Engineering Physics

SH 102

Theory	:	4	Year	:	I
Tutorial	:	1	Part	:	I/II
Practical	:	2			

Course objectives: To provide the concept and knowledge of Physics with the emphasis of present-day application. The background of Physics corresponding to Proficiency Certificate Level is assumed.

Chapter	Syllabus	Micro syllabus
		(Prerequisites: Periodic motion, SHM & terminology, Simple pendulum & its time period, uses, rotational motion & I)
1. Oscillation (6 hrs)	**1.1 Physical pendulum**	1.1 Differential equation of SHM & solution, description, example in daily life, definition of Compound or Physical or Rigid pendulum, derivation of differential equation with solution, time period, equivalent length of simple pendulum, problems
	1.1.1 Bar pendulum	1.1.1 Bar Pendulum, study between time period & length of point of suspension from CG, proof of four collinear points having same time period in a bar pendulum, uses for determination of 'g' and 'K'
	1.1.2 Interchangeability of point of suspension and point of oscillation	1.1.2 Concept of point of suspension & oscillation in physical pendulum, proof of interchangeability of point of suspension and point of oscillation
	1.1.3Minimum time period in case of physical pendulum	1.1.3 Derive the condition for minimum time period, problems
	1.1.4Torsion pendulum	1.1.4 Description, derivation (time period), Uses for determination of 'η' and 'I', problems
	1.2 Damped and Forced Oscillation	1.2 Concept of free, damped & forced oscillation
	1.2.1 Damped harmonic oscillator	1.2.1 Derivation of differential equation, with solution, special cases of damping, condition for oscillation, problems
	1.2.2 Difference between free and damped oscillator	1.2.2 Differentiate with example, relation for frequency of free & damped oscillation
	1.2.3 Energy in damped oscillation	1.2.3 Expression of Energy in damped oscillation, Energy loss, problems
	1.2.4 Relaxation time	1.2.4 Definition, graphical representation, Relaxation time ($\tau = \frac{2m}{b}$), problems

	1.2.5 Forced oscillation and resonance 1.2.6 Sharpness of resonance 1.2.7 Quality factor	1.2.5 Derivation of differential equation for forced oscillation & solution (no derivation), explanation of resonance with mathematical expression 1.2.6 Definition only, factors affecting sharpness of resonance 1.2.7 Definition, expression (no derivation), band width, problems
2. Acoustics (3 hrs)	**2.1 Introduction** 2.1.1 Threshold of hearing and loudness 2.1.2 Reverberation and reverberation time 2.1.3 Absorption coefficient 2.1.4 Sabine's Law 2.1.5 Conditions for good acoustics	*(Prerequisites: Sound & its propagation, various sound phenomena,characteristics of sound)* 2.1 Introduction to Acoustic phenomena 2.1.1 Sound intensity equation, threshold of hearing, Intensity level, loudness 2.1.2 Definition, relation between sound intensity & time in a room, 2.1.3 Definition, perfect absorber, average absorption coefficient 2.1.4 Derivation , problems 2.1.5 Acoustic of building, conditions for good acoustics
	2.2 Ultrasound 2.2.1Production piezoelectric) of ultrasound and its applications 2.2.2Test of structure and materials 2.2.3 Medical uses	2.2 Definition 2.2.1 Concept of piezoelectric effect & its use for production of Ultrasound with figure, various applications of ultrasound 2.2.2 Explanation of test of structure and materials by using Ultrasound 2.2.3 Use of ultrasound for medical
3. Heat and Thermo-dynamics (8 hrs)	**3.1 Quantity of Heat** 3.1.1 Calorific value of Foods and Fuels 3.1.2 Bomb Calorimeter 3.1.3 Specific heat of solid: Dulong - Petit law, Einstein's law.	*(Prerequisites: Heat & Temperature, Specific Heat capacity, Calorimeter & calorimetry, Stefan's law of heat radiation and Newton's law of Cooling, thermodynamics & laws, enthalpy, entropy)* 3.1.1 Definition, values for important Foods & Fuels 3.1.2 Construction with figure, expression for calorific value, problems 3.1.3 Specific heat of solid: Classical Theory of Heat Capacity of Solid and Einstein's Quantum Theory of Heat Capacity of Solid, problems.
	3.2 **Nature of Heat** 3.2.1 Degree of freedom 3.2.2 Maxwell's law of equipartition of energy	 3.2.1 Definition (for mono, di, & tri-atomic molecule) 3.2.2 Maxwell's Law of equipartition of Energy, problems

	3.2.3 Atomicity of gases 3.2.4 Vander-Waal's equation of real gases 3.2.5 Critical constants	3.2.3Atomicity of mono, di & tri-atomic Gases 3.2.4Vander-Waal's Equation of Real Gas (i) correction for pressure and (ii) correction for volume 3.2.5 Vander-Waal's critical constants $\mathbf{V_C = 3b}$, $\mathbf{T_C = \frac{8a}{27Rb}}$, $\mathbf{P_C = \frac{a}{27b^2}}$, problems
	3.3 Thermodynamics 3.3.1 Laws of thermo-dynamics 3.3.2 Clapeyron latent heat equation 3.3.3 Entropy and Third law of thermo-dynamics 3.3.4 Negative energy 3.3.5 Maxwell's thermo-dynamic relations 3.3.6 Gibb's free energy and phase transitions	3.3.1 First and second law of thermodynamics (review only) 3.3.2 Derivation using thermo dynamical relation, applications, problems 3.3.3Entropy with physical concept, equation of change in entropy, third law of thermodynamics statement, numerical 3.3.4 concept of negative energy 3.3.5 Internal energy change $dU = TdS - PdV$ Enthalpy change $dH = TdS + VdP$ Helmholtz function change $dF = - SdT – PdV$ Gibb's function change $dG = - SdT + VdP$ Derivation of Clapeyron's latent heat equation from Maxwell's thermodynamic relations and show that for a perfect gas $\mathbf{\left(\frac{\partial U}{\partial V}\right)_T = 0}$ 3.3.6 Introduction, Internal energy (U), Enthalpy (H), Helmholtz free energy (F), Gibb's Free Energy (G) Phase transitions (First and second order), problems
	3.4 **Heat & mass Transfer** 3.4.1 Fourier's law of thermal conductivity 3.4.2 Use of thermal conductivity in building sciences 3.4.3 Thermal resistance 3.4.4 Types of convection 3.4.5 Law of diffusion	3.4.1 Definition and Fourier's law of thermal conductivity (derivation), problems 3.4.2 Application of thermal conduction in building science 3.4.3 Thermal resistance and diffusivity 3.4.4 Natural and Forced convection 3.4.5 Law of convection – diffusion differential equation

	3.4.6 Relation between Stefan's law and Newton's law of Cooling 3.4.7 Pyrheliometer and Pyrometer	$D\nabla^2 C - v.\nabla C - \frac{\partial C}{\partial t} + R = 0$ (Three cases explanation also) 3.4.6 Derivation of Newton's Law of Cooling from Stefan's law of black body r 3.4.7 Pyrheliometer, Radiation Pyrometer (Construction & working principle)
4. Optics (17 hrs)	**4.1 Geometrical optics** 4.1.1 Lens separation 4.1.2 Chromatism in lens combination	*(Prerequisites: Thin Lens formula, Images in lens, Lens Maker's formula, combination of lenses in contact, chromatic aberration in a lens, achromatism, Interference, condition for constructive & destructive interference, Young's double slit expt. & fringe width, basic concept of diffraction & polarization)* 4.1.1 Derivation of equivalent focal length of combination of two lenses separated at a distance, principal points & planes, numerical 4.1.2 Application of Chromatic aberration in a lens for derivation of condition of achromatism of two lenses separated at a distance (Calculus method only), for describing circle of least confusion & derivation of its diameter, problems
	4.2 Interference 4.2.1 Interference in thin films (reflected and transmitted light) 4.2.2 Fringes produced by a wedge-shaped thin film 4.2.3 Newton's rings (both reflected and transmitted case) 4.2.4 Determination of wavelength of light and refractive index of liquid by using Newton's rings	4.2.1 Derivation for path difference between two consecutive light radiations in thin film due to reflected & transmitted radiations and application for interference dark and bright fringes, numerical 4.2.2. Description with figure, derivation for fringe width, numerical 4.2.3 Description with experimental arrangement, application of interference fringes produced by a wedge-shaped thin film, derivation for radius of dark and bright rings, numerical 4.2.4 Application of derivation for diameter of dark and bright Newton's rings for determination of wavelength of light used & refractive index of a liquid, numerical
	4.3 Diffraction 4.3.1 Introduction: Fresnel and Fraunhoffer's diffraction	4.3.1 Definition, Difference between Fresnel and Fraunhoffer's diffraction

	4.3.2 Fraunhoffer's diffraction at single slit	4.3.2 Explanation with figure to obtain diffraction maxima and minima, derivation for width of central and other maxima in diffraction
	4.3.3 Intensity distribution in the diffraction pattern due to a single slit	4.3.3 Intensity distribution in the diffraction pattern due to a single slit
	4.3.4 Multiple slits, diffraction grating	4.3.4 Explanation of diffraction through multiple slits (not in detail), diffraction grating, derivation for principal maxima in diffraction grating, numerical
	4.3.5 X-ray diffraction, X-rays in material testing	4.3.5 Explanation of X-ray diffraction and uses for material testing
	4.4 Polarization	
	4.4.1 Introduction: double refraction, Nichol prism (construction and uses)	4.4.1 calcite Crystal (explanation with figure), optic axis, double refraction, Nichol prism (construction and use as polarizer and analyzer)
	4.4.2 Retardation plate (quarter and half wave plates), plane, elliptical and circular polarized light (theoretical & mathematical explanation)	4.4.2 Definition, expression for thickness, plane, elliptical and circularly polarized light (theoretical and mathematical explanation), problems
	4.4.3 Optical activity, specific rotation	4.4.3 Optically active substance & optical activity, specific rotation of optical active substance (mathematical expression only)
	4.5 Laser	
	4.5.1 Introduction: Laser and ordinary light, properties of laser	4.5.1 Definition, differences between Laser and ordinary light,
	4.5.2 Induced absorption, spontaneous and Stimulated emission, active medium, population inversion, metastable state	4.5.2 Explanation of various terminology used in Laser
	4.5.3 Pumping (types: optical, electrical, chemical and heating)	4.5.3 Definition of pumping and its types only
	4.5.4 He-Ne laser, semiconductor Laser	4.5.4 He-Ne laser (Construction & working principle with energy diagram), semiconductor Laser (introduction only)
	4.5.5 Uses of laser	4.5.5 Uses of laser

	4.6 Fiber Optics 4.6.1 Introduction: Propagation of light wave 4.6.2 Types of optical fiber: step index and graded index 4.6.3 Fiber transmission – single & multimode, self- focusing, acceptance angle and numerical aperture 4.6.4 Applications	4.6.1 Introduction, Propagation of light wave due to total internal reflection 4.6.2 Types of optical fiber 4.6.3 Fiber transmission, single and multimode, self-focusing, derivation of acceptance angle and numerical aperture, problems 4.6.4 Applications
5.Electrostatics (9 hrs)	**5.1Electric field** : 5.1.1 Electric field due to electric dipole (along axial and equatorial line) 5.1.2 Electric dipole in an external electric field 5.1.3 Electric field due to linear electric quadrupole (along axial line) 5.1.4 Electric field: a ring of charge, and disc of charge	*(Prerequisites: Electric charges & nature, electric field, electric potential due to a point charge, capacitor and capacitance, parallel plate capacitor, factors affecting capacitance, energy stored in capacitor, dielectric)* 5.1.1. Definition, figure, examples, mathematical expression, relation between electric potential & field, comparison (along axial and equatorial line), problems 5.1.2 Mathematical expression only and problems 5.1.3 Definition, figure, example, mathematical expression (along axial line), problems 5.1.4. Derivation with figure for electric field due to a ring of charge, condition of maximum intensity, problems. Derivation with figure for electric field due to a disc of charge, condition of an infinite sheet (one side of non-conductor), problems
	5.2 Electric potential 5.2.1 Electric potential due to electric dipole, 5.2.2 Electric potential due to linear electric quadrupole 5.2.3 Electric potential due to continuous charge distribution, ring of charge and disc of charge	5.2.1 Derivation with figure, special cases, problems 5.2.2 Derivation with figure, (along axial line only), problems 5.2.3 Mathematical expression only for electric potential due to continuous charge distribution , Derivation with figure for electric potential due to ring of charge, problems, Derivation with figure for electric potential due to disc of charge, problems

	5.3 Capacitors 5.3.1 Cylindrical capacitor 5.3.2 Charging and discharging of capacitor 5.3.3 Capacitor with dielectrics: dielectrics and Gauss law 5.3.4 High intensity of electrostatics fields: uses and hazards (xerography, inkjet, precipitation)	5.3.1 Use of general steps to determine the capacitance of cylindrical capacitor, Energy stored in electric field and energy density in electric field, problems 5.3.2 Mathematical expression for instantaneous charge during charging and discharging of capacitor, graphical representation, problems 5.3.3 Polar and non-polar dielectrics, explanation of effect of dielectric in capacitor, Gauss's law and ($\vec{D} = \varepsilon_0\vec{E} + \vec{P}$), Supercapacitor: Construction, properties and application of supercapacitors 5.3.4 Application of high intensity of electrostatics fields and hazards (xerography, inkjet, precipitation)
6.Electromagnetism (5 hrs)	**6.1 Electromagnetic induction** 6.1.1 Faraday's laws 6.1.2 Induction and energy transformation 6.1.3 Induced electric field 6.1.4 Self-induction and mutual induction 6.1.5 LR circuit 6.1.6 Energy stored in a magnetic field and energy density 6.1.7 Induced magnetic field: modified Ampere's law and displacement current	*(Prerequisites: Magnetic effect of current, Biot-Savart's law & its application, concept of electromagnetic induction)* 6.1.1 Statement & derivation , Physical interpretation of induced electric field 6.1.2 Introduction, derivation and interpretation, problems 6.1.3 Definition, mathematical expression 6.1.4 Concept of Self and Mutual induction, mathematical expression, Self-induction of Solenoid and Toroid, problem 6.1.5 LR Circuit, growing and decay current with mathematical and graphical explanation, problems 6.1.6 Mathematical expression, problems 6.1.7 Mathematical expression, problems
	6.2 Eddy Current 6.2.1 Introduction 6.2.2 Applications: Induction cooker, Electric Guitar, Metal Detector and Eddy Current Breaking	6.2.1 Introduction 6.2.2 Applications of eddy current: Induction cooker, Electric Guitar, Metal detector and Eddy current Breaking (only physical explanation)

	6.2.3 Cyclotron and Synchrotron	6.2.3 Cyclotron (Working principle & derivation, problems) and Synchrotron (only physically explanation)
7. Electromagnetic waves (6 hrs)	**7.1 Maxwell's Equations** 7.1.1Differential and integral forms 7.1.2 Conversion of Maxwell's equations from integral form to differential form and differential form to integral form 7.1.3 Maxwell's equations in different media	7.1.1 Mathematical expression, physical interpretation 7.1.2 Conversion of Maxwell's equations from integral form to differential form only, differential form to integral form (only elaborate and detail conservation not necessary) 7.1.3 Maxwell's equations in free space, non- conducting and Conducting medium
	7.2 Applications 7.2.1 Wave equations: non conducting and conducting medium and free space 7.2.2 Plane solution of wave equations, amplitude of electromagnetic waves, speed of electromagnetic waves, ratio of electric and magnetic fields 7.2.3 Continuity equation 7.2.4 Energy transfer and Poynting vector, Radiation pressure	7.2.1 Derivation of wave equations: non conducting and conducting medium and free Space 7.2.2 Derivation of plane solution of wave equations in free space, in conducting & non-conducting (expression only), amplitude of electromagnetic waves, speed of electromagnetic waves(free space), ratio of electric and magnetic fields (Derivation), problems 7.2.3 Introduction and derivation using Maxwell's equations 7.2.4 Introduction & derivation to average pointing vector, problems, Radiation pressure(mathematical expression), problems
8. Photon and matter waves (6 hrs)	**8.1 Quantum Physics** 8.1.1 Inadequacy of classical mechanics, rise of quantum mechanics, quantization of energy 8.1.2 Group velocity and phase velocity, electron and matter waves 8.1.3 de-Broglie wavelength, its applications 8.1.4 Heisenberg uncertainty principle and its applications	8.1.1 Inadequacy of classical mechanics, explanation & examples of quantum phenomena, concept of quantization of energy 8.1.2 Definition, explanation and mathematical relation 8.1.3 Expression, applications, problems 8.1.4 Expression, applications, problems

	8.1.5 Wave functions and its significance	8.1.5 Definition, physical significance
	8.2 Schrodinger wave equation 8.1.2 Time-independent and time-dependent equations 8.2.2 Probability distribution 8.2.3 One dimensional infinite potential well, Particle in a box 8.2.4 Barriers Tunneling effect (reflection and transmission coefficient qualitative)	 8.1.2 Derivation of time-independent and time-dependent Schrodinger wave equation (1-D) 8.2.2 Explanation of normalization and probability density 8.2.3 Derivation, Energy eigen value and eigen function, Discrete energy states diagram, problems 8.2.4 Explanation, expression for transmission and reflection coefficient (no derivation), problems

Question grid

Unit	Long questions	Short questions	Very Short questions
1. Oscillation	1	1	0
2. Acoustics	1	0	0
3. Heat & Thermodynamics	1	1	1
4. Optics	4	0	1
5. Electrostatics	2	0	1
6. Electromagnetism	1	0	1
7. Electromagnetic Waves	1	1	0
8. Photon & Matter Waves	1	1	0
Total	12×4 = 48	4×2 = 8	4×1 = 4

Note: *Out of twelve long questions there will be at least five numerical and out of four short questions there will be at least two one step numerical.*