

**2021**  
**PHYSICS**  
**[HONOURS]**  
**Paper : VII**

Full Marks : 80

Time : 4 Hours

*The figures in the right-hand margin indicate marks.*

*Candidates are required to give their answers in their own words as far as practicable.*

**GROUP–A**

1. Answer any **seven** questions: 1×7=7
- a) Distinguish between Fresnel and Fraunhofer class of diffractions.
  - b) Write down Maxwell's electromagnetic field equations.
  - c) What is population inversion?
  - d) What is the nature of central fringe in Lloyd's mirror experiment?
  - e) What is displacement current?
  - f) State the postulates of Einstein's special theory of relativity.

- g) Write down the components of four-vector momentum for a particle of rest mass  $m_0$ .
- h) Why is it necessary to use narrow source for Fresnel's biprism experiment?
- i) What is dichroism?

**GROUP–B**

2. Answer any **six** questions: 2×6=12
- a) A rectangular waveguide has a dimension of 5 cm×2.5 cm. Calculate the group velocity of propagation along this waveguide for  $(TE)_{10}$  mode at a frequency of 6 GHz.
  - b) Show that two simultaneous events at different points for an observer A at rest in the frame of reference S remain no longer simultaneous to an observer B at rest in the frame S' moving with uniform velocity v along the X-axis relative to S.
  - c) State and explain Malus's law.
  - d) Is the light energy destroyed in the region of destructive interference? Justify your answer.
  - e) Mention some important applications of lasers.

- f) A He-Ne laser has a coherence length of 10 m. What is the coherence time?
- g) What is Kerr electro-optic effect?
- h) A step index fibre has a core of refractive index 1.55 and cladding of refractive index 1.53. Determine its numerical aperture and acceptance angle.

**GROUP-C**

3. Answer any **three** questions: 7×3=21
- a) What is optical activity? What do you mean by optically active substance? Define specific rotation. The specific rotation of the quartz for  $\lambda = 508.6 \text{ nm}$  is 29.73 deg/mm. Calculate the difference between the refractive indices for left and right circularly polarised light for quartz. 1+2+2+2
  - b) Consider the incidence of electromagnetic wave at the boundary between two dielectric media. Derive expression for reflectance and transmittance when electric field  $\vec{E}$  is parallel to the plane of incidence. A light wave that is linearly polarised in the plane of incidence impinges at  $30^\circ$  on a crown glass ( $n=1.52$ ) plate in air. Compute the amplitude of

reflection and transmission coefficients at the interface. 4+3

- c) Show that  $E^2 - c^2B^2$  is an invariant quantity under Lorentz transformation. Where  $\vec{E}$  and  $\vec{B}$  are the electric and magnetic field and  $c$  is the velocity of light. Also show that if  $\vec{E}$  and  $\vec{B}$  are perpendicular to each other in one Lorentz frame, they are perpendicular in all Lorentz frame. Calculate the distance traversed by a particle in the laboratory frame during one mean life if it travels with a speed of  $2.22 \times 10^{10} \text{ cm/s}$ . (Given proper mean life =  $2.5 \times 10^{-8} \text{ s}$ ) 3+2+2
- d) Describe with necessary theory the Fresnel type of diffraction produced at a straight edge. How can you determine the wavelength of light from a study of this pattern? Draw a graph showing the intensity distribution of light in the diffraction pattern. 4+2+1
- e) Give a ray diagram of the light path in Michelson interferometer. What is the role of the compensator in Michelson interferometer? What will be the change in the interference pattern when monochromatic light is replaced by white light? In Michelson interferometer

1000 fringes cross the field of view when the movable mirror is displaced through 0.293 mm. Calculate the wavelength of light.

2+2+1+2

#### GROUP-D

4. Answer any **four** questions: 10×4=40

a) What is a quarter wave plate? How it can be used for the production of circularly and elliptically polarised light? Elliptically polarised light is incident normally on a quarter wave plate. Find the state of polarisation of the emergent light if the major axis of the ellipse make an angle  $0^\circ$  and  $90^\circ$  with the principal plane of the quarter wave plate.

2+(2+2)+(2+2)

b) Obtain the intensity expression for Fraunhofer diffraction pattern of a double slit. Deduce the conditions for maxima and minima. What is missing order in a double slit pattern? Calculate the least width that a grating must have, to resolve two components of sodium D-lines (having wavelength 589 nm and 589.6 nm) in the second order. The number of lines per mm of the grating is 80.

4+2+1+3

c) Give the theory of Newton's ring in reflected monochromatic light and from this study deduce an expression for the measurement of the wavelength of the monochromatic light. What will be the nature of the centre fringe of Newton's rings in transmitted light and reflected light? Newton's rings are formed in reflected light of wavelength 600 nm with a combination of plane plate of glass and a plano-convex lens of 1 m radius of curvature. On introducing a liquid between the lens and the plate it is found that the diameter of 7th dark ring decreases by 0.54 mm. Find the refractive index of the liquid.

(4+2)+1+3

d) Discuss the Lorentz transformation formulae and hence deduce length contraction and time dialation. Derive the velocity addition formula from the Lorentz transformation equations for a frame  $S'$  moving with velocity  $v$  with respect to frame  $S$ . Show how it varifies the postulate of the constancy of the velocity of light.

(2+2+2)+3+1

e) What do you mean by scattering cross-section? Derive an expression for Rayleigh scattering cross-section and hence explain the red colours of sunrise and sunset.

2+6+2

- f) A plane electromagnetic wave travelling in a dielectric medium incident normally on the surface of a conductor. Show that the field amplitudes are spatially attenuated inside the conductor. Hence find an expression for skin depth. Also show that  $\vec{E}$  and  $\vec{H}$  are mutually perpendicular and also they are perpendicular to the direction of propagation. For silver the conductivity  $\sigma = 3 \times 10^7 \text{ mho-m}^{-1}$ . Find its skin depth at a frequency of 10 GHz. 4+2+2+2
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