CORE COURSES (HONOURS IN PHYSICS)

Semester I

PH 111-MECHANICS
Credits-04 (4-0-0)

Course objectives:

- This course comprises the study of basic concepts and formulations of Newton's Laws of Motion and ends with the Fictitious Forces and Special Theory of Relativity.
- Moreover, students will also appreciate the Collisions in CM Frame, Gravitation, Rotational Motion and Oscillations.
- The emphasis of this course is to enhance the understanding of the basics of mechanics.
- By the end of this course, students should be able to solve the seen or unseen problems/numerical in mechanics.

Fundamentals of Dynamics: Inertial frames, Review of Newton's laws of motion, Principle of conservation of momentum, Momentum of variable mass system: motion of rocket, Dynamics of a system of particles, determination of Centre of Mass of discrete and continuous objects, Non-inertial frame of references.
Work and Energy: Work and kinetic energy theorem, Conservative and non-conservative forces, potential energy, energy diagram, Force as gradient of potential energy, Work and potential energy, Workdone by non-conservative forces, Law of conservation of energy.
Collisions: Elastic and inelastic collisions, Centre of mass and laboratory frames.
Rotational Dynamics: Angular momentum of a particle and system of particles, Torque, Principle of conservation of angular momentum, Rotation about a fixed axis, Moment of inertia, theorem of parallel and perpendicular axes (statements only), Determination of moment of inertia of discrete and continuous objects, Kinetic energy of rotation, Motion involving both translation and rotation.
Gravitation and Central Force Motion: Law of gravitation, Gravitational potential energy, Inertial and gravitational mass, Potential and field due to spherical shell and solid sphere.
Motion of a particle under a central force field: Two-body problem and its reduction to one-body problem with solution, Reduction of angular momentum, kinetic energy and total energy, the energy equation and energy diagram, Kepler's Laws, Satellite in circular orbit, Geosynchronous orbits.
Oscillations: Idea of Simple Harmonic Motion (SHM), Differential equation of SHM and its solution, Kinetic energy, potential energy, total energy and their time-average values, Compound pendulum, Damped oscillation, Forced oscillations: Transient and steady states, sharpness of resonance and Quality Factor.
Special Theory of Relativity: Outcomes of Michelson-Morley Experiment, Postulates of Special Theory of Relativity, Lorentz Transformations, Simultaneity, Length contraction, Time dilation, Relativistic transformation of velocity, Variation of mass with velocity, Massless Particles, Mass-energy Equivalence, Relativistic Doppler effect, Relativistic Kinematics, Transformation of energy and momentum.

Text/ References:

1. An Introduction to Mechanics, Daniel Kleppner & Robert Kolenkow, 2007, Tata McGraw Hill
2. Mechanics, D S Mathur, P S Hemne, 2012, S. Chand
3. University Physics, F W Sears, M W Zemansky & H D Young 13/e, 1986, Addison Wesley
4. Mechanics Berkeley Physics course, v.1: Charles Kittel, et.al. 2007, Tata McGraw Hill
5. Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
6. Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press

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PH 113-MECHANICS LAB
Credits: 02 (0-0-4)

Course objectives:

- This laboratory provides the practical knowledge about laws of motion, moment of inertia and gravitation etc.
- Students would also get familiar with various measuring instruments and would learn the importance of accuracy of measurements.

At least 08 experiments from the following

1. Measurements of length (or diameter) using Vernier calliper, 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.
13. To determine the value of g using simple pendulum.
14. To determine the moment of inertia of an irregular body about an axis passing through it gravity and perpendicular to its plane by dynamical method (Inertia table).
15. To determine the spring constant by Hooke's law
16. To determine the Poisson ratio of rubber.

Text/Reference:

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

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PH 115-MATHEMATICAL PHYSICS-I
Credits: 04 (4-0-0)

Course objectives:

- The objective of the respective course is to enhance the understanding of mathematical tools in solving problems of interest to physicists.
- By the end of this course, students are to be examined based on problems, seen and unseen.

Calculus: Plotting of functions, Approximation: Taylor and binomial series (statements only).
First Order Differential equations: First Order Differential equations: variable separable, homogeneous, non-homogeneous, exact and inexact differential equations and integrating factor.

Second Order Differential equations: Homogeneous equations with constant coefficients, Wronskian and general solution, Particular Integral with operator method, method of undetermined coefficients and variation method of parameters, Euler differential equation and simultaneous differential equations of first and second order.
Vector Algebra: Properties of vectors, Scalar product and vector product, Scalar triple product and their interpretation in terms of area and volume respectively, Scalar and vector fields.
Vector Calculus: 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 Integration: Ordinary integrals of vectors, Double and triple integrals, change of order of integration, 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 verification (no rigorous proofs).
Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates, Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical coordinate systems.
Probability and statistics: Independent and dependent events, Conditional Probability. Bayes' Theorem, Independent random variables, Probability distribution functions, special distributions: Binomial, Poisson and Normal, Sample mean and variance and their confidence intervals for Normal distribution.

Text/Reference:

1. Mathematical Methods for Physicists, G B Arfken, H J Weber, F E Harris, 2013, 7th Edn., Elsevier
2. An introduction to ordinary differential equations, E A Coddington, 2009, PHI learning
3. Differential Equations, George F. Simmons, 2007, McGraw Hill
4. Advanced Engineering Mathematics, D G Zill and W S Wright, 5 Ed., 2012, Jones and Bartlett Learning
5. Vector Analysis: Schaum's Outlines Series, M Spiegel, S Lipschutz, 2017, 2nd Edition, McGraw-Hill
6. Engineering Mathematics, S Pal and S C Bhunia, 2015, Oxford University Press
7. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India

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PH 117-MATHEMATICAL PHYSICS-I LAB

Credits: 02 (0-0-4)

Course objectives:

- This laboratory would introduce students with the basic knowledge of scientific programming languages and implementation of C++/C/Scilab simulations for Mathematical Physics problems.

At least 10 programs must be attempted from the following

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 and overflow - emphasize the importance of making equations in terms of dimensionless variables, Iterative methods, Algorithms and Flow charts: Purpose, symbols and description.
Introduction to C++: Introduction to Programming: Algorithms: Sequence, Selection and repetition, Structured programming, basic idea of Compilers, Data Types, Enumerated Data, Conversion and casting, constants and variables, Mathematical, Relational, Logical and Bitwise Operators, Precedence of Operators, Expressions and Statements, Scope and Visibility of Data, block, Local and Global variables, Auto, static and External variables.

C++ Control Statements and loops: if-statement, if-else statement, Nested if Structure, Else-if statement, Ternary operator, Go to statement, switch statement, Unconditional and Conditional looping, While loop, Do-while loop, For loop, nested loops, break and continue statements.

Programs:

1. To calculate area of a rectangle.
2. To check size of variables in bytes (Use of size of ( ) Operator).
3. To find roots of a quadratic equation.
4. To find largest of three numbers.
5. To check whether a number is prime or not.
6. To list Prime numbers up to 1000.
7. To find the sum and average of a list of numbers.
8. Program to check whether even or odd number.
9. To find the largest of a given list of numbers and its location in the list.
10. Sorting of numbers in ascending and descending order using Bubble sort, Sequential sort or Binary search.
11. To generate the Fibonnaci series.
12. To find the factorial of a number.
13. Solution of Algebraic and Transcendental equations by Bisection and Regula-Falsi method.
14. Solution of Algebraic and Transcendental equations by Newton Raphson and secant method.
15. Interpolation by Newton Gregory Forward and Backward difference formula.
16. Error estimation of linear interpolation.
17. Numerical differentiation using Forward and Backward difference formula.
18. Numerical integration using Trapezoidal and Simpson rules.

Text/Reference:

1. Schaum's Outline of Programming with C++, J Hubbard, 2000, McGraw-Hill Pub
2. Numerical Recipes in C^{++}: The Art of Scientific Computing, W H Press et. al., 2nd Edn., 2013, Cambridge University Press
3. An introduction to Numerical methods in C^{++}, Brian H. Flowers, 2009, Oxford University Press
4. Elementary Numerical Analysis, K E Atkinson, 3rd Edn 2007, Wiley India Edition
5. Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.

Semester II

PH 112-ELECTRICITY AND MAGNETISM

Credits: 04 (4-0-0)

Course objectives:

- The course covers static and dynamic electric and magnetic field, and the principles of electromagnetic induction.
- It also includes analysis of electrical circuits and introduction of network theorems.
- Moreover, student will be able to appreciate Maxwell’s equations.

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, Conservative nature of Electrostatic field, Electrostatic potential, Laplace’s and Poisson equations, The Uniqueness theorem, Potential and electric field of a dipole, Force and torque on a dipole, Electrostatic energy of system of charges, 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 (i) Plane infinite sheet and (ii) Sphere.

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.
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, Ampere's circuital law and its application to (i) Solenoid and (ii) Toroid, Properties of **B**: curl and divergence, Vector potential, Magnetic force on (i) point charge (ii) current carrying wire (iii) between current elements, Torque on a current loop in a uniform magnetic field.
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.
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.
Electrical Circuits: AC Circuits: Kirchhoff's laws for AC circuits, Complex Reactance and Impedance, Series LCR Circuit: (i) Resonance, (ii) Power dissipation and (iii) Quality factor, and (iv) Band width, Parallel LCR Circuit.
Network theorems: Ideal constant-voltage and constant-current sources, Review of Kirchhoff's current Law and Kirchhoff's voltage law, Mesh and node analysis, Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum power transfer theorem, Applications to dc circuits.

Text/Reference:

1. Fundamentals of Electricity and Magnetism, Arthur F. Kip, 2nd Edn.1981, McGraw-Hill
2. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
3. Introduction to Electrodynamics, D J Griffiths, 3rd Edn., 1998, Benjamin Cummings
4. Feynman Lectures Vol.2, R P Feynman, R B Leighton, M Sands, 2008, Pearson Education
5. Electricity and Magnetism, J H Fewkes and J Yarwood, Vol. I, 1991, Oxford Univ. Press
6. Network, Lines and Fields, John D. Ryder, 2nd Edn., 2015, Pearson
7. Schaum's Outline of Electric Circuits, J Edminister and M Nahvi, 3rdEdn., 1995, McGraw Hill

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PH 114-ELECTRICITY AND MAGNETISM LAB

Credits: 02 (0-0-4)

Course objective:

- The laboratory content compliments the theoretical knowledge of Electricity and Magnetism and henceforth, gives hands-on experience.
- It also provides the observational understanding of the subject.
- It enhances the qualitative and quantitative skills of the students.

At least 08 experiments from the following

1. Use a multimeter for measuring (i) Resistances, (ii) Ac and Dc Voltages, (iii) DC current, (iv) Capacitances, and (v) 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 (i) Resonant frequency, (ii) Impedance at resonance, (iii) Quality factor Q and (iv) Band width.
11. To study the response curve of a parallel LCR circuit and determine its (i) Anti-resonant frequency and (ii) Quality factor Q.
12. Measurement of charge sensitivity, 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.
16. To determine the specific resistance of a wire or unknown capacitance by Wien's bridge.
17. To determine the magnetic field along the axis of the current carrying coil and estimate the radius of coil using Tangent Galvanometer.
18. To study Hysteresis curve of a given ferromagnetic sample and determine magnetic susceptibility and permeability.
19. To study faraday's law and induced electromotive force (emf).
20. Calibration of a voltmeter/ammeter with the help of a potentiometer.

Text/Reference:

1. Advanced Practical Physics for students, B L Flint and H T Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. Engineering Practical Physics, S Panigrahi and B Mallick, 2015, Cengage Learning

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PH 116-WAVES AND OPTICS

Credits: 04(4-0-0)

Course objectives:

- This course begins with explaining ideas of superposition of harmonic oscillations leading to physics of travelling and standing waves.
- It also provides an in depth understanding of wave phenomena of light, namely, interference and diffraction with emphasis on practical applications of the same.

Superposition of Collinear Harmonic oscillations: Simple harmonic motion (SHM), Linearity and Superposition principle, Superposition of two collinear oscillations having equal frequencies and different frequencies (Beats), Superposition of N collinear Harmonic Oscillations with (i) equal phase differences and (ii) equal frequency differences.

Superposition of two perpendicular Harmonic Oscillations: Graphical and analytical methods, Lissajous figures with equal and unequal frequencies and their uses.

Wave Motion: Plane and Spherical waves, Longitudinal and Transverse waves, Plane progressive (Travelling) waves, Wave equation, Particle and wave velocities, Pressure of a longitudinal wave, Energy transport, Intensity of wave.

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, Longitudinal standing waves and normal modes, Open and closed pipes, Superposition of N harmonic waves.

Wave Optics: Electromagnetic nature of light, Definition and properties of wave front, Huygens principle, Temporal and spatial coherence.

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.

Interferometer: Michelson Interferometer-(i) Idea of form of fringes (No theory required), (ii) Determination of wavelength, (iii) Wavelength difference, (iv) Refractive index, and (i) Visibility of fringes, Fabry-Perot interferometer.
Diffraction: Fraunhofer diffraction: Single slit, Rectangular and circular aperture, Resolving power of a telescope, Double slit, Multiple slits, Diffraction grating, Resolving power of grating, 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, Cornu's spiral and its applications, Straight edge, a slit and a wire.

Text/Reference:

1. Vibrations and Waves, A P French, 1st Edn., 2003, CRC press
2. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill
3. Fundamentals of Optics, F A Jenkins and H E White, 1981, McGraw-Hill
4. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press
5. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
6. The Physics of Waves and Oscillations, N K Bajaj, 1998, Tata McGraw Hill
7. Fundamental of Optics, A Kumar, H R Gulati and D R Khanna, 2011, R. Chand Publications
8. Optics, Eugene Hecht, 4thEdn., 2014, Pearson Education

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PH 118-WAVES AND OPTICS LAB
Credits: 02 (0-0-4)

Course objective:

- The laboratory content compliments the theoretical knowledge of Waves and Optics and gives hands-on experience.
- Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.

At least 08 experiments from the following

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^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 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 wavelength of sodium light using Fresnel biprism.
9. To determine 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 wavelength of (i) Na source and (ii) spectral lines of Hg source using plane diffraction grating.
12. To determine dispersive power and resolving power of a plane diffraction grating.
13. To study interference and diffraction pattern with slits.
14. Focal length of a combination of two lenses using Nodal slide assembly.
15. To determine the frequency of AC mains using Sonometer.

Text/Reference:

1. Advanced Practical Physics for students, B L Flint and H T Worsnop, 1971, Asia Publishing House

2. A Text Book of Practical Physics, I Prakash and Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D P Khandelwal,1985, Vani Pub.

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Semester III

PH 211-MATHEMATICAL PHYSICS-II
Credits: 04(4-0-0)

Course objectives:

- The focus of the course is on applications in problems solving of interest to physicists.
- Students should able to learn, understand and apply the concepts/formulas of Fourier transformation, differential equations, Bessel function, Beta and Gamma functions etc. to solve the mathematical problems.

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, Even and odd functions and their Fourier expansions, Application, Summing of Infinite series, Parseval identity and its application to summation of infinite series.
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, 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 [$J_o(x)$ and $J_1(x)$] and orthogonality.
Some Special Integrals: Beta and Gamma functions and Relation between them, Expression of Integrals in terms of Gamma functions.
Partial Differential Equations: Solutions using separation of variables: Laplace's equation in problems of rectangular geometry, Solution of wave equation for vibrational modes of a stretched string, rectangular and circular membranes, Solution of 1D heat flow equation (equation not to be derived).

Text/Reference:

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier
2. Fourier Analysis by M R Spiegel, 2004, Tata McGraw-Hill
3. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
4. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill
5. Engineering Mathematics, S Pal and S C Bhunia, 2015, Oxford University Press
6. Mathematical methods for Scientists & Engineers, D A McQuarrie, 2003, Viva Books

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PH 213-MATHEMATICAL PHYSICS-II LAB
Credits: 02 (0-0-4)

Course objectives:

- The aim of this Lab is to use the computational methods to solve physical problems.
- The course will consist of lectures (both theory and practical) in the Computer Lab.

At least two programs must be attempted from each programming section.

Introduction to Scilab Software

Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Sub-array, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Introduction to plotting, 2D and 3D plotting,
Branching statements and program design, Relational and logical operators, the while loop, for loop, details of loop operations, break and continue statements, nested loops, logical arrays and vectorization.
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,
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.

Programming related to Numerical methods:

1. Curve fitting, Least square fit, Goodness of fit, standard deviation using Scilab:
2. Ohms law - calculate R, Hooke's law, Calculate spring constant, Given Bessel's function at N points find its value at an intermediate point.
3. Solution of linear system of equations by Gauss elimination method and Gauss-Seidel method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen-value problems:
4. Solution of mesh equations of electric circuits (3 meshes), Solution of coupled spring mass systems (3 masses)
5. Generation of special functions using user defined functions in Scilab:
6. Generating and plotting Legendre Polynomials, Generating and plotting Bessel function
7. Solution of ODE, First order differential equation Euler, modified Euler and Runge- Kutta (RK), second and fourth order methods, Second order differential equation, Fixed difference method,
8. First order differential equation: Radioactive decay Current in RC, LC circuits with DC source Newton's law of cooling, Classical equations of motion.
9. Second order differential equation: Harmonic oscillator (no friction), Damped Harmonic oscillator Forced harmonic oscillator, LCR circuits.
10. Partial differential equations, Wave equation, Heat equation, Poisson equation.

Text/Reference:

1. Mathematical Methods for Physics and Engineers, K F Riley, M P Hobson and S J Bence, 3rd ed., 2006, Cambridge University Press
2. Computational Physics, D Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.
3. A Guide to MATLAB, B R Hunt, R L Lipsman, J M Rosenberg, 2014, 3rdEdn., Cambridge University Press
4. Getting started with Matlab, Rudra Pratap, 2010, Oxford University Press.
5. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications, A V Wouwer, P Saucez, C V Fernández, 2014 Springer

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PH 215-THERMAL PHYSICS

Credits: 04(4-0-0)

Course objectives:

- This course explains the relationship between macroscopic properties of the physical system in equilibrium.

- Students will be able to apply the Zero/First/Second laws and Maxwell thermodynamics equations for solving the numerical problems.
- It will also give basic knowledge of Heat engines, and exposure of Kinetic theory of gases, transport phenomenon involved in ideal gases, phase transitions and behavior of real gases.

Introduction to Thermodynamics:

Zeroth and First Law of Thermodynamics: Extensive and intensive thermodynamic variables, Thermodynamic equilibrium, Zeroth law of thermodynamics and concept of temperature, Concept of work and heat, State functions, First law of thermodynamics and its differential form, Internal energy, First law and various processes, Applications of first law: General relation between C_P and C_V, Work done during Isothermal and Adiabatic processes, Compressibility and expansion co-efficient.
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 and efficiency, Refrigerator and 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.
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, Entropy changes in reversible and irreversible processes, Principle of increase of entropy, Temperature–entropy diagrams for Carnot's cycle, Third law of thermodynamics, Unattainability of absolute zero.
Thermodynamic Potentials: Thermodynamic potentials: Internal energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy, their definitions, Properties and applications, Magnetic work, Cooling due to adiabatic demagnetization, First and second order phase transitions with examples, Clausius Clapeyron equation and Ehrenfest equations.
Maxwell's Thermodynamic Relations: Derivation of Maxwell's thermodynamic relations and their applications, Maxwell's relations: (i) Clausius Clapeyron equation, (ii) value of C_p-C_v, (iii) Tds equations, (iv) Energy equations.
Kinetic Theory of Gases: Distribution of velocities: Maxwell-Boltzmann law of distribution of velocities in an Ideal gas and its experimental verification, Mean, RMS and most probable speeds, Degrees of freedom, Law of equipartition of energy (No proof required), Specific heats of gases.
Molecular Collisions: Mean Free Path, Collision probability, Estimation of Mean free path, Transport phenomenon in Ideal gases: (i) Viscosity, (ii) Thermal Conductivity and (iii) Diffusion, Brownian motion and its significance.
Real Gases: Behavior of real gases: deviations from the Ideal gas equation, Andrew's experiments on CO_2 gas, Virial equation, Critical constants, Continuity of liquid and gaseous state, Vapour and gas, Boyle temperature, van der Waal's equation of state for real gases, Values of critical constants, Law of corresponding states, Comparison with experimental curves, P-V diagrams, 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.

Text/Reference:

1. Heat and Thermodynamics, M W Zemansky, Richard Dittman, 1981, McGraw-Hill
2. A Treatise on Heat, Meghnad Saha and B N Srivastava, 1958, Indian Press
3. Thermal Physics, S Garg, R Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
4. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa
5. Heat Thermodynamics & Statistical Physics, Brij Lal and Subramaniam, 1stEdn., 2008, S. Chand

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PH 217-THERMAL PHYSICS LAB
Credits: 02(0-0-4)

Course objectives:

- The laboratory content develops experimental and data analysis skills through a wide range of experiment of Thermal Physics
- Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students

At least 08 experiments from the following

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 using a null method. And also calibrate the Thermocouple in a specified temperature range.
7. To calibrate a thermocouple to measure temperature in a specified range using Op-amp difference amplifier and to determine neutral temperature.
8. To determine the coefficient of linear expansion of given sample.
9. To determine the mechanical equivalent of heat (J) with the help of Joule's calorimeter.
10. To determine the coefficient of real expansion of a liquid (water) by up-thrust method.
11. To determine the thermal conductivity of rubber in the form of tube.
12. To determine the critical temperature and critical pressure of a gas.
13. To determine the value of γ (the ratio of two specific heats of gas) for air by Clement and Desorme's method.
14. To determine specific heat of a given liquid by method of cooling.

Text/Reference:

1. Advanced Practical Physics for students, B L Flint and H T Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I Prakash & Ramakrishna, 11^{th} Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M Ogborn, 4^{th} Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D P Khandelwal,1985, Vani Pub

PH 219-DIGITAL SYSTEMS AND APPLICATIONS

Credits: 04 (4-0-0)

Course objectives:

- This introduces the concept of Boolean algebra and the basic digital electronics of various logic Gates and memory elements.
- In this course, students will be able to understand the working principle of CRO, Data processing circuits, Arithmetic Circuits, sequential circuits like registers, counters etc. based on flip flops.
- In addition, students will get an overview of microprocessor architecture and programming.

Digital Circuits: Difference between Analog and Digital circuits, Examples of linear and digital ICs, Binary numbers and conversion, BCD, Octal and hexadecimal numbers, AND, OR, NOT gates (using DTL and TTL), NAND, NOR, XOR, XNOR gates.

Boolean algebra: De Morgan's theorems, Simplification of logic circuit using Boolean Algebra, Minterms and Maxterms, Karnaugh's map, Minimization of logic circuits by Sum-of-Products and Product-of-Sums method.

Data processing and Arithmetic circuits: Binary addition, Binary subtraction using 2's complement, Half and full adders, Half and full subtractors, 4-bit binary Adder/Subtractor multiplexers, De-multiplexers, Decoders, Encoders.

Sequential Circuits: S-R and J-K Flip-Flops, Clocked (Level and Edge Triggered) Flip-Flops, D and T Flip-Flop, Preset and clear operations, Race-around conditions in J-K Flip-Flop, M/S J-K Flip-Flop.

Timers: IC 555: block diagram and applications: A stable multivibrator and Mono stable multivibrator.

Registers and Counters: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits), Ring counter, Asynchronous counters, Decade Counter, Synchronous Counter A/D and D/A converter.

Computer Organization: Input/Output Devices, Data storage (idea of RAM and ROM), Computer memory, Memory organization and addressing, Memory Interfacing, Memory map.

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, Introduction to Assembly Language: 1 byte, 2 byte and 3-byte instructions.

Text/Reference:

1. Fundamentals of Digital Circuits, Anand Kumar, 2ndEdn, 2009, PHI Learning Pvt. Ltd.
2. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill
3. Digital Electronics, G K Kharate ,2010, Oxford University Press
4. Logic circuit design, Shimon P Vingron, 2012, Springer
5. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning
6. Digital Electronics, S K Mandal, 2010, 1st edition, McGraw Hill
7. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall

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PH 221-DIGITAL SYSTEMS AND APPLICATIONS LAB

Credits: 02(0-0-4)

Course objectives:

- The laboratory content develop experimental and data analysis skills through a wide range of experiment gives hands-on experience.
- Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.

At least 08 experiments each from section A and Section B

Section-A: ~~**Programs using 8085 Microprocessor:**~~

1. (a) To design a combinational logic system for a specified Truth Table.
   (b) To convert Boolean expression into logic circuit and design it using logic gate ICs.
   (c) To minimize a given logic circuit.
2. Half Adder, Full Adder and 4-bit binary Adder.
3. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
4. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
5. To build JK Master-slave flip-flop using Flip-Flop ICs
6. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
7. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.

8. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO and to design an astable multivibrator of given specifications using 555 Timer.
9. To design a monostable multivibrator of given specifications using 555 Timer.

Section-B: **Programs using 8085 Microprocessor:**

1. Addition and subtraction of numbers using direct addressing mode
2. Addition and subtraction of numbers using indirect addressing mode
3. Multiplication by repeated addition.
4. Division by repeated subtraction.
5. Handling of 16-bit numbers.
6. Use of CALL and RETURN Instruction.
7. Block data handling.
8. Parity Check
9. Other programs (e.g. using interrupts, etc.).

Text/Reference:

1. Modern Digital Electronics, R P Jain, 4th Edition, 2010, Tata McGraw Hill
2. Basic Electronics: A text lab manual, P B Zbar, A P Malvino, M A Miller, 1994, Mc-Graw Hill
3. Microprocessor Architecture Programming and applications with 8085, R S Goankar, 2002, Prentice Hall
4. Microprocessor 8085: Architecture, Programming and interfacing, A Wadhwa, 2010, PHI Learning

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Semester IV

PH 212-MATHEMATICAL PHYSICS-III
Credits 04(4-0-0)

Course objectives:

- This course introduces the mathematical methods essential for solving the advanced problems in physics.
- The knowledge of mathematical concepts and techniques would be beneficial in further research and development as it serves as a tool in almost every branch of science and engineering.

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, Simply and multiply connected region, Laurent and Taylor's expansion, Residues and Residue theorem, Application in solving Definite Integrals.
Integrals Transforms: Fourier Transforms: Fourier Integral theorem (Statement only), Fourier transform, Fourier sine and cosine transform, Examples, Fourier transform of single pulse, trigonometric, exponential, and Gaussian functions, Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem, Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.), One dimensional wave equation.
Laplace Transforms: Laplace Transform (LT) of elementary functions, Properties of LT: Change of Scale theorem, Shifting theorem. LTs of 1st and 2nd order derivatives and Integrals of functions, Derivatives, and Integrals of LTs, LT of unit step function, Periodic functions, Convolution theorem, Inverse LT, Application of Laplace transforms to 2nd order differential equations: Coupled differential equations of 1st order, Solution of heat flow along semi-infinite bar using Laplace transform.

Dirac delta function: Definition and properties, Representation of Dirac delta function as a Fourier Integral, Laplace and Fourier transform of Dirac delta function.

Text/Reference:

1. Mathematical Methods for Physics and Engineers, K F Riley, M P Hobson and S J Bence, 3rd ed., 2006, Cambridge University Press
2. Mathematics for Physicists, P Dennery and A Krzywicki, 1967, Dover Publications
3. Complex Variables, A S Fokas and M J Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
4. Complex Variables, A K Kapoor, 2014, Cambridge Univ. Press
5. Complex Variables and Applications, J W Brown and R V Churchill, 7th Ed. 2003, Tata McGraw-Hill

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PH 214-MATHEMATICAL PHYSICS-III LAB

Credits 02 (0-0-4)

Course objectives:

- This laboratory would introduce students with the basic knowledge of scientific programming languages and graphical analysis.
- Also, the students would be able to implement C++/C/Scilab simulations for common and scientific problems.

C++/C/Scilab based simulations experiments will be based on following Mathematical Physics problems:

1. Solve first order and second order differential equations.
2. Evaluate problems with Dirac Delta functions.
3. Evaluate the Fourier coefficients and find the Fourier Series of a given periodic function.
4. Frobenius method and evaluation of Special functions.
5. Evaluation of trigonometric functions. Given Bessel's function at N points and find its value at an intermediate point.
6. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).
7. Calculation of least square fitting manually for a given data set and confirmation of least square fitting of data through computer program.
8. Application of Fast Fourier Transform

Text/Reference:

1. Mathematical Methods for Physics and Engineers, K F Riley, M P Hobson and S J Bence, 3rd ed., 2006, Cambridge University Press
2. Mathematics for Physicists, P Dennery and A Krzywicki, 1967, Dover Publications
3. 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
4. A Guide to MATLAB, B R Hunt, R L Lipsman, J M Rosenberg, 2014, 3rdEdn., Cambridge University Press
5. Getting started with MATLAB, Rudra Pratap, 2010, Oxford University Press.

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PH 216-ELEMENTS OF MODERN PHYSICS

Credits:04 (4-0-0)

Course objectives:

- This course introduces modern development in Physics. Starting from Planck's law, it develops the idea of probability interpretation and then discusses the formulation of Schrodinger equation.
- It also introduces basic concepts of nuclear physics.

Quantum Theory of Light and Particle: Planck's quantum theory, 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.

Position measurement-gamma ray microscope, Wave-particle duality, Heisenberg uncertainty principle, Derivation from Wave Packets, Impossibility of a particle following a trajectory, Estimating minimum energy of a confined particle, Energy-time uncertainty principle.

Two slit interference experiment with photons, atoms and particles, linear superposition principle as a consequence, 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.

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization, quantum mechanical tunneling in one dimension-across a step potential and rectangular potential barrier.

Nuclear Physics: Size and structure of atomic nucleus and its relation with atomic weight, Impossibility of an electron being in the nucleus (using uncertainty principle), Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy.

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, Fission and fusion- mass deficit, relativity and generation of energy, Fission-nature of fragments and emission of neutrons, Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions)

Lasers: Metastable states, Spontaneous and Stimulated emissions, Optical Pumping and Population Inversion.

Text/Reference:

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill
2. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
3. Introduction to Quantum Mechanics, David J Griffith, 2005, Pearson Education.
4. Physics for Scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
5. Modern Physics, G Kaur and G R Pickrell, 2014, McGraw Hill
6. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2ndEdn, Tata McGraw-Hill Publishing Co. Ltd.
7. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.

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PH 218-ELEMENTS OF MODERN PHYSICS LAB

Credits 02 (0-0-4)

Course objectives:

- This laboratory provides the theoretical knowledge of Modern Physics and gives hands-on experience.
- Students will learn how to measure different universal constants with several experiments.
- Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students

At least 08 experiments from following:

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 the 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 (i) Magnetic focusing or (ii) 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 (i) wavelength and (ii) angular spread of He-Ne laser using plane diffraction grating.

Text/Reference:

1. Advanced Practical Physics for students, B L Flint and H T Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practical, Michael Nelson and Jon M Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, I Prakash and Ramakrishna, 11thEdn, 2011, Kitab Mahal

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PH 220-ANALOG SYSTEMS AND APPLICATIONS
Credits: 04 (4-0-0)

Course objectives:

- This course explains about the physics of semiconductor p-n junction and devices, transistor biasing and stabilization circuits are explained.
- The concept of feedback in the amplifiers and oscillator circuits are also discussed in detail.
- This will also give an understanding of working principle of operational amplifiers, CRO and their applications.

Semiconductor Diodes: p and n-type semiconductors, Energy level diagram, Conductivity and mobility, Concept of drift velocity, Barrier formation, Barrier potential, Current flow mechanism in forward and reverse biased diode.
Two-terminal Devices and their Applications: Half-wave and full-wave rectifiers, Ripple factor and rectification efficiency, Zener diode and Voltage regulation, Principle, Structure and characteristics of LED, Photodiode and solar cell, Qualitative idea of Schottky diode and Tunnel diode.

Bipolar Junction transistors: n-p-n and p-n-p transistors, I-V characteristics of CB and CE configurations, Current gains α and β and relations between them, DC load line and Q-point, Physical mechanism of current flow.
Amplifiers: Transistor biasing and stabilization, Fixed bias and voltage divider Bias, Two-port network, h-parameter equivalent circuit, Single-stage CE amplifier using hybrid model, Input and output impedance, Current, Voltage and power gains, Classification of class A, B and C amplifiers, Two stage RC-coupled amplifier and its frequency response.
Feedback and Oscillators: Positive and negative feedback, Effect of negative feedback on input impedance, Output impedance, Gain, Stability, Distortion and noise, Barkhausen's criterion for self-sustained oscillations, RC Phase shift oscillator, determination of frequency, Hartley and Colpitts oscillators.
Operational Amplifiers: Characteristics of Op-Amp, Open-loop and closed-loop gain, Frequency response, CMRR, Slew rate and concept of virtual ground, Inverting and non-inverting amplifiers, Adder, Subtractor, Differentiator, Integrator, Log amplifier, Comparator, Zero crossing detector, Wein Bridge oscillator, Schmitt trigger, D/A resistive networks.
Introduction to CRO: Block diagram of CRO, Electron gun, Deflection system and time base, Deflection sensitivity, Applications of CRO: (i) Study of waveform, (ii) Measurement of voltage, current, frequency and phase difference.

Text/Reference:

1. Integrated Electronics, J Millman and C C Halkias, 1991, Tata Mc-Graw Hill
2. Electronics: Fundamentals and Applications, J D Ryder, 2004, Prentice Hall
3. Solid State Electronic Devices, B G Streetman & S K Banerjee, 6th Edn.,2009, PHI Learning
4. Electronic Devices & circuits, S Salivahanan & N S Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
5. Op-Amps and Linear Integrated Circuit, R A Gayakwad, 4th edition, 2000, Prentice Hall
6. Microelectronic circuits, A S Sedra, K C Smith, A N Chandorkar, 2014, 6thEdn., Oxford University Press
7. Microelectronic Devices & Circuits, David A Bell, 5th Edn.,2015, Oxford University Press

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PH 222-ANALOG SYSTEMS AND APPLICATIONS LAB
Credits: 02 (0-0-4)

Course objectives:

- This laboratory provides a hands-on experiment based on PN junction diode, transistors, Op-amp, amplifiers etc.
- Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.

At least 08 experiments from the following:

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.

Text/Reference:

1. Basic Electronics: A text lab manual, P B Zbar, A P Malvino, M A Miller, 1994, Mc-Graw Hill
2. Op-Amps and Linear Integrated Circuit, R A Gayakwad, 4th edition, 2000, Prentice Hall
3. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill
4. Electronic Devices & Circuit Theory, R L Boylestad & L D Nashelsky, 2009, Pearson

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Semester V

PH 311-QUANTUM MECHANICS AND APPLICATIONS

Credits: 04 (4-0-0)

Course objectives:

- This course is an application of Schrodinger equation to various quantum mechanical problems.
- This gives fair idea of formulation of eigenvalues and eigen functions.

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.
Time independent Schrodinger equation: Hamiltonian, stationary states and energy eigen values, 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, eigenfunctions using Frobenius method, Hermite polynomials, ground state, zero point energy and uncertainty principle.
General discussion of bound states in an arbitrary potential- continuity of wavefunction, boundary condition and emergence of discrete energy levels, application to one-dimensional problem-square well potential, Quantum mechanics of simple harmonic shapes of the probability densities for ground and first excited states, Orbital angular momentum quantum numbers l and m, s, p, d shells.
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 and quantum numbers.
Atoms in Electric and Magnetic Fields: Electron angular momentum, Angular momentum quantization, Electron spin and spin angular momentum, Larmor's theorem, Spin magnetic moment, Stern-Gerlach experiment, Normal Zeeman effect: Electron magnetic moment and magnetic energy.

Many electron atoms: Pauli's Exclusion Principle, Symmetric and antisymmetric wave functions, Spin orbit coupling, Spectral notations for atomic states, Total angular momentum, Spin-orbit coupling in atoms-L-S and J-J couplings.

Text/Reference:

1. A Text book of Quantum Mechanics, P M Mathews and K Venkatesan, 2nd Ed., 2010, McGraw Hill
2. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley
3. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill
4. Quantum Mechanics for Scientists and Engineers, D A B Miller, 2008, Cambridge University Press
5. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
6. Introduction to Quantum Mechanics, D J Griffith, 2nd Ed. 2005, Pearson Education

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PH 313-QUANTUM MECHANICS LAB

Credits: 02 (0-0-4)

Course objectives:

- This lab compliments the problem based on Quantum Mechanics using C++ programming language.

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

1. To solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom: Obtain the energy eigenvalues and plot the corresponding wavefunctions.
2. Solve the s-wave radial Schrodinger equation for an atom. Find the energy of the ground state of the atom and plot the corresponding wavefunction.
3. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

Laboratory based experiments (Optional):

4. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency.
5. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
6. Quantum efficiency of CCDs

Text/Reference:

1. Schaum's outline of Programming with C++, J Hubbard, 20 00, McGraw-Hill Publication
2. An introduction to computational Physics, T Pang, 2nd Edn., 2006, Cambridge Univ. Press
3. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández.2014 Springer
4. Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
5. A Guide to MATLAB, B R Hunt, R L Lipsman, J M Rosenberg, 2014, 3rd Edn., Cambridge University Press

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PH 315-SOLID STATE PHYSICS

Credits: 04(4-0-0)

Course objectives:

- This aims to provide a general introduction to theoretical and experimental topics in solid state physics.
- This course also elucidates the main features of crystal lattices and phonons, understand the elementary lattice dynamics and its influence on the properties of materials.
- It also explains the main features of the physics of electrons in solids, explain the dielectric ferroelectric and magnetic properties of solids and understand the basic concept in superconductivity.

Crystal Structure: Amorphous and crystalline materials, Lattice translation vectors, Lattice with a Basis, Space lattice, Basic symmetry operations, Symmetry elements, Unit cell and primitive lattice cell, Miller indices, Fundamental types of lattices (Bravais Lattices), Reciprocal lattice, Brillouin zones, Diffraction of x-rays by crystals, Bragg's law, Laue condition, Atomic scattering factor and Geometrical strucure factor.
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.
Electrons in Solids: Electrons in metals- Drude Model, Density of states, Elementary band theory: Kronig Penny model, Band Gap, Effective mass, mobility, Hall Effect (Metal and Semiconductor).
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 on B-H curve, Hysteresis loss, soft and hard material and energy Loss.
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 Sellmeir relations, Langevin-Debye equation, Complex dielectric constant.
Ferroelectric Properties of Materials: Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.
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).

Text/Reference:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edn., 2004, Wiley India Pvt. Ltd
2. Elements of Solid-State Physics, J P Srivastava, 2nd Edn., 2006, Prentice-Hall of India
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
4. Solid State Physics, N W Ashcroft and N D Mermin, 1976, Cengage Learning
5. Solid-state Physics, H Ibach and H Luth, 2009, Springer
6. Solid State Physics, Rita John, 2014, McGraw Hill
7. Solid State Physics, M A Wahab, 2011, Narosa Publications

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PH 317-SOLID STATE PHYSICS LAB

Credits: 02(0-0-4)

Course objectives:

- The laboratory content compliments the theoretical knowledge of Solid-state physics and gives hands-on experience.
- Students will learn different kind of material and their nature by performing several experiments.
- Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.

At least 08 experiments from the following

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 and determine energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) with temperature (up to 150ºC) by four-probe method and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.
11. Analysis of X-Ray diffraction data in terms of unit cell parameters and estimation of particle size.
12. Measurement of change in resistance of a semiconductor with magnetic field (Magneto-resistance).

Text/Reference:

1. Advanced Practical Physics for students, B L Flint and H T Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I Prakash and Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Elements of Solid-State Physics, J P Srivastava, 2nd Ed., 2006, Prentice-Hall of India

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Semester VI

PH 312-ELECTROMAGNETIC THEORY
Credits: 04(4-0-0)

Course objectives:

- The course covers Maxwell's equations, propagation of electromagnetic waves in different homogeneous-isotropic as well as anisotropic unbounded and bounded media, production, and detection of different types of polarized electromagnetic waves, general information as waveguides and fibre optics.
- Students will be able to apply the laws/formulas to solve the numerical problems of quarter/half wave plates, internal reflection, numerical aperture etc.

Maxwell Equations: Review of Maxwell's equations, Displacement current, Vector and Scalar potentials, Gauge transformations: Lorentz and Coulomb gauge, 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.
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 ionosphere.
EM Wave in Bounded Media: Boundary conditions at a plane interface between two media, Reflection and Refraction of plane waves at plane interface between two dielectric media-Laws of

Reflection and Refraction, Fresnel's Formulae for perpendicular and parallel polarization cases, Brewster's law, Reflection and Transmission coefficients, Total internal reflection, evanescent waves, Metallic reflection (normal Incidence).

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 and extraordinary refractive indices, Production and 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, 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.

Wave Guides: Planar optical wave guides, Planar dielectric wave guide, Condition of continuity at interface, Phase shift on total reflection, Eigenvalue equations, Phase and group velocity of guided waves, Field energy and power transmission.

Optical Fibres: Numerical aperture, Step and Graded indices (Definitions only), Single and multiple mode fibres.

Text/Reference:

1. Introduction to Electrodynamics, D J Griffiths, 3rd Ed., 1998, Benjamin Cummings
2. Electromagnetic Field and Waves, P Lorrain and D Corson, 2nd Ed., 2003, CBS Publisher
3. Elements of Electromagnetics, M N O. Sadiku, 2001, Oxford University Press
4. Fundamentals of Electromagnetics, M A W Miah, 1982, Tata McGraw Hill
5. Electromagnetic field Theory, R S Kshetrimayun, 2012, Cengage Learning
6. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill
7. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill
8. Electromagnetic field theory fundamentals, B Guru and H Hiziroglu, 2015, Cambridge University Press
9. Classical Electrodynamics, J D Jackson, 3rdEdn., 2010, Wiley
10. Principle of Optics, M Born and E Wolf, 6thEdn., 1980, Pergamon Press
11. Optics, A Ghatak, 5thEdn., 2012, Tata McGraw Hill Education

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PH 314-ELECTROMAGNETIC THEORY LAB

Credits: 02(0-0-4)

Course objectives:

- The laboratory content compliments the theoretical knowledge of Electromagnetic Theory and gives hands-on experience.
- Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.

At least 08 experiments from the following

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 (i) glass and (ii) 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 Boltzmann constant using V-I characteristics of PN junction diode.
13. To find Numerical Aperture of an Optical Fibre.
14. To verify Brewster's law and to find the Brewster's angle.

Text/Reference:

1. Advanced Practical Physics for students, B L Flint and H T Worsnop, 1971, Asia Publishing House
2. Advanced level Physics Practicals, Michael Nelson and Jon M Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. Electromagnetic Field Theory for Engineers and Physicists, G Lehner, 2010, Springer

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PH 316-STATISTICAL MECHANICS

Credits: 04(4-0-0)

Course objectives:

- This course provides elementary and applied Statistical Mechanics for exploring the Bose-Einstein statics, Fermi-Dirac statics, Relativistic Fermi-Gas, Black body radiation, Stefan-Boltzmann law etc.
- The objective of this course work is to introduce and apply the techniques of Statistical Mechanics which have applications in; Astrophysics, Semiconductors, Plasma Physics, Bio-Physics, Chemistry etc.

Classical Statistics: Macrostate and Microstate, Phase space, Elementary concept of ensemble, 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, Concept of negative temperature.

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.

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.

Theory of Radiation: Properties of thermal radiation, Blackbody radiation, Pure temperature dependence, Radiation pressure, Kirchhoff's law, Stefan-Boltzmann law: Thermodynamic proof, Wien's displacement law, Wien's distribution law, Saha's Ionization formula, Rayleigh-Jean's law, Ultraviolet Catastrophe, Spectral distribution of Black Body radiation, Planck's quantum postulates, Planck's law of Blackbody radiation: experimental verification, Deduction of (i) Wien's Distribution law, (ii) Rayleigh-Jeans law, (iii) Stefan-Boltzmann law, (iv) Wien's Displacement law from Planck's law.

Text/Reference:

1. Statistical Mechanics, R K Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press

2. Statistical Physics, Berkeley Physics Course, F Reif, 2008, Tata McGraw-Hill
3. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W Sears and Gerhard L Salinger, 1986, Narosa
4. An Introduction to Statistical Mechanics and Thermodynamics, R H Swendsen, 2012, Oxford Univ. Press
5. Statistical Physics , F. Mandl, 2ndEdn., 2003, Wiley
6. Introductory Statistical Mechanics, R Bowley and M Sanchez, 2nd Edn., 2007, Oxford Univ. Press

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PH 318-STATISTICAL MECHANICS LAB
Credits: 02 (0-0-4)

Course objectives:

The laboratory content develops experimental and data analysis skills through a wide range of experiment of Statistical Mechanics.
Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative data analysis skills of the students.

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(E) 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(E), average energy $\langle E \rangle$, energy fluctuation ΔE, 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 Raleigh-Jeans Law at large and small wavelength for a given 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.
5. Plot the following functions with energy at different temperatures
   a) Maxwell-Boltzmann distribution
   b) Fermi-Dirac distribution
   c) Bose-Einstein distribution
6. Plot the distribution of particles w.r.t. energy (dN/dE versus E) for
   a) Relativistic and non-relativistic bosons both at high and low temperature.
   b) Relativistic and non-relativistic fermions both at high and low temperature.

Text/Reference:

1. Elementary Numerical Analysis, K E Atkinson, 3^{rd} Edn . 2007, Wiley India Edition
2. Statistical Mechanics, R K Pathria, Butterworth Heinemann: 2^{nd} Ed., 1996, Oxford University Press
3. Introduction to Modern Statistical Mechanics, D Chandler, 1987, Oxford University Press,
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W Sears and Gerhard L Salinger, 1986, Narosa
5. Modern Thermodynamics with Statistical Mechanics, Carl S Helrich, 2009, Springer
6. Statistical and Thermal Physics with computer applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010

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Skill Enhancement Course (any two) (Credit: 04 each)- SEC1 and SEC2

PH223-COMPUTATIONAL PHYSICS
Credits-04 (2-0-4)

Course objectives:

- The aim of this course is to teach computer programming and numerical analysis and emphasize its role in solving problems in Physics and Science.
- It also highlights the use of computational methods to solve physical problems along with the use of computer language as a tool.
- This course will also consist of hands-on training on the problem solving on Computers.

Introduction: Importance of computers in Physics, paradigm for solving physics problems for solution**.**

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

Scientific Programming in Python: Basic elements: 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. I/O Statements, Executable and Non-Executable Statements, format of writing program and concept of coding, Examples from physics problems.

Control Statements: Types of Logic, Branching Statements, Looping Statements, Arrays, Functions and Subroutines, Structure, I/O Statements, Examples from physics problems.

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.

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.
6. Plotting trajectory of a projectile projected horizontally.
7. Plotting trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. 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 particle in a central force field and plot the output for visualization.

Text/Reference:

1. Introduction to Numerical Analysis, S.S. Sastry, 5thEdn., 2012, PHI Learning Pvt. Ltd.
2. Python Cook Book, B Jones, D Beazly, 3rdEdn. 2013, Shroff.
3. Python for Beginners, H Bhasin, 1stEdn. 2018, New Age International Publishers.
4. LaTeX–A Document Preparation System", Leslie Lamport (Second Edition, Addison-Wesley, 1994).
5. Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)
6. Computational Physics: An Introduction, R C Verma, et al. New Age International Publishers, New Delhi (1999)
7. Elementary Numerical Analysis, K E Atkinson, 3rd Edn., 2007, Wiley India Edition.

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PH 225-ELECTRICAL CIRCUITS AND NETWORK

Credits-04 (2-0-4)

Course objectives:

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

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

Electrical Circuits: Basic 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.

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.

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

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.

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.

Electrical Protection: Relays, Fuses and disconnect switches, Circuit breakers, Overload devices, Ground-fault protection, Grounding and isolating, Phase reversal, Surge protection, Relay protection device.

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: wirenuts, crimps, terminal blocks, and solder, Preparation of extension board.

Network Theorems: Thevenin's and Norton's theorem , Superposition theorem, Maximum Power Transfer theorem.

Laboratory exercises:

At least 08 experiments from the following

1. Series and Parallel combinations: Verification of Kirchoff's law.
2. To verify network theorems: (i) Thevenin (ii) Norton (iii) Superposition theorem (iv) Maximum power transfer theorem.
3. To study frequency response curve of a Series LCR circuit.
4. To verify (i) Faraday's law and (ii) Lenz's law.
5. Programming with Pspice/NG spice.
6. Demonstration of AC and DC generator.
7. Speed of motor.
8. To study the characteristics of a diode.
9. To study rectifiers (i) Half wave (ii) Full wave rectifier (iii) Bridge rectifier.
10. Power supply (i) C-filter, (ii) π- filter.
11. Transformer – Step up and Step down.
12. Preparation of extension board with MCB/fuse, switch, socket-plug, Indicator.
13. Fabrication of Regulated power supply.

Text/Reference:

1. Electrical Circuits, K A Smith and R E Alley, 2014, Cambridge University Press
2. A text book in Electrical Technology - B L Theraja, A K Theraja- S Chand & Co.
3. Performance and design of AC machines - M G Say ELBS Edn.

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PH 227-BASIC INSTRUMENTATION

Credits-04 (2-0-4)

Course objectives:

- The course covers the Basic of Measurement that enables student to learn instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects.
- It also covers multimeter that provides the learning of principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance.

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.
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, Block diagram ac millivoltmeter**,** specifications and their significance.
Oscilloscope: Block diagram of basic CRO, CRT, electrostatic focusing and acceleration (Explanation only–non mathematical treatment), brief discussion on screen phosphor, visual persistence, Time base operation, synchronization, Front panel controls, Specifications of CRO and their significance, Use of CRO for the measurement of voltage (dc and ac), frequency and time period, Special features of dual trace, introduction to digital oscilloscope, probes, Digital storage Oscilloscope: principle of working.

Signal and pulse Generators: Block diagram, explanation and specifications of low frequency signal generator and pulse generator, Brief idea for testing, specifications, Distortion factor meter, wave analysis.
Impedance Bridges: Block diagram of bridge, Working principles of basic (balancing type) RLC bridge, Specifications of RLC bridge, Block diagram and working principles of a Q- Meter, Digital LCR bridges.
Digital Instruments: Comparison of analog and digital instruments, Characteristics of a digital meter, Working principles of digital voltmeter.
Digital Multimeter: Block diagram and working of a digital multimeter, Working principle of time interval, frequency and period measurement using universal counter/frequency counter, time- base stability, accuracy and resolution.

The test of lab skills will be of the following test items:
1. Use of an oscilloscope.
2. Oscilloscope 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 using Oscilloscope.
5. Measurement of time period, frequency, average period using universal counter/ frequency counter.
6. Measurement of rise, fall and delay times using a Oscilloscope.
7. Measurement of distortion of a RF signal generator using distortion factor meter.
8. Measurement of R, L and C using LCR bridge/ universal bridge.

Text/Reference:

1. A text book in Electrical Technology - B L Theraja - S Chand and Co.
2. Performance and design of AC machines - M G Say ELBS Edn.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Logic circuit design, Shimon P Vingron, 2012, Springer.
5. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
6. Electronic Devices and circuits, S Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill

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PH 224-APPLIED OPTICS
Credits-04 (2-0-4)

Course objectives
- The objective of this course to understand the 'nature of light' is a favorite inquiry of mankind since ancient times.
- By the advent of lasers, holography, and optical fibres in twentieth century the optics now-a-days finds application in several branches of science and engineering.

- This paper provides the conceptual understanding of these branches of modern optics to the students.

Photo-sources and Detectors: Lasers: an introduction, Planck's radiation law (qualitative idea), Energy levels, Absorption process, Spontaneous and stimulated emission processes, Theory of laser action, Population of energy levels, Einstein's coefficients and optical amplification, properties of laser beam, Ruby laser, He-Ne laser, and semiconductor lasers, Light Emitting Diode (LED) and photo-detectors.

Experiments on Lasers:

1. To determine the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid-state laser.
2. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid-state laser.
3. To find the polarization angle of laser light using polarizer and analyzer.
4. Thermal expansion of quartz using laser.
5. To determine the wavelength and angular spread of laser light by using plane diffraction grating.

Experiments on Semiconductor Sources and Detectors:

1. V-I characteristics of LED.
2. Study the characteristics of solid-state laser.
3. Study the characteristics of LDR.
4. Characteristics of Photovoltaic Cell/ Photodiode.
5. Characteristics of IR sensor.

Fourier Optics and Fourier Transform Spectroscopy (Qualitative explanation): Concept of Spatial frequency filtering, Fourier transforming property of a thin lens, Fourier Transform Spectroscopy (FTS): measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry, and forensic science.

Experiments on Fourier Optics:

1. Optical image addition/subtraction
2. Optical image differentiation
3. Fourier optical filtering
4. Construction of an optical 4f system

Experiments on Fourier Transform Spectroscopy

To study the interference pattern from a Michelson interferometer as a function of mirror separation in the interferometer. The resulting interferogram is the Fourier transform of the power spectrum of the source. Analysis of experimental interferograms allows one to determine the transmission characteristics of several interference filters. Computer simulation can also be done.

Holography: Introduction, Basic principle and theory: recording and reconstruction processes, Requirements of holography-coherence, etc. Types of holograms: The thick or volume hologram, Multiplex hologram, white light reflection hologram; application of holography in microscopy, interferometry, and character recognition.

Experiments on Holography and interferometry:

1. Recording and reconstruction of holograms (Computer simulation can also be done).
2. To construct a Michelson interferometer or a Fabry Perot interferometer.
3. To determine the wavelength of sodium light by using Michelson's interferometer.
4. To measure the refractive index of air.

Photonics: Fibre Optics: Optical fibres: Introduction and historical remarks, Total Internal reflection, Basic characteristics of the optical fibre: Principle of light propagation through a fibre, the coherent bundle, The numerical aperture, Attenuation in optical fibre and attenuation limit, Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating.

Experiments on Fibre Optics

1. To measure the numerical aperture of an optical fibre.
2. To measure the near field intensity profile of a fibre and study its refractive index profile.
3. To study the variation of the bending loss in a multimode fibre.

4. To determine the power loss at a splice between two multimode fibre.
5. To determine the mode field diameter (MFD) of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern.

Text/Reference:

1. LASERS: Fundamentals & applications, K Thyagrajan & A K Ghatak, 2010, Tata McGraw Hill
2. Introduction to Fourier Optics, Joseph W Goodman, McGraw- Hill, 1996.
3. Introduction to Fiber Optics, A Ghatak and K Thyagarajan, Cambridge University Press.
4. Fibre optics through experiments, M R Shenoy, S K Khijwania, et.al. 2009, Viva Books
5. Optical Electronics, Ajoy Ghatak and K Thyagarajan, 2011, Cambridge University Press
6. Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.
7. Optoelectronic Devices and Systems, S C Gupta, 2005, PHI Learning Pvt. Ltd.

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PH 226-RENEWABLE ENERGY AND ENERGY HARVESTING

Credits-04 (4-0-0)

Course objectives:

- The aim of this course is to impart theoretical knowledge to the students and to provide them with exposure and hands-on learning wherever possible.

Fossil Fuels and Alternate Sources of Energy: Fossil fuels and nuclear energy, their limitation, 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.
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 green houses, solar cell, absorption air conditioning, Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.
Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.
Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices, Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.
Geothermal Energy: Geothermal Resources, Geothermal Technologies.
Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources.
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
Electromagnetic Energy Harvesting: Linear generators, physics mathematical models, recent applications. Carbon captured technologies, cell, batteries, power consumption.

Text/Reference:

1. Non-conventional energy sources, B H Khan, McGraw Hill
2. Solar energy, Suhas P Sukhative, Tata McGraw - Hill Publishing Company Ltd.
3. Renewable Energy, Power for a sustainable future, Godfrey Boyle, 3rdEdn., 2012, Oxford University Press
4. Solar Energy: Resource Assessment, Handbook, P Jayakumar, 2009

5. Photovoltaics, J Balfour, M Shaw and S Jarosek, , Lawrence J Goodrich (USA)

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PH 228-RADIATION SAFETY

Credits-04 (2-0-4)

Course objectives:

- It is a course focus on the applications of nuclear techniques and radiation protection.
- It will not only enhance the skills towards the basic understanding of the radiation but will also provide the knowledge about the protective measures against the radiation exposure.
- This will prepare the work force for jobs in industry and medical fields. The list of laboratory skills and experiments listed below the course are to be done in continuation of the topics.

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 element, 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.
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.
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 Geiger Muller Counter), Scintillation Detectors (Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermo luminescent Dosimetry.
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.
Application of nuclear techniques: Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archeology, Art, Crime detection, Mining and oil, Industrial Uses: Tracing, Gauging, Material Modification, Sterilization, Food preservation.

Experiments: Minimum four experiments need to be perform from the following,

1. Estimate the energy loss of different ions in Water and carbon, using SRIM/TRIM etc simulation software.
2. Simulation study (using SRIM/TRIM or any other software) of radiation depth in materials (Carbon, Silver, Gold, Lead) using H-ion.
3. Comparison of interaction of H like ions in given medium (Carbon/Water) using simulation software (SRIM etc).
4. Study the background radiation in different places and identify the source material from gamma ray energy spectrum.
5. Study the background radiation levels using Radiation meter.

6. Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
7. Study of counting statistics using background radiation using GM counter.
8. Study of radiation in various materials (e.g. KSO4 etc.). Investigation of possible radiation in different routine materials by operating GM counter at operating voltage.
9. Study of absorption of beta particles in Aluminum using GM counter.
10. Detection of α-particles using reference source and determining its half life using spark counter.
11. Gamma spectrum of Gas Light mantle (Source of Thorium).

Text/Reference:

1. Nuclear and Particle Physics, W E Burcham and M Jobes, (1995) Harlow Longman Group, 1995
2. Radiation detection and measurement, G F Knoll, 4th Edition, (2010) Wiley Publications
3. Thermoluminescence dosimetry, A F Mcknlay, Bristol, Adam Hilger (Medical Physics Hand book 5)
4. Fundamental Physics of Radiology, W J Meredith and J B Massey, (1989) John Wright and Sons, UK
5. An Introduction to Radiation Protection, A Martin and S A Harbisor, (1981) John Willey & Sons,Inc. New York
6. Medical Radiation Physics, W R Hendee, (1981) Year book Medical Publishers, Inc., London
7. Nuclear Physics: Principles and Applications, John Lilley, (2006) Wiley Publication
8. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed, (2007) Academic Press Elsevier
9. Technique for Nuclear and Particle Physics experiments, William R Leo,(1994) Springer
10. IAEA Publications: (a) General safety requirements Part 1, No. GSR Part 1 (2010), Part 3 No. GSR Part 3 (Interium) (2010); (b) Safety Standards Series No. RS-G-1.5 (2002), Rs-G-1.9(2005), Safety Series No. 120 (1996); (c) Safety Guide GS-G-2.1 (2007).
11. AERB Safety Guide (Guide No. AERB/RF-RS/SG-1), Security of radioactive sources inradiation facilities, 2011
12. AERB Safety Standard No. AERB/SS/3 (Rev. 1), Testing and Classification of sealed Radioactivity Sources, 2007

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PHYSICS-DSE 1-4 (ELECTIVES): Select any four paper

Odd Semester Options (DSE 1 – 2): Select any 02 papers

PH 319-EXPERIMENTAL TECHNIQUES
Credits: 04(4-0-0)

Course objectives:
- This course aims to describe the errors in measurement and statistical analysis of data required while performing an experiment.
- Also, students will learn the working principle, efficiency and applications of transducers and industrial instruments like digital multimeter, RTD, Thermistor, Thermocouples and Semiconductor type temperature sensors.

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.
Signals and 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, Methods of safety grounding, Energy coupling, Grounding, Shielding: Electrostatic shielding, Electromagnetic Interference.
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, Qualitative difference between Transducers and Sensors, Types of sensors (Physical, Chemical and Biological), Characteristics of Transducers, Transducers as electrical element and their signal conditioning, 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.
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.
Impedance Bridges and Q-meter: Block diagram and working principles of RLC bridge, Q-meter and its working operation, Digital LCR bridge.
Vacuum Systems: Characteristics of vacuum: Gas law, Mean free path, Application of vacuum, Vacuum system- Chamber with roughing and backing, Mechanical pumps (Rotary and root pumps), Diffusion pump and Turbo Molecular pump, Ion pumps, Pumping speed, throughput, Pressure gauges (Pirani, Penning, ionization, cold cathode).

Text/Reference:

1. Experimental Methods for Engineers, J P Holman, McGraw Hill
2. Introduction to Measurements and Instrumentation, A K Ghosh, 3rd Edition, PHI Learning Pvt. Ltd.
3. Transducers and Instrumentation, D V S Murty, 2nd Edition, PHI Learning Pvt. Ltd.
4. Instrumentation Devices and Systems, C S Rangan, G R Sarma, V.S.V. Mani, Tata McGraw Hill
5. Electronic circuits: Handbook of design & applications, U Tietze, Ch Schenk, Springer

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PH321-EXPERIMENTAL TECHNIQUES LAB
Credits: 02(0-0-4)

Course objectives:

- This laboratory guides the students to understand gauges, thermistors, vacuum pumps, and other laboratory equipment's by performing experiments.
- It enhances the qualitative and quantitative skills of the students.

At least 08 experiments each from the following:

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

Text/Reference:

1. Electronic circuits: Handbook of design and applications, U Tietze and C Schenk, 2008, Springer
2. Basic Electronics: A text lab manual, P B Zbar, A P Malvino, M A Miller, 1990, Mc-Graw Hill
3. Measurement, Instrumentation and Experiment Design in Physics & Engineering, M Sayer and A Mansingh, 2005, PHI Learning

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PH323-PHYSICS OF DEVICES AND COMMUNICATION

Credits-04 (4-0-0)

Course objectives:

- This paper is based on advanced electronics which covers the devices such as UJT, JFET, MOSFET, CMOS etc.
- Process of IC fabrication is discussed in detail. Digital Data serial and parallel Communication Standards are described along with the understanding of communication systems.

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, SiO_2-Si based MOS, C-V characteristics of MOS, MOSFET– their frequency limits, Enhancement and Depletion Mode MOSFETS, CMOS, Charge coupled devices.

Processing of Devices: Basic process flow for IC fabrication, Crystal plane and orientation, Diffusion and implantation of dopants, Passivation, Oxidation Technique for Si, Contacts and metallization technique, Wet etching, Dry etching (RIE), Positive and Negative Masks, Photolithography, Electron-lithography, Basic idea of SSI, MSI, LSI, VLSI and USI.

RC Filters: Passive-Low pass and High pass filters, Active (1^{st} order butterworth) –Low Pass, High Pass, Band Pass and Band Reject Filters.

Phase Locked Loop (PLL): Basic Principles, Phase detector (XOR and edge triggered), Voltage Controlled Oscillator (Basics, varactor), Lock and capture, Basic idea of PLL IC (565 or 4046).

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, 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.

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, Frequency modulation and demodulation, Basic idea of Frequency, Phase, Pulse and Digital Modulation including ASK, PSK, FSK.

Text/Reference:

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

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PH 325-PHYSICS OF DEVICES AND COMMUNICATION LAB

Credits-02 (0-0-4)

Course objectives:

- This laboratory guides the students to understand the electronic devices such as filters, transistors etc., by performing experiments and simulations.
- It enhances the qualitative and quantitative skills of the students.

At least 08 experiments each from 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 envelope detector for demodulation of AM signal.
12. Study of ASK and FSK modulator.
13. Glow an LED via USB port of PC.
14. 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 electronic circuits and devices***

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 1^{st} order active low pass and high pass filters of given cutoff frequency.
6. Design a Wein's 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.

Text/Reference:

1. Basic Electronics: A text lab manual, P B Zbar, A P Malvino, M A Miller,1994, Mc-Graw Hill
2. Integrated Electronics, J Millman and C C Halkias, 1991, Tata Mc-Graw Hill
3. Electronics: Fundamentals and Applications, J D Ryder, 2004, Prentice Hall
4. Op-Amps and Linear Integrated Circuit, R A Gayakwad, 4^{th} edn., 2000, Prentice Hall
5. Introduction to PSPICE using ORCAD for circuits& Electronics, M H Rashid, 2003, PHI Learning
6. PC based instrumentation; Concepts & Practice, N Mathivanan, 2007, Prentice-Hall of India

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PH327-CLASSICAL DYNAMICS

Credits-06 (5-1-0)

Course objectives:

- This course begins with the review of Newton's Laws of Motion and ends with the Special Theory of Relativity by 4-vector approach and fluids.
- Students will also appreciate the Lagrangian and Hamiltonian Mechanics. The emphasis of this course is to enhance the understanding of Classical Mechanics (Lagrangian and Hamiltonian Approach).
- By the end of this course, students should be able to solve the seen or unseen problems/numerical in classical mechanics.

Classical Mechanics of Point Particles: Review of Newtonian Mechanics, Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field-gyroradius and gyrofrequency, motion in crossed electric and magnetic fields, Degrees of freedom of a system, Generalized coordinates and velocities, Hamilton's Principle, Lagrangian and Lagrange's equations of motion of one-dimensional simple harmonic oscillators, falling body in uniform gravity, Cyclic coordinates, Canonical momenta and Hamiltonian, Hamilton's equations of motion, Comparison of Newtonian, Lagrangian and Hamiltonian mechanics, Applications of Hamiltonian mechanics: Hamiltonian for a simple harmonic oscillator, solution of Hamilton's equations for simple harmonic oscillations (1-D), particle in a central force field – conservation of angular momentum and energy.

Small Amplitude Oscillations: Minima of potential energy and points of stable equilibrium, small amplitude oscillations about the minimum, normal modes of longitudinal simple harmonic oscillations, Kinetic energy and potential energy in terms of normal co-ordinates, T and V matrices: finding eigen-frequencies and eigen-vectors using these matrices.

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, simultaneity Four-vectors: space-like, time-like and light-like, Four-displacement, 4-acceleration, Metric tensor and alternating tensor and their properties, Four-momentum and energy-momentum relation, Concept of four-force, Transformation Laws of Four-force, Orthogonal relations, Conservation of four-momentum, Lagrangian and Hamiltonian of a relativistic free particle.

Fluid Dynamics: Density and pressure 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.

Text/Reference:

1. Classical Mechanics, H Goldstein, C P Poole, J L Safko, 3rd Edn. 2002, Pearson Education
2. Mechanics, L D Landau and E M Lifshitz, 1976, Pergamon
3. Classical Mechanics, P S Joag, N C Rana, 1st Edn., McGraw Hall
4. Classical Mechanics, R Douglas Gregory, 2015, Cambridge University Press
5. Solved Problems in Classical Mechanics, O L Delange and J Pierrus, 2010, Oxford Press
6. Classical Mechanics, Tai L Chow, CRC Press

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PH329-NANO MATERIALS AND APPLICATIONS

Credits-04 (4-0-0)

Course objectives:

- This course introduces the essence of nano materials, their synthesis, and characterization.
- On successful completion of the module students should also be able to understand the optical properties and electron transport phenomenon in nanostructures.
- It also covers few important applications of nano materials used in this technological era.

Nanoscale systems: Density of states (1-D, 2-D, 3-D), Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods)**,** Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.

Synthesis of nanostructure materials: Metals, Metal Oxide, Carbon based nanomaterials CNT, C_{60}, graphene, Top down and Bottom-up approach, Photolithography, Ball milling, Gas phase condensation, Vacuum deposition, Physical vapor deposition (PVD): Thermal evaporation, Chemical Vapor Deposition (CVD), Sol-Gel, Spray pyrolysis, Hydrothermal synthesis, Preparation through colloidal methods, MBE growth of quantum dots.

Characterization: X-Ray Diffraction, Optical Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy, Scanning Tunneling Microscopy.

Optical properties: Concept of dielectric constant for nanostructures and charging of nanostructure, Quasi-particles and excitons, Excitons in direct and indirect band gap semiconductor nanocrystals, Quantitative treatment of quasi-particles and excitons, charging effects, Radiative processes: General formalization-absorption, emission and luminescence, Optical properties of heterostructures and nanostructures.

Electron transport: Carrier transport in nanostructures, Coulomb blockade effect, thermionic emission, tunneling and hopping conductivity, Defects and impurities: Deep level and surface defects.

Applications: Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells), Single electron transfer devices (no derivation), CNT based transistors, Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage, Magnetic quantum well, magnetic dots - magnetic data storage, Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).

Text/Reference:

1. Introduction to Nanotechnology, C P Poole, Jr. Frank J Owens, Wiley India Pvt. Ltd.

2. S K Kulkarni, Nanotechnology: Principles & Practices, Capital Publishing Company
3. Introduction to Nanoscience and Technology, K K Chattopadhyay and A N Banerjee, PHI Learning Pvt. Ltd.
4. Introduction to Nanoelectronics, V V Mitin, V A Kochelap and M A Stroscio, 2011, Cambridge University Press
5. Nanotechnology, Richard Booker, Earl Boysen, John Wiley and Sons

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PH331-NANO MATERIALS AND APPLICATIONS LAB

Credits-02 (0-0-4)

Course objectives:

- This laboratory content compliments the students about the different kind of nanomaterial synthesis, their characterization by performing experiments.
- It enhances the qualitative and quantitative skills of the students.

At least 08 experiments from the following:

1. Synthesis of metal nanoparticles by chemical route.
2. Synthesis of semiconductor nanoparticles.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
4. Analysis of XRD pattern of nanomaterials and estimation of particle size.
5. To study the effect of size on color of nanomaterials.
6. To prepare composite of CNTs with other materials.
7. Growth of quantum dots by thermal evaporation.
8. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering, and study its XRD.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study transmittance spectra in UV-Visible region.
10. Prepare a thin film capacitor and measure capacitance as a function of temperature or frequency.
11. Fabricate a PN diode by diffusing Al over the surface of n-type Si and study its V-I characteristic.

Text/Reference:

1. Introduction to Nanotechnology, C P Poole, Jr Frank J Owens, Wiley India Pvt. Ltd.
2. Nanotechnology: Principles & Practices, S K Kulkarni, Capital Publishing Company
3. Introduction to Nanoscience and Technology, K K Chattopadhyay and A N Banerjee, PHI Learning Pvt. Ltd.
4. Nanotechnology, Richard Booker, Earl Boysen, John Wiley and Sons

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PH 333-ASTRONOMY AND ASTROPHYSICS

Credits-06 (5-1-0)

Course objectives:

- The objective of this course is to provide excellent platform for understanding the origin and evolution of the Universe.
- It gives a comprehensive introduction on the measurement of basic astronomical parameters.
- This course gives an overview on key developments in observational astrophysics, reviews the formation of planetary system and its evolution with time and emphasizes on the physical laws that enable us to understand the origin and evolution of galaxies, presence of dark matter and large-scale structures of the Universe.

Basic Astronomical Parameters: Astronomical scales (Distance, Mass and Time), Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus, Measurement of Astronomical Quantities (Distances, Stellar Radii, Masses of Stars from binary orbits, Stellar Temperature, Color index of stars).
Basic concepts of positional astronomy: Celestial Sphere, Geometry of a Sphere, Astronomical Coordinate Systems, Horizon System, Equatorial System, Coordinate transformation between Horizon and Equatorial system, Diurnal Motion of the Stars, Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Julian Date.
Stellar spectra: Spectral types and their temperature dependence, Hertzsprung-Russell Diagram.
Astronomical telescopes and techniques: Atmospheric Windows, Optical telescopes Radio telescope, Telescope mountings, Magnification, Light gathering power, resolving power and diffraction limit, Detection limit of telescope, Modern terrestrial and space telescopes (GMRT, Keck, Chandra, HST).
Stellar structure: Derivation of Virial Theorem for N bodies, Basic Equations of stellar structure, simple stellar models (Polytropic model, Derivation of the Lane-Emden equation, analytical solutions of the Lane-Emden equation).
The Sun and the Solar System: Solar Atmosphere, Solar Photosphere, Chromosphere, Corona, Solar Activity, Basics of Solar Magneto-hydrodynamics, Origin of the Solar System (The Nebular Model, Tidal Forces, Planetary Rings and their formation), Extra-Solar Planets.
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 Constants, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Stellar Clusters, Morphological classification of the Galaxies.
Large Scale Structure and Expanding Universe: Main sequence fitting, Standard candles (Cepheid variables, Supernovae), Cosmic Distance Ladder, Clusters of Galaxies (Virial theorem and Dark Matter), Hubble's Law.

Text/Reference:

1. An Introduction to Modern Astrophysics and Cosmology (Second Edition), B W Carroll and D A Ostlie, (2006) Addison-Wesley Publishing Co.,
2. Introductory Astronomy and Astrophysics, M Zeilik and S A Gregory, Fourth Edition, (1998), Saunders College Publishing
3. Fundamental of Astronomy, H. Karttunen et al., Fifth Edition, 2007, Springer
4. Textbook of Astronomy and Astrophysics with elements of cosmology, V B Bhatia, (2001), Narosa Publication
5. The Cosmic Perspective, J O Bennet, M Donahue, N Schneider & M Voit, Eighth Edition (2010) Pearson Publications
6. The Physical Universe: An Introduction to Astronomy, Frank Shu, (1985) Oxford University Press
7. Astrophysics: Stars and Galaxies, K D Abhyankar, (2001) Universities Press

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PH 335-ATMOSPHERIC PHYSICS

Credits-04 (4-0-0)

Course objectives:

- This paper aims to describe the characteristics of earth's atmosphere and its dynamics. Atmospheric waves along with the basic concepts of atmospheric Radar and Lidar are discussed in detail.

General features of Earth's atmosphere: Thermal structure of the Earth's Atmosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze, Instruments for meteorological observations including RS/RW, meteorological processes and convective systems, fronts, Cyclones and anticyclones, thunderstorms.
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.
Atmospheric Waves: Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a non homogeneous medium, Lamb wave, Ross by waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration.
Atmospheric Radar and Lidar: Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Applications of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon, Data analysis tools and techniques.
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.

Text/Reference:

1. Fundamental of Atmospheric Physics, M L Salby; Academic Press, Vol 61, 1996
2. The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3rd edn. 2002
3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
4. Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014

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PH 337-ATMOSPHERIC PHYSICS LAB
Credits-02 (0-0-4)

Course objectives:

- This laboratory content compliments the students regarding the atmospheric physics problem by performing Scilab/C++ based simulation.
- It enhances the qualitative skills of the students.

Scilab/C^{++} based simulations experiments based on Atmospheric Physics problems like (at least 08 experiments)

1. Numerical Simulation for atmospheric waves using dispersion relations
   (i) Atmospheric gravity waves (AGW)
   (ii) Kelvin waves
   (iii) Rossby waves, and mountain waves
2. Offline and online processing of radar data

(i) VHF radar,
(ii) X-band radar, and
(iii) 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.
7. PM 2.5 measurement using compact instruments.
8. Field visits to National center for medium range weather forecasting, India meteorological departments, and ARIES Nainital to see onsite radiosonde balloon launch, simulation on computers and radar operations on real time basis.

Text/Reference:

1. Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61, 1996
2. The Physics of Atmosphere – J T Houghton; Cambridge Univ. Press; 3rd edn. 2002
3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
4. Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014

Even Semester Options (DSE 3– 4): Select any 02 papers

PH 320- APPLIED DYNAMICS
Credits-04 (4-0-0)

Course objectives:

- This course is to provide basic and applied knowledge of dynamical systems, phase space, trajectories, and fluid dynamics.
- By the end of this course, students should be able to solve the seen or unseen problems/numerical in applied dynamics.

Introduction to Dynamical systems: Definition of a continuous first order dynamical system, The idea of phase space, flows and trajectories, Simple mechanical systems as first order dynamical systems: simple and damped harmonic oscillator, Sketching flows and trajectories in phase space, Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems, Examples of dynamical systems –Population models e.g. exponential growth and decay, logistic growth, predator-prey dynamics, Rate equations for chemical reactions e.g. auto catalysis, biostability.

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

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.

Nonlinear time series analysis and chaos characterization: Detecting chaos from Return map, Power spectrum, Autocorrelation, Lyapunov exponent, Correlation dimension.

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 and non-uniform flows, viscous and inviscid flows, incompressible and compressible flows, laminar and turbulent flows, rotational and irrotational flows, separated and unseparated flows, Flow visualization - streamlines, pathlines, Streaklines.

Text/Reference:

1. Nonlinear Dynamics and Chaos, S H Strogatz, Levant Books, Kolkata, 2007
2. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
3. Nonlinear Dynamics: Integrability, Chaos and Patterns, M Lakshmanan and S Rajasekar, (2003) Springer,.
4. An Introduction to Fluid Dynamics, G K Batchelor, (2002) Cambridge Univ. Press,
5. Fluid Mechanics, 2nd Edition, L D Landau and E M Lifshitz, (1987) Pergamon Press, Oxford

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PH 322-APPLIED DYNAMICS LAB

Credits-02 (0-0-4)

Course objectives:

- The laboratory content develops experimental and data analysis skills through a wide range of experiment of Applied Dynamics lab.
- Also, it provides the observational understanding of the subject. It enhances the qualitative and quantitative skills of the students.

Computing and visualizing trajectories using software such as Scilab, Maple, Octave, based on Applied Dynamics problems (at least 08 experiments)

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, predator-prey dynamics.
5. To study rate equations for chemical reactions e.g. auto catalysis, bistability.
6. To study examples from game theory.
7. To study period doubling route to chaos in logistic map.
8. To study various attractors of Lorenz equations.
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, Streaklines.

Text/Reference:

1. Nonlinear Dynamics and Chaos, Steven H. Strogatz, (2007) Levant Books, Kolkata,
2. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
3. An Introduction to Fluid Dynamics, G K Batchelor,(2002) Cambridge Univ. Press
4. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A VandeWouwer, P Saucez, C V Fernández, (2014) Springer

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PH 324-COMMUNICATION SYSTEM
Credits-04 (4-0-0)

Course objectives:

- This paper aims to describe the concepts of electronics in communication.
- Communication techniques based on Analog Modulation, Analog and digital Pulse Modulation including PAM, PWM, PPM, ASK, PSK, FSK are described in detail.
- Communication and Navigation systems such as GPS and mobile telephony system are introduced.

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.
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.
Analog Pulse Modulation: Channel capacity, Sampling theorem, Basic Principles-PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing.
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).
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.
Mobile Telephony System –Basic concept of mobile communication, frequency band sused 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), GPS navigation system (qualitative idea only).

Text/Reference:

1. Electronic Communications, D Roddy and J Coolen, Pearson Education India
2. Advanced Electronics Communication Systems- Tomasi, 6th edition, Prentice Hall
3. Modern Digital and Analog Communication Systems, B P Lathi, 4th Edition, 2011, Oxford University Press
4. Electronic Communication systems, G Kennedy, 3rdEdn., 1999, Tata McGraw Hill
5. Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill
6. Communication Systems, S. Haykin, 2006, Wiley India
7. Electronic Communication system, Blake, Cengage, 5th edition.
8. Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press

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PH 326-COMMUNICATION SYSTEM LAB
Credits-02 (0-0-4)

Course objectives:
- The laboratory content develops experimental and data analysis skills through a wide range of experiment of Communication lab.
- Also, it provides the observational understanding of the communication in real systems. It enhances the qualitative and technical skills of the students.

At least 08 experiments from the following
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.

Text/Reference:
1. Electronic Communication systems, G Kennedy, 1999, Tata McGraw Hill.
2. Electronic Communication system, Blake, Cengage, 5th edition.

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PH 328-NUCLEAR AND PARTICLE PHYSICS
Credits-06 (5-1-0)

Course objectives:
- The objective of the course is to impart the understanding of the sub atomic particles and their properties.
- It will emphasize to gain knowledge about the different nuclear techniques and their applications in different branches of Physics and societal application.
- The acquire knowledge can be applied in the areas of nuclear, medical, archaeology, geology and other interdisciplinary fields of Physics and Chemistry. It will enhance the special skills required for these fields.

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/Z plot, angular momentum, parity, magnetic moment, electric moments.
Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, nucleon separation energies, Fermi gas model, evidence for nuclear shell structure and the basic assumption of shell model.
Radioactivity decay: Decay rate and equilibrium (i) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, decay Chains. (ii) β-decay: energy kinematics for β-decay, β-spectrum, positron emission, electron capture, neutrino hypothesis. (iii) Gamma decay: Gamma ray emission from the excited state of the nucleus and kinematics, internal conversion.

Nuclear Reactions: Types of Reactions, units of related physical quantities, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering).
Interaction of Nuclear Radiation with matter: Energy loss due to ionization, energy loss of electrons, Cerenkov radiation, Gamma ray interaction through matter, neutron interaction with matter.
Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle for ionization chamber and GM Counter, Basic principle of Scintillation Detectors and construction of photo-multiplier tube, Semiconductor Detectors for charge particle and photon detection, neutron detector.
Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator, Linear accelerator, Cyclotron, Synchrotrons.
Particle physics: Particle interactions, basic features, types of particles and its families, Conservation Laws, concept of quark model, color quantum number and gluons.

Text/Reference:

1. Basic Ideas and concepts in Nuclear Physics: An introductory Approach by K Heyde, 3rd edition, 1999, IOP Publication.
2. Nuclear Physics by S. N. Ghoshal, First edition, 2010, S. Chand Publication,
3. Concepts of Nuclear Physics by Bernard L Cohen, 1974, Tata McGraw Hill Publication,
4. Introductory Nuclear Physics by Kenneth S, Krane, 2008, Wiley-India Publication,
5. Nuclear Physics: principles and applications by John Lilley, 2006, Wiley Publication,
6. Physics and Engineering of Radiation Detection by Syed Naeem Ahmed, 2007, Academic Press Elsevier
7. Radiation detection and measurement, G F Knoll, 2010, John Wiley &amp Sons
8. Technique for Nuclear and Particle Physics experiments by William R Leo, 1994, Springer,
9. Introduction to Modern Physics, Mani &amp, Mehta, 1990, Affiliated East-West Press
10. Introduction to elementary particles, David J Griffiths, 2008, Wiley
11. Modern Physics, Serway, Moses and Moyer, 2012, CENGAGE LEARNING,
12. Concepts of Modern Physics, Arthur Beiser, 2009, McGraw Hill Education,

For Numerical

1. Schaum's Outline of Modern Physics, 1999, McGraw-Hill Education,
2. Modern Physics, R. Murugaeshan, 2010, S. Chand Publication

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PH 330-DIGITAL SIGNAL PROCESSING

Credits-04 (4-0-0)

Course objectives:

- This paper describes the discrete-time signals and systems, Fourier Transform Representation of Aperiodic Discrete-Time Signals.
- This paper also highlights the concept of filters and realization of Digital Filters.
- At the end of the syllabus, students will develop the understanding of Discrete and fast Fourier Transform.

Discrete-Time Signals and Systems: Classification of Signals, Transformations of the Independent Variable, Periodic and Aperiodic Signals, Energy and Power Signals, Even and Odd Signals, Discrete-Time Systems, System Properties, Impulse Response, Convolution Sum, Graphical Method, Analytical Method, Properties of Convolution, Commutative, Associative, Distributive, Shift, Sum Property System Response to Periodic Inputs, Relationship Between LTI System Properties and the Impulse Response, Causality, Stability, Invertibility, Unit Step Response.

Discrete-Time Fourier Transform: Fourier Transform Representation of Aperiodic Discrete-Time Signals, Periodicity of DTFT, Properties, Linearity, Time Shifting, Frequency Shifting, Differencing in Time Domain, Differentiation in Frequency Domain, Convolution Property.
The*z*-Transform: Bilateral (Two-Sided) *z*-Transform, Inverse *z*-Transform, Relationship Between *z*-Transform and Discrete-Time Fourier Transform, *z*-plane, Region-of-Convergence, Properties of ROC, Properties, Time Reversal, Differentiation in the *z*-Domainm, Power Series Expansion Method (or Long Division Method), Analysis and Characterization of LTI Systems, Transfer Function and Difference-Equation System, Solving Difference Equations.
Filter Concepts: Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters, Simple IIR Digital Filters, All pass Filters, Averaging Filters, Notch Filters.
Discrete Fourier Transform: Frequency Domain Sampling (Sampling of DTFT), The Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, Properties, Periodicity, Linearity, Circular Time Shifting, Circular Frequency Shifting, Circular Time Reversal, Multiplication Property, Parseval's Relation, Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution), Circular Convolutions, Linear Convolution with aliasing.
Fast Fourier Transform: Direct Computation of the DFT, Symmetry and Periodicity Properties of the Twiddle factor (*WN*), Radix-2 FFT Algorithms, Decimation-In-Time (DIT) FFT Algorithm, Decimation-In-Frequency (DIF) FFT Algorithm, Inverse DFT Using FFT Algorithms.
Realization of Digital Filters: Non Recursive and Recursive Structures, Canonic and Non Canonic Structures, Equivalent Structures (Transposed Structure), FIR Filter structures, Direct-Form, Cascade-Form, Basic structures for IIR systems, Direct-Form I.
Finite Impulse Response Digital Filter: Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR and IIR Filters, Difference Between FIR and IIR Filters, Desirability of Linear-Phase Filters, Frequency Response of Linear-Phase FIR Filters, Impulse Responses of Ideal Filters, Windowing Method, Rectangular, Triangular, Kaiser Window, FIR Digital Differentiators.
Infinite Impulse Response Digital Filter: Design of IIR Filters from Analog Filters, IIR Filter Design by Approximation of Derivatives, Backward Difference Algorithm, Impulse Invariance Method.

Text/Reference:

1. Digital Signal Processing, Tarun Kumar Rawat, 2015, Oxford University Press, India
2. Digital Signal Processing, S K Mitra, McGraw Hill, India.
3. Principles of Signal Processing and Linear Systems, B P Lathi, 2009, 1st Edn. Oxford University Press
4. Fundamentals of Digital Signal processing using MATLAB, R J Schilling and S L Harris, 2005, Cengage Learning
5. Fundamentals of signals and systems, P D Cha and J I Molinder, 2007, Cambridge University Press
6. Digital Signal Processing Principles Algorithm & Applications, J G Proakis and D G Manolakis, 2007, 4thEdn., Prentice Hall

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PH 332-DIGITAL SIGNAL PROCESSING LAB
Credits-02 (0-0-4)

Course objectives:
- The laboratory content develops experimental and data analysis skills through a wide range of experiment of digital signal processing lab.
- Also, it provides the observational understanding of the digital signal using MATLAB programming. It enhances the qualitative and quantitative analysis skills of the students.

At least 08 experiments from the following using Scilab/Matlab.

1. Write program to generate and plot sequences.
2. Write a program to compute the convolution sum of a rectangle signal (or gate function) with itself.
3. Determine and plot the steady state response of an LTI system.
3. For a given casual system, find and sketch its pole-zero plot; Plot the frequency response.
4. Design a high-pass filter at a given sampling frequency. Plot its pole zero diagram, magnitude response, input and output of the filter.
5. Compute the DFT of a 4-point sequence and plot its magnitude.
6. Write a program to compute the linear convolution of two four point sequences using circular convolution.
7. Using a rectangular window, design a FIR low-pass filter with a pass-band gain of unity, given the cut-off frequency, sampling frequency and impulse response.
8. Design of an FIR band-pass filter with the given specifications: passband edge, stopband edge, Passband attenuation, Stopband attenuation, Sampling frequency.
9. The frequency response of a linear phase digital differentiator is given. Design a digital FIR differentiator. Plot the amplitude response.

Text/Reference:

1. Digital Signal Processing, Tarun Kumar Rawat, Oxford University Press, India.
2. A Guide to MATLAB, B R Hunt, R L Lipsman, J M Rosenberg, 2014, 3rdEdn., Cambridge University Press
3. Fundamentals of Digital Signal processing using MATLAB, R J Schilling and S L Harris, 2005, Cengage Learning
4. Getting started with MATLAB, Rudra Pratap, 2010, Oxford University Press
5. Digital Signal Processing, S K Mitra, McGraw Hill, India.
6. Fundamentals of signals and systems, P D Cha and J I Molinder, 2007, Cambridge University Press

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PH 334-DISSERTATION

Credits: 12

Dissertation involves project work with the intention of exposing the student to research/development. It involves open ended learning based on student ability and initiative, exposure to scientific writing and inculcation of ethical practices in research and communication.

The dissertation work should not be a routine experiment or project at the under graduate level. It should involve more than text book knowledge. Referring text books for preparation and understanding concepts is allowed; however, one component of the dissertation must include study of research papers or equivalent research material and/or open-ended project.

The dissertation report should be of around 30 pages. It must have minimum three chapters namely (1) Introduction, (2) the main work including derivations / experimentation and Results, and (3) Discussion and Conclusion. At the end, adequate references must be included. Plagiarism should be avoided by the student and this should be checked by the supervisor.

Generic Elective Papers (GE) (Minor-Physics) (any four- 01 from each group) for other Departments/Disciplines: (Credit: 06 each)

SEMESTER-I: (Choose any one)

PH 119-MECHANICS

Credits-04 (4-0-0)

Vectors: Vector algebra, Derivatives of a vector with respect to a parameter, Scalar and vector products of two, three and four vectors, Gradient, divergence and curl of vector fields, Polar and Axial vectors.
Laws of Motion: Review of Newton's Laws of motion, Dynamics of a system of particles, Concept of Centre of Mass, determination of center of mass for discrete and continuous systems having cylindrical and spherical symmetry.
Work and Energy: Motion of rocket, Work-Energy theorem for conservative forces, Force as a gradient of Potential Energy, Conservation of momentum and energy, Elastic and inelastic Collisions.
Rotational Dynamics: Angular velocity, Angular momentum, Torque, Conservation of angular momentum, Moment of Inertia, Theorem of parallel and perpendicular axes (statements only), Calculation of Moment of Inertia of discrete and continuous objects, Kinetic energy of rotation, Motion involving both translation and rotation.
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 (statements only), Satellite in circular orbit and applications, Geosynchronous orbits.
Oscillations: Simple harmonic motion, Differential equation of SHM and its solutions, Kinetic and Potential Energy, Total Energy and their time averages, Compound pendulum, Differential equations of damped oscillations and forced oscillations and their solution.
Special Theory of Relativity: Frames of reference, Gallilean Transformations, Inertial and Non-inertial frames, Outcomes of Michelson Morley's Experiment, Postulates of Special Theory of Relativity, Length contraction, Time dilation, Relativistic transformation of velocity, Relativistic variation of mass, Mass-energy equivalence, Transformation of Energy and Momentum.

Text/Reference:

1. University Physics, F W Sears, M W Zemansky and H D Young13th Ed., 1986, Addison-Wesley
2. Mechanics: Berkeley Physics course, v.1: Charles Kittel, et.al. 2007, Tata McGraw-Hill
3. Physics, Resnick, Halliday & Walker 9th Ed., 2010, Wiley
4. Engineering Mechanics, Basudeb Bhattacharya, 2nd Ed., 2015, Oxford University Press
5. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

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PH 121-MATHEMATICAL PHYSICS

Credits-04 (4-0-0)

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials, Integrating factor, with simple illustration, Constrained Maximization using Lagrange Multipliers,
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, Even and odd functions and their Fourier expansions, Application, Summing of Infinite Series.
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 Differential Equations, Properties of Legendre Polynomials: Rodrigues Formula, Orthogonality, Simple recurrence relations.
Some Special Integrals: Beta and Gamma Functions and Relation between them, Expression of Integrals in terms of Gamma Functions.
Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular geometry, Solution of 1D wave equation.
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, Integration of a function of a complex variable, Cauchy's Integral formula.

Text/Reference:

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier
2. Fourier Analysis, M R Spiegel, 2004, Tata McGraw-Hill
3. Essential Mathematical Methods, K F Riley and M P Hobson, 2011, Cambridge University Press
4. Engineering Mathematics, S Pal and S C Bhunia, 2015, Oxford University Press
5. An Introduction to Ordinary Differential Equations, E A Coddington, 1961, PHI Learning
6. Differential Equations, George F Simmons, 2006, Tata McGraw-Hill

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SEMESTER-II: (Choose any one)

PH 120-ELECTRICITY AND MAGNETISM

Credits-04 (4-0-0)

Vector Analysis: Vector algebra (Scalar and Vector product), gradient, divergence, Curland their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem (statement only).
Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics, Applications of Gauss theorem, Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor, Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere, Calculation of electric field from potential, Capacitance of an isolated spherical conductor, Parallel plate, spherical and cylindrical condenser, Energy per unit volume in electrostatic field, Dielectric medium, Polarisation, Displacement vector, Gauss's theorem in dielectrics, Parallel plate capacitor completely filled with dielectric.
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.
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, Introduction to Maxwell`s equations.

Text/Reference:

1. Vector analysis – Schaum's Outline, M R Spiegel, S Lipschutz, D Spellman, 2ndEdn., 2009, McGraw- Hill Education
2. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
3. Electricity & Magnetism, J H Fewkes & J Yarwood. Vol. I, 1991, Oxford University Press
4. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House

5. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole
6. Introduction to Electrodynamics, D J Griffiths, 3rd Edn, 1998, Benjamin Cummings

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PH 122-WAVES AND OPTICS

Credits-04 (4-0-0)

Superposition of Two Collinear Harmonic oscillations: Simple harmonic motion (SHM), Linearity and Superposition Principle, (i) Oscillations having equal frequencies and (ii) Oscillations having different frequencies (Beats).
Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods, Lissajous Figures (1:1 and 1:2) and their uses.
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.
Sound: Sound waves, production and properties, Intensity and loudness of sound, Decibels, Intensity levels, General idea of musical notes and musical scale, Acoustics of buildings (General idea).
Wave Optics: Electromagnetic nature of light, Definition and Properties of wave front, Huygens Principle.
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, Newton's Rings: measurement of wavelength and refractive index.
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.
Polarization: Transverse nature of light waves, Plane polarized light–production and analysis, Circular and elliptical polarization (General idea).

Text/Reference:

1. Vibrations and Waves, A P French, 1stEd., 2003, CRC press
2. The Physics of Waves and Oscillations, N K Bajaj, 1998, Tata McGraw Hill
3. Fundamentals of Optics, F A Jenkins and H E White, 1976, McGraw-Hill
4. Principles of Optics, B K Mathur, 1995, Gopal Printing
5. Fundamentals of Optics, A Kumar, H R Gulati and D R Khanna, 2011, R. Chand Publications
6. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley
7. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill

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SEMESTER-III: (Choose any one)

PH 229- THERMAL PHYSICS AND STATISTICAL MECHANICS

Credits-04 (4-0-0)

Laws of Thermodynamics: Thermodynamic Description of system: Zero'th 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, Reversible and irreversible processes, Second law, Entropy, Carnot's cycle & theorem, Entropy

changes in reversible and irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.
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.
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.
Theory of Radiation: Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's law, Rayleigh-Jeans Law, Stefan Boltzmann Law &Wien's displacement law from Planck's law.
Statistical Mechanics: Maxwell-Boltzmann law - distribution of velocity – Quantum statistics – Macrostate and Microstate – Entropy and Thermodynamic Probability - Phase space - Fermi-Dirac distribution law - Bose-Einstein distribution law - photon gas - comparison of three statistics.

Text/Reference:

1. Thermal Physics, S Garg, R Bansal and C Ghosh, 1993, Tata McGraw-Hill
2. A Treatise on Heat, Meghnad Saha, and B N Srivastava, 1969, Indian Press
3. Heat and Thermodynamics, M W Zemasky and R Dittman, 1981, McGraw Hill
4. Thermodynamics, Kinetic theory & Statistical thermodynamics, F W Sears and G L Salinger. 1988, Narosa
5. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole
6. Thermal Physics, A Kumar and S P Taneja, 2014, R. Chand Publications

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PH 231-ELEMENTS OF MODERN PHYSICS
Credits-04 (4-0-0)

Quantum theory of wave and particle: 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.
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, 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, 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.
One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example, Quantum mechanical scattering and tunneling in one dimension - across a step potential and across a rectangular potential barrier.
Nuclear Physics: Size and structure of atomic nucleus and its relation with atomic weight, Impossibility of an electron being in nucleus as a consequence of the uncertainty principle, Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy.
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.

Text/Reference:

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

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SEMESTER-IV: (Choose any one)

PH 230-NUCLEAR AND PARTICLE PHYSICS

Credits-06 (5-1-0)

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/Z plot, angular momentum, parity, magnetic moment, electric moments.

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, nucleon separation energies (up to two nucleons), Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure and the basic assumption of shell model.

Radioactivity decay: Decay rate and equilibrium (Secular and Transient) (i) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, decay Chains, (ii) β-decay: energy kinematics for β-decay, β-spectrum, positron emission, electron capture, neutrino hypothesis. (iii) Gamma decay: Gamma rays emission from the excited state of the nucleus & kinematics, internal conversion.

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

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.

Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle for 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.

Particle Accelerators: Accelerator facility available in India: Van-de Graff Generator (Tandem accelerator), Linear accelerator, Cyclotron.

Particle physics: Particle interactions (concept of different types of forces), basic features, Cosmic Rays, types of particles and its families, Conservation Laws (energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness) concept of quark model, color quantum number and gluons.

Text/Reference:

1. Basic Ideas and concepts in Nuclear Physics: An introductory Approach by K Heyde, 1999,Third edition, IOP Publication
2. Nuclear Physics by S. N. Ghoshal, First edition, 2010, S. Chand Publication
3. Concepts of Nuclear Physics by Bernard L Cohen, 1974, Tata McGraw Hill Publication
4. Introductory Nuclear Physics by Kenneth S, Krane, 2008, Wiley-India Publication
5. Nuclear Physics: principles and applications by John Lilley, 2006, Wiley Publication

6. Physics and Engineering of Radiation Detection by Syed Naeem Ahmed, 2007, Academic Press Elsevier,
7. Radiation detection and measurement, G F Knoll, 2010, John Wiley & Sons
8. Technique for Nuclear and Particle Physics experiments by William R Leo, 1994, Springer
9. Introduction to Modern Physics by Mani & Mehta, 1990, Affiliated East-West Press
10. Introduction to elementary particles by David J Griffiths, 2008, Wiley
11. Modern Physics by Serway, Moses and Moyer, 2012, Cengage Learning
12. Concepts of Modern Physics by Arthur Beiser, 2009, McGraw Hill Education

For Numericals
1. Schaum's Outline of Modern Physics, 1999, McGraw-Hill Education
2. Modern Physics by R Murugaeshan, 2010, S. Chand Publication

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PH 232-DIGITAL, ANALOG CIRCUITS AND INSTRUMENTATION
Credits-04 (4-0-0)

Digital Circuits
Difference between Analog and Digital Circuits, Binary Numbers, Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates, NAND and NOR Gates as Universal Gates, XOR and XNOR Gates, 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 (i) Sum of Products Method and (ii) Karnaugh Map, Binary Addition, Binary Subtraction using 2's Complement Method, Half Adders and Full Adders and Subtractors, 4-bit binary Adder-Subtractor.
Semiconductor Devices and Amplifiers: Semiconductor Diodes: p and n type semiconductors, p-n junction and its characteristics, Static and dynamic Resistance, Bipolar Junction transistors: n-p-n and p-n-p Transistors, Characteristics of CB, CE and Configurations, Active, Cutoff & Saturation regions, Current gains α and β. Relations between α and β, Load Line analysis of Transistors, DC Load line & Q-point, Voltage Divider Bias Circuit for CE Amplifier, h-parameter Equivalent Circuit of transistor, Analysis of single-stage CE amplifier using hybrid model, Input and output Impedance, Current and Voltage gains.
Operational Amplifiers: 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: (i) Inverting and non-inverting Amplifiers, (ii) Adder, (iii) Subtractor, (iv) Differentiator, (v) Integrator, (vi) Zero crossing detector.
Sinusoidal Oscillators: Barkhausen's Criterion for Self-sustained Oscillations, Determination of Frequency of RC Phase-shift Oscillator.
Instrumentations: Introduction to CRO: Block diagram of CRO, Applications of CRO: (i) Study of waveform, (ii) Measurement of voltage, current, frequency, and phase difference.
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.
Timer IC: IC 555 Pin diagram and its application as Astable and Monostable Multivibrator.

Reference Books:
1. Integrated Electronics, J Millman and C C Halkias, 1991, Tata Mc-Graw Hill
2. Electronic devices & circuits, S Salivahanan & N S Kumar, 2012, Tata Mc-Graw Hill
3. Microelectronic Circuits, M H Rashid, 2nd Edn., 2011, Cengage Learning
4. Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper,1990, PHI Learning

5. Digital Principles and Applications, A P Malvino, D P Leach and Saha, 7th Ed., 2011, Tata McGraw Hill
6. Microelectronic circuits, A S Sedra, K C Smith, A N Chandorkar, 2014, 6thEdn., Oxford University Press
7. OP-AMP & Linear Digital Circuits, R A Gayakwad, 2000, PHI Learning Pvt. Ltd.

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PH 234-DIGITAL, ANALOG CIRCUITS AND INSTRUMENTATION LAB
Credits-02 (0-0-2)
At least 08 Experiments from the following

1. To measure (i) Voltage, and (ii) Frequency of a periodic waveform using CRO.
2. To minimize a given (i) logic circuit and (ii) Boolean equation.
3. Half adder, Full adder and 4-bit Binary Adder.
4. To design an astable multivibrator of given specifications using 555 Timer.
5. To design a monostable multivibrator of given specifications using 555 Timer.
6. To study IV characteristics of (i) p-n diode, (ii) Zener diode and (iii) LED.
7. To study the characteristics of a Transistor in CE configuration.
8. To design a CE amplifier of given gain (mid-gain) using voltage divider bias.
9. (i) To design an inverting amplifier using Op-amp 741 and study its frequency response.
   (ii) To design a non-inverting amplifier using Op-amp 741 and study its frequency response.
10. To study Differential Amplifier of given I/O specification using Op-amp.
11. To investigate a differentiator made using Op-amp.
12. To design a Wien Bridge Oscillator using an Op-amp.

Text/Reference:

1. Integrated Electronics, J Millman and C C Halkias, 1991, Tata Mc-Graw Hill
2. Fundamentals of Digital Circuits, Anand Kumar, 4nd Edn, 2018, PHI Learning Pvt. Ltd.

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