

Bachelor of Engineering (Mechanical) Examination 2022
(First Year First Semester)

PHYSICS

Time: 3 hours

Full Marks: 100

Answer **any ten** questions

1. (a) Determine the average kinetic energy of a particle executing simple harmonic motion.
(b) The displacement of a particle executing SHM at a time t is given by $x = a \sin(\pi/6)t + b \cos(\pi/6)t$ where $a = 3\text{m}$ and $b = 4\text{m}$. Find the (i) amplitude and (ii) displacement, velocity and acceleration at a time $t = 2\text{s}$.
[6+4]

2. (a) Write down the differential equation for the motion of a particle executing damped vibration. Explain the physical meaning of each term and constant in the equation.
(b) What is resonance? What is sharpness of resonance?
(c) When a tuning fork is set into vibration in air, the vibrations are damped. Explain it with reasons.
[(2+2)+(2+2)+2]

3. (a) Deduce Poiseuille's equation for the rate of steady flow of a liquid through a narrow tube. What are the conditions to be satisfied for the deduction of the equation?
(b) Find the terminal velocity of an oil-drop of density 0.95 g/cm^3 and radius 10^{-4} cm falling through air of density 0.0013 g/cm^3 , if the viscosity of air is $181 \times 10^{-6} \text{ c.g.s. units}$.
[(5+2)+3]

4. (a) State and prove Stokes' law.
(b) Find out the minimum pressure required to force the blood from the heart to the top of head (vertical distance 0.45 m). Take the density of blood to be 1045 kgm^{-3} . Neglect friction. Given $g = 10 \text{ ms}^{-2}$.
[(2+4)+4]

5. (a) What do you mean by interference of light? Explain why coherent sources are essential for observing sustained interference pattern.
(b) Derive the conditions for maxima and minima for the Young's double slit experiment. What will be the fringe width?
[(2+1)+(5+2)]

6. (a) Distinguish between Fresnel and Fraunhofer diffraction.
(b) What is a plane transmission grating? Describe the diffraction pattern produced by a plane transmission grating.
(c) A diffraction grating used at normal incidence gives a line 540 nm in a certain order superposed on another line 405.5 nm of the next higher order. If the angle of diffraction be 30° , how many lines per cm are there on the grating?
[2+(1+4)+3]

[Turn over

7. (a) What is polarisation of light? Do sound waves show this phenomenon?
 (b) Describe the Brewster's Law of polarisation.
 (c) What is O-ray and E-ray? Describe the construction of a Nicole prism. [(2+1)+(3)+(2+2)]
8. (a) What is de Broglie wavelength? Explain its significance
 (b) For an electron being accelerated by a potential of 100 V, calculate its de Broglie wavelength.
 (c) State and describe the Heisenberg's uncertainty principle. [4+3+3]
9. (a) What is the wave function of a particle? What is its physical significance?
 (b) What are the properties of a well-behaved wave function?
 (c) Derive the time-dependent Schrödinger equation for an unrestricted particle of total energy E and momentum p moving along x -direction. [3+2+5]
10. (a) Write the time-dependent Schrödinger equation for a particle of mass m in one-dimension infinite square potential well of width a .
 (b) Calculate its energy eigen values and wavefunctions.
 (c) Estimate the probability of finding the particle in $0.25a < x < 0.5 a$ for the ground state. [3+5+2]
11. (a) Define time constant for a C-R circuit.
 (b) Obtain an expression for the growth of charge in a C-R circuit.
 (c) Sketch the variation of growth and decay of charge in a C-R circuit.
 (d) Prove that the time constant in a C-R circuit has the dimension of time. [1+5+2+2]
12. (a) What is displacement current? Describe how the Ampere's circuital law is modified in view of the displacement current.
 (b) Considering Maxwell's equations in free space, derive the electromagnetic wave equation in free space. [(1+2)+7]