BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
First Semester 2023-2024

MID-SEMESTER EXAMINATION (Closed Book)
Optics (PHY F213)
PART - I

Max. Marks: 35
Max. Time: 30 mins. **Date: 10.10.23**

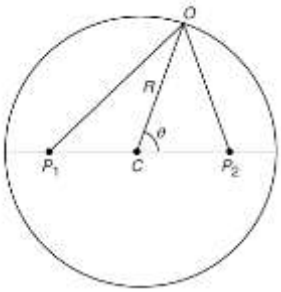
Instructions:

- **Write down ONLY the answer to each sub-part of a question in the space provided below each question, using proper alphabetical symbol(s) and with appropriate units.**

GIVEN: Avogadro Number = 6×10^{23}; $\varepsilon_0 = 8.854\times10^{-12}$ C/Nm^2; $m = 9.1\times10^{-31}$ kg.; $q = 1.6\times10^{-19}$ C.

NAME:_____ID.No.:_____**MARKS**

Q.1 C is the center of the reflecting sphere of radius R. P_1 and P_2 are two points on a diameter equidistant from the center, as shown in the figure. Obtain **(a)** the optical path length $P_1O + OP_2$ as a function of θ, and **(b)** the values of θ, for which P_1OP_2 is a ray path from reflection at the sphere. **[3 + 2]**



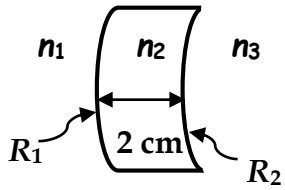
(a)

(b)

Q.2 A lens has the following specifications: $R_1 = +1.5$ cm $= R_2$; thickness = 2 cm; $n_1 = 1.00$; $n_2 = 1.6$; $n_3 = 1.3$; as shown in the adjacent figure. Write down the followings:

(a) the matrix equation relating an axial point with coordinates (λ_1, x_1) in n_1 as object to its image at (λ_2, x_2) in n_3 with all the intermediate matrices;

(b) the system matrix. ***(Use simple fractions for all elements of the matrices).*** **[3 + 2]**



(a)

(b)

Q.3 (a) What is called the bending of the lens?

(b) Consider a combination of two thin lenses, with focal lengths f and f' which are separated by a distance t, made of the same material. What is the condition that chromatic aberration is minimum for such a combination? **[3 + 2]**

(a)

(b)

P.T.O.

Q.4 (a) Rb is an alkali atom and there is one free electron per atom. Calculate the plasma wavelength, λ_p of Rb (in Å). Given: The atomic weight of Rb is 85.48 and density is 1.532 g/cm^3.

(b) A primitive model of an atom consists of a point nucleus ($+q$) surrounded by a uniformly charged electron cloud ($-q$) of radius a = 0.5 Å. Find out the natural frequency in Hz. **[3 + 3]**

(a)

(b)

Q.5 For pure silica, the following empirical formula can be assumed, where λ_0 is in μm:

$$n(\lambda_0) = 1.352 - 0.002\left(\lambda_0^2 - \frac{1}{\lambda_0^2}\right).$$

Calculate **(a)** the zero dispersion wavelength (in nm), **(b)** the material dispersion coefficient at 900 nm in ps/km.nm. **[3 + 2]**

(a)

(b)

Q.6 (a) The interference fringes formed by two coherent sources placed 1.2 mm apart are observed on a screen placed at a distance of 40 cm. If the second dark fringe is placed at a distance of 10 mm from the center of fringe, calculate the wavelength of the monochromatic light used.

(b) White light falling on two narrow slits emerges and is observed on a distant screen. If red light of wavelength 780 nm in the first order fringe overlaps violet in the second-order fringe, what is the wavelength of the violet light? **[2 + 2]**

(a)

(b)

Q.7 A soap film of refractive index μ = 1.38, under normal illumination and viewing, gives second order interference for reflected red light of λ = 690 nm. **(a)** Find out the thickness of the soap film.

(b) What happens to the circular fringe pattern if a plane mirror is used instead of the glass plate in a Newton's ring arrangement? **[3 + 2]**

(a)

(b)

The End

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
First Semester 2023-2024

MID-SEMESTER EXAMINATION (Closed Book)
Optics (PHY F213)
PART - II

Max. Marks: 70
Max. Time: 60 mins. **Date: 10.10.23**

Instructions:

- **Write answer all parts (and sub-parts) of the same question together.**
- **Numerical steps in problems & algebraic steps in derivations MUST be worked out and all assumptions must be stated.**

Q.1 (a) Write down the differential wave equation for a wave (consider $f(x, t)$) moving in one-dimension with a phase velocity v.
(b) Consider the displacement of a particle as given by $y = a\cos(\omega t + \Phi)$. Find out the expression for the total energy E. **[3 + 6]**

Q.2 A positive lens ($|R_2| > |R_1|$) of refractive index 1.5 and focal length 30 cm is bent to produce shape factors of two lenses with shape factors of 0.7 and 3.0. Determine the corresponding radii of curvatures for each of the two lenses. **[12]**

Q.3 In a metal, the drift velocity $\vec{v}$ of the free electrons follows the equation of motion:
$m\frac{d\vec{v}}{dt} + m\vec{v}v = \vec{F} = -qE_0\, e^{-i\omega t}$, where v represents the collision frequency.
(a) Find out expressions of steady state current density $\boldsymbol{J}$ and the conductivity $\sigma(\omega)$.
(b) If $\vec{\boldsymbol{r}}$ represents the displacement of the electron, find out an expression of polarization $\boldsymbol{P}$ in terms of the electric field $\boldsymbol{E}$.
(c) Find out also an expression for $\kappa(\omega)$, the dielectric constant variation. **[5+2+5]**

Q.4 (a) Derive an expression for the group velocity v_g relating it to the phase velocity v_p in terms of λ and $\frac{dv_p}{d\lambda}$.
(b) Waves on the ocean have different velocities, depending on their depth. Long wavelength waves, traveling deep in the ocean, have a speed given approximately by $v = \sqrt{\frac{g\lambda}{2\pi}}$, where g is the acceleration due to gravity. Short wavelength waves, corresponding to surface ripples, have a velocity approximately given by $v = \sqrt{\frac{2\pi T}{\lambda\rho}}$, where ρ is the density and T is the surface tension. Find out the relation between v_g and v_p for both long- and short- wavelength waves, using the expression as derived in **(a).** **[4 + 4 +4]**

Q.5 In a Fresnel mirror experiment, a source slit is parallel to the intersection between the mirrors and 50 cm away. The screen is 1 m from the same intersection, measured along the normal to the screen. When illuminated with sodium light of wavelength 589.3 nm, fringes appear on the screen with a spacing of 0.5 mm. Find out the angle between the two-plane adjacent mirrors, in radians. **[10]**

Q.6 (a) In an air wedge experiment, the angle of a wedge is 0.18° and the illumination is by a sodium lamp which gives two lines of wavelengths 5890 Å and 5896 Å. Find the distance from the apex at which the maxima due to two wavelengths first coincide when observed in reflected light. **[8]**
(b) In a Newton's rings set-up the diameter of the tenth bright ring changes from 1.32 cm to 1.17 cm, when a liquid is introduced between the lens and the glass plate. Calculate the refractive index of the liquid. **[7]**

********** ***The End*** **********