UNIT VI

OPTICS

Weightage Marks : 14

TOPICS TO BE COVERED

Reflection of light, spherical mirrors, mirror formula.

Refraction of light, total internal reflection and its applications, optical fibres, refraction through spherical surfaces, lenses thin lens formula

Lens makers formula.

Magnification, power of a lens, Combination of thin lenses in contact, Refraction and dispersion of light through a prism, scattering of light – blue colour of the sky and reddish appearance of the sun at sunrise and sunset.

Optical Instruments: Human eye, image formation and accommodation, correction of eye defects (myopia, hyper-metropia, presbyopia and astigmatism) using lenses.

Microscopes and astronomical telescopes (reflecting and refracting) and their magnifying powers.

Wave optics: Wave front and huygen's principle, reflection and refraction of plane wave at a plane surface using wave fronts, Proof of laws of reflection and refraction using huygen's Principle. Interference, Young's double slit experiment and expression for fringe width coherent sources and sustained interference of light; Diffraction due to a single slit, width of central maximum.

Resolving power of microscopes and astronomical telescopes. Plane polarized light, Brewster's law, uses of plane polarized light and polaroids.

KEY POINTS

Physical Quantity	*Formulae*	*SI Unit*
	Ray Optics	
Refractive index of medium '*b*' w.r.t. '*a*'	$^{a}\mu_{b} = \frac{\sin i}{\sin r}$	
Refractive index of medium w.r.t. vacuum (or air)	$\mu = \frac{\text{Velocity of Light in Vacuum } (c)}{\text{Velocity of Light in Medium } (v)}$	–
Refractive index in terms of Real and Apparent Depths	$^{a}\mu_{w} = \frac{AO}{AI} = \frac{\text{Real Depth}}{\text{Apparent Depth}}$	
Relation between refractive index of medium and critical angle	$^{a}\mu_{b} = \frac{1}{\sin i_C}$	
Lateral shift	$d = \frac{t\sin(i-r)}{\cos r}$	m
Spherical refracting surface	$\frac{\mu_2 - \mu_1}{R} = \frac{\mu_2}{V} - \frac{\mu_1}{u}$	
	or $\frac{\mu - 1}{R} = \frac{\mu}{v} - \frac{1}{u}$	m^{-1}
Lens Maker's formula	$\frac{1}{f} = \frac{1}{V} - \frac{1}{u} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$	
Magnification	$m = \frac{h_i}{h_o} = +\frac{v}{u} = \frac{f}{f+u} = \frac{f-v}{f}$	–

Combination of thin lenses

$$\therefore \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\Rightarrow P = P_1 + P_2 \text{ and } m = m_1 \times m_2$$

Refraction in a prism

$$\delta + A = i + e$$

$$\mu = \frac{\sin i}{\sin r} = \frac{\sin \frac{(A + \delta_m)}{2}}{\sin \frac{A}{2}}$$

Cauchy's formula (Relation b/w refractive index and λ)

$$\mu = a + \frac{b}{\lambda^2} + \frac{c}{\lambda^4}$$

Rayleigh's criteria of scattering

$$\text{Amount of scattering} \propto \frac{1}{\lambda^4}$$

Compound Microscope

Magnification

$$m = \frac{\beta}{\alpha} = m_e m_o = \frac{v_o}{u_o}\left(1 + \frac{D}{f_e}\right)$$

When image is formed at D

$$m = \frac{L}{f_o}\left(1 + \frac{D}{f_e}\right) = \frac{L}{f_o}\frac{D}{f_e}$$

When image is formed at infinity

$$m = \frac{v_o}{u_o} \times \frac{D}{f_e}$$

The limit of resolution

$$d = \frac{1.22\lambda}{2\mu \sin\theta}$$

Numerical aperture

$$\mu \sin \theta$$

The resolving power $\frac{1}{d} = \frac{2\mu \sin\theta}{1.22\lambda}$

Astronomical Telescope

Magnification

(a) When image is formed at infinity $m = \frac{\beta}{\alpha} = \frac{f_o}{f_e}$

(b) When image is formed at D $m = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$

Length of tube $L = f_o + f_e$

Angular limit of resolution $\alpha = \frac{1.22\lambda}{D}$

The resolving power $\frac{1}{\alpha} = \frac{D}{1.22\lambda}$

Reflection Telescope

Magnifying power $m = \frac{f_o}{f_e}$

Wave Optics

Young's Double Slit Experiment

Intensity of light $I = a_1^2 + a_2^2 + 2a_1a_2 \cos\phi$

Constructive Interference

Phase difference	$\phi = 2n\pi$	$n = 0, 1, 2, 3...$
Path difference	$x = n\lambda$	

Destructive interference

Phase difference	$\phi = (2n - 1)\pi$	$n = 1, 2, 3, 4...$
Path difference	$x = (2n - 1)\ \lambda/2$	

Ratio of light intensity at maxima and minima $\quad \dfrac{I_{max}}{I_{min}} = \dfrac{(a_1 + a_2)^2}{(a_1 - a_2)^2}$

Path difference $\quad x = \dfrac{yd}{D}$

Fringe width (For Dark and Bright Fringes) $\quad \beta = y_n - y_{n-1} = \lambda D/d$

The angular width of each fringe $\quad \Delta\theta = \dfrac{\beta}{D} = \dfrac{\lambda}{d}$

Single Slit Diffraction

Central maximum $\quad \sin\theta_1 = \dfrac{\lambda}{a}$; $\theta_1 \rightarrow$ angle up to which central maximum extends on both sides from centre.

Angular width $= 2\theta_1$

For n^{th} secondary minima $\quad \sin\theta_n = n\lambda/a$

For n^{th} secondary maxima $\quad \sin\theta'_n = \dfrac{(2n - 1)\lambda}{2a}$

Fringe width (For Dark and Bright Fringes) $\quad \beta = y_n - y_{n-1} = y'_n - y'_{n-1} = \dfrac{\lambda D}{a}$

Fresnel distance $\quad Z_F = \dfrac{a^2}{\lambda}$

Brewster's Law

$$r + p = 90^\circ \quad \text{and} \quad \mu = \tan p$$

Law of Malus

$$I = I_0 \cos^2 \theta$$

If two coherent beams have different intensities I_1 and I_2, the resulting minima and maxima will be

$$I_{max} = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos 0^0$$

$$= \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$$

$$I_{min} = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos 180^\circ$$

If two plane mirror are kept at an angle θ w.r.t. each other and an object is kept between them, than the number of images formed.

$$n = \frac{360^\circ}{\theta} - 1$$

QUESTIONS

VERY SHORT ANSWER QUESTIONS (I Mark)

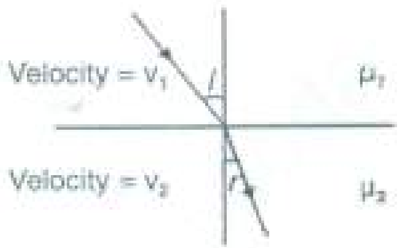
1. Write the value of angle of reflection for a ray of light falling normally on a mirror.

2. How does the dispersive power of glass prism change when it is dipped in water?

3. Light falls from glass to air. Find the angle of incidence for which the angle of deviation is 90°.

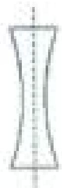
4. Name the phenomenon due to which one cannot see through fog.

5. What is the ratio of sin i and sin r in terms of velocities in the given figure.



6. What is the shape of fringes in young's double slit experiment?

7. A equiconcave lens of focal length 15 cm is cut into two equal halves along dotted line as shown in figure. What will be new focal length of each half.



8. For the same angle of the incidence the angle of refraction in three media A, B and C are 15°, 25° and 35° respectively. In which medium would the velocity of light be minimum?

9. What is the phase difference between two points on a cylindrical wave front?

10. What is the 'power' of plane glass plate.

11. Show with the help of diagram, why a beam of white light passing through a hollow prism does not give spectrum.

12. How does focal length of lens change when red light incident on it is replaced by violet light?

13. A myopic person prefers to remove his spectacles while reading a book. Why?

14. Lower half of the concave mirror is painted black. What effect will this have on the image of an object placed in front of the mirror?

Ans. : The intensity of the image will be reduced (in this case half) but no change in size of the image.

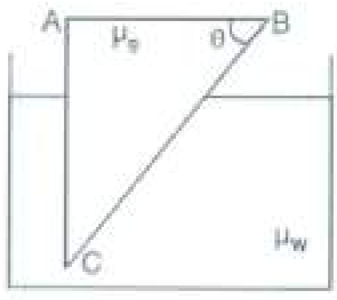
SHORT ANSWER QUESTIONS (2 Marks)

1. A near sighted person can clearly see objects up to a distance of 1.5m. Calculate power of the lens necessary for the remedy of this defect. (P = – 0.67D)

2. A person can adjust the power of his eye lens between 50D and 60D. His far point is infinity. Find the distance between retina and eye lens.

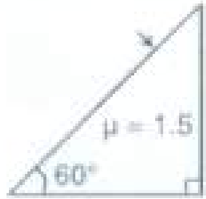
3. Calculate the value of θ, for which light incident normally on face AB grazes along the face BC.

$\mu_{glass} = 3/2 \qquad \mu_{water} = 4/3$



4. Name any two characteristics of light which do not change on polarisation.

5. Complete the path of light with correct value of angle of emergence.

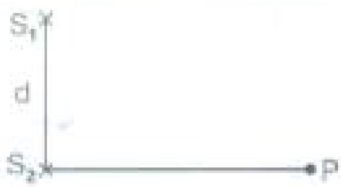


6. Define diffraction. What should be the order of the size of the aperture to observe diffraction.

7. Show that maximum intensity in interference pattern is four times the intensity due to each slit if amplitude of light emerging from slits is same.

8. Two poles-one 4m high and the other is 4.5 m high are situated at distance 40m and 50m respectively from an eye. Which pole will appear taller?

9. S_1 and S_2 are two sources of light separated by a distance d. A detector can move along S_2P perpendicular to S_1S_2. What should be the minimum and maximum path difference at the detector?



10. If a jogger runs with constant speed towards a vehicle, how fast does the image of the jogger appear to move in the rear view mirror when

    (i) the vehicle is stationery

    (ii) the vehicle is moving with constant speed.

    Ans : The speed of the image of the jogger appears to increase substantially, though jogger is moving with constant speed.

    Similar phenomenon is observed when vehicle is in motion.

11. A person looking at a mesh of crossed wire is able to see the vertical wire more distinctly than the horizontal wire. Which defect he is suffering from? How can this defect be corrected?

12. Is optical density same as mass density? Give an example.

    Ans : Optical density is the ratio of the speed of light in two media whereas mass density e.g. mass per unit volume of a substance.

e.g. Mass density of turpentine oil in less than that of water but its optical density is higher.

13. When does (i) a plane mirror and (ii) a convex mirror produce real image of objects.

Ans : Plane and convex mirror produce real image when the object is virtual that is rays converging to a point behind the mirror are reflected to a point on a screen.

14. A virtual image cannot be caught on a screen. Then how do we see it?

Ans : The image is virtual when reflected or refracted rays divergent, these are converged on to the retina by convex lens of eye, as the virtual image serves as the object.

15. Draw a diagram to show the advance sunrise and delayed sunset due to atmospheric refraction. NCERT Pg 318

16. Define critical angle for total internal reflection. Obtain an expression for refractive index of the medium in terms of critical angle.

17. The image of a small bulb fixed on the wall of a room is to be obtained on the opposite wall 's' m away by means of a large convex lens. What is the maximum possible focal length of the lens required.

Ans : For fixed distance 's' between object and screen, for the lens equation to give real solution for $u = v = 2f$, 'f' should not be greater than $4f = s$.

$\therefore f = s/4$

18. The angle subtended at the eye by an object is equal to the angle subtended at the eye by the virtual image produced by a magnifying glass. In what sense then does magnifying glass produce angular magnification?

Ans : The absolute image size is bigger than object size, the magnifier helps in bringing the object closer to the eye and hence it has larger angular size than the same object at 25 cm, thus angular magnification is achieved.

19. Obtain relation between focal length and radius of curvature of (i) concave mirror (ii) convex mirror using proper ray diagram.

20. Two independent light sources cannot act as coherent sources. Why?

21. How is a wave front different from a ray? Draw the geometrical shape of the wavefronts when.

    (i) light diverges from a point source,

    (ii) light emerges out of convex lens when a point source is placed at its focus.

22. What two main changes in diffraction pattern of single slit will you observe when the monochromatic source of light is replaced by a source of white light.

23. You are provided with four convex lenses of focal length 1cm, 3cm, 10cm and 100 cm. Which two would you prefer for a microscope and which two for a telescope.

24. Give reasons for the following

    (i) Sun looks reddish at sunset

    (ii) clouds are generally white

25. Using Huygens Principle draw ray diagram for the following

    (i) Refraction of a plane wave front incident on a rarer medium

    (ii) Refraction of a plane wave front incident on a denser medium.

SHORT ANSWER QUESTIONS (3 Marks)

1. Using mirror formula show that virtual image produced by a convex mirror is always smaller in size and is located between the focus and the pole.

2. Obtain the formula for combined focal length of two thin lenses in contact, taking one divergent and the other convergent.

3. Derive snell's law on the basis of Huygen's wave theory.

4. A microscope is focussed on a dot at the bottom of the beaker. Some oil is poured into the beaker to a height of 'b' cm and it is found that microscope has to raise through vertical distance of 'a' cm to bring the dot again into focus. Express refractive index of oil is terms of a and b.

5. Define total internal reflection. State its two conditions. With a ray diagram show how does optical fibres transmit light.

6. A plane wave front is incident on (i) a prism (ii) A convex lens (iii) a concave mirror. Draw the emergent wavefront in each case.

7. Explain with reason, how the resolving power of a compound microscope will change when (i) frequency of the incident light on the objective lens is increased. (ii) focal length of the objective lens is increased. (iii) asperture of objective lens is increased.

8. Derive Mirror formula for a concave mirror forming real image.

9. Two narrow slits are illuminated by a single monochromatic sources.

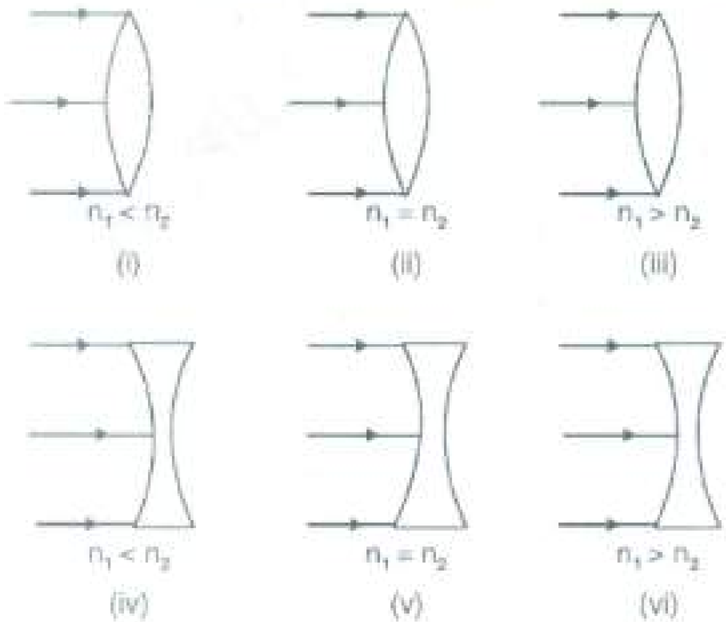
   (a) Draw the intensity pattern and name the phenomenon

   (b) One of the slits is now completely covered. Draw the intensity pattern now obtained and name the phenomenon.

10. Explain briefly (i) sparkling of diamond (ii) use of optical fibre in communication.

11. Using appropriate ray diagram obtain relation for refractive index of water in terms of real and apparent depth.

12. Complete the ray diagram in the following figure where, n_1, is refractive index of medium and n_2 is refractive index of material of lens.



LONG ANSWER QUESTIONS (5 MARKS)

1. With the help of ray diagram explain the phenomenon of total internal reflection. Obtain the relation between critical angle and refractive indices of two media. Draw ray diagram to show how right angled isosceles prism can be used to :

   (i) Deviate the ray through 180°.

   (ii) Deviate the ray through 90°.

   (iii) Invert the ray.

2. Draw a labelled ray diagram of a compound microscope and explain its working. Derive an expression for its magnifying power.

3. Diagrammatically show the phenomenon of refraction through a prism. Define angle of deviation in this case. Hence for a small angle of incidence derive the relation $\delta = (\mu - 1) A$.

4. Name any three optical defects of eye. Show by ray diagram :

   (i) Myopic eye and corrected myopic eye.

   (ii) Hypermetropic eye and corrected hypermetropic eye.

5. Define diffraction. Deduce an expression for fringe width of the central maxima of the diffraction pattern, produced by single slit illuminated with monochromatic light source.

6. What is polarisation? How can we detect polarised light? State Brewster's Law and deduce the expression for polarising angle.

7. Derive lens maker formula for a thin converging lens.

8. Derive lens formula $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$ for

   (a) a convex lens,

   (b) a concave lens.

9. Describe an astronomical telescope and derive an expression for its magnifying power using a labelled ray diagram.

10. Draw a graph to show the angle of deviation with the angle of incidence i for a monochromatic ray of light passing through a prisin of refracting angle A. Deduce the relation

$$\mu = \frac{\sin(A + \delta_m)/2}{\sin A/2}$$

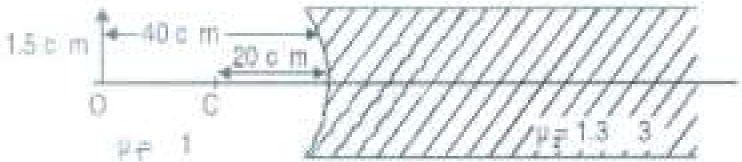
11. State the condition under which the phenomenon of diffraction of light takes place. Derive an expression for the width of the central maximum due to diffraction of light at a single slit. Also draw the intensity pattern with angular position.

NUMERICALS

1. An object of length 2.5cm is placed at a distance of 1.5f from a concave mirror where f is the focal length of the mirror. The length of object is perpendicular to principal axis. Find the size of image. Is the image erect or inverted?

2. Find the size of image formed in the situation shown in figure.

[5 cm, Inverted]



1.6 cm approx.

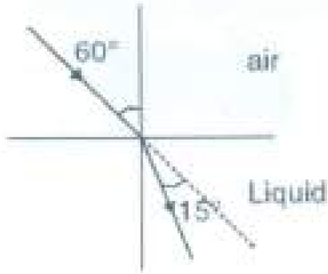
3. A ray of light passes through an equilateral prism in such a manner that the angle of incidence is equal to angle of emergence and each of these angles is equal to 3/4 of angle of prism. Find angle of deviation.

[Ans. : 30°]

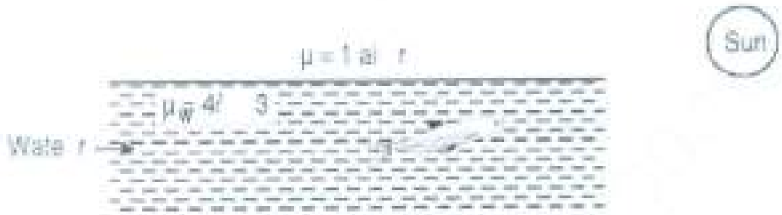
4. Critical angle for a certain wavelength of light in glass is 30°. Calculate the polarising angle and the angle of refraction in glass corresponding to this. $[i_p = \tan^{-1} 2$

5. A light ray passes from air into a liquid as shown in figure. Find refractive index of liquid.

$$\left[{}^{air}\mu_{Liquid} = \sqrt{3/2}\right]$$

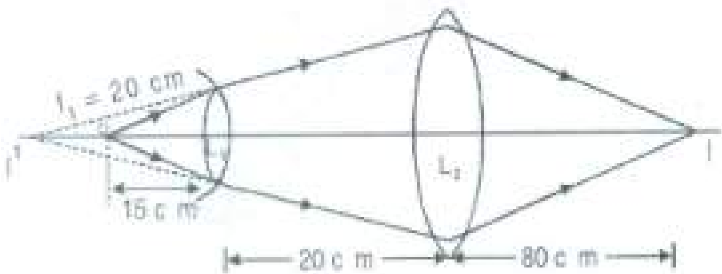


6. At what angle with the water surface does fish in figure see the setting sun?



[At critical angle, fish will see the sun.]

7. In the following diagram, find the focal length of lens L_2. [40 cm]



8. A hypermetropic person whose near point is at 100 cm wants to read a book. Find the nature and power of the lens needed.

Ans. $v = -100$ cm

$u = -25$ cm

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{-1}{100} + \frac{1}{25} = \frac{3}{100}$$

$f = \frac{100}{3} = \pm 33.3\,cm$ so a converging lens

$P = \frac{100}{f} = 3$ *dioptre*

9. For a man shortest distance of distinct vision is 20 cm. What will be the type and power of lens which w ould enable him to read a book at a distance of 60 cm?

Ans. $v = -20$ cm

$u = -60$ cm

$$\frac{1}{f} = \frac{-1}{20} + \frac{1}{60} = \frac{-2}{60} = \frac{-1}{30}$$

$f = -30$ cm. So a diverging lens

$$p = \frac{100}{-30} = -3.3 \textit{ dioptre}$$

10. Using the data given below, state which two of the given lenses will be preferred to construct a (i) telescope (ii) Microscope. Also indicate which is to be used as objective and as eyepiece in each case.

Lenses	*Power (p)*	*Apetune (A)*
L_1	6 D	1 cm
L_2	3 D	8 cm
L_3	10 D	1 cm

Ans. : For telescope, less L_2 is chosen as objective as it aperture is largest, L_3 is chosen as eyepiece as its focal length is smaller.

For microscope lens L_3 is chosen as objective because of its small focal length and lens L_1, serve as ey e piece because its focal length is not larges.

11. Two thin converging lens of focal lengths 15 cm and 30 cm respectively are held in contact with each other. Calcualte power and focal length of the combination.

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{15} + \frac{1}{30} = \frac{1}{10}$$

F = 10 cm

P = 10 D

VERY SHORT ANSWER QUESTIONS (I Mark)

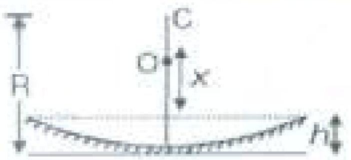
1. An air bubble is formed inside water. Does it act as converging lens or a diverging lens?

[Diverging lens]

2. A water tank is 4 meter deep. A candle flame is kept 6 meter above the level. μ for water is 4/3. Where will the image of the candle be formed? [6m below the water level]

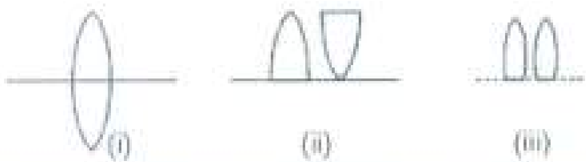
SHORT ANSWER QUESTIONS (2 Marks)

1. Water (refractuive index μ) is poured into a concave mirror of radius of curvature 'R' up to a height h as shown in figure. What should be the value of x so that the image of object 'O' is formed on itself?



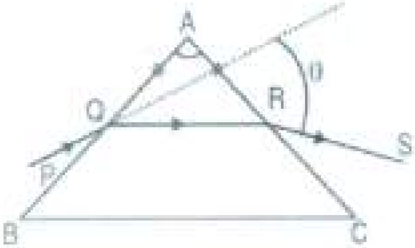
2. A point source S is placed midway between two concave mirrors having equal focal length f as shown in Figure. Find the value of d for which only one image is formed.

3. A thin double convex lens of focal length f is broken into two equal halves at the axis. The two halves are combined as shown in figure. What is the focal length of combination in (ii) and (iii).



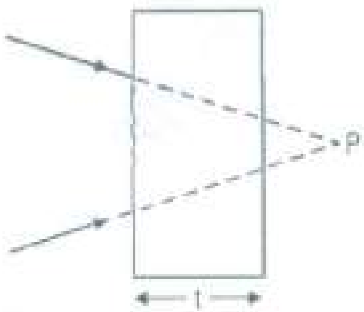
4. How much water should be filled in a container 21 cm in height, so that it appears half filled when viewed from the top of the container. $({}^a\mu_w = 4/3)$?

5. A ray PQ incident on the refracting face BA is refracted in the prism BAC as shown in figure and emerges from the other refracting face AC as RS such that AQ = AR. If the angle, of prism A = 60° and μ of material of prism is $\sqrt{3}$ then find angle θ.



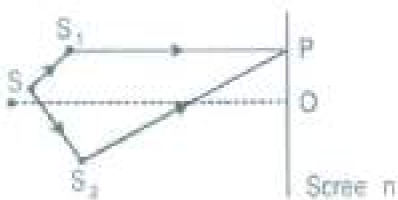
SHORT ANSWER QUESTIONS (3 Marks)

1. A converging beam of light is intercepted by a slab of thickness t and refractive index μ. By what distance will the convergence point be shifted? Illustrate the answer.



$$x = \left(1 - \frac{1}{\mu}\right)t$$

2. In double slit experiment SS_2 is greater than SS_1 by 0.25λ. Calculate the path difference between two interfering beam from S_1 and S_2 for minima and maxima on the point P as shown in Figure.



ANSWERS

1 MARK QUESTIONS

1. Zero
2. Decreases.
3. Angle of incidence is 45°.
4. Scattering.
6. Hyperbolic
7. 30 cm
8. 15°
9. Zero
10. Zero
12. Decreases
13. A myopic person is short sighted.

2 MARKS QUESTIONS

2. For point is infinity so in this case focal length is maximum. Hence power is minimum.
3. $\theta = \sin^{-1}(8/9)$
4. Speed and frequency
5. $\sin^{-1}(3/4)$
8. 4 m pole
9. Minimum path difference is zero (when p is at infinity)

   Maximum path difference = d.
11. Astigmatism – Cylindrical lens

21. A wavefront is a surface obtained by joining all points vibrating in the same phase.

A ray is a line drawn perpendicular to the wavefront in the direction of propagation of light.

(i) Spherical

(ii) Plane

22. (i) In each diffraction order, the diffracted image of the slit gets dispersed into component colours of white light. As fringe width α λ, $\therefore$ red fringe with higher wavelength is wider than violet fringe with smaller wavelength.

(ii) In higher order spectra, the dispersion is more and it causes overlapping of different colours.

23. $f_o = 1$ cm and $f_e = 3$ cm for Microscope and

$f_o = 100$ cm and $f_e = 1$ cm for a Telescope

25. N.C.E.R.T. Fig. 10.5; Fig. 10.4.

3 MARKS QUESTIONS

7. R.P. of a compound Microscope

$$= \frac{2\mu \sin\theta}{\lambda} = 2\mu \sin\theta \frac{v}{c}$$

(i) When frequency v increases, R.P. increases

(ii) R.P. does not change with change in focal length of objective lens.

(iii) When aperture increases, θ increases $\therefore$ R.P. increases.

ANSWERS OF HOTS

2 MARKS QUESTIONS

1. Distance of object from p should be equal to radius of curvature.

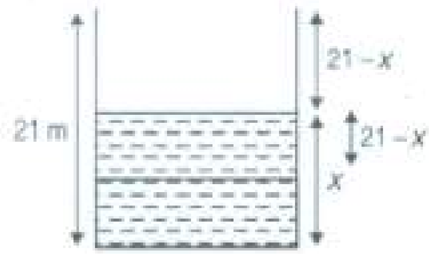
$$R = \mu x + h \Rightarrow x = \frac{R - h}{\mu}.$$

2. Distance between mirror will be $2f$ or $4f$.

3. (i) Focal length of combination is infinite.

(ii) f/2

4.



$$\frac{\text{Real depth}}{\text{Apparent depth}} = \mu$$

$$\frac{x}{21 - x} = \frac{4}{3} \quad \Rightarrow \quad x = 12 \text{ cm.}$$

5. This is a case of min. deviation $\theta = 60°$.

3 MARKS QUESTIONS

1. $x1 = \left(- \frac{1}{\mu} \right) 1$

2. Path diff. : $(SS_2 + S_2P) - (SS_1 + S_1P) = (SS_2 - SS_1) + (S_2P - S_1P) = (0.25\lambda + S_2P - S_1P)$

For maxima, path diff. = $n\lambda$.

So $\qquad S_2P - S_1P = n\lambda - 0.25\lambda = (n - 0.25)\lambda$

For minima, path diff. = $(2n + 1)\frac{\lambda}{2}$

So $\qquad S_2P - S_1P = (2n + 0.5)\ \lambda/2$

UNIT V

ELECTROMAGNETIC WAVES

Weightage Marks : 03

TOPICS TO BE COVERED

Displacement cu rrent, el ectromagnetic wa ves an d t heir c haracteristics (qualitative ideas only).

Transverse nature of electromagnetic wav es. Electromagnetic spectrum (radio-waves, micro-waves, infrared, visible, ultraviolet, X-rays, gamma rays) including elementary facts about their uses.

KEY POINTS

- EM wav es are produced b y accelerated (only b y the change in speed) charged particles.
- $\vec{E}$ and $\vec{B}$ v ectors oscillate with the frequency of oscillating charged particles.
- Properties of em waves :
  - (i) Transverse nature
  - (ii) Can travel though vacuum.
  - (iii) $E_0/B_0 = E/B = v$ $\quad v \rightarrow$ Speed of EM waves.
  - (iv) Speed $= 3 \times 10^8$ m/s in vacuum.
  - (v) In any medium $v = \dfrac{1}{\sqrt{\mu \epsilon}}$

Where $\mu = \mu_r \mu_0, \varepsilon = \varepsilon_r \varepsilon_0$

n = refractive index of medium $\sqrt{\epsilon_r} = n$

Also $v = c/n$

(vi) Wave intensity equals average of Poynting vector $I = |\vec{S}|_{av} = \frac{B_0 E_0}{2\mu_0}$

(vii) Average electric and average magnetic energy densities are equal.

- In an em spectrum, different waves have different frequency and wavelengths.
- Penetration power of em waves depends on frequency. Higher the frequency larger the penetration power.
- Wavelength λ and frequency ν are related with each other $v = \lambda\nu$. Here v is the wave velocity.
- A wave travelling along +x axis is represented by

$$E_y = E_{oy} \cos(\omega t - kx)$$

$$B_z = B_{oz} \cos(\omega t - kx)$$

$$\omega = \frac{2\pi}{T} = 2\pi\nu \qquad \frac{\omega}{k} = \lambda\nu = v \text{ wave speed}$$

$$k = \frac{2\pi}{\lambda} = 2\pi\bar{\nu}$$

$\nu \rightarrow$ frequency

$\bar{\nu} = \frac{1}{\lambda}$ wave number.

QUESTIONS

VERY SHORT ANSWER QUESTIONS (I Mark)

1. Every *EM* wave has certain frequency. Name two parameters of an em wave that oscillate with this frequency.

2. What is the phase difference between electric and magnetic field vectors in an em wave?

3. Name em radiations used for detecting fake currency notes.

4. Give any two uses of microwaves.

5. Name the phenomenon which justifies the transverse nature of em waves.

6. Arrange the following em waves in descending order of wavelengths : γ ray, microwaves UV radiations.

7. Which component $\vec{E}$ or $\vec{B}$ of an em wave is responsible for visible effect?

8. Write expression for speed of em waves in a medium of electrical permittivity ε and magnetic permeability μ.

9. Which of the following has longest penetration power?

   UV radiation, X-ray, Microwaves.

10. Which of the following has least frequency?

    IR radiations, visible radiation, radio waves.

11. Which physical quantity is the same for microwaves of wavelength 1 mm and UV radiations of 1600 A° in vacuum?

12. Name two physical quantities which are imparted by an em wave to a surface on which it falls.

13. Name the physical quantity with unit same as that of

    $$I_d = \varepsilon_0 \frac{d\phi_e}{dt} \quad \text{where } \phi_e \rightarrow \text{electric flux.}$$

14. What is the source of energy associated with propagating em waves?

15. What is the wavelength range of em waves that were produced and observed by J.C. Bose?

16. Name the device used for producing microwaves.

17. Name the em radiations which are detected using Gieger tube.

18. Relative electric permittivity of a medium is 8 and relative permeability is

19. Identify the part of the electromagnetic spectrum to which the following wavelengths belong :

(i) 10^{-1} m (ii) 10^{-12} m

20. Name the part of the electromagnetic spectrum of wavelength 10^{-2} m and mention its one application.

21. Which of the following, if any, can act as a source of electromagnetic waves?

    (i) A charge moving with a constant velocity.

    (ii) A charge moving in a circular orbit.

    (iii) A charge at rest.

22. Mention the pair of space and time varying E and B fields which would generate a plane em wave trevelling in Z-direction.

23. The charging current for a capacitor is 0.2A. What is the displacement Current?

24. Give the ratio of Velocities of light waves of wavelengths 4000A° and 8000A° in Vaccum.

25. Which physical quantity, If any has the same value for waves belonging to the different parts of the electromagnetic spectrum?

SHORT ANSWER QUESTIONS (2 Marks)

1. Give one use of each of the following (i) UV ray (ii) γ-ray

2. Represent *EM* waves propagating along the *x*-axis. In which electric and magnetic fields are along *y*-axis and *z*-axis respectively.

3. State the principles of production of *EM* waves. An *EM* wave of wavelength λ goes from vacuum to a medium of refractive index n. What will be the frequency of wave in the medium?

4. An *EM* wave has amplitude of electric field E_0 and amplitude of magnetic field is B_0 the electric field at some instant become $\frac{3}{4}E_0$. What will be

5. State two applications of infrared radiations.

6. State two applications of ultraviolet radiations.

7. State two applications of x-rays.

8. Show that the average energy density of the electric field $\vec{E}$ equals the average energy density of the magnetics fields $\vec{B}$?

SHORT ANSWER QUESTIONS (3 Marks)

1. Name *EM* radiations used (i) in the treatment of cancer.

   (ii) For detecting flaw in pipes carrying oil.

   (iii) In sterilizing surgical instruments.

2. How would you experimentally show that *EM* waves are transverse in nature?

3. List any three properties of *EM* waves.

4. Find the wavelength of electromagnetic waves of frequency 5×10^{19} Hz in free space. Give its two applications

NUMERICALS

1. The refractive index of medium is 1.5. A beam of light of wavelength 6000 A° enters in the medium from air. Find wavelength and frequency of light in the medium.

2. An *EM* wave is travelling in vaccum. Amplitude of the electric field vector is 5×10^4 V/m. Calculate amplitude of magnetic field vector.

3. Suppose the electric field amplitude of an em wave is $E_0 = 120\ NC^{-1}$ and that its frequency is $\nu = 50.0$ MHz.

   (a) Determine B_0, ω, κ and λ

   (b) Find expressions for E and B.

4. A radio can tune into any station of frequency band 7.5 MHz to 10 MHz. Find the corresponding wave length range.

5. The amplitude of the magnetic field vector of an electromagnetic wave travelling in vacuum is 2.4mT. Frequency of the wave is 16 MHz. Find :

(i) Amplitude of electric field vector and

(ii) Wavelength of the wave.

6. An *EM* wave travelling through a medium has electric field vector.

$E_y = 4 \times 10^5 \cos(3.14 \times 10^8 t - 1.57 x)$ N/C. Here x is in m and t in s.

Then find :

(i) Wavelength

(ii) Frequency

(iii) Direction of propagation

(iv) Speed of wave

(v) Refractive index of medium

(vi) Amplitude of magnetic field vector.