5 yr. Integrated MSc Physics

2018

18CHY103 **CHEMISTRY I** **3 0 0 3**

Unit 1 Chemical Bonding

Review of orbital concept and electronic configuration, electrovalency and ionicbond formation, ionic compounds and their properties, lattice energy, solvationenthalpy and solubility of ionic compounds, covalent bond, covalency, orbital theoryof covalency - sigma and pi bonds - formation of covalent compounds and theirproperties Hybridization and geometry of covalent molecules - VSEPR theory -polar and non-polar covalent bonds, polarization of covalent bond – polarizingpower, polarisability of ions and Fajan's rule, dipole moment, percentage ioniccharacter from dipole moment, dipole moment and structure of molecules, coordinate-covalent compounds and their characteristics, molecular orbital theory forH2, N2, O2 and CO, metallic bond - free electron, valence bond and band theories,
weak chemical bonds – inter and intra molecular hydrogen bond - van der Waalsforces.

Unit 2 Thermodynamic Parameters

Stoichiometry - mole concept, significance of balanced chemical equation – simplecalculations - Conditions for occurrence of chemical reactions - enthalpy, entropyand free changes – spontaneity – Thermochemistry - heats of reactions -(formation, combustion, neutralization) - specific heats - variation of enthalpy changewith temperature - Kirchhoff' relation (integrated form) - bond enthalpy and bondorder - Problems based on the above.

Unit 3 Kinetics

Review of molecularity and order of a reaction, rate law expression and rateconstant - first, second, third and zero order reactions, pseudo-first order reactions(pseudo-unimolecular reactions) - complex reactions - equilibrium and steady stateapproximations -mechanism of these reactions - effect of temperature on reactionrates - Arrhenius equation and its significance, Michaelis Menden kinetics-enzymecatalysis.

Unit 4 Electrochemistry

Electrolytes - strong and weak, dilution law, Debye-Huckel theory, faraday's laws,origin of potential, single electrode potential, electrochemical series, electrochemicalcells, Nernst equation and its application, reference electrodes - SHE, Ag/AgCl,Calomel.

Unit 5 Photochemistry

Photochemistry, laws of photochemistry - Stark-Eistein law, Beer-Lamberts law,quantum efficiency-determination, photochemical processes - Jablonsky diagram,internal conversion, inter-system crossing, fluorescence, phosphorescence,chemiluminescence and photo sensitization, photopolymerization.

REFERENCE BOOKS:

1. Principles of Physical Chemistry, B.R. Puri, L.R. Sharma & M.S. Pathania, Vishal Publications,
46th, 2013.
2. Principles of Inorganic Chemistry, B R. Puri, L.R. Sharma, Vishal Publications, 2008

18CHY114 CHEMISTRY II 3 0 0 3

Unit 1 Ionic equilibria

Electrolytes, strong and weak - specific, equivalent and molar conductances,equivalent conductance at infinite dilution and their measurement - Kohlrausch'slaw and its applications - calculation of equivalent conductance at infinite dilutionfor weak Electrolytes and solubility of sparingly soluble salts - applications ofconductivity measurement - conductometric titrations - acid-base precipitation andcomplexometric titrations, Common ion effect and its application, concept of pH,indicators, theories of indicators – buffers and their pH - Henderson equation.

Unit 2 Chemical equilibria

Law of mass action - equilibrium constant – Relation between Kp and Kc -Temperature dependence – The van't Hoffs equation – Pressure dependence ofthe equilibrium constant Kp and Kc – Factors that change the state of equilibrium- Le-Chatelier's principle and its application to chemical equilibria.

Unit 3 Basic concepts in Organic Chemistry

Composition of organic compounds – detection and estimation of elements- carbon– hydrogen -nitrogen, oxygen, sulphur, phosphorous, halogens – Calculation ofempirical and molecular formula - determination of molecular weights – physicaland chemical methods - empirical formula and molecular formula – Classificationand Nomenclature of organic compounds. Organic reactions and their mechanisms:Electron displacement effects – inductive, electromeric, mesomeric andhyperconjugative. Reactive intermediates – carbocations, carbanions, free radicalsand carbenes.

Unit 4 Acids, Bases and Non-aqueous solvents

Concepts of acids and bases – hard and soft acids and bases - Pearson'sconcept, HSAB principle and its application - basis for hard-hard and soft-softinteractions - non-aqueous solvents - general characteristics of non-aqueoussolvent - melting point, boiling point, latent heat of fusion and vaporization, anddielectric constant - reactions such as complex formation, redox, precipitation andacid-base type in non-aqueous solvents like liquid ammonia, liquid SO_2 and liquidHF.

Unit 5 Coordination Chemistry

Werner's theory – Electronic interpretation of co-ordination compounds - EAN rule– types of ligands – Nomenclature, isomerism – stability of complexes – factorsinfluencing stability – Application of coordination compounds in qualitative andquantitative analysis. Theories of bonding in coordination.

TEXTBOOKS:

1. Puri, Sharma & Pathania, ‘Principles of Physical Chemistry’, 42nd edition, Vishal PublishingCo, Delhi, 2007.
2. Morrison and R.N. Boyd, ‘Organic Chemistry’, 6th Edition, Prentice Hall, 1992.
3. Puri B R, Sharma L R, Kalia K K., ‘Principles of Inorganic Chemistry’, 23rd edition, Shoban Lal Nagin Chand & Co, New Delhi, 1993.

REFERENCES:

1. S.F.A. Kettle, ‘Physical Inorganic Chemistry’, Spectrum, 1996
2. J. Clayden, N. Greeves, S. Warren and P. Wothers, ‘Organic Chemistry’, 2nd edition, OxfordUniversity Press, 2012.
3. R.Stephen Berry, Stuart A. Rice & John Ross, ‘Physical Chemistry’, 2nd edition, Oxford University press, 2000.

18CHY181 CHEMISTRY LAB. 0 0 2 1

1. Acid base titration (double titration).
2. Complexometric titration (double titration).
3. Redox (permanganimetry) titration (double titration).
4. Conductometric titration.
5. Potentiometric titration.
6. Colorimetric titration.

18CHY182 CHEMISTRY LAB. 0 0 2 1

1. Acid base titration (double titration).
2. Complexometric titration (double titration).
3. Redox (permanganimetry) titration (double titration).
4. Conductometric titration.
5. Potentiometric titration.
6. Colorimetric titration.

18CHY183 CHEMISTRY LAB. – INSTRUMENTAL 0 0 2 1

1. Determination equivalent conductance at infinite dilution of a strong electrolyte.
2. Conductometric titration of a mixture of strong and weak electrolytes.
3. Kinetics of acid catalysed ester hydrolysis.
4. Determination of solubility of sparingly soluble salt conductometrically.
5 Determination of molecular weight of a polymer through viscometry
6. Determination of concentration of ions by Spectrophotometer.

18CHY331 BATTERIES AND FUEL CELLS 3 0 0 3

Unit 1 Background Theory (09 Hours)

Origin of potential - electrical double layer - reversible electrode potential - standard hydrogen electrode - emf series - measurement of potential - reference electrodes (calomel and silver/silver chloride) indicator and ion selective electrodes – Nernst equation - irreversible processes - kinetic treatment - Butler-Volmer equation - Overpotential, activation, concentration and IR overpotential - its practical significance - Tafel equation and Tafel plots - exchange current density and transfer coefficients.

Unit 2 Batteries: Primary Batteries **(09 Hours)**

The chemistry, fabrication and performance aspects, packing classification and rating of the following batteries: (The materials taken their function and significance, reactions with equations, their performance in terms of discharge, capacity, and energy density to be dealt with). Zinc-carbon (Leclanche type), zinc alkaline (Duracell), zinc/air batteries; Lithium primary cells - liquid cathode, solid cathode and lithium-ferrous sulphide cells (comparative account).

Unit 3 Secondary Batteries **(09 Hours)**

Lead acid and VRLA (valve regulated (sealed) lead acid), nickel-cadmium, nickel-zinc, nickel-metal hydride batteries, lithium ion batteries, ultrathin lithium polymer cells (comparative account) Advanced Batteries for electric vehicles, requirements of the battery - sodium-beta and redox batteries.

Unit 4 Fuel Cells **(09 Hours)**

Description, working principle, anodic, cathodic and cell reactions, fabrication of electrodes and other components, applications, advantages, disadvantages and environmental aspects of the following types of fuel cells: Proton Exchange Membrane Fuel Cells, alkaline fuel cells, phosphoric acid, solid oxide, molten carbonate, direct methanol fuel cells. Membranes for fuel cells: Nafion – Polymer blends and composite membranes; assessment of performance – recent developments.

Unit 5 Fuels for Fuel Cells **(09 Hours)**

Hydrogen, methane, methanol - Sources and preparation, reformation processes for hydrogen – clean up and storage of the fuels – use in cells, advantages and disadvantages of using hydrogen as fuel.

TEXTBOOKS:

1. Dell, Ronald M Rand, David AJ, 'Understanding Batteries', Royal Society of Chemistry, (2001).
2. M. Aulice Scibioh and B. Viswanathan 'Fuel Cells – principles and applications', University

Press, India (2006).

REFERENCES:

1. Kanani N, 'Electroplating and electroless plating of copper and its alloy', ASM International, Metals Park, OH and Metal Finishing Publications, Stevenage, UK (2003).
2. Curtis, 'Electroforming', London, (2004).
3. F. Barbir, 'PEM fuel cells: theory and practice', Elsevier, Burlington, MA, (2005).
4. G. Hoogers, 'Fuel cell handbook', CRC, Boca Raton, FL, (2003).

18CHY348ELECTROCHEMISTRY 3 1 0 4

Unit 1 Background Theory

Origin of potential - electrical double layer - reversible electrode potential – standard hydrogen electrode - emf series - measurement of potential - reference electrodes (calomel and silver/silver chloride) indicator and ion selective electrodes – Nernstequation - irreversible processes - kinetic treatment - Butler-Volmer equation - Overpotential, activation, concentration and IR overpotential - its practical significance - Tafel equation and Tafel plots - exchange current density and transfer coefficients.

Unit 2 Batteries

Primary batteries: The chemistry, fabrication and performance aspects, packing classification and rating of the following batteries. Zinc-carbon (Leclanche type), zinc alkaline (Duracell), zinc/air batteries; lithium primary cells - liquid and solid cathodes cells. Secondary batteries: Lead acid and VRLA (valve regulated (sealed) lead acid), nickel-cadmium, nickel-zinc, nickel-metal hydride batteries, lithium ion batteries, ultra thin lithium polymer cells (comparative account). Reserve batteries and their applications.

Unit 3 Fuel Cells

Working principle, fabrication and performance aspects of the following: Proton Exchange Membrane Fuel Cells, alkaline fuel cells, molten carbonate, and direct methanol fuel cells. Membranes: Nafion – Polymer blends and composite membranes;assessment of performance. Fuels: Hydrogen, methane, methanol - Sources and preparation, reformation processes for hydrogen – clean up and storage of the fuels – use in cells, advantages and disadvantages of using hydrogen as fuel.

Unit 4 Electrochemical Processes

Electrochemical Processes: Principle, process description, operating conditions, process sequence and applications of Electroforming – production of waveguide and plated through hole (PTH) printed circuit boards by electrodeposition; Electroless plating of nickel, copper and gold; Electropolishing of metals; Anodizing of aluminium; Electrochemical machining of metals and alloys.

Unit 5 Corrosion Studies

Corrosion and control:Free energy concept of corrosion - different forms of corrosion. Mechanism of Electrochemical corrosion - Galvanic and Electrochemical series and their significance. Corrosion Control:Corrosion Inhibitors: Passivators - Vapour phase inhibitor.
Anodic and cathodic protection methods - Coatings - metallic and other inorganic coatings - organic coatings - stray current corrosion - cost of corrosion control methods.

TEXTBOOKS:

1. Dell, Ronald M Rand, David A J, ‘Understanding Batteries’, Royal Society of Chemistry, (2001).

2. M. Aulice Scibioh and B. Viswanathan ‘Fuel Cells – principles and applications’, University Press, India (2006).

3. Uhlig H H and Reviees R W, ‘Corrosion and its Control’, Wiley, (1985).

REFERENCES:

1. Christopher M A, Brett, 'Electrochemistry – Principles, Methods and Applications', Oxford University, (2004).
2. G. Hoogers, 'Fuel cell handbook', CRC, Boca Raton, FL, (2003).
3. ASM Metals Handbook, 'Corrosion', Vol. 13, ASM Metals Park, Ohio, USA, (1994).

18CHY353 FORENSIC SCIENCE 3 0 03

UNIT I-INTRODUCTION

Origin of forensic science, need for forensic science, trace and contact evidence, marks and impression, examination of documents, blood stain analysis, microscope in analysis, explosives, chemical analysis of explosives, forensic laboratories and courses in India.

UNIT II-NARCOTICS

Narcotics, classification of drugs, specific drugs- Psychotropic drugs, chemical screening of drugs, chemical extraction and sample preparation, chemical identification of drugs using analytical methods.

UNIT III – FINGERPRINTING and FIREARM ANALYSIS

History of fingerprinting, principles of fingerprinting, constituents of latent finger marks, fingerprint detection, chemical methods of detection, firearm examination, chemical analysis of firearm, analysis of gunshot residue.

UNIT IV –TOXICOLOGY

Introduction to Toxicology, alcohol and human body, testing of blood alcohol concentration, Toxins & Biological Poisons, Measuring Toxicity as LD50, sample and analysis, inorganic poisons, nerve agents, radioactive toxins, Pharmacokinetics and Toxicokinetics, tests for toxins, reported case studies.

UNIT V- POSTMORTEM TOXICOLOGY

Introduction, tissue and fluid specimens, specimen collection and storage, extraction procedure, analytical techniques, interpretation, case studies

Reference Books:

1. Lawrence Kobilinsky, Forensic Chemistry Handbook, John Wiley & Sons, New Jersey, 2012
2. David E. Newton, Forensic Chemistry, Facts On File, Inc, New York, 2007
3. Jay A. Siegel, Forensic Chemistry fundamentals and applications, Wiley Balckwell.
4. Suzanne Bell, Drugs, Poisons, and Chemistry, Facts On File, Inc. New York, 2009.

18CHY631 Applied Electrochemistry 3-0-0-3

Unit 1 – Electrodics (08 Hours)

Electron transfer under an interfacial electric field. A two way traffic across the interference: equilibrium and exchange current density. Dependence of the electrochemical reaction rate on over potential- quantitative version of the Butler-Volmer equation. Electrode kinetics involving the semiconductor/ solution interface. Techniques of electrode kinetics- preparation of electrode surface. Microelectrodes- applications

Unit 2 - Industrial Cathodic Process (09 Hours)

Electrodeposition of copper, nickel and chromium over mild steel – Zinc plating on MS – decorative plating of silver and cold- nano plating and microstructure of deposits – Test of adhesion, hardness, thickness, uniformity and corrosion resistance of the electro deposits- post plating passivation processes – barrel plating of small components- electroless deposition of nickel, copper, gold on metal components – making of waveguides and plated through hole boards

Unit 3 - Industrial Anodic processes (09 Hours)

Anodising of aluminium and its alloys – bath used, operating conditions and sequence determination of thickness- industrial applications- nano anodizing of titaniuim and tantalum- application to sensor filed. Electropolishing of ferrous and non-ferrous metals and alloys – mechanism of electropolishing – Electrochemical etching of ferrous and non-ferrous metals- Special processes: Electrolysis of water – electrowinning of aluminium and sodium – electrolysis of brine – photoelectrochemistry

Unit 4 – Electrochemical Energy Systems (10 Hours)

Primary batteries: Zinc-carbon (Leclanche type), zinc alkaline (Duracell), lithium primary cells- liquid cathode, solid cathode and lithium-ferrous sulphide cells, Secondary batteries: Lead acid and VRLA (valve regulated (sealed) lead acid), nickel-cadmium, nickel-zinc, nickel-metal hydride batteries, lithium ion batteries, ultra thin lithium polymer cells (comparative account) Advanced batteries for electric vehicles, requirements of battery – sodium-beta and redox batteries. Reserve batteries thermally activated batteries – remote activation – pyrotechnic materials: Fuel cells: Principle, proton exchange membrane (PEM), direct methanol (DMFC), molten carbonate electrolyte (MCFC) fuel cells and outline of biochemical fuel cells.

Unit 5 – Electro chemical sensors (09 Hours)

Potentiometric sensors, solid state Potentiometric chemical sensors, polymeric membrane sensors, ion selective field effect transistor, application, hydrovolumetric technique – hydro-dynamic voltammetric application, voltammetric sensors- electrode modification application, optical sensors bioamperometric titration. Methods involving forced convection- hydrodynamic methods

Text Books

1. Allen J Bard and Larry R. Faulkner, 'Text book for electrochemical Methods' 2 nd edition, Wiley, 2000.
2. 2. Derek Pletcher and Frank C. Walsh, Industrial Electrochemistry', Blackie Academic and Professional, (1993)

References

1. Christopher M.A. Brett, 'Electrochemistry – Principles, Methods and Applications' oxford university, (2004).

18CSA100 PROBLEM SOLVING AND COMPUTER PROGRAMMING 3 0 0 3

Introduction to problem solving: algorithm development and flowchart. Introduction to Computer terminologies and computer languages. C Fundamentals: structure of C program: directives, functions, statements, printing strings, comments; compilation and execution, Programming errors and debugging. Variables and assignment, reading input; data types, constants, identifiers, keywords, operators - arithmetic, logical, relational, assignment; expressions - precedence and associativity, type cast-implicit and explicit; selection statements:- if, if else, nested if, if else ladder, switch. Case.
Iterative structures: entry controlled and exit controlled loop, exiting from a loop: break, continue, goto; nested loops. Functions: library functions, user defined functions: defining and calling functions, function declaration, passing arguments to a function, returning values from function. Storage classes - auto, extern, static, register variables, scope of a variable. Recursion. Number systems: binary, octal and hexadecimal. Bitwise operators and enumeration.
Arrays: one dimensional numeric arrays, initialization, accessing and usage, two dimensional numeric arrays, initialization, accessing and usage. Introduction to multidimensional arrays. Strings: literal, variables: initialization, reading, writing and accessing. String handling functions. Array of strings. Passing arrays and strings to functions.

TEXTBOOK:

Jeri Hanly and Elliot Koffman, "Problem solving and program design in C", Fifth Edition, Addison Wesley (Pearson), 2007.

REFERENCE:

Reema Thareja, "Computer Fundamentals and programming in C", Oxford University Press, 2012.

18CSA180 PROBLEM SOLVING AND COMPUTER PROGRAMMING LAB
0 0 2 1

Basic Linux commands, programs using input/output statements, operators, control structures and loops. Programs using functions and recursions. Programs using numeric one-dimensional array, two-dimensional array. Programs using strings, string handling functions and string arrays. Programs using passing arrays and strings to functions.

18MAT106 TRIGNOMETRY AND DIFFERENTIAL EQUATIONS 3 1 0 4

Unit 1

Trigonometry: (Mathematics for Degree students, P.K.Mittal) Expansions of sin nθ, cosθ, tan nθ in powers of Sinθ, Cosθ, Tanθ. Expansion of Sinnθ, Cosnθ, Sinmθ, Cosmθ in terms of Sines and Cosines of Multiplies of θ – Power series for Sinθ, Cosθ, Tanθ - Hyperbolic Functions - Inverse Hyperbolic Functions - Logarithm of complex numbers - Summation of Trigonometric Series - Gregory Series - Euler Series.

Unit 2

Differentiation (Calculus, Thomas) Applications of Derivative: Mean Value theory – Concavity and Curve Sketching – Maxima and Minima.

Unit 3

Differential Equations of First Order: (Advanced Engineering Mathematics, E.Kreyszig) Formation of Differential Equations. Solutions of Differential Equations (Variable Separable, Homogeneous Equations and Equations reducible to Homogeneous Form, Linear and Equations reducible to Linear Form, Exact Differential Equations and Equations reducible to Exact form). Differential Equations not of the first degree (solvable for ‘p’, solvable for ‘y’, solvable for ‘x’, Clairaut’s Equation). Applications.

Unit 4

Differential Equations of Higher Order: (Advanced Engineering Mathematics, E.Kreyszig) Homogeneous Linear Differential Equations with Constant Coefficient and Euler- Cauchy Differential Equations, Basis of Solutions and Wronskian. Non Homogeneous Equations - Method of Undetermined Coefficients and Method of Variation of Parameters.

Unit 5

Boundary Value Problems for Second Order Equations: Green's function, Sturm Comparison Theorems and Oscillations, Eigenvalue Problems. Applications.

TEXTBOOKS:

1. ‘Calculus’, G.B.Thomas Pearson Education, 2009, 11th Edition.
2. ‘Advanced Engineering Mathematics’, E.Kreyszig, John Wiley and Sons, 2002, 8th Edition.
3. ‘Mathematics for Degree students’, P.K.Mittal, S.Chand & Co, New Delhi.
4. “Mathematics for B.Sc.”, Branch I Vol. I, Vol. II, P.Kandasamy and K.Thilagavathy, S.Chand & Co.

18MAT119 MATRICES AND VECTOR CALCULUS 3 1 0 4

Unit 1

Matrices: Matrix, Algebraic operations, Transpose of a matrix, Inverse of a matrix, Properties of matrices, Kinds of matrices: Symmetric and skew symmetric matrices, Hermitian and skew Hermitian matrices, Orthogonal and unitary matrices, Determinant of a matrix, Properties of determinants.

Unit 2
Systems of Linear Equations: Linear System of Equations, Gauss Elimination, Consistency of a linear system of equations.

Unit 3
Eigen value problems: Eigen values, Eigen vectors, Properties of Eigen values and Eigen vectors, Cayley-Hamilton theorem, Some Applications of Eigen value Problems, Similarity of Matrices, Diagonalization of a matrix, Quadratic forms and Canonical form of a quadratic form.

Unit 4
Vector differentiation: Limit of a vector function – continuity and derivative of vector function - Geometrical and Physical significance of vector differentiation - Partial derivative of vector function – gradient and directional derivative of scalar point functions – Equations of tangent plane and normal line to a level surface. Divergence and curl of a vector point function – solenoid and irrational functions – physical interpretation of divergence and curl of a vector point function.

Unit 5
Integration of vector functions – Line, surface and volume integrals. Guass - Divergence Theorem – Green's Theorem – Stoke's Theorem (Statements only). Verification of theorems and simple problems.

TEXTBOOKS:

1. 'Advanced Engineering Mathematics', Erwin Kreyszig, John Wiley and Sons, 2002, 8th Edition.
2. Textbook of Matrix Algebra, Suddhendu Biswas, PHI, 2012.
3. Vector Calculus with Applications to Physics, Shaw James Byrnie - 2009
4. T.K.Manickavasakam Pillay, Vector Calculus, 2004.

18PHY104 Mechanics & Properties of Matter3 1 0 4

UNIT 1
Physical quantities, dimensional analysis, significant figures. Vectors - basics, derivatives, elementary operations, angles, expansion in series, spehrical polar and cylindrical coordinates, vector identities.

UNIT 2
Instantaneous velocity and acceleration. One dimensional Kinematics. Kinematics in 2D: Projectile Motion, Circular Motion. Galilean Relativity: Relative velocity and acceleration.

UNIT 3
Newton's Laws of Motion Forces, Frictional Forces, Dynamics of uniform circular motion. Work, Kinetic Energy, Work-Energy Theorem, Potential Energy, Conservation of Energy Newton's law of gravitation, Motion in uniform gravitational field.

UNIT 4
Centre of Mass, Conservation of linear momentum, collisions, systems with variable mass. Torque, Angular momentum, Moment of Inertia, Conservation of Angular momentum, Kinetic Energy of Rotation.

UNIT 5
Stress, Strain, Hooke's law Elastic properties of matter.Kinematics of moving fluids, Equation of continuity, Euler's equation, Bernoulli's theorem, Viscous fluids, Reynold's number, Surface tension, Surface energy.

Text Books:
1. David Halliday, Robert Resnick & Jearl Walker, Fundamentals of Physics, John Wiley, 9E, 2012

Reference Books:
1. Kittel et al, Mechanics, Berkeley Physics Course Vol-1, Tata McGraw Hill, 2011
2. R.P. Feynman, R. P. Leighton and M. Sands, Feynman Lectures on Physics Vol.1, Narosa, 2003
3. F. W. Sears, M. W. Zemansky and H. D. Young, University Physics, Narosa, 2011
4. D. S. Mathur, Elemants of Properties of Matter, S. Chand, 2010

18PHY111 Basics of Electricity and Magnetism 3 1 0 4

Course Objective: Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: Vector algebra and vector calculus from the perspective of electrodynamics, Coulomb's law, Superposition principle concept of electric field, Potential formalism and its importance, Working of capacitors and RC circuits, Magnetic fields and their origin, Ohm's law, Faraday's law, Lenz's law and working of LC, LR, LCR circuits.

Unit 1: Vector analysis [16 hrs]
Review of vectors, Dot products, Cross products, and Triple products. Differential calculus: Gradient, Divergence, Curl, Second derivatives, Integral calculus: Fundamental theorem of calculus, Fundamental theorem of gradient, Fundamental theorem of divergence, Fundamental theorem of curls, Curvilinear coordinates: Spherical coordinates, Cylindrical coordinates. Dirac delta function.

Unit 2: Electrostatics [10 hrs]
Coulomb's law. Superposition principle. Electric field – discrete and continuous distribution, Gauss's law, Applications of Gauss's law.

Unit 3: Potential [12 hrs]

The curl of electric field, Electric potential, meaning of electric potential, Equipotential surfaces, Potential of localized charge distribution, Work and energy in electrostatics, Energy of a point charge distribution, Energy of continuous charge distribution, Conductors and Capacitors, Charging and discharging of RC Circuit.

Unit 4: Magnetostatics [10 hrs]
Magnetic fields, Magnetic forces, Currents, Biot-Savart law, Ampere's law.

Unit 5: Electrodynamics [12 hrs]
Ohm's law, EMF, Motional EMF. Electromagnetic induction: Faraday's law, Lenz's law, induced electric field, Examples of LC, LR, LCR circuits.

Text books

1. Introduction to Electrodynamics – David J. Griffiths, 4th edition, Pearson Publication
2. David Halliday, Robert Resnick, and Jearl Walker, Fundamentals of physics, 9th Edition, John Wiley, 2012

Reference books

1. Richard P. Feynman, Robert P. Leighton and Matthew Sands, Feynman Lectures on Physics Vol.1, 1E, Narosa Publishing House, 2008.

18PHY113Advanced Computer Programming – Introduction to Python 3 0 0 3

Prerequisites
The students should have studied any basic computer language as a prerequisite for the course.

Objective of the course
In this course students are introduced to use Python as a tool to solve Physics problems. The emphasis is to learn using a high level programming language without actually going through the logic behind the equations that are to be coded. A minimal understanding of the basic mathematics is assumed. This develops familiarity and equips them to code a large number of physics problems and learn how to obtain results and plots using the software.

Unit –I: Computing Software Basics
Programming Warm-up, Structured and Reproducible Program Design, Shells, Editors, and Execution, Python I/O, Computer Number Representations,Floating-Point Numbers, Over and Underflow Exercises, Machine Precision,Summing Series, Numerical Summation implementation and Assessment.
Errors and Uncertainties in Computations: Types of Errors , Model for Disaster: Subtractive Cancelation, Subtractive Cancelation Exercises, Round-off Errors, Round-off Error Accumulation, Error in Bessel Functions, Numerical Recursion, Implementation and Assessment: Recursion Relations, Experimental Error Investigation, Error Assessment.

Unit-II: Differentiation and Integration
Differentiation: Forward Difference (Algorithm), Central Difference (Algorithm), Extrapolated Difference (Algorithm), Error Assessment, Second Derivatives (Problem), Second-Derivative Assessment.

Integration: Quadrature as Box Counting , Algorithm: Trapezoid Rule, Algorithm: Simpson's Rule, Integration Error (Assessment), Algorithm: Gaussian Quadrature, Mapping Integration Points, Gaussian Points Derivation, Integration Error Assessment, Higher Order Rules (Algorithm), Monte Carlo Integration by Stone Throwing, Stone Throwing implementation, Mean Value Integration, Integration Exercises, Multidimensional Monte Carlo Integration,Multi Dimension Integration Error Assessment,Integrating Rapidly Varying Functions.Variance Reduction.

Unit- III: Matrix Computing
N–D Newton–Raphson; Two Masses on a String, Theory: Statics, Algorithm: Multidimensional Searching, Classes of Matrix Problems, Practical Matrix Computing, Python Lists as Arrays, Numerical Python (NumPy) Arrays, NumPy's linalg Package, Exercise: Testing Matrix Programs, Matrix Solution of the String Problem, Explorations

Unit – IV: Trial-and-Error Searching and Data Fitting
Algorithm: Trial-and-Error Roots via Bisection, Implementation: Bisection Algorithm, Improved Algorithm: Newton–Raphson Searching, Newton–Raphson with Backtracking, Implementation: Newton–Raphson Algorithm.
Exercises: Temperature Dependence of Magnetization, Fitting An Experimental Spectrum, Lagrange Implementation, Cubic Spline Interpolation, Fitting Exponential Decay, Least-Squares Fitting, Fitting Exponential Decay, Heat Flow and Hubble's Law, Linear Quadratic Fit.

Unit- V: Solving Differential Equations: Nonlinear Oscillations
Free Nonlinear Oscillations, Nonlinear Oscillators (Models), Types of Differential Equations, Dynamic Form for ODEs, ODE Algorithms, Euler's Rule, Runge–Kutta Rule, Adams–Bashforth–Moulton Predictor–Corrector Rule, Assessment: rk2 vs. rk4 vs. rk, Solution for Nonlinear Oscillations, Precision Assessment: Energy Conservation,, Extensions: Nonlinear Resonances, Beats, Friction, Time-Dependent Forces.
ODE Applications: Eigenvalues, Scattering, and Projectiles
Problem: Balls Falling Out of the Sky, Theory: Projectile Motion with Drag, Simultaneous Second-Order ODEs, Assessment, Exercises: 2- and 3-Body Planet Orbits and Chaotic Weather.

Text Book

Rubin H. Landu, Manuel J. Paez, and cristian C.Bordeianu, "Computational Physics Problem solving with Python" - Third Edition, Wiley VCH, 2015.

Reference Books

1. Ashok Namdev Kamthene and Amit Ashok Kamthene, "Programming and problem solving with Python" Mc Graw Hill Education, 2017.
2. Balagurusamy E, "Introduction to computing and Problem solving using Python" Mc Graw Hill Education, 2017.

18PHY183 Physics Lab. I - Mechanics & Properties of Matter 0 0 2 1

1. Compound pendulum measurement of 'g' symmetric oscillation.
2. Studies with Rigid pendulum.
3. Young' Modulus Uniform bending.
4. Young' Modulus Cantilever.

5. Torsion pendulum.
6. Studying the flow of liquid through capillary tube.
7. Studying the liquid flow through series and parallel combinations of capillaries.
8. Studying the laws of vibration on a non-metallic string with Melde's apparatus.
9. Studies on exciting the different modes of sonometer wire.
10. Studying the mass on a spring.
11. Velocity of sound in air-Kundt's tube (Ultra sonic).
12. Determination of surface tension on a mercury drop.
13. Study of collisions in two dimensions.

18PHY185ADVANCED COMPUTER PROGRAMMING - PYTHON LAB0 0 2 1

1. Program to find Area of a circle
2. Solving Monte–Carlo integration via von Neumann rejection.
3. To produces an animation of a cooling bar
4. Determines spherical Bessel functions by downward recursion method
5. Calls the random-number generator from the random package
6. Spontaneous decay simulation
7. Trapezoid integration, a<x<b, N pts , N−1 intervals
8. Gaussian quadrature generator of pts.& wts.
9. Monte–Carlo integration via. stone throwing
10. Multi Dimension Newton Search
11. Find zero via Bisection algorithm
12. Linear least–squares fit; e.g. of matrix computation arrays
13. Program for 4^{th} order Runge Kutta method
14. Adams BM method to integrate ODE
15. Numerical solution for projectile with drag

18PHY201 Basic Experimental Techniques in Physics 3 1 0 4

Expected Outcomes:

(a) Student should be capable of calculating errors in measurements
(b) Understand error propagation
(c) Plot a scatter graph, preferably of simple linear systems and fit a linear line and calculate the errors in the constants; Estimate the goodness of fits
(d) Understand basic electronics instrumentation- pick out signal from noise, description of noise, optimising and signal averaging
(e) Understand pressure and temperature measurements, vacuum science and techniques

Unit I: Error analysis

Introductory probability – Random experiment, discrete random variable, continuous random variable, probability distributions, Definition of mean, median, mode, standard deviation and standard error.Definition of Errors: Random error and systematic error, Uncertainties, precision and accuracy, reporting errors (error bars), Error Propagation. 18 hrs

Unit II: Data analysis

Curve fitting, Linear regression analysis, goodness of fits (χ^2 test), correlation analysis (R^2) – with relevance to simple physics experiments. 12 hrs

Unit III: Extraction of signal from noise

Signal to noise ratio, Types of noise, Addition of noisy waveforms and optimising of S/N ratio, signal averaging, waveform recovery. 12 hrs

Unit IV: Vacuum physics

Definition of pressure - Kinetic theory of gases, average velocity, mean free path, impingement rate, creation of vacuum using different pumps 6 hrs

Unit V: Measurement of pressure and temperature

Pressure gauges – All direct and indirect gauges, Temperature measurement – Thermocouples (basic principle and construction), creation of low temperature. 12 hrs

Text / Reference Books

1. Philip Bevington, D. Keith Robinson, Data Reduction and Error Analysis for the physical sciences, 3rd Ed., McGraw-Hill Education, 2002.
2. John. R Taylor, An introduction to error analysis: The study of uncertainties in physical measurements,University Science Books, 1997
3. Paul Horowitz , Winfield Hill,The Art of Electronics, 2nd Ed., Cambridge University Press, 1989.
4. Milton Ohring, Materials Science of Thin Films, 2nd Ed., Academic Press, 2001.
5. John H. Moore, Christopher C. David, and Michael A. Coplan, Building Scientific Appratus, 4th Ed., Cambridge University Press, 2017.

18PHY203 Optics and Wave Motion 3 1 0 4

UNIT 1

Geometrical optics: Fermat's principle- Laws of reflection and refraction. Images formed by plane mirror, Spherical mirror, Spherical refracting surfaces, Thin lens, system of thin lens-Lens aberrations, Matrix methods in optics, determining Cardinal points, Microscopes, Telescopes- reflecting type

UNIT 2

Wave Motion: One dimensional wave equation, Differential wave equation, Simple Harmonic motion (SHM), super position of two or more SHMs. Lissajous figures. Damped and forced oscillators, standing wave and resonance. Group velocity and phase velocity, Energy density and energy transmission in waves-Sound waves-Doppler effect in Sound

UNIT 3

Interference: Wave nature of light, Spatial and temporal coherence (qualitative treatments), Wave division interference –Young's experiment, Interference pattern from double slit- Intensity distribution, Fresnel's double mirror, Fresnel's biprism, Amplitude division interference: fringes from equal thickness films, unequal thickness film , phase change on reflection, Michelson's Interferometer.

UNIT 4

Diffraction: Fraunhoffer diffraction –single, double and multiple slits, circular aperture, Resolution of imaging system, diffraction grating, resolving power of grating. Bragg's Law,Fresnel diffraction: straight edge, circular aperture.

UNIT 5

Polarization: Introduction, Polarization sheets, Polarization by reflection, double refraction, Angular momentum of light, Polarization by scattering, linear, circular, and elliptic polarization, optical rotation..

Text books

1. David Halliday, Robert Resnick, and Jearl Walker, Fundamentals of Physics, 10^{th} Ed.,John Wiley, 2013.
2. A.K. Ghatak, Introduction to Modern optics, 5^{th} Ed., Tata McGraw Hill, 1977.
3. Hecht, Optics, 4^{th} Ed., Pearson Education, 2008.

Reference books

1. Bahaa E. A. Salesh, Fundamentals of photonics, 2^{nd} Ed., Wiley Interscience, 2007.
2. Richard P. Feynman, Robert. P. Leighton and Matthew Sands, Feynmann Lectures on PhysicsVol.1, Narosa Publishing House, 2008.
3. Grant R. Fowls, Introduction to Modern Optics, 2^{nd} Ed., Dover Publications, Inc., USA, 1989.
4. M. Born and E. Wolf, Principles of Optics, 7^{th} Ed., Cambridge University Press, 2002.
5. S. C. Lipson and H. Lipson, Optical Physics, Cambridge University Press, 2011.

18PHY204 Analog Electronics 3 1 0 4

UNIT 1

Network Analysis: Basic circuit analysis methods: star-delta - transformation, nodal, mesh and modified nodal-analysis. Transient analysis of RL, RC and RLC circuits.
Network Theorems: superposition theorem, Thevenin-Norton theorem, maxpower-transfer theorem, (12Hr)

UNIT 2

Diodes theory, equation and characteristic, load line analysis, half wave, full wave and bridge rectifier circuits and ripple factor, Peak detector. **Filter circuits** - Capacitor Filter Diode clippers and limiters, combination of clippers, clampers, voltage doublers, **Zener diode** – specification and operations, Voltage regulator circuits and design –Photo diode.
(10Hr)

UNIT 3

Transistor – Basics of CB, CE and CC configuration, characteristic, operating point,α, β and γ, relations, transistor switch. Basic of amplifiers and its parameters, Frequency response, Decibels computations. self biasing(base biasing),emitter biasing, Voltage divider bias, collector base biasing.(all biasing circuits-comparison), calculation of transistor dissipation, Significance of Q point in thermal runway,
(15Hr)

UNIT 4

BJT small signal analysis: Common emitter fixed bias configuration, Voltage divider bias.

Low frequency response of transistor amplifier - Effect of emitter bypasses capacitor, effect of coupling capacitor, and cascading of CE stages, feedback fundamentals. (10Hr)

UNIT 5

Operational Amplifiers - inverting and non-inverting amplifiers , Gain, input and output impedance of inverting amplifier, differential Amplifier, Summing amplifier, Op-amp as integrator, differentiator, Oscillators, Instrumentation amplifiers, Active filters. **555**- Timers fundamentals and applications. (13 Hr)

Text Books

1. Charles K. Alexander, Mattthew N. O. Sadiku. Fundamentals of electric Circuits, 5th Ed., McGraw Hill, 2013.
2. Robert L.Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory, 11th Ed., Pearson Education India, 2015.
3. Adel S. Sedra, Kenneth C. Smith, Microelectronic circuits Theory and Applications, 6th Ed., Oxford Press, 2013.

Reference Books

1. Albert Malvino, David J Bates, Electronic Principles, 7th Edition, McGraw Hill, 2017.
2. John D. Ryder, Electronic Fundamentals and Applications, 5th Ed., Prentice Hall of India Pvt. Ltd. New Delhi, 2009.
3. Horowitz and Hill, The art of Electronics, 3rd Ed., Cambridge University press, 2015.

18PHY205Introduction to Mathematical Physics3 1 0 4

Unit –I

Fourier analysis: (10Hrs)

Periodic Functions, Trigonometric Series, Fourier Series, Functions of any Period p = 2L, Even and Odd Functions, Half Range Expansions (theorem statement only), Complex Fourier Series, Applications of Parseval’s Identity.

Unit –II (10 Hrs)

Fourier Integrals, Sine and Cosine Integrals, Fourier Transforms - Sine and Cosine Transforms, Properties, Convolution Theorem, diffraction theory- Fourier method.

Unit –III

Laplace Transforms: (10 Hrs)

Laplace Transforms, Inverse Transforms, Properties, Transforms of Derivatives and Integrals, Second Shifting Theorem, Unit Step Function and Dirac-Delta Function,

Unit –IV (10 Hrs)

Differentiation and Integration of Transforms, Convolution, Initial and Final Value Theorems, Periodic Functions, Solving Linear Ordinary Differential Equations with Constant Coefficients, System of Differential Equations and Integral Equations.

Unit –V

Partial Differential Equations: (20Hrs)

Basic Concepts, Modeling; Vibrating String, Wave Equation, Separation of Variables, Use of Fourier Series, D'Alembert's Solution of The Wave Equation, Heat Equation; Solution by Fourier Series.

Text Books:

1. E Kreyszig, Advanced Engineering Mathematics, 10^{th} Ed., John Wiley and Sons, 2015.
2. P. P. G. Dyke,An Introduction to Laplace Transforms and Fourier series, 2^{nd} Ed.,Springer, 2014.
3. Larry C. Andrews and Bhimson, K. Shivamoggi, The Integral Transforms for Engineers,Prentice Hall India Learning Private Limited, 2003.

18PHY216 DIGITAL ELECTRONICS 3 1 0 4

UNIT 1

Introduction to Logic Circuits, Logic Families: Review of Number Systems**,** Variables and functions, inversion, Truth tables, Logic Gates and Networks, Boolean algebra, Synthesis gates using NAND and NOR gates. Introduction to Logic families such as ECL, TTL. **Implementation Technology:** Transistor Switches, NMOS Logic Gates, CMOS Logic Gates, Negative Logic System, tri-state logic.

UNIT 2

Optimized Implementation of Logic Functions: Karnaugh map, Strategy for minimization, Minimization of Sum of Products and Product of Sums Forms, Incompletely specified Functions, **Number Representation and Arithmetic Circuits:** Addition of unsigned Numbers, Signed numbers, Fast Adders.

UNIT 3

Combinational Circuit Building Blocks: Multiplexers, Decoders, Encoders, Priority Encoders, Code Converters, And Arithmetic Comparison Circuits.

UNIT 4

Sequential Circuit Building Blocks - Flip Flops, Registers, Counters: Basic Latch, Gated SR latch, gated latch, master slave and edge triggered D flip-flops, T flip-flop, JK flip-flop, registers, Asynchronous (ripple) counters, Reset synchronization, Design of Synchronous counters, Shift Registers, Ring counter, Johnson Counter.

UNIT 5

Introduction to D/A circuits – Weighted Resistor DAC – R-2R Ladder DAC – **Introduction to A/D Circuits** - Flash ADC – Counter type ADC **(***Only qualitative treatment required for DACs and ADCs).* **Synchronous Sequential Circuits:** Basic Design Steps, State Assignment Problem, Mealy state Model, Serial Adders, State minimization, Simple examples. **Assynchronous Sequential Circuits:** Basic Design Steps.

Text Books

1. Stephen Brown, Zvonko Vranesic, Fundamental of Digital logics with VHDL Design, 3^{rd} Ed., McGraw-Hill Education, 2008.
2. Donald P. Leach, Albert Paul Malvino, Digital principles and applications, 7^{th} Edition, Tata McGraw-Hill Education, 2011.
3. Albert Paul Malvino, Jerald A. Brown, Digital Computer Electronics, 3^{rd} Ed. McGraw-Hill, Electricity & Electronics series, 1992.

Reference Books

1. M. Morris R. Mano, Michael D. Ciletti,Digital design, 5th Edition, Pearson Publisher, 2012.

18PHY217Introduction to Computational Physics3 1 0 4

Unit I

Modeling, Computers and Error Analysis: Mathematical Modeling, Programming and Software, Approximations and Round off errors, Truncation errors and the Taylor series.

Unit II

Algebraic Equations and Curve Fitting: Bracketing Methods, Open Methods, Roots of Polynomials, Gauss Elimination, LU Decomposition and Matrix Inversion, Special Matrices and Gauss-Seidel, Least-Squares Regression, Interpolation, Fourier Approximations

Unit III

Numerical Integration and Differentiation: The Trapezoidal Rule, Simpson's Rules, Open Integration Formulas, Multiple Integrals, Gauss Quadrature, Improper Integrals, Richardson Extrapolation, Derivatives of Unequally Spaced Data, Derivatives and Integrals for Data with Errors, Partial Derivatives

Unit IV

Ordinary Differential Equations: Euler's Method, Runge-Kutta Methods, System of Equations, Stiffness, Multistep Methods, General Methods for Boundary-Value Problem, Eigenvalue Problems

Unit V

Partial Differential Equations: The Laplace Equation, Solution Technique, Boundary Conditions, The Control Volume Approach, The Heat Conduction Equation, Explicit Methods, Parabolic Equations in Two Spatial Dimensions

Text Book

1. Steven Chapra, Raymond Canale, Numerical Methods for Engineers, 7th Ed., McGraw-Hill Higher Education, 2015.

Reference Book

1. V. Rajaraman, Computer Oriented Numerical Methods, PHI LEARNING PVT LTD, 2016.

18PHY218 MODERN PHYSICS3 1 0 4

Unit 1

Special theory of relativity: Correspondence principle - reference frame, inertial systems and Galilean transformations, postulates of special theory of relativity,Michelson-Morley experiment and its consequences, Lorentz transformations, Length contraction, Time dilation, relativistic velocity addition, simultaneity, relativistic Energy and momentum, mass–energy equivalence, particles with zero rest mass, relativistic Doppler effect.

Unit 2

Origin of quantum theory of radiation: Black body radiation, photo-electric effect, Compton Effect – pair production and annihilation, De-Broglie hypothesis, description of waves and wave packets, group velocities. Evidence for wave nature of particles: Davisson-Germer experiment, Heisenberg uncertainty principle.

Unit 3

Atomic structure: Historical Development of atomic structures: Thomson's Model, Rutherford's Model: Scattering formula and its predictions, Atomic spectra - Bohr's Model, Sommerfield's Model, The correspondence principle, nuclear motion, and atomic excitation. Application: Lasers.

Unit 4

Quantum mechanics: Wave function, Probability density, expectation values - Schrodinger equation – time dependent and independent, Linearity and superposition, expectation values, operators, Eigen functions and Eigen values, Application of 1D Schrodinger Wave equation: Free particle, Particle in a box, Finite potential well, Tunnel effect, Harmonic oscillator. Quantum theory of the hydrogen atom. Schrodinger wave equation in spherical coordinates, separation of variables, quantization of energy and orbital angular momentum,

Unit 5

Many-electron atoms: Electron Spin, exclusion principle, symmetric and antisymmetric wave functions, Many-electron atoms, atomic structures, Spin-Orbit Coupling, total angular momentum, X-ray Spectra.

TEXT BOOKS

1. Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury, Concepts of Modern Physics, Tata McGraw-Hill, 7thEd., 2017.

2. Robert Eisberg and Robert Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei and particles, 2ndEd., Wiley, Reprint: 2012

REFERENCE BOOKS

1. Kenneth Krane, Modern Physics, 2nd Ed., John Wiley and Sons, 1996

2. Raymond A. Serway, Moses, Moyer, Modern Physics, 3rd Ed., Thomson Learning, 2005

3. T. Thornton and A. Rex, Modern Physics for Scientist and Engineers, 2nd Ed., Fort Worth: Saunders, 2000.

18PHY283 Physics Lab. II – Heat, Electricity and Magnetism 0 0 2 1

1. Thermal conductivity of a bad conductor – Lee's disc method

2. Spherical calorimeter – specific heat capacity
3. Thermal conductivity of good conductor – Forbe's method
4. Studying the variation of total thermal radiation with temperature.
5. Verification of Joule's Law of Heating.
6. Potentiometer calibration, potential drop Calibration of Ammeter and volt meter
7. Calibration of thermocouple using potentiometer
8. Specific resistance carry forester bridge
9. Studying the field along the axis of the coil
10. Mapping of electric field.
11. Studying of Mutual inductance
12. Deducing the magnetic properties of a sample from its Hysteresis curve on CRO
13. Studying the charging and discharging and Energy dissipation of capacitor in RC circuits.
14. Studying the amplitude response and phase relation of V_R V_C and V_L in LCR series resonance circuit.

18PHY284 Physics Lab III – Optics 0021

1. Determination of focal length of combination of lenses and nodal distance using nodal slide Assembly.
2. Studying the rresolving power of a telescope.
3. Studying the dispersive power of prism.
4. Studies on Newton's ring experiment.
5. Studying the Interference fringes in Wedge shaped films.
6. Studying the diffraction by grating – Using Spectrometer at minimum deviation condition.
7. Studying the degree of polarization of light reflected at various incident angles & verifying the Law of Malus.
8. Determination of refractive index of the liquids by applying Snell's law.
9. Diffraction at single, double and multiple slits using laser - studying the intensity distribution.
10. Diffraction at circular aperture using laser and estimation of unknown particle size.
11. Optical Fiber - Measuring the numerical aperture, beam profile and bending loss.
12. Assembling a Michelson Interferometer and measuring glass refractive index

18PHY306 THERMAL PHYSICS 3 1 0 4

UNIT 1

Temperature & Zeroth law of thermodynamics:, Introduction:-state variables, Thermal equilibrium, Zeroth law of thermodynamics. Concept of temperature & its measurement, Scales of measurement. Construction and calibration of various Liquid, gas, resistance and radiation thermometers, Thermal expansion, Equation of state. Extensive and intensive variables: Kinetic theory of gases : Pressure exerted by ideal gas, molecular properties of temperature, Mean free path, Molecular speed distribution

UNIT 2

First law of thermodynamics: Methods of work transfer, free expansion, work as a path function,heat: Specific heat capacity and latent heat First law of thermodynamics: Internal energy and work, Heat and Enthalpy, Path function and state function, Corollaries of First law of thermodynamics;

UNIT 3

Work and Heat: Heat Capacity: equation of state, measurement of specific heat, Work done in various Processes, Mayer's relation, Poisson's relation. Einstein's and Debye theory of Specific heat capacity Heat transfer mechanisms:-Conduction, Convection, and Radiation. Methods of thermal conduction, conductivity measurements, Kirchhoff's laws, Pressure of radiation, Stefan Boltzmann law. Wien's law, Rayleigh jeans law, Planck's law (qualitative analysis),Solar constant, temperature of sun, Solar spectrum.

UNIT4

Second law of thermodynamics: Kelvin Planck Statements, Entropy and its variation, State function, Engines-external and internal combustion engines-Carnot engine:-Steam engine, Gasoline engine, Diesel Engine; Stirling engine, Clausius statement of second law, Refrigerator, Equivalence of Kelvin-Planck and Clausius statement. Entropy:- entropy in reversible and irreversible process, Clausius inequality,TS diagram,

UNIT 5

Thermodynamical Potentials. Maxwell's Thermodynamical relations, Applications: Specific heat equation, Joule Thomson cooling, Temperature inversion, Clausius Clapeyron equation. Themodynamic Potentials; Relation with Thermodynamic variables, Tds equation, Heat capacity equations, Phasetransitions;First and second order, Pure substances: PV,PT,TS Phase diagram and PVT Surface . Applications of fundamental concepts, Mean free path, Equipartition of energy, Equilibrium distribution.

Text Book

1. M. W. Zemansky and R. H. DittmanAmit K. Chattopadhyay, Heat and Thermodynamics, 8th edition, Tata McGraw- Hill, 2011.
2. David Halliday, Robert Resnick, and Jearl Walker, Fundamentals of Physics,10th Edition, John Wiley, 2012.

References

1. Walter Greiner, Ludwig Neisse, Horst Stocker, Thermodynamics and statistical mechanics, 1st Ed, Springer, 1995,3rd reprint 2001 .
2. Sears.F.W and Salinger.G.L, Thermodynamics Kinetic Theory and Statistical Thermodynamics,3rd Ed, Addison Wesley,1998
3. Hugh.D. Young and Freedman, Sears& Zemansky's University Physics, 13th Ed, Pearson, 2013.
4. Richard P. Feynman, Robert. P. Leighton and Matthew Sands, Feynman Lectures on Physics, Vol.1, 1E, Narosa ,2008
5. P.K.Nag,Basic & Applied Thermodynamics,2nd edition McGraw Hill Education; 2017.

18PHY307ELECTRODYNAMICS3 1 0 4

Course Objective: Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: Electric Potentials, Boundary conditions, Maxwell's equations, Various techniques of solving Laplace equation, Electric field in matter, Magnetic field in matter, Maxwell's equations in matter, Poynting's Theorem, Maxwell's Stress Tensor, Conservation of Momentum, Angular momentum.

Unit 1

Review of electric potential, boundary conditions, Poisson's and Laplace equation, Laplace equation in one, two and three dimensions, Boundary conditions and Uniqueness theorem, Conductors and second Uniqueness theorem, Review of Electrostatics and Magnetostatics, Maxwell's equations, Maxwell's equations: Electrodynamics before Maxwell, Maxwell's correction to Ampere's law, Magnetic charge.

Unit 2

Techniques of solving Laplace equation, Numerical methods: Finite difference method, Relaxation method, other methods of finding the potentials: Method of images, Separation of variables, Spherical co-ordinates, Multipole expansion, Electric field of a dipole.

Unit 3

Electric field in matter: Induced dipoles, Polarization, Field of polarized Object, Bound charges, Physical interpretation of bound charges, Field inside a dielectric, Electric displacement, Linear dielectrics, Boundary value problem with linear dielectrics, Energy in dielectric systems, Force on dielectrics.

Unit 4

Magnetic field in matter: Diamagnets, Paramagnets, Ferromagnets. Torques and Forces on Magnetic dipoles, Effect of magnetic field on atomic Orbits, Magnetization, Bound currents, Physical interpretation of bound currents, Magnetic field inside matter, Ampere's law in magnetized materials, Linear and Nonlinear media: Magnetic susceptibility and permeability. Ferromagnetism.

Unit 5

Maxwell's equations in matter, Boundary conditions, Review of Maxwell's equations, The Continuity Equation, Poynting's Theorem, Newton's Third Law in Thermodynamics, Maxwell's Stress Tensor, Conservation of Momentum, Angular momentum.

Textbooks

1. Introduction to Electrodynamics – David J. Griffiths, 4^{th} Ed., Pearson Publication, 2015.
2. David Halliday, Robert Resnick, and Jearl Walker, Fundamentals of physics, 10^{th}Edition, John Wiley, 2017.

Reference books

1. Richard P. Feynman, Robert P. Leighton and Matthew Sands, Feynman Lectures on Physics Vol.1, 1E, Narosa Publishing House, 2008.

2. J.D. Jackson, Classical Electrodynamics, 3rd Ed., Wiley, 2007.

18PHY308Solid State Physics3 1 0 4

UNIT 1
Statistical mechanics: Statistical distribution, Maxwell Boltzmann statistics, Phase Space - molecular energies of an ideal gas, Quantum statistics: Rayleigh - Jeans Formula, Planck's radiation law, specific heat of solids, free electrons in a metal, Fermi energy and Fermi Dirac Statistics - electron-energy Distribution, Bose – Einstein condensate, Debye model of specific heat of solids.

UNIT 2
Crystal physics: Classification of crystals - Reflection and rotation symmetries - lattice and basis, unit cell and lattice parameters, primitive cell, Crystal Structures: Bravais lattice, calculation of atomic packing factor and coordination number for cubic and hexagonal close packed structure, directions, planes.

UNIT 3
Crystalline structure: Miller indices and its relation with Inter planar spacing, determination of crystalline structure: X-ray diffraction, electron-diffraction and neutron diffraction

UNIT 4
Electrons in periodic lattice: Bloch theorem, Kronnig Penny model. Classification of solids on the basis of band theory: metals, semiconductors and insulators, effective mass. Superconductivity (qualitative), bound electron pairs.

Unit 5
Dielectrics
Maxwell's equations, Macroscopic electric field, Depolarization field, Local electric field at an atom, Lorentz field, Dielectric constant and polarizability, Electronic polarizability, classical theory of Electronic polarizability, Ferroelectric crystals, antiferroelectricity and piezoelectricity.

Text books

1. Arthur Beiser, Concepts of Modern Physics, Tata McGraw- Hill,6th Ed., 2008
2. Robert Eisberg and Robert Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei and particles,2nd Ed., Wiley, Reprint: 2012
3. Charles Kittel, Introduction to Solid State Physics, Wiley, 8th Ed., Reprint: 2016.

Reference books

1. Kenneth Krane ,Modern Physics, 2nd Ed., John Wiley and Sons, 1996
2. Raymond A. Serway, Moses, Moyer, Modern Physics, 3rd Ed., Thomson Learning, 2005

3. T. Thornton and A. Rex, Modern Physics for Scientist and Engineers, 2nd Ed., Fort Worth: Saunders, 2000.

18PHY318 ATOMIC AND MOLECULAR PHYSICS 3 1 0 4

Unit 1

General discussion in Hydrogen spectra, Hydrogen-like systems, Spectra of monovalent atoms, quantum defect, penetrating and non-penetrating orbits, introduction to electron spin, spin-orbit interaction and fine structure, relativistic correction to spectra of hydrogen atom, Lamb shift.

Unit 2

Effect of magnetic field on the above spectra, Zeeman and Paschen-Back effect. Spectra of divalent atoms: Singlet and triplet states of divalent atoms.

Unit 3

Spectra of Multivalent atoms ideas only; complex spectra, equivalent electrons and Pauli Exclusion Principle.

Unit 4

Hyperfine structure in spectra of monovalent atoms, origin of X-rays spectra, screening constants, fine structure of X-ray levels, spin-relativity and screening doublet-laws, non-diagram lines, Auger effect.

Unit 5

Elements of Molecular Spectroscopy – Molecular Bond, Hydrogen Molecule, Complex Molecules, Rotational Energy Levels, Vibration Energy Levels, Electronic Spectra of Molecules.

TEXT / REFERENCE BOOKS

1. Introduction of Atomic Spectroscopy: White, McGraw-Hill Inc.US; 1st Edition, 1934.

2. Concepts of Modern Physics, Arthur Beiser, Tata McGraw Hill, 6th Edition, 2009.

18PHY319 Intermediate Mechanics 3 1 0 4

UNIT 1
Equations of Motion: Review of basic principles, Forces, Friction, Motion under Linear and Quadratic Viscous Drag, Relativistic Equations of Motion. Conservation of linear momentum, Dynamics of bodies of variable mass, Non relativistic rockets, Relativistic rockets.

UNIT 2
Conservation of Energy: Work & Kinetic Energy, Conservative forces, Potential Energy, Work Energy Theorem, Conservation of Energy, Energy Diagrams, Determining the Motion using Energy Integral. Relativistic Dynamics. **Gravitational Field:** Law of Gravitation,

Gravitational Field, Gravitational Potential, Gravitational Field Equations, Motion in a gravitational field.

UNIT 3

Rotational Dynamics ofRigid Bodies: Conservation of Angular momentum, Moment of Inertia, Rotational Kinetic Energy, Torque and Work-Energy Theorem, Properties of Centre of mass, Orthogonal Transformations, Euler Angles, Inertia Tensor, Parellel Axis Theorem, The Euler Equations.

UNIT 4

Accelerating Frames of References: Linearly accelerating Reference Frame, Rotating Coordinate Frame, Fictitious Forces, Coriolis Force, Tides, Foucault Pendulum.

UNIT 5

The Lagrangian Method: Calculus of Variation, The Lagrangian, Lagrange's Equations, Degrees of Freedom, Generalized momentum & Hamilton's Equations.

Text Books:

1. P. Hamill, Intermediate Dynamics, Jones & Bartlett, 2010.
2. David Morin, Introduction to Classical Mechanics, Cambridge University Press, 2008.

Reference Books:

1. John Taylor, Classical Mechanics, University Science Books, 1E, 2004.
2. S T Thomton and J B Marion, Classical Dynamics of Particles and Systems, Brooks Cole, 1E, 2009.
3. Walter Greiner, Classical Mechanics: Point Particles and Relativity, Springer – Verlag, 1E, 2004.

18PHY320 Modern Optics 3 1 0 4

Unit 1

Basics of Coherence theory: Introduction, spatial and temporal coherence, complex degree of coherence, partial coherence, stellar interferometer. Fourier Optics: transformers - One dimensional, two dimensional-dirac delta function, sines and cosines, Displacement and phase shifts, diffraction theory-Fourier method.

Unit 2

Laser - Fundamentals, Stimulated emission, Einstein's co-efficients, active medium, resonant cavities, Q-Switching, Mode locking, Types of lasers - Ruby Laser, He-Ne Laser, CO_2 laser and Semiconductor laser. Holography - fundamentals, construction and reconstruction of hologram.

Unit 3

Optoelectronic devices: LED, Characteristic of LED - Internal photon flux, Output photon flux, efficiency, Responsivity, Spectral distribution, Response time and device structure.

Unit 4

Characteristic of semiconductor photo detector - Quantum Efficiency, wave length dependence, Responsivity and Response time: Photo conductors, Photodiodes, PIN photodiodes.

Unit 5

Optical fibers and wave guides - Optical fiber, Critical angle of propagation, Mode of Propagation, Acceptance angle, Fractional refractive index change, Numerical aperture, Types of optical fiber, Normalized frequency, Pulse dispersion, Attenuation, optical fiber communication system, modulation and multiplexing, fiber optic networks.

TEXT BOOKS

1. Hecht, Eugene, Optics, 2ndEd, Addison Wesley, 1987.

2. A.K. Ghatak, Introduction to Modern optics, Tata McGraw Hill, 1972.

3. Bahaa E.A. Salesh, Fundamentals of photonics, 2nd Ed., Wiley Interscience, 2007.

REFERENCE BOOKS

1. Moller. K.D, Optics, University Science Books, 1988.

2. Richard P. Feynman, Robert. P. Leighton and Matthew Sands, Feynmann Lectures on Physics Vol.1, Narosa, 2003.

18PHY331 MEDICAL PHYSICS 3 0 0 3

Unit 1

Ultrasonics - production methods and properties - acoustic impedance - Doppler velocimetry - echo cardiography – resolution – speckle-ultrasound imaging - therapeutic use of ultrasound - use in diagnostics of cardiac problems.

Unit 2

X-rays – production – intensity - Hard and soft X-rays - Characteristic and continuous X-ray spectrum - attenuation of x-rays by hard and soft tissues – resolution – contrast-X-ray imaging - Fluoroscopy modes of operation - Image quality - Fluoroscopy suites - Radiation dose – Computer-aided tomography (CAT).

Unit 3

Nuclear medicine - Principles of Nuclear Physics – Natural radioactivity, Decay series, type of radiation and their applications, artificially produced isotopes and its application, accelerator principles; Nuclear Isomerism, Internal conversion - ideal energy for radiotherapy based on interactions. Radionuclide used in Medicine - radioisotope production – dosimetry – safety - radiation hazards – PET.

Unit 4

Nuclear magnetic resonance physics - magnetic moment – magnetization – relaxation- Nuclear magnetic resonance spectroscopy.

Nuclear magnetic resonance imaging (MRI) – principle - chemical shift - magnetic resonance signal induction and relaxation - pulse sequencing and spatial encoding.

Unit 5

Laser Physics – Characteristics of Laser radiation, mode locking - power of laser radiation - lasers as diagnostic tool - lasers in surgery - Laser speckle, biological effects, laser safety management.

TEXTBOOK:

Hendee W R and Rittenour E E, "Medical Imaging Physics", John Wiley & Sons, Chicago, 2001.

REFERENCE BOOKS:

- *Glasser.O. Medical Physics Vol.1,2,3 Book Publisher Inc Chicago, 1980*
- *Jerraold T Bush Berg etal, The essentials physics of medical imaging, Lippincott Williams and wilkins (2002)*

18PHY333INTRODUCTION TO NANOPHYSICS AND APPLICATIONS 3 0 0 3

Unit 1
Introduction: relation of nano to other sciences - chemistry, biology, astronomy, geology, nano in nature.

Unit 2
Properties of nanomaterials: size effect, particle's size, shape, and density, melting point, surface tension, wettability, surface area and pore, composite structure, crystal structure, surface characteristics; mechanical, electrical, properties, and optical properties.

Unit 3
Synthesis of nanoparticles: Classification of fabrication methods – top-to-bottom and bottom-to-top approaches, physical and chemical methods of preparation: CVD, controlled precipitation, sol-gel method, PLD etc; Confinement of particles - low dimensional structures - quantum wells, wires and dots.

Unit 4
Characterisation of nanoparticles: X-Ray diffraction, examples of XRD, Debye-Scherrer formula; FTIR: principle, methodologies and accessories; SEM: basics and primary mode of operation, applications; TEM: basic principles; STM: basic principles and instrumentation; AFM: basics, modes of operation and applications; Photoluminescence: basic principles.

Unit 5
Application of nanophysics: Carbon nanostructures: Fullerenes, CNTs and their applications; MEMS and NEMS devices; Quantum Cascade Lasers, Smart materials, GMR and Spintronic, multiferroics.

References:
1. Charles P Poole Jr. & Frank J Owens, Introduction to Nanotechnology, 1E, Wiley, 2007
2. W.R Fahner (Ed.), Nanotechnology and Nano electronics, Springer, 2006
3. M Hosokawa, et al, Nanoparticle Technology Handbook, Elsevier Publishers, 2007
4. S.V. Gaponenko, P.L Knight & A. Miller, Optical Properties of Semiconductor Nanocrystals, CUP, 1E, 2005
5. T Pradeep, Nano: The Essentials, TMH, 1E, 2007

18PHY335 BIOPHYSICS 3 0 0 3

Unit 1

Introduction: Laws of Physics and Chemistry, introduction to crystallography, Introduction to chromatography, electrophoresis Physico-Chemical Techniques to study Biomolecules: hydration of macromolecules, diffusion of osmosis, sedimentation, ultracentrifuge, rotational diffusion, light scattering, small angle X-ray scattering, Mass spectrometry.

Unit 2

Spectroscopy: UV spectroscopy, circular dichroism, Fluorescence spectroscopy, IR, Raman and Electron spin spectroscopy, NMR spectroscopy.

Unit 3

Molecular Modeling & Macromolecular Structure: building the structure of H_2O_2, nucleic acid structure, monomers, polymers, double helical structure of DNA, Polymorphism and-nanostructure of DNA, structure of RNA, protein structure: amino acids, virus structure.

Unit 4

Energy Pathways in Biology: free energy, couple reactions, group transfer potential, pyridinenucleotides, photosynthesis, energy conversion pathways, membrane transport. Biomechanics: strained muscles, mechanical properties of muscles, cardiovascular system.

Unit 5

Neurobiophysics: nervous system, physics of membrane potentials, sensory

mechanisms. Origin and evolution of life: prebiotic earth, theories of origin and evolution of life, laboratory experiments on formation of small molecules.

TEXTBOOKS:

2. "Cell and Molecular Biology - Concepts and Experiments" by G.Karp, 2nded. John Wiley & Sons, Inc. Singapore, 1999.
3. "Principles of Physical Biochemistry" by K.van Holde, W.C. Johnson, and P.S.Ho.Prentice Hall, 1998.

18PHY336 SPACE PHYSICS 3 0 0 3

Unit 1

Brief history of solar-terrestrial physics – The variables Sun and the heliosphere, Earth's space environment and upper atmosphere.

Unit 2

Space plasma physics - single particle motion, plasma state, Fluid description, MHD & kinetic theory, Applications

Unit 3

Solid wind & Interplanetary Magnetic field (IMF), Shocks and Instabilities in space

Unit 4

Solar wind interactions with magnetized planets - Introduction, planetary magnetic fields, spherical harmonic expansions, geomagnetic field and its measurements, variations in Earth's field.

Unit 5

Magnetosphere - Dynamics, SW-magnetosphere interactions; Ionospheres, Currents in space and Ionosphere; Neutral atmosphere -Dynamics.

Textbooks/References:

1. Hannu E.J. Koskinen, Physics of Space Storms, Springer, 2011
2. Molwin, M., An Introduction to Space Weather, CUP, 2008
3. Kallenrode, M.B., Space Physics: An introduction to plasmas and particles in the Heliosphere and Magnetosphers, Springer, 3e, 2004
4. Baumjohann, W. &Treumann, R.A., Basic Space Plasma Physics, Imperial College Press, 1997
5. Kivelson& Russell, Introduction to Space Physics, CUP, 1995

18PHY337ASTRONOMY 3 0 0 3

Unit 1

Astronomy, an Observational Science: Introduction - Indian and Western Astronomy– Aryabhatta - Tycho Brahe's observations of the heavens - The laws of planetarymotion - Measuring the astronomical unit - Isaac Newton and his Universal Law ofGravity - Derivation of Kepler's third law - The Sun - The formation of the solarsystem - Overall properties of the Sun - The Sun's total energy output – Blackbody radiation and the sun's surface temperature - The Fraunhofer lines in thesolar spectrum and the composition of the sun - Nuclear fusion - The proton–proton cycle - The solar neutrino problem - The solar atmosphere: photosphere,chromosphere and corona - Coronium - The solar wind - The sunspot cycle -Solar The Planets - Planetary orbits - Orbital inclination - Secondary atmospheres- The evolution of the earth's atmosphere.

Unit 2

Observational Astronomy -Observing the Universe - The classic Newtonian telescope - The Cassegraintelescope - Catadioptric telescopes - The Schmidt camera - The Schmidt–

Cassegraintelescope - The Maksutov–Cassegrain telescope - Active and adaptive optics - Some significant optical telescopes - Gemini North and South telescopes – TheKeck telescopes - The South Africa Large Telescope (SALT) - The Very LargeTelescope (VLT) - The Hubble Space Telescope (HST) - The future of opticalastronomy - Radio telescopes - The feed and low noise amplifier system – Radioreceivers - Telescope designs - Large fixed dishes - Telescope arrays – VeryLong Baseline Interferometry (VLBI) - The future of radio astronomy – Observingin other wavebands – Infrared – Sub-millimetre wavelengths - The Spitzer spacetelescope - Ultraviolet, X-ray and gamma-ray observatories - Observing the universewithout using electromagnetic radiation - Cosmic rays - Gravitational waves.

Unit 3

The Properties of Stars: Stellar luminosity - Stellar distances - The hydrogenspectrum - Spectral types - Spectroscopic parallax - The Hertzsprung–RussellDiagram - The main sequence - The giant region - The white dwarf region – Thestellar mass – luminosity relationship - Stellar lifetimes - Stellar Evolution – Whitedwarfs - The evolution of a sun-like star - Evolution in close binary systems –Neutron stars and black holes - The discovery of pulsars - Black holes: The MilkyWay - Open star clusters - Globular clusters - Size, shape and structure of theMilky Way – observations of the hydrogen line - Other galaxies - Elliptical galaxies
Spiral galaxies - The Hubble classification of galaxies - The universe – The Cepheid variable distance scale - Starburst galaxies - Active galaxies – Groups and clusters of galaxies – Superclusters - The structure of the universe - Cosmology – the Origin and Evolution of the Universe - The expansion of the universe - The cosmic microwave background - The hidden universe: dark matter and dark energy - The Drake equation - The Search for Extra Terrestrial Intelligence (SETI) - The future of the universe.

TEXTBOOK:

Introduction to Astronomy and Cosmology, Ian Morison, Wiley (UK), 2008

REFERENCE BOOK:

Astronomy: Principles and Practice, 4th Edition (Paperback), D. C. Clarke, A. E. RoyInstitute of Physics Publishing

18PHY338 COMPUTATIONAL METHODS FOR PHYSICISTS 3 0 0 3

Unit 1

Differentiation: Numerical methods, forward difference and central differencemethods, Lagrange’s interpolation method.

Unit 2

Integration: Newton-cotes expression for integral, trapezoidal rule, Simpson’srule, Gauss quadrature method.

Unit 3

Solution of Differential Equations: Taylor series method, Euler method, RungeKutta method, predictor - corrector method.

Unit 4

Roots of Equations: Polynomial equations, graphical methods, bisectional method,Newton-Raphson method, false position method.

Unit 5

Solution of simultaneous equations: Elimination method for solving simultaneouslinear equations, Gauss eliminations method, pivotal condensation method, Gauss-seidal iteration method, Gauss Jordan method, Matrix inversion method.

Eigen values and Eigen vectors of Matrix: Determinant of a matrix, characteristicequation of a matrix, eigenvalues and eigenvectors of a matrix, power method.

TEXTBOOK:

Rubin H Landau & Manuel Jose Paez Mejia, "Computational Physics", John Wiley & Sons

REFERENCE BOOKS:

1. *Suresh Chandra, "Computer Applications in Physics", Narosa Publishing House, New Delhi*

2. *M Hijroth Jensen, Department of Physics, University of Oslo, 2003 (Available in the Web)*

18PHY339 CONCEPTS OF NANOPHYSICS AND NANOTECHNOLOGY3 0 0 3

Unit 1

Introduction: Introduction to nanotechnology, Comparison of bulk andnanomaterials - change in band gap - novel properties of nanomaterial, classification of nanostructured materials. Synthesis of nanomaterials - Classification and fabrication methods - Top down and bottom up methods.

Unit 2

Concept of Quantum Confinement and Phonon Confinement: Basicconcepts - excitons, effective mass, free electron theory and its features, band structure of solids. Bulk to nano transition - Density of states, quantum confinement effect - weak and strong confinement regime. Electron confinement in infinitely deep square well, confinement in two and three dimension. Blue shift of band gap, Effective mass approximation. Vibrational properties of Solids - Phonon Confinement effect and presence of surface modes.

Unit 3

Tools for Characterization: Structural - X-ray Diffraction, Surface analysis-Transmission Electron Microscope, Scanning Tunneling Microscope, Atomic Force Microscope. Optical studies - UV - Visible absorption, Photoluminescence, Raman spectroscopy.

Unit 4

Nanostructured Materials: Properties and Applications. Carbon nanotube - structure,electrical, vibration and mechanical properties. Applications of carbon nanotubes - Field emission and Shielding - computers - Fuel cells - Chemical sensors - Catalysis - Mechanical reinforcement. Quantum dots and Magnetic nanomaterials – Applications.

Unit 5

Nanoelectronics and Nanodevices: Impact of nanotechnology on conventionalelectronics. Nanoelectromechanical systems (NEMSs) - Fabrication (Lithography) and applications. Nanodevices - Resonant Tunnelling Diode, Quantum Cascade lasers, Single Electron Transistors - Operating principles and applications.

TEXTBOOKS:

1. *Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, Nanoscale Science and Technology, John Wiley and Sons Ltd 2004.*
2. *W.R. Fahrner (Ed.), Nanotechnology and Nanoelectronics, Springer 2006.*

REFERENCE BOOKS:

1. *Charles P. Poole, Jr.Frank J. Owens, "Introduction to nanotechnology", A John Wiley 81 Sons, Inc., Publication*
2. *T. Pradeep, "Nano the essentials understanding nanoscience and nanotechnology", Professor Indian Institute of Technology, Madras, Chennai, India.*

18PHY340 INTRODUCTION TO PHOTONICS 3 0 0 3

Unit 1

Laser sources and detectors

Laser fundamentals - Einstein's coefficients, gain coefficient, laser rate equations, optical resonator, Q-factor and stability of optical resonator - modes of laser resonator, Q-switching and mode locking, Properties of lasers - coherence, line width and divergence,

Unit 2

Laser systems - Ruby laser, He-Ne laser, dye laser, Argon ion laser, free electron laser. Laser, applications - Material processing, holography, LIDAR, Biomedical applications, laser fusion, laser cooling and Bose-Einstein condensates - Photo detectors and display devices, photodiodes, APD, PMT, CCD, PIN photo diodes.

Unit 3

Optical fibre and its applications. Fibre Optics - classification of fibres - step index, graded index fibres, Numerical aperture, modes in optical fibre, single mode and multi-mode fibre, evanescent modes, losses in fibres - bending and coupling losses, dispersion in fibres, polarization maintaining fibres.

Unit 4

Fibreoptic sensors - advantages of FOS, intensity modulated sensors, interferometric sensors, rotation sensors, biosensors - Optical Communication - Optical communication - advantages, modulation, time division and wave length multiplexing.

Unit 5

Physical origin of nonlinear optical coefficients, second order optical nonlinearity, propagation of EMW through NLO medium, optical second harmonic generation, phase matching conditions, Third order NLO, intensity dependent refractive index, Four wave mixing and optical phase conjugation.

REFERENCES:

1. *Photonics: Optical Electronics in Modern communication (6th Edition, 2007), Ammon Yariv, Pochi yeh, oxford university.*
2. *Lasers: Fundamentals and Applications (2nd Edn (1981), Springer (New York)*
3. *Quantum Electronics (3rd Edn), 1989, Amman Yariv, John Wiley & Sons*

18PHY342 NONLINEAR OPTICS 3 0 0 3

Unit 1

Introduction to Nonlinear Optics: Brief review of electromagnetic waves – Wave propagation in an anisotropic crystal - Nonlinear optical effects - Polarization response of materials to light, Harmonic generation.

Unit 2

Second order effects: Second harmonic generation - Sum and differencefrequency generation - Phase matching - Parametric amplification, parametric fluorescence and oscillation; Concept of quasi-phase matching; Periodically poled materials and their applications in nonlinear optical devices.

Unit 3

Third order effects: Third harmonic generation – bistability - self focusing, Self-Phase modulation, Temporal and spatial solitons, Cross Phase modulation, four wave mixing, Phase conjugation.

Unit 4

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

Unit 5

Nonlinear Optical Materials: Basic requirements - Inorganics - Borates – Organics Urea, Nitro aniline - Semi organics - Thiourea complex - X-ray diffraction FTIR, FINMR- Second harmonic generation - Laser induced surface damage threshold.

TEXTBOOKS:

1. Robert W. Boyd, Nonlinear Optics, 2nd Ed., Academic Press, 2003.

2. D.L. Mills, Nonlinear Optics – Basic Concepts, Springer, 1998.

3. B.B. Laud, Lasers and Nonlinear Optics, 2nd Ed. New Age International (P) Ltd., 1991.

REFERENCE BOOKS:

1. A Yariv, Quantum Electronics, John Wiley, NY, 1989.

2. A Ghatak and K Thyagarajan, Optical Electronics, Cambridge Univ Press, 1989.

3. Scully and M S Zubairy, Quantum optics, Cambridge Univ. Press, 1997.

18PHY343 OPTICAL ENGINEERING 3 0 0 3

Unit 1

Review of Geometrical Optics, Gaussian optics, geometrical aberrations: Review of Physical Optics: waves, Interference – Young's experiment, fringe visibility, Michelson interferometer, Mach-Zehnder interferometer, two beam interference, multiple beam interference and optical thin film: Diffraction – Fraunhofer and Frenel diffractions, Fresnel–Kirchoff integral, Fourier transform in Fraunhofer diffraction, Fresnel zone plate, spatial and temporal coherence and coherence Measurement, Polarisation, Black Body radiation, Quantum nature of light.

Unit 2

Introduction to optical instruments: magnifiers, telescopes and microscopes, the human

eye and projection systems as optical instruments, optical components: principles and operations of light sources – Lamps, LED, lasers and super continuum sources, principles and operation of detectors – photoconductive detectors, photodiodes, photomultipliers, IR detectors, charge-coupled devices and detector arrays, noise and sensitivity of detectors, Recording media, Prisms, Gratings, Polarizing elements.

Unit 3

Spatial light modulators: acousto-optic modulators, magneto-optic modulators, pockel's readout optical modulators, liquid crystal light valves, micro channel plate spatial light modulators, Photoplastics devices, deformable mirror array devices, optical discs and photorefractive crystals.

Unit 4

Holography; on axis holography, off–axis holography, holographic magnifications, reflection holography, rainbow holography, one-step rainbow holograms, colour holography and photorefractive holograms.

Unit 5

Signal processing: optical system under coherent and incoherent illumination, coherent optical signal processing, spatial filter, joint transform correlator, white-light optical signal processing, hybrid optical signal processing and photorefractive matched filters: fiber optics; fiber construction, fiber waveguides, types of optical fiber, optical fiber communications – fiber communication systems, splices and connectors, couplers and switches, time and wavelength – division multiplexing, coherent light wave communication, and fibre sensors.

REFERENCES:

- *FTS Yu and X.Yang, Introduction to optical engineering, Cambridge Univ. press (1997)*
- *Sirohi, R S and Kothiyal, M.P.Optical Components, Measurement techniques, and systems, Marcel Dekker, Inc., New York (1991).*
- *Malacara, D. Geometrical and Instrument Optics. (Vol 25. Methods of experimental*

18PHY344 PHYSICS OF SEMICONDUCTOR DEVICES 3 0 0 3

Unit 1

Unit cell, Bravais lattices, crystal systems, Crystal planes and Miller indices, symmetry elements. Defects and imperfections – Point defects, line defects, surface defects and volume defects.

Unit 2

Electrical Conductivity: Classical free electron theory – Assumptions, drift velocity,mobility and conductivity, drawbacks. Quantum free electron theory – Fermi energy, Fermi factor, carrier concentration. Band theory of solids – origin of energy bands, effective mass, distinction between metals, insulators and semiconductors.

Unit 3

Theory of Semiconductors:Intrinsic and extrinsic semiconductors, band structure of semiconductors, carrier concentration in intrinsic and extrinsic semiconductors, electrical conductivity and conduction mechanism in semiconductors, Fermi level in intrinsic and extrinsic semiconductors and its dependence on temperature and carrier concentration. Carrier generation - recombination, mobility, drift-diffusion current. Hall effect.

Unit 4

Theory of p-n junctions – diode and transistor: p-n junction under thermal equilibrium, forward bias, reverse bias, carrier density, current, electric field, barrier potential. V-I characteristics, junction capacitance and voltage breakdown - Bipolar junction transistor, p-n-p and n-p-n transistors: principle and modes of operation, current relations. V-I characteristics. Fundamentals of MOSFET, JFET. Heterojunctions – quantum wells.

Unit 5

Optical devices: optical absorption in a semiconductor, e--hole generation. Solar cells – p-n junction, conversion efficiency, heterojunction solar cells. Photo detectors– photo conductors, photodiode, p-i-n diode. Light emitting diode (LED) – generation of light, internal and external quantum efficiency.

Modern Semiconducting Devices: CCD-Introduction to nano devices, fundamentals of tunneling devices, design considerations, physics of tunneling devices.

TEXTBOOKS:

1. C Kittel, "Introduction to Solid State Physics", Wiley, 7th Edn. 1995.

2. DA Neamen, "Semiconductor Physics and Devices", TMH, 3rd Edn. 2007.

REFERENCES:

1. SM Sze, "Physics of Semiconductor Devices", Wiley, 1996.

2. P Bhattacharya, "Semiconductor Opto-Electronic Devices", Prentice Hall, 1996.

3. MK Achuthan & KN Bhat, "Fundamentals of Semiconductor Devices", TMH, 2007.

4. J Allison, "Electronic Engineering Materials and Devices", TMH, 1990.

18PHY345 PRINCIPLES OF LASERS AND LASER APPLICATIONS 3 0 0 3

Unit 1

Review of basic concepts and principles of laser: Introduction to light and its properties: Reflection, Refraction, Interference, Diffraction and Polarization. Photometry – calculation of solid angle. Brewster's law. Snell's law and, its analysis.

Introduction to Lasers: Interaction of radiation with matter - Induced absorption, spontaneous emission, stimulated emission. Einstein's co-efficients. Active material. Population inversion – concept and discussion about different techniques. Resonant cavity.

Unit 2

Gain mechanism, Threshold condition for population inversion, Emission broadening-line width, derivation of FWHM. Natural emission line width as deduced by quantum mechanics - Additional broadening process: collision broadening, broadening due to dephasing collision, amorphous crystal broadening, Doppler broadening and broadening in gases due to isotope shifts. Saturation intensity of laser, condition to attain saturation intensity.

Properties – Coherence, Intensity, directionality, monochromaticity and Focussibility.

Laser transition – Role of electrons in laser transition, levels of laser action: 2 level, 3 level and 4 level laser system.

Unit 3

Types of Lasers: Solid State lasers: (i) Ruby laser – Principle, Construction, working and application. (ii) Neodymium (Nd) lasers. Gas laser: (i) He-Ne laser - Principle, Construction, working and application. (i) CO2 laser - Principle, Construction, working and application.

Liquid Chemical and Dye lasers. Semiconductor laser: Principle, Characteristics, Diode lasers, homo-junction and hetero-junction lasers, high power semi-conductor diode lasers.

Unit 4

Applications in Communication field: Laser Communication: Principle, construction, types, modes of propagation, degradation of signal, Analogue communication system, digital transmission, fiber optic communication.

Unit 5

Applications of lasers in other fields: Holography: Principle, types, intensity distribution, applications. Laser induced fusion. Harmonic generation. Laser spectroscopy. lasers in industry: Drilling, cutting and welding. Lasers in medicine: Dermatology, cardiology, dentistry and ophthalmology.

REFERENCES:

1. William T Silfvast, "Laser Fundamentals",2nd Ed., Cambridge University Press, UK (2008).

2. BB Laud, "Lasers and Non-linear Optics", New Age International (P) Ltd., New Delhi. (2011)

3. Andrews, "An Introduction to Laser Spectroscopy (2e)", Ane Books India (Distributors).

4. KR Nambiar, “Lasers: Principles, Types and Applications”, New Age International (P) Ltd., New Delhi (2009).
5. T Suhara, “Semiconductor Laser Fundamentals”, Marcel Dekker (2004).

18PHY346 Laser Theory 3 0 0 3

Unit 1
Thermal radiation: factors influencing coherence. Radiation in Vacuum: intensity, energy density and pressure of radiation. Radiation in a cavity: Modes of oscillation, black body radiation.
Unit 2
Radiation and Matter: mass and atomic absorption coefficients, Einstein coefficients, photo excitation cross- section, lifetimes of excited states, amplification of radiation, spectral line shapes, and line broadening mechanisms, grain profiles, threshold condition, gain saturation.
Unit 3
Optical Resonators: Fresnel number, time constant and Q factor of an optical cavity. Geometric theory : plane and spherical mirror resonator configurations, general conditions of stability, matrix treatment. Wave theory II confocal multimode resonators and fields, non confocal resonators, circular mirrors, spherical annular mirrors, unstable resonators, mode degeneracy, ring resonators.
Unit 4
Gain and saturation effects: Theory of gain saturation. Gain narrowing. Effect of gain saturation on modes. Power output, single mode operation, mirror transition and power optimization. Hole burning effects. Lab dip. Mode pulling, frequency bandwidth of laser output.
Unit 5
Q-modulation : High inversion fast switching case. Arbitrary inversion fast switching case, giant pulse dynamics. Mode locking: Generation and measurement of ultra short optical pulses. dynamics of mode locking, efficiencies of mode locking. Cavity dumping. Pulse amplification: Limitations of peak power. Pulse shortening. Amplified spontaneous emission and mirror-less lasers.

References :
1. A. Maitland and M.H. Dunn, Laser Physics, North Holland (1970).
2. A. Yariv, Quantum Electronics, John Wiley (1975).
3. M. Sargent III, Marian O Scully, and W.E. Lamb, Laser Physics, Addison-Wesley (1974).
4. W.V. Smith and P.P. Sorokin, The Laser, McGraw-Hill (1966).
5. J. T. Verdeyen, Laser Electronics, Prentice Hall (1981).
6. A. Yariv, Optical Electronics, Holt Rinehart & Winston (1976).
7. Laser Theory, Encylopedia of Physics, Vol. 25/20, Springer (1984).
8. D.C.O. Shea, W.R. Callen and W.T. Rhodes, Introduction to Lasers and Their Applications, Addison Wesley (1978).
9. O. Svelto, Principles of Lasers, Plenum (176).

18PHY347 Laser Applications 3 0 0 3

Unit 1
Characteristics of laser radiation. Propagation of Gaussian beams
Holography, HNDT (Holographic Non -Destructive Testing) holographic storage, optical disk storage.
Laser speckle and speckle meteorology, SNDT (Speckle Non - Destructive Testing).

Unit 2
Optical computing and signal processing, fiber optical communication, Robotics, laser- based guidance and control.
Unit 3
Spectroscopic applications of lasers: saturation spectroscopy, excited state spectroscopy non-linear spectroscopy, time domain and its applications.
Unit 4
Lasers and interaction with matter: materials processing, cutting, drilling, welding, alloying, glazing, oblation, laser chemical vapour deposition (LCVD), laser thermal deposition, hardening, annealing.
Laser fusion, Isotope separation, Medical applications, photo-chemical applications
Unit 5
Fiber-optic sensors: intensity, phase, polarization and frequency dependent techniques.
Laser Doppler Anemometry .principles, two-component measurement technique.
Lasers as frequency standards

References :

1. Monte Ross (Ed.), Laser Applications, Vol.1,Academic Press (1971).
2. S. Dubois and F.T. Arecchi (Ed.), Laser Handbook, Vols. 1-4, Nor1h Holland (1972).
3. K. Koebner (Ed.), Industrial Applications of Lasers, Wiley (1984)
4. J.T. Cuxon and D.E. Parker, Industrial Lasers and their Applications, Prentice Hall (1985).
5. B. Culshaw, Optial Fiber Sensing and Signal Processing, Peter Peregrinus Ltd. (1984).
6. F.C. Appard, Fiber Optics Handbook, McGraw-Hill (1989)

18PHY384 PHYSICS LAB IV - MODERN PHYSICS 0 0 2 1

1. Studying the Energy gap of semiconductors
2. To estimate the value of Planck's constant
3. To estimate the value of Rydberg's constant
4. Estimation of Charge of electron – Thomson's method
5. Studying the Hall Effect and estimation of Hall voltage, Hall Coefficient and number of charge carriers.
6. Studying the characteristic of Photoelectric effect.
7. Studying the characteristic of solar cell Studying the characteristic of photodiode, photo transistor, LDR and opto coupler
8. Studying the thermal Expansion of crystal Using Interference fringes.
9. Michelson Interferometer – to find the refractive index of transparent material.
10. Fabry Perot Interferometer

18PHY385 Physics Lab. V Electronics 0 0 2 1

1. Design and performance study of active filters (Low pass, high pass, band pass, band rejection)
2. Characteristic of Zener diode, and voltage regulation using Zener diode (Line and load regulation).
3. bridge rectifier and regulator circuits using CRO

4. Construction of Power supply, Dual supply with 12 V - IC regulator
5. Study of frequency response of transistor amplifier.
6. Basic Opp –amp circuits- Inverting and non inverting amplifier, Summing and difference amplifier
7. Multi vibrators Astable, Monostable and Bistable- Using 555 -Timers
8. Combination of gate universal- NAND and NOR as universal building blocks and verification of DeMorgan's theorem
9. Flip flop s ,RS JK Master slave
10. Half adder and Subtractor
11. Counters 4 bits
12. Encoders and Decoders 4 bits
13. full adder IC 7483s
14. Registers 4 bits

18PHY399 PROJECT 6 cr

Students who want to exercise the exit-option at the end of the sixth semester shall decide on it at the end of the fourth semester. These students shall execute a project and earn six credits. The proposed project work will get initiated at the beginning of the fifth semester and is to be credited during the sixth semester. The project work involves simple experimental/ simulation methods in various research and development institutes or existing research laboratories at university departments for solving research problems. The project work will be supervised by a faculty from physics department and periodical reviews of the work accomplished will be conducted by a panel involving minimum of three faculty members. The student should give a presentation of the work carried out at the end of the sixth semester to a panel of experts.

18PHY501 Classical Mechanics 3 1 0 4

UNIT 1

Constrained Motion: Constraints, Classification of Constraints, Principal of Virtual Work, D'Alembert's principal and its applications.

UNIT 2

Lagrangian formulation: Generalized coordinates, Langrange's equations of motion, properties of kinetic energy function, theorem on total energy, generalized momenta, cyclic-coordinates, integrals of motion, Jacobi integrals and energy conservation, Concept of symmetry, invariance under Galilean transformation, velocity dependent potential.

UNIT 3

Hamilton's formulation: Hamilton's function and Hamilton's equation of motion, configuration space, phase space and state space, Lagrangian and Hamiltonian of relativistic particles and light rays.

UNIT 4

Canonical Transformations: Generating function, Conditions for canonical transformation and problem. **Poisson Brackets:** Definition, Identities, Poisson theorem, Jacobi-Poisson theorem, Jacobi identity,(Statement only), invariance of PB under canonical transformation.

UNIT 5

Central Force Problem: Kepler's laws, Orbital Dynamics, Stability

Rotational Motion: Rotating frames of reference, inertial forces in rotating frames, Larmour precision, electromagnetic analogy of inertial forces, effects of Coriolis force, Focoult's pendulum.

Text Books:

H. Goldstein, Classical Mechanics, Addison – Wesly, 2E, 1980.

Reference Books:

1. Landau and Lifshitz, Mechanics, Butterworth-Heinemann, 3, 1976
2. S T Thomton and J B Marion, Classical Dynamics of Particles and Systems, Brooks Cole, 1E, 2009
3. Walter Greiner, Classical Mechanics: Systems of Particle and Hamiltonian Dynamics, Springer – Verlag, 1E, 2004

18PHY502 Quantum Mechanics I 3 1 0 4

Objective

The course emphasize the students to familiarise the mathematical background (Hilbert space) required to understand the basic and applied quantum mechanics. The course further emphasize the students to understand the basic postulate and standard one dimensional problems of quantum mechanics. As outcome of the course, the students is expected to solve physical problems in few selected topics like quantum angular momentum, one and two body problems etc,.

UNIT 1:

Mathematical Introduction

Linear Vector Spaces : Basics, Inner Product Spaces , Dual Spaces and the Dirac Notation, Subspaces, Linear Operators, Matrix Elements of Linear Operators, Active and Passive Transformations, The Eigenvalue Problem, Functions of Operators and Related Concepts, Generalization to Infinite Dimensions.

UNIT 2:

Review of Classical Mechanics

The Principle of Least Action and Lagrangian Mechanics, The Electromagnetic Lagrangian, The Two-Body Problem, The Hamiltonian Formalism, The Electromagnetic Force in the Hamiltonian Scheme, Cyclic Coordinates, Poisson Brackets, and Canonical Transformations, Symmetries and Their Consequences

The Postulates of Quantum Mechanics

The Postulates, Discussion of Postulates I-III, The Schrödinger Equation, The Free Particle, The Particle in a Box, The Continuity Equation for Probability, The Single-Step Potential, The Double-Slit Experiment, Absence of degeneracy in one dimensional bound states, Ehrenfest's theorem.

UNIT 3:
The Harmonic Oscillator
Review of the Classical Oscillator, Quantization of the Oscillator (Coordinate Basis), The Oscillator in the Energy Basis, Passage from the Energy Basis to the X Basis.
Derivation of the Uncertainty Relations. (2 hours)

UNIT 4:
Systems with N Degrees of Freedom
N- Particles in One Dimension, More Particles in More Dimensions, Identical Particle
Symmetries and Their Consequences
Overview, Translational Invariance in Quantum Theory, Time Translational Invariance, Parity Invariance, Time-Reversal Symmetry

UNIT 5:
Rotational Invariance and Angular Momentum
Translations in Two Dimensions, Rotations in Two Dimensions, The Eigenvalue Problem of Angular Momentum in Three Dimensions, The Eigenvalue Problem of L^2 and L_z . Solution of Rotationally Invariant Problems
The Hydrogen Atom
The Eigenvalue Problem, The Degeneracy of the Hydrogen Spectrum, Numerical Estimates and Comparison with Experiment, Multi electron Atoms and the Periodic Table.

Text Books:
1. R Shankar, Principles of Quantum Mechanics, Pearson India (LPE), 2nd Ed., 2005.
2. JJ Sakurai, Modern Quantum Mechanics, Pearson, 1st Ed., 1994.

Referene Books:
- S Gasiorowicsz, Quantum Physics, Wiley India, 2E
- L I Schiff, Quantum Mechanics, TMH, 3E, 2010.
- David Griffiths, Introduction to Quantum Mechanics, Pearson India (LPE), 2E, 2005.

18PHY503 Mathematical Physics 1 3 1 0 4

UNIT 1:
VECTOR ANALYSIS:
Laws of vector algebra, Unit vectors, Rectangular unit vectors, Components of a vector, Scalar fields, Vector fields, Reciprocal sets of vectors, Ordinary derivatives of vectors, Space curves, Continuity and differentiability, Differen-tiation formulas, Partial derivatives of vectors Differentials of vectors, Differential geometry, Mechanics.
The vector differential operator del, Gradient, Divergence, Curl, Formulas involving del, Ordinary integrals of vectors, Line integrals, Surface integrals, Volume integrals, Divergence theorem of Gauss, Stokes' theorem, Green's theorem in the plane, integral theorems, Integral operator form for del.

Unit- II
Transformation of coordinates, Orthogonal curvilinear coordinates, Unit vectors in curvilinear systems, Arc length and volume elements, Gradient, divergence and curl, Special orthogonal coordinate systems, Cylindrical coordinates,
Spherical coordinates, Parabolic cylindrical coordinates, Paraboloidal coordinates, Elliptic cylindrical coordinates, Prolate spheroidal coordinates, Oblate spheroidal coordinates,

Ellipsoidal coordinates, Bipolar coordinates.

Unit- III
TENSOR ANALYSIS:
Physical laws, Spaces of N dimensions, Coordinate transformations, The summation convention, Contravariant and covariant vectors, Contravariant, covariant and mixed tensors. The Kronecker delta. Tensors of rank greater than two. Scalars or invariants.
Tensor fields. Symmetric and skew-symmetric tensors. Fundamental operations with tensors. The line element and metric tensor.
Conjugate or reciprocal tensors. Associated tensors. Physical components. Christoffel's symbols. Transformation laws of Christoffel's symbols. Geo-desics. Covariant derivatives. Permutation symbols and tensors. Tensor form of gradient, divergence and curl. The intrinsic or absolute derivative. Relative and absolute tensors.

Unit- IV
GROUP THEORY Part – 1:
Elements of Group Theory :
Correspondences and transformations, Groups. Definitions and examples, Subgroups. Cayley's theorem, Cosets, Lagrange's theorem, Conjugate classes, Invariant subgroups, Factor groups, Homomorphism, Direct products.
Symmetry Groups :
Symmetry elements. Pole figures, Equivalent axes and planes, Two-sided axes, Groups whose elements are pure rotations, uniaxial groups, dihedral groups, The law of rational indices, Groups whose elements are pure rotations, Regular polyhedra, Symmetry groups containing rotation reflections, Adjunction of reflections to Cn, Adjunction of reflections to the groups Dn, The complete symmetry groups of the regular polyhedra, Summary of point groups. Other systems of notation, Magnetic symmetry groups (color groups).

Unit- V
Group Representations:
Linear vector spaces, Linear dependence; dimensionality, Basis vectors (coordinate axes), coordinates Mappings, linear operators, matrix representations, equivalence, Group representations, Equivalent representations, characters, Construction of representations, Addition of representations, Invariance of functions and operators, lassification of eigenfunctions, Unitary spaces; scalar product, unitary matrices, Hermitian matrices.

Unitary representations, Hilbert space, Analysis of representations, reducibility, irreducible representations. Schur's lemmas, The orthogonality relations, Criteria for irreducibility. Analysis of representations. The general theorems. Group algebra, Expansion of functions in basis functions of irreducible representations. Representations of direct products.

Text Books:

1. Murray R Spiegel, Seymour Lipschutz, Schaum's Outline of Vector Analysis, 2nd Ed., Schaums' Outline Series, 2009.
2. Murray Spiegel, Vector Analysis And An Introduction To Tensor Analysis, Tata Mcgraw Hill. 1989
3. Morton Hamermesh, Group Theory and its Application to Physical Problems, Reprint Ed., Addison-Wesley Publishing Company Inc. 1989.
4. Arfken & Weber, Mathematical Methods for Physicists, Elsevier Indian Reprint, 7th Ed., 2012.

Reference Books:

* Riley K F, Hobson M P, Bence S J, Mathematical Methods for Physics and Engineering, CUP, 3E, 2010
* M Boas, Mathematical Methods in Physical Sciences, Wiley Indian Reprint 3E, 2006.
* Mathews J and Walker R L, Mathematical Methods of Physics, Pearson India, 2E, 2004.

18PHY504 Computational Physics 3 1 0 4

Course Objective: The objective of the Computational Physics course is to introduce the students to computational methods, to solve problems in physics which are hard to solve analytically. Therefore, the course is designed to make students think of programming as a way to learn physics, learn how to approach a problem computationally. It covers examples from various important core branches of Physics such as Mathematical Physics, Mechanics, Heat and Thermodynamics, Electrodynamics, Quantum Mechanics and Statistical Mechanics. The objective is to introduce computational techniques by considering one or two pedagogical examples in each of these fields and is by no means exhaustive. Students are therefore encouraged to work out further examples to consolidate their understanding of the subject through computational means.

Prerequisite: 1) Problem solving and computer programming: Introduction to Python 2) Introduction to Computational Physics.

Unit I
Methods of Mathematical Physics and introduction to programming languages: Python, Fortran/Matlab.

Unit II
Mechanics, Heat and Thermodynamics: Optimisation techniques, finite element and finite volume methods. Introduction to heat transfer.

Unit III
Electrodynamics: Boundary value problems, Solutions to Laplace Equations, finite difference method, relaxation methods. Calculations of magnetic field in a solenoid and Helmholtz coil.

Unit IV
Solutions for Quantum Mechanical problems: Functions as vectors, Differential operators as matrices, 1D potential well. Step Potentials.

Unit V
Advanced topics: Monte Carlo method for atomic collisions: Introduction to Monte Carlo method, Random Numbers, Distribution Functions, Monte-Carlo Integration, application to Coulomb collisions.

Text / Reference books

1. P. Hamill, Intermediate Dynamics, Jones & Bartlett, 2010.
2. David Morin, Introduction to Classical Mechanics, Cambridge University Press, 2008.
3. Lecture notes -Numerical Methods in Quantum Mechanics - Paolo Giannozzi, 2017. (http://www.fisica.uniud.it/~giannozz/Corsi/MQ/LectureNotes/mq.pdf)
4. Computational Electrodynamics: The Finite-Difference Time-Domain Method - Allen Taflove, Susan C. Hagness, Artech. House, 2005

18PHY511 Quantum Mechanics II3 1 0 4

Objective

The course emphases the students to familiarise the application of quantum mechanical postulates on single, multi body problems and method of approximations etc,.

UNIT 1:
Spin
Introduction, Nature of Spin, Kinematics of Spin, Spin Dynamics, Return of Orbital Degrees of Freedom.

UNIT 2:
Addition of Angular Momenta
Example, The General Problem, Irreducible Tensor Operators, Explanation of Some "Accidental" Degeneracies.
Variational and WKB Methods
The Variational Method, The Wentzel-Kramers-Brillouin Method.

UNIT 3:
Time-Independent Perturbation Theory
The Formalism, Some Examples, Degenerate Perturbation Theory

Time-Dependent Perturbation Theory
The Problem, First-Order Perturbation Theory, Higher Orders in Perturbation Theory, A General Discussion of Electromagnetic Interactions, Interaction of Atoms with Electromagnetic Radiation.

UNIT 4:
Scattering Theory
Introduction, Recapitulation of One-Dimensional Scattering and Overview, The Born Approximation (Time-Dependent Description), Born Again (The Time-Independent Approximation). The Partial Wave Expansion, Two-Particle Scattering.

UNIT 5:
The Dirac Equation
The Free-Particle Dirac Equation, Electromagnetic Interaction of the Dirac Particle, More on Relativistic Quantum Mechanics.
TEXT BOOKS:
1. *R Shankar, Principles of Quantum Mechanics, Pearson India (LPE), 2E 2005*
2. *JJ Sakurai, Modern Quantum Mechanics, Pearson, 1E, 1994*

REFERENCE BOOKS:
1. S Gasiorowicsz, Quantum Physics, Wiley India, 2E
2. L I Schiff, Quantum Mechanics, TMH, 3E, 2010
3. David Griffiths, Introduction to Quantum Mechanics, Pearson India (LPE), 2E, 2005

18PHY512 Mathematical Physics II3 1 0 4

UNIT 1:
GROUP THEORY Part – 2:

Irreducible Representations of the Point Symmetry Groups, Abelian groups, Nonabelian groups, Characterables for the crystal point groups, Operations with Group, Representations, Product representations (Kronecker products), Symmetrized and antisymmetrized products, The adjoint representation. The complex conjugate representation, conditions for existence of invariants, Real representations, The reduction of Kronecker products. The Clebsch-Gordan series, Clebsch-Gordan coefficients, Simply reducible groups, Three-j symbols.

Physical Applications :

Classification of spectral terms, Perturbation theory, Selection rules, coupled systems. The Symmetric Group, The deduction of the characters of a group from those of a subgroup, Frobenius' formula for the characters of the symmetric group. Graphical methods, Lattice permutations, Young patterns, Young tableaux, Graphical method for determining characters, Recursion formulas for characters, Branching laws, Calculation of characters by means of the Frobenius formula, The matrices of the irreducible representations of Sn.

Yamanouchi symbols, Hund's method, Group algebra, Young operators, The construction of product wave functions of a given symmetry, Fock's cyclic symmetry conditions, Outer products of representations of the symmetric group, Inner products. Clebsch-Gordan series for the symmetric group, Clebsch-Gordan (CG) coefficients for the symmetric group.
Symmetry properties, Recursion formulas.

Unit – II
Continuous Groups:

Summary of results for finite groups, Infinite discrete groups, Continuous groups, Lie groups, Examples of Lie groups, Isomorphism. Subgroups. Mixed continuous groups, One-parameter groups, Infinitesimal transformations, Structure constants, Lie algebras, Structure of Lie algebras, Structure of compact semisimple Lie groups and their algebras, Linear representations of Lie groups, Invariant integration, Irreducible representations of Lie groups and Lie algebras,
The Casimir operator, Multiple-valued representations. Universal covering group.

Axial and Spherical Symmetry, The rotation group in two dimensions, The rotation group in three dimensions, Continuous single-valued representations of the three-dimensional rotation group, Splitting of atomic levels in crystalline fields (single-valued representations), Construction of crystal eigenfunctions, Two-valued representations of the rotation group, The unitary unimodular group in two dimensions, Splitting of atomic levels in crystalline fields, Double-valued, representations of the crystal point groups, Coupled systems, Addition of angular momenta. Clebsch-Gordan coefficients.

Unit – II
Linear Groups in n-dimensional Space:

Irreducible Tensors, Tensors with respect to GL(n), The construction of irreducible tensors with respect to GL(n), The dimensionality of the irreducible representations of GL(n), Irreducible representations of subgroups of U(n), SU(n), The orthogonal group in n dimensions, Contraction, Traceless tensors, The irreducible representations of 0{n), Decomposition of irreducible representations of JJ{n) with respect to 0+{n), The symplectic group Sp(ri), Contraction, Traceless Tensors, The irreducible representations of Sp(n), Decomposition of irreducible representations of U(n) with respect to its simplistic subgroup.

Applications to Atomic and Nuclear Problems (Optional) 1#
The classification of states of systems of identical particles according to SU(n), Angular

momentum analysis, Decomposition of representations of SU(n) into representations of 0+(3), The Pauli principle, Atomic spectra in Russell-Saunders coupling, Seniority in atomic spectra, Atomic spectra in jj-coupling, Nuclear structure, Isotopic spin, Nuclear spectra in L-S coupling, Supermultiplets, The L-S coupling shell model, The jj-coupling shell model, Seniority in jj-coupling.

COMPLEX VAIRABLES:

COMPLEX NUMBERS :

The Real Number System, Graphical Representation of Real Numbers, The Complex Number System, Fundamental Operations with Complex Numbers, Absolute Value, Axiomatic Foundation of the Complex Number System, Graphical Representation of Complex Numbers, Polar Form of Complex Numbers, De Moivre's Theorem, Roots of Complex Numbers, Euler's Formula, Polynomial Equations, The n th Roots of Unity, Vector Interpretation of Complex Numbers, Stereographic Projection, Dot and Cross Product, Complex Conjugate Coordinates, Point Sets.

Unit –IV
FUNCTIONS, LIMITS, AND CONTINUITY:

Variables and Functions, Single and Multiple-Valued Functions, Inverse Functions, Transformations, Curvilinear Coordinates, The Elementary Functions, Branch Points and Branch Lines, Riemann Surfaces, Limits, Theorems on Limits, Infinity, Continuity, Theorems on Continuity, Uniform Continuity, Sequences, Limit of a Sequence, Theorems on Limits of, Sequences, Infinite Series.

C**OMPLEX DIFFERENTIATION AND THE CAUCHY–RIEMANN EQUATIONS:**

Derivatives, Analytic Functions, Cauchy–Riemann Equations, Harmonic Functions, Geometric Interpretation of the Derivative, Differentials, Rules for Differentiation, Derivatives of Elementary Functions, Higher Order Derivatives, L'Hospital's Rule, Singular Points, Orthogonal Families, Curves Applications to Geometry and Mechanics, Complex Differential Operators,
Gradient, Divergence, Curl, and Laplacian.

Unit – V
COMPLEX INTEGRATION AND CAUCHY'S THEOREM:

Complex Line Integrals, Real Line Integrals, Connection Between, Real and Complex Line Integrals, Properties of Integrals, Change of Variables, Simply and Multiply Connected Regions, Jordan Curve Theorem, Convention Regarding Traversal of a Closed Path, Green's Theorem in the Plane, Complex Form of Green's Theorem, Cauchy's Theorem, The Cauchy–Goursat Theorem, Morera's Theorem, Indefinite Integrals, Integrals of Special Functions, Some Consequences of Cauchy's Theorem. Cauchy's Integral Formulas, Some Important Theorems

INFINITE SERIES TAYLOR'S AND LAURENT'S SERIES:

Sequences of Functions, Series of Functions, Absolute Conver-gence, Uniform Convergence of Sequences and Series, Power Series, Some Important Theorems, Taylor's Theorem, Some Special Series, Laurent's Theorem, Classification of Singularities, Entire Functions, Meromorphic Functions, Lagrange's, Expansion, Analytic Continuation.

THE RESIDUE THEOREM EVALUATION OF INTEGRALS AND SERIES:

Residues, Calculation of Residues, The Residue Theorem, Evaluation of Definite Integrals, Special Theorems Used in Evalua-ting Integrals, The Cauchy Principal Value of Integrals, Differentiation Under the Integral Sign. Leibnitz's Rule, Summation of Series, Mittag–Leffler's Expansion Theorem, Some Special Expansions.

CONFORMAL MAPPING (Optional) 2#

Transformations or Mappings, Jacobian of a Transformation, Complex Mapping Functions, Conformal Mapping, Riemann's Mapping Theorem, Fixed or Invariant Points of a Transformation, Some General Transformations, Successive Transformations, The LinearTransformation, The Bilinear or Fractional Transformation, Mapping of a Half Plane onto a Circle, The Schwarz–Christoffel Transformation. Transformations of Boundaries in Parametric Form, Some Special Mappings,

PHYSICAL APPLICATIONS OF CONFORMAL MAPPING (Optional) 3 #

Boundary Value Problems, Harmonic and Conjugate Functions, Dirichlet and Neumann Problems, The Dirichlet Problem for the, Unit Circle, Poisson's Formula, The Dirichlet Problem for the Half Plane, Solutions to Dirichlet and Neumann Problems by Conformal Mapping, Applications to Fluid Flow, Basic Assumptions, The Complex Potential, Equipotential Lines and Streamlines, Sources and Sinks, Some Special Flows, Flow Around Obstacles, Bernoulli's Theorem, Theorems of Blasius, Applications to Electrostatics, Coulomb's Law, Electric Field Electro-static Potential, Gauss' Theorem, The Complex Electrostatic, Potential, Line Charges, Conductors, Capacitance, Applications to Heat Flow, Heat Flux, The Complex Temperature.

SPECIAL TOPICS (Optional) 4#

Analytic Continuation, Schwarz's Reflection Principle, Infinite Products, Absolute, Conditional and Uniform Convergence of Infinite Products, Some Important Theorems on Infinite Products, Weierstrass' Theorem for Infinite Products, Some Special Infinite Products, The Gamma Function, Properties of the Gamma Function, The Beta Function, Differential Equations, Solution of Differential Equations by Contour Integrals, Bessel Functions, Legendre Functions, The Hypergeometric Function, The Zeta Function, Asymptotic Series, The Method of Steepest Descents, Special Asymptotic Expansions, Elliptic Functions.

Note:The topics #1, #2, #3, and #4 may be taught if time permits.

Text Books:

5. *Murray R Spiegel, Seymour Lipschutz,* "Schaum's Outline of Vector Analysis, 2ed (Schaums' Outline Series)" second Edition.
6. *Murray Spiegel,* Vector Analysis And An Introduction To Tensor Analysis, Tata Mcgraw Hill.
7. *Morton Hamermesh,* Group Theory and its Application to Physical Problems, Addison-Wesley Publishing Company Inc. 1962.
8. *Arfken & Weber,* Mathematical Methods for Physicists, Elsevier Indian Reprint, 6E, 200.

Reference Books:

* *Riley K F, Hobson M P, Bence S J, Mathematical Methods for Physics and Engineering, CUP, 3E, 2010*
* *M Boas, Mathematical Methods in Physical Sciences, Wiley Indian Reprint 3E, 2006*
* *Mathews J and Walker R L, Mathematical Methods of Physics, Pearson India, 2E, 2004*

18PHY513 Statistical Mechanics3 1 0 4

UNIT 1
Review of thermodynamic variables and thermodynamic potentials. Review of probability functions- random walk problem.

UNIT 2
Foundations of statistical mechanics-specification of states of a system-contact between statistics and thermodynamics-classical ideal gas-entropy of mixing and Gibb's paradox

UNIT 3
Micro canonical ensemble - phase space - trajectories and density of states - Lowville's theorem - canonical and grand canonical ensembles-partition function - calculation of statistical quantities - Energy and density fluctuations.

UNIT 4
Statistics of indistinguishable particles - Maxwell- Boltzman, Fermi Dirac and Bose Einstein statistics-properties of ideal Bose and Fermi gases-Bose-Einstein condensation

UNIT 5
Phase transitions- phase diagram for a real gas- Analogy of fluid and magnetic systems- Cluster expansion of classical gas - Landau theory of phase transition - critical indices - scale transformation and dimensional analysis.

Text Books:
F Reif, Foundations of Statistical and Thermal Physics, TMH, IE, 2011

Reference Books

1. Silivio Salinas, Introduction to Statistical Physics, Springer Indian Reprint, IE, 2006
2. Statistical Mechanics - R K Pathria
3. Statistical and Thermal Physics – Landau and Lifshitz
4. Statistical Physics- An Introductory course, Daniel J Amit and Yosef Verbin- World Scientific Co Pvt Ltd, 1995

18PHY514Advanced Electrodynamics3 1 0 4

Course Objective: Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: The connection between Electromagnetic phenomena and light, Wave equations for electromagnetic waves, Reflection and Transmission in dielectric media, Reflection and Transmission in conducting media, Waveguides, Radiation, Power radiated by a point charge, The physical basis of radiation reaction. Special theory of relativity and its connection to Electrodynamics, Applications of electrodynamics in modern experimental techniques, Basic charged particle optics, Theory of linear accelerators.

Unit 1

The wave equation, Sinusoidal waves, Boundary conditions: Reflection and Transmission Polarization, The wave equation for E and B, Monochromatic plane waves, Energy and Momentum in Electromagnetic Waves, Propagation in linear media, Reflection and Transmission at Normal Incidence, Reflection and Transmission at Oblique Incidence. [14 hrs]

Unit 2

Electromagnetic Waves in Conductors, Reflection at a Conducting Surface, The frequency dependence of Permittivity, Wave Guides, The waves in a Rectangular Wave Guide, The Coaxial Transmission Line. [12 hrs]

Unit 3

Definition of radiation, Electric dipole radiation, Magnetic dipole radiation, Radiation from an arbitrary source, Power radiated by a point charge, Radiation reaction, The physical basis of radiation reaction. [10 hrs]

Unit 4

Einstein's postulates, Geometry of relativity, The Lorentz transformations, The Structure of space time, Proper time and proper velocity, Relativistic energy and momentum, Relativistic kinematics, Relativistic dynamics, Magnetism as a relativistic phenomenon, How the fields transform, The field tensor, Electrodynamics in tensor notation. [14 hrs]

Unit 5

Applications of electrodynamics in modern experimental techniques, Basic charged particle optics, Theory of linear accelerators, Wancroft accelerators, pulsed drift tubes, rf linacs, circular accelerators and synchrotron radiation. Basic beam line equipment and design. [10 hrs]

Textbooks

1. Introduction to electrodynamics – David J Griffiths, 4th edition, Pearson publication

Reference books

1. J.D. Jackson, Classical Electrodynamics, 3E, Wiley, 2007
2. W, Greiner, Classical Electrodynamics, 1E, Springer, 2006
3. The Physics of Particle Accelerators: An Introduction - Klaus Wille, Oxford University Press, 2000

18PHY515 EXPERIMENTAL TECHNIQUES 3 1 0 4

Expected Outcomes:

(a) Build up on existing idea of probability to analyse continuous distribution functions

(b) Review error propagation and linear/non linear regression analysis

(c) Introduction and definite level of understanding in principles of diffraction, and spectroscopy

Unit I: Error and data analysis:

Review of error analysis – estimate confidence intervals – statistical inferences – linear and non linear regression analysis including analysis of fits (χ^2 test), correlation analysis (R^2)

Unit II: Review of Fourier Transforms:

Time domain and frequency domain spectra, Implementing Fast Fourier Transforms.

Unit III: X-ray diffraction and detectors

Production of X-rays, Scattering from an electron, atom and unit cell (calculation of structure factors), Powder X-ray diffraction and determination of crystal structures from diffraction data, particle and photon detectors: GM counter, Scintillation detector, Proportional counter

Unit IV: Microscopy

Scanning electron microscopy and transmission electron microscopy – Discussion of electron sources, Secondary and Back scattered electrons, analytical electron microscopy, electron diffraction, amplitude and phase contrast microscopy.

Unit V: Spectroscopy

Review of IR, EPR and NMR spectral lines including selection rules, calculation of g-factor, instrumentation for IR, EPR and NMR

Text Books:

For Error analysis (Unit I):

1. Bevington and Robinson, Data Reduction and Error Analysis for the physical sciences, 3rd Ed., McGraw-Hill Education, 2002.
2. John. R Taylor, An introduction to error analysis: The study of uncertainties in physical measurements, 2nd Ed., University Science Books, 1997.

For Fourier Transforms (Unit II):

1. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Ed., Wiley, 2015.
2. J. F James, A students guide to Fourier Transforms, 3rd Ed., Cambridge University Press, 2012.

For X-ray diffraction and detection (Unit III):

1. S S Kapoor and V S Ramamoorthy, Nuclear Radiation detectors, New Age International, 1993.
2. Ramakanth Hebbar, Basics of X-ray diffraction and its applications, 1st Ed., I. K. International Publishing House, 2011.
3. B E Warren, X-ray diffraction, New edition Ed., Dover Publications Inc. 1990.

For Microscopy (Unit IV):

1. Ray F Egerton, Physical Principles of Electron Microscopy: An introduction to SEM, TEM and AEM, Springer, 2005.

For Spectroscopy (Unit V):

1. Colin Banwell, Elaine Mccash, Fundamentals of Molecular spectroscopy, McGraw Hill Education, 4th Ed., 1994.
2. "Instrumental methods of analysis" by Williams, Merrit, Dean and Settle (***Chemistry section of our library***)

Reference books:

1. Schaums Series on Probability and Statistics
2. "Elements of X-ray diffraction", B. D. Cullity
3. "Transmission electron microscopy" by Williams and Carter

4. “X-ray diffraction : In crystals, Imperfect crystals and amorphous bodies” by A Guiner
5. “X-ray diffraction” by West

18PHY581 Advanced Physics Lab 0062

1. Current-Voltage characteristics of dc glow discharge
2. Calibration of a vacuum gauge (Pirani) with the aid of McLeod gauge.
3. Mass susceptibility of paramagnetic Liquid substance by Quinkes’s method
4. Studying the Hall Effect parameters
5. Elastics Constants – Elliptical and Hyperbolic Fringes
6. Skin depth in Al using electromagnetic radiation.
7. Thermionic Emission
8. Verification of Bohr’s theory Franck – Hertz Experiment.
9. Stefan’s constant – Black body radiation.
10. Study of plasma density, plasma conductivity and plasma temperature by glowing discharge method.
11. Van der Pauw method or Four Probe Method – Measurement of resistivity and Hall Coefficient of Thin Film .
12. e’ by Millikan oil drop method.
13. Counting statistics, G.M. tube.

18PHY582Simulation Lab0062

Mechanics:

(1) Motion of a Body Falling in Viscous Medium

(2) Motion of One-Dimensional Simple Harmonic Oscillator

(3) Motion of a Projectile Thrown Horizontally

(4) Motion of a Satellite

Waves and Optics:

(5) Construction of Standing Wave

(6) Formation of Square Wave

(7) Dispersion of Light Wave

(8) Polarization of Light Waves

18PHY583 ADVANCED ELECTRONICS LAB 0 0 6 2

Design and study of CE amplifier with and without feedback, two stage amplifier, Power amplifier, Differential amplifier, Voltage regulated power supplies with Zener diodes and transistors, Design of basic DL. TI and TTL logic gates, RS and JK flip flops using NOR-NAND gates, Schmitt trigger using op-amp, Uses of IC 741, Phase shift oscillator, 555 timer, three terminal IC voltage regulator, Familiarization of 8085 kit and programming, A/D and D/A converters, control of stepper motor.

TEXTBOOK/ REFERENCES:

Paul B. Zbar & Alert P Malvino, Basic Electronics - A text-Lab Manual.

18PHY591 Mini Project 2 cr

The aim of mini project work is to give first exposure to students on research methodology. This can include literature survey, review, data collection, theoretical / experimental work on small part of research area chosen by the faculty guiding the mini project work.

18PHY601Atomic Molecular and Optical Physics 3 1 0 4

Course Objective: Having successfully completed this module, the student will be able to demonstrate knowledge and understanding of: Origin of line widths and shapes in atomic spectra, Quantum number and their physical significance, Quantum mechanical states of the hydrogen atom, Effect external electric and magnetic fields on atoms, Origins of fine structure in atomic spectra, Hyperfine structure and Lamb shifts, Origin of molecular spectra, Bonding and antibonding orbitals, Molecular symmetry, Vibration spectroscopy, Einstein A and B coefficients and the relationship between them and various line broadening mechanisms.

Note: Existing title is an obsolete usage. The new title is suggested in the brackets. Also, the existing syllabus is bit too lengthy and it has been modified with relevance to the ongoing research areas of our campus.

Unit 1
One electron atoms -1:
Brief Review of Quantum mechanics. One electron atoms: Operators and observables, Angular momentum, Schrodinger equation for one electron atoms, energy levels, eigen function of the bound states, Expectation values and the Virial theorem.

Unit 2
One electron atoms -2: Fine structure of Hydrogen like atoms, Zeeman Effect, Stark effect, Lamb shift, Hyperfine structure and isotope shifts.

Unit 3
Molecular structure and Spectra:
Nature of Molecular structure, Electronic structure of Molecules, Building principle:

determination of term manifold, LCAO approximation, Molecular Orbital theory treatment of H_2^+ and H_2 electronic energy levels, σ and π – bonds, Formation of bonding and anti-bonding orbitals from atomic orbitals in simple diatomic molecules.

Unit 4

Molecular symmetry and vibrations: Properties of Symmetry, Point groups, Characters and representation groups, Reducible and irreducible representations, Normal co-ordinates and normal modes of vibration, Infrared and Raman spectra, Selection rules, Application of group theory to molecular vibrations

Unit 5

Absorption and emission of radiation: Interaction of radiation with matter, Einstein's A and B coefficients, Beer's law for normal absorption, electric dipole approximation, width and shape of spectral lines, Homogenous and inhomogeneous broadening, natural broadening, Doppler broadening, Doppler broadening: estimation of half-widths, external effects – collision broadening and pressure broadening.

Text books

1. B. H. Bransden and C. J. Joachain, Physics of Atoms and Molecules, 2nd Ed., Prentice Hall, 2003.
2. C.J. Foot, Atomic Physics, 1st Ed., Oxford Master Series in Physics, 2004.

Reference books

1. Peter W. Atkins and Ronald S. Friedman, Molecular Quantum Mechanics, 5th Ed., Oxford University Press, 2012.
2. Demtröder, Wolfgang, Atoms, Molecules and Photons: An Introduction to Atomic-Molecular- and Quantum Physics, Springer-Verlag Berlin Heidelberg, 2010.

18PHY602Condensed Matter Physics 3 1 0 4

Prerequisites:

This course requires the basics of solid state physics, electrodynamics, quantum mechanics and statistical physics.

Course outcome:

This course gives an extended knowledge about crystalline structure and defects, electronic band structure, electrical, thermal and magnetic properties of solid state systems and their technological applications.

UNIT 1

Review on crystal physics: Crystal Structure and symmetry, Point and Space groups, Crystal systems, planes and direction, Structure Property-Relations, Diffraction of waves by crystals, Scattered wave amplitude: Fourier analysis, Reciprocal Lattice vectors, Diffraction conditions, Laue equations, Brillouin zones: Reciprocal lattice to SC, BCC and FCC lattice, Fourier analysis of Basis: Structure and atomic Form factor.

Crystal defects: Classification of defects - Points defect - The Schottky defect - The Frenkel defect -colour centers - F center - other colour centers - Dislocations - Slip and plastic deformation - Shear strength of single crystals - Edge dislocation - Screw dislocation - Stress field around an edge dislocation. (5 hrs)

UNIT 2 Metals I : The Free-Electron model

Free electron gas in three-dimension, Heat capacity of the free electrons, Electrical conductivity; effects of Fermi surface, Motion in magnetic fields; cyclotron resonance and the Hall effect, Thermal conductivity in metals

Unit 3:

Energy Bands in Solids and Fermi surfaces: Nearly free electron model: Origin of Energy Gap, Brillouin zones, Bloch functions, Construction of Fermi surfaces, Tight binding method for energy bands, Wigner-Seitz method, Cohesive energy, Pseudopotential methods, Experimental methods in Fermi surface studies; Quantization of Orbits in a Magnetic field, De Haas-van Alphen Effect, Landau levels

Superconductivity: Meissner effect, London's equations, introduction to BCS theory and its predictions, Ginzburg-Landau theory, flux quantization, Josephson effects; application: SQUID

UNIT 4 Semiconductors

Semiconductors: energy band structure, intrinsic and extrinsic semiconductors, Fermi levels of intrinsic and extrinsic semi-conductors, Direct and indirect gap semiconductors, Effective mass, Hydrogenic model of impurity levels and p-n junctions: theory of I–V characteristics, Schottky-barrier.

UNIT 5 Magnetism

Langevin theory of diamagnetism and paramagnetism, Quantum theory of Diamagnetism of Mononuclear systems, Quantum theory of paramagnetism: Rare Earth Ions, Hund Rules, Iron group ions, Crystal field splitting, Cooling by Isentropic Demagnetization, Paramagnetic susceptibility of conduction electrons, Ferromagnetism and antiferromagnetism: Ferromagnetic order, Curie point and exchange integral, Temperature dependence of saturation magnetization, Ferrimagnetic order: Curie temperature and susceptibility of ferrimagnets, antiferromagnetic order, susceptibility below Neel temperature, Ferromagnetic domains.

Text Books/ References:

1. N.W. Ashcroft and N.D. Mermin, Solid Satate Physics, Brooks Cole, 1 E12003.
2. Ibach and Luth, Soil State Physics, Springer India, 3E, 2002.
3. M.Marder, Condensesd Matter Physics, Wiley Intersciences, 1E, 2000.
4. *Charles Kittel, Introduction to Solid State Physics, Wiley, 8th Edition, Reprint: 2016*

5. M. Ali Omar, Elementary Solid State Physics: Principles and Applications, Pearson Education India.
6. Adrianus J. Dekker, Solid State Physics, Library of Congress Catalog Card No.: 57-8688, 1958.

18PHY603Nuclear and Particle Physics3 1 0 4

Unit I Basic Concepts: History and Overview, Units and Dimensions, Nuclear Properties, Radius, Mass and Abundance of nuclides, Binding energy, Angular Momentum, Spin and Parity, Electromagnetic moments and Nuclear excited states

Unit II Nuclear Stucture: The Deuteron, Nucleon-Nucleon Scattering, Proton-Protron and Neutron-Neutron Interactions, Properties of Nuclear Forces, The Exchange Force Model, Nuclear Models, Liquid-Drop Model, Shell Model, Collective Model of the Nucleus

Unit III Radioactive Decay: Alpha Decay, The Q-value of alpha decay, Gamow's theory of alpha decay, Beta decay, Fermi theory of beta decay, Parity violation in beta decay, Gamma Decay, Internal conversion, Nuclear Isomers

Unit IV Nuclear Reactions:The Optical Model, The Compound Nucleus and Direct Reactions, Resonance Reactions, Heavy-Ion Reactions, Nuclear Fission, Characteristics of Fission, Energy in Fission, Nuclear Fusion, Characteristics of Fusion, Solar Fusion

Unit V Particle Physics: Particle Interactions and Families, Symmetry and Conservation laws, Standard Model, Quark Dynamics, Grand Unified Theories

Text Book: S. Krane, Introductory Nuclear Physics, 2nd Ed., Wiley India Pvt Ltd, 2013.

Reference Book: V. Devanathan, Nuclear Physics, Narosa Publishing House, 2012.

18PHY633 BIOPHOTONICS 3 0 0 3

Unit 1

Photobiology: Interaction of light with cells and tissues, Photo–processes in Biopolymers, human eye and vision, photosynthesis. Photo-excitation: free space propagation, optical fiber delivery system, articulated arm delivery, hollow tube wave-guides. Optical coherence tomography, special and time-resolved imaging, fluorescence resonance energy transfer (FRET) imaging, nonlinear optical imaging, Bio-imaging:

Unit 2

Transmission microscopy, Kohler illumination, microscopy based on phase contrast, dark-field and differential interference contract microscopy, fluorescence, confocal and multiphoton microscopy. Applications of bio-imaging: Bio-imaging probes and fluorophores, imaging of microbes, cellular imaging and tissue imaging.

Unit 3

Optical biosensors: Fluorescence and energy transfer sensing, molecular beacons and optical geometries of bio-sensing, biosensors based on fibre optics planar waveguides, evanescent waves, interferometry and surface Plasmon resonance. Flow cytometry: Basics, fluorochromes for flow cytometry, DNA analysis.

Unit 4

Laser activated therapy: Photodynamic therapy, photo-sensitizers for photodynamic therapy, applications of photodynamic therapy, two photon photodynamic therapy. Tissue engineering using light: Contouring and restructuring of tissues using laser, laser tissue regeneration, femto-second laser surgery.

Unit 5

Laser tweezers and laser scissors, design of laser tweezers and laser scissors, optical trapping using non Gaussian optical beam, manipulation of single DNA molecules, molecular motors, lasers for genonmocs and proteomics, semiconductor quantum dots for bio imaging, metallic nano-particles and nano-rods for bio-sensing. Photonics and biomaterials: Baceria as bio-synthesizers for photonic polymers.

TEXTS:

1. *Introduction to Bio-photonics- V N Prasad (Wiley-Interscience April 2003)*

2. *Biomedical photonics: A Handbook - Tu Vo Dinh (CRC Press, Boca Raton, FL 2003)*

REFERENCES:

1. *A Handbook of Optical Biomedical diagnostics, SPIE press monograph vol pm 107*
2. *Biomedical Optics - Principles and Imaging - Lihong V and Hsin-IWU, Wiley Interscience 1 sted, 2007*
3. *Optical coherence Tomography - Principles and Applications – Mark E.Brezinski, (Academic press 1st ed, 2006)*
4. *Biophysics - An Introduction - Rodney cotterill, (John Wiley Student edition)*

18PHY634 EARTH'S ATMOSPHERE 3 0 0 3

Unit 1

Earth's atmosphere: overview and vertical structure. Warming the earth and the atmosphere: temperature and heat transfer; absorption, emission, and equilibrium; incoming solar energy. Air temperature: daily variations, controls, data, human comfort, measurement. Humidity, condensation, and clouds: circulation of water in the atmosphere; evaporation, condensation, and saturation; dew and frost; fog.

Unit 2

Cloud development and precipitation: atmospheric stability & determining stability, cloud development and stability, precipitation processes, collision and coalescence, precipitation types, measuring precipitation. Air pressure and winds: atmospheric pressure, pressure measurement, surface and upper-air charts, surface winds, winds and vertical air motions, measuring and determining winds. Atmospheric circulations: scales of atmospheric motion, eddies, local wind systems, global winds, global wind patterns and the oceans.

Unit 3

Air masses, fronts, and mid-latitude cyclones. Weather forecasting: acquisition of weather information, forecasting methods and tools, forecasting using surface charts. Thunderstorms: ordinary (air-mass) thunderstorms, mesoscale convective complexes, floods and flash floods, distribution of thunderstorms, lightning and thunder. Tornadoes: severe weather and Doppler radar, waterspouts.

Unit 4

Hurricanes (cyclones, typhoons): tropical weather; anatomy, formation, dissipation and naming of hurricanes. Air pollution: a brief history, types and sources, factors that affect air pollution, the urban environment, acid deposition. Global climate: climatic classification; global pattern of climate.

Unit 5

Climate change: possible causes; carbon dioxide, the greenhouse effect, and recent global warming. Light, color, and atmospheric optics: white and colors, white clouds and scattered light; blue skies and hazy days, red suns and blue moons; twinkling, twilight, and the green flash; the mirage; halos, sundogs, and sun pillars; rainbows; coronas and cloud iridescence.

TEXTBOOK:

C. Donald Ahrens: Essentials of Meteorology: An Invitation to the Atmosphere (6th edition), Brooks-Cole, 2010.

REFERENCE:

Frederick K. Lutgens & Edward J. Tarbuck: The Atmosphere, An Introduction to Meteorology (11th Edition), Prentice Hall, 19 January, 2009

18PHY635 EARTH'S STRUCTURE AND EVOLUTION 3 0 0 3

Unit 1

Introduction: geologic time; earth as a system, the rock cycle, early evolution, internal structure & face of earth, dynamic earth. Matter and minerals: atoms, isotopes and radioactive decay; physical properties & groups of minerals; silicates, important nonsilicate minerals, resources. Igneous rocks: magma, igneous processes, compositions & textures; naming igneous rocks; origin and evolution of magma, intrusive igneous activity, mineral resources and igneous processes.

Unit 2

Volcanoes and volcanic hazards: materials extruded, structures and eruptive styles, composite cones and other volcanic landforms, plate tectonics and volcanic activity. W eathering and soils: earth's external processes; mechanical & chemical weathering, rates; soils, controls of formation, profile, classification, human impact, erosion, weathering and ore deposits. Sedimentary rocks: the importance and origins of sedimentary rocks; detrital & chemical sedimentary rocks, coal, converting sediment into sedimentary rock; classification & structures, nonmetallic mineral & energy resources. Metamorphism and metamorphic rocks: metamorphic textures, common metamorphic rocks, metamorphic environments & zones.

Unit 3

Mass wasting: gravity, mass wasting and landform development, controls and triggers, classification of mass-wasting processes, slump, rockslide, debris flow, earthflow, slow movements. Running water: hydrologic cycle, running water, streamflow, work of running water, stream channels, base level and graded streams, shaping stream valleys, depositional landforms, drainage patterns, floods and flood control. Groundwater: importance and distribution, water table, factors influencing storage and movement, springs, wells, artesian wells, environmental problems, hot springs and geysers, geothermal energy, geologic work. Glaciers and glaciation: formation and movement, erosion & landforms, deposits, other effects, causes. Deserts and wind: distribution and causes, geologic processes, basin and range, wind transport, erosion & deposits.

Unit 4

Shorelines: coastal zone, waves & erosion, sand movement, shoreline features & stabilization; erosion problems along U.S. coasts, hurricanes, coastal classification, tides. Earthquakes and earth's interior: faults, seismology, locating the source of an earthquake, measuring intensity, belts and plate boundaries, destruction, damage east of the Rocky Mountains, earthquake prediction, earth's interior. Plate tectonics: continental drift, divergent boundaries, convergent boundaries, transform fault boundaries, testing the plate tectonics model, the breakup of Pangaea, measuring plate motion, what drives plate motions, plate tectonics in the future.

Unit 5

Origin and evolution of the ocean floor: continental margins, features of deep-ocean basins, anatomy of oceanic ridge, oceanic ridges and seafloor spreading, nature of oceanic crust, continental rifting, destruction of oceanic lithosphere. Crustal deformation and mountain building: structures formed by ductile & brittle deformation, mountain building at subduction zones, collisional mountain belts, fault-block mountains, vertical movements of the crust. Geologic time: time scales, relative dating, correlation of rock layers; dating with radioactivity, the geologic time scale, difficulties in dating. Earth's evolution: birth of a planet, origin of the atmosphere and oceans, Precambrian (formation of continents); Phanerozoic (formation of modern continents & earth's first life); Paleozoic (life explodes); the Mesozoic (dinosaurs); Cenozoic era (mammals). Global climate change: climate & geology, climate system, detecting change; atmospheric basics & heating the atmosphere; natural & human causes; carbon dioxide, trace gases, and climate change; climate-feedback mechanisms, aerosols, some possible consequences.

TEXTBOOK:

Frederick K. Lutgens, Edward J. Tarbuck & Dennis G. Tasa: Essentials of Geology (11th edition), Prentice Hall, 8 March, 2012.

REFERENCE:

Graham R. Thompson & Jonathan Turk: Introduction to Physical Geology (2nd Edition), Brooks Cole, 23 June, 1997.

18PHY636 FIBRE OPTIC SENSORS AND APPLICATIONS3 0 0 3

Unit 1

MM and SM fibers for sensing, Lasers & LEDs suitable for sensing, PIN & APDs for fiber optic sensing. Principles of electro optic modulators bulk & integrated optic modulators. Optical sensor types, advantages and disadvantages of fiber optic sensors, Sensor system performance: basic specifications, Intensity modulated sensors, reflective concept, micro-bend concept, evanescent fibers sensors, polarization modulated sensors.

Unit 2

In-fiber Bragg grating based sensors – sensing principles – temperature and strain sensing, integration techniques, cross sensitivity, FB Gmultiplexing techniques. Long period fiber grating sensors - temperature and stain sensing, refractive index sensing, optical load sensors and optical bend sensors.

Unit 3

Interferometric sensors, Mach-Zehnder & Michelson interferometric sensors, theory-expression for fringe visibility, Fabry-perot fiber optic sensors – theory and configurations, optical integration methods and multiplication techniques, application– temperature, pressure and strain measurements, encoded sensors.

Unit 4

Sagnac interferometers for rotation sensing fiber gyroscope sensors – Sagnac effect – open loop biasing scheme – closed loop signal processing scheme – fundamental limit – performance accuracy and parasitic effects – phase-type bias error – shupe effect – anti-shupe winding methods – applications of fiber optic gyroscopes. Faraday effect sensors. Magnetostriction sensors - Lorentz force sensors.

Unit 5

Biomedical sensors, sensors for physical parameters, pressure, temperature, blood flow, humidity and radiation loss, sensors for chemical parameters. pH, oxygen, carbon, dioxide, spectral sensors. Distributed fiber optic sensors – intrinsic distributed fiber optic sensor – optical time domain reflectometry based Rayleigh scattering – optical time domain reflectometry based Raman scattering – optical time domain reflectometry – quasi – distributed fiber optic sensors. An overview on the optical fiber sensors in nuclear power industry, flyby light aircraft, oil field services, civil and electrical engineering, industrial and environmental monitoring.

TEXTBOOKS:

- *Francis T.S Yu, Shizhuo Yin (Eds), Fiber Optic Sensors, Marcel Dekker Inc., New York, 2002*
- *Dakin J and Culshow B., (Ed), Optical fiber sensors, Vol. I, II, III, Artech House, 1998*
- *Pal B.P, Fundamentals of fiber optics in telecommunication and sensor systems, Wiley Eastern, 1994*

REFERENCES:

- *Jose Miguel Lopez-Higuera (Ed), Handbook of optical fiber sensing technology, John Wiley and Sons Ltd., 2001*
- *Eric Udd (Ed), Fiber optic sensors: An introduction for engineers and scientists, John Wiley and Sons Ltd., 1991*
- *B.D Gupta, Fiber optic Sensors: Principles and applications, New India Publishing Agency, New Delhi., 2006*
- *Bio-medical sensors using optical fibers, Report on progress in physics Vol 59.1,1996*

18PHY637 FIBRE OPTICS AND TECHNOLOGY 3 0 0 3

Unit 1

Classification of fibers: based on refractive index profiles, modes guided applications and materials. Fibers for specific applications: polarization maintaining fibers (PMF), dispersion shifted and dispersion flattened fibers, doped fibers. Photonic crystal fibers, holly fibers.

Fiber specifications: Numerical aperture of SI and GI fibers, Fractional refractive index difference, V–parameter, Cut off wavelength, dispersion parameter, bandwidth, rise time and Non linearity coefficient.

Unit 2

Impairment in fibers: group velocity dispersion (GVD), wave guide and modal dispersions. Polarization mode dispersion (PMD), Birefringence – liner and circular.

Fiber drawing and fabrication methods: modified chemical vapor deposition (MCVD) and VAD techniques.

Unit 3

Mode theory of fibers – different modes in fibers. Dominant mode, Derivations for modal equations for SI and GI fibers. Approximate number of guided modes in a fiber (SI and GI fibers). Comparison of single mode and multimode fibers for optical communications. LED and LD modulators. Coupling of light sources to fibers – (LED and LD) – Derivations required. Theory and applications of passive optical components: connectors, couplers, splices, Directional couplers, gratings: FBGs and AWGs, reflecting stars: Optical add drop multiplexers and SLMs.

Unit 4

Active components: Optical Amplifiers (OAS) - Comparative study of OAS - SLAs, FRAs, FBAs EDFAs and PDFAs based on signal gain, pump efficiency, Noise Figure, Insertion loss and bandwidth. Design and Characterization of forward pumped EDFAs.

Unit 5

Fiber measurements: Attenuation measurement – cut back method. Measurement of dispersion – differential group delay, Refractive index profile measurement.

Numerical aperture (NA) measurement, diameter measurement, mode field diameter (MFD) measurement, V-Parameter, Cut off wavelength Measurement, splicing and insertion losses, OTDR – working principle and applications. OSA - Basic block schematic and applications in measurements. (John M senior).

TEXTBOOKS:

- *Gerd Keiser, Optical Fiber communications, McGraw Hill, 200*
- *Maynbav, Optical Fiber Technology, Pearson Education, 2001*
- *John M senior, Optical fiber communications, PHI, 1992*

REFERENCES:

1. *Joseph C Palais, Optical Fiber communications, Pearson Education.1998.*
2. *Dennis Deriikson, Fiber optic test and measurement, Prentice hall,1998.*
3. *David Bailey and Edwin wright, practical Fiber optics, Elsevier 2003.*
4. *Franz and Jain, optical Fiber communication systems and Components, Naros Publishers, 2004.*
5. *Ajoy Ghatak and K.Thyagarajan, Introduction to Fiber optics: Cambridge university press,1999.*

18PHY638 NANOPHOTONICS 3 0 0 3

Unit 1

Introduction to nanoscale interaction of photons and electrons. Near field interaction and microscopy - near field optics and microscopy - single molecule spectroscopy - nonlinear optical process.

Unit 2

Materials for nanophotonics - quantum confinement - optical properties with examples - dielectric confinement - super lattices - organic quantum confined structures.

Unit 3

Plasmonics - metallic nanoparticles and nanorods - metallic nanoshells - local field enhancement - plasmonic wave guiding - applications of metallic nanostructures.

Unit 4

Nanocontrol of excitation dynamics - nanostructure and excited states - rare earth doped nanostructures - up converting nanophores - quantum cutting. Growth and characterization of nanomaterials – epitaxial – PLD – nanochemistry – XRD – XPS – SEM – TEM – SPM.

Unit 5

Concept of photonic band gap – photonic crystals – theoretical modeling – features optical circuitry - photonic crystal in optical communication - nonlinear photonic crystal - applications. Nanoelectronic devices – Introduction - single electron transistor. Basic ideas of nanolithography and biomaterials - nanophotonics for Biotechnology and Nanomedicine – nanophotonics and the market place.

TEXTBOOKS:

- *Paras N. Prasad, Nanophotonics, Wiley Interscience, 2004*
- *Lukas Novotny and Bert Hecht, Principles of Nano-Optics, Cambridge University Press, 2006*

REFERENCE:

1. *Herve Rigneault, jean-Michel Lourtioz, Claude Delalande, Juan Ariel Levenson, Nanophotonics, ISTE Publishing Company, 2006.*
2. *Surface Plasmon Nanophotonics, Mark L. Brongersma, Pieter G. Kik, Springer-Verlag, 2006.*
3. *Photonic Crystals, by John D. Joannopoulos, Robert D. Meade, Joshua N. Winn Pri-enceton University Press.*

18PHY639 NONLINEAR DYNAMICS 3 0 0 3

Unit 1

Introduction, Phase Space, and Phase Portraits: Linear systems and theirclassification; Existence and uniqueness of solutions; Fixed points and linearization; Stability of equilibria; Pendulum and Duffing oscillator, Lindstedt’s method; Conservative and reversible systems.

Unit 2

Limit Cycles: The van der Pol oscillator, Method of Averaging; Relaxationoscillators; Weakly nonlinear oscillators; Forced Duffing oscillator, Method of Multiple Scales; Forced van der Pol oscillator, Entrainment; Mathieu’s equation, Floquet Theory, Harmonic Balance.

Unit 3

Bifurcations: Saddle-node, transcritical, and pitchfork bifurcations; Center manifoldtheory; Hopf bifurcation; Global bifurcations; and Poincaré maps.

Unit 4

Nonlinear Normal Modes: Nonlinear Normal Mode manifolds of multidegree-of-freedom systems; external and internal resonances; and Energy transfer through nonlinear interactions.

Unit 5

Chaotic Dynamics: Lorentz equations; Lorentz map; Logistics map; LyapunovExponents; fractal sets and their dimensions; box, pointwise and correlation dimensions; strange attractors; and forced two-well oscillator.

TEXTBOOKS:

1. *Richard H. Rand, Lecture Notes on Nonlinear Vibrations, version 52, 2005. Available online athttp://audiophile.tam.cornell.edu/randpdf/nlvibe52.pdf*
2. *S.H. Strogatz, Nonlinear Dynamics and Chaos with Applications to Physics, Biology, Chemistryand Engineering, Perseus Books Publishing, 2000.*

REFERENCE BOOKS:

- *J.C. Sprott, Chaos and Time-Series Analysis, Oxford University Press, 2003.*
- *G.L. Baker and J.P. Gollub, Chaotic Dynamics, 2nd edition, Cambridge University Press, New York, 1996.*
- *Edward Ott, Chaos in Dynamical Systems, Cambridge, 1993.*
- *K.T. Alligood, T.D. Sauer, and J.A. Yorke, CHAOS - An Introduction to Dynamical Systems, Springer, 1996.*
- *D. Kaplan and L. Glass, Understanding nonlinear dynamics, Springer-Verlag, New York, 1995.*
- *J.M.T. Thompson and H.B. Stewart, Nonlinear dynamics and chaos, John Wiley and Sons, New York, 1986.*

18PHY640 NUCLEAR PHYSICS 3 0 0 3

Unit 1

Two-nucleon scattering - partial wave analysis, effective range theory, coherent scattering, spin-flip and polarization, comparison of n-n and p-p scattering.

Unit 2

Nuclear reactions - reaction and scattering cross sections, compound nuclear reactions, resonance reactions, Breit-W eigner formula, experimental determination of resonance widths and shapes, statistical theory, optical model, transfer reactions, pick-up and stripping reactions, spectroscopic factors.

Unit 3

Heavy ion reactions - salient features at low, intermediate and high energies, classical dynamical model, heavy ion fusion, fusion excitation function, deep inelastic collision.

Unit 4

Some aspects of nuclear measurement techniques: (i) Detectors and electronics for high resolution gamma and charge particle spectroscopy; (ii) Fast neutron, detection (iii) Neutrino detection, (iv) Drift chambers, RICH, calorimeter.

BOOKS RECOMMENDED:

1. *Nuclear Physics: L.R.B Elton*
2. *Nuclear reactions: Blatt and Weisskopf*
3. *Nuclear Theory - Roy and Nigam*
4. *Nuclear Physics - B. Cohen*
5. *Nuclear Physics - Preston and Bhaduri*
6. *Nuclear structure - Bohr and Mottelson*
7. *Nuclear structure - M. K. Pal*
8. *Techniques in experimental nuclear physics - Leo*
9. *Techniques in experimental nuclear physics - Knoll*
10. *Techniques in experimental nuclear physics - S.S. Kapur*

18PHY641 OPTOELECTRONIC DEVICES 3 0 0 3

Unit 1

Introduction: Semiconductor materials; Crystal lattices; Bulk Crystal growth, epitaxial growth.

Unit 2

Energy bands and Charge carriers in Semiconductors: direct and indirect semiconductors; variation of Energy bands with alloy composition. Charge carriers in semi-conductors-electrons, holes, effective mass; intrinsic and extrinsic materials. Drift of carriers in electric and magnetic fields.

Unit 3

Excess carries in Semiconductors: Optical absorption; luminescence – photoluminescence, electroluminescence. Carrier lifetime and photoconductivity, diffusion of carriers.P-N Junction Diode: Current-Voltage Characteristics; hetrojunctions.

Unit 4

Optoelectronic Devices: Principle of diodes, lasers, photo detectors, solar systems in optoelectronic devices.operation and characteristics; Light emittingcells. Relevance of III-V and IV-VI material-

Unit 5

Integrated Optics: Optical waveguides - passive, electro-optical; optical modulatorsand switches; optical storage devices.

TEXTBOOK:

Pallab Bhattacharya, "Semiconductor Optoelectronic Devices", 2nd Edition.

REFERENCE BOOKS:

1. Street B G and Banerjee S, "Solid State Electronic Devices", PHI New Delhi, (2004)
2. Sze S M, "Physics of Semiconductors Devices", Wiley Eastern Limited, New Delhi.
3. Wilson and Hawkes, "Optoelectronics; An Introduction", 2nd Ed., PHI.
4. Hummel R E, "Electronic Properties of Materials", Narosa Publishing House, New Delhi.

18PHY642 PHYSICS OF COLD ATOMS AND IONS 3 0 0 3

Unit 1

Two level atom in a radiation field, Laser light pressure, Atoms in motion, Travelling wave and standing wave - Multilevel atoms, Alkali metal atoms, metastable noble gas atoms, Polarization and interference, Angular momentum and selection rules and Optical transitions in Multilevel atoms.

Unit 2

Temperature and Thermodynamics in Laser Cooling, Kinetic Theory and the Maxwell-Boltzmann Distribution, Random Walks, The Fokker-Planck Equation and Cooling Limits, Phase Space and Liouville's Theorem.

Unit 3

Optical Molasses: Introduction, Low-Intensity Theory for a Two-Level Atom in One Dimension, Atomic Beam Collimation, Low-Intensity Case, Experiments in One- and Two-Dimensions, Experiments in Three-Dimensional Optical Molasses.

Unit 4

Cooling below the Doppler limit - Magnetic trapping of neutral atoms. Optical Traps Magneto optical traps - Evaporative cooling.

Unit 5

Applications to atom mirrors, lenses, atomic fountain, nano fabrication, atomic clocks and nonlinear optics - Optical lattices - Bose Einstein condensation Entangled states and quantum computing.

TEXTBOOKS:

1. *Laser cooling and trapping by H J Metcalf and Peter Van der Straten Springer-VerlagNew York 1999.*
2. *Laser Manipulation of atoms and ions – Proceedings of the international school of Physics "Enrico Fermi" Course CXVII, Amsterdam (1993) North Holland.*

18PHY643 QUANTUM ELECTRODYNAMICS 3 0 0 3

Unit 1

Lorentz Covariance of the Dirac Equation: Covariant form of the Dirac equation, Proof of Covariance, Space Reflection, Bilinear Covariants, Solution of the Dirac Equation for a free particle: Plane wave Solutions, Projection Operators for Energy and Spin, Physical Interpretations of Free-particle solutions and packets.

Unit 2

The Foldy-Wouthuysen Transformation: Introduction, Free-particle Transformation, The Hydrogen atom Hole Theory: The problem of Negative Energy Solutions, Charge Conjugation, Vacuum Polarization, The time Reversal and other Symmetries.

Unit 3

General Formulation of the Quantum Field Theory: Implication of the Description in Terms of Local Fields, Canonical Formulation and Quantization Procedure for particles, Canonical Formulation and Quantization for Fields, The Klein-Gordon Field: Quantization and Particle Interpretation, Symmetry of the States, Measurability of the Field and Microscopic Causality, Vacuum Fluctuations, The Charged Scalar Field, Feynman Propagator.

Unit 4

Second Quantization of the Electromagnetic Field: Quantum Mechanics of N-identical Particles, The Number Representation for Fermions, The Dirac Theory, Momentum Expansions, Relativistic Covariance, The Feynman Propagator.

Quantization of the Electromagnetic Field: Introduction, Quantization, Covariance of the Quantization Procedure, Momentum Expansions, Spin of the Photon, The Feynman Propagator for Transverse Photons.

TEXTBOOKS:

1. Bjorken & Drell: "Relativistic Quantum Mechanics"

2. Bjorken & Drell: "Relativistic Quantum Fields"

REFERENCE BOOKS:

1. Schweber, Bethe and Hoffmann: Mesons and Fields

2. Sakural: Advanced Quantum Mechanics

3. Lee: Particle Physics and Introduction to Field Theory

18PHY644 QUANTUM OPTICS 3 0 0 3

Unit 1

Correlation functions of light waves. Spectral representation of mutual coherence function.Calculation of mutual intensity and degree of coherence, propagation of mutual intensity.Rigorous theory of partial coherence. Coherency matrix of a quasi-monochromatic plane wave. Stochastic description of light and higher order coherence effects.

Unit 2

Quantization of the radiation field, Quantum mechanical harmonic oscillator, the zero point energy, states of the quantized radiation field, single mode number states and phase states, coherent photon states.

Unit 3

Quantum theory of the laser: photon rate equations, time dependence of photon coherence, laser threshold condition, rate equations for atoms and laser photons, laser photon distribution, fluctuations in laser light and laser phase diffusion.

Unit 4

Statistical optics of photons: Photon coherence properties, photon counting, photon distribution for coherent and chaotic light, quantum mechanical photon counting distribution.

Unit 5

Super radiance: collective cooperative spontaneous radiation. Diecke's theory. Photon echoes. Quantum beats. Quantum chaos and instability hierarchies of laser light, chaos and its routes. Squeezed states of light.

REFERENCES:

1. *L. Mandel and E. Wolf, Coherence and Quantum Optics, Plenum (1973). 41*
2. *H. Haken, Light. Vol.1 & 2, North Holland (1981).*

3. *S.M. Kay and A. Maitland, Quantum Optics. Academic Press (1970).*
4. *R. Loudon, Quantum Theory of Light, Clarendon Press (1979).*
5. *J. Fox, (Ed.), Optical Masers, Interscience Publishers (1963).*
6. *R.G. Brewer and A. Mooradian, Laser Spectroscopy, Plenum (1974).*
7. *Laser Theory: Encyl. of Phy. Vol. 25/2C, Springer-Verlag (1976).*
8. *M.O. Scully, W.E. Lamb and M. Sargent III, Laser Physics, Addison Wesley (1974).*
9. *J. Jacob, M. Sargent III, Laser Applications to Optics and Spectroscopy, Addison Wesley (1975).*
10. *R.H. Pantell and H.E. Puthoff, Fundamentals of Quantum Electronics Wiley (1969).*

18PHY645 THIN FILM TECHNOLOGY 3 0 0 3

Unit 1

Preparation methods: Physical methods: thermal evaporation, cathodicsputtering, Molecular beam epitaxy and laser ablation methods. Chemical methods: electrolytic deposition, chemical vapour deposition.

Unit 2

Thickness measurement and Characterisation: electrical, mechanical, opticalinterference, microbalance, quartz crystal methods. Analytical techniques of characterization: X-ray diffraction, electron microscopy, high and low energy electron diffraction, Auger emission spectroscopy.

Unit 3

Growth and structure of films: General features-Nucleation theories - Effectof electron bombardment on film structure – Post-nucleation growth - Epitaxial film growth - Structural defects.

Unit 4

Properties of films: elastic and plastic behaviour. Optical properties - Reflectanceand transmittance spectra - Absorbing films - Optical constants of film material -Multilayer films - Anisotropic and isotropic films. Electric properties to films: Conductivity in metal, semiconductor and insulating films - Discontinuous films - Superconducting films.

Unit 5

Magnetism of films: Molecular field theory - Spin wave theory - Anisotropy inmagnetic films - Domains in films - Applications of magnetic films. Thin film devices: fabrication and applications.

TEXTBOOKS:

1. K.L. Chopra, Thin Film Phenomena, McGrawHill (1983),

2. George Hass. Physics of Thin Films: Volumes 1':12. Academic Press (1963).

REFERENCE BOOKS:

1. K.L. Chopra and I.J. Kaur, Thin Film Solar Cells, Plenum Press (1983).

2. L.I. Maissel and Giang (Eds.), Handbook of Thin film Technology, McGrawHill (1970).

3. J.C. Anderson, The Use of Thin Films in Physical Investigation, Academic Press (1966).

4. J.J. Coutts, Active and Passive Thin Film Devices, Academic Press (1978).

5. R.W. Berry, P.M. Hall and M.T. Harris, Thin Film Technology, Van Nostrand (1968). 47

18PHY646 FUNDAMENTALS OF PLASMA PHYSICS 3 0 0 3

Unit 1

Introduction – Spatial scale of an unmagnetized plasma – Debye Length, time scale plasma period, gyroradius and gyrofrequency of magnetized plasma, single particle motion in prescribed fields- ExB, grad-B, Curvature and polarization drifts, magnetic moment, adiabatic invariants of particle motion, magnetic mirror.

Unit 2

Kinetic theory of plasmas, Boltzmann equation, Maxwell-Boltzmann distribution, Vlasov description of collision less plasmas, Moments of the Boltzmann equation, Systems of macroscopic equations: Cold and Warm plasma models.

Unit 3

Plasmas as fluids - Two fluid description, equation of motion, Drifts perpendicular to B, parallel pressure balance.

Unit 4

Single fluid theory of plasmas: Magneto hydrodynamics (Hydro magnetic, MHD).

Unit 5

Introduction to waves in plasmas, waves in cold magnetized and unmagnetized plasma, Fourier representation, Dispersion relation, Waves in hot (magnetized) plasmas, Landau Damping, CMA diagram, Instabilities, MHD Waves, Alfven Waves, MHD discontinuities.

TEXTBOOKS/REFERENCES:

1. *Umran S. Inan & Marek Golkowski, Principles of Plasma Physics for Engineers and Scientists, Cambridge, 2011*
2. *Francis F. Chen, Introduction to Plasma Physics and controlled fusion, Springer, 2006*
3. *D.A. Gumett & A. Bhattacharjee, Introduction to Plasma Physics, CUP, 2006*
4. *Boyd, T.J.M., and Sanderson, J.J.: The Physics of plasmas, CUP, 2003*
5. *Krall, N.A, Trivelpiece, A.W., Principles of plasma physics, McGraw Hill, 1973*
6. *Stix, T.H., Waves in plasmas, Springer, 1992*

18PHY648Ultrafast lasers and Applications 3 0 0 3

Objectives: To introduce ultrafast lasers and some of their applications.
UNIT 1: Ultrafast Light Sources:
Q-switching and modelocking, Nano second, Pico second and Femtosecond Lasers, Synchrotron source.
UNIT 2: Applications in Time-Domain Spectroscopy:
Need of lifetime measurements in semiconductors/ organic materials. Various methods of lifetime
measurements: Oscilloscope method, Time-correlated single photon counting, Fluorescence upconversion,
pump-probe spectroscopy.
UNIT 3: Applications in Nonlinear Optics:
Self-focusing and self-defocusing, Optical rectification, Z-scan and four wave mixing technique,
measurement of second and third order optical nonlinear susceptibility, Idea of optical gates.
UNIT 4: Applications in Fibre optic Communication:
Basics of optical fibre, photodetectors, fibre lasers, semiconductor lasers and optical communication,
Group velocity dispersion and dispersion compensation
Unit 5: Applications in Tunable Lasers and High Harmonic Generation:
White light continuum generation, Transient absorption, Optical parametric oscillators, Petta Watt lasers
and other applications

Books and references:

1. Few-Cycle Laser Pulse Generation and its Applications, Franz X. Kärtner, SPRINGER, 2004
2. Pulse fluorometry using simultaneous acquisition of fluorescence and excitation, D. J. S. Birch, R. E. Imhof, and A. Dutch, Rev. Sci. Instrum. 55, 1255 (1984).
3. The Principles of Nonlinear Optics, Y. R. Shen, Wiley-Interscience , 2003
4.. Nonlinear Fibre Optics, G. P. Agrawal, Academic Press, 2001

18PHY649 Energy and Environment in the 21st Century 3 0 0 3

Abstract
The energy and related environmental problems, the physics principles of using energy and the various real and hypothetical options are discussed from a physicist point of view. The lecture is intended for students of all ages with an interest in a rational approach to the energy problem of 21st century.

Objective Scientists and especially physicists are often confronted with questions related to the problems of energy and the environment. The lecture tries to address the physical principles of todays and tomorrow energy use and the resulting global consequences for the world climate.

The lecture is for students which are interested to participate in a rational and responsible debate about the energy problem of 21 Century.

Unit - 1

Introduction: Energy types, energy carriers, energy density and energy usage. How much energy does human needs/uses?

Energy conservation and the first and second law of thermodynamics

Unit - 2

Fossil fuels (our stored energy resources) and their use. Burning fossil fuels and physics of greenhouse effect.

Unit - 3

Physics basics of nuclear fission and fusion energy controlled nuclear fission energy today, the different types of nuclear power plants, uranium requirements and resources, natural and artificial radioactivity and the related waste problems from the nuclear fuel cycle.

Unit - 4

Nuclear reactor accidents and the consequences, a comparison with risks from other energy using methods. The problems with nuclear fusion and the ITER project.

Nuclear fusion and fission: ``exotic" ideas.

Unit - 5

Hydrogen as an energy carrier: ideas and limits of a hydrogen economy. New clean renewable energy sources and their physical limits (wind, solar, geothermal etc.)

Energy perspectives for the next 100 years and some final remarks

References

1. http://ihp-lx2.ethz.ch/energy21/
2. Die Energiefrage - Bedarf und Potentiale, Nutzung, Risiken und Kosten:
3. Klaus Heinloth, 2003, VIEWEG ISBN: 3528131063;
4. Environmental Physics: Boeker and Egbert New York Wiley 1999.

18PHY651MICRO AND NANO MAGNETISM-MATERIALS AND ITS APPLICATIONS 3 0 0 3

Required Knowledge

Scholars are expected to have completed the course Quantum Mechanics, Mathematical physics, Electrodynamics and Atomic physics. They should be familiar with the motivations of quantum mechanics and its historical development such as the ultraviolet catastrophe; Young's double-slit experiment etc. They should be familiar with the concept of a wave function; wave function collapse, and the expression of observables as operators. They should be able to apply the Schrödinger Equation to simple potentials and also familiarity with mathematical concepts such as vector spaces and Fourier series. This course will have some overlap with Atomic Physics.

Intended Learning Outcomes

The aim of this course is to provide an introduction to the physics underlying properties of strongly correlated systems. The course also provides examples of how Quantum Mechanics, Mathematical physics, Electrodynamics and Atomic physics can be applied in order to understand phenomena emergent in complex systems. By the end of the course, students should be able to: describe the key physical principles of magnetism; demonstrate a knowledge and understanding of the theory and applications of ferromagnetism and the macroscopic behavior of ferromagnets. Also by the end of the course, students should have acquired the problem solving skills, such as

1.Calculation of susceptibilities for different magnetic orderings;
2. Calculate spin wave dispersions for different magnetic structures;
3. Estimate reduction of magnetization
4. Estimate energies of nucleating a domain and forming a magnetic domain wall etc.

Course Outline: Details of the course content are listed below:

Unit 1 Magnetism of electrons

Introduction:-A brief history of magnetism; Magnetism and hysteresis; Magnet applications;Magnetostatics:- The magnetic dipole moment; Magnetic fields; Maxwell's equations; Magnetic field calculations; Magnetostatic energy and forces

Orbital and spin moments; Magnetic field effects; Theory of electronic magnetism; Magnetism of electrons in solids; Magnetism of localized electrons on the atom: The hydrogenic atom and angular momentum; The many-electron atom; Paramagnetism; Ions in solids; crystal-field interactions

Unit 2 Ferromagnetism; Anti-ferromagnetism and other magnetic order

Mean field theory; Exchange interactions; Band magnetism; Collective excitations; Anisotropy; Ferromagnetic phenomena

Molecular field theory of antiferromagnetism; Ferrimagnets; Frustration; Amorphous magnets; Spin glasses; Magnetic models

Unit 3 Micro and Nano-magnetism, domains and hysteresis

Micromagnetic energy; Domain theory; Reversal, pinning and nucleation.

Nanoscale magnetism; Characteristic length scales; Thin films; Thin-film heterostructures; Wires and needles; Small particles; Bulk nanostructures; Magnetic resonance:- Electron paramagnetic resonance; Ferromagnetic resonance; Nuclear magnetic resonance; Other methods

Experimental methods: Materials growth; Magnetic fields; Atomic-scale magnetism; Domain-scale measurements; Bulk magnetization measurements; Excitations; Numerical methods

Unit 4 Magnetic materials

Introduction; Iron group metals and alloys; Rare-earth metals and inter-metallic compounds; Interstitial compounds; Oxides with ferromagnetic interactions; Oxides with anti-ferromagnetic interactions

Applications of soft and hard magnets

Soft magnetic materials; applications:- Low-frequency and High-frequency applications
Magnetic circuits; Permanent magnet materials; Static and Dynamic applications with mechanical recoil; Dynamic applications with active recoil; Magnetic microsystems

Unit 5 Spin electronics and magnetic recording

Spin-polarized currents; Materials for spin electronics; Magnetic sensors; Magnetic memory; Magnetic recording
Special topics:- Magnetic liquids; Magneto-electrochemistry; Magnetic levitation; Magnetism in biology and medicine; Planetary and cosmic magnetism.

Text books

1. Magnetism and Magnetic Materials; J. M. D. COEY; CAMBRIDGE UNIVERSITY PRESS.
2. Text Book Of MagnetismBy R.K. Verma, DPH
3. Magnetism Fundamentals, edited by Etienne Du Trémolet de Lacheisserie, Damien Gignoux, Michel Schlenker, Springer
4. Magnetism: From Fundamentals to Nanoscale DynamicsBy Joachim Stöhr, Hans Christoph Siegmann; Springer
5. Introduction to Magnetism and Magnetic Materials, Second EditionBy David C. Jiles; Taylor and Francis
6. The Quantum Theory of Magnetism;By Norberto Majlis; World Scientific Publishing Co. Pte. Ltd

18PHY652X-RAY DIFFRACTION AND ITS APPLICATIONS3 0 0 3

UNIT I
X-RAY BASICS
The scattering of X-rays, Diffraction from a crystal
X-ray interaction with matter, X-ray sources, X-ray optics, X-ray detectors

UNIT II
X-RAY DIFFRACTOMETERS
High-Resolution Diffractometers; Powder Diffractometers

UNIT III
APPLICATIONS TO MATERIALS SCIENCE: STRUCTURE ANALYSIS; PHASE ANALYSIS; PREFERRED ORIENTATION (TEXTURE) ANALYSIS

UNIT IV
APPLICATIONS TO MATERIALS SCIENCE: LINE BROADENING ANALYSIS
Line Broadening due to Finite Crystallite Size; Line Broadening due to Microstrain Fluctuations; Williamson-Hall Method; The Convolution Approach Instrumental Broadening; Relation between Grain Size-Induced and Microstrain-Induced Broadenings of X-Ray Diffraction Profiles.

UNIT V

APPLICATIONS TO MATERIALS SCIENCE:RESIDUAL STRAIN/STRESSMEASUREMENTS

Strain Measurements in Single-Crystalline Systems; Residual Stress Measurements in Polycrystalline Materials.

IMPACT OF LATTICE DEFECTS ON X-RAY DIFFRACTION

Text books and References

1. Emil ZolotoyabkoBasic Concepts of X-Ray Diffraction; John Wiley & Sons, 21-Apr-2014 - Science
2. M. M. Woolfson; An Introduction to X-ray Crystallography; Cambridge University Press
3. Werner Massa; Crystal Structure Determination; (March 31, 2004) ISBN-10: 3540206442
4. Crystal Structure Analysis by: Jenny Glusker and Kenneth Trueblood (August 1992) ISBN-10: 0195035313
5. Crystal Structure Analysis: Principles and Practice (International Union of Crystallography Monographs on Crystallography) by Peter Main, William Clegg, Alexander J. Blake, Robert O. Gould. (January 28, 2002) ISBN-10: 019850618X
6. The Determination of Crystals Structures by: H. Lipson & W. Cochran (June 1966) ISBN-10: 080140276X
7. Fundamentals of Powder Diffraction and Structural Characterization of Materials by: Vitalij Pecharsky and Peter Zavalij (March 3, 2005) ISBN-10: 0387241477
8. Structure Determination by X-ray Crystallography by: Mark Ladd and Rex Palmer (September 30, 2003) ISBN-10: 0306474549
9. X-ray Structure Determination by: George Stout and Lyle Jensen (April 24, 1989) ISBN-10: 0471607118
10. X-ray Analysis and the Structure of Organic Molecules by: Jack Dunitz (December 16, 1996) ISBN-10: 3906390144

18PHY653 Solar Energy Conversions3 0 0 3

Unit I

Introduction to Semi conductors: Types of semiconductors;, Density of States, electron and hole currents, Electron distribution function, Fermi Dirac Statistics, Drift and Diffusion currents, Semiconductor transport equations; Calculation of carrier and current densities, General solution for current density,Metal semiconductor junction, Semiconductor – semiconductor junctions, Analysis of the P-N-Junctions, p-n junction under dark and under illumination. The Solar Resource and types of solar energy converters, Requirements of an ideal photoconverter, Photovoltaic cell and power generation, Characteristic of the Photovoltaic Cell, Material and design issues; Shockley–Queisser limit, Beyond the limit. Optics in solar energy conversion, antireflection coatings, concentration of light: Light confinement, photon recycling, multiple exciton generation.

Unit II

Silicon Solar cell, Mono -crystalline and poly–crystalline cells, Metallurgical Grade Si, Electronic Grade Si, wafer production, Mono–crystalline Si Ingots, Poly–crystalline Si Ingots, Si–wafers, Si–sheets, Solar grade Silicon, Si usage in solar PV, Commercial Si solar cells, process flow of commercial Si cell technology, Process in solar cell technologies, Sawing and surface texturing, diffusion process, thin film layers, Metal contact.

Unit III

2nd generation solar cell, Thin film solar cell,Advantage of thin film, Thin film deposition techniques, Evaporation, Sputtering, LPCVD and APCVD, Plasma Enhanced, Hot Wire

CVD, closed space sublimation, Ion Assisted Deposition, Substrate and Super -state configuration, Thin film module manufacturing, Thin film and Amorphous Si Solar cell, Cadmium Telluride Solar Cell, CIGS solar Cell, CZTS solar cell, New materials for thin film solar cell.

Unit IV

3rd generation Solar cell; **Advances in Photovoltaics**, Photochemical and photosynthetic energy conversion; DSSC, Solution processed thin film, Organic Solar Cell, Hydride Perovskite solar cell and multi junction tandem solar cells.

Solar PV modules: Series and Parallel connections, Mismatch between cell and module, Design and structure, PV module power output, PV system configuration, standalone system with DC / AC load with and without battery, Hybrid system, Grid connected systems.

TEXT BOOKS / REFERENCES:

1. Physics of Solar cells-Jenny Nelson, Imperial College Press (2006).
2. Solar Energy Conversion (Second Edition):Richard C. Neville; Elsevier Science (1995).
4. Physics of solar cells: P. Wurfel (Wiley-VCH, 2013).
5. Solar cell device physics;J. Fonash(AP, 2010).
6. Solar Energy: The Physics and Engineering of Photovoltaic Conversion, Technologies and Systems: UIT Cambridge, (2016).

18PHY654 Fabrication of Advanced Solar cell: Understanding the device physics 3 0 0 3

Unit- I

The Solar Resource and types of solar energy converters, Requirements of an ideal photoconverter, Principles of a solar cell design, material and design issues; Revisions of Semiconductor Physics, Physics of semiconductor Junctions; p-n junction under dark and under illumination, effect on junction characteristics, Other device structures. Photovoltaic cell and power generation, Characteristic of the Photovoltaic Cell.

Unit-II

Silicon Solar cell, Mono -crystalline and poly–crystalline cells, Metallurgical Grade Si, Electronic Grade Si, wafer production, Mono–crystalline Si Ingots, Poly–crystalline Si Ingots, Si–wafers, Si–sheets, Solar grade Silicon, Si usage in solar PV, Commercial Si solar cells, process flow of commercial Si cell technology, Process in solar cell technologies, Sawing and surface texturing, diffusion process, thin film layers, Metal contact.

Unit-III

2nd generation solar cell, Thin film solar cell,Advantage of thin film, Thin film deposition techniques, Evaporation, Sputtering, LPCVD and APCVD, Plasma Enhanced, Hot Wire CVD, closed space sublimation, Ion Assisted Deposition, Substrate and Super -state configuration, Thin film module manufacturing, Thin film and Amorphous Si Solar cell, Cadmium Telluride Solar Cell, CIGS solar Cell, CZTS solar cell, New materials for thin film solar cell.

Optics in solar energy conversion: antireflection coatings, concentration of light: Light confinement, photon recycling, multiple exciton generation.

Unit-IV

3rd generation Solar cell; **Advances in Photovoltaics**, Photochemical and photosynthetic energy conversion; DSSC,, Solution processed thin film, Organic Solar Cell, Hydride Perovskite solar cell and multijunction tandem solar cells;

Solar PV modules: Series and Parallel connections, Mismatch between cell and module, Design and structure, PV module power output, PV system configuration, standalone system with DC / AC load with and without battery, Hybrid system, Grid connected systems.

Unit-V

Hand on experience on solar cell fabrication, DSSC fabrication, Perovskite solar cell fabrication, Thin film solar cell fabrication.

TEXT BOOKS / REFERENCES:

1. Physics of Solar cells-Jenny Nelson, Imperial College Press(2006)
2. Crystalline Silicon Solar Cells, by A. Goetzberger, J. Knobloc h, and B. Voss (Wiley, 1998)
3. Third Generation Photovoltaics: Advanced Solar Energy Conversion, by M. A. Green (Springer, 2006)
4. Semiconductor Materials for Solar Photovoltaic Cells; Paranthaman, M.P. (et al.) (Eds.) (2016)

18PHY655Astrophysics and Cosmology3 0 0 3

Unit I Introduction to Astrophysics: Mass, length and time scales in astrophysics, Magnitude scale, Source of astronomical information, Astronomical nomenclature, Theory of radiative transfer, Basic characteristics of thermodynamical equilibrium in stars

Unit II Stellar Structure and Dynamics: Basic equations of stellar structure, Constructing stellar models, Stellar quantities, Stellar observational data, HR Diagram star clusters, Main nuclear reactions in stellar interior, Stellar evolution, Stellar Winds

Unit III Compact Stars and Interstellar Matter: Supernovae, Degeneracy pressure of a Fermi gas, White Dwarf and Chandrasekhar mass limit, Neutron stars, Pulsars, Blackholes, Event Horizon and Schwarzchild radius, Phases of Interstellar Matter, Interstellar cloud and dust

Unit IV Properties and Classification of Galaxies: The shape and size of our galaxy, Galactic rotation and Oort's constant, Missing mass problem and Dark matter, Morphological classification and physical characteristics of normal galaxies, Active galaxies, Unified model of active galaxies

Unit V Cosmology: Hubble's law and the age of the Universe, Early Universe and Nucleosynthesis, Cosmic Microwave Radiation, Big Bang and Steady State model of the Universe, The horizon problem and inflation, Baryogenesis, Evidence and Nature of Dark matter and Dark energy

Text Book: "Astrophysics for Physicists" by Aranb Rai Choudhuri

Ref. Book: "Introduction to Astronomy and Cosmology" by Ian Morison

18PHY656Special Theory of Relativity 3 0 0 3

Pre-requisites: Electrodynamics & Intermediate Mechanics (both are compulsory Int. M.Sc. courses)
Level: **UG final year** / **PG I or II** – Elective or Core

Aim: To have a comprehensive physical idea and mathematical understanding of Special theory of Relativity and its applications in Electrodynamics, Fluid Dynamics etc using four-dimensional covariant analysis.

UNIT 1
Classical Mechanics and Relativity: Galilean Relativity, Newtonian Mechanics, Electrodynamics and Galilean Relativity, Ether, Michelson–Morley experiment, Attempts by Lorentz & Poincare.
7 hrs

UNIT 2
Special Theory of Relativity: Einstein's postulates, Lorentz's transformation, Length contraction,
Time dilation. Relativistic Kinematics, Doppler shift, Minkowski Diagrams, Boosts and Minkowski space.
14 hrs

UNIT 3
Four dimensional Space-Time geometry: Space-time continuum, Lorentz transformations as coordinate transformations, tensors, contravariant and covariant objects, four vectors
Relativistic Dynamics: Four velcocity, Four momentum, Four acceleration, Relativistic Collisions, Conservation of four-momentum, Equivalence of Mass and Energy. Central force problem in relativity.
14 hrs

UNIT 4
Electromagnetic Theory in covariant form: Maxwell's equations in covariant form, Four dimensional vector potential, Energy-Momentum Tensor and Conservation Laws, Lagrangian formulation of Electrodynamics, Radiation.
13 hrs

UNIT 5
Covariant formulation Fluid Dynamics: Perfect fluids, Pressure and proper density, Energy-Momentum tensor, Relativistic Euler equations, Equation of state, Speed of sound.
The Lorenz & Poincare groups: The The Lorentz and Poincare algebras and their representations.
The Principle of Equivalence and preamble to General Theory of Relativity. 12 hrs

Text Books:
1. N. M. J. Woodhouse, Special Theory of Relativity, Springer, 2003
2. Steven Weinberg, Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity, Wiley India, 2008

Reference Books:
1. Landau & Lifshitz, Classical Field Theory, University Science Books, 1E, 2004
2. Ashok Das, Lectures on Electromagnetism, Hindustan Book Agency – World Scientific, 2013

3. A. Einstein, Relativity: The Special and the General Theory

18PHY681 SPECTROSCOPY LAB 0 0 6 2

1. Determination of Wavelength and distance between D1 & D2 of sodium vapor light using Michelson Interferometer
2. Thermal expansively using interferometric technique
3. Observation of hyperfine splitting of spectral lines - Fabry-Perot Interferometer
4. Determination of e/m of electron by Normal Zeeman effect using Fabry-Perot etalon
5. Mach-Zehnder Interferometer using a He-Ne laser.
6. Fourier Filtering
7. Measurement and analysis of fluorescence spectrum of I2 vapor
8. Measurement of optical spectrum of an alkali atoms or alkaline earth metals
9. Measurement of Band positions and determination of vibrational constants of N2 molecule
10. Electron Spin Resonance Spectroscopy.
11. Energy band gap of semiconductor by studying the luminescence spectra
12. Study of temperature variation of refractive index of a liquid using hollow prism and laser source.
13. Clausius – Mossotti equation using sugar solution.

18PHY696 DISSERTATION18cr

The aim of the project work is to give more detailed exposure to the student for research methodology. This can include literature survey, review, data collection,and theoretical/ experimental work on small parts of research in area chosen by the faculty guiding the project work. If the project to be carried out at other institutions/ laboratories, the experts from these institutions are to be associated in choosing the research topic and its execution.

18PHY697 Viva-voce 1 cr

A comprehensive viva-voce will be conducted to assess the general understanding of the student in the basic courses that he/she has studied. It will not be topic-specific, but will cover both basic and PG level of physics. This is meant to evaluate the student's grasp on the subject, and also to help students face interviews.