Syllabus, Lesson Plan and Course outcome of Physics (Honours)

Semester-I

Course Code: BPHSCCHC101 Course Title: Mathematical Physics I
Course Type CC-1 Credit: 6
Course Instructor: Dr. Sahazada Aziz
Total class allotted: 70 Total Hours: 80

Module-I Calculus
Lectures: 21 Hours: 21

Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). **(2 Lectures)**

First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. **(13 Lectures)**

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

Module-II Vector Calculus
Lectures: 33 Hours: 33

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields. **(5 Lectures)**

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities. **(8 Lectures)**

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs). **(14 Lectures)**

Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. **(6 Lectures)**

Module-III Introduction to probability
Lectures: 6 Hours: 6

Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance. Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing. **(4 Lectures)**

Dirac Delta function and its properties
Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function. **(2 Lectures)**

Module-IV Practical
Instructor: Dr. Sahazada Aziz
Class: 10 Hours: 20

Introduction and Overview
Computer architecture and organization, memory and Input/output devices

Basics of scientific computing
Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow &overflow emphasize the importance of making equations in terms of dimensionless variables, Iterative methods

Errors and error Analysis
Truncation and round off errors, Absolute and relative errors, Floating point computations.

Introduction to programming in python
Introduction to programming, constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, iteration, compound statements, indentation in python, the if-else-if-else block, for and while loops, nested compound statements, lists, tuples, dictionaries and strings, basic ideas of object oriented programming.

Programs
Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search

Introduction to plotting graphs with Gnuplot
Basic 2D and 3D graph plotting, plotting functions and datafiles, fitting data using gnuplot's fit function, polar and parametric plots, modifying the appearance of graphs, Surface and contour plots, exporting plots.

Numerical Methods
1. Solution of Algebraic and Transcendental equations (Bisection, Newton-Raphson method)
2. Numerical differentiation (Forward and Backward difference formula)
3. Numerical Integration (Trapezoidal and Simpson rules)

Course Outcome

- Recapitulate calculus they have learned in higher-secondary level.
- Students will learn vector calculus and differential calculus: two of the most important skill one can have to solve real life problems. Vector calculus has direct applications in solving problems related to Mechanics, Electrostatics, Magnetostatics etc.
- Most of the problems of Engineering and Physics boil down to solving a diffrential equation subjected to initial or boundary conditions. In this course students will learn some basic methods of solving the equations.
- Students will learn to solve simple problems of probability and statistics which will help them to analyze large data.
- Learning Dirac-delta function will help understanding quantum mechanics better.
- Not all the problems are solved exactly using conventional methods-we have to take resort to resort to Numerical Methods then, to solve the problems numerically. In the practical sections students learn to solve such problems.
- Learning Programming language is a must for modern day professionals: in the practical section students learn the basics of PYTHON programming. Their basic computer skills are also bound to enhance through this.
- For data visualization they are acquainted with GNUPlot- a free software for graph plotting.
- In summary, learning Mathematical Physics I course will open the window of the whole science and technology to the students and enhance the mathematical and computational skill sets to a greater deal.

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P.O. - Laulara, Dist.-Purulia

Course Code: BPHSCCHC10 Course Title: Mechanics Course Type: CC-2 Credit: 6
Instructor: Mr. Ujjal Bid

Theory
Module-I: Fundamentals of Dynamics
Lectures/Class: 25 Hours: 25

Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable- mass system: motion of rocket. Motion of a projectile in Uniform gravitational field Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. **(6 Lectures)**

Work and Energy
Work and Kinetic Energy Theorem. Conservative and non- conservative forces. Potential Energy. Qualitative study of one dimensional motion from potential energy curves. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy. **(4 Lectures)**

Collisions
Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames. **(3 Lectures)**

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. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation. **(12 Lectures)**

Module-II: Properties of Matter and Gravitation
Lectures/Class: 11 Hours: 14

Elasticity
Relation between Elastic constants. Twisting torque on a Cylinder or Wire. **(3 Lectures)**

Fluid Motion
Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube. **(2 Lectures)**

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. **(3 Lectures)**
Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). **(6 Lectures)**

Module-III Oscillations and Non-Inertial Systems
Lectures/Class: 11 Hours: 11

Oscillations
SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor. **(7 Lectures)**

Non-Inertial Systems:
Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems. **(4 Lectures)**

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Module-IV Special Theory of Relativity
Lectures/Class: 10 Hours: 10

Special Theory of Relativity
Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Concept of zero rest mass of photon. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum. (10 Lectures)

Module-V Practical
Lectures/Class: 10 Hours: 20

List of Practicals (at least six practicals)

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.

2. To study the random error in observations.

3. To determine the Moment of Inertia of a Cylinder.

4. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).

5. To determine the Young's Modulus of a Wire by Flexural/ Optical Lever Method.

6. To determine the value of g using Kater's Pendulum.

7. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.

8. To determine the elastic Constants of a wire by Searle's method.

9. To study the Motion of Spring and calculate, (a) Spring constant, (b) g and (c) Modulus of rigidity.

Course Outcome

The students would learn about the behaviour of physical bodies it provides the basic concepts related to the motion of all the objects around us in our daily life. They will also learn about various properties of matter which are used in our everyday life, like viscosity, surface-tension and elasticity. The course builds a foundation of various applied field in science and technology; especially in our day-to-day life. The course comprises of the study vectors, laws of motion, momentum, energy, rotational motion, gravitation, fluids, elasticity and special relativity.

LAB: Students would perform basic experiments related to mechanics and also get familiar with various measuring instruments would learn the importance of accuracy of measurements.

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Semester-II

Course Code: BPHSCCHC201 Course Title: Electricity and Magnetism Course Type: CC-3 Credit: 6
Course Instructor: Dr. Sahazada Aziz
Total class allotted: 70 Total Hours: 80

Module-I Electrostatics
Lectures/Class: 30 Hours: 30

Electric Field and Electric Potential
Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry.**(6 Lectures)**

Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole.**(6 Lectures)**

Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Uniqueness theorem (statement). Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere. **(10 Lectures)**

Dielectric Properties of Matter
Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector D. Relations between E, P and D. Gauss' Law in dielectrics. **(8 Lectures)**

Module-II Magnetostatics and Electromagnetic Induction
Lectures/Class: 21 Hours: 21

Magnetic Field
Magnetic force between current elements and definition of Magnetic Field B. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole).
(5 Lectures)

Ampere's Circuital Law and its application to (1) infinite straight wire, (2) Infinite planar surface current, and (3) Solenoid. Properties of B: curl and divergence. Axial vector property of B and its consequences. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field.
(5 Lectures)

Magnetic Properties of Matter
Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis.
(4 Lectures)

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.
(7 Lectures)

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Module-III Electric Circuits
Lectures/Class: 9 Hours: 9

Electrical Circuits

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

Network theorems

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

Module-IV Practical
Lectures/Class: 10 Hours: 20
Electrical Circuits

General topic

Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.

List of Practicals (at least 6)

1. To study the characteristics of a series RC Circuit.
2. To determine an unknown Low Resistance using Potentiometer.
3. To determine an unknown Low Resistance using Carey Foster's Bridge.
4. To determine the resistance of a galvanometer by half deflection method.
5. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
6. To verify the Thevenin and Norton theorems.
7. To verify the Superposition, and Maximum power transfer theorems.
8. To determine self-inductance of a coil by Anderson's bridge.
9. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
10. To study the response curve of a parallel LCR circuit and determine its (a) Anti- resonantfrequency and (b) Quality factor Q.

<u>Course Outcome</u>

- In this course students understand one of the four fundamentals and most commonly felt force of nature and its manifestations: electrostatics, magnetostatics, electricity and magnetism.
- They learn the origin of electric and magnetic field and potentials. The course also teach them to solve real life problems involving charge and currents. These have direct bearings to technology.
- Students learn that changing electric field produces magnetic field and vice-versa. These principles used in most of the electrical equipment and machines starting with fans, motors to turbines, electrical engines etc.
- Students learn to work with both DC and AC currents and their circuits.
- All the factories, Research labs, Defense labs, Large and Small engines, communications have electrical and magnetic components; These course help the students to acquire the skills and basic working knowledge to handle those equipment.
- The practicals performed in the departmental laboratory equip them to handle more complicated and heavy electrical set ups of the real world and also help them to understand the theories they learn in the classroom.

Course Code: BPHSCCHC202 Course Title: Waves and Optics Course Type: CC-3 Credit: 6
Course Instructor: Dr. Soumendra Nath Ruz
Total class allotted: 70 Total Hours: 80

Module-I Oscillations and Waves
Lectures/Class: 25 Hours: 25

Superposition of Collinear Harmonic oscillations
Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). **(2 Lectures)**

Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. **(2 Lectures)**

Superposition of two perpendicular Harmonic Oscillations
Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. **(3 Lectures)**

Wave Motion
Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves. **(4 Lectures)**

Velocity of Waves
Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction. **(6 Lectures)**

Superposition of Two Harmonic Waves
Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves. **(7 Lectures)**

Module-II Wave Optics
Lectures/Class: 36 Hours: 36

Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. **(3 Lectures)**

Interference
Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index. **(9 Lectures)**

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

Diffraction and Holography
Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula. (Qualitative discussion only) **(2 Lectures)**

Fraunhofer diffraction
Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. **(8 Lectures)**

Fresnel Diffraction
Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire. **(7 Lectures)**

Holography
Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms. **(3 Lectures)**

Module-III Practical
Lectures/Class: 10 Hours: 20

Practical
List of Practicals
1. To determine refractive index of the Material of a prism using sodium source.
2. To determine the wavelength of sodium source using Michelson's interferometer.
3. Familiarization with: Schuster`s focusing; determination of angle of prism.
4. To determine wavelength of sodium light using Fresnel Biprism.
5. To determine wavelength of sodium light using Newton's Rings.
6. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
7. To determine dispersive power and resolving power of a plane diffraction grating.
8. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ2 –T law.
9. To investigate the motion of coupled oscillators.
10. To study Lissajous Figures.

COURSE OUTCOME

The course comprises of the study of superposition of harmonic oscillations, waves motion (general), oscillators, sound, wave optics, interference, diffraction, polarization. The course is important for the students to make their career in various branches of science and engineering, especially in the field of photonic engineering.
LAB: The practical knowledge of wave motion doing experiments: Tuning fork, electric vibrations. They would also learn optical phenomena such as interference, diffraction and dispersion and do experiments related to optical devices: Prism, grating, spectrometers.

SEMESTER-III

Course Code: BPHSCCHC301 Course Title: Mathematical Physics-II Course Type: CC-5 Credit: 6
Course Instructor: Dr. Sahazada Aziz
Total class allotted: 70 Total Hours: 80

Module-I Fourier Series
Lectures/Class: 10 Hours: 10

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

Module-II Frobenius Method and Special Functions
Lectures/Class: 28 Hours: 28

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 (Jo(x) and J1(x))and Orthogonality. **(24 Lectures)**

Some Special Integrals
Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral). **(4 Lectures)**

Module-III Variational Calculus
Lectures/Class: 6 Hours: 6
Variational calculus in physics
Functionals. Basic ideas of functionals. Extremization of action as a basic principle in mechanics. Lagrangian fomulation. Euler's equations of motion for simple systems: harmonics oscillators, simple pendulum, spherical pendulum, coupled oscillators. Cyclic coordinates. Symmetries and conservation laws. Legendre transformations and the Hamiltonian formulation of mechanics. Canonical equations of motion. Applications to simple systems. **(6 Lectures)**

Module-IV Partial Differential Equations
Lectures/Class: 14 Hours: 14

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

Module-IV Practical
Lectures/Class: 10 Hours: 20

Introduction to Numerical computation using numpy and scipy
Introduction to the python numpy module. Arrays in numpy, array operations, array item selection, slicing, shaping arrays. Basic linear algebra using the linalg submodule. Introduction to online graph plotting using matplotlib. Introduction to the scipy module. Uses in optimization and solution of differential equations.

Solution of Ordinary Differential Equations (ODE), First order Differential equation (Runge-Kutta (RK) second and fourth order methods)

First order differential equation
► Radioactive decay

► Current in RC, LC circuits with DC source
► Newton's law of cooling
► Classical equations of motion
► Harmonic oscillator (no friction)
►Damped Harmonic oscillator a) Over damped b) Critical damped
►Oscillatory Motion
►Forced Harmonic oscillator
►Transient and Steady state solution
►Apply above to LCR circuits also

Partial differential equations
1. Wave equation
2. Heat equation
3. Poisson equation
4. Laplace equation

Second order differential equation Fixed difference method

Solution of Linear system of equations (Gauss elimination method and Gauss Seidal method)

1. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems
2. Solution of mesh equations of electric circuits (3 meshes)
3. Solution of coupled spring mass systems (3 masses)

COURSE OUTCOME

This course comprise some topics on mathematical physics-the topics are Fourier series, solution of differential eqaution by series solution method, Legendre and Bessel's polynomial, Beta and Gamma functions and variational calculus, After studying this course students will gain the mathematical skill to solve the problems related to wave motion, solution of longitudinal and transverse waves, solution of Schroedinger equation in Hydrogen atoms, kinetic theories etc. Variational calculus is the backbone of Lagrangian and Hamiltonian mechanics which is the most fundamental branch of physics.
In the practical section students learn to apply the numerical techniques and Python programming to solve problems of differential equtions.

Course Code: BPHSCCHC302 Course Title: Thermal Physics Course Type: CC-6 Credit: 6
Course Instructor: Dr. Soumendra Nath Ruz
Total class allotted: 70 Total Hours: 80

Module-I Introduction to Thermodynamics
Lectures/Class: 18 Hours: 18

Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient. **(8 Lectures)**

Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of temperature and its Equivalence to Perfect Gas Scale. **(10 Lectures)**

Module-II Entropy and Thermodynamic Potential
Lectures/Class: 21 Hours: 21

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 Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero. **(7 Lectures)**

Thermodynamic Potentials

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature, Magnetic Work. Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations. **(7 Lectures)**

Maxwell's Thermodynamic Relations

Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of Cp-Cv, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van derWaal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process. **(7 Lectures)**

Module-III Kinetic Theory and Real Gases
Lectures/Class: 21 Hours: 21

Kinetic Theory of Gases

Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases. **(7 Lectures)**

Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance. **(4 Lectures)**

Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule- Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule- Thomson Cooling. **(10 Lectures)**

Module-III Practical
Lectures/Class: 10 Hours: 20

List of Practicals

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.

2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.

3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.

4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.

5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).

6. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.

7. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.

COURSE OUTCOME

The course makes the students able to understand the basic physics of heat and temperature and their relation with energy, work, radiation and matter. The students also learn how laws of thermodynamics are used in a heat engine to transform heat into work. The course contains the study of laws of thermodynamics, thermodynamic description of systems, thermodynamic potentials, kinetic theory of gases, theory of radiation and statistical mechanics.

LAB: Students would gain practical knowledge about heat and radiation, thermodynamics, thermo emf, RTD etc. and perform various experiments.

Course Code: BPHSCCHC303 Course Title: Analog Systems and Applications Course Type: CC-7 Credit: 6
Course Instructor: Mr. Ujjal Bid
Total class allotted: 70 Total Hours: 80

Module-I Semiconductor Diodes
Lectures/Class: 16 Hours: 16

Semiconductor Diodes
P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current Flow Mechanism in Forward and Reverse Biased Diode. **(10 Lectures)**

Two-terminal Devices and their Applications
Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter, Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell. **(6 Lectures)**

Module-II BJT and FET
Lectures/Class: 10 Hours: 10

Bipolar Junction transistors
n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions. **(8 Lectures)**

Field Effect transistors
Basic principle of operations only. **(2 Lectures)**

Module-III Amplifiers and Oscillators
Lectures/Class: 19 Hours: 19

Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. Frequency response of a CE amplifier. **(8 Lectures)**

Coupled Amplifier: Two stage RC-coupled amplifier and its frequency response. **(3 Lectures)**

Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. **(4 Lectures)**

Sinusoidal Oscillators:
Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators. **(4 Lectures)**

Module-IV Operational Amplifiers and Oscillator
Lectures/Class: 15 Hours: 15

Operational Amplifiers (Black Box approach):
Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. **(4 Lectures)**

Applications of Op-Amps: Linear - (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Weinbridge oscillator. Non-linear – (1) inverting and non-inverting comparators, (2) Schmidt triggers. **(8 Lectures)**

Conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation) **(3 Lectures)**

Module-IV Practical
Class: 10 Hours: 20

List of Practicals (at least 6 experiments)

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. To study the characteristics of a Bipolar Junction Transistor in CE configuration.

4. To design an inverting amplifier using Op-amp (741) for dc voltage of given gain

5. To design inverting amplifier using Op-amp (741) and study its frequency response

6. To design non-inverting amplifier using Op-amp (741) & study its frequency response

7. To add two dc voltages using Op-amp in inverting and non-inverting mode

8. To investigate the use of an op-amp as an Integrator.

9. To investigate the use of an op-amp as a Differentiator.

10. To study the various biasing configurations of BJT for normal class A operation.

11. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.

COURSE OUTCOME

At the end of this course, students will be able to
1. To analyze the BJT and MOS amplifiers.
2. To analyze the differential amplifiers.
3. To analyze negative feedback amplifiers.
4. To analyze the power amplifiers.

Course Code: BPHSCCHC305 Course Title: Renewable Energy and Energy harvesting Course Type: SEC-1 Credit: 2
Course Instructor: Dr. Soumendra Nath ruz
Total class allotted: 20 Total Hours: 20

Module-I

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. **(3 Lectures)**

Solar energy

Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems. **(6 Lectures)**

Wind Energy harvesting

Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. **(3 Lectures)**

Ocean Energy

Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. **(3 Lectures)**
Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass. **(2 Lectures)**

Geothermal Energy

Geothermal Resources, Geothermal Technologies. (2 Lectures)

Hydro Energy

Hydropower resources, hydropower technologies, environmental impact of hydro power sources. (2 Lectures)

Piezoelectric Energy harvesting

Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power. (4 Lectures)

Electromagnetic Energy Harvesting

1. Linear generators, physics mathematical models, recent applications . (2 Lectures)

2. Carbon captured technologies, cell, batteries, power consumption (2 Lectures)

3. Environmental issues and Renewable sources of energy, sustainability. (1 Lectures)

Demonstrations and Experiments

1. Demonstration of Training modules on Solar energy, wind energy, etc.

2. Conversion of vibration to voltage using piezoelectric materials

3. Conversion of thermal energy into voltage using thermoelectric modules.

COURSE OUTCOME

This course helps the student to understand the concepts of energy sources and their technologies. To learn the environmental pollution and climate change. To understand the basic need of carbon free energy. Student will acquire enough knowledge about the renewable energy sources. To understand the different kinds of Energy sources to study the basis of solar energy, solar radiation measurement and applications of solar energy to learn the fundamental principles and theory of wind energy conversion system. To understand the biogas production from biomass and to study the additional alternate energy sources.

Semester-IV

Course Code: BPHSCCHC401 Course Title: Mathematical Physics III
Type: CC-8 Credit: 6
Course Instructor: Dr. Sahazada Aziz
Total class allotted: 70 Total Hours: 80

Module-I Complex Analysis
Lectures/Class: 30 Hours: 30

Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, DeMoivre'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.

Module-II Integrals Transforms
Lectures/Class: 15 Hours: 15

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations.

Module-III Matrices
Lectures/Class: 15 Hours: 15

Matrices
Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit Matrices. Upper-Triangular and Lower-Triangular Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew- Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of a Matrix. Inner Product. **(8 Lectures)**

Eigen-values and Eigenvectors
Cayley- Hamiliton Theorem. Diagonalization of Matrices. Solutions of Coupled Linear Ordinary Differential Equations. Functions of a Matrix. **(7 Lectures)**

Module-IV Practical
Class: 10 Hours: 20

List of Practicals

1. Solve differential equations:

2. Dirac Delta Function:

3. Fourier Series

4. Generation of Special functions using User defined functions (Generating and plotting Legendre Polynomials Generating and plotting Bessel function)

5. Frobenius method and Special functions: recursion relations.

6. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).

7. (i) Evaluation of trigonometric functions e.g. sin θ, (ii) Given Bessel's function at N points find its value at an intermediate point. (iii) Complex analysis: Integrate 1/(x2+2) numerically and check with computer integration.

8. Compute the nth roots of unity for n = 2, 3, and 4.

9. Find the two square roots of −5+12j.

10. Integral transform: FFT of exp(-x2)

COURSE OUTCOME

This is a mathematical physics course that enhances the mathematical skill and analytical thinking of a student. The course comprises the techniques of solving problems of complex variable, matrices and Fourier transform. Techniques learnt here will be very useful to tackle real life problems, especially the problems of electricity, quantum mechanics, classical dynamics etc. In practicals students learn to apply the techniques of numerical methods and Python programming to solve various problems.

Course Code: BPHSCCHC402 Course Title: Elements of Modern Physics
Type: CC-9 Credit: 6
Course Instructor: Dr. Soumendranath Ruz
Total class allotted: 70 Total Hours: 80

Module-I Origin of Quantum Physics
Lectures/Class: 14 Hours: 14

Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions. (14 Lectures)

Module-II Uncertainty Principle and Schroedinger equation
Lectures/Class: 15 Hours: 15

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to virtual particles and range of an interaction. **(5 Lectures)**

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension. **(10 Lectures)**

Module-III Some simple quantum systems
Lectures/Class: 10 Hours: 10

One dimensional infinitely rigid box- energy eigenvalues and eigen functions, normalization; Quantum dot as example; Quantum mechanical scattering and tunneling in one dimension-across a step potential & rectangular potential barrier. (10 Lectures)

Module-IV Nuclear and laser Physics
Lectures/Class: 21 Hours: 21

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers. **(6 Lectures)**

Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay-energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation:

electron-positron pair creation by gamma photons in the vicinity of a nucleus. **(8 Lectures)**

Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions). **(3 Lectures)**

Lasers: Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing. **(4 Lectures)**

Module-V Practical
Lectures/Class: 10 Hours: 20

List of Practicals (at least 6)

1. To determine the Planck's constant using LEDs of at least 4 different colours.

2. To determine the ionization potential of mercury.

3. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.

4. To show the tunneling effect in tunnel diode using I-V characteristics.

5. To determine the wavelength of laser source using diffraction of single slit.

6. To determine the wavelength of laser source using diffraction of double slits.

7. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating

COURSE OUTCOME

The objective of this course is to teach the physical and mathematical foundations necessary for learning various topics in modern physics which are crucial for understanding atoms, molecules, photons, nuclei and elementary particles. These concepts are also important to understand phenomena in laser physics, condensed matter physics and astrophysics.

After getting exposure to this course, the following topics would be learnt:
Main aspects of the inadequacies of classical mechanics as well as understanding of the historical development of quantum mechanics.
Formulation of Schrodinger equation and the idea of probability interpretation associated with wave-functions.
The spontaneous and stimulated emission of radiation, optical pumping and population inversion. Three level and four level lasers. Ruby laser and He-Ne laser in details. Basic lasing The properties of nuclei like density, size, binding energy, nuclear forces and structure of atomic nucleus, liquid drop model and nuclear shell model and mass formula.
Decay rates and lifetime of radioactive decays like alpha, beta, gamma decay. Neutrino, its properties and its role in theory of beta decay.
Fission and fusion: Nuclear processes to produce nuclear energy in nuclear reactor and stellar energy in stars.

LAB: The students will get opportunity to measure Planck's constant, verify photoelectric effect, determine e/m of electron, Ionization potential of atoms, study emission and absorption line spectra. They will also find wavelength of Laser sources by single and Doubleslit experiment, wavelength and angular spread of He-Ne Laser using plane diffraction grating.

Course Code: BPHSCCHC403 Course Title: Digital Systems and Applications
Type: CC-10 Credit: 6
Course Instructor: Mr. Ujjal Bid
Total class allotted: 70 Total Hours: 80

Module-I IC and Digital Circuits
Lectures/Class: 14 Hours: 14

Integrated Circuits
Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs. **(6 Lectures)**

Digital Circuits
Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. **(8 Lectures)**

Module-II Boolean algebra
Lectures/Class: 10 Hours: 10

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

Module-III Data processing circuits
Lectures/Class: 10 Hours: 30

Data processing circuits
Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. **(4 Lectures)**

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor. **(5 Lectures)**

Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop. **(8 Lectures)**

Timers
IC 555: block diagram, Operation and applications: Astable multivibrator and Monostable multivibrator. **(5 Lectures)**

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

Counters (4 bits)
Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter. **(4 Lectures)**

Module-IV Computer Organization
Lectures/Class: 6 Hours: 6

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

Module-V Practical
Class: 10 Hours: 20

List of Practicals

1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.

2. To test a Diode and Transistor using a Multimeter.

3. To design a switch (NOT gate) using a transistor.

4. To verify and design AND, OR, NOT and XOR gates using NAND gates.

5. To design a combinational logic system for a specified Truth Table.

6. To convert a Boolean expression into logic circuit and design it using logic gate ICs.

8. Half Adder, Full Adder and 4-bit binary Adder.

9. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.

10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.

11. To build JK Master-slave flip-flop using Flip-Flop ICs

12. To design a monostable multivibrator of given specifications using 555 Timer.

COURSE OUTCOME

After studying this course the students would gain enough knowledge
1. Have a thorough understanding of the fundamental concepts and techniques used in digital electronics.
2. To understand and examine the structure of various number systems and its application in digital design.
3. The ability to understand, analyze and design various combinational and sequential circuits.
4. Ability to identify basic requirements for a design application and propose a cost effective solution.
5. The ability to identify and prevent various hazards and timing problems in a digital design.
6. To develop skill to build, and troubleshoot digital circuits.

Course Code: BPHSSEHT405 Course Title: Computational Physics Skills
Type: SEC-2 Credit: 2
Course Instructor: Dr. Soumendranath Ruz
Total class allotted: 20 Total Hours: 20

Introduction
Importance of computers in Physics, paradigm for solving physics problems for solution. Usage of linux as an Editor. Algorithms and Flowcharts: Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) Lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal. **(3 Lectures)**

Scientific Programming
Some fundamental Linux Commands (Internal and External commands). **(2 Lectures)**

Basic elements of C programming:

UNIT-I (3 Lectures)

1. Fundamentals of C language: C character set-Identifiers and Keywords-Constants -Variables-Data types-Declarations of variables-Declaration of storage class-Defining symbolic constants- Assignment statement.

2. Operators: Arithmetic operators-Relational operators-Logic operators-Assignment operators- Increment and decrement operators-Conditional operators.

UNIT-II (8 Lectures)

3. Expressions and I/O Statements: Arithmetic expressions-Precedence of arithmetic operators-Type converters in expressions-Mathematical (Library) functions - Data input and output-The getchar and putchar functions-Scanf-Printf simple programs.

4. Control statements:If -Else statements -Switch statements - The operators - GO TO - While, Do - While, FOR statements - BREAK and CONTINUE statements.

UNIT-III (6 Lectures)

5. Arrays: One dimensional and two dimensional arrays - Initialization - Type declaration - Inputting and outputting of data for arrays - Programs of matrices addition, subtraction and multiplication

6. Structure, Disk I/O Statements, open a file, writing in a file, reading from a file

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. **(4 Lectures)**

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. **(4 Lectures)**

Hands on exercises

Write a program that reads an alphabet from keyboard and display in the reverse order.

Write a program for converting centigrade to Fahrenheit temperature and Fahrenheit temperature centigrade.

To print out all natural even/ odd numbers between given limits.

To find maximum, minimum and range of a given set of numbers.

Write a program for generation of even and odd numbers up to 100 using while, do-while and for loop.

To find a set of prime numbers and Fibonacci series.

Write a program to find the largest element in an array.

To compile a frequency distribution and evaluate mean, standard deviation etc.

To evaluate sum of finite series and the area under a curve.

Motion of a projectile using simulation and plot the output for visualization.

To write program to open a file and generate data for plotting using Gnuplot.

Plotting trajectory of a projectile projected horizontally.

Plotting trajectory of a projectile projected making an angle with the horizontally.

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.

Motion of a projectile using simulation and plot the output for visualization.

Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.

Motion of particle in a central force field and plot the output for visualization.

To find the roots of a quadratic equation.

Write a program to solve the quadratic equation using Bisection method.

Write a program for integration of function using Trapezoidal rule.

Write a program for solving the differential equation using Simpson's 1/3 rule

COURSE OUTCOME

This course would introduce students with the basic knowledge of computers their applications in solving common and scientific problems, the course includes scientific programming languages, scientific word processing and graphical analysis.

Semester-V

Course Code: BPHSCCHC501 Course Title: Quantum Mechanics & Applications
Type: CC-11 Credit: 6
Course Instructor: Dr. Sahazada Aziz
Total class allotted: 70 Total Hours: 80

Module-I Basics of quantum Mechanics
Lectures/Class: 28 Hours: 28

Schrodinger Equation
Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle. **(6 Lectures)**

Time independent Schrodinger equation-Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigen functions; 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 wave function; Position-momentum uncertainty principle. **(10 Lectures)**

General discussion of bound states in an arbitrary potential
continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle. **(12 Lectures)**

Module-II Quantum theory of hydrogen-like atoms
Lectures/Class: 10 Hours: 10

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

Module-III Atoms in Electric & Magnetic Fields and Many electron atoms
Lectures/Class: 22 Hours: 22

Atoms in Electric & Magnetic Fields
Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. **(8 Lectures)**

Atoms in External Magnetic Fields
Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only). **(4 Lectures)**

Many electron atoms
Pauli's Exclusion Principle. Symmetric & Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms- L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.). **(10 Lectures)**

Module-IV Practicals
Class: 10 Hours: 20

Practical
1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom
2. Solve the s-wave radial Schrodinger equation for an atom
3. Solve the s-wave radial Schrodinger equation for a particle of mass m
4. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule

COURSE OUTCOME

Quantum Mechanics is the most fundamental subject ever developed by humans. After learning the subject students will appreciate that all of the microscopic physics and many macroscopic phenomenon like magnetism, superconductivity can find its explanation to Quantum Mechanics. This course is a continuation to the earlier modern physics course. In this undergraduate course students learn the basics mathematics behind quantum theory and its application to Hydrogen atom problem-which is the only exactly solvable real problem. Apart from this, students learn the basic concept of spin of particles and many effects of electric and magnetic field on atoms, and lasly many electron atom and a little bit of atomic physics.

Course Code: BPHSCCHC502 Course Title: Solid State Physics
Type: CC-12 Credit: 6
Course Instructor: Mr. Ujjal Bid
Total class allotted: 70 Total Hours: 80

Module-I Crystal structure and lattice vibration
Lectures/Class: 22 Hours: 22

Crystal Structure
Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis –Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor. **(12 Lectures)**

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. T3 law . (**10 Lectures)**

Module-II Magnetic, Dielectric and Ferroelectric properties
Lectures/Class: 22 Hours: 22

Magnetic Properties of Solids
Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss. **(8 Lectures)**

Dielectric Properties of Solids
Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes. **(8 Lectures)**

Ferroelectric Properties of Solids
Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop. **(6 Lectures)**

Module-III Electron states and Superconductivity
Lectures/Class: 16 Hours: 16

Electron States in Solids
Sommerfeld's free electron theory of metals. Free electron gas in three dimensions. Fermi energy, temperature, velocity, and momentum. Concepts of energy bands in solids: Periodic potential and Bloch theorem (proof not required). Qualitative discussion on Kronig-Penny model, energy band structure. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient. **(10 Lectures)**

Superconductivity
Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation) **(6 Lectures)**

Module-IV Practicals
Class: 10 Hours: 20

List of Practical

1. To determine the Hall coefficient of a semiconductor sample.

2. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.

3. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 oC) and to determine its band gap.

4. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)

5. To measure the Dielectric Constant of a dielectric materials with frequency

COURSE OUTCOME

After completing this course the students should be able to
1. Understand the historic development of solid-state physics and how they explain specific heat of solids.
2. The details about the vibrations in the atomic chain and the applications of scattering experiments in solids.
3. 3. The details about the vibrations in the atomic chain and the applications of scattering experiments in solids.
4. 4. Summarize the details of band theory and the developments of semiconductor physics and bandgap engineering.
5. differentiate between different Lattice types and explain the concepts of reciprocal lattice and crystal diffraction.
6. predict electrical and thermal properties of solids and explain their origin.
7. explain the concept of energy bands and effect of the same on electrical properties.
8. explain superconductivity, its properties, important parameters related to possible applications.

Course Code: BPHSDSHT2 Course Title: Classical Dynamics
Type: DSE-1 Credit: 6
Course Instructor: Dr. Sahazada Aziz
Total class allotted: 75 Total Hours: 75

Module-I Classical Mechanics
Lectures/Class: 25 Hours: 25
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, gyro-radius and gyro-frequency, motion in crossed electric and magnetic fields. Generalized coordinates and velocities.

Recap of Lagrangian mechanics. Lagrange's undetermined multipliers, Lagrange's equation for non-holonomic systems, Virial theorem, Principle of mechanical similarity. Hamiltonian Mechanics, Applications: Hamiltonian for a harmonic oscillator, solution of Hamilton's equation for Simple Harmonic Oscillations; particle in a central force field-conservation of angular momentum and energy. Effective potential. The Laplace-Runge-Lenz vector.

Module-II Small Amplitude Oscillations
Lectures/Class: 10 Hours: 10

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

Module-II Special Theory of Relativity
Lectures/Class: 30 Hours: 30

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

Module-III Fluid Dynamics
Lectures/Class: 10 Hours: 10

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, Navier-Stokes equation, qualitative description of turbulence, Reynolds number.

COURSE OUTCOME

The course deals with the fundamental principles of Physics and Technology.

- The students recapitulate the basic principles of mechanics
- learn how a charged particle moves in electric and magnetic field
- gain appreciable knowlede of small oscillations and motion of coupled system
- students acquire enough knowledge of Lagrangian and Hamiltonian mechanics to apply in other fields
- they get an ample exposure to special theory of relativity- one of the cornerstones of science and technology
- Students are introduced to Fluid dynamics.

Course Code: BPHSDSHT3 Course Title: Astronomy & Astrophysics
Type: DSE-2 Credit: 6
Course Instructor: Dr. Soumendranath Ruz
Total class allotted: 75 Total Hours: 75

Greek Astronomy, Astronomy in the Era of Copernicus, Tycho, Kepler, and Galileo; Kepler's Laws of Planetary Motion, Introduction to Electromagnetic Waves; Doppler Effect, Atomic Spectra spectra. **(5 Lectures)**

Basic concepts of positional astronomy:
Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar. Concept of Constellations. **(15 Lectures)**

Astronomical Scales:
Astronomical Distance, Mass and Time Scales, Brightness, Radiant Flux and Luminosity, Basic Parameters of Stars,

Stellar Radii, Masses of Stars, Stellar Temperature.
Measurement of Astronomical Quantities: Determination of Distance by Parallax Method; Distance Measurement using Cepheid Variables, Apparent and Absolute magnitude scale, Determination of Temperature and Radius of a star; Stellar Spectra, Spectral Types and Their Temperature Dependence, Black Body Approximation. **(10 Lectures)**

Astronomical techniques:
Basic Optical Definitions for Astronomy (Magnification Light Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Telescope Mountings, Space Telescopes, Detectors and Their Use with Telescopes (Types of Detectors, detection Limits with Telescopes). **(5 Lectures)**

The sun:
Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity, Solar cycle.
The solar family: Solar System: Facts and Figures, Origin of the Solar System: The Nebular Model, Tidal Forces and Planetary Rings, Extra-Solar Planets. **(10 Lectures)**

Stellar spectra and classification Structure:
Stellar Spectral Classification, Hertzsprung-Russell Diagram. Luminosity Classification.
Stellar structure: Hydrostatic Equilibrium of a Star, Some Insight into a Star: Virial Theorem, Sources of Stellar Energy, Nuclear Reactions in Stars, Modes of Energy Transport.
Star formation: Basic composition of Interstellar medium, Interstellar Gas, Formation of Protostar, Jeans criterion.
Stellar evolution and Nucleosynthesis: Cosmic Abundances, Stellar Nucleosynthesis, Evolution of Stars, Evolution to the Main Sequence, Difference between Jupiter and Sun, Evolution beyond the Main Sequence, Redgiant, Supernovae, Planetary Nebula.
Compact stars: Basic Familiarity with Compact Stars, Degenerate Pressure of Fermions, White Dwarfs and the Chandrasekhar Limit (qualitatively), Neutron Star (Detection of Neutron Star: Pulsars), Black Holes. **(15 Lectures)**

The milky way:
Basic Structure, size and Properties of the Milky Way (Bulges, Disks, Galactic Halo), Nature of Rotation of the Milky Way, Nature of the Spiral Arms, Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus, Rotation Curve of Galaxy and the Dark Matter.
Galaxies: Galaxy Morphology, Elliptical Galaxies. Spiral and Lenticular Galaxies, Clusters of Galaxies. **(15 lectures)**

COURSE OUTCOME

The Course would be helpful in understanding our composition and universe, the dynamics of stars including our solar system and radiation. This Course provides an opportunity to students to know about various experimental techniques astronomical observations; these include Detectors, Photometry and spectroscopic observational instruments, radio astronomical telescope, interferometer etc. Students would also learn about the Galactic system, extragalactic systems, cosmology and gravitation.
The knowledge of representation of very large and small distances and their practical units are introduced. The students gain knowledge of the different techniques to measure distance of a star and formulas for measuring distances. It is taught here that the sun is a controlled thermonuclear reactor with a variety of new physics that emerged out of the study of the light and neutron coming out of it. The sun has two faces one that exists for a few days/months and other that exist for millions of years. The use of quantum mechanics, nuclear physics and statistical mechanics are learned by them here.
It is shown here that they need Einstein's General theory of Relativity for describing the phenomena of the universe and in the case of neutron stars and Black holes. They also learn how the universe originated in the past (Big Bang theory) and what are the different phases. The experimental tests upon which the cosmological theories are built up. The different cosmological parameters for understanding the observed universe

The students learn to solve problems to determine the surface temperature of a star in terms of the surface temperature of the sun if the luminosity of the star is determined. They determine the age of the universe, the density of an X-ray Pulsar from the knowledge of its time period of rotation, many features of the universe which are not understood by STR and Classical Mechanics, life history of a star, Galaxy, clusters and superclusters.

Semester-VI

Course Code: BPHSCCHC601 Course Title: Electro-magnetic Theory
Type: CC-13 Credit: 6
Course Instructor: Dr. Soumendra Nath Ruz
Total class allotted: 70 Total Hours: 80

Maxwell Equations
Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density. **(12 Lectures)**

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. **(9 Lectures)**

Dispersion: Equation of motion of an electron in a radiation field : Lorentz theory of dispersion - normal and anomalous; Sellmeier's and Cauchy's formulae, absorptive and dispersive mode, half power frequency, band width. **(3 Lectures)**

EM Wave in Bounded Media
Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence) **(8 Lectures)**

Polarization of Electromagnetic Waves
Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light. **(12 Lectures)**

Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter. **(5 Lectures)**

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.
(8 Lectures)

Optical Fibres
Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only). **(3 Lectures)**

Practical

List of Practicals

1. To verify the law of Malus for plane polarized light.

2. To determine the specific rotation of sugar solution using Polarimeter.

3. To determine the Boltzmann constant using V-I characteristics of PN junction diode.

4. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.

5. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.

6. To verify the Stefan`s law of radiation and to determine Stefan’s constant.

COURSE OUTCOME

The study of electromagnetic theory provides basic foundation for the students to understand advanced courses of physics. The course involves the study of electromagnetic theory, Maxwell’s equations and electromagnetic waves, radiations from moving charges, solar and stellar systems.

Course Code: BPHSCCHC602 Course Title: Statistical Mechanics
Type: CC-14 Credit: 6
Course Instructor: Dr. Sahazada Aziz
Total class allotted: 70 Total Hours: 80

Module-I Classical Statistical Mechanics
Lectures/Class: 18 Hours: 18

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

Module-II Classical and Quantum Theory of Radiation
Lectures/Class: 15 Hours: 15

Classical Theory of Radiation
Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff’s law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien’s Displacement law. Wien’s Distribution Law. Saha’s Ionization Formula. Rayleigh-Jean’s Law. Ultraviolet Catastrophe. **(9 Lectures)**
Quantum Theory of Radiation
Spectral Distribution of Black Body Radiation. Planck’s Quantum Postulates. Planck’s Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien’s Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien’s Displacement law from Planck’s law. **(6 Lectures)**

Module-III Bose-Einstein Statistics
Lectures/Class: 12 Hours: 12

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.

Module-IV Fermi-Dirac Statistics
Lectures/Class: 15 Hours: 15

Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit. (15 Lectures)

Module-V Practical
Lectures/Class: 10 Hours: 20

List of Practicals

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(ß) 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(ß), average energy <E>, energy fluctuation 👎E, specific heat at constant volume Cv, 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 high temperature and low temperature.

4. Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.

5. Plot the following functions with energy at different temperatures
a) Maxwell-Boltzmann distribution
b) Fermi-Dirac distribution
c) Bose-Einstein distribution

COURSE OUTCOME

Statistical mechanics is the physics behind the thermal science. Students learn classical and quantum statistical distribution of very large number of systems and their interactions. They learn BE and FD statistics which help them to understand the many natural phenomena occurred in nature, for example specific heat of gases, Black body radiation and CMB, physics of stars, nuclear models etc.

Course Code: BPHSDSHT4 Course Title: Nuclear and Particle Physics
Type: DSE-3 Credit: 6
Course Instructor: Dr. Sahazada Aziz
Total class allotted: 75 Total Hours: 75

Module-I Nuclear properties and Models
Lectures/Class: 22 Hours: 22

General Properties of Nuclei
Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, chargedensity (matter density), binding energy, average binding energy and its variation with massnumber, main features of binding energy versus mass number curve, N/A plot, angularmomentum, parity, magnetic moment, electric moments, nuclear excites states. **(10 Lectures)**

Nuclear Models
Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.**(12 Lectures)**

Module-II Radioactivity, Nuclear reactions and Interaction of Nuclear Radiation with matter
Lectures/Class: 26 Hours: 26

Radioactivity decay
Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttall law, Beta decay: energy kinematics for delay, positron emission, electron capture, neutrino hypothesis. Gamma decay: Gamma rays emission and kinematics, internal conversion. **(10 Lectures)**
Nuclear Reactions
Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering). **(8 Lectures)**
Interaction of Nuclear Radiation with matter
Energy loss due to ionization (Bethe- Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter.
(8 Lectures)

Module-III Detectors and Accelerators
Lectures/Class: 13 Hours: 13

Detector for Nuclear Radiations
Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GMCounter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.**(8 Lectures)**
Particle Accelerators
Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.**(5 Lectures)**
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Module-IV Particle physics
Lectures/Class: 14 Hours: 14

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

COURSE OUTCOME

Nuclear and Particle physics deals with the most fundamental constituents of matter.
After learning and understanding the course students will able to know

- Basic nuclear properties and practical applications of quantum mechanics and statistical mechanics
- About the various nuclear models
- about nuclear force and strong interactions
- how radioactive decay happens and their applications-how sun emits energy etc.
- How the charged particles are accelerated and detected in laboratory
- Some working idea about the four fundamental interactions
- All the fundamental particles of the universe and an idea about their production, decay and interactions.

Course Code: BPHSDSHT5 Course Title: Communication Electronics
Type: DSE-4 Credit: 6
Course Instructor: Mr. Ujjal Bid
Total class allotted: 75 Total Hours: 75

Module-I Electronic communication and Analog Modulation
Lectures/Class: 20 Hours: 20

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 communicationsystem in India (TRAI). Electromagnetic communication spectrum, band designations and usage.Channels and base-band signals. Concept of Noise, signal-to-noise (S/N) ratio. **(8 Lectures)**
Analog Modulation
Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver. **(12 Lectures)**

Module-II Pulse Modulation
Lectures/Class: 20 Hours: 20
Analog Pulse Modulation
Channel capacity, Sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing.**(10 Lectures)**

Digital Pulse Modulation
Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques,Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK). **(10 Lectures)**

Module-II Communication
Lectures/Class: 20 Hours: 20

Satellite Communication– Introduction, need, Geosynchronous satellite orbits geostationarysatellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), pathloss, ground station, simplified block diagram of earth station. Uplink and downlink. **(10 Lectures)**
Mobile Telephony System
Basic concept of mobile communication, frequency bands used inmobile 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) **(10 Lectures)**

Module-IV Practical
Lectures/Class: 10 Hours: 20

List of Practicals

1. To design an Amplitude Modulator using Transistor.

2. To study Pulse Amplitude Modulation (PAM)

3. To study Pulse Width Modulation (PWM)

4. To study AM Transmitter and Receiver

5. To study FM Transmitter and Receiver

6. To study Time Division Multiplexing (TDM)

7. To study envelope detector for demodulation of AM signal

COURSE OUTCOME

At the end of this course Students will be able to

· 1.Design system components that meet the requirement of public safety and offer solutions to the societal and environmental concerns.

· 2.Apply research based knowledge to design and conduct experiments, analyze, synthesize and interpret the data pertaining to Electronics and Communication Engineering problems and arrive at valid conclusions.

· 3.Construct, choose and apply the techniques, resources and modern engineering tools required for Electronics and Communication Engineering applications.

· 4.Apply the contextual knowledge to assess societal, health, safety and cultural issues and endure the consequent responsibilities relevant to the professional practice.

· 5.Examine the impact of engineering solutions in global and environmental contexts and utilize the knowledge for sustained development.

· 6.Develop consciousness of professional, ethical and social responsibilities as experts in the field of Electronics and Communication.

· 7.Perform effectively as a member/leader

Teacher-in-Charge
Ramananda Centenary College
P.O. - Laulara, Dist.-Purulia