Core T1 – Mathematical Physics

4 Credits

Calculus

Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation.
Approximation: Taylor series.

Second Order Differential equations: Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral.

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials.

Vector Calculus

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

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.

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

Orthogonal Curvilinear Coordinates

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

Introduction to probability

Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples.

Dirac Delta function and its properties

Definition of Dirac delta function. Properties of Dirac delta function.

Mathematical Physics Lab 2 credits

Introduction to plotting graphs with Gnuplot

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

Introduction to programming in Python/Fortran/C/C++:

Introduction to programming, constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, iterables, compound statements, indentation in python, the if-elif-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

Random number generation

Area of circle, volume of sphere

Solution of Algebraic and Transcendental equations by Newton Raphson method

Solution of First Order Ordinary Differential Equationsby Runge-Kutta (RK) second order method.

Core T2 – Mechanics 4 Credits

Fundamentals of Dynamics

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

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. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy.

Collisions

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

Rotational Dynamics

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

Elasticity

Relation between Elastic constants.

Fluid Motion

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

Gravitation and Central Force Motion

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

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 .

Oscillations

Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation.

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.

Special Theory of Relativity

Postulates of Special Theory of Relativity. Lorentz Transformations. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Mass-energy Equivalence.

Mechanics Lab

Mechanics 2 Credits

General Topic

Discussion on random errors in observations.

List of Practical (choose any 6)

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

GE T1 Mechanics
Credit 4

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

Laws of Motion
Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass. Momentum and Energy, Conservation of momentum. Work and energy. Conservation of energy.

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

Gravitation
Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only).

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

Elasticity
Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder

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

GE P1 – Mechanics Lab
Credit 2

List of Practicals (Choose any 5)

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

GE T3 Thermal Physics and Statistical Mechanics

4 Credits

Laws of Thermodynamics

Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature, First law and internal energy, conversion of heat into work, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Second law and Entropy, Carnot's cycle, Entropy changes in reversible & irreversible processes.

Thermo-dynamical Potentials

Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations JouleThompson Effect, Clausius- Clapeyron Equation, Expression for ($C_P - C_V$), TdS equations.

Kinetic Theory of Gases

Derivation of Maxwell's law of distribution of velocities, Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.

Theory of Radiation

Blackbody radiation, Spectral distribution, Statement of Planck's law (no derivation), Rayleigh- Jeans Law and Wien's displacement law from Planck's law.

Statistical Mechanics

Phase space, Macrostate and Microstate, Quantum statistics - Fermi-Dirac distribution law - electron gas.

GE P3 – Thermal Physics and Statistical Lab 2 Credits

List of Practical (Choose any five)

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