2019

PHYSICS — HONOURS

Paper : CC-4

Full Marks : 50

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer ***question no.*** **1** and ***any four*** questions from the rest.

1. Answer ***any five*** questions : 2×5

(a) The superposition of two harmonic oscillations in the same direction results in the oscillation of a particle according to the law

$$x = a \cos 20\, t \cos 50\, t$$

where t is in seconds. Find the frequencies of the constituent oscillations.

(b) What is sharpness of resonance?

(c) The phase velocity of a wave is given by $v = \frac{a}{\sqrt{\lambda}}$, where λ is the wavelength of the wave. Find group velocity.

(d) What do you mean by coherent light sources? In interference experiments, why are the two beams always derived from the same source of light?

(e) What is meant by "missing order" in a double slit diffraction pattern?

(f) In a Fraunhofer diffraction from a double slit with yellow light the central maximum contains 5 bright lines. Find the ratio of the width of the slits and opaque space.

(g) When the movable mirror of Michelson's interferometer is shifted by 0·0589 mm a shift of 200 fringes is observed. Find the wavelength of light.

2. (a) Consider the equation of a damped harmonic oscillator

$$\frac{d^2x}{dt^2} + 2\beta\frac{dx}{dt} + \omega_0^2\, x = 0 .$$

For the critical damping $\beta = \omega_0$, find the general solution for $x(t)$. Sketch $x(t)$ vs. t for the following situations :

(i) At $t = 0$, the oscillator starts from rest at x_0.

(ii) At $t = 0$, the oscillator starts from $x = 0$ at velocity v_0.

(b) Calculate the resultant of two simple harmonic oscillations of equal time periods when they act at right angles to each other and their phase difference is (i) zero, (ii) $\pi/2$. (4+2)+4

3. (a) Consider the transverse vibrations of a stretched string having a uniform mass per unit length and fixed at both ends. The tension in the string is assumed to be constant. Find (i) the wave velocity (ii) the kinetic energy per unit length and (iii) the potential energy per unit length.

(b) The wave equation for spherically symmetric waves is given by :

$$\frac{\partial^2 \xi}{\partial r^2} + \frac{2}{r}\frac{\partial \xi}{\partial r} = \frac{k^2}{\omega^2}\frac{\partial^2 \xi}{\partial t^2}.$$

Show that this equation is satisfied by a simple harmonic wave whose amplitude falls off inversely with r. (4+1+2)+3

4. (a) A progressive wave is given by

$\psi(x, t) = A \sin\frac{2\pi}{\lambda}(vt - x)$ (notation is standard). Find kinetic and potential energies at different points. Is the total energy conserved? If not explain.

(b) Derive an expression for the speed of longitudinal waves in a fluid. What is Newton's formula for velocity of sound in gases? Why and how it was modified by Laplace? (3+1)+(4+2)

5. (a) Using Huygen's principle, obtain the laws of refraction of a plane wave at a plane surface. What is the condition for total internal reflection?

(b) In a plane diffraction grating at normal incidence, an orange line (λ_1 = 610·0 nm) of m-th order coincides with a blue line (λ_2 = 457·5 nm) of $(m + 1)$th order. If the angle of diffraction be 45°, find the value of m and calculate the grating constant. (4+2)+4

6. (a) What are the conditions necessary for observing interference fringes? Derive an expression for the resultant intensity when two coherent beams of light are superposed. Sketch the resultant intensity distribution.

(b) In Newton's rings experiment the diameter of 23rd ring was found to be 0·501 cm and that of 3rd ring was 0·181 cm. If the radius of curvature of the plano-convex lens is 0·5 m. calculate the wavelength of light used. (2+3+1)+4

7. (a) What are the conditions of Fresnel and Fraunhofer diffraction?

(b) Consider Fraunhofer diffraction from a single slit. Calculate the intensity and conditions for bright and dark fringes.

(c) Explain temporal and spatial coherence. 2+5+3