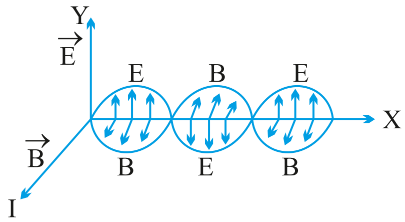
Unit V & VI
ELECTROMAGNETIC WAVES AND OPTICS

KEY POINTS

1. EM waves are produced by accelerated (only by the change in speed) charged particles.
2. $\vec{E}$ and $\vec{B}$ vectors oscillate with the frequency of oscillating charged particles.
3. Propagation of wave along x-direction.



4. Properties of em waves :
   (i) Transverse nature
   (ii) Can travel though vacuum.
   (iii) $\frac{E_0}{B_0} = \frac{E}{B} = \lambda \nu = C$ $\quad$ C → Speed of EM waves.
   (iv) Speed of em wave C = 3×10^8 m/s in vacuum and

$$C = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = 3 \times 10^8 \text{ m/sec (in vacuum)}$$

(v) In any medium $v = \frac{1}{\sqrt{\mu\varepsilon}}$

Where $\mu = \mu_r \mu_0$ $\varepsilon = \varepsilon_r \varepsilon_o$

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

Also $v = \frac{c}{n}$

(vi) A material medium is not required for the propagation of e.m. waves.

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

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

$U_E = \frac{1}{2}\varepsilon_0 E^2$ and $U_B = \frac{1}{2}\frac{B^2}{\mu_0}$

(ix) The electric vecotr is responsible for optical effects due to electro magnetic wave. For this reason, electric vector is called light vector.

- In an em spectrum, diffferent 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 v are related with each other $v = v\lambda$. Here V is the wave velocity.
- A wave travelling along $+x$ axis is represented by

$$E_y = E_0 \cos(\omega t - kx)$$

$$B_z = B_0 \cos(\omega t - kx)$$

$$\omega = \frac{2\pi}{T} = 2\pi v$$

$$\frac{\omega}{k} = \lambda v = V = C \text{ wave speed}$$

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

$v \rightarrow$ frequency

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

Electromagnetic Soectrum

Name	Wavelength range	Production	Uses
Gamma Rays	$< 10^{-12}$ m	Gamma rays produced in radio active decay of nucleus	in treatment of cancer and to carry out nuclear reactions.
x-rays	10^{-9} m to 10^{-12} m	*x*-ray tubes or inner shell electrons	used as diagnostic tool in medical to find out fractures in bones. to find crack, flaws in metal part of machine
UV rays	4×10^{-7} to 10^{-9} m	by very hot bodies like sun and by UV lamps	in water purifier in detection of forged documents, in food preservation.
Visible light	7×10^{-7} m to 4×10^{-7}m	by accelerated tiny (electrons) charge particles	to see every thing around us
IR rays	10^{-3} m to 7×10^{-7} m	due to vibration of atoms	in green houses to keep plant warm to reveal secret writings on walls in photography during fog and smoke
Microwaves	10^{-1} m to 10^{-3} m	produced in klystron Valve and magnetron Valve	in RADAR in microwave ovens
Radio waves	> 0.1 m	by accelerated charged particles excited electrical circuits excited	in radio telecommunication system in radio astrology

Displacement Current—Current produced due to time varying electric field or electric flux.

$$I_D = \varepsilon_0 \frac{d\phi_e}{dt}, , \quad \phi_e \text{ is electric flux}$$

Modified Ampere's Circuital law by Maxwell

$$\oint \vec{B}.d\vec{l} = \mu_0 \left(I_C + \varepsilon_0 \frac{d\phi_e}{dt} \right)$$

$$I_c \rightarrow \text{Conduction current}$$

$$I_C = I_D$$

OPTICS
RAY OPTICS

GIST

1. REFLECTION BY CONVEX AND CONCAVE MIRRORS

a. Mirror formula $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ where u is the object distance, v is the image distance and f is the focal length.

b. Magnification $m=-\frac{v}{u}=\frac{f-v}{f}=\frac{f}{f-u}$ m is $-ve$ for real images and $+ve$ for virtual images.

c. Focal length of a mirror depends up only on the curvature of the mirror $\left(f=\frac{R}{2}\right)$. It does not depend on the material of the mirror or on wave length of light.

2. REFRACTION

d. Ray of light bends when it enters from one medium to the other, having different optical densities.
When light wave travels from one medium to another, the wave length and velocity changes but frequency of light wave remains the same.

e. Sun can be seen before actual sunrise and after actual sun set due to Atmospheric refraction.

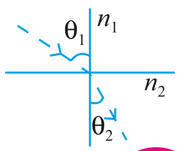
f. An object under water (any medium) appears to be raised due to refraction when observed obliquely.

$n=\frac{\text{Real depth}}{\text{apparent depth}}$ n · refractive index

and normal shift in the position (apparent) of object is

$x=t\left\{1-\frac{1}{n}\right\}$ where t is the actual depth of the medium.

g. Snell's law states that for a given colour of light, the ratio of sine of the angle of incidence to sine of angle of refraction is a constant, when light travels from one medium to another.



$n_1 \sin\theta_1 = n_2 \sin\theta_2$

h. Absolute refractive index is the ratio between the velocities of light in vacuum to velocity of light in medium. For air regractive index is 1.003 for practical uses taken to be 1

$$n = \frac{c}{v}$$

3. T.I.R.

i. When a ray of light travels from denser to rarer medium and if the angle of incidence is greater than critical angle, the ray of light is Reflected back into thedenser medium. This phenomenon is called total internal refiection. (T.I.R.)

$$\sin C = \frac{n_R}{n_D}$$

Essential conditions for T.I.R.

1. Light should travel from denser to rarer medium.
2. Angle of incidence must be greater than critical angle $(i > i_C)$

j. Diamond has a high refractive index, resulting with a low critical angle ($C = 24.4^0$). This promotes a multiple total internal reflection causing its brilliance and luster. Working of an optical fibre and formation of mirage are the examples of T.I.R.

4. When light falls on a spherical refracting surface, from rarer to denser medium the relation among, u, v and R is given by $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$.

5. Lens maker formula for a thin lens is given by

$$\frac{1}{f} = \left(\frac{n_2 - n_1}{n_1}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

For Convex Lens R_1 + ve; R_2 – ve and Concave lens R_1 –ve; R_2 + ve. The way in which a lens behaves as converging or diverging depends upon the values of n_2 and n_1.

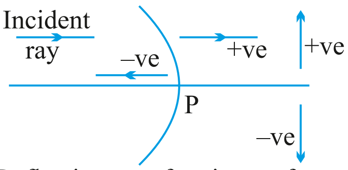
6. When two lenses are kept in contact the equivalent focal length is given by

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \text{ and Power } P = P_1 + P_2$$

Magnification $m = m_1 \times m_2$

7. The lens formula is given by $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

Sign convention for mirrors and lenses → Distances in the direction of incident ray are taken as positive. All the mesurement is done from pole (P).



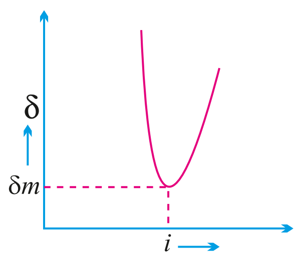
Reflecting or refracting surface

8. When ray of light passes through a glass prism it undergoes refraction, then $A + \delta = i + e$ and, the expression of refractive index of glass prism

$$n = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

As the angle of incidence increses, the angle of deviation decreases, reaches a minimum value and then increases. This minimum value of angle of deviation is called angle of minimum deviation "δ_m".

9.

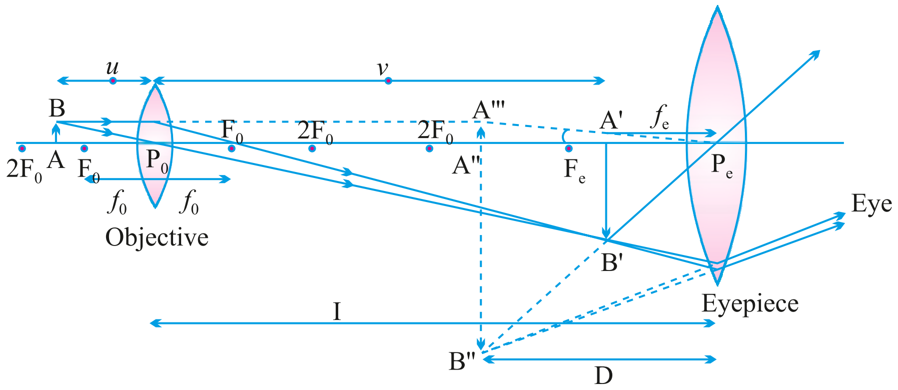


$i = \rightarrow$

Where δ is minimum, $i = e$, refracted ray lies parallel to the base. For a small angled prism d min = $(n - 1)$A.

10. When white light is passed through a glass prism, it splits up into its constituent colours (Monochromatic). This phenomenon is called Dispersion.

Compound Microscope :



Objective : The converging lens nearer to the object.

Eyepiece : The converging lens through which the final image is seen.

Both are of short length. Focal length of eyepiece is slightly greater than that of the objective.

4. Angular Magnification or Magnifying Power (M) :

$$\mathbf{M = M_e \times M_o}$$

(a) When final is formed atleast distance of distinct vision.

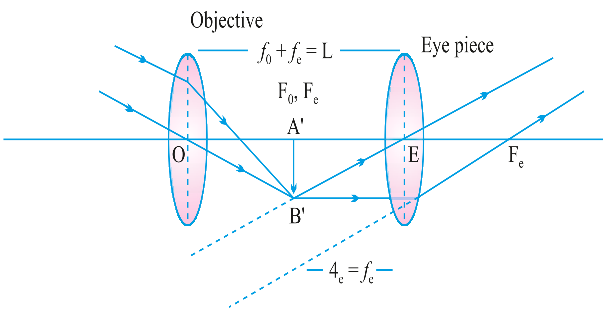
$$\boxed{M = \frac{v_0}{-u_0}\left(1+\frac{D}{f_e}\right)} \quad \boxed{M = \frac{-L}{f_0}\left(1+\frac{D}{f_e}\right)}$$

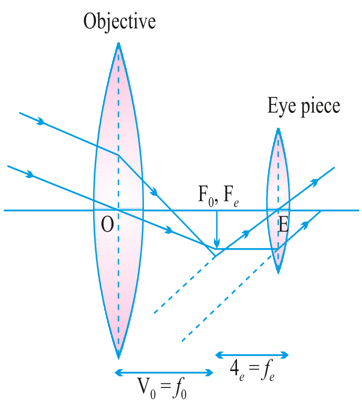
(b) When final image is formed at infinity $M = \frac{-L}{f_0}\frac{D}{f_e}$

(Normal adjustment *i.e.* image at infinity) Length of tube

$$L = |v_0| + |u_e|$$

5. Formation of Image by Astronomical Telescope : at infinity Normal Adjustment Position)





Focal length of the objective is much greater than that of the eyepiece. A perture of the objective is also large to allow more light to pass through it.

6. **Angular magnification or Magnifying power of a telescope.**

(a) When final image is formed at infinity (Normal adjustment)

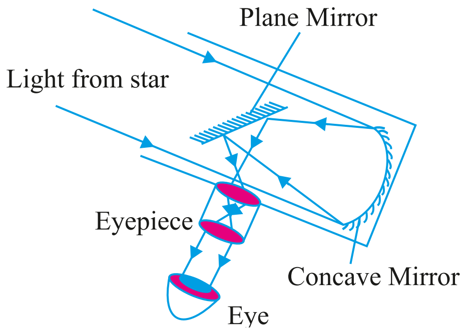
$$M=\frac{\beta}{\alpha} \qquad M=\frac{-f_o}{f_e}$$

($f_o + f_e$ = L is called the length of the telescope in normal adjustment).

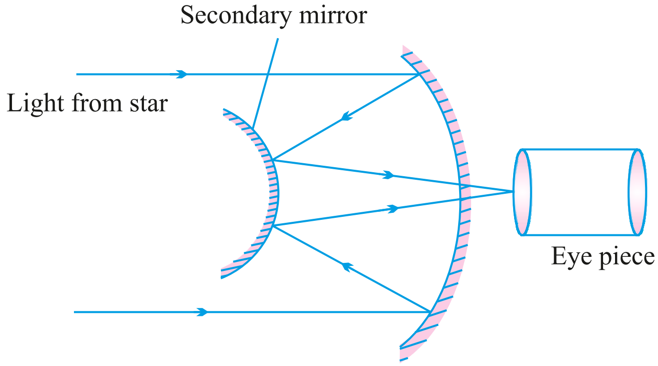
(b) When final image is formed at least distance of distinct vision.

$$m=\frac{-f_o}{f_e}\left(1+\frac{f_o}{D}\right) \text{ and } L=f_o+|u_e|$$

7. **Newtonian Telescope : (Reflecting Type)**



8. **Cassegrain telescope** be



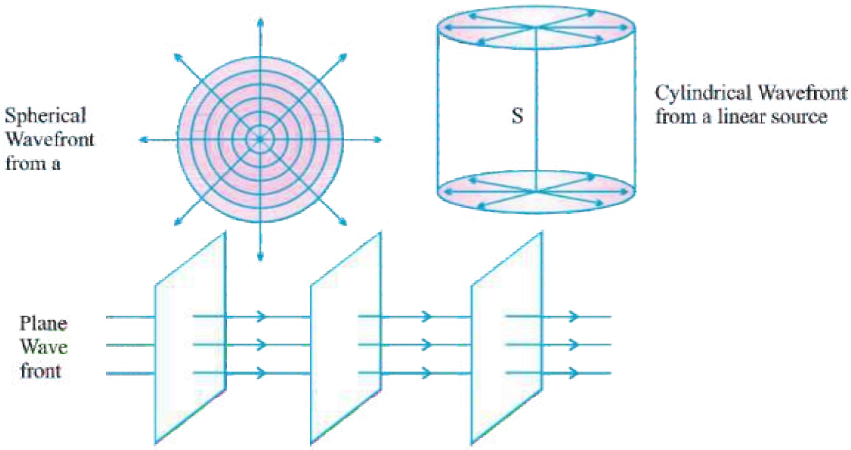
WAVE OPTICS

Wave front :

A wavelet is the point of disturbance due to propagation of light.

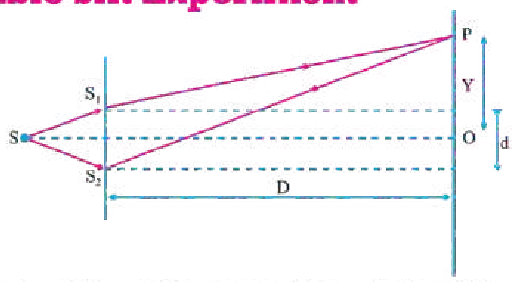
A wavefront is the locus of points (wavelets) having the same phase of vibrations.

A perpendicular to a wavefront in forward direction is called a ray.



INTERFERENCE OF WAVES

Young's Double Slit Experiment



The waves from S_1 and S_2 reach the point P with some phase difference and hence path difference

$$\Delta = S_2P - S_1P$$

$$S_2P^2 - S_1P^2 = \left[D^2 + \left\{y + \left(\frac{d}{2}\right)\right\}^2\right] - \left[D^2 + \left\{y - \left(\frac{d}{2}\right)\right\}^2\right]$$

$$(S_2P - S_1P)(S_2P + S_1P) = 2yd \qquad S_2P \approx S_1P \approx D$$

$$\Delta(2D) = 2yd$$

$$\Delta = \frac{yd}{D}$$

Interference phenomenon

1. Resultant intensity at a point on screen

$$I_R = K\,(a_1^2 + a_2^2 + 2a_1a_2 \cos\phi)$$

$$I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi \qquad \text{Where } I_1 = ka_1^2,\; I_2 = ka_2^2$$

$$\text{If } I_1 = I_2 = I_o, \text{ then } I_R = 4 I_o \cos^2\left(\frac{\phi}{2}\right)$$

2. $I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$ If $I_1 = I_2 = I_0$, $I_{max} = 4I_0$

$I_{min} = \left(\sqrt{I_1} - \sqrt{I_1}\right)^2$ If $I_1 = I_2 = I_0$, $I_{max} = 0$

3. $$\frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{I_1} + \sqrt{I_2}\right)^2}{\left(\sqrt{I_1} - \sqrt{I_2}\right)^2}$$

4. $$\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2}$$

5. $\frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} = \frac{w_1}{w_2}$, w_1 and w_2 are widths of two slits

6. Constructive interference

Phase difference, $\phi = 2n\pi$

Path difference, $x = n\lambda$

Destructive interference

Phase difference $\phi = (2n + 1)\pi$

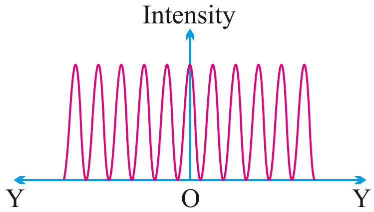
Path difference $x = (2n+1)\frac{\lambda}{2}$

Where $n = 0, 1, 2, 3, ...$

7. Fringe width (dark or bright) $\beta = \frac{\lambda D}{d}$

Angular width of fringe $\Delta\theta = \frac{\beta}{D} = \frac{\lambda}{d}$

Distribution of Intensity

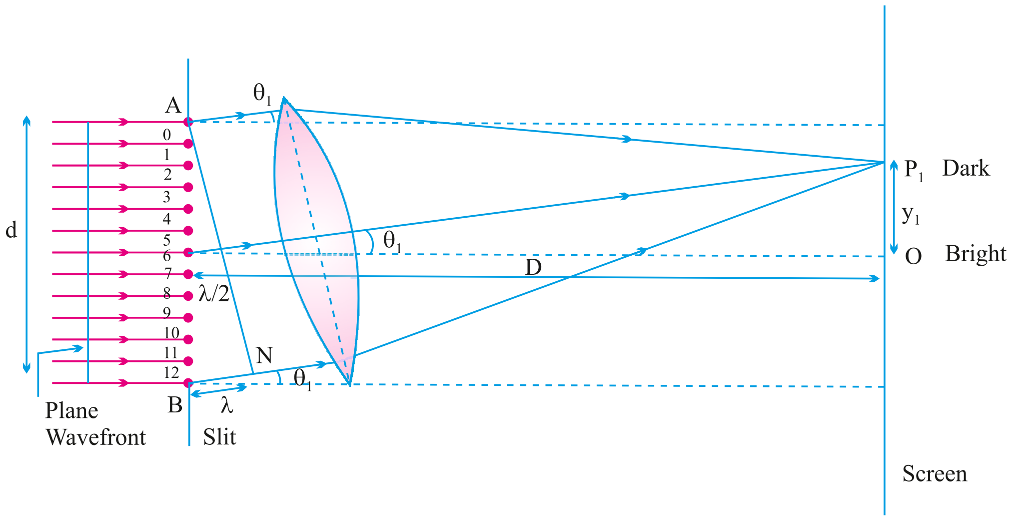


Conditions for Sustained Interference :

1. The two sources must be coherent.
2. The two interfering wave trains must have the same plane of polarisation.
3. The two sources must be very close to each other and the pattern must be observed at a large distance to have sufficient width of the fringe $b = \frac{\lambda D}{d}$ Angnlar width $a = l/d$
4. The sources must be monochromatic. Otherwise, the fringes of different colours will overlap.
5. The two waves must be having same amplitude for better contrast between bright and dark fringes.

DIFFRACTION OF LIGHT AT A SINGLE SLIT :

Width of Central Maximum :



$$y_1 = \frac{D\lambda}{d}$$

Since the Central Maximum is spread on either side of O, the width is

$$\boxed{\beta_0 = \frac{2D\lambda}{d}}$$

Fresnel's Distance :

$$y_1 = \frac{D\lambda}{d}$$

At Fresnel's distance, $y_1 = d$ and $D = D_F$

So, $$\frac{D_F \lambda}{d} = d \text{ or } D_F = \frac{d^2}{\lambda}$$

QUESTIONS

SECTION - A

VERY SHORT ANSWER QUESTIONS (I Mark)

1. In which situation is there a displacement current but no conduction current between plates capacitor?
   (a) Only during charging of parallel plate capacitor
   (b) Only during discharging of paralle plate capacitor
   (c) Only during charging or discharging of parallel plate capacitor
   (d) This will never happen
2. The charging current for a capacitor is 0.25A. What is the displacement current across its plates?
   (b) 5A (b) 0.25A
   (c) 0.125A (c) 1A
3. A plane electromagnetic wave travels in vacuum along z-direction. The directions of electric field vector and magnetic field vector will be
   (a) electric field along x-axis, Magnetic field along y-ans
   (b) electric field along x-axis, Magnetic field along x-axis
   (c) electric field along y-axis, Magnetic field along y-awis
   (d) electric field along y-axis, Magnetic field along x-axis

4. Which part of electromagnetic wave are used in operating 'RADAR'

(a) Infrared waves (b) Microwaves X-Rays

(d) x-Rays (d) Gamma Rays

5. The change on parallel plate capacitor varies as $q = q_0 \cos 2\pi vt$. The plates are very lagrge and close together. Neglecting the edge effect, find the displacement current through the capacitor?

(a) $2\pi q_0 v \sin 2\pi vt$ (b) $-2\pi q_0 v \sin 2\pi vt$

(c) $2\pi q_0 v \cos 2\pi vt$ (d) $-2\pi q_0 v \cos 2\pi vt$

6. For the same value of angle of incidence, the angle of refraction in three media A, B, and C are 15°, 25° and 35° respectively. The velocity of light will be minimum in-

(a) A (b) B

(c) C (d) same in all media

7. Which of the following statement is not true.

(a) Optical fibre is based on the principle of total internal reflection.

(b) The refractive index of the material of the core is less than that of the cladding

(c) an optical fibre can be used to act as an optical pipe

(d) there is no appreciable loss in the intensity of the light signal while propagating through an optical fibre

8. A thin converging lens of focal length 10 cm and a thin diverging lens of focal length 20 cm are placed coaxially in contact. The power of the combination is:

(a) –5 D (b) +5 D

(c) +15D (d) 15D

9. A diamond is immersed in a liquid with a refractive index greater than water. Then the critical angle for total internal reflection will

(a) Increase

(b) Decrease

(c) Depend on the nature of the liquid

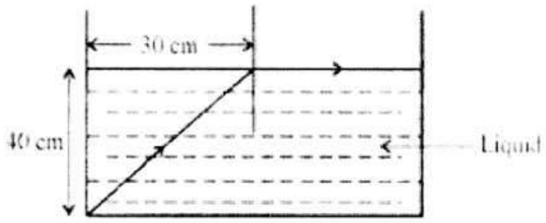
(d) Remains the same

10. Which of the following correctly define refractive index of a medium.

(a) Real depth/App depth (b) App depth/ Real depth

(c) App depth × Real depth (d) Real depth + App depth

11. The magnification due to a compound microscope does not depend upon
    (A) the aperture of the objective and the eye-piece
    (b) the focal length of the objective and the eye-piece
    (c) the length of the tube
    (d) the colour of the light used



12. In the above diagram, calculate the speed of light in the liquid of unknown refractive index.
    (a) 1.2×10^8 m/s   (b) 14×10^8 m/s
    (c) 1.6×10^8 m/s   (d) 18×10^8 m/s
13. A mirror forms 3 times magnified image of an object. The mirror can be-
    (a) Concave   (b) convex
    (c) Plane   (d) both convex and concave
14. Focal length of a convex mirror is 20 cm. it forms1/2 times magnified virtual image of an object. The image distance is:
    (a) 30 cm   (b) 10 cm
    (c) 20/3 cm   (d) 40/3 cm
15. A magician puts some glass object into a liquid. the object gets disappeared. Then,
    (a) the refractive index of object is more than that of liquid
    (b) the refractive index of object is less than that of liquid
    (c) the refractive index of object is equal to that of liquid
    (d) data insufficient
16. The phenomena which is not explained by Huygen's construction of wavefront
    (a) reflection   (b) diffraction
    (c) refraction   (d) photo electric effect

17. Two slits in Young's double slit experiment have widths in the ratio 36:1. The ratio of the amplitudes of light waves is

(a) 3 :1 (b) 3:2

(c) 9:1 (d) 6:1

18. Which of the following is true for interference of light

(a) energy is created in the region of bright band

(b) energy is destroyed in the region of dark band

(c) conservation of energy does not hold good

(d) conservation of energy holds good and energy is redistributed

19. In Young's Double Slit experiment using sodium light (λ = 5898 Å), 92 fringes are seen. If greenish colour (5480 Å) is used, how many fringes will be seen?

(a) 62 (b) 99

(c) 67 (d) 85

20. Two coherent monochromatic light beams of intensities I and 91 are superimposed. The maximum and minimum possible intensities in the resulting beam are

(a) 9I and I (b) 161 and 41

(c) 91 and 31 (d) 5I and 31

21. A diffraction pattern is obtained by using a beam of blue light. What will happen if the blue light is replaced by the red light

(a) No change will take place

(b) Bands become broader and farther apart

(c) Bands disappear

(d) Diffraction bands become narrower and crowded

22. Two waves, originating from sources S_1 and 5_2 having zero phase difference and common wavelength λ, will show completely destructive interference at a point P if $(S_2P - S_1P)$ is

(a) $(13/2)\lambda$ (b) 3A

(c) 4λ (d) $(5/4)\lambda$

23. Light of wavelength λ falls normally on a slit of width 'a'. The diffraction due to slit will be most prominently observed when-

(a) $a = 5\lambda$ (b) $a = 50\lambda$

(c) $a = 500\,\lambda$ (d) $a = 5000\,\lambda$

24. Nishchay performs YDSE by using yellow, blue and red lights in turn. If the fringe width measures in three cases are x_1, x_2 and x_3, respectively, then which of the following is correct?

(a) $x_1 > x_2 > x_3$ (b) $x_3 > x_1 > x_2$

(c) $x_2 > x_1 > x_3$ (d) $x_1 < x_2 < x_3$

25. When monochromatic light is replaced by white light in a single slit experiment, then

(a) the diffraction pattern disappears

(b) the diffraction band becomes circular

(c) a white band is formed at the centre and coloured bands are formed at both its sides

(d) only a white band is formed at the centre

26. If in a diffraction experiment, the width of the slit is slightly increased, then the central maximum of the diffraction pattern becomes:

(a) broader and brighter

(b) broader and fainter

(c) narrow and brighter

(d) narrow and fainter

27. A parallel beam of light of wavelength 500 nm falls on a narrow slit. The diffraction pattern is observed on a screen 1 m away. The first minimum is at a distance of 2.5 mm from the centre of the screen. The width of the slit is:

(a) 0.16 mm (b) 0.20 mm

(c) 0.40 mm (d) 0.60 mm

28. Two sources of light are said to be coherent, when both emit light waves of:

(a) same amplitude and have a varying phase difference.

(b) same wavelength and a constant phase difference.

(c) different wavelengths and same intensity.

(d) different wavelengths and a constant phase difference.

29. The fringe width in YDSE is β. If the whole set-up is immersed in a liquid of refractive index n , then the new fringe width will be :

(a) β (b) β/n

(c) βn (d) β/n^2

30. The total path difference between two waves meeting at points P_1 and P_2 on the screen are $3\lambda/2$ and 2λ respectively. Then :

(a) bright fringes are formed at both points

(b) dark fringes are formed at both points.

(c) a bright fringe is formed at P_1 and a dark fringe is formed at P_2

(d) a bright fringe is formed at P_2 and a dark fringe is formed at P_1

Answers

1. (c)	2. (b)
3. (a)	4. (b)
5. (b)	6. (a)
7. (b)	8. (b)
9. (a)	10. (a)
11. (a)	12. (c)
13. (a)	14. (c)
15. (b)	16. (d)
17. (d)	18. (d)
19. (b)	20. (b)
21. (a)	22. (a)
23. (b)	24. (c)
25. (c)	26. (c)
27. (b)	28. (b)
29. (b)	30. (d)

Assertion And Reason : (Unit V)

In the following questions, a statement of assertion A is followed by a statement of reason R. Mark the correct choice as :

a) If both assertion and reason are correct and reason is the correct explanation of assertion.

b) If both assertion and reason are correct and reason is not the correct explanation of assertion.

c) If assertion is true but reason is false.

d) If both assertion and reason are false.

Reason - Assertion Question (Option)

31. Assertion : When entire experimental set-up is immersed in water, the fringes became less wider in young's double shit experiments.

    Reason : Wave length of light decreases when it travels from rarer to denser medium. Ans. (a)

32. Assertion : Two light sources emitting light waves of equal amplitude, equal frequency and equal wavelength all called coherent sources.

    Reason: Phase difference between any to sources is always constant.

    Ans. (d)

33. Assertion : The objective of on astronomical telescope is taken of larger focal length to increase magnifying power. Ans. (d)

    Reason : The normal adjustment mode in preferred over near point vision on image formed at infinity in now comfortable to view due to relaxed eye.

    Ans. (b)

34. Assertion : A white light when passed through a prism ut splits its constituent colours.

    Reason : All colours travels with same speed in a particular medium. Ans. (c)

35. Assertion : Electromagnetic waves exert pressure.

Reason : Electromagnetic waves carry both momentum and energy.

(Ans. b)

36. Assertion : Microwave communication is preferred over optical communication.

Reason : Microwaves provide large band width compared to optical signals.

(Ans. d)

37. Assertion : Electromagnetic waves don't require medium for propagation.

Reason : Electromagnetic waves can't travel in medium.

(Ans. c)

38. Assertion : Microwaves are preferred over Radio waves for satellite communication.

Reason : Microwaves have low wavelength than Radio waves.

(Ans. b)

39. Assertion : The intensity of solar radiation is greater Mars as compared to Jupiter.

Reason : The intensity of solar radiation is inversely proportional to the square of radius ($\frac{1}{r^2}$) of the planet. Ans. (a)

$$I \text{ x} \frac{1}{r^2}$$

Case - Study Question (Option)(Unit VI)

I. Lens is a transparent medium bounded by two refracting surfaces. It can be converging or diverging. The converging or diverging behaviour a lens is dependent on refractive index of surrounding medium focal length of a lens is given by

$$\frac{1}{f} = \left[\frac{n_2}{n_1} - 1\right]\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

This is called lens maker's formula. It is useful to design lenses of designed focal length using surface of suitable radii of curvature.

1. A convex lens is-
   a) Always converging
   b) Always diverging
   c) Converging when placed in a rarer medium wrt medium lens.
   d) Converging when placed in a denser medium wrt medium lens.
2. An equiconvex lens is cut into equal halves perpendicular to the principal axis. If focal length of original lens in f, then focal length of each halve is -
   a) f
   b) f/2
   c) 2f
   d) $\frac{3}{2}$ f
3. A concave lens is made with a material of refractive index 1.52. It is placed in a medium of refractive index 1.60. The nature of lens would be-
   a) Converging
   b) Diverging
   c) Can be converging as well as diverging
   d) Neither converging nor diverging
4. A convex lens of refractive index 1.5 is immersed in a liquid medium. The lense gets disappeared in this medium, the refractive index of the medium is-
   a) More than 1.5
   b) Less than 1.5
   c) Equal to 1.5
   d) Can take any value between 1 to infinity.
5. In a particular medium, a convex lens behave as converging lens and concave lens as diverging lens. Now the two lens are put in contact with other. The nature of combination would be-

a) Converging only
b) Either converging or diverging
c) Neither converging nor diverging
d) Both b) & c) are possible

Ans. 1. (c), 2. (b), 3. (b), 4. (c), 5. (d)

II. When an opaque object is placed in the path of light rays, we see a shadow of object on a screen under some specific condition, we see a bright spot at the centre of geometrical shadow region. This happens due to a phenomenon called diffraction. Diffraction is a characteristic shown by all types of waves. When the double slit in young's experiment is replaced by a single narrow slits (illuminated by a monochromatic source), a broad pattern with a central bright region is seen, on either sides, there are alternate dark and bright regions.

1. The size of an opaque object is 0.5μm. Which of the following wave would exhibit diffraction pattern on the screen.
   a) Red light
   b) Yellow light
   c) Green light
   d) Orange light
2. Which of the following is "INCORRECT".
   a) In YDSE light waves from two different wave fronts superposed on each other to produce interference pattern.
   b) In single slit experiment light wave from different parts of same wave front superposed to produce different pattern.
   c) The intensity of bright bands in YDSE is same for all
   d) The intensity of all maxima's single shit experiment in same
3. In a single slit experiment, the screen is moved away from the plane of slits such that distance between screen and slit is doubled. The angular width of central maxima would-

a) Become 4 times (b) Remain unchanged

c) Become 2 times (d) Become ½ times

4. Which the following can be explained by both wave nature and particle nature of light-

a) Diffraction

b) Reflection of light

c) Reflection of light

d) Both reflection and refraction of light

Ans. 1. (c), 2. (d), 3. (b), 4. (d)

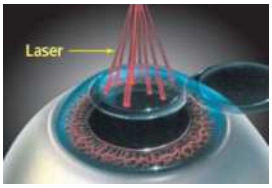
(UNIT : V)

Case Study

III. LASIK (Laser-assisted in Situ Keratomileusis).

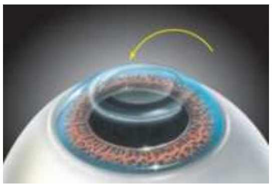
It is commonly know as Laser Eye Surgery for the correction of myopia, hyper metropia and astigmatism. For clear vision the eye's cornea and lens must refract light rays properly. This allows images to be focused on retina properly. Else images will be blurry. This blurriness is known as refractive error.

Lasik uses an excimer laser (An Ultra violet laser) to remove a thin layer of cornea tissue. LASIK causes the cornea to be thinner.



Flap
A special surgical knife slices a flap open on the surface of the cornea.

Cornea
Once tissue has been removed, the flap is folded back onto the cornea and heals quickly.



UV Laser
Pulses of ultraviolet laser light vaporise surface tissue, reshaping the cornea.

Retina
After surgery, light rays entering the eye are focused to a point on the retina, producing a much cleared image.

This gives the cornea a new shape so that light rays are focused on retina clearly. It reduces a person's need for glasses or contact lenses.

1. The frequency range of ultra violet rays is

   a) 10^{10} Hz - 10^{11} Hz

   b) 10^{12} Hz - 10^{15} Hz

   c) 10^{15} Hz - 10^{17} Hz

   d) 10^{18} Hz - 10^{21} Hz

2. Which of the following are not E.M radiations?

   a) Gamma rays

   b) Ultra violet rays

   c) Heat rays

   d) Beta rays

3. The structure of solids is investigated by using

   a) Microwave

   b) Ultra violet rays

   c) X-rays

   d) Gamma rays

4. The energy possessed by per photon of ultra violet radiation is about

   a) 12.41 eV b) 12.4 KeV

   c) 12.4 MeV d) 12.4 meV

5. The electromagnetic radition produced by electric arcs and lights like mercury vapor lamps used to ionise atoms is

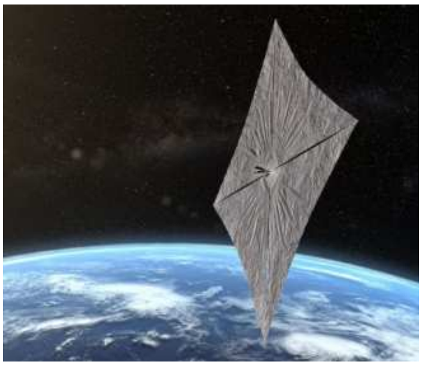
   a) Infrared radiation b) X-rays

   c) UV radiation d) Microwave

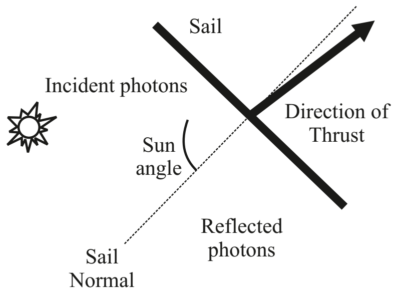
Answers

1. c)
2. d)
3. c)
4. a)
5. c)

Solar Sails :



Solar sails are a method of space craft propulsion using "Radiation Pressure" exerted by sunlight on large scales mirrors. Solar pressure affects all space crafts, whether in inter planetary space or in orbit around a planet. A typical space-craft going to Mars, for example, will be displated thousands of kilometers by solar pressure, so the effects must be accounted for in trajectory planning. Solar pressure also affects the orientation of a space craft. If a radiation falls on the surface (100% reflection) at on angle then, force will be $F = \frac{2P}{c}$ cos where P is power of radiation.



$$\rightarrow \text{Pressure} = \frac{f}{A} \rightarrow \frac{F}{A} = \frac{2P}{Ac} \cos$$

$$\rightarrow (\text{Radiation Pressure} = 2\frac{I}{c} \cos)$$

1. The intensity of solar radiation on Earth's surface is 1360 W/m^2. How much pressure will be exerted on a surface (100% reflecting) incident normally, approx.

   a) 9. Pa   b) 9 mPa

   c) 9 Pμa   d) 9 kPa

2. If a beam of EM wave is completely absorbed by the surface, then the pressure exited by radiation (Radiation Pressure) will be

a) $\frac{I}{c}$ b) $P=\frac{2I}{c}$ c) $P=\frac{I}{2c}$ d) P=o

3. A point source of EM waves emit the waves iso tropically in all directions. The intensity of wave at distance r from a point source of power P_s is

a) $I=\frac{P_s}{r^2}$ b) $I=\frac{P_s}{\pi r^2}$ c) $I=\frac{P_s}{4\pi r^2}$ d) $I=\frac{P_s}{2\pi r}$

4. The time-averaged rate per unit area at which energy is transported is intensity I of the wave can be expressed as

a) $I=\frac{2E^2_{rms}}{c\mu o}$ b) $I=\frac{E^2_{rms}}{c\mu o}$ c) $I=\frac{E^2_{rms}}{\mu o}$ d) $I=\frac{E^2_{rms}}{2c}$

5. Find the intensity of radiation at distance 7m from the source of 14 W.

a) 0.02 w/m^2 b) 0.2 w/m^2 c) 44 w/m^2 d) 4.4 w/m^2

Answers :

1. a) 2. a) 3. c) 4. b) 5. a)

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 magnetic field at this instant? (Wave is travelling in vacuum).

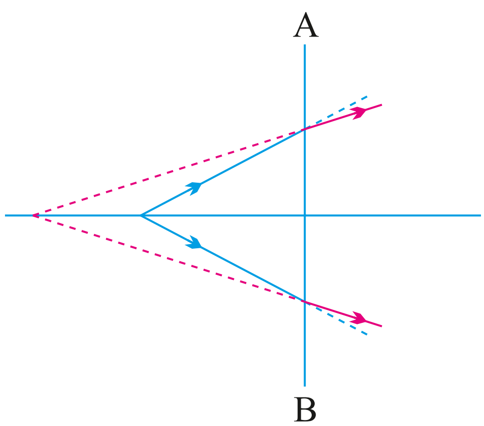
5. State two applications of infrared radiations.

6. State two applications of radio waves.

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 magnetic field $\vec{B}$?

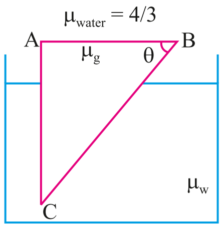
9. The line AB in the ray diagram represents a lens. State whether the lens is convex or concave.



10. Use mirror equation to deduce that an object placed between the pole and focus of a concave mirror produces a virtual and enlarged image.

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

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



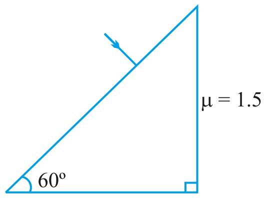
12. What is the effect on the interference fringes is YDSE when

(i) the screen is moved away from the plane of the slits (ii) the sepration between the two slits is increased

Ans. (i) As $\beta = \dfrac{\lambda D}{d}$; $\beta \propto D$ Therefore β increases

(ii) however angular sepration $(\dfrac{\lambda}{d})$ remains same when d increases β decreases

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

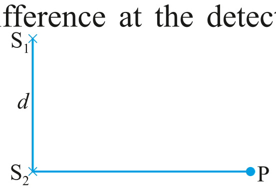


14. Define diffraction. What should be the order of the size of the aperture to observe diffraction.

15. 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.

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

17. 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?



18. 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 towards jogger.

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.

19. Why is interference pattern is not detected when two coherent sources are (i) far apart (ii) infinitely close to each other

Ans. (i) We know $\beta \alpha \frac{l}{d}$; since d is very large β may reduce so much i.e beyond visible region.

(ii) Since d is two small, β becomes very large. field of view may even be occupied by single slit on screen resulting no detection of pattern.

20. A parallel beam of light of wavelength 600 nm is incident normally on a slit of width 'd'. if the distance between the slit and screen is 0.8m and distance of 2nd order maximum from the centre of screen is 15 mm, calculate the width of the slit.

$$\text{Since } \alpha \text{ sing } \theta = (2n+1)\frac{\lambda}{2} \ \alpha \left(\frac{\chi}{d}\right) = (2x2+1)\ \lambda/2$$

$$\alpha = \frac{5\lambda D}{2\chi} = \frac{5x(6x10^{-7})x0.8D}{2x15x10^{-3}} = 0.8x11^{-4}m = 80\ \mu m$$

21. 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.

22. 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.

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

24. 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 $4f = s$.

$$\therefore \quad f = s/4$$

25. 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.

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

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

28. 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.

29. 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.

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

31. For a glass prism($\mu=\sqrt{3}$), the angle of minimum deviation is equal to the angle of the prism. Find the angle of the prism.

Ans. Hence $\delta m = A$; $\mu = \dfrac{\text{Sin }(A+\delta m)/2}{\text{Sin } A/2}$; $\sqrt{3} = \dfrac{\text{Sin } A}{\text{Sin } A/2}$

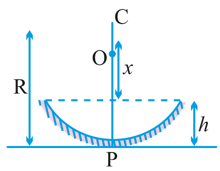
$$\sqrt{3} = \frac{2\text{Sin } A/2 \text{ Cos } A/2}{\text{Sin } A/2} \Rightarrow A = 60^0$$

32. Using Huygens Principle draw ray diagram for the following :

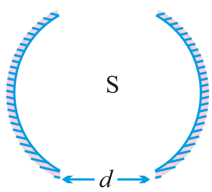
(i) Refraction of a plane wave front incident on a rarer medium

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

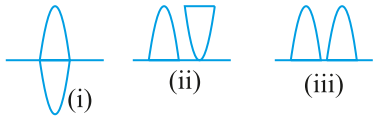
33. Water (refractive index μ) is poured into a concave mirror of radius of curvature 'R' up to a height *h* as shown in figure. What should be the value of *x* so that the image of object 'O' is formed on itself?



34. 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.

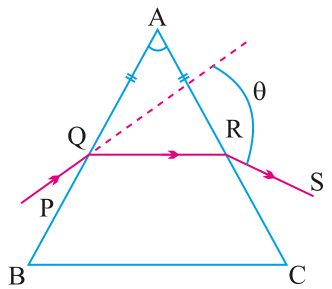


35. A thin double convex lens of focal length f is broken into two equal halves at the axis. The two halves are combined as shown in figure. What is the focal length of combination in (ii) and (iii).



36. 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. $({}_a\mu_\omega = 4/3.)$

37. 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. Name EM radiations used
   (i) in the treatment of cancer.
   (ii) For detecting flow 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.
5. 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.
6. Obtain the formula for combined focal length of two thin lenses in contact, taking one divergent and the other convergent.

7. Derive Snell's law on the basis of Huygen's wave theory.

8. 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*.

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

10. 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.

11. Why is diffraction of sound waves more evident in daily experience than that of light waves ?

Ans. To occur diffraction condition required is " size of obstacle/operture must be of the order of wavelength of waves to be diffracted" since wavelength of light waves is of the order of 10^{-7} m, obstacles/apertures of this much of small size are hardly available.

While wavelength of sound waves vary from 15 m to 15 mm and obstacles / apertures of this size are commonly available.

There diffraction of sound waves is more evident in day to day life.

12. Derive Mirror formula for a concave mirror forming real Image.

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

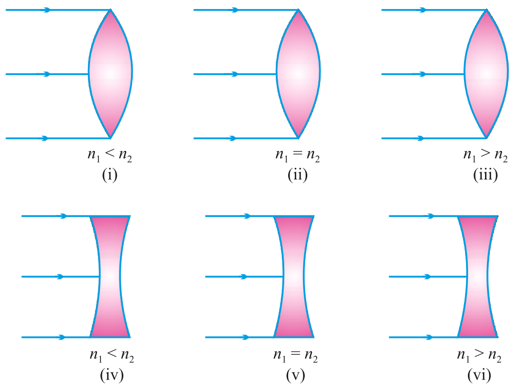
(a) Draw the intensity pattern and name the phenomenon

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

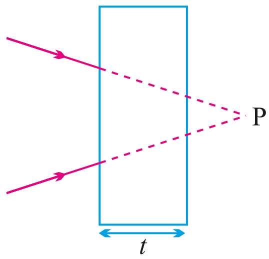
14. Explain (i) sparkling of diamond (ii) use of optical fibre in communication.

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

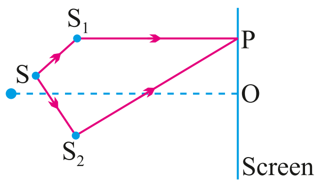
16. Complete the ray diagram in the following figure where, n_1 is refractive index of medium and n_2 is refractive index of material of lens.



17. 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 shiffted? Illustrate the answer.



18. 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.



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 if final image is formed at least distance of distant vision.
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. Explain the following :
   (a) Sometimes distant radio stations can be heard while nearby stations are not heard.
   (b) If one of the slits in Youngs Double Slit Experiment is covered, what change would occur in the intensity of light at the centre of the screen?

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

6. What is meant by interference of light ? Define coherent sources of light. Describe briefly young's double slit experiment with the help of labelled ray diagram to demonstrate interference of light

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. When final image is formed at least distance of distinct vision.

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 prism of refracting angle A. Deduce the relation

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

11. State the condition under which the phenomenon of diffraction of light takes place. Also draw the intensity pattern with angular position.

12. How will the interference pattern in Youngs double slit experiment change, when

(i) distance between the slits S_1 and S_2 is reduced and

(ii) the entire set up is immersed in water ?

Justify your answer in each case.

Ans. Fringe width $\beta = \frac{\lambda D}{d}$

(i) If d decreases, fringe width $\beta \propto \frac{1}{d}$ increases

(ii) When apparatus is immersed in water, wavelength reduces to $\frac{\lambda}{\mu_\omega}$. Therefore, fringe width $\beta \propto \lambda$ decreases.

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 vacuum. 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 $v = 50.0$ 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

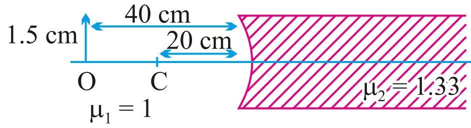
(iv) Speed of wave

(v) Refractive index of medium

(vi) Amplitude of magnetic field vector.

7. An object of length 2.5 cm is placed at a distance of 1.5 f 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? [5 cm, Inverted]

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



[5 cm, Inverted]

1.6 cm approx.

[1.2 cm, approx.]

9. 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°]

10. Two thin lenses are in contact and the focal length of the combination is 80 cm. If the focal length of one lens is 20 cm, then what would be the power of the other lens?

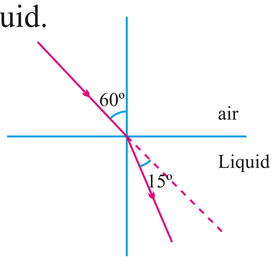
$$\text{Since } P = \frac{1}{f(\text{metre})} = \frac{100}{80} = 1.25D$$

$$P = \frac{1}{f_1} = \frac{100}{20} = 5D$$

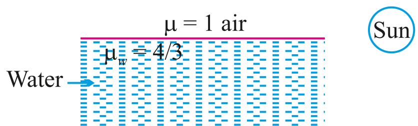
$$\because \; P = P_1 + P_2 \quad \Rightarrow P_2 = P - P_1 = 1.25 - 5 = -3.75 \text{ D}$$

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

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



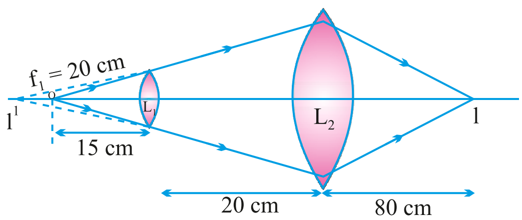
12. At what angle with the water surface does fish in figure see the setting sun ?



$[C = \text{Sin}^{-1}\,(0.7518)]$

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

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



14. Three immiscible liquids of densities $d_1 > d_2 > d_3$ and refractive indices $\mu_1 > \mu_2 > \mu_3$ are put in a beaker. The height of each liquid is $\frac{h}{3}$. A dot is made at the bottom of the beaker. For near normal vision, find the apparent depth of the dot.

Ans. (Hint : the image formed by first medium act as an object for second medium) Let the apparent depth be O_1 for the object seen from $O_1 = \frac{\mu_2}{\mu_1} \cdot \frac{h}{3}$ image formed by medium 1, O acts as an object for medium 2. It is seen from M_3, the apparent depth is O_2.

Similarly, the image found by medium 2, O_2 act as an object for medium 3

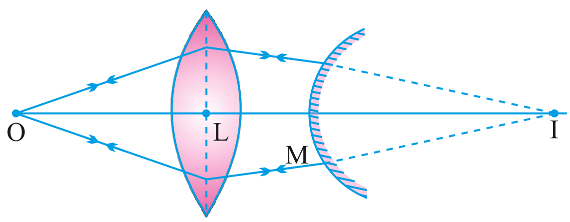
$$O_2 = \frac{\mu_3}{\mu_2}\left(\frac{h}{3} + O_1\right)$$

$$O_3 = \mu_3\left(\frac{h}{3} + O_2\right) \qquad \text{putting value of } O_2 \text{ and } O_1$$

$$O_3 = \frac{h}{3}\left(\frac{1}{\mu_1} + \frac{1}{\mu_2} + \frac{1}{\mu_3}\right)$$

15. A point object O is kept at a distance of 30 cm from a convex lens of power + 4D towards its left. It is observed that when a convex mirror is kept on right side at 50 cm from the lens, the image of object O formed by lens-mirror combination coincides with object itself. Calculate focal length of mirror.

Ans. Image formed by combination coincides with the object itself. It implies that I is the centre of curvature of convex mirror.



For lens

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\frac{1}{25} = \frac{1}{v} + \frac{1}{30}$$

$$v = 150 \text{ cm}$$

$$MI = LI - LM = 150 - 50 = 100 \text{ cm}$$

$$f_m = \frac{MI}{2} = \frac{100}{2} = 50 \text{ cm}$$

16. 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, lens 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 eye piece because its focal length is not larges.

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

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$= \frac{1}{15} + \frac{1}{30} = \frac{1}{10}$$

$$F = 10 \text{ cm}$$

$$P = 10D$$

18. An object is placed in front of a concave mirror of focal length 20 cm. The image is formed three times the size of the object. Calculate two possible distances of the object from the mirror.

Ans. $m = \pm 3$

$$m = \frac{-v}{u} = +3 \text{ for virtual image}$$

$$v = -3u$$

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{-34}+\frac{1}{u} = -\frac{1}{20}$$

$$u = -\frac{40}{3}\text{cm}$$

$$m = \frac{-v}{u} = -3 \text{ for real image}$$

$$v = 3u$$

$$\frac{1}{v}+\frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{3u}+\frac{1}{u} = -\frac{1}{20}$$

$$u = -\frac{80}{3}\text{cm.}$$

Question for Practice

1. Which part of the electromagnetic spectrum is used in RADAR? Give its frequency range.

2. How is the equation for Ampere's circuital law modified in the presence of displacement current?

3. How are electromagnetic waves produced by oscillating charges? What is the source of the energy associated with the em waves?

4. Name the radiation of the electromagnetic spectrum which is used for the following:

(a) (i) Radar (ii) Eye surgery

(b) To photograph internal parts of human body

(c) For taking photographs of the sky during night and foggy conditions

Give the frequency range in each case.

5. In young's double slit experiment using monochromatic light of wavelength λ, the intensity of light at a point on the screen where path difference is λ is "K" units. Find the intensity of light at a point where path difference is $\frac{\lambda}{3}$.

$$\text{Phase iff.} = \frac{2\pi}{\lambda}\times\frac{\lambda}{3}=\frac{2\pi}{3}=120°$$

and $$I = I_0 \cos^2 \frac{\phi}{2} = \frac{K}{4}$$

$$\left[\text{Hint} \quad I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi\right]$$

6. In young's double slit experiment, a light of wavelength 630 nm produces an interference pattern where bright fringes are separated by 8.1 mm. Another light produces the interference pattern. Where the bright fringes are separated by 72 mm. Calculate the wavelength of second light.

$$\left[\text{Hint} \quad \beta = \frac{\lambda D}{d}\right]$$

Ans. 560 nm

7. A beam of light consisting of two wavelength 800 nm and 600 nm is used to obtain the interference pattern in young's double slit experiment on a screen placed 1.4 m away. If the separation between two slits in 0.28 mm. Calculate the least distance from the central bright maximum, where the bright fringes of two wavelengths coincide.

Ans. $$x = n\lambda_1 \frac{D}{d} = (n+1)\lambda_2 \frac{D}{d}$$

$\therefore$ $$n \times 800 = (n+1)\lambda_2 \frac{D}{d}$$

$\therefore$ $$n = 3$$

$\therefore$ $$x = n\lambda_1 \frac{D}{d} = 3 \times 800 \times \frac{10^{-9} \times 1.4}{0.28 \times 10^{-3}} = 12 \text{ mm}$$

Numericals

1. The focal lengths of objective and eye peace of a microscope are 1.25 cm and 5 cm respectively find the position of the object relative to the objective in order to obtain an angular magnification of 30 in normal adjustment.

Ans. In normal adjustment

$$m_e = \frac{d}{f_e} = \frac{25}{5} = 5$$

$$m = m_0 m_e$$

$\therefore$ $$m_0 = \frac{m}{m_e} = \frac{30}{5} = 6$$

and $$m_0 = \frac{V_0}{u_0} = -6$$

$\therefore$ $$V_0 = -6u_0$$

$\therefore$ $$\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0}$$

$$\frac{1}{-6u_0} - \frac{1}{u_0} = \frac{1}{f_0}$$

here $$f_0 = 1.25 \text{ cm}$$

$u_0 = -1.46$ cm

2. A small telescope has an objective lens of focal length 150 cm and an eye piece of focal length 5 cm. If his telescope is used to view a 100 m high tower 3 km away find the height of the final image when it find the height of the final image when it is formed 25 cm away from the eye pieces.

Ans. $$\tan\alpha = \frac{100}{3000} = \frac{1}{30} \text{ radian}$$

again $$\tan\alpha = \frac{h}{f_0}$$

$$\therefore \qquad \frac{1}{30} = \frac{h}{150}$$

$$h = 5 \text{ cm}$$

h height of image of tower

$$\therefore \qquad m_e = \left(1 + \frac{\alpha}{f_e}\right) = \left(1 + \frac{25}{5}\right) = 6$$

$$\text{and} \qquad m_e = \frac{h'}{h}$$

$$\therefore \qquad h' = 5 \times 6 = 30 \text{ cm}$$

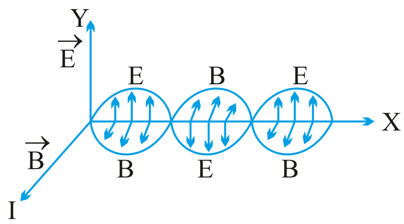
h' height of final image.

ANSWER OF 2 MARKS QUESTIONS

1. UV ray – In water purifier.

γ ray – In treatment of cancer

2.



3. An accelerated charge produces oscillating electric field in space, which produces an oscillating magnetic field, which in turn, is a source of oscillating electric field and so on. The oscillating electric & magnetic fields produces each other & give rise to e.m. waves.

4. In vacuum $\qquad C = \frac{E_0}{B_0}$

If electric field become $\frac{3}{4}E_0$, magnetic field will be $\frac{3}{4}B_0$.

5. (i) In green houses to keep plants warm.

(ii) In reading secret writings on ancient walls.

6. (i) In radio & tele communication systems.

(ii) In radio astronomy.

7. (i) In medical to diagnose fractures in bones.

(ii) In engineering for detecting cracks, flaws & holes in metal parts of a machine.

8.

$$\mu_E = \frac{1}{2}\varepsilon_0 E^2 \quad \& \quad u_B = \frac{1}{2}\frac{B^2}{\mu_0}$$

$$\mu_E = \frac{1}{2}\varepsilon_0 E^2 = \frac{1}{2}\varepsilon_0 (CB)^2 \qquad \text{As } c = \frac{E}{B}$$

$$= \frac{1}{2}\varepsilon_0 \frac{B^2}{\mu_0 \varepsilon_0} \qquad c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$

$$= \frac{B^2}{2\mu_0}$$

$$= \mu_B$$

10. For concave mirror

$$f < 0 \quad \text{and} \quad u < 0$$

$$f < u < 0$$

$$\frac{1}{f} > \frac{1}{u} \quad \text{or} \quad \frac{1}{f} - \frac{1}{u} > 0$$

$$\text{or} \quad \frac{1}{v} > 0$$

Virtual image is formed.

Also $$\frac{1}{v} < \frac{1}{|u|} \quad \text{or} \quad v > |u|$$

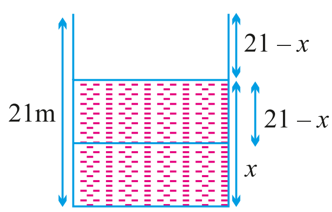
$$m = \frac{v}{|u|} > 1$$

magnified image.

11. $\theta = \sin^{-1}(8/9)$
13. $\sin^{-1}(3/4)$
16. 4 m pole
17. Minimum path difference is zero (when p is at infinity).
Maximum path difference = d.
29. 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
30. (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 cause overlapping of different colours.
31. f_0 = 1 cm and f_e = 3 cm for Microscope and
f_0 = 100 cm and f_e = 1 cm for a Telescope
33. N.C.E.R.T. Fig. 10.5; Fig. 10.4.
34. Distance of object from p should be equal to radius of curvature.

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

35. Distance between mirror will be $2f$ or $4f$.
36. (i) Focal length of combination is infinite,
(ii) $f/2$
37.



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

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

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

ANSWERS OF 3 MARKS QUESTIONS

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

18. Path difference :

$$(SS_2 + S_2P) - (SS_1 + S_1P) = (SS_2 - SS_1) + (SS_2P - S_1P)$$
$$= (0.25\lambda + S_2P - S_1P)$$

For maxima, path difference $= n\lambda$

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

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

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