

**B.E. MECHANICAL ENGINEERING**  
**FIRST YEAR**  
**FIRST SEMESTER**  
**SUPPLEMENTARY EXAM 2023**  
**SUBJECT: PHYSICS**

**Time: 3 hours**

**Full Marks: 100**

Answer **any ten** questions

1. (a) Give Poiseuille's method of measuring the viscosity of liquids. Derive the theoretical expression on which the method is based.  
(b) A flat plate of an area 100 sq. cm. is separated from a large plate by a layer of oil 2 mm thick. If the co-efficient of viscosity of the liquid is 15.5 poise, what horizontal force is required to keep the plate moving with a velocity of 3 cm/s? [7+3]
2. (a) What is terminal velocity? How does it depend upon (i) the radius of the falling spherical body (ii) the coefficient of viscosity of the medium (iii) the densities of the body and the medium?  
(b) Find the terminal velocity of an oil-drop of density  $0.95 \text{ g/cm}^3$  and radius  $10^{-4} \text{ cm}$  falling through air of density  $0.0013 \text{ g/cm}^3$ , if the viscosity of air is  $181 \times 10^{-6} \text{ c.g.s. units}$ . [7+3]
3. (a) Show that the sum of the Pressure Head, Gravitational Head, and Velocity Head is a constant for a fluid flow under static conditions.  
(b) Why do two ships moving side by side and parallel to each other tend to come closer together? [8+2]
4. (a) Derive the general solution of a damped harmonic vibration.  
(b) What is Logarithmic decrement? [8+2]
5. (a) Determine the average kinetic energy of a particle executing simple harmonic motion.  
(b) Two linear SHM's of equal amplitude but of frequencies  $\omega$  and  $2\omega$  are impressed simultaneously on a particle along the axes X and Y, respectively. If the initial phase-difference between them is  $\pi/2$ , find the resultant path followed by the particle. [6+4]
6. (a) Write down Maxwell's equations in free space.  
(b) Prove that the speed of electromagnetic waves in vacuum is given by  $v = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$ , where all the symbols have their usual meanings.  
(c) Suppose electromagnetic waves fall normally on the air-glass interface. Calculate the reflectance and transmittance. Given the refractive index of glass is 1.5. [4+4+2]

[ Turn over

7. (a) Two infinite plane parallel sheets carry surface charge density  $\pm\sigma$ . Calculate the electric field outside and in between the two sheets.  
 (b) Check whether  $\vec{E} = y^2\hat{i} + (2xy + z^2)\hat{j} + 2yz\hat{k}$  can represent an electrostatic field or not.  
 (c) State and explain Gauss law in the presence of dielectrics. [4+3+3]
8. (a) State Ampere's law in magnetostatics. Using Ampere's law obtain an expression for the magnetic field in a solenoid.  
 (b) State and explain Faraday's law of electromagnetic induction. [(3+4)+3]
9. (a) What are the conditions for sustained interference of light.  
 (b) What is coherence? Calculate the frequency bandwidth for white light (range  $4 \times 10^{14} - 7.5 \times 10^{14}$  Hz). Find the related coherence time and coherence length. [4+(2+4)]
10. (a) In a Young's double slit experiment, the fringe width is 0.4 mm. If the whole apparatus is immersed in water of refractive index  $\mu=4/3$  without changing its geometry. Find out the new fringe width.  
 (b) Find out an expression for the displacement of the fringes after introducing a thin transparent sheet of thickness  $t$  and refractive index  $\mu$  in one of the interfering beam's path of Young's double slit experiment. [5+5]
11. (a) Derive the condition for maxima and minima of a single slit diffraction pattern. Plot the corresponding intensity distribution profile.  
 (b) Explain and hence derive the condition for absent spectra of a diffraction grating.  
 (c) What is the highest order spectrum which may be seen with monochromatic light of wavelength 6000 Å by means of a diffraction grating with 5000 lines/cm. [(4+1)+2+3]
12. (a) What do you mean by plane of polarization and plane of vibration of an em wave propagating along the y-axis. What are the types of polarization? Explain.  
 (b) An unpolarized light falls on two polarized sheets placed one on top of the other. What must be the angle between the characteristic direction of the sheets if the intensity of the transmitted light is one-third the intensity of the incident light? [(4+2)+4]
13. (a) What are characteristics of de Broglie matter waves?  
 (b) State and explain Heisenberg's uncertainty principle. An electron has a speed of 600 m/s with an accuracy of 0.005%. Calculate the certainty with which we can locate the position of the electron. [ $h = 6.625 \times 10^{-34}$  Joule.s and mass of electron is  $9.1 \times 10^{-31}$  kg] [4+ (2+4)]
14. (a) What do you mean by the wave function of a particle? What is its physical significance?  
 (b) What are the properties of a well-behaved wave function?  
 (c) An eigenfunction of the operator  $\frac{d^2}{dx^2}$  is  $\Psi=e^{2x}$ . Find the corresponding eigenvalue. [4+2+4]
15. (a) Calculate the energy eigen values and wavefunctions for a particle of mass  $m$  trapped in a one-dimensional infinite square potential well of width  $a$ .  
 (b) Find the ground state probability of finding a particle between 0.45L and 0.55L which is trapped in a box of width L. [6+4]