

MODULE II BIOSIGNAL ACQUISITION 9

Physiological signal amplifiers – Isolation amplifiers – Medical preamplifier design – Bridge amplifiers – Line driving amplifier – Current amplifier – Chopper amplifier – Biosignal analysis – Signal recovery and data acquisition – Drift Compensation in operational amplifier – Pattern recognition – Physiological Assist Devices. Pacemakers – Pacemakers batteries – Artificial heart valves – Defibrillators – nerve and muscle stimulators Heart – Lung machine – Kidney machine.

MODULE III BIOPOTENTIAL RECORDERS 9

Characteristics of the recording system – Electrocardiography (ECG) – Electroencephalography (EEG) – Electromyography (EMG) – Electroethinogrphy (ERG) and Electroculography (EOG) – Recorders with high accuracy – recorders for OFF line analysis.

MODULE IV OPERATION THEATRE EQUIPMENT 9

Surgical diathermy- shortwave diathermy – Microwave diathermy – Ultrasonic disathermy – Therapeutic effect of heat – Range and area of irritation of different techniques – Ventilators – Anesthesia machine – Blood flowmeter – Cardiac Output measurements – Pulmonary function analyzers – Gas analyzers – Blood gas analyzers – Oximeters – Elements of intensive care monitoring.

MODULE V SPECIALISED MEDICAL EQUIPMENTS 9

Blood Cell counter – Electron microscope – Radiation detectors – Photometers and colorimeters – digital thermometer – audiometers – X-rays tube – X-ray machine – image intensifiers – Angiography – Application of X-ray examination. Safety instrumentation: Radiation safety instrumentation – Physiological effects due to 50Hz current passage – Microshock and macroshock – electrical accident Hospitals – Devices to protect against electrical hazards – Hospitals architecture.

Total Hours: 45

REFERENCES:

1. Arumugam M., Biomedical Instrumentaion, Anurada Agencies Publishers, 1992.
2. Khandpur R.S., Handbook of Biomedical Instrumentation, Third Edition, Tata McGraw-Hill Education, 2014.
3. Shakti Chatterjee and Aubert Miller, Biomedical Instrumentation Systems, Cengage Learning Publisher, 2010.
4. Gromwell L., Fred J. Weibell, Erich A. Pfeiffer, Biomedical Instrumentation and Measurements, Second Edition, Prentice Hall, 1980.
5.

OUTCOMES:

At the end of the course, the students will be able to understand

- the human physiological systems.
- the different aspects of biosignal acquisition.
- different biopotential recorders.
- biomedical instruments involved in medicine field.
- the various methods available in the use of new modern techniques in biomedicine.

PHDY114 **RADIATION PHYSICS** **L T P C**
3 0 0 3

OBJECTIVES:

- To understand the theory of electromagnetic radiation.
- To know the difference between natural and artificial radioactivity
- To understand the effect of radiation factors.
- To study the interaction of radiation with matter and its effects.
- To understand the interaction of charged particles with matter.

MODULE I ELECTROMAGNETIC RADIATION 9

Wave model – Quantum Model– visible light and fluorescence particulate radiation – inverse square law.

MODULE II NATURAL AND ARTIFICIAL RADIOACTIVITY 9

Radioactivity – General properties of alpha, beta and gamma rays – Laws Of radioactive disintegration – Radioactive decay constant – Half-life period – average life – Isotopes, Isobars, Isomers – Isotones and Isodiapheres – Natural radioactive series – Radioactive equilibrium –Radioactive decay - a particle decay – ß particle decay – Theory of beta decay – Gamma emission – Electron capture – Internal conversion – Nuclear isomerism – Artificial radioactivity - Nuclear reactions –a, p reaction - a, n reaction- Proton bombardment – deuteron bombardment- neutron bombardment – photo disintegration – Activation of nuclides - Elementary ideas of fission, fusion and nuclear reactors.

MODULE III RADIATION FACTORS 9

Quantities to describe a radiation beam - particle flux and fluence- Photon flux and fluence- cross section- linear and mass absorption coefficient- stopping power and LET Activity – Curie – Becquerel. Exposure and its measurements
– Roentgen, Radiation absorbed Dose- Gray - kerma- kerma rate constant - Electronic equilibrium - relationship between kerma, exposure and absorbed dose – Relative biological effectiveness (RBE)- radiation weighting factors.

MODULE IV INTERACTION OF RADIATION WITH MATTER 9

Interaction of electromagnetic radiation with matter: Ionization – Photon beam exponential attenuation – Rayleigh scattering – Photoelectric effect – Compton effect - energy absorption – Pair production – Attenuation, energy transfer and mass energy absorption coefficients – Relative importance of various types of interactions.

MODULE V INTERACTION OF CHARGED PARTICLES WITH MATTER 9

Classical theory of inelastic collisions with atomic electrons – Energy loss per ion pair by primary and secondary ionization – Dependence of collision energy losses on the physical and chemical state of the absorber – Cerenkov radiation – Electron absorption process – scattering excitation and ionization – Radiative collision – Bremmstrahlung – Range energy relation – Continuous slowing down approximation (CSDA) – straight ahead approximation and detour factors – transmission and depth dependence methods for determination of particle penetration - empirical relations between range and energy – Back scattering.

Total Hours: 45

REFERENCES:

1. Segre E., Experimental Nuclear Physics, Vol 3, John Wiley, 1959.
2. Theraja B.L., Modern Physics, S.Chand Company, 1995.
3. Faiz M Khan , The Physics of Radiation Therapy, Lippincott Williams & Wilkins Publishers, 2010.
4. Oliver R., Radiation Physics in Radiology, Blackwell Scientific Publication, 1974.
5. Frank Herbert Attix, Introduction to Radiological Physics and Radiation Dosimetry, Wiley-VCH Publishers, 1991.

OUTCOMES:

At the end of course, students will be able to understand

- concepts of electromagnetic radiation.
- theory of artificial and natural radioactivity
- interaction of radiation with matter.
- the interaction of radiation with matter and its effects.
- the interaction of charged particles with matter.

M.Sc. Physics

PHDY115 LASER SPECTROSCOPY AND ITS APPLICATIONS

L T P C
3 0 0 3

OBJECTIVE:

- To endow the students with the knowledge of the fundamentals of spectroscopy.
- To learn the basics in high resolution spectroscopy.
- To understand the applications of laser spectroscopy in various fields.
- To learn about the photobiology and medical lasers.
- To understand the thermal and non-thermal applications of lasers.

MODULE I TIME-RESOLVED SPECTROSCOPY 10

Generation of short optical pulses - generation of ultra short optical pulses - Measurement techniques for Optical Transcients: Transient - Digitizer - Boxcar - Delayed coincidence- Streak-camera & Pump-probe techniques. Basics of lifetime measurements - Methods of measuring radiative properties - linewidth measurements - ODR and LC - Beam foil techniques - Beam laser techniques - Time resolved spectroscopy with pulsed lasers - Phase- shift method and emission method - The hook method - Quantum-Beat spectroscopy.

MODULE II HIGH RESOLUTION SPECTROSCOPY 8

Spectroscopy on collimated atomic beams: Detection through fluorescence - detection by photoionization - detection by the recoil effect - detection by magnetic deflection. Saturation spectroscopy and related techniques -Doppler-free two-photon absorption - spectroscopy of trapped ions and atoms.

MODULE III APPLICATIONS OF LASER-SPECTROSCOPY 10

Diagnostics of combustion processes: Background - Laser-inducedfluorescence and related techniques - Raman spectroscopy - coherent anti- stokes Raman scattering - Velocity measurements. Laser remote sensing of the atmosphere: Optical heterodyne detection - long path absorption techniques - LIDAR techniques. Laser-induced fluorescence and Raman spectroscopy in liquids and solids: Hydrospheric remote sensing - monitoring of surface layers. Laser-induced chemical processes: Laser-induced chemistry - laser isotope separation - spectroscopic aspects of lasers in medicine.

MODULE IV PHOTOBIOLOGY AND MEDICAL LASERS 9

Study of biological functions - Microradiation of cells - optical properties of tissues (normal and diseased state) - Experimental methods to determine the reflectance, absorption, transmittance and emission properties of tissues - Laser systems in medicine and biology - Nd: YAG, Ar ion, CO_2, Excimer, N_2, Gold Vapour laser - Beam delivery and measuring systems

MODULE V THERMAL APPLICATIONS 9

Surgical applications of lasers - Sterilization - hermostasis - Cancer Liver stomach gynecological surgeries - Performance evaluation - Lasers in Opthalmology - Dermatology and Dentistry - Cosmetic Surgery.

Total hours: 45

REFERENCES:

1. S. Svanberg, "Atomic and Molecular Spectroscopy", Springer Verlag, Germany, 1992.
2. J. R. Lakowicz, "Principles of Fluorescence Spectroscopy", Kluwer Academic/ Plenum Publishers, New York, 1999.
3. Z. Wang and H. Xia, "Molecular and Laser Spectroscopy", Springer Series in Chemical Physics, Vol.50, 1991.
4. S.S. Martellucci and A.N. Chester, "Laser Photobiology and Photomedicine", Plenum Press, New York, 1985.
5. R. Pratesi and C.A. Sacchi, "Lasers in Photomedicine and Photobiology", Springer verlag, West Germany, 1980.
6. Carruth JAS & AL Mckenzie, "Medical Lasers Science and Clinical Practice", Adam Hilger Ltd., Bristol, 1991.
7. T. Kaluylu and M. Tsukakoshi, "Laser Microradiation of cells", Harward Academic publishers, New York, 1990.

OUTCOME:

At the end of the course the student will be able to get knowledge in,

- different types spectroscopy and applications of laser spectroscopy in various fields.
- high resolution spectroscopy.
- laser tissue interaction.
- photobiology and medical lasers.
- photobiology and thermal and non-thermal applications of lasers and safety of lasers.

PHDY116	NANO PHOTONICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand basic concepts of Nano Photonics.
- To know the importance of nanophotonics materials.
- To understand concept of Plasmonics.
- To know electronics and photonic molecular materials and its applications
- To understand the application of plasmonics

MODULE I BASIC OF PHOTONICS. 9

Similarities and differences between photon and electron- Free- Space propagation. Co-operative effects and confinement of Photons and Electrons. Maxwell equation for Photonic systems. Concept of near-field phenomena in photonics crystals. Band structures of photonics crystal. Optical properties of photonics materials. Confinement in 1-D, 2-D and 3-D structure.

MODULE II NEW APPROACHES IN NANOPHOTONICS 9

Near-Field Optics- Aperture near-field optics- Apertureless near-field optics-Near-field scanning optical microscopy (NSOM or SNOM)- SNOM based detection of plasmonic energy transport- SNOM based visualization of waveguide structures- SNOM in nanolithography- SNOM based optical data storage and recovery.

MODULE III PLASMONICS 9

Internal reflection and evanescent waves- plasmons and surface plasmon resonance (SPR)- Attenuated total reflection- Grating SPR coupling- Optical waveguide SPR coupling- SPR dependencies and materials- plasmonics and nanoparticles.

MODULE IV ELECTRONIC& PHOTONIC MOLECULAR MATERIALS 9

Preparation – Electroluminescent Organic materials - Laser Diodes - Quantum well lasers: Quantum cascade lasers - Cascade surface-emitting photonic crystal laser - Quantum dot lasers - Quantum wire lasers:- White LEDs - LEDs based on nanowires - LEDs based on nanotubes - LEDs based on nanorods - High Efficiency Materials for OLEDs - Quantum well infrared photo detectors.

MODULE V ELEMENTS OF PLASMONICS AND APPLICATIONS 9

Introduction to Plasmonics, merging photonics and electronics at nanoscale dimensions, single photon transistor using surface plasmon, nanowire surface plasmons-interaction with matter, single emitter as saturable mirror, photon correlation, and integrated systems. All optical modulation by plasmonic excitation of quantum dots, Channel plasmon-polariton guiding by subwavelength metal grooves, Near-field photonics: surface plasmon polaritons and localized surface plasmons, Slow guided surface plasmons at telecom frequencies.

Total Hours: 30

REFERENCES:

1. Masuhara. H, Kawata. S and Tokunaga. F, Nano Biophotonics, Elsevier Science, 2014.
2. Saleh. B.E.A and Teich. A.C, Fundamentals of Photonics, John-Wiley & Sons, New York, 2014.
3. Ohtsu.M, Kobayashi.K, Kawazoe.T and Yatsui.T, Principles of Nanophotonics (Optics and Optoelectronics), University of Tokyo, Japan, 2013.
4. Joannopoulos.J.D, Meade. R.D and Winn. J.N, Photonic Crystals, Princeton University Press, Princeton, 2010.
5. Ranier. W, Nano Electronics and Information Technology, Wiley, 2013.

OUTCOMES:

At the end of the course, the students will be able to explain

- the concepts of nano photonics.
- the approaches and importance of Nano photonics.
- the concept of Plasmonics
- the importance applications of Nano photonics in design of devices
- the application of Plasmonics

PHDY117 NANOSCIENCE AND TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To enable students understand the general principles of nanomaterials.
- To learn the different tools for characterization.
- To get into Insight of the materials, fabrication and other experimental techniques that can be used on the nanoscale, as well as their limitations.
- To get in-depth knowledge of at least one specialisation area within the field of nanoscience and nanotechnology.
- To gain Sufficient scientific background to undertake research.

MODULE I NANOMATERIALS AND STRUCTURES 9

Nanomaterials and types: nanowires, nanotubes, fullerenes, quantum dots, nanocomposites – properties – Methods of preparation: top-down, bottom-up.

MODULE II CHARACTERIZATION TOOLS 9

Electron Microscopy Techniques – SEM, TEM, X ray methods – optical methods Fluorescence Microscopy – Atomic Force Microscopy, STM and SPM.

MODULE III NANOMAGNETISM 9

Mesoscopic magnetism – Magnetic measurements: miniature Hall detectors, integrated DC SQUID Microsusceptometry – magnetic recording technology, biological magnets.

MODULE IV NANOELECTRONICS AND INTEGRATED SYSTEMS 9

Basics of nanoelectronics – Single Electron Transistor – quantum computation – tools of micro-nanofabrication – nanolithography – quantum electronic devices – MEMS and NEMS – dynamics of NEMS – limits of integrated electronics.

MODULE V BIOMEDICAL APPLICATIONS OF NANOTECHNOLOGY 9

Biological structures and functions – drug delivery systems – organic-inorganic nanohybrids – inorganic carriers – nanofluidics.

Total Hours: 45

REFERENCES:

1. Jan Korvink and Andreas Greiner, Semiconductors for Micro and Nanotechnology – an Introduction for Engineers, Weinheim Cambridge: Wiley-VCH, 2001.
2. Murty B.S., Shankar P. & et al., Textbook of Nanoscience and Nanotechnology, Universities Press (India) Private Ltd., 2012.
3. Richard Booker and Earl Boysen, Nanotechlongy, Wiley Publishing, 2005.
4. Timp G (ed), Nanotechnology, AIP press, Springer, 1999.
5. Wilson M., Kannangara K., Smith G., Simmons M. and Raguse B., Nanotechnology: Basic Sciences and Energy Technologies, Overseas Press, 2005.

OUTCOMES:

At the end of the course, the students will be able to understand

- the basic concepts about the Nano materials.
- the importance of use of nano materials in design and synthesis of novel materials.
- the instrumentation in nanomagnetism.
- the nanoelectronics and integrated systems
- the application of nanomaterials in biomedical field.

PHDY118 THIN FILM SCIENCE AND TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To familiarize with preparation and properties of thin films.
- To understand the different kinetics of thin film nucleation.
- To understand the characterization tools for thin films.
- To study the different properties of thin films.
- To apply the knowledge of thin film technology into applications.

MODULE I PREPARATION OF THIN FILMS 9

Kinetic aspects of gases in a vacuum chamber – classifications of vacuum ranges – production of vacuum - pressure measurement in vacuum systems– thin film (epitaxy) – definition – types of epitaxy. Different Growth Techniques: Liquid phase epitaxy – vapour phase epitaxy – molecular beam epitaxy – metal organic vapour phase epitaxy – sputtering (RF & DC) – pulsed laser deposition. Thickness Measurement: Microbalance technique – photometry-ellipsometry– interferometry.

MODULE II KINETICS OF THIN FILMS 9

Nucleation Kinetics: types of nucleation – kinetic theory of nucleation – energy formation of a nucleus – critical nucleation parameters; spherical and non spherical (cap, disc and cubic shaped) Growth Kinetics: Kinetics of binary (GaAs, InP, etc.), ternary (Al1-xGaxAs, Ga1-xInxP, InAs1-xPx, etc.) and quaternary (Ga1-xInxAs1 -yPy, etc.) semiconductors – derivation of growth rate and composition expressions.

MODULE III CHARACTERIZATION 9

X-ray diffraction – photoluminescence – UV-Vis-IR spectrophotometer – Atomic Force Microscope – Scanning Electron Microscope – Hall effect – Vibrational Sample Magnetometer – Secondary Ion Mass Spectrometry – X-ray Photoemission Spectroscopy.

MODULE IV PROPERTIES OF THIN FILMS 9

Dielectric properties – experimental technique for the determination of dielectric properties – optical properties – experimental technique for the determination of optical constants – mechanical properties – experimental technique for the determination of mechanical properties of thin films – magnetic and superconducting properties.

MODULE V APPLICATIONS 9

Optoelectronic devices: LED and Solar cell – Micro Electromechanical Systems (MEMS) – Fabrication of thin film capacitor – application of ferromagnetic thin films; data storage, Giant Magnetoresistance (GMR) – sensors – fabrication and characterization of thin film transistor and FET – quantum dot - Cryptography.

Total Hours: 45

REFERENCES:

1. Goswami. A, Thin Film Fundamentals, New Age International (P) Limited, New Delhi, 1996.
2. AichaEishabini-Riad, Fred D. Barlow and ISHN, Thin film Technology Handbook, McGraw-Hill Professional Publishers, 1997.
3. Krishna Seshan, Handbook of Thin Film Deposition, William Andrew Publishers, 2012.
4. Donald Smith, Thin-Film Deposition: Principles and Practice, McGraw-Hill Professional Publishers, 1995.
5. K.L.Chopra, “Thin Film Phenomena”, Malabar: Robert E. Krieger Publishing Company, 1979.

OUTCOMES:

At the end of the course, the students will be able to understand

- the basic concepts about the thin film technology.
- The different kinetics of thin film nucleation.
- the characterization tools for thin films.
- different properties of thin films.
- the importance of use of thin films in application and research.

PHDY119 CORROSION SCIENCE AND TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To enable the students understand principles behind corrosion science.
- To expose the students to various instrumental techniques.
- To familiarize the students with methods of coating.
- To help the students to understand the corrosion in selected environments
- To make the students to understand various corrosion processes and engineering applications.

MODULE I CORROSION PROCESSES 12

Basic principles of electrochemistry and aqueous corrosion processes - Electrochemical Thermodynamics and Electrode Potential - Electrochemical Kinetics of Corrosion Cathodic and anodic behavior - Faraday's Law - Nernst equation; standard potentials Pourbaix diagram - Tafel equations, corrosion rate - Evans diagram - pitting, crevice and exfoliation corrosion; influence of deposits and anaerobic conditions; corrosion control; high temperature oxidation and hot corrosion; corrosion/mechanical property interactions.

MODULE II INSTRUMENTAL TECHNIQUES 9

X-ray diffraction, TEM, SEM and EDX, WDX analysis, surface analysis by AES, XPS and SIMS, overview of other techniques.

MODULE III COATING MANUFACTURE 9

Electrodeposition; flame and plasma spraying; thermal, HV of detonation gun, gas dynamic spray, physicalvapour deposition; chemical vapour deposition; HIP surface treatments.

MODULE IV CORROSION IN SELECTED ENVIRONMENTS 7

Atmospheric Corrosion, Corrosion in Automobiles, Corrosion in Soils, Corrosion of Steel in Concrete, Corrosion in Water, Microbiologically Induced Corrosion, Corrosion in the Body, Corrosion in the Petroleum Industry, Corrosion in the Aircraft Industry, Corrosion in the Microelectronics Industry

MODULE V COATING APPLICATIONS 8

Abrasive, erosive and sliding wear.The interaction between wear and corrosion. Coating systems for corrosion and wear protection; new coating concepts including multi-layer structures, functionally gradient materials, intermetallic barrier coatings and thermal barrier coatings.

Total Hours: 45

REFERENCES:

1. D.A. Jones, Principles and Prevention of Corrosion, 2nd Edition, Macmillan Publishing Co., 1995.
2. J.O.M. Bockris, B.E. Conway, E. Yeager and White, Electrochemical Materials Science in Comprehensive Treatise of Electrochemistry, Volume 4, Plenum press, 2001.
3. M.G. Fontanna and N.D. Greene, Corrosion Engineering, McGraw-Hill publishing, 1978
4. I.M. Hutchings, Tribology: Friction and Wear of Engineering Materials, CRC press, Boca Raton, 1992 D.O. Sprowds, Corrosion Testing and Evaluation, Corrosion Metals Hand book, vol. 13, 1986.

OUTCOMES:

At the end of the course the students will be able to understand the

- corrosion process and analytical technique.
- various instrumental techniques.
- applications of coatings.
- coating manufacture technique and corrosion environment.
- various corrosion processes and engineering applications.

PHDY120 **BIOMATERIALS** **L T P C**
3 0 0 3

OBJECTIVES:

- To enable the students understand importance of and properties of Biomaterials
- To familiarize the students with different orthopaedic materials.
- To understand different cardiovascular materials.
- To help students study about materials in opthalmology
- To make the students understand applications of various biomaterials

MODULE I BIOLOGICAL PERFORMANCE OF MATERIALS 9

Biocompatibility- Introduction to the biological environment – Material response: swelling and leaching, corrosion and dissolution, deformation and failure, friction and wear – Host response: the inflammatory process - coagulation and hemolysis- approaches to thrombo- resistant materials development.

MODULE II ORTHOPAEDIC MATERIALS 9

Bone composition and properties - temporary fixation devices - joint replacement – Biomaterials used in bone and joint replacement: metals and alloys – Stainless steel, cobalt based alloys, titanium based materials – Ceramics: carbon, alumina, zirconia, bioactive calcium phosphates, bioglass and glass ceramics – polymers: PMMA, UHMWPE/HDPE, PTFE – Bone cement – Composites.

MODULE III CARDIOVASCULAR MATERIALS 9

Blood clotting – Blood rheology – Blood vessels – The heart – Aorta and valves – Geometry of blood circulation – The lungs - Vascular implants: vascular graft, cardiac valve prostheses, cardiac pacemakers – Blood substitutes – Extracorporeal blood circulation devices.

MODULE IV DENTAL MATERIALS 9

Teeth composition and mechanical properties – Impression materials – Bases, liners and varnishes for cavities – Fillings and restoration materials – Materials for oral and maxillofacial surgery – Dental cements and dental amalgams – Dental adhesives.

MODULE V MATERIALS IN OPTHALMOLOGY 9

Biomaterials in ophthalmology – Viscoelastic solutions, contact lenses, intraocular lens materials – Tissue grafts – Skin grafts – Connective tissue grafts – Suture materials – Tissue adhesives – Drug delivery: methods and materials – Selection, performance and adhesion of polymeric encapsulants for implantable sensors-biomemtic materials-Technology from nature.

Total Hours: 45

REFERENCES:

1. Sujata V. Bhat. Biomaterials, Narosa Publication House, New Delhi, 2002.
2. Jonathn Black. Biological Performance of Materials: Fundamentals of biocompatibility, Marcel Dekker Inc, New York, 1992.
3. D.F.Williams (editor). Materials Science and Technology: A comprehensive treatment, Volume 14. Medical and Dental Materials, VCH Publishers Inc, New York, 1992.
4. F.Silver and C.Doillon. Biocompatibility: Interactions of Biological and implantable materials. Volume I Polymers, VCH Publishers Inc, New York, 1989.
5. L.L.Hench and E.C.Ethridge. Biomaterials: An Interfacial Approach, Academic Press, 1982.
6. Joon Park, R. S. Lakes, Biomaterials. An Introduction, Springer, third edition, 2010. Springer

OUTCOMES:

At the end of the course the students will be able to understand the

- importance and properties of biomaterial.
- different classes of orthopaedic materials.
- different types of cardiovascular materials.
- various types of materials used in ophthalmology.
- applications of various biomaterials.