Ex/UG/Sc./Core/Phy/TH/04/2022

B. SC. PHYSICS FIRST YEAR SECOND SEMESTER – 2022

Subject: Physics (Waves and Optics)

Core 4

Time: 2 hour

Full Marks: 40

Answer any 2 from Group A and two from Group B

Group - A

1. (a) State and express Fermat's principle in mathematical form. Give an example where light travelling from one point to another is maximum or stationary. (2+1)

   b) An equiconvex lens located in air has radii of 5.2 cm, an index of 1.68, and thickness of 3.5 cm. Establish the system matrix and hence calculate the (a) the focal length and (b) the power of the lens. Find (c) the distances from the vertices to (c) the principal points. (5)

   c) Consider the propagation of plane wave incident normally on a negative uniaxial crystal. Draw the refracted wave front when the optic axis is (a) parallel and (b) perpendicular to the incident direction. (2)

2. (a) Derive the expression for radii of Newton's rings in terms of thickness of the air film formed in between plano-convex lens and plane mirror. (3)

   b) Explain with schematic ray diagram the basic principle of Michelson interferometer. (4)

   c) How far must the movable mirror of a Michelson interferometer be displaced for 2500 fringes of the red cadmium line (6438 Å) to cross the center of the field of view. (3)

3. (a) Suppose a monochromatic coherent source of light passes through three parallel slits, each separated by a distance d from its neighbour. The waves have the same amplitude E_0 and angular frequency ω but a constant phase difference $\phi = 2\pi d \frac{sin\theta}{\lambda}$. Show that the intensity is $I = \frac{I_0}{9}\,[1 + 2\cos(2\pi d\; sin\theta/\lambda)]^2$ where, I_0 is the maximum intensity associated with the primary maxima. (3)

   b) Fraunhofer diffraction pattern is observed by double slit having slit width 0.16 mm and separation between the slits is 0.8 mm. Find the missing orders. (3)

   c) Make a qualitative sketch for the intensity pattern for five equally spaced slits having $\frac{d}{b} = 4$, where d is the distance between slits and b is the width of the slit.

[Turn over

Label several points on the x axis with the corresponding values of $\beta(\frac{\pi}{\lambda} bsin\theta)$ and γ $(\frac{\pi}{\lambda} dsin\theta)$ (2)

d) If $(a + b) < n\lambda$, will you expect nth order spectrum of the grating? Where, $a + b$ is the grating element? State the reason on your answer. (2)

Group - B

4. (a) The displacement of a particle is given by $y = 4cos^2\frac{t}{2}sin\,\omega t$. Prove that the motion of the particle is the superposition of individual harmonic motions. What are the angular frequencies of these individual harmonic motions? (2)

(b) Let us consider superposition of 20 simple harmonic vibrations of equal amplitude a and equal successive phase difference $\mathbf{0.05\pi}$. Using vector method, obtain the resultant vector. What will be its approximate magnitude? (3)

(c) A particle is subjected to two mutually perpendicular simple harmonic oscillations $x = a_1 \cos \omega t$ and $y = a_1 \cos(2\omega t + \delta)$
Trace the trajectory of the motion of the particle using analytical method. Using the graphical method obtain the resulting curve for $\delta=\pi$. (5)

5. (a) Deduce the wave equation for a spherical wave and find its solution. Write the physical significance of the solution. (3)

(b) Find the path difference between the two waves given as:

$y_1 = a_1 \sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)$ and $y_2 = a_1 \cos 2\pi\left(\frac{t}{T} - \frac{x}{\lambda} + \frac{\pi}{4}\right)$ (2)

(c) Explain with appropriate diagram that the curvature of a vibrating string at any point is proportional to the acceleration of the string at that point. (2)

(d) Apply Fourier series to analyse square waveform. (3)

6. (a)Write the general solution to a wave equation for a string. Obtain the expression for initial displacement and initial velocity. (4)

(b) If a string of length L tied at both ends is plucked at an arbitrary point then obtain the general solution as a series sum of different modes. Show that amplitudes of high frequency components decay rapidly. (6)