

## Department of Physics

### Teaching plans

#### Semester- I

Course code & Name	Assigned Teacher	Containts
CC-1, Mathematical Physics I (Theory)	<b>AH</b>	<p><b>2. Vector Algebra and Vector Calculus:</b> (a) Recapitulation of Vector Algebra. Idea of linear independence, completeness, basis and representation of vectors. Properties of vectors under rotations. Scalar product and its invariance under coordinate rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively.</p> <p>(b) Vector Differentiation: Scalar and Vector fields. Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities. (c) 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). (d) Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Spherical and Cylindrical Coordinate Systems.</p>
CC-1, Mathematical Physics I (Practical)	<b>SM</b>	<p><b>1. Introduction to plotting graphs with Gnuplot</b> (a) Plotting 2D graphs: both functions and data files. Changing plot range, plot style: the options- with points (w p), with dots (w d), with lines (w l), with linespoints (w lp), linetype (lt), linewidth (lw). Using the set command for samples, xrange, yrange, xlabel , ylabel, title etc. The using and every options. (b) User defined functions [Including the use of ternary operator (? :) for piece-wise defined functions.] (c) Fitting data files using gnuplot. (d) Polar and parametric plots. [Graphs to be saved by using GUI - The "export" protocol is not needed.]</p> <p><b>2. Introduction to programming in python:</b> (a) Introduction • Using the python interpreter as a calculator • Variable and data types (int, float, complex, list, tuple, string, the type() function) • Basic mathematical operations • Compound statements in python – Conditionals if: elif: else: – Loops for: , while: – User defined functions def: [return statement, default values for arguments, keyword arguments] • Importing modules with math and cmath as examples • Using online help • Basic idea of namespaces-local and global • Python scripts, I/O operations (including opening and writing to files) (b) The python iterables data type • List:defining lists,reading and changing elements from lists,</p>

		<p>slicing (with discussion on the difference between <math>l=mm</math> and <math>l=mm[:]</math>, concatenation, list comprehension. built in functions involving lists: <code>range()</code>, <code>len()</code>, <code>sum()</code>, <code>min()</code>, <code>max()</code> – list methods: <code>append()</code>, <code>extend()</code>, <code>count()</code>, <code>index()</code>, <code>sort()</code>, <code>insert()</code>, <code>pop()</code>, <code>remove()</code>, <code>reverse()</code> • Tuples: Contrast and compare with lists, packing/unpacking using tuples (including <code>a,b=b,a</code> to swap variables) • Strings: defining strings, the use of single, double or triple quotes as string delimiters, <code>len()</code>, indexing, slicing, string concatenation, some string methods: <code>strip()</code>, <code>split()</code>, <code>join()</code>, <code>find()</code>, <code>count()</code>, <code>replace()</code>, string formatting in python (using the <code>%</code> operator) (c) Problems and applications: Problem 0: Observe and interpret the result of the following two scripts <code>i=0 a=1 while a&gt;0: i=i+1 a=a/2 print i</code> <code>i=0 a=1 b=1 while a+b &gt; b: i=i+1 a=a/2 print i</code> Problem 1. Root finding for a single variable (basic theory and algorithm) • Bisection method • Newton-Raphson Method Problem 2. Sorting of lists (algorithm, flowchart and code) • Bubble sort • Selection sort Problem 3. ODE in one and two dimensions using Euler algorithm (output to be saved in data files and <code>gunuplot</code> to be used to plot graphs) • Capacitor charging/discharging • Simulating a half-wave rectifier with a capacitor filter • Particle dynamics in 1D Problem 4. Matrix operations using list of lists • Matrix Addition • Matrix Multiplication • Transpose of a Matrix</p>
<p>CC-2, Mechanics (Theory)</p>	<p>AH</p>	<p><b>1.Fundamentals of Dynamics:</b> (a) Review of Newtons Laws: Mechanistic view of the Universe. Concepts of Inertial frames, force and mass. Galilean transformations and Galilean invariance. Solution of the equations of motion (E.O.M.) in simple force fields in one, two and three dimensions using cartesian, cylindrical polar and spherical polar coordinate systems. (b) Dynamics of systems of particles: Difficulty of solving the E.O.M. for systems of particles. Newton's third Law. External and Internal forces. Momentum and Angular Momentum of a system. Torque acting on a system. Conservation of Linear and Angular Momentum. Centre of mass and its properties. Two-body problem. (c) Variable mass system: motion of rocket. <b>2. Work and Energy:</b> (a) Work Kinetic Energy Theorem. Conservative Forces: Force as the gradient of a scalar field. concept of Potential Energy. Other equivalent definitions of a Conservative Force. Conservation of Energy. (b) Qualitative study of one dimensional motion from potential energy curves. Stable and Unstable equilibrium. (c) Energy of a system of particles. <b>3. Gravitation and Central Force Motion:</b> (a) Central Force. Reduction of the two body central force problem to a one body problem. Setting up the E.O.M. in plane polar coordinates. (b) Differential equation for the path. Motion under an Inverse square force. Newton's Law of Gravitation. Inertial and gravitational mass. Kepler's Laws. Satellite in circular orbit and applications. Weightlessness. (c) Gravitational potential energy. Potential and field due to spherical shell and solid sphere.</p>

	<b>MDG</b>	<b>4. Non-Inertial Systems:</b> Non-inertial frames and idea of fictitious forces. E.O.M with respect to a uniformly accelerating frame. E.O.M with respect to a uniformly rotating frame - Centrifugal and Coriolis forces. Laws of Physics in a laboratory on the surface of the earth. <b>5. Rotational Dynamics:</b> (a) The Rigid Body: Constraints defining the rigid body. Degrees of freedom for a rigid body; (b) Relation between Angular momentum and Angular Velocity: Moment of Inertia Tensor. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. (c) Equation of motion for rotation about a fixed axis. Principal Axes transformation. Transformation to a body fixed frame. E.O.M for the rigid body with one point fixed (Euler's equations of motion). Torque free motion. Kinetic energy of rotation.
CC-2, Mechanics (Practical)	<b>MDG</b>	1. To determine the Moment of Inertia of a metallic cylinder / rectangular bar about an axis passing through the C.G. and to determine the Modulus of Rigidity of the suspension wire. 2. To determine the Moment of Inertia of a Flywheel. 3. To determine the Young modulus, modulus of rigidity and Poisson ratio of the material of a wire by Searle's dynamic method. 4. To determine the value of g using Bar Pendulum. 5. To determine the height of a building (or a suitable vertical height) using sextant. 6. Determination of Young's modulus of the material of a beam by the method of flexure.

## Semester- II

<b>Course code &amp; Name</b>	<b>Assigned Teacher</b>	<b>Contents</b>
CC-3, Electricity and Magnetism (Theory)	<b>AH</b>	<b>1. Dirac delta function and its properties:</b> Dirac delta function: definition of dirac delta function. Delta function as limit of different representations. Properties of delta function. Three dimensional delta function. Proof of the relation $\nabla \cdot (\hat{r} / r^2) = 4\pi\delta^3(\vec{r})$ . <b>2. Electrostatics:</b> (a) Coulombs law, principle of superposition, electrostatic field. Electric field and charge density, surface and volume charge density, charge density on the surface of a conductor. Force per unit area on the surface. (b) Divergence of the Electrostatic field, flux, Gauss's theorem of electrostatics, applications of Gauss theorem to find Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. (c) Curl of the Electrostatic Field. Conservative nature of electrostatic field,

		<p>Introduction to electrostatic potential, Calculation of potential for linear, surface and volume charge distributions, potential for a uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. <b>3. Dielectric properties of matter:</b> Electric dipole moment, electric potential and field due to an electric dipole, force and Torque on a dipole. Electric Fields inside matter, Electric Polarisation, bound charges, displacement density vector, relation between <math>\vec{E}</math>, <math>\vec{P}</math> and <math>\vec{D}</math>. Gauss's theorem in dielectrics, linear Dielectric medium, electric susceptibility and permittivity. Electrostatic boundary conditions for <math>\vec{E}</math> and <math>\vec{D}</math>. <b>4. Method of Images:</b> Laplace's and Poisson equations. Uniqueness Theorems. Method of Images and its application to: Plane Infinite metal sheet, Semi-infinite dielectric medium and metal Sphere. <b>5. Electrostatic Energy:</b> Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Energy per unit volume in electrostatic field. <b>6. The Magnetostatic:</b> (a) Biot-Savart's law. Application of Biot-Savart's law to determine the magnetic field of a straight conductor, circular coil. Force on a moving point charge due to a magnetic field: Lorentz force law. Force between two straight current carrying wires. (b) Divergence of the magnetic field and its solenoidal nature. Magnetic vector potential, calculation for simple cases. (c) Curl of the magnetic field. Ampere's circuital law. Its application to (1) Infinite straight wire, (2) Infinite planar surface current, and (3) Infinite Solenoid.</p>
	<b>MDG</b>	<p><b>7. Magnetic properties of matter:</b> (a) Potential and field due to a magnetic dipole. Magnetic dipole moment. Force and torque on a magnetic dipole in a uniform magnetic field. (b) Magnetization, Bound currents. The magnetic intensity <math>\vec{H}</math>. Relation between <math>\vec{B}</math>, <math>\vec{H}</math> and <math>\vec{M}</math>. Linear media. Magnetic Susceptibility and Permeability. Boundary conditions for <math>\vec{B}</math> and <math>\vec{H}</math>. Brief introduction of dia-, para- and ferro-magnetic materials. B-H curve and hysteresis. <b>8. Electro-magnetic induction:</b> Ohms law and definition of E.M.F. Faraday's laws of electromagnetic induction, Lenz's law. Self-Inductance and Mutual Inductance. Reciprocity Theorem. Introduction to Maxwell's Equations. Charge conservation. Displacement current and resurrection of Equation of Continuity. <b>9. Electrical circuits:</b> 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.</p>
CC-3, Electricity and Magnetism (Practical)	<b>MDG</b>	<p>1. To determine an unknown Low Resistance using Potentiometer. 2. To determine an unknown Low Resistance using Carey Foster's Bridge. 3. 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. 4. To study the ac characteristics of a series RC Circuit. Study as low/high pass filter. Calculation of capacitance from current reactance graph. 5. To study mutual inductance between two coils. 6. Determination of horizontal component of the Earth's magnetic field.</p>

<p>CC-4, Waves and Optics (Theory)</p>	<p><b>MDG</b></p>	<p><b>1. Oscillations:</b> Differential equation of Simple Harmonic Oscillation 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. <b>2. Superposition of Harmonic Oscillations:</b> (a) Superposition of Two Collinear Harmonic oscillations having equal frequencies and different frequencies (Beats). (b) Superposition of Two Perpendicular Harmonic Oscillation for phase difference <math>\delta = 0, \pi/2, \pi</math>: Graphical and Analytical Methods, Lissajous Figures with equal and unequal frequency and their uses. <b>3. Wave motion:</b> Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Traveling) Waves. Wave Equation for travelling waves. Particle and Wave Velocities. (Solution of spherical wave equation may be assumed) <b>4. Superposition of Harmonic Waves:</b> (a) Velocity of Transverse Vibrations of Stretched Strings, Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. (form of the solution of wave equation may be assumed). Plucked and Struck Strings. (b) Superposition of N Harmonic Waves. Phase and Group Velocities</p>
	<p><b>AH</b></p>	<p><b>5. Wave optics:</b> (a) Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. (b) Temporal and Spatial Coherence. <b>6. Interference:</b> 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. <b>7. Interferometers:</b> (a) 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. (b) Multiple beam interferometry, Fabry-Perot interferometer. <b>8. Diffraction:</b> (a) Fraunhofer diffraction: Single slit. Circular aperture (solution may be assumed), Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. Rayleigh criterion for resolution. (b) 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.</p>
<p>CC-4, Waves and Optics (Practical)</p>	<p><b>MDG</b></p>	<p>1. To determine the frequency of an electric tuning fork by Melde's experiment and verify <math>\lambda = 2 - T</math> law. 2. To study the variation of refractive index of the Material of a prism with wavelengths and hence the Cauchy constants using mercury/helium source. 3. To determine wavelength of sodium light using Fresnel Biprism. 4. To determine wavelength of sodium light/radius of plano convex lens using Newton's Rings. 5. To determine the thickness of a thin paper by measuring the width of the</p>

		interference fringes produced by a wedge-shaped Film. 6. Measurement of the spacing between the adjacent slits in a grating by measuring $\sin\theta$ vs graph of a certain order of grating spectra.
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### Semester- III

Course code & Name	Assigned Teacher	Containts
CC-5, Mathematical Physics II (Theory)		
CC-5, Mathematical Physics II (Practical)	<b>SM</b>	<p><b>1. Introduction to numpy and scipy • the numpy array:</b> – properties: size, shape, ndim, dtype – creating arrays * zeros, one(), full(), fill() * arange(), linspace(), logspace() * identity(), eye() * astype() – indexing and slicing arrays (view versus copy) – important array methods * reshape(), ravel(), flatten() * hstack() and vstack() – Element wise functions: native numpy functions, the vectorise() method – Aggregate functions np.sum(), np.prod(), np.mean(), np.std(), np.var(), np.min(), np.max(), np.argmax(), np.argmax()</p> <p><b>• Using numpy for matrix operators (the 2D numpy array):</b> addition, multiplication(dot) – Gauss elimination (using partial pivoting)(numpy code) HONOURS: SEMESTER 3. CC 5, CC 6, CC 7, SEC A 24 * for evaluating the determinant * for solving linear equation – the numpy linalg module * solving equations * diagonalisation</p> <p><b>• Scientific Applications – Interpolation:</b> * Lagrange Interpolation * Newton Forward Interpolation Using both numpy and scipy.interpolate(for visualization of the results use matplotlib) -basic numerical analysis theory to be explained. – <b>Numerical Integration:(for both functions and equi-spaced data):</b> * Trapezoidal rule * Simpson’s one-third rule Using both numpy and scipy.integrate.quad(), scipy.integrate.trapz(), scipy.integrate.simps() -basic numerical analysis theory to be explained. * Numerical Integration by n-point Gaussian Quadrature method. [Basic theory and numpy code - nodes and weights to be read from files, Integration by scipy.integrate.quad().] – <b>Solution of ODE:</b> * Solution of 1st order and 2nd order ordinary differential equation using 4th order Runge Kutta (RK4) algorithm [algorithm and numpy code - detailed theory not required] – <b>Curve fitting:</b> * with numpy polynomials * with user defined functions using scipy.optimize module</p> <p><b>2. Introduction to matplotlib (Using the pyplot submodule):</b> •</p>

		figure, axes, subplot • plot(), scatter(), show() • labels, legends, titles, styles, ticks • dynamically updating curves • saving graphs
CC-6, Thermal Physics (Theory)	<b>AC</b>	<b>1. Introduction to Thermodynamics:</b> (a) 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, Internal Energy and First Law of Thermodynamics. Its differential form, First Law & various processes. Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient. (b) 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. (c) Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. (d) 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. Principle of Increase of Entropy. Temperature-Entropy diagrams for Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.
	<b>MDG</b>	<b>2. Thermodynamic Potentials:</b> (a) 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. (b) Maxwell's Thermodynamic Relations. Derivations and applications of Maxwell's Relations: (1) Clausius Clapeyron equation, (2) Values of CP - CV, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. (c) Joule-Thomson Porous Plug Experiment: Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule Thomson Cooling.
	<b>AH</b>	<b>3. Kinetic Theory of Gases:</b> (a) 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. (b) Molecular

		<p>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. (c) Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO<sub>2</sub> 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. 3. Kinetic Theory of Gases 15 Lectures (a) 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. (b) 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. (c) Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO<sub>2</sub> 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.</p>
CC-6, Thermal Physics (Practical)	AC	<p>1. Determination of the coefficient of thermal expansion of a metallic rod using an optical lever. 2. Calibration of a thermocouple by direct measurement of the thermo-emf using potentiometer and the constants. [one end in ice and another end at water bath which to be heated. 3. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method. 4. To determine the boiling point of a liquid using Platinum Resistance Thermometer (PRT). 5. To determine Temperature Coefficient of Resistance using Carey Foster bridge.</p>
CC-7, Modern Physics (Theory)	AH	<p><b>1. Radiation and its nature:</b> (a) Blackbody Radiation, Planck's quantum hypothesis, Planck's constant (derivation of Planck formula is not required). Photoelectric effect and Compton scattering - light as a collection of photons. Davisson-Germer experiment. De Broglie wavelength and matter waves. Wave-particle duality. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Probability interpretation: Normalized wave functions as probability amplitudes. (b) Two-slit experiment with photons and electrons. Linear superposition principle as a consequence. (c) Position measurement, gamma ray microscope thought experiment. Heisenberg uncertainty principle (Statement with illustrations).</p>

		<p>Impossibility of a particle following a trajectory. <b>2. Basics of Quantum Mechanics:</b> (a) Quantum measurements: Deterministic vs probabilistic view points. States as normalised vectors (normalised wave functions). Dynamical variables as linear Hermitian operators (position, momentum, angular momentum, and energy as examples). (b) Schrödinger equation as a first principle. Probabilistic interpretation of wavefunction and equation of continuity (in 1D). Time evolution of wavefunction and <math>\exp(iHt/\hbar)</math> as the evolution operator. Stationary states. Eigenvalue equation. (c) Application to one dimensional systems: Boundary conditions on wave functions. Particle in an infinitely rigid box: energy eigenvalues and eigenfunctions, normalization. Quantum dot. Quantum mechanical tunnelling across a step potential &amp; rectangular potential barrier, <math>\alpha</math>-decay as an example. (d) Simultaneous measurements: Compatible and incompatible observables and their relation to commutativity. Heisenberg's uncertainty relation for a pair of incompatible observables. Illustration of the ideas using <math>[x_i, p_j]</math> and <math>[L_i, L_j]</math>. 3. Nuclear Structure 10 Lectures (a) 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. (b) Nature of nuclear force, NZ graph. (c) Nuclear Models: Liquid Drop model. semi-empirical mass formula and binding energy. Nuclear Shell Model. Magic numbers. <b>4. Interaction with and within nucleus:</b>(a) Radioactivity: 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. (b) 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) <b>5. Lasers:</b> 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 action.</p>
CC-7, Modern Physics (Practical)	<b>SM</b>	<p>1. Measurement of Plank constant using LED 2. Verification of Stefan's law of radiation by the measurement of voltage and current of a torch bulb glowing it beyond draper point. 3. Determination of e/m of electrons by using bar magnet. 4. To study the photoelectric effect: variation of photocurrent versus intensity and wavelength of light. 5. To show the tunneling effect in tunnel diode using I-V characteristics.</p>
SEC-A, Scientific Writing (Theory)	<b>AH</b>	<p><b>1. Introduction to LATEX:</b> The difference between WYSIWYG and WYSIWYM. Preparing a basic LATEX file. Compiling LATEX file. <b>2. Document classes :</b> Different type of document classes, e.g., article, report, book etc. <b>3. Page Layout:</b> Titles,</p>

		Abstract, Chapters, Sections, subsections, paragraph, verbatim, References, Equation references, citation. <b>4. List structures:</b> Itemize, enumerate, description etc. <b>5. Representation of mathematical equations:</b> Inline math, Equations, Fractions, Matrices, trigonometric, logarithmic, exponential functions, line-surfacevolume integrals with and without limits, closed line integral, surface integrals, Scaling of Parentheses, brackets etc. <b>6. Customization of fonts:</b> Bold fonts, emphasise, mathbf, mathcal etc. Changing sizes Large, Larger, Huge, tiny etc. <b>7. Writing tables:</b> Creating tables with different alignments, placement of horizontal, vertical lines. <b>8. Figures:</b> Changing and placing the figures, alignments.
SEC-A, Scientific Writing (Project)	<b>AH</b>	1. Writing articles/ research papers/reports 2. Writing mathematical derivation 3. Writing Resume 4. Writing any documentation of a practical done in laboratory with results, tables graphs. 5. Writing graphical analysis taking graphs plotted in gnuplot

### Semester- IV

Course code & Name	Assigned Teacher	Containts
CC-8, Mathematical Physics III (Theory)		
CC-8, Mathematical Physics III (Practical)	<b>SM</b>	<p><b>1. Exploring Gaussian Integrals and the delta function:</b></p> <ul style="list-style-type: none"> <li>Numerically handling improper integrals over infinite intervals</li> <li>Numerically verifying the Gaussian integral result <math>\int_{-\infty}^{\infty} \exp(-ax^2 + bx + c) dx = \sqrt{\frac{\pi}{a}} \exp\left(\frac{b^2}{4a} + c\right)</math></li> <li>Verifying that the convolution of two Gaussian function is a Gaussian</li> <li>Verifying that <math>\int_{-\infty}^{\infty} \exp(-ax^2) \delta(x-a) f(x) dx = f(a)</math> using different limiting representation of <math>\delta(x)</math>.</li> </ul> <p><b>2. Solution of Differential Equation:</b> First order and 2nd order ODE by <code>scipy.integrate.odeint()</code>.</p> <p><b>3. Special functions:</b> Use of special functions taken from <code>scipy.special</code>. Plotting and verification of the properties of special functions. Orthogonality relations and recursion relations. Examples, (a) <math>zJ'_\nu(z) + \nu J_\nu(z) = zJ_{\nu-1}(z)</math> (b) <math>(1-x^2)P'_n(x) + (n+1)xP_n(x) - (n+1)P_{n+1}(x) = 0</math> (c) <math>\int_{-\infty}^{\infty} P_n(x)P_m(x) dx = 2\delta_{2n+1}</math></p> <p><b>4. Solution of some basic PDEs:</b> (a) Boundary value problems. Finite</p>

		<p>discrete method with fixed step sizes. Idea of stability. Application to simple physical problems. (b) Laplace equation <math>\partial^2 \phi / \partial x^2 + \partial^2 \phi / \partial y^2 = 0</math>, on a square grid with specified potential at the boundaries. (c) Wave equation in 1+1 dimension: <math>\partial^2 \phi / \partial t^2 = \lambda \partial^2 \phi / \partial x^2</math>. Vibration of a string with ends fixed with given initial configurations: <math>\phi(x, 0)</math> and <math>\partial \phi / \partial t(x, 0)</math>. (d) Heat equation in 1+1 dimension, <math>\partial u / \partial t = \alpha \partial^2 u / \partial x^2</math> with specified value of temperature at the boundaries with given initial temperature at the boundaries with given initial temperature profile. <b>5. Fourier Series:</b> Evaluate the Fourier coefficients of a given periodic function using <code>scipy.integrate.quad()</code>. Examples: square wave, triangular wave, saw-tooth wave. Plot to see a wave form from <code>scipy.signal</code> and the constructed series along with.</p>
CC-9, Analog Systems and Applications (Theory)	AC	<p><b>1. Circuits and Network:</b> Discrete components, Active &amp; Passive components, 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. <b>2. Semiconductor Diodes and application:</b> (a) 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. (b) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, L and C filter. Circuit and operation of clipping and clamping circuit. (c) Principle and structure of • LEDs • Photodiode • Solar Cell • Varactor diode <b>3. Bipolar Junction transistors and biasing:</b> (a) n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Physical Mechanism of Current Flow. Current gains <math>\alpha</math> and <math>\beta</math>, Relations between them. Active, Cut-off and saturation Regions. DC Load line and Q-point. (b) Transistor Biasing and Stabilization Circuits; Fixed Bias, collector to base bias, emitter or self bias, 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. <b>4. Field Effect transistors:</b> JFET and MOSFET (both depletion and enhancement type) as a part of MISFET. Basic structure &amp; principle of operations and their characteristics. Pinch off, threshold voltage and short channel effect.</p>
CC-9, Analog Systems and Applications (Practical)	AC	<p>To study the reverse characteristics of Zener diode and study the load and line regulation. 2. To study the static characteristics of BJT in CE Configuration. 3. To design and study the frequency response of the BJT amplifier in CE mode. 4. Construction of a series regulated power supply from an unregulated power supply. 5. To study OPAMP: inverting amplifier, non inverting amplifier, adder, subtractor, comparator, Schmitt trigger, Integrator, differentiator, relaxation</p>

		oscillator. 6. To design a Wien bridge oscillator for given frequency using an op-amp.
CC-10, Quantum Mechanics (Theory)	<b>AH</b>	<p><b>1. Wavepacket description:</b> Description of a particle using wave packets. Spread of the Gaussian wave-packet for a free particle in one dimension. Fourier transforms and momentum space wavefunction. Position-Momentum uncertainty. <b>2. General discussion of bound states in an arbitrary potential:</b> Continuity of wave function, boundary condition and emergence of discrete energy levels. Application to one dimensional square well potential of finite depth. <b>3. Quantum mechanics of simple harmonic oscillator:</b> Setting up the eigenvalue equation for the Hamiltonian. Energy levels and energy eigenfunctions in terms of Hermite polynomials (Solution to Hermite differential equation may be assumed). Ground state, zero point energy &amp; uncertainty principle. <b>4. Quantum theory of hydrogen-like atoms:</b> Reduction of a two body problem to a one body problem. The time independent Schrodinger equation for a particle moving under a central force, the Schrodinger equation in spherical polar coordinates. Separation of variables. Angular equation and orbital angular momentum. Spherical Harmonics (Solution to Legendre differential equation may be assumed). Radial equation for attractive coulomb interaction - Hydrogen atom. Solution for the radial wavefunctions (Solution to Laguerre differential equation may be assumed). Shapes of the probability densities for ground &amp; first excited states. Orbital angular momentum quantum numbers <math>l</math> and <math>m</math>; s, p, d shells. <b>5. Generalized Angular Momenta and Spin:</b> (a) Generalized angular momentum. Electron's magnetic Moment and Spin Angular Momentum. <math>J = L + S</math>. Gyromagnetic Ratio and Bohr Magneton and the <math>g</math> factor. Energy associated with a magnetic dipole placed in magnetic field. Larmor's Theorem. Stern-Gerlach Experiment. (b) Addition of angular momenta - statement only. Allowed values of angular momentum. <b>6. Spectra of Hydrogen atom and its fine structure:</b> (a) Formula for first order nondegenerate perturbative correction to the eigenvalue statement only. (b) Spin-orbit interaction and relativistic correction to the kinetic energy and Darwin term. (c) Fine structure of the hydrogen atom spectrum (No rigorous derivation is required). <b>7. Atoms in Electric &amp; Magnetic Fields:</b> (a) Zeeman Effect: Normal and Anomalous Zeeman Effect (Formula for first order perturbative correction to the eigenvalue to be assumed). (b) Paschen Back effect &amp; Stark effects (Qualitative Discussion only). <b>8. Many electron atoms:</b> (a) Identical particles. Symmetric &amp; Antisymmetric Wave Functions. Pauli's Exclusion Principle. Hund's Rule. Periodic table. (b) Fine structure splitting. L-S and J-J coupling scheme. Spectral Notations for Atomic States and Term symbols. Spectra of Alkali Atoms (Na etc.).</p>
CC-10, Quantum	<b>SM</b>	<b>1. Finding eigenstates solving transcendental equation:</b> To find eigenvalues of the bound state particle of mass $m$ in a one dimensional potential well by solving the transcendental equation that appears as

Mechanics (Practical)		<p>the eigenvalue condition (graphs are to be plotted for appropriate guess values, scipy root searching package may be used) and to plot the eigenfunctions. <b>2. Use of shooting algorithm:</b> Shooting algorithm for solving bound state problems (solving the ode using both Euler and Numerov algorithms) : conversion to dimensionless variable, eigenvalues and eigenvectors of the ground and first excited states. • in one dimension (for example, the Harmonic oscillator, the Morse potential, the triangular well etc.) • the s wave radial equation for a particle moving in a central potential, <math>\frac{d^2 U(r)}{dr^2} = A(r)U(r)</math> where <math>A(r) = 2m \sim^2 [V(r) - E]</math> some Examples <math>V(r) = -e^{-2r}</math> <math>V(r) = -e^{-2r} e^{-r/a}</math> <math>V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3</math> <math>V(r) = D e^{-2\alpha r} - e^{-\alpha r}</math>, where <math>r' = r - r_0</math></p> <p><b>3. Time Evaluation of Wave Packet:</b> • Time evolution of a wave packet moving in free space by the numerical solution of the time dependent Schrödinger equation. • Solving the TDSE to study Barrier penetration and tunneling for an initially Gaussian wavepacket. Reference Books 1. An Introduction to computational Physics, T.Pang, 2nd Edn., 2006, Cambridge Univ. Press 2. Scientific Computing in Python, Abhijit Kar Gupta, Techno World 3. Computational Physics problem solving with Computers, Landau, Paez, Bordeianu etextbook in Python 3rd Edition 4. Computational Methods for physics, Joel Franklin, Cambridge University Press 5. Computational Quantum Mechanics, Joshua Izaac, Jingbo Wang, Springer</p>
SEC-B, Arduino (Theory)		
SEC-B, Arduino (Project)		

### Semester- V

Course code & Name	Assigned Teacher	Containts
CC-11, Electromagnetic Theory (Theory)	AC	<p><b>1.Maxwell Equations:</b> Review of Maxwell's equations. 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,</p>

		Momentum Density and Angular Momentum Density. <b>2. EM Wave Propagation in Unbounded Media:</b> 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.
	<b>AH</b>	<b>3. EM Wave in Bounded Media:</b> 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, Reflection & Transmission coefficients, Brewster's law. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence). <b>4. Polarization:</b> Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in birefringent medium
	<b>MDG</b>	<b>5. Polarization in uniaxial crystals:</b> Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Phase Retardation Plates: QuarterWave and Half-Wave Plates. Production & analysis of polarized light. Babinet Compensator and its Uses. <b>6. Rotatory polarization:</b> 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 and biquartz polarimeters.
CC-11, Electromagnetic Theory (Practical)	<b>AH</b>	1. To determine Brewster's angle for air-glass interface using a prism. 2. To study Fresnel's law by the reflection on the surface of a prism. 3. To verify the Malus law using a pair of polaroids. 4. To study the specific rotation of optically active solution using polarimeter. 5. To determine dispersive power and resolving power of a plane diffraction grating
CC-12, Statistical Physics (Theory)	<b>AH</b>	<b>1. Classical Statistical Mechanics:</b> (a) Macrostate & Microstate, Elementary Concept of Ensemble and Ergodic Hypothesis (statement only ). Phase Space. (b) Microcanonical ensemble, Postulate of Equal a-priori probabilities. Boltzmann hypothesis: Entropy and Thermodynamic Probability. (c) Canonical ensemble, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox. Equivalence of microcanonical and canonical ensemble. (d) Sackur Tetrode equation, Law of Equipartition of Energy (with proof) Applications to Specific Heat and its Limitations. Thermodynamic Functions of a Two-Energy Level System. Negative Temperature. (e) Grand canonical ensemble. Application of ideal gas using grand canonical ensemble. chemical potential. <b>2. Systems of Identical particles:</b> Collection of non-interacting identical particles. Classical approach and quantum approach: distinguishability and indistinguishability. Occupation number and MB distribution, emergence of Boltzmann factor. Composite system postulate and symmetry postulate of

		quantum mechanics (for a pair of particles only). Bosons and Fermions. Symmetric and Antisymmetric wave functions. state counting for bosons and fermions. <b>3. Bose-Einstein Statistics:</b> B-E distribution law. Thermodynamic functions of a strongly degenerate Bose Gas, Bose Einstein condensation and properties of liquid He IV (qualitative description only).
	<b>MDH</b>	<b>Radiation: classical and quantum aspects:</b> (a) Spectral Distribution of Black Body Radiation. Rayleigh-jeans law, UV catastrophe, Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of Rayleigh- Jeans Law, Stefan-Boltzmann Law, Wien's Displacement law from Planck's law. (b) Bose derivation of Planck's law. Radiation as a photon gas and Thermodynamic functions of photon gas. chemical potential of photon gas. <b>5. Fermi-Dirac Statistics:</b> Fermi-Dirac Distribution Law. Thermodynamic functions of strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals due to electrons.
CC-12, Statistical Physics (Practical)	<b>AH</b>	<b>1. Study of Random Numbers and Time series:</b> Introduction to the numpy.random() module • Histogram (by matplotlib.pyplot.hist) and autocorrelation function of a given time series. • Generating exponential variates from uniform variate using transformation • Gaussian variate from uniform variate using central limit theorem. • Study of histogram and moments of random sequences of different probability density using numpy.random. <b>2. Applications of Random Numbers:</b> • Coin tossing. Fit with binomial distribution. • Nuclear Decay: Simulation assuming a constant decay probability per unit time. • Random Walk: – In 1D and in 2D (Square grid) – Plot of r.m.s. value of end to end distance as a function of time step – fitting and finding of exponent • Monte Carlo Integration <b>3. Scaling and plots, exponents and parameters:</b> Laws and distributions from Statistical Mechanics Some Problems • Maxwell-Boltzmann distribution • Bose-Einstein distribution • Fermi-Dirac distribution • Plot of specific Heat of Solids _____ Dulong-Petit law _____ Einstein distribution function _____ Debye distribution function for high temperature and low temperature and compare them for these two cases
DSE-A1, Laser and Fiber Optics (Theory)	<b>AH</b>	<b>1.Einstein coefficients and Rate equations:</b> Historical background of laser, Einstein coefficients and stimulated light amplification: population inversion. Three level & four level lasers: Rate equation, condition for population inversion and threshold condition. minimum amount of pump power. <b>2. Basic properties of laser:</b> Coherence, directionality, monochromaticity, brightness. <b>3. Resonators:</b> Optical resonators. Different configurations of optical resonators. stability condition (no derivation required) and stability diagram for optical resonators. Cavity lifetime. The Quality factor. <b>4. Transient effect:</b> Transverse and Longitudinal mode

		<p>selection. Principle of Q-switching and Mode locking. Different methods of Q-switching : electro-optic Q-switching, Pockels cell .</p> <p><b>5. Basic Laser Systems:</b> (i) Gas Laser • He-Ne laser • CO<sub>2</sub> Laser (ii) Solid state laser • Ruby Laser • Nd:YAG laser • Semiconductor laser (iii) Liquid laser: Dye laser. <b>6. Practical properties and uses of laser:</b> (a) The Line-shape function. Various Line broadening mechanisms: collisional broadening , Natural broadening, Doppler broadening. (b) Basic idea of Laser cooling and trapping.</p>
DSE-B1, Nuclear and Particle Physics (Theory)	<b>MDG</b>	<p><b>1. Introduction:</b> Recapitulation of general properties of nuclei, nuclear models and radioactivity. <b>2. Nuclear Reactions:</b> 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). <b>3. Interaction of Nuclear Radiation with matter:</b> 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's interaction with matter. <b>4. Detector for Nuclear Radiations:</b> 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. <b>5. Particle Accelerators:</b> Accelerator facility available in India, Different type of accelerators • Van-de Graaf generator (Tandem accelerator) • Linear accelerator • Cyclotron • Betatron • Synchrotrons <b>6. Particle Physics:</b> Fundamental particles and their families. Fundamental particle-interactions and their basic features. Gellmann Nishijima formula. Quark structure of hadrons. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm. concept of quark model, color quantum number and gluons.</p>

## Semester- VI

<b>Course code &amp; Name</b>	<b>Assigned Teacher</b>	<b>Containts</b>
CC-13, Digital Systems and	AC	<p><b>1. Integrated Circuits</b> Principle of Design of monolithic Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only w.r.t. micron/submicron feature length). <b>2. Number System:</b> Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and</p>

Applications (Theory)		Hexadecimal numbers. Signed and unsigned number representation of binary system. Representation of negative number. 1's Complement and 2's Complement method of subtraction. <b>3. Digital Circuits:</b> (a) Difference between Analog and Digital Circuits. Introduction of switching algebra, Huntington's postulates. Combinational logic, Truth table. Introduction of basic logic functions AND, OR and NOT. Implementation of OR, AND, NOT Gates (realization using Diodes and Transistor). De Morgan's Theorems. NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. Circuit representation of gates (both Usual and IEEE symbols). Introduction to different logics like DTL, TTL, MOS and CMOS. MOS and CMOS inverter circuit. NAND/NOR circuit using MOS logic. (b) Product term and sum term in logical expression. Sum of Product and Product of Sum and mixed expression. Minterm and Maxterm in the expressions. Conversion between truth table and logical expression. Simplification of logical expression using Karnaugh Map. <b>4. Implementation of different circuits:</b> Half and Full Adders. Subtractors, 4-bit binary adder/Subtractor. Combinational logic circuits using PAL/PLA, use of IC 7483 as adder and subtractor. <b>5. Data processing circuits:</b> Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. <b>6. Sequential Circuits:</b> Introduction to Next state present state table, excitation table and truth table for Sequential circuits. SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race condition in SR and Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop, T type FF. <b>7. Registers and Counters:</b> (a) 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). (b) Counters (4 bits): Asynchronous counters: ripple counter, Decade Counter. Synchronous Counter, Ring counter.
CC-13, Digital Systems and Applications (Practical)	<b>AH</b>	1. To design OR & AND logic with diode and resistor. Basic logic gates with Transistors. To verify the logics by any type of universal gate NAND/NOR. 2. Construction of half adder and full adder 3. Construction of SR, D, JK FF circuits using NAND gates. 4. Construction of 4 bit shift registers (serial & parallel) using D type FF IC 7476. 5. Construction of $4 \times 1$ Multiplexer using basic gates and IC 74151.
CC-14, Solid State Physics (Theory)	<b>AH</b>	<b>1. Crystal Structure:</b> (a) 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. Laue and Bragg's Law and their equivalence. Atomic and Geometrical Structure Factor. Basic idea of crystal indexing: examples with SC, BCC, FCC structure. <b>2. Elementary Lattice Dynamics:</b> (a) Lattice Vibrations and Phonons: Linear Monatomic 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

		<p>heat of solids, T 3 law. <b>3. Magnetic Properties of Matter:</b> Dia, Para, Ferri and Ferromagnetic Materials. Classical Langevin Theory of Dia and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism (using partition function). Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss. <b>4. Dielectric Properties of Materials:</b> Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeier relations. Langevin-Debye equation. Complex Dielectric Constant. <b>5. Drude's theory:</b> Free electron gas in metals, effective mass, drift current, mobility and conductivity, Hall effect in metals. Thermal conductivity. Lorentz number, limitation of Drude's theory</p>
	<b>MDG</b>	<p><b>6. Elementary band theory:</b> Kronig Penny model. Band Gap. effective mass and effective mass tensor. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (4 probe method) &amp; Hall coefficient. <b>7. Superconductivity:</b> Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect.</p>
CC-14, Solid State Physics (Practical)	<b>AH</b>	<p>1. To study BH hysteresis of ferromagnetic material 2. To determine dielectric constant of different materials (solid and liquid) using fixed frequency alternating source. 3. Measurement of variation of resistivity in a semiconductor and investigation of intrinsic band gap using linear four probe. 4. Measurement of hall voltage by four probe method 5. To study temperature coefficient of a semiconductor (NTC thermistor) and construction of temperature controller with comparator and relay switch. 6. Measurement of magnetic susceptibility of solids</p>
DSE-A2, Nano Materials and Applications (Theory)	<b>MDG</b>	<p><b>1. Nanoscale Systems:</b> 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, Quantum confinement: Applications of Schrodinger equation: Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences. <b>2. Synthesis of Nanostructure Materials:</b> (a) Top down and Bottom up approach, Photolithography. Ball milling. Gas phase condensation. (b) Vacuum deposition • Physical vapor deposition (PVD) • Thermal evaporation – Electron beam evaporation – Pulsed Laser deposition • Chemical vapor deposition (CVD) • MBE growth of quantum dots (c) Chemical Synthesis • Chemical bath deposition • Electro deposition • Spray pyrolysis • Hydrothermal synthesis • Sol-Gel synthesis • Preparation through colloidal methods <b>3. Characterization:</b> (a) X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy (SEM). Transmission Electron Microscopy (TEM). Atomic Force Microscopy (AFM). Scanning Tunneling Microscopy (STM). <b>4.</b></p>

		<p><b>Optical Properties:</b> (a) Coulomb interaction in nanostructures. 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. <b>5. Electron Transport:</b> (a) Carrier transport in nanostructures. Coulomb blockade effect, thermionic emission, tunneling and hopping conductivity. Defects and impurities: Deep level and surface defects. <b>6. Applications:</b> (a) 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).</p>
DSE-B2, Advanced Statistical Mechanics (Theory)	AH	<p><b>1. Calculus of Variations:</b> (a) Definition of a functional : Idea of a functional as a definite integral. Examples: shortest distance between two points in a plane, on a sphere, Brachistochrone problem. Fermat's principle. (b) Extremization of the Lagrangian to obtain the equation of motion, i.e. the Euler Lagrange equation. (c) Calculus of variations in presence of constraints: Lagrange's equation for the first kind using undetermined multipliers. Applications using simple examples: block moving on a fixed and freely movable frictionless inclined plane, particle sliding along a cylinder and losing contact etc. (c) Lagrangian and its formulation for a non-inertial frame; appearance of the centrifugal force and the Coriolis' force from the Lagrangian picture. Lagrangian for charged particle in electromagnetic field and Lorentz force law. (d) Symmetries and Conservation laws. Virial theorem in classical mechanics. (e) Formulation of Hamiltonian Mechanics. Basic idea of Poisson bracket and its properties. Hamilton's EOM using Poisson bracket. <b>2.Small Oscillations:</b> 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 3 identical masses connected in a linear fashion to 2 - identical springs. <b>3. Rigid Body Motion:</b> Idea of rigid body in terms of constraints and degrees of freedom. Combination of translation and rotation as a general motion. Rotation of rigid body about an arbitrary axis; angular momentum, angular velocity, moments of inertia, products of inertia, kinetic energy. Principal axis transformation.</p>