

B.Sc. (Physics Honours) Syllabus

under CBCS

Nagaland University

PHYSICS HONOURS COURSE STRUCTURE UNDER CBCS

Sem	Core Courses (CC)	Discipline Specific Elective Courses (DSE)	Ability Enhancement Elective Courses (SEC)	Generic Elective Courses (GE) <i>For Non-Physics Honours</i>
1	1. (C I) Mathematical Physics – I 2. (C II) Mechanics			1. (GEC I) Mechanics 2. (GEC II) Digital, and Analog Circuits and Instrumentation
2	1. (C III) Electricity and Magnetism 2. (C IV) Waves & Optics			1. (GEC III) Electricity & Magnetism 2. (GEC IV) Mathematical Physics
3	1. (C V) Mathematical Physics – II 2. (C VI) Thermal Physics 3. (C VII) Digital Systems and Applications		1. (SEC I) Computational Physics Skills 2. (SEC II) Electrical Circuits and Network Skills 3. (SEC III) Basic Instrumentation Skills 4. (SEC IV) Technical Drawing	1. (GEC V) Thermal Physics and Statistical Mechanics 2. (GEC VI) Waves and Optics 3. (GEC VII) Elements of Modern Physics
4	1. (C VIII) Mathematical Physics – III 2. (C IX) Elements of Modern Physics 3. (C X) Analog Systems and Applications	Note: Only TWO papers are to be selected for each Semester	1. (SEC V) Physics Workshop Skills 2. (SEC VI) Renewable Energy and Energy Harvesting 3. (SEC VII) Radiation Safety 4. (SEC VIII) Weather Forecasting	1. (GEC VIII) Nuclear and Particle Physics 2. (GEC IX) Solid State Physics 3. (GEC X) Quantum Mechanics
5	1. (C XI) Quantum Mechanics and Application 2. (C XII) Solid State Physics	1. (DSE I) Experimental Techniques 2. (DSE II) Physics of Devices and Communication Systems 3. (DSE III) Advanced Mathematical Physics – I 4. (DSE IV) Classical Dynamics 5. (DSE V) Nuclear and Particle Physics 6. (DSE VI) Atmospheric Physics 7. (DSE VII) Biological Physics	Note: Only ONE paper is to be selected for each Semester	Note: Only ONE paper is to be selected for each Semester
6	1. (C XIII) Electromagnetic Theory 2. (C XIV) Statistical Mechanics	1. (DSE VIII) Advanced Mathematical Physics – II 2. (DSE IX) Applied Dynamics 3. (DSE X) Communication Systems 4. (DSE XI) Astronomy and Astrophysics 5. (DSE XII) Physics of the Earth 6. Dissertation		

CORE COURSES

Semester I

PHYSICS - C I MATHEMATICAL PHYSICS - I

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

The emphasis of the course is on applications in solving problems of interest to physicists. The students are to be examined entirely on the basis of problems, seen and unseen.

Unit - 1

Calculus:

Recapitulation:

Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions, Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only).

(2 Lectures)

First Order and Second Order Differential equations:

First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral.

(13 Lectures)

Unit - 2

Calculus of functions of more than one variable:

Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.

(6 Lectures)

Introduction to Probability:

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.

(4 Lectures)

Unit - 3

Vector Calculus:

Recapitulation of vectors:

Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

(5 Lectures)

Vector Differentiation:

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

(8 Lectures)

Unit - 4

Vector Integration:

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 (no rigorous proofs).

(14 Lectures)

Unit - 5

Orthogonal Curvilinear Coordinates:

Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

(6 Lectures)

Dirac Delta Function and its Properties:

Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function.

(2 Lectures)

Reference Books:

- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
 - An Introduction to Ordinary Differential Equations, E.A. Coddington, 2009, PHI learning
 - Differential Equations, George F. Simmons, 2007, McGraw Hill.
 - Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
 - Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
 - Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
 - Mathematical Physics, Goswami, 1st edition, Cengage Learning
 - Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
 - Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
 - Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press.
 - Mathematical Methods in the Physical Sciences, Mary L. Boas, Wiley-India
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PHYSICS LAB - C I

MATHEMATICAL PHYSICS - I

60 Lectures

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

- *Highlights the use of computational methods to solve physical problems*
- *The course will consist of lectures (both theory and practical) in the Lab*
- *Evaluation done not on the programming but on the basis of formulating the problem*
- *Aim at teaching students to construct the computational problem to be solved*
- *Students can use any one operating system Linux or Microsoft Windows*

Topics	Description with Applications
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow - emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.
Review of C & C++ Programming fundamentals	Introduction to Programming, constants, variables and data types, operators and expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops), Arrays (1D & 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects
Programs:	Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search
Random number generation	Area of circle, area of square, volume of sphere, value of pi (π)
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equations, solving $\alpha = \tan \alpha$; $I = I_0 \left(\frac{\sin \alpha}{\alpha} \right)^2$ in optics

Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometric functions e.g. $\sin \theta$, $\cos \theta$, $\tan \theta$, etc.
Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method	Given position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop
Solution of Ordinary Differential Equations (ODE) First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods	<p>First order differential equation</p> <ul style="list-style-type: none"> • Radioactive decay • Current in RC, LC circuits with DC source • Newton's law of cooling • Classical equations of motion <p>Attempt following problems using RK 4 order method:</p> <ul style="list-style-type: none"> • Solve the coupled differential equations $\frac{dx}{dt} = y + x - \frac{x^3}{3}; \quad \frac{dy}{dx} = -x$ for four initial conditions $x(0) = 0, y(0) = -1, -2, -3, -4$ Plot x vs y for each of the four initial conditions on the same screen for $0 \leq t \leq 15$ <p>The differential equation describing the motion of a pendulum is $\frac{d^2\theta}{dt^2} = -\sin \theta$. The pendulum is released from rest at an angular displacement α, i.e. $\theta(0) = \alpha$ and $\theta'(0) = 0$. Solve the equation for $\alpha = 0.1, 0.5$ and 1.0 and plot θ as a function of time in the range $0 \leq t \leq 8\pi$. Also plot the analytic solution valid for small θ, ($\sin \theta = \theta$)</p>

Referred Books:

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.
- Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Press *et al*, 3rd Edn. , 2007, Cambridge University Press.
- A First Course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
- Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn. , 2007, Wiley India Edition.
- Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
- An Introduction to Computational Physics, T.Pang, 2nd Edn. , 2006, Cambridge Univ. Press
- Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.

PHYSICS - C II

MECHANICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Fundamentals of Dynamics:

Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable-mass system: motion of rocket. Motion of a projectile in a uniform gravitational field. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse.

(6 Lectures)

Work and Energy:

Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy.

(4 Lectures)

Unit - 2

Collisions:

Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames.

(3 Lectures)

Rotational Dynamics:

Angular momentum of a particle and a system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

(12 Lectures)

Unit - 3

Gravitation and Central Force Motion:

Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to a spherical shell and solid sphere.

(3 Lectures)

Motion of a Particle under a Central Force Field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS).

(6 Lectures)

Unit - 4

Non-Inertial Systems:

Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of velocity and acceleration in Cylindrical and Spherical Coordinate Systems.

(4 Lectures)

Special Theory of Relativity:

Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum.

(10 Lectures)

Unit - 5

Oscillations:

SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor.

(7 Lectures)

Elasticity:

Relation between Elastic constants. Twisting torque on a Cylinder or Wire.

(3 Lectures)

Fluid Motion:

Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube.

(2 Lectures)

Reference Books:

- An Introduction to Mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
- Mechanics, Berkeley Physics, Vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
- Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
- Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning
- Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
- Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- Introduction to Mechanics, Mahendra K Verma, Universities Press

Additional Books for Reference

- Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
 - University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
 - Physics for Scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning
 - Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.
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PHYSICS LAB - C II

MECHANICS

60 Lectures

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the height of a building using a Sextant.
4. To study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine g and velocity for a freely falling body using Digital Timing Technique
7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
8. To determine the Young's Modulus of a Wire by Optical Lever Method.
9. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
10. To determine the elastic Constants of a wire by Searle's method.
11. To determine the value of g using Bar Pendulum.
12. To determine the value of g using Kater's Pendulum.

Reference Books:

- Advanced Practical Physics for Students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
 - Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
 - A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal
 - Engineering Practical Physics, S.Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt. Ltd.
 - Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.
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Semester II

PHYSICS - C III

ELECTRICITY AND MAGNETISM

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Electric Field and Electric Potential

Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry.

(6 Lectures)

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.

(6 Lectures)

Unit - 2

Electrostatics

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.

(10 Lectures)

Dielectric Properties of Matter:

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.

(8 Lectures)

Unit - 3

Magnetic Field:

Magnetic force between current elements and definition of Magnetic Field **B**. 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.

(9 Lectures)

Magnetic Properties of Matter:

Magnetization vector (**M**). Magnetic Intensity (**H**). Magnetic Susceptibility and permeability. Relation between **B**, **H**, **M**. Ferromagnetism. B-H curve and hysteresis.

(4 Lectures)

Unit - 4

Electromagnetic Induction:

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.

(6 Lectures)

Ballistic Galvanometer:

Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR.

(3 Lectures)

Unit - 5

Electrical Circuits:

AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit.

(4 Lectures)

Network theorems:

Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits.

(4 Lectures)

Reference Books:

- Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
 - Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
 - Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
 - Feynman Lectures Vol.2, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
 - Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
 - Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.
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PHYSICS LAB - C III

ELECTRICITY AND MAGNETISM

60 Lectures

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De'Sauty's bridge.
6. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
7. To verify the Thevenin and Norton theorems.
8. To verify the Superposition, and Maximum power transfer theorems.
9. To determine self inductance of a coil by Anderson's bridge.
10. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
11. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer
13. Determine a high resistance by leakage method using Ballistic Galvanometer.
14. To determine self-inductance of a coil by Rayleigh's method.
15. To determine the mutual inductance of two coils by Absolute method.

Reference Books:

- Advanced Practical Physics for Students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
 - A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
 - Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
 - Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning.
 - A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Pub.
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PHYSICS - C IV

WAVES AND OPTICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Superposition of Collinear Harmonic oscillations:

Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences.

(5 Lectures)

Superposition of two perpendicular Harmonic Oscillations:

Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequency and their uses.

(2 Lectures)

Wave Motion:

Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves.

(4 Lectures)

Unit - 2

Velocity of Waves:

Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction.

(6 Lectures)

Superposition of Two Harmonic Waves:

Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves.

(7 Lectures)

Unit - 3

Wave Optics:

Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.

(3 Lectures)

Interference:

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.

(9 Lectures)

Unit - 4

Interferometers:

Michelson Interferometer - (1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes.
Fabry-Perot interferometer.

(4 Lectures)

Diffraction:

Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula. (Qualitative discussion only)

(2 Lectures)

Fraunhofer diffraction:

Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating.

(8 Lectures)

Unit - 5

Fresnel Diffraction:

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.

(7 Lectures)

Holography:

Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms.

(3 Lectures)

Reference Books:

- Waves: Berkeley Physics Course, Vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
 - Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
 - Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
 - Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
 - The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
 - The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
 - Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.
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PHYSICS LAB - C IV

WAVES AND OPTICS

60 Lectures

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify $\lambda^2 - T$ law.
2. To investigate the motion of Coupled Oscillators.
3. To study Lissajous Figures.
4. Familiarization with: Schuster's focusing; determination of angle of prism.
5. To determine the refractive index of the material of a prism using sodium source.
6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
7. To determine the wavelength of Sodium source using Michelson's interferometer.
8. To determine the wavelength of Sodium light using Fresnel Biprism.
9. To determine the wavelength of Sodium light using Newton's Rings.
10. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
11. To determine the wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
12. To determine the dispersive power and resolving power of a plane diffraction grating.

Reference Books:

- Advanced Practical Physics for Students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
 - A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
 - Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
 - A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Pub.
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Semester III

PHYSICS - C V MATHEMATICAL PHYSICS-II

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.

Unit - 1

Fourier Series:

Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity.

(10 Lectures)

Unit - 2

Frobenius Method and Special Functions:

Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations.

(12 Lectures)

Unit - 3

Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions ($J_0(x)$ and $J_1(x)$) and Orthogonality.

(12 Lectures)

Unit - 4

Partial Differential Equations:

Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation.

(14 Lectures)

Unit - 5

Some Special Integrals:

Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).

(4 Lectures)

Theory of Errors:

Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit. Error on the slope and intercept of a fitted line.

(6 Lectures)

Reference Books:

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
 - Fourier Analysis, M.R. Spiegel, 2004, Tata McGraw-Hill.
 - Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
 - Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
 - Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
 - Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
 - Mathematical Methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books
 - Mathematical Methods in the Physical Sciences, Mary L. Boas, Wiley-India
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PHYSICS LAB - C V

MATHEMATICAL PHYSICS-II

60 Lectures

The aim of this Lab is to use computational methods to solve physical problems. The course will consist of lectures (both theory and practical) in the Lab. Evaluation done not on the programming but on the basis of formulating the problem

Topics	Description with Applications
Introduction to Numerical computation software Scilab/Python	Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting (2), Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continue statements, nested loops, logical arrays and vectorization (2) User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays (2) an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program (2).
Curve fitting, Least square fit, Goodness of fit, standard deviation	Ohm's law to calculate R, Hooke's law to calculate Spring Constant
Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen value problems	Solution of mesh equations of electric circuits (3 meshes) Solution of coupled spring mass systems (3 masses)
Generation of Special functions using User defined functions in Scilab	Generating and plotting Legendre Polynomials Generating and plotting Bessel function

<p>Solution of ODE</p> <p>First order Differential equation Euler, modified Euler and Runge-Kutta second order methods</p> <p>Second order differential equation Fixed difference method Partial differential equations</p>	<ul style="list-style-type: none"> ● First order differential equation ● Radioactive decay ● Current in RC, LC circuits with DC source ● Newton's law of cooling ● Classical equations of motion <p>Second order Differential Equation</p> <ul style="list-style-type: none"> ● Harmonic oscillator (no friction) ● Damped Harmonic oscillator ● Over damped ● Critical damped ● Oscillatory ● Forced Harmonic oscillator ● Transient and ● Steady state solution ● Apply above to LCR circuits also ● Solve $x^2 \frac{d^2y}{dx^2} - 4x(1+x) \frac{dy}{dx} + 2(1+x)y = x^3$ with the boundary conditions at $x = 1, y = \frac{1}{2}e^2, \frac{dy}{dx} = -\frac{3}{2}e^2 - 0.5$ in the range $1 \leq x \leq 3$. Plot y and $\frac{dy}{dx}$ against x in the given range on the same graph. <p>Partial Differential Equation:</p> <ul style="list-style-type: none"> ● Wave equation ● Heat equation ● Poisson equation ● Laplace equation
<p>Using Scicos / xcos</p>	<ul style="list-style-type: none"> ● Generating square wave, sine wave, saw tooth wave ● Solution to harmonic oscillator ● Study of beat phenomenon ● Phase space plots

Reference Books:

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S.J. Bence, 3rd ed., 2006, Cambridge University Press
- Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
- First Course in Complex Analysis with Applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett
- Computational Physics, D.Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.
- A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández. 2014 Springer
- Scilab by example: M. Affouf 2012, ISBN: 978-1479203444
- Scilab (A free software to Matlab): H. Ramchandran, A.S.Nair. 2011 S.Chand & Company
- Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
- www.scilab.in/textbook_companion/generate_book/291

PHYSICS - C VI

THERMAL PHYSICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

(Include related problems for each topic)

Unit - 1

Introduction to Thermodynamics

Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between C_p and C_v , Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion coefficient.

(8 Lectures)

Unit - 2

Second Law of Thermodynamics

Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

(10 Lectures)

Entropy

Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Temperature-Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

(7 Lectures)

Unit - 3

Thermodynamic Potentials

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibbs Free Energy. Their definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations.

(7 Lectures)

Maxwell's Thermodynamic Relations

Derivations and applications of Maxwell's Relations, (1) Clausius Clapeyron equation (2) Values of $C_p - C_v$ (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waals Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process.

(7 Lectures)

Unit - 4

Kinetic Theory of Gases

Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases.

(7 Lectures)

Molecular Collisions:

Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance.

(4 Lectures)

Unit - 5

Real Gases:

Behavior of Real Gases: Deviations from the Ideal Gas Equation. the Virial Equation, Andrew's Experiments on CO₂ gas, Critical Constants, Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waals Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling.

(10 Lectures)

Reference Books:

- Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
 - A Treatise on Heat, Meghnad Saha and B.N. Srivastava, 1958, Indian Press
 - Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
 - Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
 - Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
 - Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
 - Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.
 - Thermal Physics, B.K. Agrawal, Lok Bharti Publications.
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PHYSICS LAB - C VI

THERMAL PHYSICS

60 Lectures

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
7. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.

Reference Books:

- Advanced Practical Physics for Students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
 - A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
 - Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
 - A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Pub.
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PHYSICS - C VII

DIGITAL SYSTEMS AND APPLICATIONS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Introduction to CRO:

Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.

(3 Lectures)

Integrated Circuits

(Qualitative treatment only): Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital ICs.

(3 Lectures)

Digital Circuits:

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realizations using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers.

(6 Lectures)

Unit - 2

Boolean algebra:

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map

(6 Lectures)

Data processing circuits:

Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

(4 Lectures)

Arithmetic Circuits:

Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor.

(5 Lectures)

Unit - 3

Sequential Circuits:

SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.

(6 Lectures)

Timers:

IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator.

(3 Lectures)

Unit - 4

Shift registers:

Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).

(2 Lectures)

Counters (4 bits):

Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.

(4 Lectures)

Introduction to Assembly Language:

1 byte, 2 byte & 3 byte instructions.

(4 Lectures)

Unit - 5

Computer Organization:

Input/output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map.

(6 Lectures)

Intel 8085 Microprocessor Architecture:

Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing and Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI.

(8 Lectures)

Reference Books:

- Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw
 - Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
 - Digital Circuits and Systems, Venugopal, 2011, Tata McGraw Hill.
 - Digital Electronics, G K Kharate, 2010, Oxford University Press
 - Digital Systems: Principles & Applications, R.J. Tocci, N.S. Widmer, 2001, PHI Learning
 - Logic Circuit Design, Shimon P. Vingron, 2012, Springer.
 - Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
 - Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
 - Microprocessor Architecture Programming & Applications with 8085, 2002, R.S. Goankar, Prentice Hall.
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PHYSICS LAB - C VII

DIGITAL SYSTEMS AND APPLICATIONS

60 Lectures

1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
2. To test a Diode and Transistor using a Multimeter.
3. To design a switch (NOT gate) using a transistor.
4. To verify and design AND, OR, NOT and XOR gates using NAND gates.
5. To design a combinational logic system for a specified Truth Table.
6. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
7. To minimize a given logic circuit.
8. Half Adder, Full Adder and 4-bit binary Adder.
9. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
11. To build JK Master-slave flip-flop using Flip-Flop ICs
12. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
13. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
14. To design an astable multivibrator of given specifications using 555 Timer.
15. To design a monostable multivibrator of given specifications using 555 Timer.
16. Write the following programs using 8085 Microprocessor
 - a. Addition and subtraction of numbers using direct addressing mode
 - b. Addition and subtraction of numbers using indirect addressing mode
 - c. Multiplication by repeated addition.
 - d. Division by repeated subtraction.
 - e. Handling of 16-bit Numbers.
 - f. Use of CALL and RETURN Instruction.
 - g. Block data handling.
 - h. Other programs (e.g. Parity Check, using interrupts, etc.).

Reference Books:

- Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
 - Basic Electronics: A Text Lab Manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
 - Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, Prentice Hall.
 - Microprocessor 8085:Architecture, Programming and Interfacing, A. Wadhwa, 2010, PHI Learning.
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Semester IV

PHYSICS - C VIII MATHEMATICAL PHYSICS - III

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.

Unit - 1

Complex Analysis:

Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions.

(10 Lectures)

Unit - 2

Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula.

(7 Lectures)

Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals.

(7 Lectures)

Unit - 3

Integrals Transforms:

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples.

(12 Lectures)

Unit - 4

Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations.

(6 Lectures)

Laplace Transforms:

Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem.

(6 Lectures)

Unit - 5

LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.

Reference Books:

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
 - Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications
 - Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
 - Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press
 - Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill
 - First Course in Complex Analysis with Applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett
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PHYSICS LAB - C VIII

MATHEMATICAL PHYSICS - III

60 Lectures

Scilab/C++ /etc. based simulations experiments based on Mathematical Physics problems like

1. Solve differential equations:

$$dy/dx = e^{-x} \text{ with } y = 0 \text{ for } x = 0$$

$$dy/dx + e^{-x}y = x^2$$

$$d^2y/dt^2 + 2 dy/dt = -y$$

$$d^2y/dt^2 + e^{-t}dy/dt = -y$$

2. Dirac Delta Function:

Evaluate $\frac{1}{\sqrt{2\pi\sigma^2}} \int e^{-\frac{(x-2)^2}{2\sigma^2}} (x+3) dx$ for $\sigma = 1, 0.1, 0.001$ and show it tends to 5.

3. Fourier Series:

Program to sum $\sum_{n=1}^{\infty} (0.2)^n$

Evaluate the Fourier coefficients of a given periodic function (square wave)

4. Frobenius method and Special functions:

$$\int_{-1}^1 P_n(\mu) P_m(\mu) d\mu = \delta_{n,m}$$

Plot $P_n(x), j_\nu(x)$

Show recursion relation

5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).
6. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.
7. Evaluation of trigonometric functions e.g. $\sin \theta$, Given Bessel's function at N points find its value at an intermediate point. Complex analysis: Integrate $1/(x^2+2)$ numerically and check with computer integration.
8. Compute the n^{th} roots of unity for $n = 2, 3,$ and 4 .
9. Find the two square roots of $-5+12j$.
10. Integral transform: FFT of e^{-x^2}
11. Solve Kirchoff's Current law for any node of an arbitrary circuit using Laplace's transform.
12. Solve Kirchoff's Voltage law for any loop of an arbitrary circuit using Laplace's transform.
13. Perform circuit analysis of a general LCR circuit using Laplace's transform.

Reference Books:

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
 - Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
 - Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
 - A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
 - Scilab by Example: M. Affouf, 2012. ISBN: 978-1479203444
 - Scilab (A free software to Matlab): H. Ramchandran, A.S.Nair. 2011 S.Chand & Company
 - Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
 - https://web.stanford.edu/~boyd/ee102/laplace_ckts.pdf
 - ocw.nthu.edu.tw/ocw/upload/12/244/12handout.pdf
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PHYSICS - C IX

ELEMENTS OF MODERN PHYSICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Quantum Mechanics

Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions.

(14 Lectures)

Unit - 2

Position measurement

Gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets, impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle - application to virtual particles and range of an interaction.

(5 Lectures)

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.

(10 Lectures)

Unit - 3

One Dimensional Problems

One dimensional infinitely rigid box - energy eigenvalues and eigenfunctions, normalization; Quantum dot as example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and rectangular potential barrier.

(10 Lectures)

Unit - 4

Nuclear Physics

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers.

(6 Lectures)

Radioactivity

Stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay, energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.

(8 Lectures)

Unit - 5

Fission and fusion

Mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions).

(3 Lectures)

Lasers:

Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing.

(4 Lectures)

Reference Books:

- Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
- Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
- Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
- Physics for Scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
- Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill
- Quantum Mechanics: Theory & Applications, A.K. Ghatak & S. Lokanathan, 2004, Macmillan

Additional Books for Reference

- Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
 - Theory and Problems of Modern Physics, Schaum's outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
 - Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
 - Basic Ideas and Concepts in Nuclear Physics, K. Heyde, 3rd Edn., Institute of Physics Pub.
 - Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill
 - Quantum Mechanics, R. Eisberg and R. Resnick, John Wiley & Sons.
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PHYSICS LAB - C IX

ELEMENTS OF MODERN PHYSICS

60 Lectures

1. Measurement of Planck's constant using black body radiation and photo-detector
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the absorption lines in the rotational spectrum of Iodine vapour.
8. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.
10. To show the tunneling effect in tunnel diode using I-V characteristics.
11. To determine the wavelength of laser source using diffraction of single slit.
12. To determine the wavelength of laser source using diffraction of double slits.
13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating

Reference Books

- Advanced Practical Physics for Students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
 - Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
 - A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal
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PHYSICS - C X

ANALOG SYSTEMS AND APPLICATIONS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Semiconductor Diodes:

P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode.

(10 Lectures)

Unit - 2

Two-terminal Devices and their Applications:

(1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge, Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell.

(6 Lectures)

Bipolar Junction transistors:

n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β , Relations between α and β . Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.

(6 Lectures)

Unit - 3

Amplifiers:

Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers.

(10 Lectures)

Coupled Amplifier: Two stage RC-coupled amplifier and its frequency response.

(4 Lectures)

Unit - 4

Feedback in Amplifiers:

Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

(4 Lectures)

Sinusoidal Oscillators

Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.

(4 Lectures)

Conversion:

Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation)

(3 Lectures)

Unit - 5

Operational Amplifiers

(Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.

(4 Lectures)

Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator.

(9 Lectures)

Reference Books:

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
 - Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
 - Solid State Electronic Devices, B.G. Streetman & S.K. Banerjee, 6th Edn., 2009, PHI Learning
 - Electronic Devices & Circuits, S. Salivahanan & N.S. Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
 - OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
 - Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.
 - Electronic Circuits: Handbook of design & applications, U. Tietze, C. Schenk, 2008, Springer
 - Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
 - Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
 - Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India
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PHYSICS LAB - C X

ANALOG SYSTEMS AND APPLICATIONS

60 Lectures

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the various biasing configurations of BJT for normal Class A operation.
6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
7. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
8. To design a Wien bridge oscillator for given frequency using an op-amp.
9. To design a phase shift oscillator of given specifications using BJT.
10. To study the Colpitt's oscillator.
11. To design a digital to analog converter (DAC) of given specifications.
12. To study the analog to digital convertor (ADC) IC.
13. To design an inverting amplifier using Op-amp (741, 351) for dc voltage of given gain
14. To design inverting amplifier using Op-amp (741, 351) and study its frequency response
15. To design non-inverting amplifier using Op-amp (741, 351) & study its frequency response
16. To study the zero-crossing detector and comparator
17. To add two dc voltages using Op-amp in inverting and non-inverting mode
18. To design a precision differential amplifier of given I/O specification using Op-amp.
19. To investigate the use of an op-amp as an Integrator.
20. To investigate the use of an op-amp as a Differentiator.
21. To design a circuit to simulate the solution of a 1st/2nd order differential equation.

Reference Books:

- Basic Electronics: A Text Lab Manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
 - OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
 - Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
 - Electronic Devices & Circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009, Pearson
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Semester V

PHYSICS - C XI: QUANTUM MECHANICS AND APPLICATIONS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Time dependent Schrodinger equation:

Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.

(6 Lectures)

Time independent Schrodinger equation

Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

(10 Lectures)

Unit - 2

General discussion of bound states in an arbitrary potential

Continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem - square well potential; Quantum mechanics of simple harmonic oscillator - energy levels and energy eigen functions using Frobenius method; Hermite polynomials; ground state, zero point energy and uncertainty principle.

(12 Lectures)

Unit - 3

Quantum theory of hydrogen-like atoms:

Time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m ; s, p, d,.. shells.

(10 Lectures)

Unit - 4

Atoms in Electric & Magnetic Fields:

Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton.

(8 Lectures)

Atoms in External Magnetic Fields:

Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only).

(4 Lectures)

Unit - 5

Many electron atoms:

Pauli's Exclusion Principle. Symmetric & Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms - L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.).

(10 Lectures)

Reference Books:

- A Text book of Quantum Mechanics, P.M .Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
- Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press
- Quantum Mechanics, John L. Powell and Bernd Crasemann, Addison-Wesley Publishing Company

Additional Books for Reference

- Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
 - Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
 - Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer
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PHYSICS LAB - C XI

QUANTUM MECHANICS AND APPLICATIONS

60 Lectures

Use C/C++/Scilab for solving the following problems based on Quantum Mechanics like

1. Solve the *s*-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2} [V(r) - E] \text{ where } V(r) = -\frac{e^2}{r}$$

Here, *m* is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take $e = 3.795$ (eVÅ)^{1/2}, $\hbar c = 1973$ (eVÅ) and $m = 0.511 \times 10^6$ eV/c².

2. Solve the *s*-wave radial Schrodinger equation for an atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2} [V(r) - E]$$

where *m* is the reduced mass of the system (which can be chosen to be the mass of an electron) for the screened coulomb potential

$$V(r) = -\frac{e^2}{r} e^{-r/a}$$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take $e = 3.795$ (eVÅ)^{1/2}, $m = 0.511 \times 10^6$ eV/c², and $a = 3$ Å, 5 Å, 7 Å. In these units $\hbar c = 1973$ (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the *s*-wave radial Schrodinger equation for a particle of mass *m*:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2} [V(r) - E]$$

For the anharmonic oscillator potential

$$\frac{1}{2} kr^2 + \frac{1}{3} br^3$$

for the ground state energy (in MeV) of a particle to an accuracy of three significant digits.

Also, plot the corresponding wave function. Choose $m = 940$ MeV/c², $k = 100$ MeV fm⁻², $b = 0, 10, 30$ MeV fm⁻³. In these units, $\hbar c = 197.3$ MeV fm. The ground state energy is expected to lie between 90 and 110 MeV for all three cases.

4. Solve the *s*-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2\mu}{\hbar^2} [V(r) - E]$$

Where μ is the reduced mass of the two-atom system for the Morse potential

$$V(r) = D(e^{-2\alpha r'} - e^{-\alpha r'}), r' = \frac{r-r_0}{r}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.

Take $m = 940 \times 10^6$ eV/C², $D = 0.755501$ eV, $\alpha = 1.44$, $r_0 = 0.131349$ Å

Laboratory based experiments:

5. Study of Electron spin resonance - determine magnetic field as a function of the resonance frequency
6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
7. To show the tunneling effect in tunnel diode using I-V characteristics.
8. Quantum efficiency of CCDs

Reference Books:

- Schaum's Outline of Programming with C++. J.Hubbard, 2000,McGraw-Hill Publication
 - Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rd Edn., 2007, Cambridge University Press.
 - An Introduction to Computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press
 - Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer.
 - Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
 - A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
 - Scilab Image Processing: L.M.Surhone.2010 Betascript Publishing ISBN:978-6133459274
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PHYSICS - C XII: SOLID STATE PHYSICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Crystal Structure:

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.

(12 Lectures)

Unit - 2

Elementary Lattice Dynamics:

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

(10 Lectures)

Unit - 3

Magnetic Properties of Matter:

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.

(8 Lectures)

Unit - 4

Dielectric Properties of Materials:

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 Sellmeier Relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes.

(8 Lectures)

Ferroelectric Properties of Materials:

Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.

(6 lectures)

Unit - 5

Elementary band theory:

Kronig Penny Model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) and Hall coefficient.

(10 Lectures)

Superconductivity:

Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and Type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)

(6 Lectures)

Reference Books:

- Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
 - Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
 - Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
 - Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
 - Solid State Physics, H. Ibach and H. Luth, 2009, Springer
 - Solid State Physics, Rita John, 2014, McGraw Hill
 - Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
 - Solid State Physics, M.A. Wahab, 2011, Narosa Publications
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PHYSICS LAB - C XII

SOLID STATE PHYSICS

60 Lectures

1. Measurement of susceptibility of paramagnetic solution (Quinck's Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. To determine the refractive index of a dielectric layer using SPR
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 °C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

Reference Books:

- Advanced Practical Physics for Students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
 - Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
 - A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
 - Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.
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Semester VI

PHYSICS - C XIII ELECTROMAGNETIC THEORY

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Maxwell's Equations:

Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at the 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.

(12 Lectures)

Unit - 2

EM Wave Propagation in Unbounded Media:

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 ionized gases, plasma frequency, refractive index, skin depth, application to propagation through the ionosphere.

(10 Lectures)

Unit - 3

EM Wave in Bounded Media:

Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at a 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. Metallic reflection (normal incidence)

(10 Lectures)

Unit - 4

Polarization of Electromagnetic 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. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light

(12 Lectures)

Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.

(5 Lectures)

Unit - 5

Wave Guides: Planar optical waveguides. Planar dielectric waveguide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission.

(8 Lectures)

Optical Fibres:- Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only).

(3 Lectures)

Reference Books:

- Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
- Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
- Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
- Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
- Electromagnetic Field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
- Engineering Electromagnetic, William H. Hayt, 8th Edition, 2012, McGraw Hill.
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Additional Books for Reference

- Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.
 - Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
 - Electromagnetic Field Theory Fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge University Press
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PHYSICS LAB - C XIII

ELECTROMAGNETIC THEORY

60 Lectures

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized light by using a Babinet's compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
6. To study the reflection, refraction of microwaves
7. To study Polarization and double slit interference in microwaves.
8. To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
9. To determine the refractive index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
10. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
11. To verify the Stefan's law of radiation and to determine Stefan's constant.
12. To determine the Boltzmann constant using V-I characteristics of PN junction diode.

Reference Books:

- Advanced Practical Physics for Students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
 - Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
 - A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
 - Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
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PHYSICS - C XIV

STATISTICAL MECHANICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Classical Statistics:

Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature.

(18 Lectures)

Unit - 2

Classical Theory of Radiation:

Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe.

(9 Lectures)

Unit - 3

Quantum Theory of Radiation:

Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law.

(5 Lectures)

Unit - 4

Bose-Einstein Statistics:

B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law.

(13 Lectures)

Unit - 5

Fermi-Dirac Statistics:

Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.

(15 Lectures)

Reference Books:

- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
 - Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill
 - Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall
 - Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
 - Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
 - An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press
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PHYSICS LAB - C XIV

STATISTICAL MECHANICS

60 Lectures

Use C/C++/Scilab/other numerical simulations for solving the problems based on Statistical Mechanics like

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:
 - a. Study of local number density in the equilibrium state (i) average; (ii) fluctuations
 - b. Study of transient behavior of the system (approach to equilibrium)
 - c. Relationship of large N and the arrow of time
 - d. Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution
 - e. Computation and study of mean molecular speed and its dependence on particle mass
 - f. Computation of fraction of molecules in an ideal gas having speed near the most probable speed
2. Computation of the partition function $Z(\beta)$ for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics:
 - a. Study of how $Z(\beta)$, average energy $\langle E \rangle$, energy fluctuation ΔE , specific heat at constant volume C_v , depend upon the temperature, total number of particles N and the spectrum of single particle states.
 - b. Ratios of occupation numbers of various states for the systems considered above
 - c. Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T .
3. Plot Planck's law for Black Body radiation and compare it with Rayleigh-Jeans Law at high temperature and low temperature.
4. Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.
5. Plot the following functions with energy at different temperatures
 - a. Maxwell-Boltzmann distribution
 - b. Fermi-Dirac distribution
 - c. Bose-Einstein distribution

Reference Books:

- Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn . 2007, Wiley India Edition
 - Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
 - Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987
 - Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
 - Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
 - Statistical and Thermal Physics with Computer Applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010.
 - Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896 Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
 - Scilab Image Processing: L.M. Surhone. 2010, Betascript Pub., ISBN: 978-6133459274
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DISCIPLINE SPECIFIC ELECTIVE COURSES

Semester V

PHYSICS - DSE I EXPERIMENTAL TECHNIQUES

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit 1

Measurements:

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. Gaussian distribution.

(7 Lectures)

Signals and Systems:

Periodic and aperiodic 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.

(7 Lectures)

Unit 2

Shielding and Grounding:

Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference.

(4 Lectures)

Transducers & Industrial Instrumentation (working principle, efficiency, applications):

Static 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.

(6 Lectures)

Unit 3

Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filled detector, Ionization chamber, Scintillation detector.

(15 Lectures)

Unit 4

Digital Multimeter:

Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement.

(5 Lectures)

Impedance Bridges and Q-meter:

Block diagram and working principles of RLC bridge. Q-meter and its working operation. Digital LCR bridge.

(4 Lectures)

Unit 5

Vacuum Systems:

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, ionization).

(12 Lectures)

Reference Books:

- Measurement, Instrumentation and Experiment Design in Physics and Engineering, M. Sayer and A. Mansingh, PHI Learning Pvt. Ltd.
 - Experimental Methods for Engineers, J. P. Holman, McGraw Hill
 - Introduction to Measurements and Instrumentation, A.K. Ghosh, 3rd Edition, PHI Learning Pvt. Ltd.
 - Transducers and Instrumentation, D.V. S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
 - Instrumentation Devices and Systems, C. S. Rangan, G. R.Sarma, V. S. V. Mani, Tata McGraw Hill
 - Principles of Electronic Instrumentation, D. Patranabis, PHI Learning Pvt. Ltd.
 - Electronic Circuits: Handbook of Design & Applications, U. Tietze, Ch. Schenk, Springer
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PHYSICS LAB - DSE I

EXPERIMENTAL TECHNIQUES

60 Lectures

1. Determine output characteristics of an LVDT and measure displacement using LVDT
2. Measurement of Strain using Strain Gauge.
3. Measurement of level using capacitive transducer.
4. To study the characteristics of a Thermostat and determine its parameters.
5. Study of distance measurement using ultrasonic transducer.
6. Calibrate Semiconductor type temperature sensor (AD590, LM35 or LM75)
7. To measure the change in temperature of ambient using Resistance Temperature Device (RTD).
8. Create vacuum in a small chamber using a mechanical (rotary) pump and measure the chamber pressure using a pressure gauge.
9. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2m length, understanding of the importance of grounding using function generator of mV level and an oscilloscope.
10. To design and study the Sample and Hold Circuit.
11. Design and analyze the Clippers and Clampers circuits using junction diode
12. To plot the frequency response of a microphone.
13. To measure Q of a coil and influence of frequency, using a Q-meter.

Reference Books:

- Electronic Circuits: Handbook of Design and Applications, U. Tietze and C. Schenk, 2008, Springer
 - Basic Electronics: A Text Lab Manual, P. B. Zbar, A. P. Malvino, M. A. Miller, 1990, Mc-Graw Hill
 - Measurement, Instrumentation and Experiment Design in Physics & Engineering, M. Sayer and A. Mansingh, 2005, PHI Learning.
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PHYSICS - DSE II

PHYSICS OF DEVICES AND COMMUNICATION SYSTEMS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Devices:

Characteristic and small signal equivalent circuits of UJT and JFET. Metal-semiconductor Junction. Metal oxide semiconductor (MOS) device. Ideal MOS and Flat Band voltage. SiO₂-Si based MOS. MOSFET – their frequency limits. Enhancement and Depletion Mode MOSFETS, CMOS. Charge coupled devices. Tunnel diode.

(14 Lectures)

Unit - 2

Multivibrators:

Astable and Monostable Multivibrators using transistors.

(3 Lectures)

Phase Locked Loop (PLL):

Basic Principles, Phase detector (XOR & edge triggered), Voltage Controlled Oscillator (Basics, varactor). Loop Filter – Function, Loop Filter Circuits, transient response, lock and capture. Basic idea of PLL IC (565 or 4046).

(5 Lectures)

Unit - 3

Processing of Devices:

Basic process flow for IC fabrication, Electronic grade silicon. Crystal plane and orientation. Defects in the lattice. Oxide layer. Oxidation Technique for Si. Metallization technique. Positive and Negative Masks. Optical lithography. Electron lithography. Feature size control and wet anisotropic etching. Lift off Technique. Diffusion and implantation.

(12 Lectures)

Unit - 4

Digital Data Communication Standards:

Serial Communications: RS232, Handshaking, Implementation of RS232 on PC. Universal Serial Bus (USB): USB standards, Types and elements of USB transfers. Devices (Basic idea of UART). Parallel Communications: General Purpose Interface Bus (GPIB), GPIB signals and lines, Handshaking and interface management, Implementation of a GPIB on a PC. Basic idea of sending data through a COM port.

(5 Lectures)

Power supply and Filters:

Block Diagram of a Power Supply, Qualitative idea of C and L Filters. IC Regulators, Line and load regulation, Short circuit protection, Active and Passive Filters, Low Pass, High Pass, Band Pass and band Reject Filters.

(6 Lectures)

Unit - 5

Introduction to Communication Systems:

Block diagram of electronic communication system, Need for modulation. Amplitude modulation. Modulation Index. Analysis of Amplitude Modulated wave. Sideband frequencies in AM wave. CE Amplitude Modulator. Demodulation of AM wave using Diode Detector. basic idea of Frequency, Phase, Pulse and Digital Modulation including ASK, PSK, FSK.

(15 lectures)

Reference Books:

- Physics of Semiconductor Devices, S.M. Sze & K.K. Ng, 3rd Ed.2008, John Wiley & Sons
 - Electronic Devices and Integrated Circuits, A.K. Singh, 2011, PHI Learning Pvt. Ltd.
 - Op-Amps and Linear Integrated Circuits, R.A.Gayakwad,4 Ed. 2000,PHI Learning Pvt. Ltd
 - Electronic Devices and Circuits, A. Mottershead, 1998, PHI Learning Pvt. Ltd.
 - Electronic Communication Systems, G. Kennedy, 1999, Tata McGraw Hill.
 - Introduction to Measurements and Instrumentation, A.K. Ghosh, 3rd Ed., 2009, PHI Learning Pvt. Ltd.
 - Semiconductor Physics and Devices, D.A. Neamen, 2011, 4th Edition, McGraw Hill
 - PC based instrumentation; Concepts and Practice, N.Mathivanan, 2007, Prentice-Hall of India
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PHYSICS LAB - DSE II

PHYSICS OF DEVICES AND COMMUNICATION

60 Lectures

Experiments from both Section A and Section B:

Section-A

1. To design a power supply using bridge rectifier and study effect of C-filter.
2. To design the active Low pass and High pass filters of given specification.
3. To design the active filter (wide band pass and band reject) of given specification.
4. To study the output and transfer characteristics of a JFET.
5. To design a common source JFET Amplifier and study its frequency response.
6. To study the output characteristics of a MOSFET
7. To study the characteristics of a UJT and design a simple Relaxation Oscillator.
8. To design an Amplitude Modulator using Transistor.
9. To design PWM, PPM, PAM and Pulse code modulation using ICs.
10. To design an Astable multivibrator of given specifications using transistor.
11. To study a PLL IC (Lock and capture range).
12. To study envelope detector for demodulation of AM signal.
13. Study of ASK and FSK modulator.
14. Glow an LED via USB port of PC.
15. Sense the input voltage at a pin of USB port and subsequently glow the LED connected with another pin of USB port.

Section-B:

SPICE/MULTISIM simulations for electrical networks and electronic circuits

1. To verify the Thevenin and Norton Theorems.
2. Design and analyze the series and parallel LCR circuits
3. Design the inverting and non-inverting amplifier using an Op-Amp of given gain
4. Design and Verification of op-amp as integrator and differentiator
5. Design the 1st order active low pass and high pass filters of given cutoff frequency
6. Design a Wein Bridge oscillator of given frequency.
7. Design clocked SR and JK Flip-Flops using NAND Gates
8. Design 4-bit asynchronous counter using Flip-Flop ICs
9. Design the CE amplifier of a given gain and its frequency response.
10. Design an Astable multivibrator using IC555 of given duty cycle.

Reference Books:

- Basic Electronics: A Text Lab Manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill
 - Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
 - Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
 - OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edn., 2000, Prentice Hall.
 - Introduction to PSPICE using ORCAD for circuits & Electronics, M.H. Rashid, 2003, PHI Learning.
 - PC Based Instrumentation; Concepts and Practice, N.Mathivanan, 2007, Prentice-Hall of India
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PHYSICS - DSE III

ADVANCED MATHEMATICAL PHYSICS I

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.

Unit - 1

Linear Vector Spaces:

Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices.

(12 Lectures)

Unit - 2

Matrices:

Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit Matrices. Upper-Triangular and Lower-Triangular Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrix. Trace of a Matrix. Inner Product.

(8 Lectures)

Eigen-values and Eigenvectors.

Cayley-Hamilton Theorem. Diagonalization of Matrices. Solution of Coupled Linear Ordinary Differential Equations. Functions of a Matrix

(10 Lectures)

Unit - 3

Cartesian Tensors:

Transformation of Co-ordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Invariant Tensors : Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors : Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities.

(10 lectures)

Unit - 4

Cartesian Tensors - 2

Tensorial Formulation of Analytical Solid Geometry: Equation of a Line. Angle Between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor (No Derivation). Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors : Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law.

(10 lectures)

Unit - 5

General Tensors: Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor.

(10 Lectures)

Reference Books:

- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications
 - Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970, Elsevier.
 - Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press
 - Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, Dover Pub.
 - Linear Algebra, W. Cheney, E.W.Cheney & D.R.Kincaid, 2012, Jones & Bartlett Learning
 - Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
 - Mathematical Methods for Physicists & Engineers, K.F.Riley, M.P.Hobson, S.J.Bence, 3rd Ed., 2006, Cambridge University Press
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PHYSICS LAB - DSE III

ADVANCED MATHEMATICAL PHYSICS I

60 Lectures

Scilab/ C⁺⁺ based simulations experiments based on Mathematical Physics problems like

1. Linear algebra:

- Multiplication of two 3×3 matrices.
- Eigenvalue and eigenvectors of

$$\begin{pmatrix} 2 & 1 & 1 \\ 1 & 3 & 2 \\ 3 & 1 & 4 \end{pmatrix}; \begin{pmatrix} 1 & -i & 3+4i \\ +i & 2 & 4 \\ 3-4i & 4 & 3 \end{pmatrix}; \begin{pmatrix} 2 & -i & 2i \\ +i & 4 & 3 \\ -2i & 3 & 5 \end{pmatrix}$$

2. Orthogonal polynomials as eigenfunctions of Hermitian differential operators.
3. Determination of the principal axes of moment of inertia through diagonalization.
4. Vector space of wave functions in Quantum Mechanics: Position and momentum differential operators and their commutator, wave functions for stationary states as eigenfunctions of Hermitian differential operator.
5. Lagrangian formulation in Classical Mechanics with constraints.
6. Study of geodesics in Euclidean and other spaces (surface of a sphere, etc).
7. Estimation of ground state energy and wave function of a quantum system.

Reference Books:

- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
 - Scilab by Example: M. Affouf, 2012, ISBN: 978-1479203444
 - Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 978-6133459274
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PHYSICS - DSE IV

CLASSICAL DYNAMICS

(Credits: Theory-05, Tutorials-01)

Theory: 75 Lectures

The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined on the basis of problems, seen and unseen.

Unit - 1

Classical Mechanics of Point Particles 1:

Review of Newtonian Mechanics; Application to the motion of a charged particle in external electric and magnetic fields - motion in uniform electric field, magnetic field - gyroradius and gyrofrequency, motion in crossed electric and magnetic fields. Generalized coordinates and velocities, Hamilton's principle, Lagrangian and the Euler-Lagrange equations, one-dimensional examples of the Euler-Lagrange equations - one-dimensional Simple Harmonic Oscillations and falling body in uniform gravity; applications to simple systems such as coupled oscillators

(12 Lectures)

Unit - 2

Classical Mechanics of Point Particles 2:

Canonical momenta and Hamiltonian. Hamilton's equations of motion.

Applications: Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations; particle in a central force field - conservation of angular momentum and energy.

(10 Lectures)

Unit - 3

Small Amplitude Oscillations:

Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations, example of N identical masses connected in a linear fashion to (N - 1) identical springs.

(10 Lectures)

Unit - 4

Special Theory of Relativity:

Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction and twin paradox. Four-vectors: space-like, time-like and light-like. Four-velocity and acceleration. Metric and alternating tensors. Four-momentum and energy-momentum relation. Doppler effect from a four-vector perspective. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle.

(33 Lectures)

Unit - 5

Fluid Dynamics:

Density and pressure P in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille's equation for flow of a liquid through a pipe, Navier-Stokes equation, qualitative description of turbulence, Reynolds number.

(10 Lectures)

Reference Books:

- Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.
 - Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
 - Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.
 - The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
 - Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
 - Classical Mechanics, P.S. Joag, N.C. Rana, 1st Edn., McGraw Hall.
 - Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
 - Classical Mechanics: An Introduction, Dieter Strauch, 2009, Springer.
 - Solved Problems in Classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press
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PHYSICS - DSE V

NUCLEAR AND PARTICLE PHYSICS

(Credits: Theory-05, Tutorials-01)

Theory: 75 Lectures

Unit - 1

General Properties of Nuclei:

Constituents of nucleus and their intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excited states.

(10 Lectures)

Particle physics:

Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons.

(14 Lectures)

Unit - 2

Nuclear Models:

Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.

(12 Lectures)

Unit - 3

Radioactivity decay:

(a) Alpha decay: basics of α -decay processes, theory of α -emission, Gamow factor, Geiger Nuttall law, α -decay spectroscopy. (b) beta-decay: energy kinematics for beta-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma ray emission and kinematics, internal conversion.

(10 Lectures)

Unit - 4

Nuclear Reactions:

Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering).

(8 Lectures)

Interaction of Nuclear Radiation with matter:

Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter.

(8 Lectures)

Unit - 5

Detectors for Nuclear Radiations:

Gas detectors: estimation of electric field, mobility of particle, ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.

(8 Lectures)

Particle Accelerators:

Accelerator facilities available in India: Van-de Graaff Generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.

(5 Lectures)

Reference Books:

- Introductory Nuclear Physics, Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
 - Concepts of Nuclear Physics, Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
 - Introduction to the Physics of Nuclei and Particles, R.A. Dunlap. (Thomson Asia, 2004).
 - Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
 - Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
 - Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
 - Basic Ideas and Concepts in Nuclear Physics - An Introductory Approach, K. Heyde (IOP-Institute of Physics Publishing, 2004).
 - Radiation Detection and Measurement, G.F. Knoll (John Wiley & Sons, 2000).
 - Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
 - Theoretical Nuclear Physics, J.M. Blatt and V.F. Weisskopf (Dover Pub.Inc., 1991)
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PHYSICS - DSE VI

ATMOSPHERIC PHYSICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

General features of Earth's atmosphere:

Thermal structure of the Earth's Atmosphere, Ionosphere, Composition of the atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect and effective temperature of Earth, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations, including RS/RW, meteorological processes and different systems, fronts, Cyclones and anticyclones, thunderstorms.

(12 Lectures)

Unit - 2

Atmospheric Dynamics:

Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscale circulations, The general circulations, Tropical dynamics.

(12 Lectures)

Unit - 3

Atmospheric Waves:

Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a non-homogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration

(12 Lectures)

Unit - 4

Atmospheric Radar and Lidar:

Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Application of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques.

(12 Lectures)

Unit - 5

Atmospheric Aerosols:

Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosols, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars.

(12 Lectures)

Reference Books:

- Fundamental of Atmospheric Physics, Murry L Salby; Academic Press, Vol 61, 1996
 - The Physics of Atmosphere, John T. Houghton; Cambridge University press;3rd edn. 2002.
 - An Introduction to Dynamic Meteorology, James R Holton; Academic Press, 2004
 - Radar for meteorological and atmospheric observations, S Fukao and KHamazu, Springer Japan, 2014
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PHYSICS LAB - DSE VI

ATMOSPHERIC PHYSICS

60 Lectures

Scilab/C++ based simulations experiments based on Atmospheric Physics problems like

1. Numerical Simulation for atmospheric waves using dispersion relations
 - a. Atmospheric gravity waves (AGW)
 - b. Kelvin waves
 - c. Rossby waves, and mountain waves
2. Offline and online processing of radar data
 - a. VHF radar,
 - b. X-band radar, and
 - c. UHF radar
3. Offline and online processing of LIDAR data
4. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe.
5. Handling of satellite data and plotting of atmospheric parameters using radio occultation technique
6. Time series analysis of temperature using long term data over metropolitan cities in India – an approach to understand the climate change

Reference Books:

- Fundamental of Atmospheric Physics, Murry L Salby; Academic Press, Vol 61, 1996
 - The Physics of Atmosphere, J.T. Houghton; Cambridge Univ. Press; 3rd edn. 2002.
 - An Introduction to Dynamic Meteorology, James R Holton; Academic Press, 2004
 - Radar for Meteorological and Atmospheric Observations, S Fukao and K Hamazu, Springer Japan, 2014
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PHYSICS - DSE VII

BIOLOGICAL PHYSICS

(Credits: Theory-05, Tutorials-01)

Theory: 75 Lectures

Unit - 1

Overview:

The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self-replication as a distinct property of biological systems. Time scales and spatial scales. Universality of microscopic processes and diversity of macroscopic form. Types of cells. Multicellularity. Allometric scaling laws.

(9 lectures)

Unit - 2

Molecules of life:

Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling.

Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell.

Simplified mathematical models of transcription and translation, small genetic circuits and signaling pathways. Random walks and applications to biology. Mathematical models to be studied analytically and computationally.

(22 lectures)

Unit - 3

The complexity of life:

At the level of a cell: The numbers of distinct metabolites, genes and proteins in a cell. Complex networks of molecular interactions: metabolic, regulatory and signaling networks. Dynamics of metabolic networks; the stoichiometric matrix. Living systems as complex organizations; systems biology. Models of cellular dynamics. The implausibility of life based on a simplified probability estimate, and the origin of life problem.

(15 Lectures)

Unit - 4

At the level of a multicellular organism: Numbers and types of cells in multicellular organisms. Cell types as distinct attractors of a dynamical system. Stem cells and cellular differentiation. Pattern formation and development.

Brain structure: neurons and neural networks. Brain as an information processing system. Associative memory models. Memories as attractors of the neural network dynamics.

At the level of an ecosystem and the biosphere: Foodwebs. Feedback cycles and self-sustaining ecosystems.

(15 lectures)

Unit - 5

Evolution:

The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution. The concept of genotype-phenotype map. Examples.

(14 lectures)

References:

- Physics in Molecular Biology; Kim Sneppen & Giovanni Zocchi (CUP 2005)
 - Biological Physics: Energy, Information, Life; Philip Nelson (W H Freeman & Co, NY, 2004)
 - Physical Biology of the Cell (2nd Edition), Rob Phillips et al (Garland Science, Taylor & Francis Group, London & NY, 2013)
 - An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013)
 - Evolution; M. Ridley (Blackwell Publishers, 2009, 3rd edition)
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Semester VI

PHYSICS - DSE VIII

ADVANCED MATHEMATICAL PHYSICS – II

(Credits: Theory-05, Tutorials-01)

Theory: 75 Lectures

Unit - 1

Calculus of Variations 1:

Variable Calculus: Variational Principle, Euler's Equation and its Application to Simple Problems. Geodesics. Concept of Lagrangian. Generalized co-ordinates. Definition of canonical moment, Euler-Lagrange's Equations of Motion and its Applications to Simple Problems (e.g., Simple Pendulum and One dimensional harmonic oscillator).

(13 Lectures)

Unit - 2

Calculus of Variations 2:

Definition of Canonical Momenta. Canonical Pair of Variables. Definition of Generalized Force: Definition of Hamiltonian (Legendre Transformation). Hamilton's Principle. Poisson Brackets and their properties. Lagrange Brackets and their properties.

(12 Lectures)

Unit - 3

Group Theory 1:

Review of sets, Mapping and Binary Operations, Relation, Types of Relations. Groups: Elementary properties of groups, uniqueness of solution, Subgroup, Centre of a group, Co-sets of a subgroup, cyclic group

(12 Lectures)

Unit - 4

Group Theory 2:

Permutation/Transformation. Homomorphism and Isomorphism of group. Normal and conjugate subgroups, Completeness and Kernel. Some special groups with operators. Matrix Representations: Reducible and Irreducible

(13 Lectures)

Unit - 5

Advanced Probability Theory:

Fundamental Probability Theorems. Conditional Probability, Bayes' Theorem, Repeated Trials, Binomial and Multinomial expansions. Random Variables and probability distributions, Expectation and Variance, Special Probability distributions: The Binomial distribution, The Poisson distribution, Continuous distribution: The Gaussian (or normal) distribution, The principle of least squares.

(25 Lectures)

Reference Books:

- Mathematical Methods for Physicists, Weber and Arfken, 2005, Academic Press.
 - Mathematical Methods for Physicists, A Concise Introduction: Tai L. Chow, 2000, Cambridge Univ. Press.
 - Elements of Group Theory for Physicists, A. W. Joshi, 1997, John Wiley.
 - Group Theory and its Applications to Physical Problems, Morton Hamermesh, 1989, Dover
 - Introduction to Mathematical Physics: Methods & Concepts, Chun Wa Wong, 2012, Oxford University Press
 - Introduction to Mathematical Probability, J. V. Uspensky, 1937, McGraw-Hill.
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PHYSICS - DSE IX

APPLIED DYNAMICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Introduction to Dynamical systems 1

Definition of a continuous first order dynamical system. The idea of phase space, flows and trajectories. Simple mechanical systems as first order dynamical systems : the free particle, particle under uniform gravity, simple and damped harmonic oscillator. Sketching flows and trajectories in phase space; sketching variables as functions of time, relating the equations and pictures to the underlying physical intuition.

Other examples of dynamical systems –

In Biology: Population models e.g. exponential growth and decay, logistic growth, species competition, predator-prey dynamics, simple genetic circuits

In Chemistry: Rate equations for chemical reactions e.g. auto catalysis, bistability

In Economics: Examples from game theory.

Illustrative examples from other disciplines.

(13 Lectures)

Unit - 2

Introduction to Dynamical systems 2

Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems, with applications to the above examples.

Computing and visualizing trajectories on the computer using software packages.

Discrete dynamical systems. The logistic map as an example.

(13 Lectures)

Unit - 3

Introduction to Chaos and Fractals 1

Examples of 2-dimensional billiard, Projection of the trajectory on momentum space. Sinai Billiard and its variants. Computational visualization of trajectories in the Sinai Billiard. Randomization and ergodicity in the divergence of nearby phase space trajectories, and dependence of time scale of divergence on the size of obstacles. Electron motion in mesoscopic conductors as a chaotic billiard problem. Other examples of chaotic systems; visualization of their trajectories on the computer.

Self similarity and fractal geometry: Fractals in nature – trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure. Fractals in dynamics – Sierpinski gasket and DLA.

(10 Lectures)

Unit - 4

Introduction to Chaos and Fractals 2

Chaos in nonlinear finite-difference equations - Logistic map: Dynamics from time series. Parameter dependence - steady, periodic and chaos states. Cobweb iteration. Fixed points. Defining chaos - aperiodic, bounded, deterministic and sensitive dependence on initial conditions. Period-Doubling route to chaos.

Nonlinear time series analysis and chaos characterization: Detecting chaos from return map. Power spectrum, autocorrelation, Lyapunov exponent, correlation dimension.

(10 Lectures)

Unit - 5

Elementary Fluid Dynamics:

Importance of fluids: Fluids in the pure sciences, Fluids in technology. Study of fluids: Theoretical approach, experimental fluid dynamics, computational fluid dynamics. Basic physics of fluids: The continuum hypothesis - concept of fluid element or fluid parcel; Definition of a fluid - shear stress; Fluid properties - viscosity, thermal conductivity, mass diffusivity, other fluid properties and equation of state; Flow phenomena - flow dimensionality, steady and unsteady flows, uniform & non-uniform flows, viscous and inviscid flows, incompressible & compressible flows, laminar and turbulent flows, rotational and irrotational flows, separated and unseparated flows. Flow visualization - streamlines, pathlines, Streamlines.

(14 Lectures)

Reference Books

- Nonlinear Dynamics and Chaos, S.H. Strogatz, Levant Books, Kolkata, 2007
 - Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
 - An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
 - Fluid Mechanics, 2nd Edition, L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, 1987.
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PHYSICS LAB - DSE IX

APPLIED DYNAMICS

60 Lectures

Laboratory/Computing and visualizing trajectories using software such as Scilab, Maple, Octave, XPPAUT based on Applied Dynamics problems like

1. To determine the coupling coefficient of coupled pendulums.
2. To determine the coupling coefficient of coupled oscillators.
3. To determine the coupling and damping coefficient of damped coupled oscillator.
4. To study population models e.g. exponential growth and decay, logistic growth, species competition, predator-prey dynamics, simple genetic circuits.
5. To study rate equations for chemical reactions e.g. auto catalysis, bistability.
6. To study examples from game theory.
7. Computational visualization of trajectories in the Sinai Billiard.
8. Computational visualization of trajectories Electron motion in mesoscopic conductors as a chaotic billiard problem.
9. Computational visualization of fractal formations of Deterministic fractal.
10. Computational visualization of fractal formations of self-similar fractal.
11. Computational visualization of fractal formations of Fractals in nature – trees, coastlines, earthquakes.
12. Computational Flow visualization - streamlines, pathlines, Streamlines.

Reference Books:

- Nonlinear Dynamics and Chaos, Steven H. Strogatz, Levant Books, Kolkata, 2007
 - Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
 - An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
 - Fluid Mechanics, 2nd Edn, L.D.Landau & E.M. Lifshitz, Pergamon Press, Oxford, 1987
 - Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
 - Scilab by Example, M. Affouf, 2012, ISBN: 978-1479203444
 - Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 978-6133459274
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PHYSICS - DSE X

COMMUNICATION SYSTEMS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Electronic communication:

Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. Concept of Noise, signal-to-noise (S/N) ratio.

(8 Lectures)

Unit - 2

Analog Modulation:

Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver

(12 Lectures)

Unit - 3

Analog Pulse Modulation:

Channel capacity, Sampling theorem, Basic Principles - PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing.

(9 Lectures)

Digital Pulse Modulation:

Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK).

(10 Lectures)

Unit - 4

Introduction to Communication and Navigation systems:

Satellite Communication – Introduction, need, Geosynchronous satellite orbits, geostationary satellite, advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station. Uplink and downlink.

(10 Lectures)

Unit - 5

Mobile Telephony System

Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only).

(10 Lectures)

GPS navigation system (qualitative idea only)

(1 Lecture)

Reference Books:

- Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
 - Advanced Electronics Communication Systems, Tomasi, 6th edition, Prentice Hall.
 - Electronic Communication systems, G. Kennedy, 3rd Edn., 1999, Tata McGraw Hill.
 - Principles of Electronic Communication Systems, Frenzel, 3rd edition, McGraw Hill
 - Communication Systems, S. Haykin, 2006, Wiley India
 - Electronic Communication System, Blake, Cengage, 5th edition.
 - Wireless Communications, Andrea Goldsmith, 2015, Cambridge University Press
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PHYSICS LAB - DSE X

COMMUNICATION SYSTEMS

60 Lectures

1. To design an Amplitude Modulator using Transistor
2. To study envelope detector for demodulation of AM signal
3. To study FM Generator and Detector circuit
4. To study AM Transmitter and Receiver
5. To study FM Transmitter and Receiver
6. To study Time Division Multiplexing (TDM)
7. To study Pulse Amplitude Modulation (PAM)
8. To study Pulse Width Modulation (PWM)
9. To study Pulse Position Modulation (PPM)
10. To study ASK, PSK and FSK modulators

Reference Books:

- Electronic Communication Systems, G. Kennedy, 1999, Tata McGraw Hill.
 - Electronic Communication System, Blake, Cengage, 5th edition.
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PHYSICS - DSE XI

ASTRONOMY AND ASTROPHYSICS

(Credits: Theory-05, Tutorials-01)

Theory: 75 Lectures

Unit - 1

Astronomical Scales:

Astronomical Distance, Mass and Time, Scales, Brightness, Radiant Flux and Luminosity, Measurement of Astronomical Quantities, Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature.

Basic concepts of positional astronomy:

Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates, Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar.

(14 Lectures)

Unit - 2

Basic Parameters of Stars

Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a star; Determination of Masses from Binary orbits; Stellar Spectral Classification, Hertzsprung-Russell Diagram.

(10 Lectures)

The Sun

Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity, Basics of Solar Magneto-hydrodynamics. Helioseismology.

The Solar System:

Facts and Figures, Origin of the Solar System: The Nebular Model, Tidal Forces and Planetary Rings, Extra-Solar Planets.

(6 Lectures)

Unit - 3

Astronomical Techniques:

Basic Optical Definitions for Astronomy, Magnification, Light Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows, Optical Telescopes; Types of Reflecting Telescopes, Telescope Mountings, Space Telescopes, Detectors and Their Use with Telescopes, Types of Detectors, Detection Limits with Telescopes.

Physical principles

Gravitation in Astrophysics, Virial Theorem, Newton versus Einstein, Systems in Thermodynamic Equilibrium.

(9 Lectures)

Unit - 4

Stellar Spectra and Classification Structure

Atomic Spectra Revisited, Stellar Spectra, Spectral Types and Their Temperature Dependence, Black Body Approximation, H R Diagram, Luminosity Classification

(5 Lectures)

The Milky Way

Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way, Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms, Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus.

(14 Lectures)

Unit - 5

Galaxies

Galaxy Morphology, Hubble's Classification of Galaxies, Elliptical Galaxies, The Intrinsic Shapes of Elliptical Stars and Gas, de Vaucouleurs Law. Spiral and Lenticular Galaxies, Bulges, Disks, Galactic Halo, The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms.

(7 Lectures)

Large Scale Structure & Expanding Universe:

Cosmic Distance Ladder, An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables, Hubble's Law, Distance - Velocity Relation, Clusters of Galaxies, Virial theorem and Dark Matter.

(10 Lectures)

Reference Books:

- Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
 - Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.
 - The Physical Universe: An Introduction to Astronomy, F.Shu, Mill Valley: University Science Books.
 - Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
 - Astrophysics A Modern Perspective, K.S. Krishnasamy, Reprint, New Age International (p) Ltd, New Delhi, 2002.
 - An Introduction to Astrophysics, Baidyanath Basu, Second printing, Prentice-Hall of India Private limited, New Delhi,2001.
 - Textbook of Astronomy and Astrophysics with Elements of Cosmology, V.B. Bhatia, Narosa Publication.
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PHYSICS - DSE XII

PHYSICS OF THE EARTH

(Credits: Theory-05, Tutorials-01)

Theory: 75 Lectures

Unit - 1

The Earth and the Universe:

1. Origin of the universe, creation of elements and earth. A holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences.
2. General characteristics and origin of the Universe. The Milky Way galaxy, solar system, Earth's orbit and spin, the Moon's orbit and spin. The terrestrial and Jovian planets. Meteorites & Asteroids. Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age.
3. Energy and particle fluxes incident on the Earth.
4. The Cosmic Microwave Background.

(17 Lectures)

Unit - 2

Structure:

1. The Solid Earth: Mass, dimensions, shape and topography, internal structure, magnetic field, geothermal energy. How do we learn about Earth's interior?
2. The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. River systems.
3. The Atmosphere: variation of temperature, density and composition with altitude, clouds.
4. The Cryosphere: Polar caps and ice sheets. Mountain glaciers.
5. The Biosphere: Plants and animals. Chemical composition, mass. Marine and land organisms.

(18 Lectures)

Unit - 3

Dynamical Processes:

1. The Solid Earth: Origin of the magnetic field. Source of geothermal energy. Convection in Earth's core and production of its magnetic field. Mechanical layering of the Earth. Introduction to geophysical methods of earth investigations. Concept of plate tectonics; sea-floor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Volcanoes: types products and distribution.
2. The Hydrosphere: Ocean circulations. Oceanic current system and effect of coriolis forces. Concepts of eustasy, wind – air-sea interaction; wave erosion and beach processes. Tides. Tsunamis.
3. The Atmosphere: Atmospheric circulation. Weather and climatic changes. Earth's heat budget. Cyclones.

(18 Lectures)

Unit - 4

Climate:

1. Earth's temperature and greenhouse effect.
2. Paleoclimate and recent climate changes.
3. The Indian monsoon system.

Biosphere: Water cycle, Carbon cycle, Nitrogen cycle, Phosphorous cycle. The role of cycles in maintaining a steady state.

(8 Lectures)

Disturbing the Earth – Contemporary dilemmas

1. Human population growth.
2. Atmosphere: Green house gas emissions, climate change, air pollution.
3. Hydrosphere: Fresh water depletion.
4. Geosphere: Chemical effluents, nuclear waste.
5. Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.

(4 Lectures)

Unit - 5

Evolution:

Nature of stratigraphic records, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Introduction to geochronological methods in their application in geological studies. History of development in concepts of uniformitarianism, catastrophism and neptunism. Law of superposition and faunal succession. Introduction to the geology and geomorphology of Indian subcontinent.

1. Time line of major geological and biological events.
2. Origin of life on Earth.
3. Role of the biosphere in shaping the environment.
4. Future of evolution of the Earth and solar system: Death of the Earth.

(10 Lectures)

Reference Books:

- Planetary Surface Processes, H. Jay Melosh, Cambridge University Press, 2011.
 - Consider a Spherical Cow: A Course in Environmental Problem Solving, John Harte. University Science Books
 - Holme's Principles of Physical Geology. 1992. Chapman & Hall.
 - Planet Earth, Cosmology, Geology and the Evolution of Life and Environment, Emiliani, C, Cambridge University Press, 1992.
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SKILL ENHANCEMENT COURSES

Semester III

PHYSICS - SEC I COMPUTATIONAL PHYSICS SKILLS

(Credits: 02)

Theory: 30 Lectures

The aim of this course is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

- *Highlights the use of computational methods to solve physical problems*
- *Use of computer language as a tool in solving physics problems (applications)*
- *Course will consist of hands on training on the Problem solving on Computers.*

Unit - 1

Introduction:

Importance of computers in Physics, paradigm for solving physics problems for solution. Usage of linux as an Operating System.

Algorithms and Flowcharts:

Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types.

Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of $\sin(x)$ as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.

(4 Lectures)

Unit - 2

Scientific Programming:

Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.

(5 Lectures)

Unit - 3

Control Statements:

Types of Logic (Sequential, Selection, Repetition), Branching Statements (Logical IF, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO-CONTINUE, DO-ENDDO, DO-WHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN,

CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.

Programming:

1. Exercises on syntax on usage of FORTRAN
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.
3. To print out all natural even/ odd numbers between given limits.
4. To find maximum, minimum and range of a given set of numbers.
5. Calculating Euler number using $\exp(x)$ series evaluated at $x=1$

(6 Lectures)

Unit - 4

Scientific word processing: Introduction to LaTeX:

TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns - Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.

(6 Lectures)

Unit - 5

Visualization:

Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot

Hands on exercises:

1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot. Plotting trajectory of a projectile projected horizontally.
6. Plotting trajectory of a projectile projected making an angle with the horizontal.
7. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen.
8. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of a particle in a central force field and plot the output for visualization.

(9 Lectures)

Reference Books:

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
 - Computer Programming in Fortran 77, V. Rajaraman (Publisher: PHI).
 - LaTeX – A Document Preparation System, Leslie Lamport (Second Edition, Addison-Wesley, 1994).
 - Gnuplot in Action: Understanding Data with Graphs, Philip K Janert, (Manning 2010)
 - Schaum's Outline of Theory and Problems of Programming with Fortran, S Lipshutz and A Poe, 1986Mc-Graw Hill Book Co.
 - Computational Physics: An Introduction, R. C. Verma, *et al.* New Age International Publishers, New Delhi(1999)
 - A First Course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning
 - Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn, 2007, Wiley India Edition.
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PHYSICS - SEC II

ELECTRICAL CIRCUITS AND NETWORK SKILLS

(Credits: 02)

Theory: 30 Lectures

The aim of this course is to enable the students to design and troubleshoot electrical circuits, networks and appliances through hands-on mode

Unit - 1

Basic Electricity Principles:

Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with multimeter, voltmeter and ammeter.

(3 Lectures)

Understanding Electrical Circuits:

Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.

(4 Lectures)

Unit - 2

Electrical Drawing and Symbols:

Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop.

(4 Lectures)

Generators and Transformers:

DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.

(3 Lectures)

Unit - 3

Electric Motors:

Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters and motors. Speed and power of ac motor.

(4 Lectures)

Solid-State Devices:

Resistors, inductors and capacitors. Diode and rectifiers. Components in series or in shunt. Response of inductors and capacitors with DC or AC sources

(3 Lectures)

Unit - 4

Electrical Protection:

Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device)

(4 Lectures)

Unit - 5

Electrical Wiring:

Different types of conductors and cables. Basics of wiring - Star and Delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wire nuts, crimps, terminal blocks, split bolts, and solder. Preparation of extension board.

(5 Lectures)

Reference Books:

- A Text Book in Electrical Technology, B L Theraja - S Chand & Co.
 - A Text Book of Electrical Technology, A K Theraja
 - Performance and Design of AC Machines, M G Say ELBS Edn.
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PHYSICS - SEC III

BASIC INSTRUMENTATION SKILLS

(Credits: 02)

Theory: 30 Lectures

This course is to get exposure with various aspects of instruments and their usage through hands-on mode. Experiments listed below are to be done in continuation of the topics.

Unit - 1

Basic of Measurement:

Instruments: accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance.

(4 Lectures)

Unit - 2

Electronic Voltmeter:

Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/Multimeter and their significance. AC millivoltmeter: Type of AC millivoltmeters: Amplifier - rectifier, and rectifier - amplifier. Block diagram ac millivoltmeter, specifications and their significance.

(4 Lectures)

Signal Generators and Analysis Instruments:

Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis.

(4 Lectures)

Unit - 3

Cathode Ray Oscilloscope:

Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only – no mathematical treatment), brief discussion on screen phosphor, visual persistence and chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance.

(6 Lectures)

Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.

(3 Lectures)

Unit - 4

Impedance Bridges and Q-Meters:

Block diagram of bridge. working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram and working principles of Q-Meter. Digital LCR bridges.

(3 Lectures)

Unit - 5

Digital Instruments:

Principle and working of digital meters. Comparison of analog and digital instruments. Characteristics of digital meter. Working principles of digital voltmeter.

(3 Lectures)

Digital Multimeter:

Block diagram and working of digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/frequency counter, time-base stability, accuracy and resolution.

(3 Lectures)

The test of lab skills will be of the following test items:

1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of Digital multimeter/VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment,
6. Winding a coil / transformer.
7. Study the layout of receiver circuit.
8. Trouble shooting a circuit
9. Balancing of bridges

Laboratory Exercises:

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q-meter.
4. Measurement of voltage, frequency, time period and phase angle using CRO.
5. Measurement of time period, frequency, average period using universal counter/ frequency counter.
6. Measurement of rise, fall and delay times using a CRO.
7. Measurement of distortion of a RF signal generator using distortion factor meter.
8. Measurement of R, L and C using a LCR bridge/universal bridge.

Open Ended Experiments:

1. Using a Dual Trace Oscilloscope
2. Converting the range of a given measuring instrument (voltmeter, ammeter)

Reference Books:

- Text book in Electrical Technology, B L Theraja, S Chand and Co.
 - Performance and Design of AC Machines, M G Say ELBS Edn.
 - Digital Circuits and Systems, Venugopal, 2011, Tata McGraw Hill.
 - Logic Circuit Design, Shimon P. Vingron, 2012, Springer.
 - Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
 - Electronic Devices and Circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
 - Electronic Circuits: Handbook of Design and Applications, U.Tietze, Ch.Schenk, 2008, Springer
 - Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India
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PHYSICS - SEC IV

TECHNICAL DRAWING

(Credits: 02)

Theory: 30 Lectures

Unit - 1

Introduction:

Drafting Instruments and their uses. lettering: construction and uses of various scales: dimensioning as per I.S.I. 696-1972. Engineering Curves: Parabola: hyperbola: ellipse: cycloids, involute: spiral: helix and loci of points of simple moving mechanism. 2D geometrical construction. Representation of 3D objects. Principles of projections.

(4 Lectures)

Unit - 2

Projections:

Straight lines, planes and solids. Development of surfaces of right and oblique solids. Section of solids.

(6 Lectures)

Unit - 3

Object Projections

Orthographic projection. Interpenetration and intersection of solids. Isometric and oblique parallel projection of solids.

(4 Lectures)

Unit - 4

CAD Drawing:

Introduction to CAD and Auto CAD, precision drawing and drawing aids, Geometric shapes, Demonstrating CAD - specific skills (graphical user interface. Create, retrieve, edit, and use symbol libraries. Use inquiry commands to extract drawing data). Control entity properties. Demonstrating basic skills to produce 2-D and 3-D drawings.

(8 Lectures)

Unit - 5

3D modeling with Auto CAD (surfaces and solids), 3D modeling with Sketch up, annotating in Auto CAD with text and hatching, layers, templates and design center, advanced plotting (layouts, viewports), office standards, dimensioning, internet and collaboration, Blocks, Drafting symbols, attributes, extracting data. basic printing, editing tools, Plot/Print drawing to appropriate scale.

(8 Lectures)

Reference Books:

- Engineering Graphic, K. Venugopal and V. Raja Prabhu, New Age International
 - AutoCAD 2014 and AutoCAD 2014, Donnie Gladfelter, Sybex, ISBN:978-1-118-57510-9
 - Architectural Design with Sketchup, Alexander Schreyer, John Wiley & Sons/ISBN: 978-1-118-12309-6
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Semester IV

PHYSICS - SEC V PHYSICS WORKSHOP SKILLS

(Credits: 02)

30 Lectures

The aim of this course is to enable the students to have familiarity and experience with various mechanical and electrical tools through hands-on mode

Unit - 1

Introduction:

Measuring units. Conversion to SI and CGS. Familiarization with meter scale, Vernier Calliper, Screw gauge and their utility. Measurement of the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc. Use of Sextant to measure height of buildings, mountains, etc.

(4 Lectures)

Unit - 2

Mechanical Skills:

Concept of workshop practice. Overview of manufacturing methods: casting, foundry, machining, forming and welding. Types of welding joints and welding defects. Common materials used for manufacturing like steel, copper, iron, metal sheets, composites and alloy, wood.

(5 Lectures)

Unit - 3

Concept of machine processing, Introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet using blade. Smoothing of cutting edge of sheet using file. Drilling of holes of different diameter in metal sheet and wooden block. Use of bench vice and tools for fitting. Making funnel using metal sheet.

(5 Lectures)

Unit - 4

Electrical and Electronic Skills:

Use of Multimeter. Soldering of electrical circuits having discrete components (R, L, C, diode) and ICs on PCB. Operation of oscilloscope. Making regulated power supply. Timer circuit, Electronic switch using transistor and relay.

(10 Lectures)

Unit - 5

Introduction to prime movers:

Mechanism, Gear system, wheel, Fixing of gears with motor axle. Lever mechanism, Lifting of heavy weight using lever. Braking systems, Pulleys, Working principle of power generation systems. Demonstration of pulley experiment.

(6 Lectures)

Reference Books:

- A Text Book in Electrical Technology, B L Theraja, S. Chand and Company.
 - Performance and Design of AC Machines, M.G. Say, ELBS Edn.
 - Mechanical Workshop Practice, K.C. John, 2010, PHI Learning Pvt. Ltd.
 - Workshop Processes, Practices and Materials, Bruce J Black 2005, 3rd Edn., Editor Newnes [ISBN: 0750660732]
 - New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN: 0861674480]
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PHYSICS - SEC VI

RENEWABLE ENERGY AND ENERGY HARVESTING

(Credits: 02)

Theory: 30 Lectures

The aim of this course is not just to impart theoretical knowledge to the students but to provide them with exposure and hands-on learning wherever possible

Unit - 1

Fossil fuels and Alternate Sources of Energy:

Fossil fuels and nuclear energy, their limitations, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.

(3 Lectures)

Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar greenhouses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

(6 Lectures)

Unit - 2

Wind Energy harvesting

Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.

(3 Lectures)

Geothermal Energy: Geothermal Resources, Geothermal Technologies.

(2 Lectures)

Unit - 3

Ocean Energy

Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices.

(3 Lectures)

Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

(2 Lectures)

Unit - 4

Hydro Energy

Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

(2 Lectures)

Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power.

(4 Lectures)

Unit - 5

Electromagnetic Energy Harvesting

Linear generators, physics mathematical models, recent applications

(2 Lectures)

Carbon captured technologies, cell, batteries, power consumption

(2 Lectures)

Environmental issues and Renewable sources of energy, sustainability.

(1 Lecture)

Demonstrations and Experiments

1. Demonstration of Training modules on Solar energy, wind energy, etc.
2. Conversion of vibration to voltage using piezoelectric materials
3. Conversion of thermal energy into voltage using thermoelectric modules.

Reference Books:

- Non-conventional Energy Sources, G.D Rai, Khanna Publishers, New Delhi
 - Solar Energy, M P Agarwal, S Chand and Co. Ltd.
 - Solar Energy, Suhas P Sukhative, Tata McGraw - Hill Publishing Company Ltd.
 - Renewable Energy, Power for a Sustainable Future, Godfrey Boyle, 2004, Oxford University Press, in association with The Open University.
 - Solar Energy: Resource Assessment Handbook, Dr. P Jayakumar, 2009
 - Photovoltaics, J.Balfour, M.Shaw and S. Jarosek, Lawrence J Goodrich (USA).
 - http://en.wikipedia.org/wiki/Renewable_energy
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PHYSICS - SEC VII

RADIATION SAFETY

(Credits: 02)

Theory: 30 Lectures

The aim of this course is for awareness and understanding regarding radiation hazards and safety. The list of laboratory skills and experiments listed below the course are to be done in continuation of the topics

Unit - 1

Basics of Atomic and Nuclear Physics:

Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, The composition of nucleus and its properties, mass number, isotopes of elements, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half life, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission.

(6 Lectures)

Unit - 2

Interaction of Radiation with matter:

Types of Radiation: Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources,

Interaction of Photons - Photo-electric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients,

Interaction of Charged Particles: Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channeling and Cherenkov radiation. Beta Particles- Collision and Radiation loss (Bremsstrahlung),

Interaction of Neutrons- Collision, slowing down and Moderation.

(7 Lectures)

Unit - 3

Radiation detection and monitoring devices:

Radiation Quantities and Units: Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC).

Radiation detection: Basic concept and working principle of gas detectors, Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Gieger Muller Counter, Scintillation Detectors (Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermo luminescent Dosimetry.

(7 Lectures)

Unit - 4

Radiation safety management

Biological effects of ionizing radiation, Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation, introduction of safety and risk management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management.

(5 Lectures)

Unit - 5

Application of nuclear techniques:

Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterilization, Food preservation.

(5 Lectures)

Experiments:

1. Study the background radiation levels using Radiation meter
Characteristics of Geiger Muller (GM) Counter:
2. Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
3. Study of counting statistics using background radiation using GM counter.
4. Study of radiation in various materials (e.g. K₂SO₄ etc.). Investigation of possible radiation in different routine materials by operating GM at operating voltage.
5. Study of absorption of beta particles in Aluminum using GM counter.
6. Detection of α particles using reference source and determining its half life using spark counter
7. Gamma spectrum of Gas Light mantle (Source of Thorium)

Reference Books

- Nuclear and Particle Physics , W.E. Burcham and M. Jobes, Longman (1995)
 - Radiation Detection and Measurements, G.F.Knoll
 - Thermoluminescence Dosimetry, Mcknlly, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)
 - Fundamental Physics of Radiology, W.J. Meredith and J.B. Massey, John Wright and Sons, UK, 1989.
 - Fundamentals of Radiation Dosimetry, J.R. Greening, Medical Physics Hand Book Series, No.6, Adam Hilger Ltd., Bristol 1981.
 - Practical Applications of Radioactivity and Nuclear Radiations, G.C. Lowental and P.L. Airey, Cambridge University Press, U.K., 2001
 - An Introduction to Radiation Protection, A. Martin and S.A. Harbisor, John Willey & Sons, Inc. New York, 1981.
 - NCRP, ICRP, ICRU, IAEA, AERB Publications.
 - Medical Radiation Physics, W.R. Hendee, Year Book, Medical Publishers Inc. London, 1981
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PHYSICS - SEC IX

WEATHER FORECASTING

(Credits: 02)

Theory: 30 Lectures

The aim of this course is not just to impart theoretical knowledge to the students but to enable them to develop an awareness and understanding regarding the causes and effects of different weather phenomenon and basic forecasting techniques

Unit - 1

Introduction to atmosphere:

Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement; cyclones and anticyclones: its characteristics.

(9 Lectures)

Unit - 2

Measuring the weather:

Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in the atmosphere; radiation laws.

(4 Lectures)

Unit - 3

Weather systems:

Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.

(3 Lectures)

Unit - 4

Climate and Climate Change:

Climate: its classification; causes of climate change; global warming and its outcomes; air pollution; aerosols, ozone depletion, acid rain, environmental issues related to climate.

(6 Lectures)

Unit - 5

Basics of weather forecasting:

Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts.

(8 Lectures)

Demonstrations and Experiments:

1. Study of synoptic charts and weather reports, working principle of weather station.
2. Processing and analysis of weather data:
 - a. To calculate the sunniest time of the year.
 - b. To study the variation of rainfall amount and intensity by wind direction.
 - c. To observe the sunniest/driest day of the week.
 - d. To examine the maximum and minimum temperature throughout the year.
 - e. To evaluate the relative humidity of the day.
 - f. To examine the rainfall amount month wise.
3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.
4. Formats and elements in different types of weather forecasts/warning (both aviation and non aviation)

Reference books:

- Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books
 - The Weather Observer's Hand Book, Stephen Burt, 2012, Cambridge University Press.
 - Meteorology, S.R. Ghadkar, 2001, Agromet Publishers, Nagpur.
 - Text Book of Agrometeorology, S.R. Ghadkar, 2005, Agromet Publishers, Nagpur.
 - Why the Weather, Charles Franklin Brooks, 1924, Chapman & Hall, London.
 - Atmosphere and Ocean, John G. Harvey, 1995, The Artemis Press.
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GENERIC ELECTIVE COURSES

Semester I

PHYSICS - GEC I MECHANICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Vectors

Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter.

(4 Lectures)

Ordinary Differential Equations

1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients.

(6 Lectures)

Unit - 2

Laws of Motion

Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass.

(10 Lectures)

Momentum and Energy

Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.

(6 Lectures)

Unit - 3

Rotational Motion

Angular velocity and angular momentum. Torque. Conservation of angular momentum.

(5 Lectures)

Gravitation

Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS). Weightlessness. Physiological effects on astronauts.

(8 Lectures)

Unit - 4

Oscillations

Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations.

(6 Lectures)

Elasticity

Hooke's law - Stress-strain diagram - Elastic moduli - Relation between elastic constants - Poisson's Ratio, Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion - Torsional pendulum, Determination of Rigidity modulus and moment of inertia - q , η and σ by Searle's method.

(8 Lectures)

Unit - 5

Special Theory of Relativity

Constancy of the speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities.

(7 Lectures)

Note: Students are not familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate

Reference Books:

- University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley
 - Mechanics Berkeley Physics, V.1, Charles Kittel, et. al. 2007, Tata McGraw-Hill.
 - Physics, Resnick, Halliday & Walker 9/e, 2010, Wiley
 - Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press
 - University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
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PHYSICS LAB - GEC I

MECHANICS

60 Lectures

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To determine the Height of a Building using a Sextant.
3. To determine the Moment of Inertia of a Flywheel.
4. To determine the Young's Modulus of a Wire by Optical Lever Method.
5. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
6. To determine the Elastic Constants of a Wire by Searle's method.
7. To determine g by Bar Pendulum.
8. To determine g by Kater's Pendulum.
9. To study the Motion of a Spring and calculate (a) Spring Constant, (b) g .

Reference Books:

- Advanced Practical Physics for Students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
 - Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
 - Engineering Practical Physics, S.Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt. Ltd.
 - A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
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PHYSICS - GEC II

DIGITAL AND ANALOG CIRCUITS AND INSTRUMENTATION

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Digital Circuits

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates.

(4 Lectures)

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

(5 Lectures)

Binary Addition. Binary Subtraction using 2's Complement Method. Half Adders and Full Adders and Subtractors, 4-bit binary Adder-Subtractor.

(4 Lectures)

Unit - 2

Semiconductor Devices and Amplifiers

Semiconductor Diodes: P and N type semiconductors. Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode. PN junction and its characteristics. Static and Dynamic Resistance. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell.

(5 Lectures)

Instrumentations 1

Power Supply: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter, Zener Diode and Voltage Regulation.

(6 Lectures)

Unit - 3

Transistors

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Active, Cutoff and Saturation regions Current gains α and β . Relations between α and β . Load Line analysis of Transistors. DC Load line and Q-point. Voltage Divider Bias Circuit for CE Amplifier. h-parameter Equivalent Circuit. Analysis of single-stage CE amplifier using hybrid Model. Input and output Impedance. Current, Voltage and Power gains. Class A, B and C Amplifiers.

(12 Lectures)

Unit - 4

Operational Amplifiers (Black Box approach)

Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop and closed-loop Gain. CMRR, concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non-inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Zero crossing detector.

(13 Lectures)

Unit - 5

Sinusoidal Oscillators

Barkhausen's Criterion for Self-sustained Oscillations. Determination of Frequency of RC Oscillator

(5 Lectures)

Timer IC: IC 555 Pin diagram and its application as Astable and Monostable Multivibrator.

(3 Lectures)

Instrumentations 2

Introduction to CRO: Block Diagram of CRO. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.

(3 Lectures)

Reference Books:

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
 - Electronic Devices & Circuits, S. Salivahanan & N.S. Kumar, 2012, Tata Mc-Graw Hill
 - Microelectronic Circuits, M.H. Rashid, 2nd Edn., 2011, Cengage Learning.
 - Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper, 1990, PHI Learning
 - Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGraw Hill
 - Microelectronic Circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.
 - Fundamentals of Digital Circuits, A. Anand Kumar, 2nd Edition, 2009, PHI Learning Pvt. Ltd.
 - OP-AMP and Linear Digital Circuits, R.A. Gayakwad, 2000, PHI Learning Pvt. Ltd.
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PHYSICS LAB - GEC II

DIGITAL AND ANALOG CIRCUITS AND INSTRUMENTATION

60 Lectures

1. To measure (a) Voltage, and (b) Frequency of a periodic waveform using CRO
2. To verify and design AND, OR, NOT and XOR gates using NAND gates.
3. To minimize a given logic circuit.
4. Half adder, Full adder and 4-bit Binary Adder.
5. Adder-Subtractor using Full Adder I.C.
6. To design an astable multivibrator of given specifications using 555 Timer.
7. To design a monostable multivibrator of given specifications using 555 Timer.
8. To study IV characteristics of PN diode, Zener and Light emitting diode
9. To study the characteristics of a Transistor in CE configuration.
10. To design a CE amplifier of given gain (mid-gain) using voltage divider bias.
11. To design an inverting amplifier of given gain using Op-amp 741 and study its frequency response.
12. To design a non-inverting amplifier of given gain using Op-amp 741 and study its Frequency Response.
13. To study Differential Amplifier of given I/O specification using Op-amp.
14. To investigate a differentiator made using op-amp.
15. To design a Wien Bridge Oscillator using an op-amp.

Reference Books:

- Basic Electronics: A Text Lab Manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
 - Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
 - OP-Amps and Linear Integrated Circuits, R.A. Gayakwad, 4th Edn, 2000, Prentice Hall.
 - Electronic Principles, Albert Malvino, 2008, Tata Mc-Graw Hill.
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Semester II

PHYSICS - GEC III ELECTRICITY AND MAGNETISM

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Vector Analysis

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 (statement only).

(12 Lectures)

Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field.

(6 Lectures)

Unit - 2

Electrostatics 1

Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to a 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.

(12 Lectures)

Unit - 3

Electrostatics 2

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.

(10 Lectures)

Unit - 4

Magnetism

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 ferro-magnetic materials.

(10 Lectures)

Unit - 5

Maxwell's equations and Electromagnetic wave propagation

Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization.

(10 Lectures)

Reference Books:

- Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
 - Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press
 - Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
 - University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
 - Introduction to Electrodynamics, D.J.Griffiths, 3rd Edn, 1998, Benjamin Cummings.
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PHYSICS LAB - GEC III

ELECTRICITY AND MAGNETISM

60 Lectures

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. Ballistic Galvanometer:
 - a. Measurement of charge and current sensitivity
 - b. Measurement of CDR
 - c. Determine a high resistance by Leakage Method
 - d. To determine Self Inductance of a Coil by Rayleigh's Method.
3. To compare capacitances using De'Sauty's bridge.
4. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx)
5. To study the Characteristics of a Series RC Circuit.
6. To study a series LCR circuit LCR circuit and determine its (a) Resonant frequency, (b) Quality factor
7. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q
8. To determine a Low Resistance by Carey Foster's Bridge.
9. To verify the Thevenin and Norton theorems
10. To verify the Superposition, and Maximum Power Transfer Theorems

Reference Books:

- Advanced Practical Physics for Students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
 - Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
 - A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed.2011, Kitab Mahal
 - Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.
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PHYSICS - GEC IV

MATHEMATICAL PHYSICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

The emphasis of the course is on applications in solving problems of interest to physicists. Students to be examined on the basis of problems, seen and unseen.

Unit - 1

Calculus of functions of more than one variable

Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.

(6 Lectures)

Some Special Integrals

Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral).

(4 Lectures)

Unit - 2

Fourier Series

Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series.

(10 Lectures)

Unit - 3

Frobenius Method and Special Functions

Singular Points of 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. Simple recurrence relations.

(16 Lectures)

Unit - 4

Partial Differential Equations

Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry.

(10 Lectures)

Unit - 5

Complex Analysis

Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula.

(14 Lectures)

Reference Books:

- Mathematical Methods for Physicists, Arfken, Weber, 2005, Harris, Elsevier.
 - Fourier Analysis, M.R. Spiegel, 2004, Tata McGraw-Hill.
 - Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
 - An Introduction to Ordinary Differential Equations, E.A Coddington, 1961, PHI Learning
 - Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
 - Partial Differential Equations for Scientists and Engineers, S.J. Farlow, 1993, Dover Publications.
 - Mathematical Methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Books.
 - Mathematical Methods in the Physical Sciences, Mary L. Boas, Wiley-India
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PHYSICS LAB - GEC IV MATHEMATICAL PHYSICS

60 Lectures

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

- The course will consist of lectures (both theory and practical) in the Lab
- Evaluation done on the basis of formulating the problem
- Aim at teaching students to construct the computational problem to be solved

Topics	Description with Applications
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow - emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.
Review of C & C++ Programming fundamentals	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops), Arrays (1D & 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects
Programs: using C/C++ language	Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search
Random number generation	Area of circle, area of square, volume of sphere, value of π
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equations, solving $\alpha = \tan \alpha$; $I = I_0 \left(\frac{\sin \alpha}{\alpha} \right)^2$ in optics
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometric functions e.g. $\sin\theta$, $\cos\theta$, $\tan \theta$, etc.

<p>Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method</p>	<p>Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop</p>
<p>Solution of Ordinary Differential Equations (ODE)</p> <p>First Order Differential equation Euler modified Euler and Runge-Kutta (RK) second and fourth order methods</p>	<p>First order differential equation</p> <ul style="list-style-type: none"> ● Radioactive decay ● Current in RC, LC circuits with DC source ● Newton's law of cooling ● Classical equations of motion <p>Attempt following problems using RK 4 order method:</p> <ul style="list-style-type: none"> ● Solve the coupled differential equations $\frac{dx}{dt} = y + x - \frac{x^3}{3}; \quad \frac{dy}{dx} = -x$ for four initial conditions $x(0) = 0, y(0) = -1, -2, -3, -4$ Plot x vs y for each of the four initial conditions on the same screen for $0 \leq t \leq 15$ <p>The differential equation describing the motion of a pendulum is $\frac{d^2\theta}{dt^2} = -\sin\theta$. The pendulum is released from rest at an angular displacement α, i.e. $\theta(0) = \alpha$ and $\dot{\theta}(0) = 0$. Solve the equation for $\alpha = 0.1, 0.5$ and 1.0 and plot θ as a function of time in the range $0 \leq t \leq 8\pi$. Also plot the analytic solution valid for small θ, ($\sin\theta = \theta$)</p>

Referred Books:

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
- Schaum's Outline of Programming with C⁺⁺. J. Hubbard, 2000, McGraw-Hill Pub.
- Numerical Recipes in C⁺⁺: The Art of Scientific Computing, W.H. Press et al., 3rd Edn., 2007, Cambridge University Press.
- A First Course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
- Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.
- Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
- An Introduction to Computational Physics, T. Pang, 2nd Edn., 2006, Cambridge Univ. Press

Semester III

PHYSICS - GEC V

THERMAL PHYSICS AND STATISTICAL MECHANICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Laws of Thermodynamics 1

Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between C_p and C_v , Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient,

(12 Lectures)

Unit - 2

Laws of Thermodynamics 2

Reversible and irreversible processes, Second law and Entropy, Carnot's cycle and theorem, Entropy changes in reversible and irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

(10 Lectures)

Unit - 3

Thermodynamical Potentials

Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for $(C_p - C_v)$, C_p/C_v , TdS equations.

(10 Lectures)

Unit - 4

Kinetic Theory of Gases

Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.

(10 Lectures)

Theory of Radiation: Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh-Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law.

(6 Lectures)

Unit - 5

Statistical Mechanics

Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Maxwell-Boltzmann law, distribution of velocity, Quantum statistics, Fermi-Dirac distribution law, electron gas, Bose-Einstein distribution law, photon gas, comparison of three statistics.

(12 Lectures)

Reference Books:

- Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
 - A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
 - Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
 - Heat and Thermodynamics, M.W.Zemasky and R. Dittman, 1981, McGraw Hill
 - Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and G.L. Salinger. 1988, Narosa
 - University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
 - Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. chand Publications.
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PHYSICS LAB - GEC V

THERMAL PHYSICS AND STATISTICAL MECHANICS

60 Lectures

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 Cu 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 coefficient 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 a 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

Reference Books:

- Advanced Practical Physics for Students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
 - Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
 - A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
 - A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.
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PHYSICS - GEC VI

WAVES AND OPTICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Superposition of Two Collinear Harmonic oscillations

Linearity and Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).

(4 Lectures)

Superposition of Two Perpendicular Harmonic Oscillations

Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequency and their uses.

(2 Lectures)

Waves Motion- General

Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity.

(7 Lectures)

Unit - 2

Fluids: Surface Tension: Synclastic and anticlastic surface, Excess of pressure, Application to spherical and cylindrical drops and bubbles, variation of surface tension with temperature, Jaeger's method. Viscosity, Rate flow of liquid in a capillary tube, Poiseuille's formula, Determination of coefficient of viscosity of a liquid, Variations of viscosity of liquid with temperature, lubrication.

(6 Lectures)

Sound: Simple harmonic motion, forced vibrations and resonance, Fourier's Theorem, Application to saw tooth wave and square wave, Intensity and loudness of sound, Decibels, Intensity levels, musical notes, musical scale. Acoustics of buildings: Reverberation and time of reverberation, Absorption coefficient, Sabine's formula, measurement of reverberation time, Acoustic aspects of halls and auditoria.

(6 Lectures)

Unit - 3

Wave Optics

Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.

(3 Lectures)

Interference

Interference: Division of amplitude and division of 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.

(10 Lectures)

Unit - 4

Michelson's Interferometer

Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index, and Visibility of fringes.

(3 Lectures)

Polarization

Transverse nature of light waves. Plane polarized light, production and analysis. Circular and elliptical polarization.

(5 Lectures)

Unit - 5

Diffraction

Fraunhofer diffraction, Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.

(14 Lectures)

Reference Books:

- Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill
 - Principles of Optics, B.K. Mathur, 1995, Gopal Printing
 - Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications
 - University Physics, F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley
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PHYSICS LAB - GEC VI

WAVES AND OPTICS

60 Lectures

1. To investigate the motion of coupled oscillators
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify $\lambda^2 - T$ Law.
3. To study Lissajous Figures
4. Familiarization with Schuster's focussing; determination of angle of prism.
5. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
6. To determine the Refractive Index of the Material of a Prism using Sodium Light.
7. To determine Dispersive Power of the Material of a Prism using Mercury Light
8. To determine the value of Cauchy Constants.
9. To determine the Resolving Power of a Prism.
10. To determine wavelength of sodium light using Fresnel Biprism.
11. To determine wavelength of sodium light using Newton's Rings.
12. To determine the wavelength of Laser light using Diffraction of Single Slit.
13. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating
14. To determine the Resolving Power of a Plane Diffraction Grating.
15. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.

Reference Books:

- Advanced Practical Physics for Students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
 - Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
 - A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
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PHYSICS - GEC VII

ELEMENTS OF MODERN PHYSICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Unit - 1

Quantum Mechanics

Planck's quantum, Planck's constant and light as a collection of photons; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment.

(8 Lectures)

Bohr's Model

Problems with Rutherford model, instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra.

(4 Lectures)

Unit - 2

Uncertainty Principle

Position measurement, gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle, impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.

(4 Lectures)

Wave Function

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension.

(11 Lectures)

Unit - 3

Quantum Mechanical Problems for Simple Potentials

One dimensional infinitely rigid box, energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension, across a step potential and across a rectangular potential barrier.

(12 Lectures)

Unit - 4

Nuclear Physics

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy.

(6 Lectures)

Fission and fusion - mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions.

(4 Lectures)

Unit - 5

Radioactivity

stability of nucleus; Law of radioactive decay; Mean life and half life α decay; β decay, energy released, spectrum and Pauli's prediction of neutrino; γ -ray emission.

(11 Lectures)

Reference Books:

- Concepts of Modern Physics, Arthur Beiser, 2009, McGraw-Hill
 - Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2009, PHI Learning
 - Six Ideas that Shaped Physics: Particle Behave like Waves, Thomas A. Moore, 2003, McGraw Hill
 - Quantum Physics, Berkeley Physics, Vol.4. E.H. Wichman, 2008, Tata McGraw-Hill Co.
 - Modern Physics, R.A. Serway, C.J. Moses, and C.A. Moyer, 2005, Cengage Learning
 - Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill
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PHYSICS LAB - GEC VII

ELEMENTS OF MODERN PHYSICS

60 Lectures

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To determine work function of material of filament of directly heated vacuum diode.
3. To determine the ionization potential of mercury.
4. To determine value of Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the absorption lines in the rotational spectrum of Iodine vapour.
7. To study the diffraction patterns of single and double slits using laser and measure its intensity variation using Photosensor & compare with incoherent source – Na.
8. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
9. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
10. To setup the Millikan oil drop apparatus and determine the charge of an electron.

Reference Books:

- Advanced Practical Physics for Students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
 - Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
 - A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
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Semester IV

PHYSICS - GEC VIII NUCLEAR AND PARTICLE PHYSICS

(Credits: Theory-05, Tutorials-01)

Theory: 75 Lectures

Prerequisites: Knowledge of "Elements of Modern Physics"

Unit - 1

General Properties of Nuclei

Constituents of nucleus and their intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excited states.

(10 Lectures)

Particle physics

Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons.

(14 Lectures)

Unit - 2

Nuclear Models

Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model, degenerate fermion gas, nuclear symmetry potential in Fermi gas, evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.

(12 Lectures)

Unit - 3

Radioactivity decay

(a) Alpha decay: basics of α -decay processes, theory of α -emission, Gamow factor, Geiger Nuttall law, α -decay spectroscopy. (b) β -decay: energy kinematics for β - decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion.

(10 Lectures)

Unit - 4

Nuclear Reactions

Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction, resonance reaction, Coulomb scattering (Rutherford scattering).

(8 Lectures)

Interaction of Nuclear Radiation with matter

Energy loss due to ionization (Bethe- Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter.

(8 Lectures)

Unit - 5

Detector for Nuclear Radiations

Gas detectors: estimation of electric field, mobility of particle, ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection, concept of charge carrier and mobility, neutron detector.

(8 Lectures)

Particle Accelerators

Accelerator facility available in India: Van-de Graaff generator, Tandem accelerator, Linear accelerator, Cyclotron, Synchrotrons.

(5 Lectures)

Reference Books:

- Introductory Nuclear Physics, Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
 - Concepts of Nuclear Physics, Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
 - Introduction to the Physics of Nuclei and Particles, R.A. Dunlap. (Thomson Asia, 2004)
 - Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
 - Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
 - Basic Ideas and Concepts in Nuclear Physics - An Introductory Approach, K. Heyde (IOP-Institute of Physics Publishing, 2004).
 - Radiation Detection and Measurement, G.F. Knoll (John Wiley & Sons, 2000).
 - Theoretical Nuclear Physics, J.M. Blatt & V.F. Weisskopf (Dover Pub.Inc., 1991)
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PHYSICS - GEC IX

SOLID STATE PHYSICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Prerequisites: Knowledge of "Elements of Modern Physics"

Unit - 1

Crystal Structure

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.

(12 Lectures)

Unit - 2

Elementary Lattice Dynamics

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

(10 Lectures)

Unit - 3

Magnetic Properties of Matter

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.

(12 Lectures)

Unit - 4

Dielectric Properties of Materials

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 Sellmeier relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons.

(10 Lectures)

Unit - 5

Elementary band theory

Kronig Penny model. Band Gaps. Conductors, Semiconductors and insulators. P and N type Semiconductors. Conductivity of Semiconductors, mobility, Hall Effect, Hall coefficient.

(10 Lectures)

Superconductivity

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

(6 Lectures)

Reference Books:

- Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.
 - Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India
 - Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
 - Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
 - Solid State Physics, Rita John, 2014, McGraw Hill
 - Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
 - Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
 - Solid State Physics, M.A. Wahab, 2011, Narosa Publications
 - Solid State Physics, R. K. Puri and V. K. Babbar, S. Chand & Company Ltd
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PHYSICS - GEC IX

SOLID STATE PHYSICS

60 Lectures

1. Measurement of susceptibility of paramagnetic solution (Quinck's Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. To determine the refractive index of a dielectric layer using SPR
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To study the BH curve of iron using a Solenoid and determine the energy loss.
9. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (room temperature to 150 °C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

Reference Books:

- Advanced Practical Physics for Students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
 - Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
 - A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn., 2011, Kitab Mahal
 - Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India
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PHYSICS - GEC X

QUANTUM MECHANICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Prerequisites: Knowledge of (1) Mathematical Physics and (2) Elements of Modern Physics

Unit - 1

Time dependent Schrodinger equation

Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum & Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.

(6 Lectures)

Time independent Schrodinger equation

Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to the spread of Gaussian wave packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

(10 Lectures)

Unit - 2

General discussion of bound states in an arbitrary potential

Continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem, square well potential; Quantum mechanics of simple harmonic oscillator, energy levels and energy eigenfunctions using Frobenius method.

(12 Lectures)

Unit - 3

Quantum theory of hydrogen-like atoms

Time independent Schrodinger equation in spherical polar coordinates; separation of variables for the second order partial differential equation; angular momentum operator and quantum numbers; Radial wavefunctions from Frobenius method; Orbital angular momentum quantum numbers l and m ; s, p, d,.. shells (idea only)

(10 Lectures)

Unit - 4

Atoms in Electric and Magnetic Fields

Electron Angular Momentum. Space Quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment & Magnetic Energy, Gyromagnetic Ratio & Bohr Magneton.

(8 Lectures)

Atoms in External Magnetic Fields

Normal and Anomalous Zeeman Effect.

(4 Lectures)

Unit - 5

Many electron atoms

Pauli's Exclusion Principle. Symmetric and Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total Angular Momentum. Vector Model. Spin-orbit coupling in atoms, L-S and J-J couplings.

(10 Lectures)

Reference Books:

- A Text book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, 2nd Ed., 2010, McGraw Hill
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldas, 2nd Edn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics for Scientists and Engineers, D.A.B. Miller, 2008, Cambridge University Press

Additional Books for Reference

- Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
 - Introduction to Quantum Mechanics, David J. Griffith, 2nd Ed. 2005, Pearson Education
 - Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer
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PHYSICS LAB - GEC X

QUANTUM MECHANICS

60 Lectures

Use C/C++/Scilab for solving the following problems based on Quantum Mechanics like

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2} [V(r) - E] \quad \text{where } V(r) = -\frac{e^2}{r}$$

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take $e = 3.795$ (eVÅ)^{1/2}, $\hbar c = 1973$ (eVÅ) and $m = 0.511 \times 10^6$ eV/c².

2. Solve the s-wave radial Schrodinger equation for an atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2} [V(r) - E]$$

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential

$$V(r) = -\frac{e^2}{r} e^{-r/a}$$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take $e = 3.795$ (eVÅ)^{1/2}, $m = 0.511 \times 10^6$ eV/c², and $a = 3$ Å, 5 Å, 7 Å. In these units $\hbar c = 1973$ (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solve the s-wave radial Schrodinger equation for a particle of mass m :

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2} [V(r) - E]$$

For the anharmonic oscillator potential

$$V(r) = \frac{1}{2} kr^2 + \frac{1}{2} br^3$$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose $m = 940$ MeV/c², $k = 100$ MeV fm⁻², $b = 0, 10, 30$ MeV fm⁻³. In these units, $\hbar c = 197.3$ MeV fm. The ground state energy I expected to lie between 90 and 110 MeV for all three cases.

4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2\mu}{\hbar^2} [V(r) - E]$$

where μ is the reduced mass of the two-atom system for the Morse potential

$$V(r) = D(e^{-2\alpha r'} - e^{-\alpha r'}), \quad r' = \frac{r-r_0}{r_0}$$

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.

Take $m = 940 \times 10^6$ eV/C², $D = 0.755501$ eV, $\alpha = 1.44$, $r_0 = 0.131349$ Å

Some laboratory based experiments:

5. Study of Electron spin resonance - determine magnetic field as a function of the resonance frequency
6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
7. To study the quantum tunnelling effect with solid state device, e.g. tunnelling current in backward diode or tunnel diode.

Reference Books:

- Schaum's Outline of Programming with C++. J.Hubbard, 2000, McGraw-Hill Pub.
 - Numerical Recipes in C: The Art of Scientific Computing, W.H. Press et al., 3rd Edn., 2007, Cambridge University Press.
 - Elementary Numerical Analysis, K.E. Atkinson, 3rd Ed . 2007 , Wiley India Edition
 - A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
 - Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández. 2014 Springer
 - Scilab by Example: M. Affouf, 2012, ISBN: 978-1479203444
 - Scilab (A Free Software to Matlab), H. Ramchandran, A.S. Nair. 2011 S. Chandand Company, New Delhi ISBN: 978-8121939706
 - Scilab Image Processing, Lambert M. Surhone. 2010 Betascript Publishing ISBN: 978-6133459274A
 - Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
 - Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
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Note to the Teacher

In order to be in conformity with the University's system of having 5 units for each paper, some units have been shifted out of the ideal teaching sequence. Hence teachers are advised to refer to the standard sequence as given in the UGC syllabus.