Ref No.:SC/PHY/UG/CORE/TH/04/2023

B. SC. PHYSICS FIRST YEAR SECOND SEMESTER – 2023

Subject: Physics (Waves and Optics)

Core 4

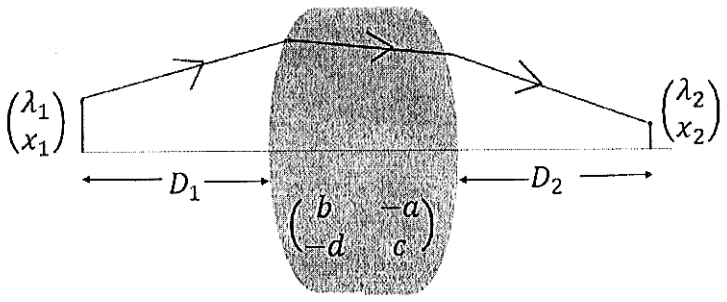
Time: 2 hour | Full Marks: 40

Answer all questions and use separate answer script for group A and B.

Group - A

1. (a) Use Fermat's principle to prove $\frac{n_2}{v} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{r}$ for a single spherical refracting surface of radius of curvature r. Other symbols have their usual meaning.

   (b) System matrix of a thick lens is given by $\begin{pmatrix} b & -a \\ -d & c \end{pmatrix}$. Let D_1 and D_2 are object and image distances, measured from first and second surface of the lens, respectively (See the figure below) .



Ray transfer from object to image position is given by $\begin{pmatrix} \lambda_2 \\ x_2 \end{pmatrix} = A \begin{pmatrix} \lambda_1 \\ x_1 \end{pmatrix}$. Find the matrix A and hence find the positions of unit planes. Establish the relation $\frac{1}{v} - \frac{1}{u} = a$, where u and v are the object and image distances measured from unit planes.

3+(3+2+2) CO3

OR

(a) Determine the refraction matrix for curved spherical interface.

(b) Consider a thick glass lens of refractive index 1.5, thickness 2.0 cm , and radii r_1 = +3 cm and r_2 = -5 cm, surrounded by air of refractive index 1.0.

(i) Determine the system matrix of the above thick lens.
(ii) Calculate the positions of the principal planes
(iii) Primary and secondary focal length of the lens.
(iv) Power of the lens

[Turn Over

2. (a) Show that two independent and incoherent sources cannot produce sustained interference pattern.

(b) In a Newton's ring experiment for reflected beam, why do you obtain dark spot at the point of contact between plano convex lens and plane glass plate? How can you convert this dark spot into a bright spot?

(c) A film of oil (Refractive index =1.7) is formed between a plane glass plate and an equi-convex lens (Refractive indices of both may be taken as 1.5). The focal length of the lens is 1 m. Find the radius of the 10^{th} dark ring when light of wavelength 6000Å falls normally on the combination.

3 + 3 + 4 CO2

OR

(a) What is Rayleigh criteria of resolution? How do you obtain resolving power of a plane transmission grating using Rayleigh criteria? Show that chromatic resolving power of the grating can be written as product of angular dispersion and width of the emerging beam.

(b) Light of two wavelengths λ= 5600 Å and λ= 5650 Å, fall normally on a plane transmission grating having 2500 lines per centimeter. The emerging parallel light is focused on a flat screen by a lens of 120 cm focal length. Find the distance on the screen in centimeters between the two spectrum lines (a) in the first order and (b) in the second order. (1+2+2) + 5

Group - B

3. (a) Explain with proper reasoning how a simple harmonic motion (S.H.M) can be expressed by a phasor diagram.

(b) Let us consider two S.H.M.s $x_1 = 3\cos\left(5\pi t + \frac{\pi}{6}\right) cm$ and $x_2 = 2\cos\left(5\pi t + \frac{\pi}{3}\right) cm$. Represent them in phasor diagrams and find out the phasor diagram of the resultant motion when they superpose. Use proper steps and explanations to obtain the phasor diagram of the resultant motion.

(c) If two collinear harmonic oscillators with different frequency superpose then show with proper derivation that the amplitude of the resultant motion is modulated. Draw the displacement-time graph of the resultant motion describing modulated amplitude, average frequency and modulated frequency. Explain why this motion is periodic but not simple harmonic? 2+4+4 **CO1**

OR

(a) Two systems are undergoing S.H.M.s with amplitude a_1 and a_2, both with angular frequency ω and initial phases ϕ_1 and ϕ_2 respectively. Use complex representation to

find out the resultant of their superposition. Explain the final expression of the complex form using the rotating vector diagram in complex plane.

(b) A particle is subjected to two mutually perpendicular simple harmonic oscillations $x = a_1 \cos \omega t$ and $y = a_1 \cos(\omega t + \delta)$
Obtain the trajectory of the motion of the particle using analytical method. Using the graphical method obtain the resulting curve for $\delta = 3\pi/4$.

4+6 **CO1**

4. (a) Consider propagation of longitudinal wave in a gas medium. Starting from a nonlinear relation between pressure and density obtain (i) continuity equation, (ii) Euler's equation of motion and (iii) finally the differential wave equation in terms of pressure variation.

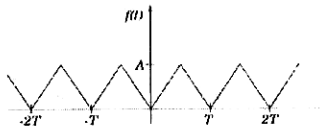
(b) Obtain the relation between group velocity and phase velocity and wavelength.

(2½+2½+2)+3 **CO2**

OR

(a) Let us consider a wire of length 87.5 cm and mass 3.5 x 10^{-2} kg stretched between two rigid supports. If the frequency of fundamental modes of vibration is 45 Hz then what is the tension in the wire?

(b) Write the Dirichlet conditions for expansion of a periodic function by Fourier series.



Apply Fourier series to analyse triangular waveform (as shown in the figure).

3+(2+5) **CO2**