2020
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) State the postulates of Einstein's special theory of relativity.

b) State Malus's Law.

c) What is a polaroid?

d) Explain the term 'negative crystal'.

e) What do you mean by normal dispersion?

f) What is Kerr electro-optic effect?

g) What is a wave guide?

h) A He-Ne laser has a coherence length of 10 m. What is the coherence time?

i) What is an anti-reflection coating?

GROUP–B

2. Answer any **six** questions: 2×6=12

a) Explain the principle of holography.

b) The refractive index of the core of an optical fibre is 1.54. What should be the refractive index of the cladding for an acceptance angle of 25^{o}?

c) What are Stokes' and anti-Stokes' lines in Raman spectrum?

d) Explain why the colour of the sky is blue.

e) What are the conditions that must be satisfied for obtaining observable interference pattern?

f) Explain the colour phenomenon exhibited by thin films.

g) 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.

h) How many orders will be visible if the wavelength of incident light is 589 nm and the number of lines in the grating is 104 per mm?

GROUP–C

3. Answer any **three** questions: 7×3=21

a) Describe with energy level diagrams the phenomenon of spontaneous emission, stimulated emission and stimulated absorption in a two level system. What is population inversion? Derive a relation between Einstein's A and B coefficients. 2+1+4

b) Describe the method of determination of wavelength of a monochromatic light by means of Lloyd's mirror. In what respect do these fringes differ from those due to biprism? Explain why the central fringe is black in Lloyd's mirror experiment. 4+2+1

c) What is meant by Rayleigh criterion of resolution? Derive an expression for the resolving power of a plane diffraction grating. Sodium light of wavelengths 589.0 nm and 589.6 nm are made incident normally on a grating having 500 lines per mm. Calculate the angular dispersion of these lines in the spectrum of first order. 1+3+3

d) A plane electro-magnetic wave travelling in a dielectric is incident normally on the surface of a conductor. Show that the field amplitudes

are spatially attenuated inside the conductor. Hence find an expression of 'skin depth'. Also show that $\vec{E}$ and $\vec{H}$ are not in phase inside the conductor. 4+1+2

e) Prove that under Lorentz transformation the d'Alembertian $\Box^2 = \nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}$ remains invariant. Show that the rest mass of a particle moving with the speed of light is zero. A body of rest mass M and moving with velocity 0.8 c collides head on with a stationary body of rest mass m. After the impact the two bodies stick together and the combined body moves in the same direction with a velocity v. Find v and the rest mass of the combined body. 2+1+4

GROUP–D

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

a) Give the theory of Newton's ring and show from their study, how the wavelength of monochromatic light can be determined. What will be the nature of Newton's ring if white light is used instead of monochromatic light? Explain with necessary theory how you can

determine the refractive index of a liquid by means of Newton's ring experiment.

(4+2)+1+3

b) Describe the basic principle on which a Fabry-Perot interferometer works. Derive an expression for the intensity of the fringe system formed by the transmitted light in such an interferometer. Calculate the chromatic resolving power of a Fabry-Perot interferometer. A Fabry-Perot interferometer just resolves two lines with $\Delta\lambda = 0.1\,\text{Å}$ at $\lambda = 5000\,\text{Å}$. Find the minimum separation between the reflecting surfaces with reflectivity 0.95. 1+4+2+3

c) What is a zone-plate? How is it constructed? Explain its action as a convex lens and hence derive an expression for its focal length. What are the differences between zone-plate and convex lens? Calculate the inner and outer radii of the 10th half-period zone for a plane wavefront with respect to a point at a distance 0.5 m from it. Assume the wavelength of light $\lambda = 500\,\text{nm}$. 1+1+3+2+3

d) State and establish Brewster's law. What is a quarter-wave plate? How can it be used to produce circularly polarised light and elliptically polarised light? What is optical activity? Define specific rotation. If 20 cm column of a certain solution causes right hand rotation of 38° and 30 cm column of a second solution causes left hand rotation of 24°, what amount of rotation would be produced by 30 cm column of a mixture of the above solutions in volume ratio 1:2? 2+1+3+1+1+2

e) What is the conclusions of Michelson-Morley experiment? On the basis of special theory of relativity derive the Lorentz transformation relations. Hence show that for small velocities Lorentz transformation relations reduce to the Galilean transformation relations. Obtain relations to show that to a moving observer the length of the rod to be shortened and a time interval appears to be dialated. Hence prove that under Lorentz transformation the four dimensional volume dx dy dz dt is invariant.

1+3+1+3+2

f) Discuss the concept of displacement current. State Poynting theorem and establish it from

Maxwell's equations. Starting from Maxwell's equations derive the equations for the electromagnetic waves in free space. Hence show that the electric field vector, magnetic field vector and the propagation vector are all mutually perpendicular to each other.

2+(1+3)+3+1

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