Table PH-1

M.Sc (Physics) – 2020-2021 Batch

COURSE COMPONENTS

Table 1

S.No	Subject Code	Program core – 60 credits & a half semester project	Credits
		Name of the Subject	
1	20PH3001	Classical Mechanics	3:1:0
2	20PH3002	Statistical Mechanics and Thermodynamics	3:1:0
3	20PH3003	Mathematical Physics I	3:1:0
4	20PH3004	Semiconductor Physics	3:1:0
5	20PH3005	Quantum Mechanics I	3:1:0
6	20PH3006	Mathematical Physics II	3:1:0
7	20PH3007	Spectroscopy-I	3:1:0
8	20PH3008	Electromagnetic theory	3:1:0
9	20PH3009	Quantum Mechanics II	3:1:0
10	20PH3010	Spectroscopy-II	3:1:0
11	20PH3011	Nuclear and Particle Physics	3:1:0
12	20PH3012	Solid state physics	3:1:0
13	20PH3019	General Physics Lab I	0:0:2
14	20PH3020	General Physics Lab II	0:0:2
15	20PH3021	Advanced Physics Lab I	0:0:2
16	20PH3022	Advanced Physics Lab II	0:0:2
17	20PH3023	Computational physics Lab	0:0:2
18	20PH3024	Materials characterization Lab	0:0:2
		Total Credits	**60**
18	HSP3999	Half Semester Project	12
		Total	72

Table 2

S.No	Subject Code	Soft Core – I Min. of 12 credits to be earned from soft core I &II	Credits
		Name of the Subject	
1	17PH3024	Nanofluids	3:0:0
2	20PH3013	Physics of Nanomaterials	3:0:0
3	20PH3014	Fabrication and testing of thinfilm devices	3:0:0
4	17PH3021	Material characterization	3:0:0
5	17NT3002	Nanoelectronics	3:0:0

Table 3

S.No	Subject Code	Soft Core – II	Credits
		Name of the Subject	
1	20PH3018	Entrepreneurship and business plan	3:0:0
2	20PH3015	Solid State Batteries	3:0:0
4	17PH3030	Computational Physics lab	0:0:2
5	17PH3031	Simulations in statistical Physics Lab	0:0:2
6	17PH3032	Heat and Optics lab	0:0:2

Table 4

S.No	Subject Code	Electives-I Min. of 6 credits to be earned	Credits
		Name of the Subject	
1	20PH3017	Astronomy and Astrophysics	3:0:1
2	20PH3016	Quantum Computing in AI	3:0:0
3	17PH3022	Crystal Growth Techniques	3:0:0
4	17PH3023	Radiation Physics	3:0:0

Table 5

M.Sc Physics credit distribution:

Subjects	Credits
Core Subjects	72
Soft core	12
Elective	7
Total Credits	91

SEMESTER-I

S.No	Sub Code	Title	credits
1	20PH3001	CLASSICAL MECHANICS	3:1:0
2	20PH3002	STATISTICAL MECHANICS AND THERMODYNAMICS	3:1:0
3	20PH3003	MATHEMATICAL PHYSICS	3:1:0
4	20PH3004	SEMICONDUCTOR PHYSICS	3:1:0
5	20PH3013	PHYSICS OF NANOMATERIALS	3:0:0
6	20PH3019	GENERAL PHYSICS LAB-I	0:0:2
7	20PH3020	GENERAL PHYSICS LAB-II	0:0:2
		TOTAL	23

SEMESTER-II

S.No	Sub Code	Title	credits
1	20PH3005	QUANTUM MECHANICS-I	3:1:0
2	20PH3006	MATHEMATICAL PHYSICS-II	3:1:0
3	20PH3007	SPECTROSCOPY-I	3:1:0
4	20PH3008	ELECTROMAGNETIC THEORY	3:1:0
5	20PH3014	FABRICATION AND TESTING OF THIN FILM DEVICES	3:0:0
6	20PH3021	ADVANCED PHYSICS LAB-I	0:0:2
7	20PH3022	ADVANCED PHYSICS LAB-II	0:0:2
		TOTAL	23

SEMESTER-III

S.No	Sub Code	Title	credits
1	20PH3009	QUANTUM MECHANICS -II	3:1:0
2	20PH3010	SPECTROSCOPY-II	3:1:0
3	20PH3011	NUCLEAR AND PARTICLE PHYSICS	3:1:0
4	20PH3012	SOLID STATE PHYSICS	3:1:0
5	20PH3015	SOLID STATE BATTERIES	3:0:0
6	20PH3023	COMPUTATIONAL PHYSICS LAB	0:0:2
7	20PH3024	MATERIALS CHARACTERISATION LAB	0:0:2
			23

SEMESTER-IV

S.No	Sub Code	Title	credits
1	20PH3016	QUANTUM COMPUTING IN AI	3:0:0
2	20PH3017	ASTRONOMY AND ASTROPHYSICS	3:0:1
3	20PH3018	ENTREPERNEURSHIP AND BUSINESS PLAN	3:0:0
4	FSP3999	PROJECT	12
			22
		Total	91

20PH3001 CLASSICAL MECHANICS

Credits: 3:1:0

Course Objectives:

1. To impart knowledge on the equations of motion for complicated mechanical systems using the Lagrangian and Hamiltonian formulations.
2. To demonstrate the theoretical methods like variation principle and Hamilton Jacobi theory for elementary mechanical systems.
3. To illustrate the fundamental conservation principles for the mechanical systems with an emphasis on central force problem and rigid body motion.

Course Outcomes:

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

1. Understand the properties of Lagrangian to interpret the physical significance of linear momentum, angular momentum and energy.
2. Interpret mathematical results in physical terms using central force problem.
3. Demonstrate the kinematics of rigid body and oscillating system.
4. Apply the techniques and results of classical mechanics to real time problems
5. Appraise the motion of physical systems with Hamilton formulation and Hamilton Jacobi equation.
6. Correlate classical mechanics with the special theory of relativity.

Unit I – Lagrangian Formulation

Mechanics of a System of Particles - Constraints – Generalized co-ordinates – Lagrange's equations of motion from D'Alembert's principle - Deduction of Lagrange's equations from Hamilton's Principle - Applications of the Lagrangian formulation.

Unit II - Central Force Problem

Reduction to an equivalent one body problem – The equation of motion and first integral – Kepler Problem: Inverse square law of force and classification of orbits – The motion in time in the Kepler's problem – Scattering in a central force field.

Unit III - The Kinematics of Rigid Body Motion

The independent coordinates of a rigid body – orthogonal transformations – The Euler Angles – Symmetric top and its applications - Small Oscillations – normal mode analysis – normal modes of a linear triatomic molecule - forced oscillations – effect of dissipative forces on free and forced oscillations.

Unit IV - The Hamilton Formulation

Canonical Transformations and the Hamilton equation of motion – Cyclic coordinates – Hamiltonian-Jacobi Theory - Hamilton-Jacobi equations for principle function-Harmonic Oscillator problem as an example of the Hamilton-Jacobi method - Actions angle variables in the Systems with one degree of freedom.

Unit V - Special Theory of Relativity
Internal frames – principle and postulate of relativity – Lorentz transformations – length contraction, time dilation and the Doppler effect – velocity addition formula –relativistic invariance of physical laws.

Reference Books

1. Classical Mechanics, H. Goldstein, Narosa publishing house, Second Edition 2001
2. Classical Mechanics, S.L.Gupta, V. Kumar & H.V.Sharma,Pragati Prakashan, Meerut., 2003
3. Classical Mechanics, T. W. B. Kibble, Frank H. Berkshire, Imperial College Press, 2004
4. Classical Mechanics, J C Upadhyaya, Himalaya Publishing House, 2012
5. Introduction to Classical Mechanics, R. G. Takwale, P. S. Puranik, Tata McGraw-Hill, 2006
6. Classical Mechanics, John Robert Taylor, University Science Books, 2005
7. Classical Mechanics, Tai L.Chow, Taylor and Francis group, 2013

20PH3002 STATISTICAL MECHANICS AND THERMODYNAMICS

Credits 3:1:0

Course Objective:

- To impart knowledge on the laws of thermodynamics from the fundamental principles of equilibrium statistical mechanics.
- To demonstrate the principles of thermodynamics using statistical mechanics .
- To create a bridge between the microscopic and macroscopic phenomena

Course Outcome:
At the end of the course, the student will able to

- Describe the different thermodynamic systems based on the laws and their consequences
- Illustrate the statistical description of systems of particles
- Examine the applications of partition function in thermodynamics
- Understand the need for quantum statistics in thermodynamic systems
- Understand the specific heat of solids and analyze the phase transitions using statistical mechanics
- Apply the statistical mechanics in solving the thermodynamic problems

Unit I :Thermodynamic systems based on laws of thermodynamics
Thermodynamic system-Intensive and extensive variables-Thermodynamic variables and equation of state-limitations-three classes of system-Zeroth law of thermodynamics-concept of heat-Thermodynamic equilibrium-Work-A path dependent function -Internal energy-First law Thermodynamic systems and its significance–consequences-concept of entropy and second law of thermodynamics-Third law of thermodynamics-Nernst heat theorem-zero point energy-thermodynamic potentialsand Maxwell relations –chemical potentials-phase equilibria.

Unit II: Statistical basis of thermodynamics

Statistical formulation of the state system – Introduction-statistical basis-three types of statistics-Probability –Principle of Equal A Priori Probability-Probability and frequency-Some basic rules of probability theory-joint probability-permutations and combinations-Microstate and Macrostate-Theromodynamic Probability-Static and dynamic system-Most Probable State-Concept of cell in a compartment-Phase Space-types-fundamental postulates of statistical mechanics -Density of quantum states –Statistical Ensembles-types-Entropy and probability-Boltzmann entropy relation-Density operator -Liouville theorem.

Unit III :Partition function and its application in thermodynamics
Boltzmann canonical distribution law-Partition function -The Equipartition of energy-statistical interpretation of II law of thermodynamics -Partition function and its relation with thermodynamic quantities: entropy-Helmholtz free energy-total energy-enthalpy-Gibbs potential-pressure and specific heat-Gibbs paradox.

Unit IV :Classical and Quantum statistics
Three kinds of particles-Statistical equilibrium-Maxwell Boltzmann distribution law-Failure of Maxwell Boltzmann statistics-Development of Quantum statistics-bosons-fermions-'h' as a natural constant-Essential difference in three statistics-Bose Einstein distribution law-Planck's radiation law for black body radiation-Bose Einstein condensation-Fermi Dirac distribution law-Electron gas-Application to liquid helium

Unit V: Statistical Mechanics approach of specific heat and phase transitions
Dulong and Petit law-drawbacks of Debye model of specific heat-Einstein Solid-A qualitative description of phase transitions-first order-Clausius-Clapeyron equation – Gibbs phase rule-second order-phase diagrams-critical points-diamagnetism-paramagnetism-ferromagnetism-Ising model-Phase transitions of the second kind – ferromagnetism.

Reference Books

1. Heat, thermodynamics, and statistical physics, Brijlal, Dr.N.Subrahmanyam, P.S.Hemne
2. Fundamentals of Statistical and Thermal Physics, FederickReif, McGraw,Hill, 1985.
3. Statistical Mechanics – B. K. Agarwal and M. Einsner, John Wiley & Sons,1988
4. Statistical Thermodynamics – M.C. Gupta, Wiley Eastern Ltd, 1990
5. Thermodynamics and statistical mechanics, By John M. Seddon, Julian D. Gale Royal Society of Chemistry, 2001
6. Introduction to statistical mechanics – S.K.Sinha, Alpha Science International, 2005
7. Elements of Statistical Mechanics,Kamal Singh & S.P. Singh, S. Chand & Company, New, 1999
8. An Introduction to Statistical Thermodynamics By Terrell L. Hill, 2007

20PH3003 MATHEMATICAL PHYSICS I

Credits: 3:1:0

Course Objective:

- To impart knowledge on basic and advanced level of Vectors and matrices

- To demonstrate the use of differential equations and special functions in solving problems in physics.
- To solve the problems in physics using mathematical principles.

Course Outcome:

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

- Master the complex mathematical analysis, integral theorems, complex function and residue theorem to evaluate definite integrals
- Solve linear systems, matrix inverses, eigen values and eigen vectors
- Solve ordinary differential equations of second order
- express any physical law in terms of tensors and coordinate transforms
- learn the theory of probability, various distribution functions, errors and residuals
- apply the mathematical concepts to solve the problems in physics.

Unit I

VECTOR ANALYSIS: Addition, Subtraction, multiplication of vectors –Simple Problems – Magnitude of Vectors – Linear Combination of vectors –Simple problems – Product of two vectors – Triple product of vectors - Simple applications of vectors to Mechanics – Work done by force - Torque of a force-Force on a particle in magnetic field-Force on a charged particle- Angular velocity - Differentiation of vectors – Scalar and vector fields - Gradient, Divergence and Curl operators – Integration of vectors – Line, surface and volume integrals –Gauss's Divergence theorem – Green's theorem – Stoke's theorem

Unit II

MATRICES: Equality of matrices – Matrix Addition, multiplication and their properties – Special matrices –Definitions: Square matrix, Row matrix, Null matrix, Unit matrix, Transpose of a matrix, Symmetric and skew symmetric matrices, Conjugate of matrix Adjoint of matrix (Simple problems)- Unitary matrix, Orthogonal matrix (simple problems) –Inverse of matrix – Problems- Rank of matrix –Problems - Solutions of linear equations –Cramer's rule – Cayley-Hamilton Theorem – Eigen Values and Eigen vectors of matrices and their properties –Quadratic forms and their reduction - Diagonalisation of matrices

Unit III

TENSOR ANALYSIS: Definition of tensors – Transformation of coordinates – The summation convention and Kronecker Delta symbol –Covariant Tensors – Contravariant tensors – Mixed Tensors - Rank of a tensor – Symmetric and anti-symmetric tensors –Quotient law of tensor - Invariant Tensors - Algebraic operations of tensors - Addition, subtraction and multiplication(inner and outer product) of tensors Derivative of tensors

Unit IV

LINEAR DIFFERENTIAL EQUATIONS:

Linear differential equations of second order with constant and variable coefficients – Homogeneous equations of Euler type – Equations reducible to homogeneous form – method of variation of parameter – Problems.

Unit V

PROBABILITY AND THEORY OF ERRORS: Definition of probability – Compound Probability – Total Probability – The multinomial law – Distribution functions - Binomial, Poisson and Gaussian distribution– Mean (Arithmetic - Individual observations ,Discrete series, Continuous series) – Median (Individual observations ,Discrete series, Continuous series) – Mode (Individual observations ,Discrete series, Continuous series) -Mean Deviation and

Standard Deviation(Individual observations ,Discrete series, Continuous series) – Different types of errors – Errors and residuals —The principle of Least squares fitting a
straight line.

Reference Books

1. Mathematical Physics – B.D.Gupta – Vikas Publishing House, 3rd edition, 2006
2. Mathematical Physics – B.S.Rajput – PragatiPrakashan – Meerut, 17th edition, 2004
3. Mathematical Methods for Engineers and Scientists – K.T.Tang – Springer Berlin Heidelberg New York ISBN,10 3,540,30273,5 (2007)
4. Mathematical Methods for Physics and Engineering – K.F.Riley, M.P.Hobson and S.J.Bence, Cambridge University Press – ISBN 0 521 81372 7 (2004)
5. Essential Mathematical Methods for Physicists – Hans J.Weber and George B.Arfken – Academic Press, U.S.A. – ISBN 0,12,059877,9 (2003)
6. Mathematical Physics Including Classical Mechanics, SatyaPrakash, Sultan Chand & Sons, New Delhi, ISBN,13: 9788180544668 (2007)

20PH3004 SEMICONDUCTOR PHYSICS

Credits: 3:0:0

Course Objective:

1. To impart knowledge on the different semiconductor devices and linear integrated circuits
2. To demonstrate the fabrication process of integrated circuits
3. To illustrate the working of logic gates, the architecture and functioning microprocessors and microcontrollers

Course Outcome:

At the end of the course students will be able to

1. Understand the construction, working and applications of semiconductor devices
2. Interpret the principle and characteristics of linear integrated circuits
3. Explain the different types of transducers and its applications.
4. Appraise different types optoelectronic devices and its applications,
5. Illustrate the fabrication and manufacturing process involved in integrated circuits
6. Develop and design special purpose devices using digital electronics

Unit I : Semiconductor Devices

PN Diode – Zener Diode, Bipolar Junction Transistor – Biasing and Operation– CB Configuration – input/output characteristics -Breakdown in transistors Uni-Junction Transistor- – FET – Construction of N Channel JFET - MOSFET and types – FET as a voltage variable resistor – SCR –- TRIAC – DIAC –- Tunnel Diode Characteristics.

Unit II : Fabrication of Integrated Circuits

Integrated circuits fabrication – Photolithographic process– epitaxial growth, diffusion, masking, metallization and etching,– Diffusion of impurities – Monolithic diodes, integrated resisters, – Construction of a bipolar transistor integrated capacitors and inductors monolithic layout, large scale integration (LSI), medium scale integration (MSI) and small scale integration (SSI)

Unit III : Operation Amplifiers and Transducers

Ideal Operational amplifiers -OPAMP stages – Parameters – Equivalent circuit – Open loop OPAMP configurations - Closed loop OPAMP configurations - OPAMP applications – summing – integrator- Differentiator - comparator – Transducers: Active and Passive transducers – Different types – Thermistor – Thermocouple – Hall effect – Piezoelectric and photoelectric transducers.

Unit IV : Optoelectronic devices

Optoelectronic Sensors - Photodetector – Junction type Photoconductive cell – Construction and characteristics – Photovoltaic sensors –Solar Cell – Construction, working, Characteristics and applications – Photo emissive sensors – Vacuum phototube – gas filled phototube – photomultiplier – Light emitting diodes – Construction, working and applications – Infrared emitters – Fiber optic communication system

Unit V: Digital Electronics

Boolean Algebra – De Morgan's Theorem – Logic gates - Karnaugh map simplifications - Counters – synchronous, asynchronous and decade- Registers – Multiplexers – Demultiplexer – Flip flops – Digital to Analog converters – Analog to Digital converters - Introduction to Microprocessor – 8085A - Basics of Microcontroller

Reference Books

1. Integrated Electronics – Millmaan. J. and Halkias C.C
2. Electronic Devices and Circuits – Allen Mottershead
3. Microwaves – Gupta K.C
4. Digital Principles and Applications – Malvino and Leach.

20PH3005 QUANTUM MECHANICS I

Credits 3:1:0

Course Objective:

- To disseminate the knowledge on the general formulation of quantum mechanics

- To impart knowledge in solving the wavefunction that represent different physical systems
- To provide information on the theoretical aspects of various time independent perturbed systems

Course Outcome:

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

- Gain an in depth understanding on the central concepts and principles of quantum mechanics
- Improve their mathematical skills necessary to solve the differential equations and eigenvalue problems using the operator formalism
- Apply the Schrodinger wave equation and obtain the solution for various quantum mechanical systems such as particle in a box, harmonic oscillator, rigid rotator and hydrogen atom.
- Develop the concepts of angular momentum, such as their addition and commutation relation with components.
- Analyze different time independent perturbed systems and solve them with the aid of approximation methods
- Appraise quantum mechanical systems involving many electron atoms and use the available models to solve them.

Unit I - GENERAL FORMALISM OF QUANTUM MECHANICS: Linear vector space- Linear operator- Eigenfunctions and Eigenvalues - Normalisation of wave function- orthonormality- Probability current density - Expectation values - operator formalism in quantum mechanics -Hermitian operator- properties of Hermitian operator - General uncertainty relation - Dirac's notation- Equations of motion – Ehrenfest's theorem - Schrodinger, Heisenberg and Dirac representation.

Unit II - ENERGY EIGEN VALUE PROBLEMS: Particle in a box – Linear Harmonic oscillator- Tunnelling through a barrier- particle moving in a spherically symmetric potential- System of two interacting particles-Rigid rotator- Hydrogen atom.

Unit III - ANGULAR MOMENTUM: Angular momentum operator in position representation - Orbital angular momentum- Spin angular momentum -Total angular momentum operators- Commutation relations of total angular momentum with components- Ladder operators - Eigen values of J_+ and J_- - Eigen values of J_x and J_y – Explicit form of the angular momentum matrices - Addition of angular momenta: Clebsch Gordon coefficients (no derivation) – properties.

Unit IV - APPROXIMATE METHODS: Stationary perturbation theory (non-degenerate case) –Application of non-degenerate perturbation theory: Normal Helium atom, First order Zeeman effect – Stationary degenerate perturbation theory – Application: First order Stark effect in hydrogen atom – Spin-orbit interaction-Variation method –Application: Ground state of Helium - WKB approximation

Unit V - MANY ELECTRON ATOMS: Indentical particles – Pauli principle- Inclusion of spin – spin functions for two electrons - The Helium Atom – Central Field Approximation –

The Born-Oppenheimer approximation -Thomas-Fermi model of the Atom – Hartree's self-consistent field method.

Reference Books

1. Quantum Mechanics – G. Aruldhas - Prentice Hall of India,2006
2. Advanced Quantum mechanics -Satya Prakash – Kedar Nath Ram Nath & Co, Meerut, 2014
3. A Text Book of Quantum Mechanics-P.M. Mathews & K. Venkatesan – Tata McGraw Hill2007
4. Introduction to Quantum Mechanics – David J.Griffiths Pearson Prentice Hall2005
5. Quantum Mechanics – L.I Schiff - McGraw Hill1968
6. Principles of Quantum Mechanics-R.Shankar, Springer2005

20PH3006 MATHEMATICAL PHYSICS II

Credits 3:1:0

Course Objective:

- To provide knowledge about elements of complex analysis and transforms
- To demonstrate group theory and its implications for applications in physics
- To enumerate numerical methods, fourier series and integral transforms.

Course Outcome:

Students will be able to

- Expand a function in terms of a Fourier series, with knowledge of the conditions for the validity of the series expansion
- Apply Fourier and Laplace transforms to solve mathematical problems and analyzing experimental data
- Solve partial differential equations of second order by use of standard methods like separation of variables, series expansion (Fourier series) and integral transforms
- Understand the fundamental concepts of group theory.
- Appraise numerical interpolation and approximation of functions, numerical integration and differentiation
- apply the mathematical concepts to solve the problems in physics.

Unit I

COMPLEX VARIABLES: Functions of a complex variable– Analytic functions – Cauchy – Riemann conditions and equation – Conjugate functions – Complex Integration – Cauchy's integral theorem, integral formula – Taylor's series and Laurent Series – Poles, Residues and contour integration - Cauchy's residue theorem – Computation of residues - Evaluation of integrals.

Unit II

FOURIER SERIES AND FOURIER TRANSFORMS:
Fourier series – Dirichilet conditions – Complex representations – Sine and Cosine series – Half range series – Properties of Fourier Series – Physics applications of Fourier series – The Fourier Transforms – Applications to boundary value problems

Unit III

APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS & GREENS FUNCTION: Solutions of one dimensional wave equation- one dimensional equation of heat conduction-Two dimensional heat equations – Steady state heat flow in two dimensions – Green's Function – Symmetry properties - Solutions of Inhomogeneous differential equation - Green's functions for simple second order differential operators.

Unit IV

GROUP THEORY: Basic definition of a group – Subgroups – Classes – Isomorphism Homomorphism – Cayley's theorem – Endomorphism and automorphism – Important Theorems of Group representations – Unitary theorem – Schur's Lemma – Equivalent Theorem – Orthogonality Theorem – Some special groups – Unitary Group – Point Group – Translation Group – Homogenous and Inhomogenous Lorentz groups – Direct product group

Unit V

NUMERICAL METHODS: Finite Differences – Shifting Operator – Numerical Interpolations – Newton's forward and backward formula – Central Difference interpolation – Lagrange's Iterpolation – Numerical Differentiation – Newton's and Stirling's Formula – Numerical Integration – Trapezoidal Rule – Simpson's 1/3 and 3/8 rule – Numerical Solution of ordinary differential equations – Runge-Kutta methods – Piccard's Methods

Reference Books

1. B.D.Gupta – Mathematical Physics –Vikas Publishing House, 3rd edition, 2006
2. B.S.Rajput – Mathematical Physics –Pragati Prakashan – Meerut, 17th edition, 2004
3. K.T.Tang – Mathematical Methods for Engineers and Scientists –Springer Berlin Heidelberg New York ISBN,10 3,540,30273,5 (2007)
4. K.F.Riley, M.P.Hobson and S.J.Bence, Mathematical Methods for Physics and Engineering – Cambridge University Press – ISBN 0 521 81372 7 (2004)
5. Hans J.Weber and George B.Arfken – Essential Mathematical Methods for Physicists – Academic Press, U.S.A. – ISBN 0,12,059877,9 (2003)
6. Satya Prakash, Mathematical Physics Including Classical Mechanics, Sultan Chand & Sons, New Delhi, ISBN,13: 9788180544668 (2007).

20PH3007 SPECTROSCOPY-I

Credits 3:0:0

Course Objective:

1. To impart knowledge on the physical and chemical properties of matter through spectroscopy
2. To illustrate the principles and the theoretical framework of different spectroscopic techniques.
3. To demonstrate the spectroscopic techniques in solving the structure of molecules

Course Outcome:

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

1. understand the fundamentals of spectroscopy and the atomic spectra of hydrogen atom
2. appreciate the role of microwaves in rotational spectroscopy and its working principle
3. experiment the use of infrared rays in finding the structure of molecules
4. articulate the use of Raman spectroscopy in studying the matter
5. analyze the structure of atoms through the electronic spectroscopy
6. Identify the best method to solve the spectroscopic problems

Unit I: Electronic Spectroscopy of atoms

Electromagnetic radiation-quantization of energy-absorption and emission process-continuous and line spectra- representation of spectra-instrument-signal to noise ratio-resolving power-width and intensity of spectral lines-concept of fourier transform-Electronic wave functions-atomic quantum numbers-electronic angular momentum-orbital-spin-total angular momentum;spin- orbit interaction and Fine structure of hydrogen atom spectrum-XPS-Zeeman effect-influence of spin.

Unit II: Microwave Spectroscopy

Rotation of molecules- Diatomic Molecules-the rigid diatomic molecule- Intensities of Spectral Lines- Effect of Isotope Substitution- Non-rigid Rotator- Polyatomic Molecules- Techniques and Instrumentation-Microwaves in space communication-chemical analysis in industries by microwave spectroscopy

Unit III: Infra-red Spectroscopy

Vibration of Diatomic Molecules- Simple harmonic Oscillator-Anharmonic Oscillator- the diatomic vibrating rotator- Vibration- Breakdown of Born-Oppenheimer Approximation-Vibration of Polyatomic Molecules- H_2O and CO_2-Vibration-Rotation Spectra of Polyatomic Molecules-Techniques and Instrumentation-applications: automobile components analysis for automobile industries, forensic department, environmental applications: food and water industries

Unit IV: Raman Spectroscopy

Quantum Theory of Raman Effect- Classical Theory- Molecular Polarizability-Rotational Raman Spectra-linear molecules-Vibrational Raman Spectra-Rule of mutual exclusion- Techniques and Instrumentation-application in pharmaceutical and cosmetic industries

Unit V: Electronic Spectroscopy of molecules

Electronic Spectra of Diatomic Molecules- Born-Oppenheimer Approximation- vibrational coarse structure-progressions-intensity of vibrational–electronic spectra-Franck-Condon

Principle- Dissociation Energy and dissociation products-Re-emission energy from Excited Molecules.

Reference Books:

1. Fundamentals of Molecular Spectroscopy by C. N. Banwell, Tata McGraw-Hill Publ.Comp. Ltd. (2010)
2. Molecular Spectra and Molecular Structure: G. Herzberg Van Nostrand, 195
3. Modern Spectroscopy; J.M.Hollas, John Wiley, (2004)
4. Introduction to Atomic Spectra, Harvey Elliot White. McGraw-Hill, 1934

20PH3008 ELECTROMAGNETIC THEORY

Credits 3:1:0

Course Objective

1. To impart knowledge on the basics of electrostatics and magnetostatics through the equations governing them.
2. To demonstrate electromagnetic field theory using Maxwells equations.
3. To provide formulations for electromagnetic wave propagation systems and solve the associated problems.

Course outcome:

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

1. Explain the concept of different laws of electro-magnetic fields
2. Solve static electric and magnetic field problems using coordinate systems
3. Relate the applications of EM Waves in different domains and to find the time average power density
4. Explain Maxwell's equation for time varying electric and magnetic fields
5. Illustrate the wave equation and its parameters for a conductor, dielectric and magnetic medium
6. Analyse moving charges and radiation from an oscillating dipole antennae

Unit I

ELECTRO STATICS: Gauss Law and Coulomb's law-surface, line and volume charge distributions-Scalar potential-Multipole expansion of electric fields-Poisson's equation-Laplace's equation-Uniqueness theorem-electrostatic potential energy and energy density-Electrostatics in matter-Polarization and electric displacement vector-Electric field at the boundary of an interface.

Unit II

MAGNETO STATICS: Biot and Savart law-Lorentz force law-Differential equations of magnetostatics and Ampere's law-The magnetic vector potential-The magnetic field of distant circuit-Magnetic moment-The magnetic scalar potential-Macroscopic magnetization-Magnetic fields in matter-Magnetization-The field of a magnetized object.

Unit III

PLANE ELECTROMAGNETIC WAVES: Plane wave in a non conducting medium – Boundary conditions – Reflection and refraction of e.m. waves at a plane interface between dielectrics – Polarization by reflection and total internal reflection - Waves in a conducting, non conducting or dissipative medium-Electromagnetic waves in vacuum – Energy and momentum of EMW – Propagation in linear media

Unit IV

ELECTRODYNAMICS: Radiation from an oscillating dipole – Radiation from a half wave antenna – Radiation damping – Thomson cross section – Lienard – Wiechert Potentials – The field of a uniformly moving point charge.

Unit V

TIME VARYING FIELDS: Electromagnetic induction – Faraday's law – Maxwell's equations – Displacement current – Vector and Scalar potentials – Gauge transformation – Lorentz gauge – Columb's gauge – Gauge invariance – Poynting's theorem-Dynamics of charged particles in static and uniform electromagnetic fields-Plasma confinement-Applications

Reference Books

1. Classical Electrodynamics, J. D. Jackson, John Wiley & Sons, 1998
2. Foundations of Electro Magnetic Theory – John R. Reits, Fredrick J. Milford & Robert W. Christy. Narosa Publishing House (1998)
3. Electromagnetics: B. B. Laud, New Age International 2nd Edition (2005)
4. Electromagnetic Waves and Radiating Systems, E. C. Jordan, K. G Balmain, PHI Learning Pvt. Ltd., 2008
5. Engineering Electromagnetics, W. H. Hayt, J. A., Buck, Tata McGraw-Hill, 2011.

20PH3009 QUANTUM MECHANICS II

Credits 3:1:0

Course Objective

- To impart knowledge on how to apply quantum mechanics to solve problems in atomic physics
- To illustrate time dependent perturbation theory using quantum mechanics
- To provide knowledge on the formulation of quantum field theory

Course Outcome:

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

- Recognize the systems that are subjected to different time dependent perturbations such as harmonic, sudden and adiabatic.
- Classify the quantum problems involving scattering and interpret them using approximations such as Born, Partial wave analysis etc.
- Solve the quantum mechanical systems related to radiation by using the semiclassical theory.
- Apply relativistic wave equation to study hydrogen like atom, free particle and other relativistic problems.

- Appraise on the quantization of wave field, non-relativistic equation, electromagnetic field energy and momentum.
- Develop appropriate skill in analytical, theoretical and/or practical techniques to further their understanding in the chosen topic.

Unit I - TIME DEPENDENT PERTURBATION THEORY: Time Dependent Perturbation Theory-Perturbation constant in time-Transition probability: Fermi Golden Rule- Harmonic Perturbation-Selection Rules – forbidden transitions - Adiabatic Approximation – Sudden approximation.

Unit II - SCATTERING THEORY: Scattering cross-sections – Differential and total Scattering cross-sections - Scattering Amplitude – General formulation of the scattering theory - Green's Function - Born approximation and its validity- Partial wave analysis - Phase Shifts - Scattering by coulomb and Yukawa Potential.

Unit III - THEORY OF RADIATION (SEMI CLASSICAL TREATMENT): Einstein's Coefficients- Spontaneous and Induced Emission of Radiation from Semi Classical Theory-Radiation Field as an Assembly of Oscillators-Interaction with Atoms-Emission and Absorption Rates-Density Matrix and its Applications.

Unit IV - RELATIVISTIC WAVE EQUATION: Klein Gordon Equation - Charge and Current Density- Klein Gordon Equation in electromagnetic field - Dirac Relativistic Equation - Dirac Relativistic Equation for a Free Particle- Electromagnetic potentials: magnetic moment of the electron –Theory of positron.

Unit V - QUANTUM FIELD THEORY: Quantization of Wave Fields- Lagrangian and Hamiltonian formulations- Field Quantization of the Non-Relativistic Schrodinger Equation-Creation, annihilation and Number Operators-Anti Commutation Relations- Quantization of Electromagnetic Field Energy and Momentum.

Reference Books

1. Advanced Quantum Mechanics -Satya Prakash – Kedar Nath Ram Nath & Co, Meerut, 2014
2. A Text Book of Quantum Mechanics -P.M. Mathews & K. Venkatesan-Tata McGraw Hill2007
3. Quantum Mechanics – G Aruldhas - Prentice Hall of India2006
4. Introduction to Quantum Mechanics – David J.Griffiths Pearson Prentice Hall2005
5. Quantum Mechanics – L.I Schiff - McGraw Hill1968
6. Quantum Mechanics - A.K. Ghatak and S. Loganathan-McMillanIndia,2004

20PH3010 SPECTROSCOPY-II

Credits 3:1:0

Course Objective:

- To impart knowledge on the physics of electron and nuclei spin in establishing the advanced spectroscopic techniques like NMR, ESR and NQR using low energy electromagnetic waves.
- To demonstrate the role of high energy electromagnetic waves in the advanced spectroscopic techniques like Mossbauer spectroscopy.
- To illustrate properties of matter by analysis and interpretation of spectral data from mass spectrometer.

Course Outcome:

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

- Understand the role of nuclei spin to know the structure of matter through NMR technique.
- Appreciate the physics of electron spin used in ESR technique.
- Determine the structure of molecules using NQR spectroscopic technique
- Appreciate the principles and working of Mossbauer spectroscopy.
- Analyze the structure of matter using mass spectroscopy.
- Identify the best method to solve the spectroscopic problems

Unit I - NMR Spectroscopy: Nature ofspinning particles-interaction between spin and a magnetic field-nuclei spin-population of energy levels-the larmor precession-NMR – Basic principles – Classical and Quantum mechanical description – Bloch equation –Spin – Spin and spin lattice relaxation times – Experimental methods – Single Coil and double coil methods – Pulsemethod

Unit II - ESR Spectroscopy: ESR basic principles – High Resolution ESR Spectroscopy – Double Resonance in ESR- ESRspectrometer.

Unit III - Nuclear Quadruple Resonance Spectroscopy: N Q R Spectroscopy – Basic Principles – Quadruple Hamiltonian Nuclear Quadrupole energy levels for axial and nonaxial symmetry – N Q R spectrometer – chemical bonding – molecular structural and molecular symmetry studies.

Unit IV - Mossbauer Spectroscopy: Basic principles, spectral parameters and spectrum display, applications to the study of bonding and structure of Fe^{2+} compounds. Isomer shieft, quadruple spliting, hyperfine interaction, instrumentations and applications**.**

Unit V - Mass Spectroscopy: Introduction- ion production- fragmentation- ion analysis- ion abundance- common functional groups- high resolution mass spectroscopy- instrumentation and application.

Reference Books:

1. Fundamentals of Molecular Spectroscopy by C. N. Banwell, Tata McGraw-Hill Publ. 1. Comp. Ltd.(2010)
2. Modern Spectroscopy; J.M.Hollas, John Wiley, (2004)High Resolution NMR-Pople,
3. Schneidu and Berstein. McGraw-Hill,(1959)
4. Principles of Magnetic Resonance - C.P. Slitcher, Harper and Row,(1963)
5. Basic Principles of Spectroscopy R. Chang, R.E. Krieger Pub.Co.(1978)
6. Nuclear Quadrupole Resonance Spectroscopy - T.P. Das and Hahn , Supplement,(1958)

20PH3011 NUCLEAR AND PARTICLE PHYSICS

Credits: 3:1:0

Course Objective:

- To describe the basic properties, structure of the nucleus and nuclear stability.
- To impart knowledge about the concepts of nuclear forces and radioactive decay modes.

- To demonstrate the working principles of various nuclear reactions and nuclear reactors and about basics of particle physics.

Course Outcome:

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

- Understand the basic structure of the nucleus and apply Weizsacker semi-empirical mass formula for determining the nuclear stability.
- Comprehend the nature of nuclear forces and its applications to real physical systems of nuclei.
- Apply the radioactive properties of certain nuclides for water, food, health, and energy sectors.
- Analyse different types of nuclear reactions with special reference to nuclear fission and fusion reactions and their applications to nuclear power reactors.
- Evaluate the classification scheme of fundamental forces and particles and their relevance to various applications in physics.
- Create new concepts in physics by comprehending the latest research in nuclear and particle physics.

Unit I : Nuclear Structure

Basic Nuclear Properties – Size, Shape and Charge Distribution – Spin and Parity – Magnetic Moments – Quadrupole Moments – Binding Energy – Bethe–Weizsäcker formula Semi-Empirical Mass Formula – Nuclear Stability – Mass Parabolas – Liquid Drop Model – Shell Model – Application of Semi-Empirical Mass Formula to Neutron Stars.

Unit II : Nuclear Forces

Nature of the Nuclear Force – Form of Nucleon-Nucleon Potential – Deuteron Problem – Ground State of Deuteron – Charge Independence and Charge-Symmetry of Nuclear Forces – Spin Dependence of Nuclear Forces – Meson Theory – Spin, Orbit and Tensor Forces – Exchange Forces. Applications: Nuclear Weapons.

Unit III : Radio Activity

Alpha Decay – Gamow's Theory – Geiger-Nuttal Law – Fine Structure of Alpha Decay – Neutrino Hypothesis – Beta Decay – Fermi's Theory – Energies of Beta Spectrum – Fermi and Gamow-Teller Selection Rules – Non-Conservation of Parity – Gamma Ray Emission – Selection Rules – Nuclear Isomerism – Applications: Radioisotopes in Health, Food Industry, Agriculture, Water Hydrology and Industry.

Unit IV : Nuclear Reactions

Level Widths in Nuclear Reaction – Nuclear Reaction Cross Sections – Partial Wave Analysis – Compound Nucleus Model – Resonance Scattering – Breit-Wigner one level formula – Optical Model – Reaction Mechanisms – Direct Reactions – Stripping and Pick-up Reactions – Elementary Theory of Fission and Fusion – Applications: India's Three Stage Nuclear Power Programme – Fusion power.

Unit V : Particle Physics

Classification of Fundamental Forces and Elementary Particles – Quantum Numbers – Charge – Spin – Parity – Isospin – Strangeness – Gell-Mann Nishijima's formula – Quark Model – Baryons and Mesons – C, P, and T Invariance – SU (3) Symmetry – Parity Non-Conservation in Weak Interaction – K meson – Relativistic Kinematics – Application of Symmetry Arguments to Particle Reactions.

Reference Books

1. Concepts of Nuclear Physics – B.L. Cohen – McGraw-Hill – 2001.
2. Introduction to Nuclear Physics – H.A. Enge – Addision-Wesley, 1983.
3. Introduction to Particle Physics : M. P. Khanna Prentice Hall of India (1990)
4. Nuclear and particle Physics : W. Burcham and M. Jobes, Addision-wesley (1998)
5. S N Ghoshal, Nuclear Physics 1st Edition, S.Chand Publishing, 1994.
6. Irving Kaplan, Nuclear Physics 2nd Edition, Narosa Publishing House, 2002.
7. Kenneth S.Krane, Introductory Nuclear Physics 1st Edition, Wiley India Pvt Ltd, 2008.
8. S L Kakani, Nuclear and Particle Physics, Viva Books Pvt Ltd.-New Delhi, 2008.
9. Gupta, Verma, Mittal, Introduction to nuclear and particle physics, 3/E 3rd Edition, PHI Learning Pvt. Ltd-New Delhi, 2013.
10. Samuel S. M. Wong, Introductory Nuclear Physics 1st Edition, PHI Learning, 2010.

20PH3012 SOLID STATE PHYSICS

Credit: 3:0:0

Course Objective:

1. To impart knowledge on the properties of crystal, dielectric, ferroelectric properties and its theories
2. To demonstrate concepts of solid-state physics and its concepts in magnetic and optical properties of materials.
3. To illustrate the properties of superconducting materials and its applications

Course Outcome:

At the end of the course students will be able to

1. Describe the crystal properties and elementary models for bonding of atoms and molecules.
2. Explain the concepts leading to dielectric and ferroelectric properties in detail.
3. Interpret the fundamental ideas of magnetic properties in solid state phenomena
4. Describe the theories involved in the magnetic and superconducting materials phenomena
5. Illustrate optical properties of materials and its importance in luminescence applications
6. Apply the solid-state physical phenomena in the areas of superconductors and its applications

Unit I : Crystal Properties and Lattice Vibrations

Bravais lattices and crystal systems - Reciprocal lattice - Diffraction and the structure factor.-Bonding of solids- Elastic properties, lattice specific heat. - Brillouin zones – Density of states - Phonons - acoustic and optical branches- -scattering of phonons. Electron motion in a periodic potential - Band Theory of Solids - Kronig-Penney model - Effective mass of electron-Nearly free electron model

Unit II : Dielectric And Ferroelectric Properties

Dipole Moment and Polarization – Types of Polarization – Ionic, Electronic and Orientation - Langevin function- Dielectric constant and polarizability – Local field – Classius – Mosotti relation – Lorentz-Lorenz formula – Elemental dielectrics- Polarization of Ionic crystals- Polar

Solids- Measurement of dielectric constant - Ferroelectricity – General properties – Dipole theory – Classification of ferroelectric materials - Antiferroelectricity

Unit III : Magnetic Properties

Magnetic Permeability- Magnetization – Bhor Magneton – Electron Spin and Magnetic Moment – Diamagnetism – Langevin's theory of diamagnetism- Para magnetism – Classical theory of Para magnetism - Weiss theory of Para magnetism – Determination of Susceptibilities – Quincke's method – Hund rules - Ferromagnetism – Weiss Molecular Field – Curie-Weiss law - Temperature dependence of magnetism - Ferromagnetic domains – Magnetization Curve – Bloch Wall – Antiferromagnetism – Neel temperature – Ferrimagnetism.

Unit IV : Crystal defects and Optical Properties

Crystal defects - Point imperfections – Concentrations of Vacancy, Frenkel and Schottky imperfections - Line Imperfections – Burgers Vector – Presence of dislocation – surface imperfections- Polorans – Excitons- Colour centers – Optical absorption in Metals, Insulators and Semiconductors - Luminescence – Excitation and emission – Decay mechanism – Thermo luminescence and glow curves – Electroluminescence – Phosphors in Fluorescent Lights.

Unit V: Superconductivity

Properties of Superconductors – Effects of magnetic field – The Meissner effect – Thermal properties of Superconductors - Type I and II superconductors - London equations : Electrodynamics –– B.C.S. theory – Quantum Tunneling - A.C. and D.C. Josephson effect – Macroscopic Quantum interference -– High temperature super conductors – Squids – Magnetic levitation and Power applications

Reference Books

1. Solid State Physics – S.O. Pillai, New Age International Publishers, 5th Edition 2002
2. Introduction to Solid State Physics- Kittel, John wiley, 8th edition,2004
3. Elementary Solid State Physics, M. Ali Omar, Pearson Education, 2004
4. Introductory solid state Physics, H.P.Myers, Second edition, Taylor and Francis, 2009
5. Advanced Solid State Physics, P.Philips, Cambridge University Press, 2012
6. Solid State Physics, Neil W. Ashcroft, N. David Mermin, Cengage Learning, 2011
7. Solid State Physics, R.J.Sing, Pearson, 2012.
8. Introduction to Solid State Physics, Kittel, John Wiley, 8th edition, 2004
9. Solid State Physics, S.O. Pillai New Age Publications, 2002

20PH3013 PHYSICS OF NANOMATERIALS

Credits 3:0:0

Course Objective:

- To illustrate the Quantum mechanical concepts for nanoscale systems
- To impart knowledge on the different nanofabrication methods

- To Demonstrate the electrical, magnetic, mechanical and optical properties of nano devices

Course Outcome:

Students will be able to

- Define quantum confinement effects in nano materials
- Describe the different fabrication techniques of nanomaterials
- Examine the characteristics of nanomaterials
- Analyse the nanodevices with different characterization tools
- Evaluate the nano devices for different applications
- Design and create advanced nano devices

Unit I

INTRODUCTION TO NANO: Basic concepts of nano materials – Density of states of 1,2 and 3D quantum well, wire, dot-Shrodinger wave equation for quantum wire, Quantum well, Quantum dot-Formulation of super lattice- Quantum confinement- Quantum cryptography

Unit II

FABRICATION OF NANOSCALE MATERIALS: Top-down versus Bottom-up –ball milling, Lithography- photo, e-beam - Etching -Synthesis -Colloidal dispersions -Atomic and molecular -manipulations –Self assembly -Growth modes, Stransky-Krastinovetc –Ostwald ripening

Unit III

ELECTRICAL AND MAGNETIC PROPERTIES : Electronic and electrical properties-One dimensional systems-Metallic nanowires and quantum conductance -Carbon nanotubes and dependence on chirality -Quantum dots –Two dimensional systems -Quantum wells and modulation doping -Resonant tunnelling –Magnetic properties Transport in a magnetic field -Quantum Hall effect. -Spin valves -Spin-tunnelling junctions -Domain pinning at constricted geometries -Magnetic vortices.

Unit IV

MECHANICAL AND OPTICAL PROPERTIES : Mechanical properties hardness – Nano indentation -Individual nanostructures -Bulk nanostructured materials-Ways of measuring-Optical properties-Two dimensional systems (quantum wells)-Absorption spectra -Excitons -Coupled wells and superlattices -Quantum confined Stark effect

Unit V

ADVANCED NANODEVICES : Background -Quantization of resistance -Single-electron transistors -quantum dot LEDs- Magnetic Nanodevices -Magnetoresistance –Spintronics- MEMS and NEMS, haptic devices, nanomaterial based drug delivery system, nanobots.

Reference Books

1. Introduction to Nanotechnology, Charles P.Poole, Jr. and Frank J.Owens, Wiley, 200
1. Silicon VLSI Technologies, J.D.Plummer, M.D.Deal and P.B. Griffin, Prentice Hall, 2000
2. Introduction to Solid State Physics, C.Kittel, a chapter about Nanotechnology, Wiley,2004

20PH3014 FABRICATION AND TESTING OF THIN FILM DEVICES

Credits 3:0:0

Course Objective:

- To impart knowledge on functioning of vacuum pumps, measuring gauges and thin film coating techniques.
- To describe the influence of different substrate materials and growth process.
- To demonstrate the properties of thin films and apply it for device fabrication.

Course Outcome:

Students will be able to

- Identify the vacuum pumps and measure the vacuum level
- Illustrate the mechanism of thin film deposition
- Apply the knowledge on the influence of substrates on the growth of thin films
- Analyse the thin film characteristics through different tools
- Appraise the latest thin film device fabrication and testing
- Create fabrication methods for thin film based devices like solar cells and gas sensors

Unit I: Vacuum system

Categories of deposition process, basic vacuum concepts, pumping systems- rotary, diffusion and turbo molecular, monitoring equipment –McLeod gauge, pirani, Penning, Capacitance diaphragm gauge.

Unit 2: Thin film coating techniques

Physical vapour deposition, sputtering - dc, rf, magnetron, Molecular beam epitaxy, Pulsed laser deposition, chemical vapour deposition, electroplating, sol gel coating, spray Pyrolysis

Unit 3: Substrate materials and Growth process

Substrate materials, material properties – surface smoothness, flatness, porosity, mechanical strength, thermal expansion, thermal conductivity, resistance to thermal shock, thermal stability, chemical stability, electrical conductivity -Substrate cleaning, substrate requirements, buffer layer, metallizationcontrol, lattice mismatch, surface morphology, Growth process- Adsoption, surface diffusion, nucleation, surface energy, texturing, structure development, interfaces, stress, adhesion, temperature control -growth monitoring, composition.

Unit 4: Structural, Optical and electrical studies on thin films

X- Ray Diffraction studies –Bragg's law – particle size – Scherrer's equation – crystal structure – UV Vis NIR Spectroscopy , Photoluminescence (PL) studies –Fourier Transform Infrared Spectroscopy(FTIR) - Electrical properties: dc electrical conductivity as a function of temperature - Hall effect – types of charge carriers – charge carrier density, C-V/I-V characteristics.

Unit 5: Device fabrication-testing and validation

Design fabrication and testing of Flexible transistor, CNT based transistor, Multilayer solar cell, flexible gas sensors, Project presentation and report submission.

Reference Books

1. Handbook of Thin Film Technology, Edited by Hartmut Frey and Hamid R.Khan, Springer, 2015.
2. Thin Films Phenomena by K L Chopra, Mcgraw Hill, 2018.
3. Thin Film Technology Handbook by AichaElshabini, AichaElshabini-Riad, Fred D. Barlow, McGraw-Hill Professional, 1998
4. Handbook of Thin-film Deposition Processes and Techniques: Principles, Method, equipment and Applications By Krishna SeshanWilliam Andrew Inc., 2002
5. Thin-film deposition: principles and practice by Donald L. Smith, McGraw-Hill Professional, 1995

20PH3015 SOLID STATE BATTERIES

Credit: 3:0:0

Course Objective

1. To impart knowledgeon the cutting edge technology in lithium ion batteries
2. To illustrate energy storage devices and their applications in smart devices/vehicles
3. To demonstrate Thin film lithium ion batteries and advancement in lithium ion battery technology

Course Outcome

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

1. Identify the terminologies (thin and bulk) used in lithium ion batteries
2. Illustrate the working of lithium ion batteries
3. Apply the knowledge on lithium ion batteries to construct lithium ion Coin –Power Micro-batteries
4. Analyze the output of the fabricated coin cell
5. Appraise the power of lithium of ion battery
6. Design lithium ion battery with smart materials

Unit I: Battery Fundamentals

Invention, Early innovators, Global Battery Markets, Voltage, Capacity, C-rates, Watts and Volt-Amps, State of Health, Octagon Battery: Specific Energy, Specific Power, Price, Cycle Life, Safety, Operating range, Toxicity, Fast Charging, Battery building blocks: Anode, Cathode, Electrolyte, Current Collectors, Separators for different battery systems; Primary and secondary batteries: Comparison, its Advantages and disadvantages; Comparison of Secondary Batteries based on Octagon terms;

Unit II: Introduction to Lithium Batteries

Types of lithium battery: primary and secondary; Fabrication and working of lithium metal battery using liquid electrolyte; Fabrication and working of lithium ion battery using liquid electrolyte; Working of lithium metal and lithium ion polymer battery: role of polymer membranes.

Unit III: Microbatteries fabrication

Fundamentals on thin and thick films- flexible and non-flexible substrates; Methods of constructing microbatteries- Rf-suputtering and Pulsed Laser Deposition Techniques. Design and working of Glove Box- Fabrication of coin-power microbatteries. Crimping Machine-working; Types of cells in fabrication of lithium ion batteries- Coin cell types, prismatic, cylindrical and other types.

Unit IV: Testing of Coin-Power Micro-batteries

Characterization of material components: X-ray Diffraction, Scanning Electron Microscope, Fourier Transform Spectroscopy; X-ray Photoelectron Spectroscopy; Battery Characteristics: Open Circuit Voltage; Cyclic Voltammetry; Galvanostatic Charge-Discharge Studies; Electrochemical Impedance Spectroscopy studies.

Unit V: Recent Progress

Recent materials for lithium ion battery; advantages and disadvantages of lithium ion battery; alternative technologies: Sodium, Postassium, Mangesium, Iron ion, Aluminium ion, Silver ion batteries and other alternative batteries, Supercpacitor, Fuel Cells. Design of lithium ion batteries for specific applications: Space craft, Land and marine applications – pros and cons.

Reference Books:

1. Lithium-Ion Batteries, Beta Writer, Heidelberg Germany, Springer Nature Switzerland AG, Springer, Cham, ISBN 978-3-030-16800 (2019)

2. Lithium Microbatteries. In: Julien C., Stoynov Z. (eds) Materials for Lithium-Ion Batteries. NATO Science Series (Series 3. High Technology), vol 85. Springer, Dordrecht, ISBN 978-0-7923-6651-5 (2000).

3. Hand Book of Batteries and Fuel cells, 3rd Edition, Edited by David Linden and Thomas. B. Reddy, McGraw Hill Book Company, N.Y. 2002.

4. Modern Electrochemistry 2A, Fundamentals of Electrodics, John O'M Bockris, Amulya K. N. Reddy and Maria Gamboa-Aldeco, Kluwer Academic Publishers, Newyork, 2000.

20PH3016 QUANTUM COMPUTING IN AI

Credits 3:0:0

Course Objective:

- To impart knowledge on the basics and scientific background of quantum computing.
- To provide knowledge on various quantum circuits and quantum algorithms.
- To demonstrate the interplay between quantum theory and artificial intelligence.

Course Outcome:

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

- Identify the origin of quantum computing and gain information about qubits, quantum superposition and entanglement.
- Understand the scientific background such as Hilbert space, tensors and operators behind quantum computing.
- Distinguish between various quantum circuits that are involved in the field of quantum computing.
- Classify different quantum algorithms and discuss the relation between quantum and classical complexity.
- Appraise on the theory of quantum information, quantum error and correction.
- Validate on the inter relation between quantum theory and artificial intelligence through applications.

Module I: FOUNDATION OF QUANTUM COMPUTING

From classical to quantum information-origin of quantum computing- postulates of quantum mechanics - qubits and multi-qubits states, bra-ket notation- Bloch sphere representation-quantum superposition- quantum entanglement – Bell's theorem

Module II: SCIENTIFIC BACKGROUND

Basis vectors and orthogonality - Hilbert spaces – density matrices - tensors – probability and measurements - unitary operators and projectors - quantum Fourier transform - Dirac notation - eigen values and eigen vectors

Module III: QUANTUM CIRCUITS AND ALGORITHMS

Quantum circuits: Single qubit gates - multiple qubit gates - quantum superposition - design of quantum circuits – quantum algorithms: classical computation on quantum computers – relationship between quantum and classical complexity classes- Deutsch's algorithm - Jozsa and Grover algorithms – Shor factorization

Module IV: QUANTUM INFORMATION AND ERROR CORRECTION

Comparison between classical and quantum information theory - quantum noise and quantum operations - applications of quantum operations and limitations – error correction: theory of quantum error and correction - tolerant quantum computation - entropy and information – basic properties of entropy - Von Neumann - strong sub additivity - data compression - entanglement as a physical resource

Module V: QUANTUM THEORY AND AI - INTERPLAY AND APPLICATIONS

Semantic analysis – recognition and discrimination of quantum states and operators - quantum neural and Bayesian networks – quantum genetic algorithm – quantum algorithms for machine learning - quantum algorithms for decision problems – quantum search – quantum game theory

References Books:

1. Micheal A. Nielsen. &Issac L. Chiang, “Quantum Computation and Quantum Information”, Cambridge University Press, Fint South Asian edition, 2002.
2. David McMahon, “Quantum Computing Explained”, Wiley, 2007.
3. Eleanor G. Rieffel and Wolfgang H. Polak, “Quantum Computing: A Gentle Introduction” (Scientific and Engineering Computation), The MIT Press.
4. C. T.Bhunia,“Introduction To Quantum Computing” , Publisher New Age International Pvt Ltd Publishers, ISBN 9788122430752.
5. Susan Shannon, “Trends in Quantum Computing Research”, Nova Publishers, 2006.
6. Sahni, “Quantum Computing”, Tata McGraw-Hill Education, 2007.
7. Phillip Kaye, Raymond Laflamme , Michele Mosca, “An Introduction to Quantum Computing”, Oxford, 2006.

20PH3017 ASTRONOMY AND ASTROPHYSICS

Credits: 3:0:1

Course Objective:

- To impart the knowledge about ancient astronomy, solar system models, various types of stars and their evolution.
- To disseminate information about the various tools available to study the cosmos.
- To provide with a fundamental understanding of galaxies, big bang theory and life in the universe.

Course outcome:

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

- ✓ Remember the various solar system models, our own solar system and earth’s immediate cosmic neighborhood.
- ✓ Understand intricate details about the life cycle of a star and different types of stars.
- ✓ Apply the modern day telescopes to explore the cosmos.
- ✓ Analyze the various types of galaxies, their formation and cosmic distant scales.
- ✓ Evaluate the formation of the universe through the big bang theory and understand about how the universe is likely to end.
- ✓ Formulate novel techniques and theorems to explore the space to solve problems yet to be solved.

Module I - THE SOLAR SYSTEM : Various Solar System Models – The Solar System in Perspective: Planets, Moons, Rings and Debris – Other Constituents of Solar System – Kepler’s laws of planetary motion. -Coronal mass ejection

Module II - THE STARS : The Sun – Important Properties of stars, HR diagram – Measuring the distances of a star –The Parallax Method – The Formation of Stars and Planets – Types of Stars – White dwarfs, Neutron Stars and Black Holes – Star Clusters – Supernovae and their types

Module III - TELESCOPES AND DETECTORS : Optical Telescopes – The Hubble Space Telescope, Modern telescopes-Ground based and space based, –Detectors and Image Processing: Photography, Phototubes, Charge Couple Devices, Signal to Noise – The New Generation of Optical Telescopes. – Other Windows to Heaven

Module IV - THE MILKY WAY GALAXY : Interstellar Matter – The milky way galaxy, The Shape and Size of the Galaxy –The Rotation and Spiral Structure of Galaxy – The Center of Galaxy – Stellar Populations –Different types of Galaxies – The Cosmological Distance Scale – The Local Group

Module V - THE UNIVERSE: Clusters of Galaxies – Super Clusters of Galaxies - Hubble's Law –Cosmological Models – The Standard Big Bang Model – The Big Bounce Theory – The Fate of the Universe – The Big Crunch Theory – The Big Rip Theory – Life in the Universe-Hunt for exo planets-methods for finding exo planets

Reference Books

1. Michael Zeilik, Stephen .A.Gregory, Introductory Astronomy and Astrophysics, Fourth Edition, Saunders College Pub., Michigan, U.S.A, 1998 ISBN 9780030062285
2. B. Bhattacharya, S. Joardar, R. Bhattacharya, Astronomy and Astrophysics, Jones and Barlett Publishers, U.S.A., (2010) ISBN 978-1-934015-05-6
3. Martin V. Zombeck, Book of astronomy and Astrophysics, Cambridge University Press, U.K. (2007) ISBN 978-0-521-78242-5
4. ThanuPadmanabhan, Theoretical Astrophysics (Vol. I, II, II): Cambridge University Press, U.S.A., (2002) ISBN 0 521 56242 2
5. Wolfgang Kundt, Astrophysics: A new approach, Second edition, Springer, 2006
6. Introduction to Astrophysics: The Stars, Jean Dufay, Dover publications,2012
7. Arnab Rai Chaudhuri, AstroPhysics for Physicists, Cambridge University Press,2010. ISBN-10 : 052117693X,
8. Frank shu The Physical Universe:

20PH3019 GENERAL PHYSICS LAB I

Credits: 0:0:2

Course Objective:

- To get practical skill on basic optical experiments.
- To get practical skill on non-ideal elements, such as lasers and optics in experiments..
- To get practical skill on basic sound and ultrasonic experiments.

Course Outcome:

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

- apply knowledge on basic Physics experiments to solve practical problems.
- apply experimental principles and error calculations to electromagnetism.
- analyze basic quantities in electromagnetism.
- present concepts and describe scientific phenomena.

- design experiments, and analyze and interpret data.
- get practical skill on analyzing the Magnetic properties of the material

HoD can give any 10 relevant experiments at the beginning of the course in each semester.

20PH3020 GENERAL PHYSICS LAB II

Credits: 0:0:2

Course Objective:

- To get practical skill on digital electronics.
- To get practical skill in studying the characteristics of low power semiconductor devices.
- To get practical skill on analyzing the characteristics of Diode and transistor.

Course Outcome:

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

- understand the practical difficulties in measuring the standard parameters.
- architecture of microprocessors and methodology of programming
- design basic electric circuits using software tools.
- identify, formulate and sole engineering problems with simulation.
- experience in building and troubleshooting electronic circuits.
- write simple program using microprocessor for practical applications.

HoD can give any 10 relevant experiments at the beginning of the course in each semester.

20PH3021 ADVANCED PHYSICS LAB I

Credits: 0:0:2

Course Objective:

To learn practical skills on

- Thin film coating devices
- Operation of physical method of thin film preparation
- Synthesis of thin films through chemical route

Course Outcome:

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

- apply the knowledge prepation of thin films
- demonstrate physical method of thin film preparation
- demonstrate the chemical method of thin film preparation
- evaluate the electrical properties of thin films
- estimate the hall measuremets
- characterize the optical properties and to find the band gap.

HoD can give any 10 relevant experiments at the beginning of the course in each semester.

20PH3022 ADVANCED PHYSICS LAB II

Credits 0:0:2

Course Objective:

- To get practical skill on various deposition techniques
- to prepare thin films and
- Crystals having nanostructures

Course Outcome:

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

- Fabricate novel nano structures
- Fabricate nano thin films
- Fabricate nano devices
- Fabricate electronics devices
- solve the out put properties of the devices
- evaluate the efficiency of the devices

HoD can give any 10 relevant experiments at the beginning of the course in each semester.

20PH3023 COMPUTATIONAL PHYSICS LAB

Credits: 0:0:2

Course Objective:

- To provide students with an opportunity to develop knowledge and understanding of the key principles of computational physics.
- Synchronising computational skills acquired with requirements of theoretical physics courses.
- Developing numerical, computational and logical skills relevant for solution of theoretical and experimental physics problems.

Course Outcome:

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

- Demonstrate knowledge in essential methods and techniques for numerical computation in physics
- Apply the programming skills to solve practical problems.
- Apply numerical and statistical problem solving skills and computer programming skills to solve research problems.
- Use appropriate numerical method to solve the differential equations governing the dynamics of physical systems
- Apply different methods to solve deterministic as well as probabilistic physical problems
- Employ appropriate numerical method to interpolate and extrapolate data collected from physics experiments

HoD can give any 10 relevant experiments at the beginning of the course in each semester.

20PH3024MATERIALS CHARACTERIZATION LAB

Credit: 0:0:2s

Course Objective:

To train the students to operate

- spectro photometer
- X-Ray diffractometer
- Scanning electron microscope

Course outcome:

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

- To demonstrate optical propertis through Spectrophotometer
- To evaluate the structure through XRD
- To identify the morphology through SEM
- To appraise the surface roughness through AFM
- To calculate the dielectric constant through Impedance analyser
- To plot the IV characteristics through NI work station.

HoD can give any 10 relevant experiments at the beginning of the course in each semester.