Ref. No.: Ex/ME(M2)/BS/B/Ph/T/112/2023

B.E. MECHANICAL ENGINEERING

FIRST YEAR

FIRST SEMESTER EXAM 2023

SUBJECT: PHYSICS

Time: 3 hours **Full Marks: 100**

Answer **any ten** questions

1. (a) Define co-efficient of viscosity of a liquid. How does the co-efficient of viscosity depend upon the temperature and pressure?

   (b) A liquid of high density and low viscosity flowing through a tube of wide bore helps motion to be turbulent. Explain

   (c) Water flows in a horizontal tube of length 13.6 cm and diameter 2 mm. The pressure difference between the two ends of the tube is balanced by the pressure of 10 cm of Hg column. If the density of mercury is 13.6×10^3 kg/m^3 and co-efficient of viscosity of water 0.1 S.I. unit, find the volume of water coming out of the tube in 1 minute.

   [(2+2)+2+4]

2. (a) A body attains terminal velocity while falling through a viscous medium – Explain. Define terminal velocity. Obtain an expression for the terminal velocity of a small spherical body falling through a liquid.

   (b) Water flows along a horizontal pipe whose cross-section is not same everywhere. The pressure is 10^{-2} m of mercury where the flow velocity is 0.35 ms^{-1}. Find the pressure at the point where the flow velocity is 0.65 ms^{-1}. [(2+1+4)+3]

3. (a) State and prove Bernoulli's theorem in hydrodynamics.

   (b) Two drops of water of the same size are falling through air with terminal velocities of 1 ms^{-1}. If the two drops combine to form a single drop, what would be the new terminal velocity?

   [6+4]

4. (a) At what points on the path of simple harmonic motion are the velocity and acceleration maximum? At what points are they minimum?

   (b) Determine the average potential energy of a particle executing simple harmonic motion.

   (c) A particle moving in a straight line with simple harmonic motion of period $2\pi/\omega$ about a centre O, is observed to have a velocity $\sqrt{3}b\omega$ when at a distance b from O. If the particle is moving away from O at that instant, show that it will travel a further distance b in time $\pi/3\omega$ before coming to rest. [2+5+3]

5. (a) What is forced vibration? Write down the differential equation for the motion of a particle executing forced vibration in a resisting medium. Explain the physical meaning of each term and constant in the equation.

[Turn over

(b) "Resonance in an air column is flat while that in a sonometer wire is sharp" – Explain. [(1+7)+2]

6. (a) Write down the differential form of Ampere's law. How Maxwell modified the Ampere's law? Mention the differences between conduction and displacement currents.

(b) State and explain Faraday's law of electromagnetic induction.

[(1+4+2)+3]

7. (a) Define Poynting vector and explain its physical significance. State Poynting Theorem.

(b) Define radiation intensity and radiation pressure. The intensity of sunlight incident on the surface of earth is 1300 W/ m^2. Calculate the magnitude of electric and magnetic fields in sunlight. Also calculate the radiation pressure. [(3+2)+(2+3)]

8. (a) State Gauss law in the presence of dielectrics. The electric field intensity in a polystyrene sample of dielectric constant κ=2.55 fills the space between the plates of a parallel plate capacitor is 10 kV/m. Calculate the electric displacement D and polarization P.

(b) State Biot-Savart law. Briefly mention the validity, if any, of the Biot-Savart's law. A wire is bent into the size of a regular hexagon. Each side of the hexagon is l. A steady current i flows though this hexagon. Show that the magnitude of magnetic field at the center of the hexagon is $B = \frac{\sqrt{3}\mu_0 i}{\pi l}$ [(2+2)+(2+1+3)]

9. (a)What do you mean by coherence and what are its types? Explain clearly with example. What are the conditions for sustained interference pattern?

(b) A light source emits visible light of two wavelengths: λ= 430 nm and λ'= 510 nm. The source is used in a double-slit interference experiment with a slit to screen distance D=1.50 m and the distance between the slits d=0.0250 mm. Find the separation distance between the third-order bright fringes. [(4+3)+(3)]

10. (a) Deduce an expression for the intensity of light at a point due to superposition of waves coming from two light sources. Hence find the condition of destructive and constructive interference. Show the intensity distribution graphically.

(b) Two straight and narrow parallel slits 3 mm apart are illuminated by a monochromatic source (λ=5.9×10^{-5} cm). Fringes are observed at distance of 30 cm from the slits. Find the fringe width. [(3+2+2)+3]

11. (a) Discuss how a double slit interference can be used for determining the thickness of very thin transparent sheets?

(b) Derive the condition for maxima and minima of a single slit diffraction pattern. Plot the corresponding intensity distribution profile. [4+(4+2)]

12. (a) Find the half angular width (in degrees) of the central bright maximum in the Fraunhofer diffraction pattern of a slit of width 120 μm when the slit is illuminated by a monochromatic light of wavelength 6000 Å?

(b) How many lines per cm are there in a grating which gives the first order diffraction spectrum for light of wavelength 6 ×10^{-5} cm at an angle of 30°.

(c) Explain and hence derive the condition for absent spectra of a diffraction grating.

[3+3+4]

Ref. No.: Ex/ME(M2)/BS/B/Ph/T/112/2023

13. (a) What is polarization of light? Explain with diagram the plane of polarization and plane of vibration for an em wave propagating along y-axis.

(b) Describe the Brewster's Law of polarization. Find Brewster's angle for a transparent liquid having refractive index of 1.5. Does Brewster's angle changes with the colour of light used?

(c) What angle is needed between the direction of polarized light and the axis of a polarizing filter to reduce its intensity by 90.0? [(1+2)+4+3]

14. (a) What is De Broglie's hypothesis of matter waves? Explain why cannot we experience the existence of matter waves in our daily life.

(b) A photon and an electron, both are moving with 1 eV of energy. Compare their De Broglie wavelength. [(3+2)+5]

15. (a) What do you mean by wave function of a particle? Explain its physical significance.

(b) The wavefunction for a quantum particle of mass m confined to move in the domain $0 \leq x \leq L$ is given by $\psi(x) = \sin(4\pi x/L)$. Normalize the wavefunction and calculate the probability of finding the particle in the region from $x = 0$ to $x = L/4$.

(c) What do you mean by Hamiltonian operator? Write down the Hamiltonian operator for a particle moving in the x-direction.

[(2+1)+(3+2)+(1+1)]