REV-01
BSP/03/08
2024/11

SET A

B.Sc. PHYSICS
THIRD SEMESTER
WAVE OPTICS & ELECTROMAGNETIC THEORY
BSP – 301

[USE OMR FOR OBJECTIVE PART]

Duration: 3 hrs. **Full Marks: 70**

(Objective)

Time: 30 min. **Marks: 20**

Choose the correct answer from the following: *1×20=20*

1. What is meant by the coherence of light waves?
   a. The ability of light waves to travel at the same speed
   b. The constant phase relationship between light waves
   c. The intensity of light waves
   d. The frequency of light waves

2. The linear magnification is given by ....
   a. Image distance/object distance
   b. Object distance/image distance
   c. The size of the object/the size of the image
   d. None of these

3. Which of the following is a measure of spatial coherence?
   a. Coherence length
   b. Wavelength
   c. Frequency
   d. Amplitude

4. The variation in the magnification produced by a lens for different axial distances results in the aberration called .....
   a. Coma
   b. Astigmatism
   c. Distortion
   d. The curvature of the field in the image

5. What is the cause of diffraction?
   a. Interference of primary wavelets
   b. Interference of secondary wavelets
   c. Reflection of primary wavelets
   d. Reflection of secondary wavelets

6. Consider interference between two waves from two sources of intensities I and 4I. What is the ratio of intensities at the point where the phase difference is π?
   a. 9I
   b. 2I
   c. I/2
   d. I

7. What happens if the monochromatic light used in Young's double-slit experiment is replaced by white light?
   a. No fringes are observed.
   b. All bright fringes become white.
   c. All bright fringes have colors between violet and red.
   d. Only the central fringe is white and all other fringes are colored.

8. In Newton's ring experiment, if the diameter of the nth Dark ring is D_n then the formula relating it to the wavelength λ and the radius of curvature R of the lens is
   a. $D_n^2 = n\lambda R$
   b. $D_n^2 = 4n\lambda R$
   c. $D_n^2 = n\lambda/R$
   d. $D_n^2 = nR/\lambda$

9. What is the velocity of light in diamond if the refractive index of diamond with respect to vacuum is 2.5?
   a. 1.2 x 108 m/s
   b. 5 x 108 m/s
   c. 1.2 x 109 m/s
   d. 2.5 x 108 m/s

10. Huygens's concept of secondary wave
   a. allow us to find the focal length of the thick lens
   b. it is a geometrical method to find the wavelength
   c. used to determine a velocity of light
   d. it is used to explain polarisation

11. Gauss' law of electrostatic states that
   a. $\nabla \cdot D = \rho$
   b. $\nabla \cdot D = \rho/\varepsilon_0$
   c. $\nabla \cdot E = \rho$
   d. $\nabla \cdot B = 0$

12. The magnitude of Poynting vector is
   a. $P = \frac{E_0 H_0}{c^2}$
   b. $P = \frac{E_0 H_0}{c}$
   c. $P = E_0 H_0$
   d. $P = c\, E_0 H_0$

13. Relaxation time is defined by
   a. $\tau = \sigma/\epsilon$
   b. $\tau = \sigma\epsilon$
   c. $\tau = \varepsilon/\sigma$
   d. $\tau = 1/\sigma\varepsilon$

14. The relation between electric and magnetic field strength is
   a. $E_0 = \frac{\omega}{\kappa} B_0$
   b. $E_0 = c^2 B_0$
   c. $E_0 = \frac{\omega}{\kappa B_0}$
   d. $E_0 = \frac{\kappa B_0}{\omega}$

15. Lorentz gauge states that
   a. $\nabla \cdot B = 0$
   b. $\nabla \cdot A + \frac{1}{c^2}\frac{\partial \Phi}{\partial t} = 0$
   c. $\nabla \cdot E + \frac{1}{c^2}\frac{\partial \Phi}{\partial t} = 0$
   d. $\nabla \cdot B + \frac{1}{c^2}\frac{\partial \Phi}{\partial t} = 0$

16. Under Coulomb gauge condition , scalar potential Φ satisfies the following equation
   a. $\nabla^2 \Phi = -\rho/\varepsilon_0$
   b. $\nabla \cdot A + \nabla^2 \Phi = -\rho/\varepsilon_0$
   c. $\nabla^2 \Phi = -\rho$
   d. $\nabla^2 \Phi = 0$

17. The de'Alembertian operator is defined by
   a. $\Box^2 = -\frac{1}{c^2}\frac{\partial^2}{\partial t^2} + \nabla^2$
   b. $\Box^2 = -\frac{1}{c^2}\frac{\partial^2}{\partial t^2} + \nabla$
   c. $\Box^2 = -\frac{1}{c^2}\frac{\partial}{\partial t} + \nabla^2$
   d. $\Box^2 = -\frac{1}{c^2}\frac{\partial}{\partial t} + \nabla$

18. Which one of the following pair is correct for electromagnetic potential?
   a. $\vec{B} = c\vec{\nabla} \times \vec{A}, \quad \vec{E} = -\frac{\partial \vec{A}}{\partial t} - \vec{\nabla}\Phi$
   b. $\vec{B} = \vec{\nabla} \times \vec{A}, \quad \vec{E} = -\frac{1}{c^2}\frac{\partial \vec{A}}{\partial t} - \vec{\nabla}\Phi$
   c. $\vec{B} = \vec{\nabla} \times \vec{A}, \quad \vec{E} = -\frac{\partial \vec{A}}{\partial t} - \vec{\nabla}\Phi$
   d. $\vec{B} = c\vec{\nabla} \times \vec{A}, \quad \vec{E} = -\frac{1}{c^2}\frac{\partial \vec{A}}{\partial t} - \vec{\nabla}\Phi$

19. The refractive index in any medium is defined by

a. $n = \sqrt{\frac{1}{\varepsilon_0 \mu_0}}$

b. $n = \sqrt{\frac{\varepsilon \mu}{\varepsilon_0 \mu_0}}$

c. $n = \sqrt{\varepsilon \mu}$

d. $n = \sqrt{\varepsilon_0 \mu_0}$

20. The average energy density of electromagnetic waves propagating in vacuum is given by

a. $U_{av} = \frac{1}{2} \varepsilon_0 E_0$

b. $U_{av} = \frac{1}{2} \varepsilon_0 E_0^2$

c. $U_{av} = \frac{1}{2} \varepsilon_0^2 E_0$

d. $U_{av} = \frac{1}{2} \varepsilon_0^2 E_0^2$

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Descriptive

Time : 2 hrs. 30 mins. **Marks : 50**

[Answer question no.1 & any four (4) from the rest]

1. A plane electromagnetic wave is incident normally at the boundary of two non-interface between two non-conducting media. Obtain an expression of reflection and transmission coefficients. **10**

2. a. Derive the theory of interference. **6+2+2 =10**

   b. Mention the conditions required for constructive and destructive interference of light.

   c. Is it necessary that the interfering waves should have the same frequency? If so, why?

3. a. Solve Maxwell's equations to deduced electromagnetic wave equations in free space. **5+5=10**

   b. Express the Lorentz force formula in terms of electromagnetic potentials.

4. a. Find the condition for achromatism of a combination of two thin lenses when in contact. **6+1+3 =10**

   b. What is the difference between pincushion and barrel-shaped distortion?

c. The focal length of an achromatic combination of two lenses in contact is 150 cm. If the dispersive powers of the two lenses are 0.018 and 0.027, calculate the focal lengths of the two lenses.

5. a. Show that curl gradient of a scalar function is zero. 3+4+3 =10

b. Find the value of charge density ρ for an electric field $\vec{E} = 3x\hat{i} - 2y\hat{j} + z\hat{k}$

c. Show that electromagnetic vector potential $\vec{A}(r,t)$ obey the identity: $\frac{d\vec{A}}{dt} = \frac{\partial\vec{A}}{\partial t} + (\vec{V}\cdot\vec{\nabla})\vec{A}$.

6. a. Give the theory of Newton's ring and show how from their study the wavelength of monochromatic light can be determined. 7+3=10

b. Define temporal coherence, spatial coherence and coherence length.

7. a. How are the scalar and vector potentials related to the electric and magnetic fields? 4+6=10

b. Establish the non-uniqueness of electromagnetic potentials and Gauge transformation.

8. a. Explain the difference between Fresnel and Fraunhoffer types of diffraction. 3+4+3 =10

b. Two coherent sources are 0.18 mm apart and the fringes are observed on a screen 80 cm away. It is found that with a certain monochromatic source of light, the fourth bright ring is situate at a distance of 10.8 mm from the central fringe. Calculate the wavelength of the light.

c. In Fraunhoffer diffraction pattern due to a narrow slit a screen is placed 2 m away from the lens to obtain the pattern. If the slit width is 0.2 mm and first minima lie 5 mm on either sides of the central maximum, find the wavelength of the light.

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