Ex./UG/SC/CORE/PHY/TH/04/GR-A/2018(NEW)

BACHELOR OF SCIENCE EXAMINATION, 2018 (NEW)

(1st Year, 2nd Semester)

PHYSICS (HONOURS)

Paper : Core - 4

Time : Two hours | Full Marks : 50

Use separate Answer Script for each group

GROUP - A (25 marks)

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

1. Answer the questions : 1x5=5

(a) A light ray is incident on a spherical reflecting surface of radius of curvature R. Write down the reflection matrix assuming the device is kept in air.

(b) In a typical laboraory diffraction experiment, what experimetal procedure do you have to perform so as to study the Fraunhofer diffraction.

(c) Name a modern microscope where the phenomenon of double refraction is used.

(d) In a achromatic doublet, what will be the separation between two thin lenses (made of same glass material) of focal lengths 10 and 20 cms in order to remove the chromatic aberration.

(e) In a Newton rings experiment, what is the minimum distance , the plano convex lens should be raised vertically in order to produce central bright spot instead of dark one.

2. (a) Discuss the state of polarization when the x and y components of the electric field is given by the following equation. Plot the rotation of the tip of the electric vector on the plane $z = 0$. 2

$$
\begin{aligned}
E_x &= E_0 sin(\omega t + kz) \\
E_y &= E_0 cos(\omega t + kz)
\end{aligned}
$$

(b) In the question 2(a) if the light is incident on a calcite half-wave plate, what will be the state of polarization in the emergent beam? 2

(c) A plane polarised light of wavelength 5200 Å is incident on a piece of quartz crystal cut parallel to the optic axis. Find the least thickness for which the emergent beam is also plane polarised ($\mu_o = 1.5442$ and $\mu_e = 1.5533$.) 2

(d) Explain how does one obtain a plane polarised light using a Dichroic crystal. Give an example of such crystal. What is Brewster's angle? 1+ 2 + 1

3. (a) Explain why two incoherent sources cannot produce sustained interference pattern. 3

   (b) Consider the formation of Newton's rings when two closely spaced wavelengths (λ_1 = 5890 Å and λ_2 = 5896 Å) are present. Calculate the thickness, t, of the air film and corresponding order of the ring at which fringe system will completely disappear. If the plano convex lens is raised vertically by an amount t, the interference fringe will be washed out. Find out the vertical separation of the lens for which fringe system will again reappear. 4

   (c) Derive the working formula of Fresnel biprism experiment to determine the thickness of a transparent glass or mica sheet. 3

4. (a) The intensity distribution due to a N-slit diffraction is given by $I = I_0 \frac{sin^2\beta}{\beta^2} \frac{sin^2 N\gamma}{sin^2\gamma}$, where, $\beta = \frac{\pi}{\lambda} b sin\theta$ and $\gamma = \frac{\pi}{\lambda} d sin\theta$. Symbols have their usual meaning. Find the positions of maxima and minima. Show that the secondary maxima are of less importance when N is very large . Plot the diffraction profile for N = 3 3+2+1

   (b) Calculate the least width that a grating must have , to resolve two components of sodium D lines of wavelengths 5890 and 5896 Å in the second order. The number of lines per mm of the grating is 80. 4

5. (a) Define unit planes of a thick lens. Draw these planes for a biconvex thick lens. When do you expect nodal planes to be same as unit planes. 1 + 1 +1

   (b) An equiconvex lens with radii of 4 cm and index n_1 = 1.5 is located 2.0 cm in front of an equiconcave lens of radii 6 cm and index = 1.6. The lenses are to be considered as thin. The surrounding media have indices $n = 1.00$, $n' = 1.33$ and $n'' = 1.00$. Find (a) the system matrix (b) the power, (c) focal lengths, (d) the principal points of the system. 3 + 1 + 1 + 2

GROUP - B (25 marks)

Answer any *five* questions.

1. (a) State and explain the characteristics of a vector field.

   (b) One of these is an impossible electrostatic field. Which one?

   (i) $\vec{E} = A[xy\hat{\imath} + 2yz\hat{\jmath} + 3xz\hat{k}]$

   (ii) $\vec{E} = A[y^2\hat{\imath} + (2xy + z^2)\hat{\jmath} + 2yz\hat{k}]$

   where A is a constant with the appropriate units.

   (c) For the possible one in (b), find the charge density ρ.

$[2 + 1\frac{1}{2} + 1\frac{1}{2}]$

2. (a) Suppose an amount of charge Q is distributed within a sphere of radius R in such a way that the charge density $\rho(r)$ at a distance r from the centre of the sphere is

$$\rho(r) = \begin{cases} K(R-r) & \text{for } 0 < r < R \\ 0 & \text{for } r > R \end{cases}$$

   Determine the constant K in terms of Q and R.

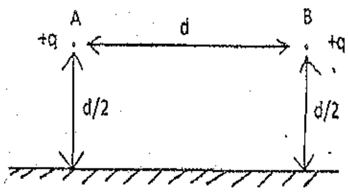
   (b) Use Gauss's law to find electric field at any point inside the sphere.

   (c) Find the value of r for which the field is maximum.

$[2 + 2 + 1]$

3. (a) What is an electrical image? State its usefulness in solving electrostatic problems.

   (b) Two equal charges $+q$ are placed a distance d apart in front of an infinite earthed conducting plane, as shown in the figure. Find the force on the charge $+q$ placed at B.



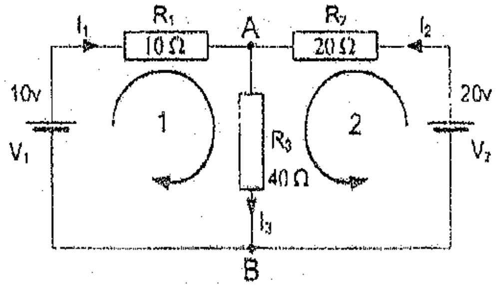
4. (a) Is it possible to design a capacitor using a single conductor? Justify your answer.

   (b) A capacitor consists of two concentric spherical conductors of radii a and b ($a < b$). The inner one is kept at potential ϕ_0 while the outer one is grounded. Use Laplace equation to find the potential function for this system. Find also an expression for the capacitance of this capacitor.

[1 + (2 + 2)]

5. (a) State and explain Kirchhoff's laws for the distribution of currents and voltages in a network.

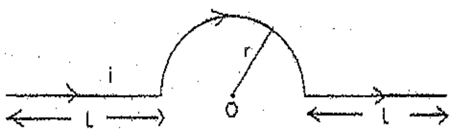
   (b) Use Kirchhoff's laws to find the currents flowing through each of the resistors, as shown in the figure.



[2 + 3]

6. (a) State and explain Biot-Savart law in vector form. Express this law also in terms of current density $\vec{j}$.

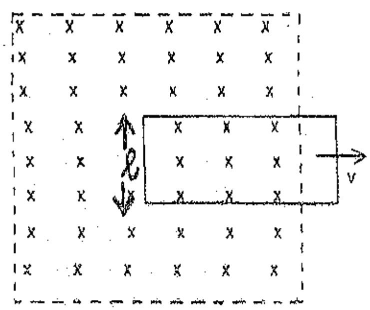
   (b) A long wire having a semi-circular loop of radius r carries a current i as shown in the figure. Find magnetic induction at the point O due to the given current configuration.



[(2 + 1) + 2]

7. (a) State and explain Faraday's laws of electromagnetic induction. Express it in differential form.

   (b) A rectangular loop of wire is placed in a uniform magnetic field $\vec{B}$ acting normally to the plane of the loop. If we attempt to put it out of the field with velocity $\vec{v}$, as shown in the figure, what will be the induced current in the loop? Take R is the resistance of the wire loop.



[(1 + 2) + 2]