CENTRAL UNIVERSITY OF KARNATAKA

NATIONAL EDUCATION POLICY 2020-BASED
4-Year UG PROGRAMME
LEADING TO

B.SC IN PHYSICS
(HONOURS/RESEARCH)

DEPARTMENT OF PHYSICS

CENTRAL UNIVERSITY OF
KARNATAKA

Learning Outcomes based Curriculum Framework for the NEP-2020 based 4-year UG Programme Leading to BACHELOR OF SCIENCE IN PHYSICS (HONOURS / RESEARCH)

July 2022

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1 VISION AND MISSION

Vision: Lay and strengthen the foundations for students to become better physicists and to train them in skills and technologies required to face the modern world with confidence.

Missions:

1. Impart quality education that cultivates the process of understanding principles and concepts in physics through logical analysis and experiential learning
2. Inculcate the art of scientific inquiry and science communication to improve to their overall competence in physics.
3. Sensitise students about contemporary techniques, practices and open problems in science and technology.
4. Develop facilities to impart skills required to formulate experiments and analyze the results.

2 FOUR YEAR UG PROGRAMME LEADING TO B.SC IN PHYSICS (HONOURS/RESEARCH)

Programme Code: UCHPH Duration: 4 years (8 semesters)

Qualification Descriptors

Upon completion of the academic program, the students will be able to:

1. Develop and demonstrate competence in foundation and discipline-specific courses of physics
2. Design simple experiments, analyze the results and present them in a manner that is consistent with current scientific practise
3. Present a scientific method or work in a professional manner to other students and scientists
4. Demonstrate scientific temperament in their approach in analyzing situations
5. Demonstrate the ability to think independently, work in a team, discuss and communicate scientific ideas to peers

Program Learning Outcomes

Upon completion of the coursework, the students will be able to:

1. Demonstrate the ability to readily apply the principles of quantum mechanics, classical mechanics, statistical mechanics and electromagnetic theory to problems in varied disciplines
2. Analyze data, generate scientific plots and perform statistical analysis
3. Handle test and measurement equipment widely used in physics laboratories
4. Perform literature survey on a specific topic and comprehend scientific literature
5. Summarize scientific work in a report and be aware of ethical guidelines related to publishing

About the Programme

The NEP-based four-year UG programme leading to B.Sc in Physics (Honours/Research) will be introduced from the academic year 2022 onward. The salient features of the programme are illustrated below:

Semesters 1 & 2

Core Courses in Physics & Chemistry

All students admitted to the this programme should undergo core courses in Physics and Chemistry in addition to Generic Electives, Minors, Skill Enhancement Courses and Value Addition Courses

End of First Year

Exit: Award of UG Certificate (Chemistry & Physics)

Semesters 3 & 4

Core Courses in Physics & Chemistry

Students continuing in the programme should undergo core courses in Physics and Chemistry in addition to Generic Electives, Minors, Skill Enhancement Courses and Value Addition Courses

End of Second Year

Exit: Award of UG Diploma in Physics / Enrollment in Chemistry or Physics streams

Students who opt for specific courses offered by the Department of Physics will be given an option to exit the course with a Diploma in Physics. The rest of students shall be enrolled in Physics or Chemistry streams based on merit-cum-choice basis. Merit shall be based on policies mandated by the University.

Semesters 5 & 6

Core and Elective in Physics Only

Students continuing their studies in the Physics stream will attend core and elective courses in Physics only in addition to other courses in skill enhancement.

End of Third Year

Exit: Award of Bachelor of Science in Physics / Enrollment in Honours or Research stream

Students who wish to exit at this stage will be awarded B.Sc in Physics. Other students will be enrolled in either Honours or Research stream based on policies mandated by the University.

Semesters 7 & 8

Theory / Project Work / Mini-project

Students enrolled in the Research stream will have special emphasis on training in research. The Honours students will be trained in advanced courses.

End of 4th year: Award of B.Sc in Physics (Honours/Research)

The four-year UG programme (FYUP) leading to the award of B.Sc in Physics (Honours / Research) is offered jointly by the Departments of Physics and Chemistry. The syllabus of the courses offered by the Department of Physics can be found in this document. The syllabus of other courses including those offered by the Department of Chemistry can be found on our University website.

Students enrolled in this programme will undergo Core and Elective courses in Physics and Chemistry in the first two years in addition to Minor courses, Generic Electives (GE), Skill/Ability Enhancement Courses (SEC/AEC) and Value Addition Courses (VAC). It is highly recommended that students opt for minor courses offered by one of the following departments:

- Department of Mathematics
- Department of Life Sciences or
- Department of Computer Sciences

Once a minor subject has been chosen in the first semester, the choice of minor subject in all the other semesters must be from the same department. For example, a student opting a minor from the Department of Mathematics in the first semester should ensure that he/she opts for minors from the Department of Mathematics only in all the semesters.

Students may opt to exit the programme at the end of first year with the award of UG Certificate in Chemistry and Physics subject to clearing all qualifications stipulated by the University.

Students may opt to exit the programme at the end of second year with the award of a UG Diploma in Chemistry or a Diploma in Physics subject to clearing all qualifications stipulated by the University. The awarded Diploma (i.e, Chemistry or Physics) will depend on the students option of subjects in Discipline Specific Elective (DSE) and Skill Enhancement Course (SEC) offered in the 4th semester. For students wishing to exit with a Diploma in Physics, both of these subjects must be from the Department of Physics.

At the end of second year, students will be enrolled in either Physics or Chemistry streams based on merit-cum-choice, the policies of which shall be stipulated by the University.

From third year onwards, students enrolled in Physics stream will undergo Core and Elective courses in Physics, in addition other courses (SEC/VAC etc.,).

Students may opt to exit the programme at the end of third year with the award of a B.Sc in Physics subject to clearing all qualifications stipulated by the University. At the end of third year, students will be enrolled in either Honours stream or Research stream, based on policies stipulated by the University.

Students enrolled in the Research stream will have special emphasis on training in research and those enrolled in the Honours stream will be trained in advanced courses. Specifically, the students enrolled in the Research stream will carry out one mini project in the 7th semester and one major project in the 8th semester. The Honours stream students will carry out only one mini project in the 8th semester. Research stream students will also have fewer theory courses compared to the Honours stream, in the final year.

At the end of the final year, students enrolled in the Honours stream will be awarded B.Sc Physics (Honours) and those enrolled in the Research stream will be awarded B.Sc Physics (Research) subject to clearing all qualifications stipulated by the University.

SEM	PHYSICS DSC 6/4* credits	CHEMISTRY DSC 6 credits	DSE 3/4* credits	GE / MINOR 3 credits	AEC 2 credits	SEC 2 credits	VAC 2 credits	RESEARCH 4/12* credits	Total Credits
1	Mathematics for Physicists	C1		GE-1 Minor-1	Language	-	VAC-1	-	22
2	Mechanics & Properties of Matter	C2		GE-2 Minor-2	Environ. science	SEC-1	-	-	22
EXIT OPTION AT THE END OF 1ST YEAR: AWARD OF UG CERTIFICATE (CHEMISTRY AND PHYSICS)									
3	Electricity, Magnetism & Optics	C3		GE-3 Minor-3	-	SEC-2	VAC-2	-	22
4	Classical Mechanics & Intro. to Quantum Mechanics	C4	Electronics#	GE-4 Minor-4	-	SEC-3 *(Electronics Lab #)*	-	-	22
EXIT OPTION AT THE END OF 2ND YEAR: AWARD OF UG DIPLOMA IN PHYSICS OR ENROLLMENT IN CHEMISTRY OR PHYSICS STREAMS									
5	-Statistical Mechanics -Adv. Quantum Mechanics -Electromagnetic Theory		**Any one of:** -Experimental Methods in Physics -MOOCs				VAC-3		23
6	-Solid State Physics -Nuclear Physics -Atomic, Mol. & Laser Phys		**Any one of:** -Instrumentation and Interfacing -MOOCs			SEC-4			23
EXIT OPTION AT THE END OF 3RD YEAR: AWARD OF B.SC IN PHYSICS OR ENROLLMENT IN HONOURS OR RESEARCH STREAMS									
7	Research Methodology & publication ethics*		**Any 3 (Res) /5 (Hons) of following** -Low dimensional physics* -Advanced Cond. Matter Physics* -Particle physics* -Any MOOCs*				**FOR RESEARCH STREAM:** Technical Tools for Research	**FOR RESEARCH STREAM:** Mini project	22
8			**Any 2 (Res) /4 (Hons) of following:** -Astronomy and Astrophysics* -Physics of Soft Matter* -Advanced Statistical Mechanics* -Any MOOCs*				**FOR HONS. STREAM:** Technical Tools for Research	**FOR RESEARCH STREAM:** Project Work* **FOR HONS. STREAM:** Mini project	20
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DSC: Discipline Specific Core | DSE: Discipline Specific Elective | GE: Generic Elective | AEC: Ability Enhancement Course | SEC: Skill Enhancement Course | VAC: Value Addition Course

GE should be a course with minimal or no overlapping content with Physics or Chemistry (courses related to Music, Languages etc.,)

Minor should be a course with contents that will complement the majors i.e, Physics and Chemistry (courses related to Mathematics, Life Sciences or Computer Science etc.,)

Only students who enroll in Electronics and Electronics Lab will be awarded Diploma in Physics on exit.

1 Semester = 15 weeks of teaching/learning sessions, including examinations and internal assessments; 1 credit = 1 contact hour per week;

3 DISCIPLINE SPECIFIC CORE (PHYSICS)

MATHEMATICS FOR PHYSICISTS DSC001 [L:5 P:0 T:1=6 Credits]

Prerequisites: Basic differentiation and integration

Detailed syllabus

Unit 1: Calculus of functions (15 hours)

Review of basic differentiation: Limits, continuity, average and instantaneous quantities, differentiation; Plotting functions, Intuitive ideas of continuous, and differentiable functions;

First Order Differential Equations: Homogeneous Equations with constant coefficients. Wronskian and its general solution; Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. Examples in Mechanics.

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximisation using Lagrange Multipliers.

Unit 2: Special Functions (5 hours)

Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Orthogonality.

Unit 3: Partial Differential Equations and Curvylinear Coordinates (10 hours)

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Simple recurrence relations. Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems, Examples in fluid dynamics and Electrodynamics.

Unit 4: Vector Calculus (15 hours)

Effect of vectors, scalar product and vector product under rotations, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields. Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities, Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications.

Unit 5: Fourier Series, transform and Delta Function: (10 hours)

Fourier expansion of a periodic function, Applications for simulating signals. Parseval's theorem theorem. Fourier transform and applications. Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function,

Unit 6: Complex Analysis (10 hours)

Representation of complex numbers, Analytical functions, integration in the complex plane, singularities, poles and residues, Cauchy's residue theorem,

Unit 7: Linear algebra (5 hours)

Basic properties of matrices, orthogonal, hermitian, unitary matrices similarity and unitary transformation, diagonalization of matrices

Unit 8: Probability and statistics (5 hours)

Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance. Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing.

Textbooks & references

1. (T) Mathematical Methods of Physicists by George Arfken and Hans J. Weber
2. (T) Mathematical Methods for Physics and Engineering, Kenneth Franklin Riley, Michael Paul Hobson, Stephen John Bence.Cambridge University Press, 1997
3. (R) Introduction to Ordinary differential equations by R. L. Rabenstein
4. (R) Complex Variables & Applications by R. V. Churchill
5. (R) Partial Differential Equation for Scientists by G. Stephenson

Course learning outcomes

At the end of the course, you must be able to :

1. Perform calculations using integration and differentiation
2. Obtain solutions of partial differential equations of varied types
3. Apply fourier transform to varied signals of interest
4. Use complex numbers in varied problems of interest
5. Apply rules of statistics and probability in different scenarios

MECHANICS AND PROPERTIES OF MATTER DSC002 [L:4 P:2 T:0=6 Credits]

Prerequisites: None

Detailed syllabus

Unit 1: Review of Newtonian Mechanics and Rigid body dynamics (12 h)

Review of Newton's laws of motion: Work, kinetic and potential energy, energy conservation, momentum and collisions; Kepler's laws of planetary motion: Gravitation; Rotational motion of rigid bodies: Moment of inertia, angular momentum and torque.

Unit 2: Waves Oscillations (12 h)

Periodic motion: simple harmonic motion, damped harmonic oscillator, driven damped harmonic oscillator; Complex wave equations: Fourier theorem and Fourier coefficients; Mechanical waves: Sound and ultrasonics.

Unit 3: Elasticity and plasticity (12 h)

Elasticity: Stess, strain, elasticity and plasticity, Hooke's law, elastic modulii

Unit 4: Fluid statics and Fluid dynamics: (12 h)

Pressure in a fluid, pressure gauges, Archimedes' principle, surface tension, pressure difference across a surface film and contact angle and capillarity; Fluid dynamics: Equation of continuity, Bernoulli's equation and its applications, Viscocity, Poiseuille's law, Stoke's law, Reynolds number.

Unit 5: Special Theory of relativity: (12 h)

Galilean and Lorentz transformation, Special relativity, Time dilation, Length contraction, Relativistic mass, energy and momentum, General relativity, Space time.

List of experiments (Any 8 to be performed in a semester)

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope
2. Measurement of surface tension of liquids
3. Random errors in observations
4. Determination of height of a building using a Sextant.
5. Study of motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity
6. Determination of Moment of Inertia of a flywheel.
7. Determination of g and velocity for a freely falling body using Digital Timing Technique
8. Determination of coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method)
9. e Young's Modulus of a Wire
10. Modulus of Rigidity of a Wire by Maxwell's needle
11. Elastic Constants of a wire by Searle's method
12. Determination of g using Bar Pendulum
13. Time dilation studies in muons.

Textbooks & references

1. (T) University Physics by F. W. Sears, M. Zemansky, R. A. Freedman, and H. D. Young, Pearson Education
2. (T) Fundamentals of Physics by D. Halliday, R. Resnick, J. Walker, John Wiley Sons
3. Concepts of Modern Physics by Arthur Beiser, Tata McGraw-Hill

Course learning outcomes

At the end of the course, you must be able to :

1. Apply classical laws to various physics use cases
2. Apply wave theory in various phenomena to predict the behaviour
3. Apply special theory of relativity and understand the behaviour of systems moving at relativistic speeds
4. Measure various material properties of matter and understand the effect of errors in measurements.

Prerequisites: Quantum mechanics 1

Detailed syllabus

Unit 1: Electric Field and Electric Potential (18 h)

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

Unit 2: Dielectric Properties of Matter (8 h)

Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector D. Relations between E, P and D. Gauss' Law in dielectrics.

Unit 3: Magnetic Field and Magnetic Properties of Matter: (10 h)

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

Unit 4: Electromagnetic induction (6 h)

Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current.

Unit 5: Wave optics and interference (10 h)

Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings:Measurement of wavelength and refractive index. Michelson Interferometer-(1) Idea of form of fringes, (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer.

Unit 5: Diffraction (8 h)

Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula. Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula. Diffraction: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire. Principle of Holography. Recording and Reconstruction Method.

List of experiments (Any 8 to be performed in a semester)

1. Measurement of resistance, AC/DC voltages and currents, capacitances and checking electrical fuses
2. Characteristics of a series RC circuit
3. Measurement of low resistance using potentiometer

4. Measurement of low resistance using Carey Foster's Bridge
5. Measurement of field strength B and its variation in a solenoid
6. Responce curves of series LCR circuit
7. Measurement of self-inductance and mutual inductance
8. Determination refractive index of the Material of a prism using Sodium source
9. Determination of the wavelength of sodium source using Michelson's interferometer.
10. Determination of the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film
11. Determination dispersive power and resolving power of a plane diffraction grating

Textbooks & references

1. (T) Foundations of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, McGraw Hill, 1994.
2. (T) Physics of atoms and molecules, 2nd ed., B. H. Bransden and C. J. Joachain, Prentice Hall, 2003.
3. (T) Lasers, A. E. Siegman, University Science Books, 1986
4. (T) Lasers Fundamentals and Applications, K.Thyagarajan and Ajoy Ghatak, Macmillan Publ. India,
5. (R) Molecular Quantum Mechanics, 3rd ed., P.W.Atkins and R.S.Freidman, OUP, 1997
6. (R) Elementary Atomic Structure by G. K. Woodgate, Clarendon Press (1989).
7. (R) Waves: Berkeley Physics Course, Vol. 3
8. (R) Optics, Ajoy Ghatak, 2008, Tata McGraw Hill

CLASSICAL MECHANICS AND INTRODUCTION TO QUANTUM MECHANICS DSC004 [L:5 P:0 T:1=6 Credits]

Prerequisites: Differential calculus, Linear Algebra (basics)

Detailed syllabus

Unit 1: Survey of elementary principles (15 h)

A brief review of Newtonian mechanics; De-Alembert's Principle, Lagrangian Formalism – constraints in dynamical systems, generalized coordinates, Lagrange's equation of motion.

Unit 2: Central force problems using Lagrangian formalism (8 h)

Two body central force problem, Kepler's law of motion; scattering due to central force fields; Equations of motion using Lagrangian formulation.

Unit 3: Hamiltonian equations of motion and Hamilton's principle (10 Hours)

Legendre's transformation of Lagrangian, Hamilton's formalism – dynamical equations, conservation laws, Variational calculus, Hamilton's principle

Unit 4: Poisson brackets, Canonical transformations and Hamilton-Jacobi theory (12 h)

Poisson brackets and their properties – equations of motion, Canonical transformation - generating functions, properties, Introduction to Hamilton-Jacobi Theory; Solution to time-dependant Hamilton-Jacobi equation, Jacobi theorem, Action angle variables

Unit 5: Rigid body dynamics and small oscillations (15 h)

Rigid body motion – infinitesimal rotations- Euler angles; Theory of small oscillations – normal modes of the system.

Unit 6 Failures of Classical Mechanics (7 h)

Blackbody radiation, Plancks hypothesis, Photoelectric effect, Specific heat of solids, Frank-Hertz experiment, Double-slit interference, Davisson-Germer experiment

Unit 7 Waves (7 h)

Representation of waves in complex notation, Superposition and interference, Fourier transforms, Uncertainty principle

Unit 8 Schrodinger's Equation (7 h)

Schrodinger's equation and its solutions, Postulates, Observables, Operators, Eigen values and measurements, Collapse of Wave function

Unit 9 1d problems (8 h)

Free particle, Infinite square well, Finite square well, Harmonic Oscillator

Unit 10 Angular Momentum and 3d Quantum Mechanics (8 h)

Angular momentum operators and commutation rules, Spin 1/2 systems, Schrodinger's equation in spherical coordinates, Hydrogen atom

Textbooks & references

1. (T) Classical Mechanics by H. Goldstein
2. (T) Classical Dynamics by Joag N. C. and Rana, P. S.
3. (R) Mechanics by Landau-Lifshitz

4. (R) Classical Mechanics by A. K. Raichaudhuri
5. (R) Classical Dynamics by J B. Marion
6. (T) Introduction to Quantum Mechanics by David Griffiths (Pearson Education)
7. (T) Quantum Physics of Atoms, Molecules, Solids Nuclei and Particles by R Eisberg, R Resnick (Wiley)
8. (R) Principles of Quantum Mechanics by R. Shankar (Springer)
9. (R) A Textbook of Quantum Mechanics by Piravonu Mathews, K. Venkatesan (Tata McGraw Hill)

STATISTICAL MECHANICS DSC005 [L:4 P:2 T:0=6 Credits]

Prerequisites: Mechanics, Quantum mechanics 1

Detailed syllabus

Unit 1: Thermodynamics and statistics (12 h)

Laws of thermodynamics and their consequences; Thermodynamic potentials – Maxwell's relations, Phase space - micro- and macro-states; Elementary statistical concepts: mean values, binomial and Gaussian distribution.

Unit 2: Statistical Thermodynamics (8 h)

Statistical Ensemble, Fundamental postulate of equilibrium statistics, Interactions between macroscopic systems: thermal and mechanical interactions, equilibrium between interacting systems, Boltzmann's entropy relation.

Unit 3: Ensembles (15 h)

Micro-canonical, canonical and grand-canonical ensembles and partition functions; chemical potential, Free energy and its connection with thermodynamic quantities.

Unit 4: Application of statistical thermodynamics formulation (15 h)

Classical and quantum statistics; Blackbody radiation and Planck's distribution law; Ideal Bose and Fermi gases; Bose-Einstein condensation.

Unit 5: Phase transitions and Diffusion (10 h)

First and second order phase transitions; Diffusion equation: random walk and Brownian motion.

List of experiments (Any 8 to be performed in a semester)

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. Measurement of Planck's constant using black body radiation.
3. To determine Stefan's Constant.
4. To determine the coefficient of thermal conductivity of copper by Searle's Apparatus.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
7. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.
8. To study the variation of thermo emf across two junctions of a thermocouple with temperature.
9. To record and analyze the cooling temperature of an hot object as a function of time using a thermocouple and suitable data acquisition system
10. To calibrate Resistance Temperature Device (RTD) using Null Method/Off-Balance Bridge

Textbooks & references

1. (T) Statistical Mechanics, R.K.Pathria and Paul D.Beale, 3rd Ed., Elsevier, 2013 (Indian Print).
2. (T) Fundamentals of Statistical and Thermal Physics, F. Reif, McGraw Hill, New York.
3. (T) Thermal Physics, Kittel, C. and Kroemer, H, W. H. Freeman publisher, 1980
4. (R) Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University press (1987)
5. (R) Equilibrium Statistical Mechanics by C. J. Thompson , Clarendon Press (1988)
6. (R) Statistical Mechanics by K. Huang, Wiley Eastern (1988)

7. (R) Advanced Practical Physics for students, B.L.Flint H.T.Worsnop, 1971, Asia Publishing House.

Prerequisites: Quantum Mechanics 1, Classical Mechanics

Detailed syllabus

Unit 1:Introduction to Dirac notation (10 h)

Linear vector spaces, Inner product spaces, Dual spaces and Dirac notation, Linear operators and Matrix elements, Generalization to infinite dimensions

Unit 2: Scattering theory and approximate methods (13 h)

Partial wave analysis, phase shifts, Born approximation, Variational principle, Ground state of He, Hydrogen Ion molecule, WKB approximation, Adiabatic approximation

Unit 3: Perturbation theory (13 h)

Time-Independent perturbation theory, Non-degenerate and degenerate cases, fine structure of Hydrogen, Time dependent perturbation theory, two level systems, Einstein's coefficients.

Unit 4: Quantum theory of radiation (11 h)

Classical radiation field, creation, annihilation operators, quantized radiation field, emission and absorption of photons by atoms.

Unit 5: Relativistic quantum mechanics (13 h)

Klein-Gordon equation, Dirac equation, Relativistic covariance, bilinear covariants, quantization of Dirac field

Textbooks & references

1. (T) Principles of Quantum Mechanics By R. Shankar (Springer)
2. (T) Quantum Mechanics: Concepts and Applications By Nouredine Zettili (Wiley)
3. (T) Advanced Quantum Mechanics By J. J. Sakurai (Pearson)
4. (R) Lectures On Quantum Field Theory By Ashok Das (World Scientific)
5. (R) Relativistic Quantum Mechanics by W. Greiner (Springer)
6. (R) Introduction to Quantum Mechanics by D. Griffith (Pearson).
7. (R) Modern Quantum Mechanics By Sakurai (Pearson)
8. (R) Advanced Quantum Mechanics by F. Dyson (World Scientific)

Prerequisites: Mathematical methods in physics

Detailed syllabus

Unit 1: Maxwell Equations and EM Wave Propagation (13 hours)

Review of Maxwell's equations. Displacement Current. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density.

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

Unit 2: EM in bound Media and Polarisation (13 hours)

Boundary conditions at a plane interface between two media. Reflection Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection Refraction. Fresnel's Formulae for perpendicular parallel polarization cases, Brewster's law. Reflection Transmission coefficients. Total internal reflection, evanescent waves.

Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation.

Unit 3: Wave guides and optical fibres (10 h)

Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission. Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only)

Unit 4: Generalised Potentials(10 h)

Coulomb and Lorentz gauge, wave equation for potentials; Gauges, Coulomb gauge, Ampere's Gauge. Solutions of equations Maxwell's equation i and their solution.Retarded potentials –Jefimenko's equations, Lienard-Wiechert potentials.

Unit 5: Radiation (7 h)

Radiation from accelerated charges - Electric dipole radiation, Magnetic dipole radiation, Radiation from an arbitrary source, power radiated by a point charge.

Unit 6:Relativistic Electrodynamics (7 h)

Faraday's law and Lorentz force, Motivations for Special Relativity, Lorentz transformations. Length, time, velocity, acceleration,EM wave: aberration and Doppler effect, Transformations of electric and magnetic fields.

List of experiments (Any 8 to be performed in a semester)

1. Study of the reflection, refraction of microwaves
2. Study of polarization and double slit interference in microwaves.
3. Dielectric relaxation of a solid measured through impedance studies of TiO^2
4. Study of radiation pattern of a bipolar Antenna
5. Study of attenuation constant for an optical fibre

6. Verification of cauchy's formula optically
7. Estimation of input impedance of a given cable coaxial cable
8. Simulating a dielectric sphere in a periodic environment using using Python
9. Simulating EM wave propagation in a rectangular wave guide using COMSOL MULTIPHYSIC
10. Simulating EM wave propagation on a metal strip using COMSOL MULTIPHYSIC

Textbooks & references

1. (T) Classical Electrodynamics: J.D.Jackson, John Wiley and Sons inc. NY
2. (T) Introduction to electrodynamics, D.J. Griffths, PHI,
3. (T) Elements of Electromagnetics, M.N.O.Sadiku
4. (R) Electromagnetic fields and waves. P. Lorrain and D. Corson, CBS
5. (R) Electromagnetism I.S Grant and W.R Phillips, John Wiley and Sons Ltd.

Prerequisites: Basic quantum mechanics

Detailed syllabus

Unit 1: Crystals and crystal structure (10 h)

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

Unit 2: Free Electron Theory and Bands(15 h)

Drude's model, Sommerfield model, Explanation of hall-effect; Failure of free electron model; Kronig Penny model. Band Gaps. Conductors, Semiconductors and insulators.Direct and indirect band gap semiconductors, concept of effective mass. Intrinsic carrier concentration and mobility. Effect of doping.

Unit 2: Elementary Lattice Dynamics (10 h)

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

Unit 3: Magnetic Properties of Matter (10 h)

Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia – and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss. Hund's rules. Paramagnetism in rare earth and iron group ions.Ferromagnetism: Curie-Weiss law. Heisenberg exchange interaction.

Unit 4: Dielectric Properties of Materials (10 h)

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

Unit 6: Superconductivity (5 h)

Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect.

List of experiments (Any 8 to be performed in a semester)

1. Measurement of resistivity using linear four probe and Van der Paw method.
2. Calibration of Lock-in- Amplifier and Measurement of small resistance using Lock – in Amplifier.
3. Measurement of magnetic susceptibility of a solid using phase sensitive detection.
4. Measurement of Dielectric Constant of a dielectric Materials with frequency
5. Determination of the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. Determination of refractive index of a dielectric layer using SPR
7. Study of PE Hysteresis loop of a Ferroelectric Crystal.
8. BH curve of Fe using Solenoid determine energy loss from Hysteresis
9. Measurement of resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 o C) and to determine its band gap.
10. Determination of Hall coefficient of a semiconductor sample.

Textbooks & references

1. (T) Solid State Physics- C Kittel, Wiley Eastern
2. (T) Solid State Physics, J.D. Patterson and B.C. Bailey; Springer (2007)
3. (R) Elementary Solid State Physic- Ali Omar, Pearson
4. (R) Solid State Physics- A J Dekker, MacMillan India Ltd
5. (R) Solid State Physics by F W Ashcroft and N D Mermin-Saunders College (1976)

NUCLEAR PHYSICS DSC009 [L:4 P:2 T:0=6 Credits]

Prerequisites: Quantum mechanics, Classical mechanics (specifically, scattering and collisions)

Detailed syllabus

Unit 1:Introduction, Basic Nuclear Constituents and Properties (8 h)

Geiger & Marsden / Rutherford's experiments to study the nucleus. Measurement of Nuclear Sizes, Binding Energy, Nuclear mass, Semi empirical formula, valley of stability, Drip Lines.

Unit 2: Nuclear Forces and Nuclear Structure Models (15 h)

Quark picture, Deuteron bound state, Phase shift analysis, Nuclear scattering. Nucleon mean potential, approximation by specific solvable potentials, single particle energy levels, magic number, moments, excited states and other predictions from shell model, failures of shell model, Collective model.

Unit 3: Radioactive decay, reactions and Astro-nuclear physics (12 h)

Alpha decay, Beta decay, Gamma decay, Nuclear reactions, Direct & Compund reactions, Nuclear Fission, Fission reactor and 4-factor formula, Nuclear Fusion, Fusion reactor, Fusion in Stars, PP and CNO cycles, Nucleosynthesis.

Unit 4: Applications of nuclear physics/ Brief introduction to particle physics (10 h)

Particle interactions with matter, Basics of heavy ion therapy for cancer treatments, The lepton and quark family, conservation laws, relativistic kinematics, Neutrino oscillations, Mass hierarchy problem, Types of neutrino oscillation experiments, Sensitivity analysis

List of experiments (Any 8 to be performed in a semester)

1. Characterisation of GM counter and study of nuclear counting statistics
2. Study of β particle range and verification of inverse square law
3. Estimation of efficiency of GM counter
4. Characterisation of a scintillation counter using a multi-channel analyser
5. Characterisation of a Silicon Photomultiplier
6. Geant4 simulation of Rutherford scattering, data analysis and estimation of cross-section
7. Geant4 simulation of Cobalt decay and data analysis
8. Geant4 simulation of Proton bragg peak and range estimation
9. Estimation of (cosmic) muon lifetime
10. Geant4 simulation of muon lifetime estimation

Textbooks & references

1. (T) Introduction to Nuclear and Particle Physics by Ashok Das and Thomas Ferbel (World Scientific)
2. (T) Introductory Nuclear Physics by Kenneth Krane (Wiley)
3. (T) Introduction to elementary particles by David Griffiths (Wiley)
4. (R) Quarks and Leptons: An Introductory Course in Modern Particle Physics by Halzen and Martin (Wiley)

Prerequisites: Quantum mechanics – I, Electrodynamics

Detailed syllabus

Unit 1: Light-matter interactions (5 h)

Review of spectrum of hydrogen atom and Bohr's theory; vector atom model, quantum mechanical theory of hydrogen atom, stimulated and spontaneous emission of light, absorption of light, Einstein's A and B coefficients.

Unit 2: Atomic Structure – One-electron atom (10 h)

Energy levels in one-electron atoms, interaction of one-electron atoms with electromagnetic radiation, fine and hyperfine structure; interaction of one-electron atoms with external electrical and magnetic fields.

Unit 3: Atomic Structure – Two and many-electrons atom (10 h)

Schrodinger equation for two-electron atoms: ortho and para states, Level scheme of two electron atoms; Many-electron atoms: the central field approximation, angular momentum of many electron atoms, L-S and j-j coupling.

Unit 4: Molecular Structure and its energy states (15 h)

Rotational states, vibrational states, rotational-vibrational states and electronic states of molecules. Interaction of molecules with electromagnetic radiation: UV, visible, infrared, microwave and Raman spectrum.

Unit 5: Lasers (5 h)

Population inversion, optical pumping, rate equation; Modes of resonators and coherence length; Types of Lasers with examples.

List of experiments (Any 8 to be performed in a semester)

1. Obtaining the wavelength of light from sodium lamp using Michelson Interferometer.
2. Study of Zeeman Effect.
3. Verification of Stefan's law for black body radiation.
4. Study of diffraction of Laser light by slits and circular aperture
5. Study of spectrum of copper.
6. Characterisation of a Laser source and related studies
7. Optical Spectrum of Hydrogen
8. Study of Newton's rings
9. Diffraction of LASER light by grating
10. Study of Mercury spectrum

Textbooks & references

1. (T) Foundations of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, McGraw Hill, 1994.
2. (T) Physics of atoms and molecules, 2nd ed., B. H. Bransden and C. J. Joachain, Prentice Hall, 2003.
3. (T) Lasers, A. E. Siegman, University Science Books, 1986
4. (T) Lasers Fundamentals and Applications, K.Thyagarajan and Ajoy Ghatak, Macmillan Publ. India,
5. (R) Molecular Quantum Mechanics, 3rd ed., P.W.Atkins and R.S.Freidman, OUP, 1997
6. (R) Elementary Atomic Structure by G. K. Woodgate, Clarendon Press (1989).

4 DISCIPLINE SPECIFIC ELECTIVES (PHYSICS)

ELECTRONICS DSE001 [L:3 P:0 T:0=3 Credits]

Prerequisites: Quantum Mechanics 1, Basic electronics

Detailed syllabus

Unit 1: Review of analog electronics (12 h)

Kirchoffs Current & Voltage Law, Superposition theorem, Norton and Thevenins Theorem, Semiconductor theory, PN junctions, Diode models, Analysis of diode circuits, time-response, Rectifier, Clipper, Clamper, Voltage doubler

Unit 2: Transistors (12 h)

BJT structure and operation, Small signal model, Early effect, Biasing techniques, Transistor as an Voltage-Controlled-Current-Source, DC-analysis, Transistor as a switch, Transistor as an amplifier, Properties of CE/CB and CC configurations, Emitter Degeneration, Cascading, Input and Output impedances, Unity-gain Buffer

Unit 3: Operational amplifiers (12 h)

Differential amplifier, Open loop gain and closed loop gain,Feedback theory, Negative and Positive Feedback, Operational amplifier circuits under ideal and non-ideal conditions: Summer, Subtractor, Integrator, Differentiator, Lograthmic amplifier, Precision amplifier, Op-amp active filters, Frequency response

Unit 4: Review of digital circuits (12 h)

Number systems: Binary, Hexadecimal, BCD and conversions, Logic gates, Construction of logic gates using transistors, Mathematical operations using logic gates, Structure and operations of TTL and CMOS gates; logic levels and noise margins, fan-out, propagation delay, transition time, power consumption, Boolean algebra, Simplification of boolean expressions using K-map, Pairs, Quads and Octets,

Unit 5: Digital circuits (12 h)

RS, JK, Master-Slave and D Flip Flops, Shift Registers, Ripple, Ring and Johnson Counters, Multiplexers, Demultiplexers, Analog to digital Conversion, Digital to analog conversion, Time & Charge to digital conversion

Textbooks & references

1. (T) Microelectronic Circuits: Theory And Applications by Adel Sedra and Smith (Oxford Press)
2. (T) Digital Principles and Applications by Malvino and Leach (Tata McGraw Hill)
3. (R) Op-amps and Linear Integrated Circuits by R Gayakwad (Prentice Hall)
4. (R) Art of Electronics by Paul Horowitz and Winfield Hill (Cambridge University Press)

Prerequisites: None

Detailed syllabus

Unit 1: Measurements and Signals (10 h)

Accuracy and precision. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting. Guassian distribution

Periodic and periodic signals. Impulse response, transfer function and frequency response of first and second order systems. Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise. Basics of grounding and shielding

Unit 2: Transducers and instrumentation (10 h)

tatic and dynamic characteristics of measurement Systems. Generalized performance of systems, Zero order first order, second order and higher order systems. Electrical, Thermal and Mechanical systems. Calibration. Transducers and sensors. Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric.Inductance sensors.

Unit 3: Optical methods (10 h)

Lasers, Choppers,Basic optical elements, Monochromators, Spectrophotometers, Calorimeters, Radiometer, Refractometer, Boxcar averaging. Optical sensors, Interference methods. Secondary harmonic generation. UV-Vis,IR spectrometers.

Unit 4: Vacuum and Low temperature methods (10 h)

Characteristics of vacuum: Gas law, Mean free path. Application of vacuum. Vacuum system- Chamber, Mechanical pumps, Diffusion pump Turbo Modular pump, Pumping speed, Pressure gauges (Pirani, Penning, ionisation).

Active cooling with cryogenics. Designing of a cryogenic systems. Heat load, Shields, Vacuum jackets.Closed cycle refrigeration, Dilution refrigeration. Magnetic field generation - superconducting magnets

Unit 5: Characterisation Instruments and Analysis tools (5 h)

LCR Meters, Source and Measure units, Electron imaging, Atomic force imaging.X- ray tools, Software tools for peak analysis tools.

Textbooks & references

1. (T)Building Scientific Apparatus, Moore,Davis and Coplan Cambridge University Press, 2009.
2. (T) Experimental Physics: Modern Methods, R. A. Dunlap, Oxford University Press, 1988.
3. (T) Vacuum technology and applications, D. J. Hucknall, Butterworth-Heinemann, 1991.
4. (R) Experimental Methods for Engineers, J.P. Holman, McGraw Hill
5. (R) Measurement, Instrumentation and Experiment Design in Physics and Engineering, M. Sayer and A. Mansingh, PHI Learning Pvt. Ltd.

Prerequisites: Basic Electronics

Detailed syllabus

Unit 1: Instrumentation System (10 h)

standards of measurement and units, Introduction, block diagram, functional elements of measurement system, static and dynamic characteristics of transducer, Measurement and calibration systems- Requirement

Error: definition, classification, statistical analysis of errors, Error correction methods.

Unit 2: Sensor and Transducer: (10 h)

Definition, working principle, classification (active, passive, primary, secondary, mechanical, electrical, analog, digital).Resistance potentiometer, Capacitance type transducers,Digital transducer,Pneumatic transducer,temperature transducers.

Unit 3: Interfacing and Data Transfer (11 h)

Computer Interfacing basics,ADC/DACs, Control systems- microcontrolers, Standard interfacing boards, NI-Boards, Open source boards. Data transfer protocols. Data cables and data-bus.

Unit 4: Software for interfacing (12 h)

LabVIEW programming. Python based programming for interfacing. Image analysis, Digital Signal processing, Mathematical and data processing tools. Introduction to R- programming.

Textbooks & references

1. (T) Rangan, Mani,Sharma.Instrumentation systems and Devices,2nd Ed.,Tata McGraw Hill.
2. (T) Microcontrollers and Interfacing, by Muhammad Ali Mazidi, Pearson Education; 2nd edition (2012)
3. (T) LabVIEW for Everyone: Graphical Programming Made Easy and Fun, Prentice Hall; 3rd edition (27 July 2006
4. (T) A. K. Sawhney, Puneet Sawhney,A course in Electrical and Electronic Measurement and Instrumentation, Dhanpat Rai and Co. Rai, 1996
5. (R) Doeblin E.D., Measurement system, Tata McGraw Hill., 4th ed, 2003.
6. (R) Johnson Curtis D., Process Control Instrumentation Technology, 8th Ed., 2005
7. (R) Principles of Electronic Instrumentation, D. Patranabis, PHI Learning Pvt. Ltd

LOW DIMENSIONAL PHYSICS DSE004 [L:4 P:0 T:0=4 Credits]

Prerequisites: Quantum mechanics 1, Solid state physics

Detailed syllabus

Unit 1: Basic Quantum Confinement (10 h)

Wave-functions in crystalline materials including metals and semiconductors; Band theory of solids; Quantum confinement. Effect on the density of states.

Unit 2: Heterostructures (10 h)

Basic heterostructures, Band Engineering, Layered structures- Wells and barriers, Doped heterostructures, strain, Optical properties and charge transport. .

Unit 3: Tunnel Junctions (10 h)

Potential steps, T- Matrix, Coherent tunnelling, Tunnelling multiple channel, Superlattices and minibands, Tunnelling heterostructures,

Unit 4: Electron transport (10 h)

Transport properties of 2D and 1D systems. Quantified conductance with Landauer-formalism. Scattering phenomena in 1D.

Unit 5: Low Dimensional Devices (10 h)

Quantum devices with controlled band gap, Devices based on quantum phenomena and Coulomb blockade.Photonic devices.Transparent electronics. Spintronics.Biological applications

Unit 6: Fabrication of Low dimensional structures(10 h)

Chemical Methods: Synthesis by Sol-Gel, Solution combustion and electrochemical techniques, chemical vapour deposition, electrochemical deposition.Physical Methods: Thermal evaporation, pulse laser deposition, magnetron sputtering,Photo and E-Beam lithography.

Textbooks & references

1. (T) Solid State Physics by N. W. Ashcroft and D. N. Mermin. Published by Cengage Learning India Private Limited, (2011).
2. (T) Low dimensional physics by John H. Davies. Published by Cambridge University Press (1997).
3. (T) Thin film phenomenon by K. L. Chopra. Published by Malabar Robert E. Krieger Publishing Company (1979).
4. (T) Quantum Wells Wires and Dots, Theoretical and Computational Physics of Semiconductor Nanostructures.Paul Harrison, WILEY, A John Wiley and Sons, Ltd, Publication 2009
5. (T) Martin T. Dove, Structure and dynamics, Oxford University press, 2002.
6. (R) The textbook of Nanoscience and Nanotechnology by T. Pradeep. Published by TataMcGraw Hill.
7. (R) Materials Characterization by Yang Leng. Published by Wiley-VCH (2013).

Prerequisites: Solid state physics, Statistical Mechanics, Basic quantum Mechanics

Detailed syllabus

Unit 1: Second Quantization and Tight binding model (12 h)

Second quantisation, Applications of second quantisation to free particle systems. Tight binding model. Evolution of band structure.

Born-Oppenheimer approximation. Effects of electron-electron interactions - Hartree- Fock approximation, exchange and correlation effects. Fermi liquid theory, elementary excitation, quasiparticles.

Unit 2: Dielectric, Optical and Thermal properties (12 h)

Dielectric screening and plasma oscillations. Landau theory of ferroelectricity, Free electron screening,Lindhard theory of Screening. Optical properties of metals, Lattice absorption, Restrahlen and Polaritons.

Review of harmonic theory of lattice vibrations, anharmonic effects, electron-phonon interaction -mass renormalization, effective interaction between electrons, polarons.

Unit 3: Magnetism and Interacting Electrons (12 h)

Quantum Theory of magnetism, Stoner Ferromagnetism, Superexchange and Antiferromagnetism,

Mermin-Wagner theorem. Metal-Insulator transition, Mott insulators, Hubbard model, spin and charge density waves,electrons in a magnetic field, Landau levels, integer quantum Hall effect.

Unit 4: Topological Insulators and Their application: (12 h)

Berry phase, Dirac fermions, Hall conductance and its link to topology.Chern insulators and two- and three-dimensional topological insulators.

Unit 5: Superconductivity: (12 h)

Zero temperature Green's functions, Wick's theorem, Feynman diagrams for transport in solids. Electron-Phonon interaction in metals, BCS theory, Landau, Ginzburg, Gorkov theory of order parameter, Type I vs type II superconductors, High-Tc systems. Introduction to granular superconductivity.

Textbooks & references

1. (T) Advanced Solid State Physics, P. Phillips, Westview Press -Advanced Book Program, 2003.
2. (T) Quantum Theory of Solids by C. Kittel.(Wiley, 1987).
3. (T) Quantum Theory of Many Particle Systems by A.L. Fetter and J.D. Walecka
4. (R) Theoretical Solid State Physics by W. Jones and N. H. March.(Courier Corporation, 1985).
5. (R) Condensed Matter Physics by M. P. Marder. (John Wiley Sons, 2010).

Prerequisites: Quantum Mechanics 1, Quantum Mechanics 2, Basic Nuclear and particle physics

Detailed syllabus

Unit 1: Introduction to elementary particles (23h)

What the Universe made of, Fermions and bosons, Fundamental forces of nature, Classification of leptons and quarks, Quantum numbers : electric charge, color, spin, parity, isospin, strangeness, hypercharge, baryon number and lepton number, Gell-Mann-Nishijima Scheme, conservation laws, Relativistic kinematics, Brief review of KG equation, Dirac equation in 4 vector notation, Dirac equation in momentum space and anti-particle states, helicity, bilinear covariants.

Unit 2: Decay rates and Cross sections (9h)

Cross section, spin sums, photon polarization sums, Bhabha scattering, Compton Scattering.

Unit 3: Weak interaction (14h)

Classification of weak interactions, Parity violation and V-A form of weak interaction, Calculations for the decay of Muon and decay of Pion, Elementary notions of leptonic decay of strange particles, The Cabibbo angle, GIM Mechanism, Charge and Neutral Current Interaction.

Unit 4: Electroweak Interactions (14h)

Weak isospin and Hypercharge, The basic electroweak interaction, Spontaneous symmetry breaking of gauge symmetry and Higgs Mechanism, masses of fermions and gauge bosons, $SU(2)_L \times U(1)_Y$ invariant Lagrangian.

Textbooks & references

1. (T) Quarks and Leptons: An Introductory Course in Modern Particle Physics by Halzen and Martin (Wiley).
2. (T) A first book on quantum field theory by A. Lahiri and P. Pal (Narosa).
3. (T) Introduction to Elementary Particles by D. J. Griffiths (Wiley).
4. (R) An Introductory Course of Particle Physics by P. Pal (CRC Press).
5. (R) Lectures On Quantum Field Theory By Ashok Das (World Scientific).
6. (R) Introduction to High Energy Physics by D. H. Perkins (Cambridge University Press).
7. (R) An introduction to quantum field theory by M.Peskin and D. Schroder (CRC Press).
8. (R) Quantum Field Theory by F. Mandl and G. Shaw (Wiley).
9. (R) Quantum Field Theory by L. H .Ryder (Cambridge University Press).
10. (R) The Quantum Theory of Fields by S. Weinberg (Cambridge University Press).

Prerequisites: Quantum Mechanics 1, Basic Nuclear and particle physics

Detailed syllabus

Unit 1: Introduction and observation (5 h)

Scales and Dimensions, Night Sky, Earth, Sun, and the Solar System, Sidereal Time, Electromagnetic Waves, Electromagnetic Spectrum, Telescopes

Unit 2: Astrometry and Photometry (8h)

Coordinate Systems, The Horizontal System, Equatorial Coordinate System, Ecliptic System, Galactic Coordinate System, Super-galactic Coordinate System, Space Velocity and Proper Motion of Stars, Doppler Effect , Coordinate Transformation, Flux Density and Intensity, Blackbody Radiation, Energy Density in an Isotropic Radiation Field, Magnitude Scale, Apparent Magnitude, Absolute Magnitude, The Color Index, Bolometric Magnitude, Stellar Temperatures, Effective Temperature, Color Temperature

Unit 3: Gravitation and Kepler's Laws (4h)

Two-Body Problem, Application to Solar System, Virial Theorem, Tidal Forces and Roche Limit

Unit 4: Stars, Stellar Spectra, and Classification (6h)

Introduction , Stellar Spectra, Harvard Classification of Stellar Spectra, Saha Equation, Derivation of the Saha Equation, Number of States of a Free Particle in a Box, HR Diagram, Star Clusters and Associations, Distance and Age Determination of Clusters Using Color-Magnitude Diagram, Radiation from Astronomical Sources

Unit 5: Stellar Nuclear Reactions and star formation (8h)

Fundamental Interactions, Fundamental Particles, PP Chain, Nuclear Reaction Rate, Nuclear Reaction Rate: Derivation, Nuclear Cross Section, Estimating the Nuclear Reaction Rate, Energy Released in Nuclear Reaction, Early Stage of Star Formation, Fragmentation, Evolution on the Main Sequence, Degenerate Free Electron Gas, Evolution beyond the Main Sequence, Population I and II Stars, White Dwarfs, Neutron Star, Black Holes, Supernova

Unit 6: The Milky Way, Galaxies, Cosmology (16h)

The Distance Ladder, Distribution of Matter in the Milky Way, Differential Rotation of the Milky Way, Mapping the Galactic Disk with Radio Waves, Formation of the Spiral Arms, Elliptical Galaxies, Spiral Galaxies, Evidence for Dark Matter, Euclidean and Curved Space, Minkowski Space-Time, Big Bang Cosmology, The Early Universe.

Textbooks & references

1. (R) Modern Astrophysics, B.W. Carroll D.A. Ostlie, Addison-Wesley Publishing Co.
2. (R) Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing

Prerequisites: Electrodynamics, Statistical mechanics

Detailed syllabus

Unit 1: Introduction to soft matter (5 h)

Overview of soft matter, entropy in disordered systems; forces, energies, and time scales in soft matter

Unit 2: Colloidal systems (10 h)

Surface phenomenon and stability of colloidal systems; The Poisson–Boltzmann Equation, DLVO theory: van der Waals versus Electrostatic Interactions, Solutions of Colloidal Particles.

Unit 3: Liquid Crystals (10 h)

Introduction to liquid crystals, Classification of liquid crystals, Electric and Magnetic Field Effects, Biological Importance of Liquid Crystals.

Unit 4: Polymers (10 h)

Single-chain conformations, The ideal (or Gaussian) Chain, Pair Correlation Function and Radius of Gyration, The Flory Chain, Chains in Interaction, The Mean Field Approach, Scaling Laws for Athermal Solutions.

Unit 5: Self-assembly and interface science (10 h)

Thermodynamics of self-assembly, formation of aggregates, critical micellar concentration, soluble monolayer and Gibbs adsorption, insoluble (Langmuir) monolayers, characterization of Langmuir monolayers; interactions in lamellar flexible systems, elasticity of neutral membranes.

Textbooks & references

1. (T) Soft condensed matter by R. A. L. Jones, Oxford University Press
2. (T) Polymer Physics by Tanaka Fumihiko, Cambridge University Press
3. (T) Liquid Crystals: Nature delicate phase of matter by P. J. Collings, Princeton University Press
4. (R) Intermolecular and surface forces by Jacob N. Israelachvili. Published by Academic Press.
5. (R) The physics of liquid crystals by P. G. de Gennes and J. Prost. Published by Oxford Science Publications.
6. (R) Soft matter physics- An introduction by Maurice Kleman and Oleg D. Lavrentovich. Published by Springer
7. (R) Fundamentals of Polymer Physics and Molecular Biophysics by Himadri Bohidar; Cambridge University Press (2015)

Prerequisites: Classical mechanics, quantum mechanics, statistical mechanics

Detailed syllabus

Unit 1: Phase transitions (15 h)

Problem of condensation, dynamical model of phase transition, Ising model in zeroth and first approximation, critical exponents, thermodynamic inequalities, Landau's phenomenological theory, scaling hypothesis for thermodynamic functions, correlations and fluctuations, critical exponents

Unit 2: Exact results for various models (10 h)

One dimensional fluid models, Ising model in one dimension, $n-$ vector models in one dimension, Ising model in two dimensions

Unit 3: Renormalization Group approach (15 h)

The conceptual basis of scaling, simple examples of renormalization, general formulation of renormalization group and its applications, finite size scaling

Unit 4: Fluctuations and non-equilibrium statistical mechanics (10 h)

Equilibrium thermodynamic fluctuations, the Einstein-Smoluchowski theory and Langevin theory of Brownian motion, Fokker-Planck equation, Weiner-Khintchine theorem, fluctuation-dissipation theorem, Onsager relations

Unit 5: Simulations (10 h)

Monte Carlo Simulations, molecular dynamics, particle simulations,

Textbooks & references

1. (T) Statistical Mechanics, by R. K. Pathria and Paul D. Beale, Elsevier
2. (T) Statistical Mechanics, by Kerson Huang, John Wiley and Sons
3. (R) Principles of condensed matter physics, by P. M. Chaikin, T. C. Lubensky, , Cambridge University Press
4. (R) Equilibrium Statistical Physics, by Michael Plischke, Birger Bergersen, World Scientific

5 SKILL ENHANCEMENT COURSES (FOR ALL DEPARTMENTS)

ELECTRONICS LABORATORY SEC001 [L:0 P:2 T:0=2 Credits]

Prerequisites: Basic electronics

List of experiments (Any 8 to be performed in a semester)

1. Study of normal and zener diode characteristics and analysis of clipper and clamper circuits
2. Design of full-wave rectifer and study of regulated power supply
3. Study of transistor characteristics, biasing and DC analysis
4. Study of transistor-based circuits and design of LDR-controlled bulb
5. Study of op-amp based circuits and wave-shapers
6. Study of op-amp filters
7. Study of RS / JK and D flip flop with logic gates
8. Design of Ripple Counter
9. Study of Multiplexer / Demultiplexer and 7-segment decoder
10. Design of IC-555 based circuit and soldering assignment
11. Simulation of a Full-wave rectifer
12. Simulation of an Op-amp based circuit (Precision rectifier, Lograthmic amplifier)

Textbooks & references

1. (T) Microelectronic Circuits: Theory And Applications by Adel Sedra and Smith (Oxford Press)
2. (T) Digital Principles and Applications by Malvino and Leach (Tata McGraw Hill)
3. (R) Op-amps and Linear Integrated Circuits by R Gayakwad (Prentice Hall)
4. (R) Art of Electronics by Paul Horowitz and Winfield Hill (Cambridge University Press)

APPLICATIONS OF MACHINE LEARNING AND DATA SCIENCE SEC002 [L:2 P:0 T:0=2 Credits]

Prerequisites: None

Detailed syllabus

Unit 1: Introduction (6 h)

Overview of machine learning, supervised problems, unsupervised problems,Basics of a linear fit, chi-square minimization, gradient-descent technique, defining a model, cost function, fundamentals of linear algebra

Unit 2: Multivariate analysis (8 h)

Polynominal regression, Extending gradient descent for multi-parameter fits, feature scaling, learning rate, basic exercises in programming

Unit 3: Classification and neural networks (10 h)

Classification problems and decision boundaries, optmizations, multiclass classification, logistic regression, overfitting, regularization, neurons and the brain, model representation of neural networks, classification using neural networks

Unit 4: Applications of ML in science: (6 h)

Applications in medical physics: Tumour identification and contouring, Applications in particle physics: track finding, triggering and event classification, Applications in Solid state physics: Material discovery, DFT functionals, Applications in soft-matter physics: peptide classification and sequence prediction

Textbooks & references

1. (T) Machine Learning and Deep Learning with Python, Scikit-learn, and TensorFlow 2, 3rd Edition By Sebastian Raschka, Vahid Mirjalili

   University Physics by F. W. Sears, M. Zemansky, R. A. Freedman, and H. D. Young, Pearson Education

2. (R) Machine Learning in High Energy Physics Community White Paper
3. (R) Recent advances and applications of machine learning in solid-state materials science
4. (R) Machine-learning-based prediction of anticancer peptides

6 VALUE ADDITION COURSES (FOR ALL DEPARTMENTS)

ART OF SCIENCE COMMUNICATION

VAC001 [L:0 P:2 T:0=2 Credits]

Prerequisites: None

Detailed syllabus

All students will give a 5-minute presentation on a science topic at the beginning of this course. This will be used a reference point for the lectures. At the end, the students will repeat the same presentation to verify how the course has helped them improve their presentation skills.

Unit 1: Overview (6 h)

Need for science communication, history of science and science communication, goals of science communication, motivations for science communication

Unit 2: Audience (6 h)

Perceptions of Scientists, Credibility, Influence and Persuasion, Audience Motivations, Knowing Your Audience

Unit 3: - Preparing Your Presentation (6 h)

Presentation Setup, defining the mission, connect With your audience, leveling the playing field

Unit 4: - Constructing Your Presentation (6 h)

Getting Started With Your Presentation, Presentation Layout, Conclusion/Call to Action, Evaluation

Unit 4: - Delivering Your Presentation (6 h)

Building your slides, Presentation Setup, Presentation Mechanics, Presentation Delivery, final presentations by the students.

Textbooks & references

1. (T) Greer S, Alexander H, Baldwin TO, Freeze HH, Thompson M, Hunt G, Snowflack DR. The Art of Science Communication-A Novel Approach to Science Communication Training

COMPUTATIONAL METHODS OF SCIENTIFIC PROGRAMMING VAC002 [L:0 P:2 T:0=2 Credits]

Prerequisites: None

Detailed syllabus

List of experiments (Any 8 to be performed in a semester)

1. File IO in Python
2. Smoothing techniques: Sliding window and Savitzky–Golay filter
3. Peak finding and background subtraction
4. Fitting algorithms: Linear, Gaussian, Lorentzian etc.,
5. Hough transform for line detection
6. Fourier analysis of a signal
7. Image analysis using openCV: blurring, edge detection and shape detection
8. GPU programming using OpenACC/CUDA
9. Scientific computations using Numba: SIMD vectorization
10. Clustering algorithm: K-means

Textbooks & references

1. (T) Introduction to Scientific Programming with Python By Joakim Sundnes

Prerequisites: None

Detailed syllabus

Unit 1: Tools for literature survey (6 h)

Searching in Scopus, Web of Science, Shodh Ganga, Google Scholar for specific keywords, patent databases

Unit 2: Online computational resources and coding apps (6 h)

Google Colab, VSCode, Jupyter notebooks, Google cloud, Microsoft Azure and Amazon AWS free usage policies

Unit 3: Version control systems (6 h)

Git, GitHub, push, pull, clone and merge operations, version numbering.

Unit 4: Typesetting (6 h)

Typesetting in LaTeX, bibliography files, tables, online resources for LaTeXcompiling, templates, proof-reading

Unit 5: Presentation tools (6 h)

Google slides, Beamer templates, drawing and plotting tools, simple animation and graphics, circuit schematic tools, flowchart tools.

7 RESEARCH-RELATED COURSES (PHYSICS)

RESEARCH METHODOLOGY AND PUBLICATION ETHICS RES001 [L:4 P:0 T:0=4 Credits]

Prerequisites: None

Detailed syllabus

Unit 1: Introduction to Research (10 h)

Objectives and Motivation for Research, Types of research and research design, Design of experiments, Sampling techniques, Types of report, Literature survey, Reading and summarising scientific articles, Formulating a problem statement, Presenting scientific work

Unit 2: Laboratory practices (5 h)

Design of experiments, calibration of instruments; fire, chemical, radiation and biological hazards, safety and disposal of materials, regulations.

Unit 3: Statistics and Data analysis (10 h)

Statistical description of data, central limit theorem, null hypothesis, statistical significance, statistical distributions (Binomial, Poisson, Gaussian, Lorentzian, Levy), Bayesian Statistics, Observation and Collection of data, Data interpretation, multivariate analysis, Model building, Sampling Methods, Data Processing and Analysis strategies, Hypothesis-testing, Errors and error analysis, Fitting strategies, presentation of data

Unit 4: Computers (10 hours)

Overview of computer architecture, general specifications, operating systems, bash/shell commands, compilers, databases, types of programming languages, Cloud computing, parallel processing, GPU, Basics of machine learning,

Unit 5: Software applications (10 h)

Origin, Labview, Mathematica/Matlab, Comsol Multiphysics, Latex, Plotting libraries in python

Unit 6: Publication ethics (15 h)

Ethics with respect to science and research, Intellectual honesty and research integrity Definition of ethics, best practices, conflicts of interest, publication misconduct, authorships and contributorships, predatory journals, plagiarism and software tools. Selective reporting and misrepresentation of data.

Textbooks & references

1. (T) Research Methodology: A Practical and Scientific Approach edited by Vinayak Bairagi
2. (T) Data Reduction and Error Analysis for the Physical Sciences
3. (T) Computer Architecture: Software Aspects, Coding, and Hardware

MINI PROJECT RES002 [L:0 P:4 T:0=4 Credits]

Prerequisites: NA

Each student will carry out an short project and submit a report on the topic under the guidance of a faculty the Department. The focus of this mini project will be on research methods and techniques specific to a given field. The students will be trained in one or more of the following activities: Operating/handling a specific equipment; performing data analysis; designing new devices; developing algorithms and codes for a specific purpose. In addition, the student may be required to teach or train junior students in simple experiments. The final evaluation will be through an open seminar and evaluation of the report by the respective guide.

PROJECT WORK RES003 [L:0 P:12 T:0=12 Credits]

Prerequisites: None

Detailed syllabus

Each student will be alloted a guide and will work on a specific problem. The guide will specify the outcomes expected at the end of the project. Students enrolled in the B.Sc by Research programme may opt to continue with the project opted in the 7th semester.

8 MINOR COURSES (FOR ALL OTHER DEPARTMENTS)

ELECTRONICS MADE EASY MIN001 [L:3 P:0 T:0=3 Credits]

Prerequisites: None

Detailed syllabus

Unit 1: Review of analog electronics (10 h)

Kirchoffs Current & Voltage Law, Superposition theorem, Norton and Thevenins Theorem, Semiconductor theory, PN junctions, Diode models, Analysis of diode circuits, time-response, Rectifier, Clipper, Clamper, Voltage doubler

Unit 2: Transistors (10 h)

BJT structure and operation, Small signal model, Early effect, Biasing techniques, Transistor as an Voltage-Controlled-Current-Source, DC-analysis, Transistor as a switch, Transistor as an amplifier, Properties of CE/CB and CC configurations, Emitter Degeneration, Cascading, Input and Output impedances, Unity-gain Buffer

Unit 3: Operational amplifiers (10 h)

Differential amplifier, Open loop gain and closed loop gain,Feedback theory, Negative and Positive Feedback, Operational amplifier circuits under ideal and non-ideal conditions: Summer, Subtractor, Integrator, Differentiator, Lograthmic amplifier, Precision amplifier, Op-amp active filters, Frequency response

Unit 4: Review of digital circuits (10 h)

Number systems: Binary, Hexadecimal, BCD and conversions, Logic gates, Construction of logic gates using transistors, Mathematical operations using logic gates, Structure and operations of TTL and CMOS gates; logic levels and noise margins, fan-out, propagation delay, transition time, power consumption, Boolean algebra, Simplification of boolean expressions using K-map, Pairs, Quads and Octets,

Unit 5: Digital circuits (5 h)

RS, JK, Master-Slave and D Flip Flops, Shift Registers, Ripple, Ring and Johnson Counters, Multiplexers, Demultiplexers, Analog to digital Conversion, Digital to analog conversion, Time & Charge to digital conversion

Textbooks & references

1. (T) Microelectronic Circuits: Theory And Applications by Adel Sedra and Smith (Oxford Press)
2. (T) Digital Principles and Applications by Malvino and Leach (Tata McGraw Hill)
3. (R) Op-amps and Linear Integrated Circuits by R Gayakwad (Prentice Hall)
4. (R) Art of Electronics by Paul Horowitz and Winfield Hill (Cambridge University Press)

Prerequisites: None

Detailed syllabus

Unit 1: Rigid body dynamics (8 h)

Newton's laws of motion: Work, kinetic and potential energy, energy conservation, momentum and collisions; Kepler's laws of planetary motion: Gravitation; Rotational motion of rigid bodies: Moment of inertia, angular momentum and torque.

Unit 2: Waves Oscillations (8 h)

Periodic motion: simple harmonic motion, damped harmonic oscillator, driven damped harmonic oscillator; Complex wave equations: Fourier theorem and Fourier coefficients; Mechanical waves: Sound and ultrasonics.

Unit 3: Elasticity and plasticity (8 h)

Elasticity: Stress, strain, elasticity and plasticity, Hooke's law, elastic modulii.

Unit 4: Fluid statics and Fluid dynamics: (8 h)

Pressure in a fluid, pressure gauges, Archimedes' principle, surface tension, pressure difference across a surface film and contact angle and capillarity; Fluid dynamics: Equation of continuity, Bernoulli's equation and its applications, Viscocity, Poiseuille's law, Stoke's law, Reynolds number.

Unit 5: Special Theory of relativity: (8 h)

Galilean and Lorentz transformation, Special relativity, Time dilation, Length contraction, Relativistic mass, energy and momentum,

Textbooks & references

1. (T) University Physics by F. W. Sears, M. Zemansky, R. A. Freedman, and H. D. Young, Pearson Education
2. (T) Fundamentals of Physics by D. Halliday, R. Resnick, J. Walker, John Wiley Sons

EVERYDAY ELECTRICITY AND MAGNETISM

MIN003 [L:3 P:0 T:0=3 Credits]

Prerequisites: None

Detailed syllabus

Unit 1: Vector Analysis (10 h)

Review of vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors.

Unit 2: Electrostatics (20 h)

Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.

Unit 3: Magnetism (10 h)

Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferromagnetic materials.

Unit 4: Electromagnetic Induction and Maxwell's equations (5 h)

Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, Equation of continuity of current, Displacement current, Maxwell's equations

Textbooks & references

1. (T) Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
2. (T) D.J.Griffiths, Introduction to Electrodynamics
3. (T) University Physics, Ronald Lane Reese, 2003, Thomson Brooks Cole.

Prerequisites: Basics of vector algebra and calculus, differential equations

Detailed syllabus

Unit 1: Lagrangian and Hamiltonian Formulations (15 h)

Constrained motions, D'Alembert's principle, Generalized coordinates, Euler-Lagrange equations, Hamiltonian as a Legendre's transformation of Lagrangian, Hamilton's equations of motion.

Unit 2: Need for quantum description of nature (7 h)

Failures of classical theories, Stern-Gerlach experiment, Black body radiation, Photoelectric effect, Dependence of Cp, Cv on degrees of freedom, Interference patterns of double slit experiment, De Broglie hypothesis, Davidson-Germer experiment, Dual nature of matter

Unit 3: Wavefunctions (15 h)

Waves, superposition and phases, Basic postulates of quantum mechanics, Wavefunction and review of simple forms of wavefunctions and their superpositions. Statistical interpretation of wave functions, normalization and expectation values. Fourier transforms, delta functions, gaussians and their relevance in quantum mechanics, Momentum-space wavefunction, Uncertainty principle, Commutation relationships, Schrodinger equation.

Unit 4: 1-dimensional problems (15 h)

Stationary states, Free particle, Infinite well potential, Harmonic oscillator potential. Bound states and scattering states, Finite square well, Potential barrier, Delta function potential and finite step. Reflection and transmission coefficients.

Unit 5: Angular Momentum (8 h)

Angular momentum operators and commutation relationships, Spin $1/2$ and Spin 1 systems, Addition of Angular Momenta, CG Coefficients

Textbooks & references

1. (T) Classical Dynamics by Joag N. C. and Rana, P. S.
2. (T) Introduction to Quantum Mechanics by David Griffiths (Pearson Education)
3. (T) Quantum Physics of Atoms, Molecules, Solids Nuclei and Particles by R Eisberg, R Resnick (Wiley)
4. (R) Principles of Quantum Mechanics by R. Shankar (Springer)
5. (R) A Textbook of Quantum Mechanics by Piravonu Mathews, K. Venkatesan (Tata McGraw Hill)

9 GENERIC ELECTIVES (FOR ALL OTHER DEPARTMENTS)

ELECTRONICS FOR EVERYONE GE001 [L:3 P:0 T:0=3 Credits]

Prerequisites: None

Detailed syllabus

Unit 1: Overview of of analog electronics (11 h)

Current and Voltage conventions, Kirchoffs Current & Voltage Law, Superposition theorem, Semiconductor theory, PN junctions, Diode models, Analysis of diode circuits, Rectifiers

Unit 2: Transistors (12 h)

BJT structure and operation, Biasing techniques, Transistor as an Voltage-Controlled-Current-Source, DC-analysis, Transistor as a switch, Transistor as an amplifier, Properties of CE/CB and CC configurations

Unit 3: Operational amplifiers (10 h)

Negative and Positive Feedback, Operational amplifier circuits under ideal conditions: Summer, Subtractor, Integrator, Differentiator, Logarithmic amplifier, Op-amp active filters, Frequency response

Unit 4: Digital circuits (12 h)

Number systems: Binary, Hexadecimal, BCD and conversions, Logic gates, Mathematical operations using logic gates, Boolean algebra, Simplification of boolean expressions using K-map, Pairs, Quads and Octets, Design of BCD to 7-segment decoder, RS and JK flipflops, Design of a digital counter.

Textbooks & references

1. (T) Microelectronic Circuits: Theory And Applications by Adel Sedra and Smith (Oxford Press)
2. (T) Digital Principles and Applications by Malvino and Leach (Tata McGraw Hill)
3. (R) Op-amps and Linear Integrated Circuits by R Gayakwad (Prentice Hall)
4. (R) Art of Electronics by Paul Horowitz and Winfield Hill (Cambridge University Press)

Prerequisites: None

Detailed syllabus

Unit 1: Rigid body dynamics (8 h)

Newton's laws of motion: Work, kinetic and potential energy, energy conservation, momentum and collisions; Kepler's laws of planetary motion: Gravitation; Rotational motion of rigid bodies: Moment of inertia, angular momentum and torque.

Unit 2: Waves Oscillations (8 h)

Periodic motion: simple harmonic motion, damped harmonic oscillator, driven damped harmonic oscillator; Complex wave equations: Fourier theorem and Fourier coefficients; Mechanical waves: Sound and ultrasonics.

Unit 3: Elasticity and plasticity (8 h)

Elasticity: Stress, strain, elasticity and plasticity, Hooke's law, elastic modulii.

Unit 4: Fluid statics and Fluid dynamics: (8 h)

Pressure in a fluid, pressure gauges, Archimedes' principle, surface tension, pressure difference across a surface film and contact angle and capillarity; Fluid dynamics: Equation of continuity, Bernoulli's equation and its applications, Viscocity, Poiseuille's law, Stoke's law, Reynolds number.

Unit 5: Special Theory of relativity: (8 h)

Galilean and Lorentz transformation, Special relativity, Time dilation, Length contraction, Relativistic mass, energy and momentum,

Textbooks & references

1. (T) University Physics by F. W. Sears, M. Zemansky, R. A. Freedman, and H. D. Young, Pearson Education
2. (T) Fundamentals of Physics by D. Halliday, R. Resnick, J. Walker, John Wiley Sons