2022
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) A He-Ne laser has a coherence length of 10 m. What is the coherence time?

b) What is Kerr electro-optic effect?

c) Explain the term 'negative crystal'.

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

e) What is an anti-reflection coating?

f) What do you mean by scattering cross section?

g) What do you mean by rotatory dispersion?

h) Why is it difficult to observe diffraction effect in sound waves?

i) What is stimulated emission?

GROUP–B

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

a) 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.

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

c) Explain the principle of holography.

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

e) The Doppler width of a source of $\lambda = 6058\,\text{Å}$ is $0.0005\,\text{Å}$. Find out the coherence length.

f) Calculate the thickness of a quarter wave plate for sodium light of wavelength 589.3 nm. Given n_0=1.5442 and n_e=1.5533.

g) The wavelength of certain light in air is 600 nm. Find its wavelength in a medium of refractive index 1.5.

h) At what velocity does the total energy of a moving particle become exactly twice its rest energy?

GROUP–C

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

a) 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

b) 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

c) 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

d) Derive velocity addition formula from the Lorentz transformation equation for a frame S' moving with velocity v with respect to a frame S. Show how it verifies postulates of constancy of the velocity of light. Show that for small velocities Lorentz transformation equations reduces to Galilean transformation equations. 4+1+2

e) Using Huygen's principle study the reflection of spherical waves from a concave mirror and establish the mirror equation $\frac{1}{u}+\frac{1}{v}=\frac{2}{r}$. Where the symbols have their usual meanings. Consider refraction of a plane wavefront by a plane interface separating two media. Using Huygen's principle show that the speed of light in a rearer medium is greater than the speed of light in a denser medium. 4+3

GROUP–D

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

a) 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

b) 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

c) 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

d) What is double refraction? If n_0 is the refractive index of O-rays and n_e is the refractive index of E-rays (in the direction perpendicular to the optic axis) then show that refractive index for E-rays in a direction making an angle θ with the optic axis is given by $\frac{1}{n_\theta^2} = \frac{\cos^2\theta}{n_0^2} + \frac{\sin^2\theta}{n_e^2}$. Describe the construction of Babinet's compensator. Explain how investigation of properties of elliptically polarized can be done using Babinet's compensator. 1+3+3+3

e) Describe the construction and working of Michelson's interferometer. In Michelson's interferometer 100 fringes cross the field of view when the movable mirror is displaced through 0.02948 mm. Calculate the wavelength of the monochromatic light used. 3+3+4

f) What do you mean by normal and anomalous dispersion? Give a theoretical account of anomalous dispersion from electromagnetic theory. Explain physically why the refractive index of glass for X-rays is less than unity. The intensity of light scattered by a polarizable substance is found to be 5 arbitrary units at a wavelength 546 nm. What would be the scattered intensity of 436 nm? 2+4+2+2

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