GUIDED REVISION

SECTION-I

Single Correct Answer Type **14 Q. [3 M (–1)]**

1. Two luminous point sources separated by a certain distance are at 10 km from an observer. If the aperture of his eye is 2.5×10^{-3} m and the wavelength of light used is 500 nm, the distance of separation between the point sources just seen to be resolved is

(A) 12.2 m (B) 24.2 m (C) 2.44 m (D) 1.22 m

2. If c is the speed of electromagnetic waves in vacuum, its speed in a medium of dielectric constant K and relative permeability μ, is

(A) $v = \frac{1}{\sqrt{\mu_r K}}$ (B) $v = \frac{c}{\sqrt{\mu_r K}}$ (C) $v = \frac{K}{\sqrt{\mu_r c}}$ (D) $v = \frac{\mu_r}{\sqrt{ck}}$

3. For an EM wave: $E = E_0 \sin 10^7[x - 2.5 \times 10^8 t]$ N/C in a medium then its refractive index is :

(A) 1.5 (B) 1.2 (C) 1.33 (D) 1.66

4. Which of the following Maxwell's equation is incorrect (where symbols have usual meanings):

(A) $\oint \vec{E} \cdot d\vec{A} = \frac{Q_{enclosed}}{\varepsilon_0}$ (B) $\oint \vec{B} \cdot d\vec{A} = \mu_0 i$

(C) $\oint \vec{E} \cdot \vec{dl} = \frac{-d\Phi_B}{dt}$ (D) $\oint \vec{B} \cdot \vec{dl} = \mu_0 i + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt}$

5. Two point white dots are 1 mm apart on a black paper. They are viewed by eye of pupil diameter 3 mm. Approximately, what is the maximum distance at which these dots can be resolved by the eye ?
[Take wavelength of light = 500 nm]

(A) 1 m (B) 3 m (C) 5 m (D) 7 m

6. If the wavelength of the incoming monochromatic light increases by 10%, then by what percentage the resolving power modifies (nearly)

(A) decreases by 9% (B) decreases by 10%
(C) increases by 9% (D) increases by 10%

7. The resolving power of a lens can be improved by increasing :

(A) Diameter of the lens (B) The object distance
(C) The wavelength of light (D) The brightness of light

8. In a single slit diffraction experiment first minima for $\lambda_1 = 660$ nm coincides with the first maxima for wavelength λ_2. Calculate λ_2 (approximately).

(A) 660 nm (B) 220 nm (C) 440 nm (D) 1320 nm

9. The rms value of the electric field of the light coming from the sun is 720 N/C. The average total energy density of the electromagnetic wave is-

(A) 4.58×10^{-6} J/m^3 (B) 6.37×10^{-9} J/m^3
(C) 81.35×10^{-12} J/m^3 (D) 3.3×10^{-3} J/m^3

10. An unpolarized light passes through three polarizing sheets whose polariging directions make an angle of 30°, 60° and 30° with y axis in same sense. What fraction of initial intensity is transmitted by the system ?

(A) $\frac{1}{2}$ (B) $\frac{9}{32}$ (C) $\frac{3}{32}$ (D) $\frac{9}{64}$

11. The electric field in an electromagnetic wave is given by $E = (50\ NC^{-1})\sin\omega\left(t - \frac{x}{c}\right)$. Find the intensity of the wave.

(A)3.3 W/m^2 (B) 0.33 W/m^2 (C) 33 W/m^2 (D) 330 W/m^2

12. When unpolarized light is converted into plane polarized light, when it is passed through a polarizer, then its intensity

(A)Remains unchanged (B) Becomes one fourth

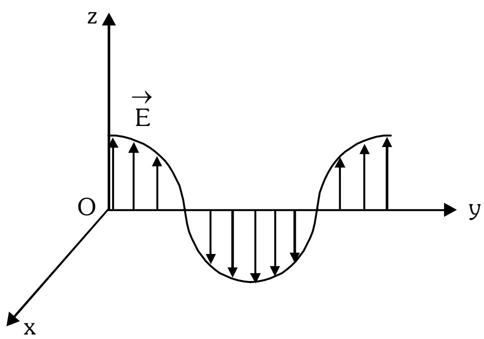
(C) Becomes half (D) Becomes double

13. A microscope objective gathers light over a cone of semi-vertex 30° and used visible light of wavelength 5500 Å. Its resolving limit is :-

(A) 2.5×10^{-5} cm (B) 4.6×10^{-5} cm

(C) 3.9×10^{-5} cm (D) 6.7×10^{-5} cm

14. The electric field for a plane electro-magnetic wave travelling in +y-direction is shown in the figure. Consider a point where electric field is in the +z direction. The magnetic field $\vec{B}$ is



(A)in the +x direction and in phase with the electric field $\vec{E}$

(B) in the –x direction and in phase with the electric field $\vec{E}$

(C) in the +z direction and in phase with the electric field $\vec{E}$

(D)in the –z direction and in phase with the electric field $\vec{E}$

Multiple Correct Answer Type 1 Q. [4 M (–1)]

15. Which of the following phenomenon can only be explained by wave nature of light :

(A) Reflection (B) Interference

(C) Photo-electric effect (D) Polarization

SECTION-IV

Matrix Match Type (4 × 5) **2 Q. [8 M (for each entry +2(0)]**

1.

	Column-I		**Column-II**
(A)	Mechanical waves in solids	(P)	Transverse only
(B)	Electromagnetic waves	(Q)	Longitudinal only
(C)	Sound waves	(R)	Require a medium to propagate
(D)	Pressure waves	(S)	Elastic parameters dependent
		(T)	None of these

2. Match the column I with column II -

	Column I (Law)		**Column II (Mathematical formula)**
(A)	Faraday law	(P)	$\oint \vec{E}.d\vec{A} = \frac{q}{\epsilon_0}$
(B)	Ampere Maxwell law	(Q)	$\oint \vec{B}.d\vec{A} = 0$
(C)	Gauss law for magnetism	(R)	$\oint \vec{E}.d\vec{\ell} = -\frac{d\phi_B}{dt}$
(D)	Gauss law for electrostatics	(S)	$\oint \vec{B}.d\vec{\ell} = \mu_0 i + \epsilon_0 \mu_0 \frac{d\phi_E}{dt}$

Subjective Type **2 Q. [4 M (0)]**

1. At what magnitude of the electric field strength in vacuum the volume energy density of this field is the same as that of the magnetic field with induction B = 1.0 T (also in vacuum) is _ _ _ _ _ _

2. Consider a prism of index of refraction n_2 separating media of different refractive indices n_1 and n_3. Is there one particular apex angle between the surfaces of the prism for which light can fall on both of its surfaces at Brewster's angle as it passes through the prism? If so, determine it.

ANSWER KEY **GR # EM WAVES, DIFFRACTION, POLARIZATION**

SECTION-I

Single Correct Answer Type **14 Q. [3 M (–1)]**

1. Ans. (C)	**2. Ans. (B)**	**3. Ans. (B)**	**4. Ans. (B)**
5. Ans. (C)	**6. Ans. (A)**	**7. Ans. (A)**	**8. Ans. (C)**
9. Ans. (A)	**10. Ans. (B)**	**11. Ans. (A)**	**12. Ans. (C)**
13. Ans. (D)	**14. Ans. (A)**		

Multiple Correct Answer Type **1 Q. [4 M (–1)]**

15. Ans. (B,D)

SECTION-IV

Matrix Match Type (4 × 5) **2 Q. [8 M (for each entry +2(0)]**

1. Ans. (A) → (R,S) ; (B) → (P) ; (C) → (Q,R,S) ; (D) → (Q,R,S)

2. Ans. (A) → (R), (B) → (S), (C) → (Q), (D) → (P)

Subjective Type **2 Q. [4 M (0)]**

1. Ans. 3.340 Ir. , $B/\sqrt{\mu_0 \epsilon_0} = 3 \times 10^8$ V/m

2. Ans. $\cot^{-1}\frac{n_2}{n_1} + \cot^{-1}\frac{n_2}{n_3}$

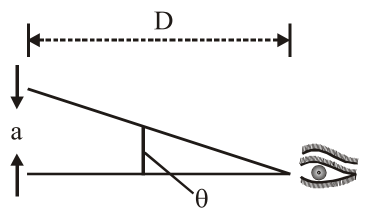
SOLUTIONS
SECTION-I

Single Correct Answer Type **14 Q. [3 M (–1)]**

1. Ans. (C)

Sol. According to Rayleigh's criterion,

$$\theta = \frac{1.22\lambda}{d_e}$$



where λ = wavelength of light,

d_e = diameter of the pupil of the eye.

$$\therefore\ \theta = \frac{1.22\times500\times10^{-9}}{2.5\times10^{-3}} = 2.44\times10^{-4}\ \text{rad} \qquad \text{But}\ \ \theta = \frac{a}{D}$$

$\therefore$ Distance of separation,

$a = D \times \theta = 10 \times 10^3 \times 2.44 \times 10^{-4} = 2.44$ m

2. Ans. (B)

Sol. $v = \dfrac{c}{\sqrt{\mu_r \in_r}}$

$\in_r = K$

$v = \dfrac{c}{\sqrt{\mu_r K}}$

3. Ans. (B)

Sol. Compare with $y = A \sin(kx - wt)$

$\therefore$ Velocity of wave $v = \dfrac{\omega}{k} = 2.5\times10^8$

$\therefore$ Refractive index

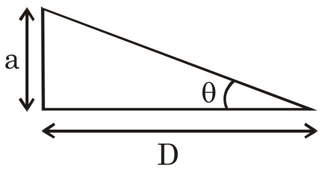
$$\mu = \frac{c}{v} = \frac{3\times10^8}{2.5\times10^8} = \frac{3}{\frac{5}{2}} = \frac{6}{5}$$

4. Ans. (B)

Sol. Conceptual.

5. **Ans. (C)**

Sol. $\theta = \frac{1.22\lambda}{d} = \frac{a}{D}$



$$\frac{1.22 \times 500 \times 10^{-9}}{3 \times 10^{-3}} = \frac{1 \times 10^{-3}}{D}$$

$D \approx 5m$

6. **Ans. (A)**

Sol. R.P. $\propto \frac{1}{\lambda}$

$R_1\lambda_1 = R_2\lambda_2$

$R_2 = R_1\left[\frac{10}{11}\right]$

R_2 decreases by $\frac{100}{11}\%$

7. **Ans. (A)**

Sol. Resolving power is given by the receprocal of the minimum separation between two points seen as distinct

$$= \frac{D}{1.22\lambda L}$$

D = Aperture diameter of lens

L = Object distance

8. **Ans. (C)**

Sol. Position of minima

$a \sin\theta = n\lambda$

$a \sin\theta = \lambda_1$

$\sin\theta_1 = \frac{\lambda_1}{a}$ ..... (i)

For maxima

$a \sin\theta = \frac{3\lambda_2}{2}$ [approximately] ..... (ii)

$\sin\theta_1 = \frac{3}{2}\frac{\lambda_2}{a}$

$\lambda_1 = \frac{3}{2}\lambda_2$

$\lambda_2 = \frac{2}{3}\lambda_1 = 440\,\text{nm}$

9. **Ans. (A)**

Sol. $E_{max} = \sqrt{2}\ E_{rms}$

average total energy density = $\frac{1}{2}\in_0 E_{max}^2$

10. Ans. (B)

Sol. $I = \frac{I_0}{2} \times \cos^2 30° \times \cos^2 30°$

$= \frac{9I_0}{32}$

11. Ans. (A)

Sol. $I = \frac{1}{2}\varepsilon_0 E_0^2 C = 3.3\ W/m^2$

12. Ans. (C)

Sol. $I = I_0 < \cos^2\theta >$

$= I_0 \times \frac{1}{2}$

$I = \frac{I_0}{2}$

13. Ans. (D)

Sol. Resolving limits of microscope is $S = \frac{1.22\lambda}{2\sin i}$

i = semi cone angle of light

$s = \frac{1.22 \times 5.5 \times 10^{-5} cm}{2 \times \sin 30} = 6.7 \times 10^{-5} cm$

14. Ans. (A)

Sol. $\vec{E} = \vec{B} \times \vec{v}$

$\hat{k} \times i = j$

Multiple Correct Answer Type — 1 Q. [4 M (–1)]

15. Ans. (B,D)

Sol. Reflection can be explained by both particle as well as wave nature of light.
Photo-electric effect can only be explained by particle nature of light.
Interference & polarization can only be explained by wave nature of light.

SECTION-IV

Matrix Match Type (4 × 5) — 2 Q. [8 M (for each entry +2(0)]

1. Ans. (A) → (R,S) ; (B) → (P) ; (C) → (Q,R,S) ; (D) → (Q,R,S)

Sol. In solids, transverse and longitudinal waves propagate. Longitudinal waves require a medium to propagate. These waves need elastic properties of medium to propagate. Pressure waves are longitudinal waves.

2. Ans. (A) – R, (B) – S, (C) – Q, (D) – P

Subjective Type — 2 Q. [4 M (0)]

1. Ans. 3.340 Ir. , $B/\sqrt{\mu_0 \in_0} = 3 \times 10^8$ V/m

Sol. $\frac{1}{2}\in_0 E^2 = \frac{B^2}{2\mu_0}$

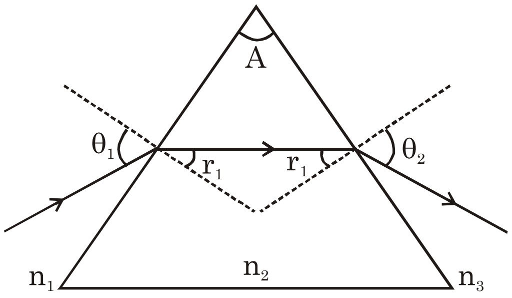
$$E = \frac{B^2}{\sqrt{\mu_0 \in_0}}$$

$$C = \frac{1}{\sqrt{\mu_0 \in_0}}$$

$E = BC$

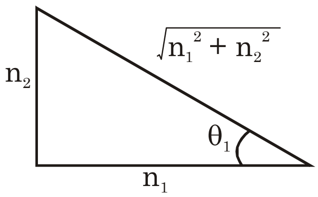
$= 1 \times 3 \times 10^8$

2. **Ans.** $\cot^{-1}\frac{n_2}{n_1} + \cot^{-1}\frac{n_2}{n_3}$

Sol. 

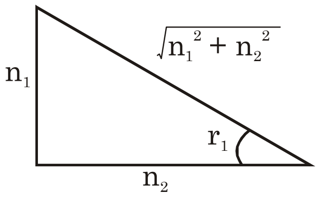
$$\tan\theta_1 = \frac{n_2}{n_1}, \qquad \tan\theta_2 = \frac{n_2}{n_3}$$

$r_1 + r_2 = A$



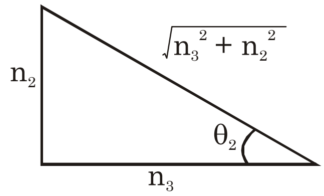
$n_1 \sin\theta_1 = n_2 \sin r_1$

or $\sin r_1 = \frac{n_1}{n_2} \times \frac{n_2}{\sqrt{n_1^2 + n_2^2}}$



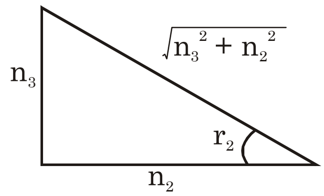
$$\cot r_1 = \frac{n_2}{n_1}, \qquad r_1 = \cot^{-1}\left(\frac{n_2}{n_1}\right)$$

$n_3 \sin\theta_2 = n_2 \sin r_2$



$$\sin r_2 = \frac{n_3}{n_2} \sin \theta_2$$

$$\sin r_2 = \frac{n_3}{n_2} \times \frac{n_2}{\sqrt{n_3^2 + n_2^2}}$$



$$\cot r_2 = \frac{n_2}{n_3}$$

$$r_2 = \cot^{-1}\left(\frac{n_2}{n_3}\right)$$

$$A = r_1 + r_2$$

$$A = \cot^{-1}\left(\frac{n_2}{n_1}\right) + \cot^{-1}\left(\frac{n_2}{n_3}\right)$$