BACHELOR OF SCIENCE EXAMINATION, 2019

(1st Year, 2nd Semester)

PHYSICS

Optics I + Electricity and Magnetism I

Paper : CORE - 4

Time : Two hours Full Marks : 50

GROUP - A (25 marks)

Answer ***q.no. 1*** and any ***two*** from the rest.

1. (a) A Ramsdens eye piece is made of two thin convex lenses having focal lengths 10 and 20 cms separated by a distance 2 cm. Find the focal length of the eye piece.

   (b) In a double slit experiment, how many interference maxima do you observe within a central diffraction maximum when separation between the slits is twice the slit width ?

   (c) Consider two thin lenses of local lengths 10 and 20 cms separated by a distance t. The lenses are made of the same material. Find the value of t so that lens system forms achromatic doublet.

   (d) It is often desirable to spit a light beam into two plane polarised components, retaining both of them for later comparison of their intensities. Give an example of a modern microscope where this phenomenon is used for contrast enhancement.

(e) Name a modern microscope (based on polarisation by reflection of light) which enable the visualization of thin films, such as Langmuir monolayers, on liquid surfaces (at air-water interface). 1x5=5

2. (a) Define and sketch the ray diagram of unit planes and nodal planes of a thick lens. 4

(b) Consider a thick concave lens made of material of refractive index 1.5. The thickness of the lens is 1 cm and redii of curvature of the 1st and 2nd surface are 10 and 20 cm respectively. Find the system matrix and the positions of principal planes. 6

3. (a) Discuss how thickness of the thin glass plate or transparent mica sheet can be measured using Fresnel biprism. 5

(b) A Fresnel biprism is to be constructed for use on an optical bench with the slit and the observing screen 180 cm apart. The biprisms is to be 60 cm from the slit. Find the angle between two refracting surfaces of the biprism if the glass has a refractive index = 1.52, sodium light is to be used, and the firnges are to be 0.1 mm apart. 5

4. (a) Make a qualitative sketch for the intensity pattern for five equally spaced slits having $\frac{d}{b} = 4$, where d is the

GROUP - B (25 marks)

Answer any ***five*** questions.

6. A positive charge Q is uniformly distributed throughout a sphere of radius R. Find the electric field and the electric potential everywhere as a function of distance r from the centre of the sphere. Show the plot of field and potential as a function of r. 2+2+1

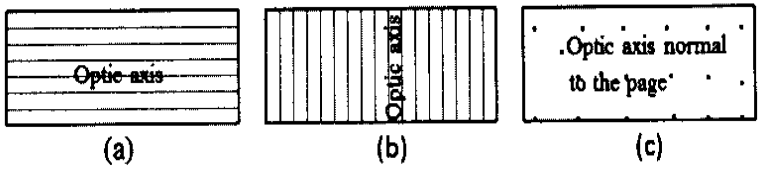
7. A cylindrical capacitor has its inner and outer radii of 5 mm and 15 mm respectively, where the inner plate is maintained at 100 V and the outer plate at 0 V. Find V, **E**, and **D** inside the capacitor. Hence, find the surface charge density σ on each plate. All the symbols have their usual meanings. [Given $\varepsilon_r = 2$] 5

8. (a) A point charge +q is placed at a distance *a* from an infinite conducting plane maintained at zero potential. Use the method of electrical images to calculate the force between the charge and the conducting plane.

(b) A point charge +q is placed at a distance d from the center of an insulated conducting sphere of radius *a*. Find the minimum charge Q that should be put on the sphere to make the force on the point charge zero. 2+3

with optic axis cut parallel to the surface. What will be the state of polarization of the emergent light? Justify your answer. Birefrengent value = 0.15. 2

(c) Consider propagation of plane wave incident normally on a negative uniaxial crystal. The figures below show the orientation of the optic axis of the crystal. Draw the wave-front of ordinary and extra-ordinary rays in each case. 3



(d) A pane polarised light of wavelength λ = 5893 Å, is incident on the quartz plate cut with optic axis parallel to the face. If the ratio of transmitted intensities of the E and O rays is 3:1, find the angle made by the light vibration wih the optic axis. 2

distance between slits and b is the width of the slit. Label several points on the x axis with the corresponding values of $\beta\left(=\frac{\pi}{\lambda}b\sin\theta\right)$ and $\gamma\left(=\frac{\pi}{\lambda}d\sin\theta\right)$. 2

(b) Calculate the width of the principal maxima of a grating spectrum. 2

(c) What should be the minimum lines a diffraction graiting must have to just resolve the doublet in the first order spectrum of sodium light consisting of two different wavelengths (5890 Å and 5896 Å). 2

(d) Light of two wavelengths, λ = 6000 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 between the two spectrum lines (i) in the first order and (ii) in the second order. 4

5. (a) What is quarter wave plate? How can it be used to produce circularly polarised light and elliptically polarised light? 3

(b) A left circularly polarised light (λ = 5800 Å) is incident on a doubly refracting crystal of thickness 0.0058 mm

9. State and prove Earnshaw's theorem. Calculate the self-energy of a uniformly charged sphere of radius R. 2+3

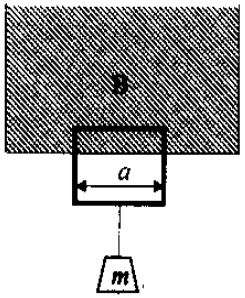
10. What do you mean by active and passive elements of any current/voltage source? Show how one can transform a voltage source into an equivalent current source. 2+3

11. Calculate the magnetic field at an axial point P at a distance x from the centre of a current carrying circular loop. Hence, explain the working principle of a Helmholtz coil. 2+3

12. (a) State Faraday's law of electromagnetic induction. Express it in differential form. What is its significance?

    (b) Find the emf induced in a coil of 200 turns and cross-sectional area of $0.4m^2$, when a magnetic field perpendicular to the plane of the coil changes from $0.1\ Wbm^{-2}$ to $0.5\ Wbm^2$ at a uniform rate over a period of 0.04 sec. $[(1+1^1/_2+1)+(1^1/_2)]$

13. (a) A rectangular loop of wire, supporting a mass m, hangs vertically with one end in a uniform magnetic field B, which points into the page in the shaded region. For what current l, in the loop, would the magnetic force upward exactly balances the gravitational force downward?



    (b) Write down the differential form of Ampere's law. Find the magnetic field at a distance's from a long straight wire carrying a steady current I. 2+3

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