R-11 (Rod)

Z(2nd Sm.)-Physics-H/CC-4/CBCS
(Syllabus : 2019-20 & 2018-19)

2023

PHYSICS — HONOURS

(Syllabus : 2019-20 and 2018-19)

Paper : CC-4

(Waves and Optics)

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.
Symbols have their usual significance.

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

1. Answer ***any five*** questions :

(a) The superposition of two harmonic oscillations in the same direction results in the oscillation of a particle according to the law $x = a \cos 20t \cos 50t$, where t is in seconds. Find the frequencies of the constituent oscillations. 2×5

(b) What are beats?

(c) Explain the concept of log decrement in case of damped oscillatory motion.

(d) What will happen for fringe width, when Young's double slit experiment is performed in water?

(e) In Fraunhofer single slit diffraction pattern, find the ratio of intensities of central maximum first order and second order maximum.

(f) Write down the similarities and dissimilarities between a zone plate and a convex lens.

(g) What are the differences between diffraction patterns produced by a single and a double slit?

2. (a) Establish the equation of motion of a simple harmonic oscillator from energy consideration.

(b) Find out the expression of the amplitude A of the displacement resulting from the superposition of N SHMs all of the equal amplitude a, equal frequency ω and equal successive phase difference. What is the importance of this result?

(c) A mass of 1 gm is acted upon by a restoring force of 10^7 dyne/cm, a retarding force of 4×10^3 dynes-sec/cm and a driving force of $10^3 \cos \omega t$ dyne.

(i) Find the amplitude at steady state.

(ii) For what value of ω the amplitude will be the maximum? 2+(3+1)+4

3. The steady state displacement of a particle serving as a linear harmonic oscillator under the action of an external periodic force $F\exp(j\omega t)$, is given by

$$x = \frac{(F/m)\exp j(\omega t - \phi)}{\left[\left(\omega_0^2 - \omega^2\right)^2 + b^2\omega^2\right]^{1/2}}.$$

(a) Find the instantaneous velocity of the particle and prove that the velocity and the displacement differ in phase by $\pi/2$.

(b) Using above determine the condition for amplitude resonance and velocity resonance.

(c) Derive an expression for sharpness of resonance in terms of half-power frequency ω_1 and ω_2.

(d) Show that for such a vibration $\dfrac{\text{Average potential energy}}{\text{Average kinetic energy}} = \dfrac{\omega_0^2}{\omega^2}$. 2+(2+2)+2+2

4. (a) Find an expression for velocity of longitudinal wave in a fluid medium.

(b) Find an expression for displacement $y(x, t)$ of transverse wave in a stretched string of length l rigidly fixed at both ends. Assume uniform tension T at all points. Find expression for characteristic frequency.

(c) The displacement of ternsverse vibration in a plucked string is given by,

$$y(x,t) = \frac{2hl^2}{a(l-a)\pi^2}\sum_{n=1}^{\infty}\frac{1}{n^2}\sin\frac{n\pi a}{l}\sin\frac{n\pi x}{l}\cos\frac{n\pi ct}{l},$$

where l is the length of the string, a is the distance of point of plucking from the left end of the string and h is the initial displacement at $x = a$. Which harmonics will be absent if the string is plucked at a distance $a = \dfrac{l}{3}$? State Young-Helmholtz law in this case. 4+3+3

5. (a) How coherent sources of light waves are produced? Explain the terms 'spatial coherence' and 'temporal coherence' with reference to the Young's double slit experiment.

(b) How can you determine the thickness of a thin film by using Fresnel's biprism method? Compare the interference patterns formed in Lloyd's mirror and Fresnel biprism. (2+2+2)+(2+2)

6. (a) How are Newton's ring formed and why they are circular in shape?

(b) In Newton's ring experiment the diameter of 5th and 15th dark ring are 3.36 mm and 5.9 mm respectively. Find the diameter of 25th dark ring. If a liquid is introduced between plano convex lens and glass plate, then new diameter of 25th dark ring appears to be 6.83 mm. Calculate refractive index of the liquid.

(c) A shift of 100 circular fringes is observed, when movable mirror of Michelson interferometer is shifted by 0.295 mm. Calculate wavelength of the light.

(d) Define 'Coefficient of finesse' for a Febry Perot interferometer. 3+3+2+2

7. (a) For a zone plate of principal focal length 20 cm, calculate the approximate area of each half period zone if light of wavelength 5000 Å is used. Also determine the radius of third half period zone.

(b) A diffraction grating just resolves two lines of wavelengths 5140Å and 5140.5Å in the first order. Will it be able to resolve the lines of wavelengths 8037 Å and 8037.5 Å? If yes, then in which order?

(c) Discuss the effect on the Fraunhofer diffraction pattern from a double slit if, (i) slit width is fixed but separation is varied, and (ii) separation between the slits is fixed and the slit widths are varied.