RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. SECOND SEMESTER EXAMINATION, AUGUST 2021

FIRST YEAR [BATCH 2020-23]

PHYSICS (HONOURS)

Paper : IV [CC4]

Date : 12/08/2021

Time : 11 am – 1 pm

Full Marks : 50

Answer **any five** of the following questions: [5×10]

1. a) Derive a differential wave equation and its general solution. [3+2]

   b) Consider the pulse described in terms of its displacement at t = 0 by

   $$y(x,t)\big|_{t=0} = \frac{C}{2+x^2}$$

   where c is a constant. Draw the wave profile. Write an expression for the wave, having a speed ν in the negative x direction, as a function of time t. If $\nu = 1\text{m/s}$, sketch the profile at t = 2sec. [1+2+2]

2. a) Derive a expression for superposition of s collinear harmonic oscillation of equal phase difference.

   b) A particle is subjected to two SHM represented by the equation x = a, sin ωt, y = a sin $(2\omega t + s)$ in a plane acting at right angles to each other. Where‘s’ is phase difference. Discuss the formation of lissajous figure due to the superposition of these two vibrations. [5+5]

3. a) What are phase and group velocity? Find a relation between them.

   b) For a wave in medium, the angular frequency ω and wave vector $\vec{k}$ are related by

   $$\omega^2 = c^2k^2\left(1+\alpha k^2\right)$$

   where C and α are constant. What is the product of group and phase velocity? [(2+3)+5]

4. a) What are normal modes of vibrating stretched string? Calculate total energy of vibrating string.

   b) Calculate the expression for normal modes of a plucked string when the plucked point is l/3. Where l is the length of the string. [3+3+4]

5. a) Explain laws of refraction using Huygens’ wave theory. In this context show that the speed of light in a rarer medium is higher than the speed of light in a denser medium.

   b) Is light energy destroyed in the resulting dark regions due to interference?

   c) In a biprism experiment with a monochromatic light of wavelength 600 nm, the fringe width is found to be 0.48 mm. When a thin transparent film is placed in the path of one of the interfering beams the central fringe shifts by 2.40 mm. Calculate the thickness of the film whose refractive index is 1.56. [(4+1)+2+3]

6. a) In Young’s double slit setup the distance between the slits is 0.1 mm and the perpendicular distance of the screen from the plane of the slits is 50 cm. Find the separation on the screen between maxima for violet light (400 nm) and the red light (700 nm) in the first order.

   b) In Newton’s ring experiment, the diameter of *m*th dark ring is 10 mm and the diameter of the (*m* + 10)th dark is 15 mm. If the radius of curvature of the lower surface of the lens is 10 m, find the wavelength of light used.

c) What do you mean by Haidinger fringes? Draw a suitable diagram and explain the formation of Haidinger fringes on to the focal plane of the telescope in case of Fabry-Perot interferometer.

[3+3+(1+3)]

7. a) In a Michelson interferometer the initial and final screw readings are 10.7347 mm and 10.7051 mm as 100 fringes pass the field of view. Find the wavelength of light used as source here.

b) Assume a fine wire is placed parallelly at the front of a narrow linear slit producing monochromatic light. Draw the diffraction pattern which may be obtained on a screen placed parallelly and behind the wire at a finite distance from it. Explain why one should get that type of diffraction pattern in this case.

c) A zone plate is designed to bring a parallel beam of light of wavelength 500 nm to the first focus at a distance of 2 m. Calculate the radius of the central element of the zone plate. [3+(2+2)+3]

8. a) Why missing orders are found in case of Fraunhofer diffraction with double slit. Justify your answer with proper example.

b) A parallel beam of light of wavelength 500 nm is incident normally on a narrow slit of width 0.2 mm. The Fraunhofer diffraction is observed on a screen which is placed at the focal plane of a convex lens (placed very close to the slit) of focal length 20 cm. Calculate the width of the central maximum and the distance between first two minima.

c) From a sodium vapour lamp (having two wavelengths 589.0 nm and 589.6 nm, which are known as *D*-lines), light incident normally on a grating having 100 lines/mm, with width of ruled area 2 cm. Calculate in the first order (i) angle of diffraction, (ii) chromatic dispersion and (iii) resolving power. Clearly justify if the *D*-lines are resolved or not in the first order. [3+3+4]

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