11 Wave Theory of Light

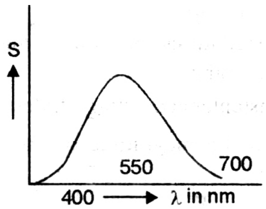
COMPREHENSIVE REVIEW

BASIC CONCEPTS :

1. Light is that form of energy which makes the objects visible.
2. Optics is that branch of physics which deals with the nature, sources, properties and effects of light.
3. The optics may be further classified as follows :
   Geometrical optics, Physical optics, Ray optics, Wave optics, Quantum optics.
4. The wave optics and the quantum optics are the branches of Physical optics.
5. Geometrical optics is the same as ray optics.
6. Quantum optics treats the light as the stream of particles.
7. The particle of light or the quantum of light is called photon.
8. Photoelectric effect, Raman effect, Compton effect are explained on the basi of the quantum nature of light.
9. Wave optics treats light as electromagnetic waves.
10. The electromagnetic waves consist of electric $(\vec{E})$ & magnetic $(\vec{B})$ field oscillations propagating in space.
11. The electric field oscillates perpendicular to the magnetic field.
    That is $\vec{E} \perp \vec{B}$
    And both $\vec{E}$ & $\vec{B}$ are perpendicular direction of velocity $\vec{c}$ of light.
    Thus :
    $$\vec{E} \perp \vec{B} \perp \vec{c}$$
12. Light does not require material medium propagation.
13. The speed of light is maximum in vacuum. It is nearly 3×10^8 m/s.
14. The oscillations of both $\vec{E}$ & $\vec{B}$ are in phase with each other.
15. The instantaneous magnitudes of $\vec{E}$ & $\vec{B}$ are related to the magnitude of the velocity of light as follows :
    $$c = \frac{E}{B}$$
    Thus, the magnitude of $\vec{B}$ is very very small as compared to that of $\vec{E}$.
16. Electromagnetic waves are transverse in nature. That is the oscillations of $\vec{E}$ & $\vec{B}$ are perpendicular to the direction of propagation $\vec{c}$.
17. The wavelength of light waves lies between 400 nm to 800 nm.
18. In air or vacuum, our eye distinguishes colours* in the wavelength ranges as follows :

Sr. No.	Colour	Wavelength (λ*) range in nm
1.	Violet	400 – 500
2.	Blue	450 – 500
3.	Green	500 – 550
4.	Yellow	550 – 600
5.	Orange	600 – 650
6.	Red	650 – 800

19. The electromagnetic radiations of wavelength immediately below the violet light are called **ultraviolet**.
20. The wavelength range of the ultraviolet radiations is between 5 nm to 400 nm.
21. The electromagnetic radiations of wavelength immediately above the red light are called **infra red**.
22. The wavelength range of the infra red radiations is between 800 nm to 106 nm or 1 mm.
23. Our eye is most sensitive to yellow green light.
24. Then sensitivity (S) of the eye varies with wavelength as follows :



25. The photographic plate is most sensitive to the violet colour and least sensitive to the red colour.

26. The speed of light is independent of the relative speed of the source and the observer.

27. The frequency of light waves is maximum for violet colour.

$$f_{max} = \frac{c}{\lambda_{min}} = \frac{3\times10^8}{400\times10^{-9}} = 7.5\times10^{14}\,\text{Hz}$$

28. The frequency of light is minimum for the red colour.

$$f_{min} = \frac{c}{\lambda_{max}} = \frac{3\times10^8}{700\times10^{-9}} = 4.3\times10^{14}\,\text{Hz}$$

29. The velocity of light of all wavelengths is same in free space or vacuum.

30. The velocity of light of different colours will be different in media other than vacuum.

Because on entering any medium, the frequency does not change. Therefore,

$$\upsilon \propto \lambda$$

That is, larger the wavelength higher will be the speed of light.

31. The speed of light was first determined by Roemer (in 1676) through the eclipse of the moon of Jupiter.

31. (a) The fust laboratory measurement of speed of light was carried out by Fizeau in 1849, with the help of rotating toothed wheel.

32. Persistence of vision.

If the time interval between two light pulses be less than 0.1 second, then our eye fails to distinguish between them. This is called persistence of vision.

33. Resolving power.

Our eye fails to see two points separately if they subtend an angle equal to or less than 1 minute. It is called resolving power of the eye.

For resolution of two points separated by a distance d, from a distance D, we find :

$$\frac{d}{D} > \frac{\pi}{180\times60}$$

34. An optical medium is said to be denser, if its refractive index is higher.

35. Higher the refractive index or denser the optical medium, smaller is the speed of light in it.

36. When light goes from one medium to another, its frequency remains unchanged but both the speed and wavelength change.

37. The colour of light depends on frequency and not on wavelength.

Therefore, when the light goes from one medium to another its colour does not change inspite of the fact that the wavelength changes.

38. Light of single frequency or wavelength is called monochromatic.

39. Light propagates as waves. The rectilinear propagation of light is observed due to its small wavelength.

40. Objects are visible from all directions due to the scattering of light.

41. An optical medium is said to be isotropic if the velocity of light in it is same in all directions. Water, air, glass etc. are isotropic media.

42. An optical medium is said to be anisotropic if the velocity of light in it is different in different directions.

43. A medium is said to be **transparent** if the light passes through it. If the light passes through the medium partially, then it is said to be **translucent**. And if no light passes through the medium, then it is called **opaque**.

44. Laser is abbreviation for Light Amplification by Stimulated Emission of Radiations.

45. Laser is monochromatic, coherent, intense and unidirectional beam of light.

46. Corpuscular theory of light

a) This theory was proposed by Newton in the year 1675.

b) This theory was based on the rectilinear propagation of light.

c) Newton suggested that the light propagates as particles called corpuscles.

On the basis of this theory, Newton explained the rectilinear propagation of light, colours of light, reflection and refraction of light on the basis of certain adhoc assumptions as follows.

d) Colours of light were explained on the basis of different sizes of the corpuscles.

e) Reflection was explained on the basis of repulsion of corpuscles from the surface.

f) Refraction was explained on the basis of attraction of the corpuscles by the surface.

g) Corpuscular theory cannot explained the phenomena such as interference, diffraction, and polarisation.

h) According to the corpuscular theory the speed of light in denser medium should be more* than that in the rarer medium. This was experimentally disproved by Focault in 1850.

***Remarks.** According to the corpuscular theory of light, the refraction occurs due to the attractive force exerted by the surface on the corpuscles. Due to this reason, the velocity of the corpuscles should increase on entering the other medium. This is not found true experime tally and led to the rejection of rhe corpuscular theory of light.

47. Wave theory of light.

a) This theory was proposed by Huygens in 1678.

b) Huygens suggested that each point on the source of light acts as a centre of disturbance from which the waves spread out in all directions,

c) The locus of all the particles in a medium vibrating in the same phase is called wave front.

d) The wave front due to a point source is spherical and due to a line source is cylindrical. The wave front corresponding to a parallel beam of light rays is plane.

e) The direction of propagation of the light (ray of light) is perpendicular to the wave front.

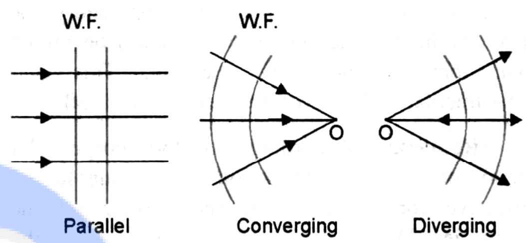
f) Each point on a wave front acts as a source of new disturbance called secondary wavelets.

g) Secondary wavelets spread out as spherical secondary wave fronts with the speed of light.

h) The tangential surface to all the secondary wave fronts gives the new wave front.

i) The intensity of the secondary wave front is given by : $I = I_0(1+\cos\phi)$ where ϕ is the angle between the original direction of propagation and the direction of observation. This shows that the secondary wave front has zero intensity in the backward direction.

j) The wave fronts for the plane, converging and diverging beams of light are as follows :



k) The wave theory explains the laws of reflection, refraction, rectilinear propagation, interference, diffraction, as well as dispersion of light.

l) The wave theory fails to explain the photoelectric effect of light.

m) Huygens had assumed that the light waves propagate in a hypothetical medium called ether. It was supposed to possess very high elasticity and very low density. However, later on it was found that no material medium is required for the propagation of light.

n) Huygens had also proposed that light waves are of longitudinal nature. As such it could not explain the polarisation of light. Later on it was found that the light propagates as transverse waves and that the transverse waves can be polarised.

48. Electromagnetic wave theory of light

a) This theory was proposed by Maxwell in the year 1873.

b) He suggested that the light travels as electromagnetic waves with a constant velocity c in free space.

c) $c = \dfrac{1}{\sqrt{\mu_0 \in_0}} \cong 3\times10^8\,\text{m/s}$

d) The velocity in any other medium is given by :

$$\upsilon = \frac{1}{\sqrt{\mu \in}} = \frac{1}{\sqrt{\mu_r \in_r}} \times \frac{1}{\sqrt{\mu_0 \in_0}} = \frac{c}{\sqrt{\mu_r \in_r}}$$

Also $\upsilon = \frac{c}{n}$, where n is the refractive index of the medium.

Hence, $n = \sqrt{\mu_r \in_r}$

e) The electromagnetic waves consist of the electric and magnetic field oscillations.

f) In the electromagnetic waves the plane of oscillation of electric field $(\vec{E})$ is perpendicular to that of magnetic field $(\vec{B})$ and both are perpendicular to the direction of propagation (velocity $\vec{c}$) of the light waves.

That is : $\vec{E} \perp \vec{B} \perp \vec{c}$

g) The magnitude of $\vec{E}$ & $\vec{B}$ at any point is related as : E = cB.

h) $\vec{E}$ & $\vec{B}$ oscillations are always in phase with each other.

i) It is often said that most of the electric properties of the light depend on the electric vector. It simply implies that the magnitude of E is much larger than that of B(E = cB).

j) Maxwell's electromagnetic wave theory was further strengthened in 1888, by the spark gap oscillator experiments of Hertz, which resulted in the production of short wavelength electromagnetic radiations.

k) The electromagnetic waves are of transverse nature.

l) Electromagnetic wave theory explains reflection, refraction, interference, diffraction, polarisation and dispersion etc. satisfactorily.

m) The electromagnetic wave theory fails to explain the photoelectric effect which was also observed by Hertz.

49. Quantum Theory of Light

a) It was proposed by Einstein in the year 1905.

b) He made use of the Planck's Quantum theory of black body radiations as the basis of his theory of the nature of light.

c) According to this theory, the light is produced, absorbed and propagated as packets of energy called photons.

d) The energy associated with each photon is,

$$E = h\nu = \frac{hc}{\lambda}.$$

where, h = Planck's constant,
v = frequency of light radiations,
c = speed of light and
λ = wavelength of the radiations

e) Einstein's Quantum theory of light was verified experimentally by Millikan.

f) Quantum theory successfully explains photoelectric effect, reflection, refraction of light, but fails to explain the interference, diffraction, polarisation and dispersion of light.

50. Dual theory of light

a) The present view about the nature of light is that it propagates both as particle as well as waves. It is called dual nature of light.

b) Eddington used to call the light as wavicles, which is derived from the words waves and particles.

c) The wave nature of light dominates when light interacts with light.

d) The particle nature of light dominates when the light interacts with matter (microscopic particles).

e) Dual nature theory of light successfully explains all the phenomena connected with light.

51. Speed of Light

In the Michelson's method for determining the speed of light, the speed is given by :

$$c = mN\ell$$

where, m = number of faces of the rotating mirror, N = number of rotations per second by the mirror and ℓ = distance travelled by the light between the reflections from the opposite faces of the mirror.

52. In the **Fizeau's method** for determining the speed of light, the speed is given by :

$$c = 4\ mnd$$

where m = number of teeth in the rotating wheel, n = number of revolutions made by the wheel per second and d = distance of the mirror from where the light is reflected.

53. Doppler's shift

The Doppler's shift for light is given by,

$$\Delta\lambda = \frac{u}{c}\lambda$$

where u is the speed of the source or the observer, c is the speed of light and λ is the original wavelength.

The wavelength increases when the source and the listener go away from each other. It is called red shift. The wavelength decreases when the source and the listener approach each other. It is called blue shift.

54. Optical phenomena explained () or not explained (×) by the different theories of light.

Sr. No.	Phenomena	Theory: Corpu-scular	Wave	E.M. wave	Quan-tum	Dual
1.	Rectilinear Propagation	√	√	√	√	√
2.	Reflection	√	√	√	√	√
3.	Refraction	√	√	√	√	√
4.	Dispersion	×	√	√	×	√
5.	Interference	×	√	√	×	√
6.	Diffraction	×	√	√	×	√
7.	Polarisation	×	√	√	×	√
8.	Double refraction	×	√	√	×	√
9.	Doppler's effect	×	√	√	×	√
10.	Photoelectric effect	×	×	×	√	√
11.	Compton effect	×	×	×	√	√
12.	Raman effect	×	×	×	√	√

55. Proposers and the year of proposing the different theories of light

Theory	Proposer	Year of proposing
Corpuscular	Newton	1675
Wave	Huygen	1678
Electromagnetic wave	Maxwell	1873
Quantum	Einstein	1905
Dual	de Broglie	1923

56. Energy density of light

i) The light energy present per unit volume in vacuum is given by,

$$u = \varepsilon_0 E_0^2 + \mu_0 B_0^2$$

where, ε_0 = permittivity, E_0 = electric field strength, μ_0 = permeability & B_0 = magnetic induction.

ii) The average energy density is given by,

$$u_a = \frac{1}{2}\varepsilon_0 E_0^2 = \frac{1}{2}\mu_0 B_0^2$$

iii) In general, the average magnetic energy density = average electric energy density in vacuum.

That is, $u_m = u_e$ or $\frac{1}{2}\varepsilon_0 E_0^2 = \frac{1}{2}\mu_0 B_0^2$

57. Radiation pressure of light

i) Radiation pressure is the momentum imparted per second per unit area on which the light falls. For non reflecting (absorbing) surface, the radiation pressure is given by :

$$p = \varepsilon E^2 = \mu B^2$$

It is equal to the energy density of light.

ii) For perfectly reflecting surface, the radiation pressure is :

$$p = 2\varepsilon E^2 = 2\mu B^2$$

iii) Average radiation pressures are as follows :

a) For perfectly non reflecting (absorbing) surface,

$$p_a = \frac{1}{3}\varepsilon E^2$$

b) For perfectly reflecting surface,

$$p_a = \frac{2}{3}\varepsilon E^2$$

58. Intensity of light

The average light energy crossing per unit area per second, (when the area in question is perpendicular to the direction of propagation of light) is called intensity of light (I).

It is given by : $I = u_a c = \frac{1}{2}\varepsilon_0 E_0^2 c$

where, u_a is the average energy density and c is the speed of light.

59. Poynting vector $(\vec{S})$

The poynting vector is defmed as the energy crossing per second per unit area. It is given by :

$$\vec{S} = \vec{E}_0 \times \vec{H}_0 = \frac{\vec{E}_0 \times \vec{B}_0}{\mu_0}$$

Here, $H = \frac{B_0}{\mu_0}$

The unit of S is watt/metre^2.

60. Light waves

Light propagates as transverse electromagnetic waves.

61. Description of light waves

The magnitude of electric field vector is much larger as compared to the magnetic field vector. (E = cB where c = speed of light).

Also, the eye is mainly affected by electric vector. Therefore, we generally prefer to describe light as electric field oscillations.

62. Unpolarized light

a) The light having electric field oscillations in all directions in the plane perpendicular to the direction of propogation is called unpolarised.

b) The unpolarised light may be diagramatically represented as follows :

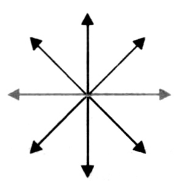


Fig. 62.1

c) The oscillations may be resolved into horizontal and vertical components as follows :

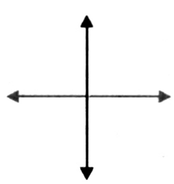


Fig. 62.2

d) Which is generally expressed as follows :

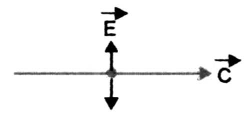


Fig. 62.3

Here, long line with one arrowhead represents the direction of propagation of light and double arrow head represents vertical oscillations. The horizontal oscillations are represented by a dot at the point of intersection of single arrow head and double arrow head lines.

e) The intensity of the horizontal oscillations is equal to that of the vertical oscillations.

63. Polarised light

a) The light having oscillations only in one plane is called polarised or plane polarised.

b) The plane in which oscillations occur in the polarised light is called plane of oscillation.

c) The plane perpendicular to the plane of oscillation is called plane of polarisation.

64. Light can be polarised by transmitting through certain crystals such as tourmaline or polaroids.

65. Polaroids are thin films of ultramicroscopic crystals of qumme idosulphate with their optic axes parallel to each other.

66. Quinine idosulphate is also called herpathite.

67. Polaroids allow the light oscillations parallel to the transmission axis pass through them.

68. If unpolarised light is incident on a polaroid, the transmitted light is plane polarised as shown below :

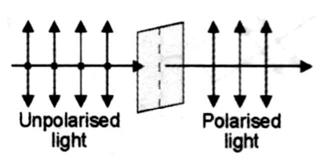


Fig. 68.1

Here, the vertical oscillations are transmitted because the transmission axis is also vertical. The horizontal oscillations are not transmitted. That is why, on the right hand side there are no dots at the intersection of lines.

69. The intensity of the transmitted light should be 50% of the incident light. However, in actual practice it is found to be about 35% of the incident light.

70. The crystal or polaroid on which unpolarised light is incident is called polariser.

71. Crystal or polaroid on which polarised light is incident is called **analyser**.

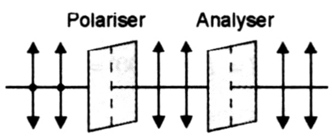


Fig.71.1

72. If the transmission axes of the polariser and analyser are parallel, then whole of the polarised light passes through the analyser.

73. If the transmission axis of the analyser is perpendicular to that of polariser, then no light passes through the analyser.

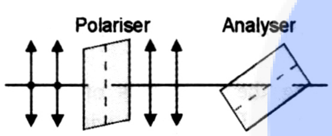


Fig. 73.1

Such polariser and analyser are said to be crossed.

74. Malus law

If I_0 be the intensity of the polarised light incident on the analyser and θ be the angle between the transmission axes of the polariser and analyser, then the intensity of the light transmitted through the analyser is given by :

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

75. If A be the amplitude of the light transmitted through the analyser and A_0 be the amplitude of the polarised light incident on it, then :

$$A^2 = A_0^2 \cos^2 \theta \quad \text{or} \quad A = A_0 \cos \theta$$

76. If I_i be the intensity of the unpolarised light incident on the polariser and I be the intensity of the light transmitted through the analyser, then :

$$I = \frac{I_i}{2} \cos^2 \theta$$

Here, $I_0 = \frac{I_i}{2}$

77. In the above expressions θ is also the angle between the plane of oscillation of the polarised light and the transmission axes of the analyser.

78. For the crossed polariser and analyser, $\theta = 90^0$

hence : $I = I_0 \cos^2 90^0 = 0$

79. Double refraction

a) When a ray of unpolarised light is indent on calcite or quartz crystal, it splits into two refracted rays. One of the refracted rays is called ordinary (O-ray) as it obeys the laws of refraction. The other refracted ray is called extraordinary ray (E-ray) because it does not obey the laws of refraction.

b) The E-ray propagates through the crystal with different speeds in different directions. That is, it has different refractive indices in different directions.

c) Along the optic axis of the crystal both O-ray as well as E-ray travel with the same speed and have the same refractive index.

d) Both the O-ray as well as E-ray are plane polarised in mutually perpendicular directions.

e) If υ_0 and υ_e represent the speed of O-ray and E-ray respectively, and μ_0 and υ_e represent the corresponding refractive indices, then

along the optic axis of the crystal

$$\upsilon_e = \upsilon_0 \text{ and } \mu_e = \mu_0$$

f) Crystal having only one optic axis is called uniaxial. Calcite, quartz, ice, tourmaline sodium nitrate are the examples of uniaxial crystals.

g) Crystal having two optic axes are called biaxial. Mica, topaz, borax etc. are the examples of biaxial crystals.

h) If a double refracting crystal is placed on a dot and rotated in its own plane, then E-ray image rotates about the O-ray image.

i) For calcite crystal,

$$\upsilon_e \geq \upsilon_0 \text{ and } \mu_e \leq \mu_0$$

Such crystals are called positive.

j) For quartz crystal,

$\upsilon_e \le \upsilon_0$

and $\mu_e \ge \mu_0$

Such crystals are called negative.

k) Polaroids also exhibit double refraction but they absorb one of the two rays. This phenomenon of absorbing either O-ray or E-ray is called **dichorism**.

l) Nicol prism is a device for producing or analysing the polarised light. It is made from calcite crystal. It is a doubly refracting crystal.

m) In the Nicol prism the E-ray has oscillations in the principal section of the crystal and the O-ray has oscillation perpendicular to the principal section.

n) By suitable cutting, the transmission of one of the rays is stopped in the nicol prism. Therefore, the light transmitted through it is plane polarised.

80. Polarisation confirms the transverse nature of the light waves.

81. Light can be polarised by the following methods.

i) Reflection

ii) Refraction

iii) Double refraction

iv) Dichorism

v) Scattering

82. Polarisation by reflection

a) If the light is incident on a surface at a certain angle known at Brewster's angle (θ_b), then the reflected light is completely polarised having oscillations perpendicular to the plane of incidence. The Brewster's angle is also called polarising angle.

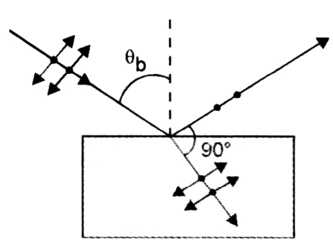


Fig. 82.1

b) The refracted ray is partially polarised.

c) When the reflected ray is completely polarised, the angle between the reflected ray and refracted ray is 90^0. Also, the refractive index of the material on which the light is incident is given by $\mu = \tan\theta_b$. Because,

$$\mu = \frac{\sin i}{\sin r} = \frac{\sin\theta_b}{\sin(90-\theta_b)} = \tan\theta_b$$

83. Polarisation by refraction

By using a pile of plates a large amount of polarised light can be obtained. Because the refracted light is only partially polarised. So, when it is incident on the next plate, we obtain more polarised light. Every subsequent plate contributes polarised light giving a strong beam of polarised light. Also, larger the number of plates greater will be the polarisation of the refracted beam. This is called polarisation by refraction.

Note. The Malus law is not applicable to the pile of plates.

84. Polarisation by scattering

Suppose, a ray of unpolarised light is incident on a microscopic particle from which it is scattered. Then the scattered light is plane polarised as shown below.

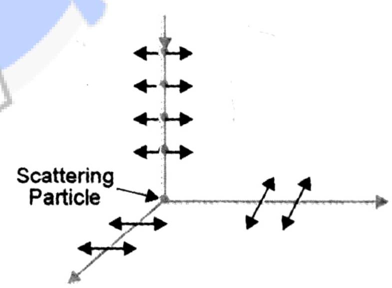


Fig. 84.1

85. Optical Activity

a) When the polarised light is passed through certain substances, its plane of polarisation is rotated about the direction of propagation. The angle of rotation is given by :

$$\theta = S\ell C$$

where, ℓ = length of the substance through which the light passes, C = concentration of the substance for solutions and vapours and S = a constant called specific rotation.

The phenomenon is called **optical activity**. It is also called **rotatory polarisation**. Substances which do so are said to be **optically active**.

b) There are two types of optically active substances.

c) **Dextro rotatory.** If we look against the direction of propagation then the dextro-rotatory substances rotate the plane of polarisation clockwise (to the right).

d) **Laevo rotatory.** These substances rotate the plane of polarisation anticlockwise (to the left) as seen against the direction of propagation of light.

e) The rotation produced by a number of optically active substances is equal to the algebraic sum of the individual rotations.

f) The rotation produced depends on wave-length light as follows :

$$\theta = a + \frac{b}{\lambda^2}$$

That is, θ is larger for shorter wavelengths. Here a and b are constants. Due to this reason, if polarised white light is passed through optically active substance, then the transmitted light is found to be coloured. It is called **rotatory dispersion**.

g) Quartz, sugar solution etc. are the examples of optically active substances.

h) One millirnetre thick quartz plates rotates the plane of polarised sodium light by 21.7^0.

i) Optical activity was thoroughly studied by Biot in 1815.

86. Elliptical and Circular polarisation of light

a) If two plane polarised beams of amplitudes *a* and *b* and phase difference ϕ are superimposed, the resultant beam of light is elliptically polarised with the plane of polarisation rotating periodically.

The amplitude also varies periodically from half of minor axis to half of the major axis of the ellipse.

b) If $a = b$ and $\phi = 90^0$, then the resultant light is circularly polarised. In such case also the plane of polarisation rotates periodically but the amplitude of the light remains constant.

87. Quarter wave and half wave plates

a) Since O-ray and E-ray travel with different speeds, therefore when they come out of the crystal, a path difference is introduced between them, which is equal to the difference of their optical paths. That is :

$$\Delta = \mu_e t - \mu_0 t$$

$$= (\mu_e - \mu_0)t \text{ for –VE crystals}$$

And $\Delta = (\mu_0 - \mu_e)t$, for +VE crystals. Here t is the thickness of the crystal.

b) For quarter wave plate,

$$\Delta = \frac{\lambda}{4}, \text{ hence } t = \frac{\lambda}{4(\mu_0 - \mu_e)}$$

c) For half wave plate,

$$\Delta = \frac{\lambda}{2}, \text{ hence } t = \frac{\lambda}{2(\mu_0 - \mu_e)}$$

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MULTIPLE CHOICE QUESTIONS

Basic Concepts :

1. That the photons possess momentum was proved by :
   a) Compton b) Bohr
   c) Planck d) Einstein
2. When a photon collides with an electron which of the following characteristics of the photon increases ?
   a) Energy b) Frequency
   c) Wavelength d) None of the above
3. In vacuum, speed of light depends upon :
   a) wavelength
   b) frequency
   c) colour
   d) none of the above
4. Out of the following of which colour the sensitivity of the human eye is the highest ?
   a) Red b) Green
   c) Blue d) Violet
5. The eye is most sensitive to the light of wavelength :
   a) 555 m b) 555 Å
   c) 555×10^{-9} m d) 555×10^{-10} m
6. The time taken by the light to travel a distance of 3 cm is :
   a) 10^{-8} s b) 10^{8} s
   c) 10^{-10} s d) 10^{10} s
7. The visibility is more with which one of the following wavelength ?
   a) 60×10^{-8} m b) 55×10^{-8} m
   c) 50×10^{-8} m d) 45×10^{-8} m
8. The distance travelled by the ray of light during the time octagonal mirror rotates through $\frac{\pi}{2}$ is ℓ. If the mirror rotates at N revolutions per second, the speed of light is :
   a) $2\,N\ell$ b) $4\,N\ell$
   c) $8\,N\ell$ d) $16\,N\ell$
9. In principle, how many faces can the rotating mirror in Michelson's method for deterrmnmg the speed of light have ?
   a) 8 or less b) only eight
   c) 16 d) any finite number
10. The wavelength of the light of a laser beam can be used as a standard of :
    a) time b) temperature
    c) length d) none of the above
11. The laser beam can be used to measure large distances because it is :
    a) coherent b) monochromatic
    c) not absorbed d) unidirectional
12. A star appears yellow. If it starts accelerating towards the earth, how will its colour appear to change ?
    a) It will turn gradually red
    b) It will turn gradually blue
    c) It will turn suddenly red
    d) It will turn suddenly blue
13. What is the order of the energy of the X-ray photon ?
    a) 1 keV b) 10 keV
    c) 100 keV d) 1 MeV
14. What is the order of the energy of the visible photon ?
    a) 1 keV b) 10 keV
    c) 100 keV d) 1 MeV
15. Out of the following of which colour a mono-chromatic beam cannot be obtained ?
    a) Red b) Green
    c) Blue d) White
16. Which of the following is **NOT** a property of light ?
    a) It can travel through vacuum
    b) It requires material medium for propagation
    c) It involves transportation of energy
    d) It has finite speed
17. Which of the following is **NOT** the property of light according to the corpuscular theory ?
    a) Light travels in straight lines.
    b) The velocity of light is more in air than in water
    c) The velocity of light changes on refraction
    d) The velocity of light does not change on reflection
18. The branch of optics dealing with the formation of images using the concept of straight line propagation of light is called :

a) corpuscular optics b) physical optics
c) geometrical optics d) quantum optics

19. Who was the first to predict the deflection of light rays by the gravitational field ?
a) Einstein b) Newton
c) Maxwell d) Galileo

20. The dynamic mass of the photon is given by :
a) $\frac{h\nu}{c}$ b) $\frac{h\lambda}{c}$
c) $\frac{h}{c\lambda}$ d) $\frac{h}{c\nu}$

21. Momentum of a photon of frequency ν is :
a) $\frac{h}{\nu}$ b) $\frac{h}{c\nu}$
c) $\frac{h\nu}{c}$ d) hcν

22. The momentum of the photon is given by :
a) $\frac{h}{\lambda}$ b) $\frac{h}{c\lambda}$
c) $\frac{hc}{\lambda}$ d) $\frac{h\lambda}{c}$

23. The energy of a photon of wavelength λ is :
a) hcλ b) $\frac{hc}{\lambda}$
c) $\frac{\lambda}{hc}$ d) $\frac{h\lambda}{c}$

24. What is momentum of photon of frequency 10^{19} c.p.s ?
a) 2.21 kg m/s
b) 2.21×10^{-23} kg m/s
c) 19.86×10^{-33} kg m/s
d) 6.62×10^{-15} kg m/s

25. What is momentum of a photon of wavelength 1 nm in SI units ?
a) h b) 10^3 h
c) 10^6 h d) 10^9 h

26. What is the dynamic mass of a photon of wave-length 1 Å ?
a) 2.21×10^{-32} kg b) 6.62×10^{-20} kg
c) 2.21×10^{-32} g d) 19.86×10^{-32} kg

27. If h is Planck's constant, the momentum of a photon of wavelength 0.01 Å is :
a) 10^{-2} h b) h
c) 10^2 h d) 10^{12} h

28. The energy of a photon corresponding the visible light of maximum wavelength is nearly :
a) 1.0 eV b) 1.6 eV
c) 3.2 eV d) 7.0 eV

29. Given Planck's constant h = 6.6×10^{-34} Js. The momentum of each photon in a given radiation is 3.3×10^{-29} kgm/s. The frequency of radiation is :
a) 3×10^3 Hz
b) 6×10^{10} Hz
c) 7.5×10^{12} Hz
d) 1.5×10^{13} Hz

30. Photons of wavelength 600 nm are emitted from a 60 watt lamp. What is the number of photons emitted per second ? Take, h = 6.6×10^{-34} Js :
a) 2×10^{16} b) 2×10^{18}
c) 2×10^{20} d) 2×10^{22}

31. Which of the following cannot be found at rest ?
a) photon b) electron
c) proton d) neutron

32. The mass of photon at rest is :
a) zero b) hυ
c) $\frac{hc}{\lambda}$ d) $\frac{h\upsilon}{c}$

33. If the speed of a proton is $\frac{c}{10}$, then wavelength associated within will be :
a) 1.32×10^{-14} m b) 52.8×10^{-10} m
c) 6.62×10^{-14} m d) 528×10^{-20} m

34. Which one of the following is incorrect statement about a photon ?
a) Photon's rest mass is zero
b) Photon's momentum is $\frac{h\nu}{c}$
c) Photons energy is hν
d) Photons exert no pressure.

35. Which of the following is not property of the photons ?
a) Momentum b) Energy
c) Frequency d) Rest mass

Wave Theory of Light :

36. What is the nature of the wave front associated with a parallel beam of light ?
 a) Plane b) Spherical
 c) Elliptical d) None of the above

37. Huygen's principle of secondary waves is used to :
 a) obtain the wave front geometrically
 b) explain polarisation
 c) obtain focal length of thick lenses
 d) explain dispersion of light

38. Huygen's concept of secondary waves is useful in :
 a) explaining polarisation
 b) determining focal length of the lens
 c) geometrical reconstruction of a wave front
 d) none of the above

39. The nature has selected electromagnetic waves of wavelength between 400 nm to 800 nm for human vision. Which of the following could be the most suitable reason for this selection ?
 a) They are of different colours
 b) They are emitted in abundance by the sun
 c) They are emitted from all bodies
 d) They can be reflected & scattered by material bodies

40. Which of the following is correct relation between the wave front and the ray of light ? The ray of light :
 a) is normal to wave front
 b) is tangential to the wave front
 c) can be inclined at any angle with the wave front
 d) does not exist according to the Huygen's principle

41. Which of the following does not support the wave nature of light ?
 a) Interference b) Diffraction
 c) Dispersion d) Photoelectric effect

42. Two points A and B are situated at the same distance from a source of light, but in opposite direction from it. The phase difference between the light waves passing through A and B will be :
 a) zero b) $\pi / 2$
 c) π d) none of the above

43. Which of the following forms a part of electro-magnetic spectrum ?
 a) α-rays b) β-rays
 c) γ-rays d) none of the above

44. Which of the following generates a plane wave front ?
 a) Point source
 b) Extended source
 c) Monochromatic source
 d) None of the above

45. We may state that the energy (E) of a proton of frequency ν is $E = h\nu$, where h is Planck's constant. The momentum p of a photon is $p = \frac{h}{\lambda}$, where λ is the wavelength of the photon. From the above statement one may conclude that the wave velocity of light is equal to :
 a) 3×10^8 ms^{-1} b) the ratio $\frac{E}{p}$
 c) the product : Ep d) the ratio $\left(\frac{E}{p}\right)^2$

Polarisation and Polaroids :

46. What is the angle between the plane of oscillation and plane of polarisation of the polarised light ?
 a) 0 b) $\frac{\pi}{4}$
 c) $\frac{\pi}{2}$ d) π

47. When the light is polarised by reflection, what is the angle between the reflected and the refracted rays ?
 a) 0 b) $\frac{\pi}{4}$
 c) $\frac{\pi}{2}$ d) π

48. Optically active substances are those which :
 a) rotate the plane of polarisation
 b) cause double refraction
 c) polarise light
 d) none of the above

49. When the light is incident at the pol arising angle, which of the following is completely polarised ?
a) Reflected light
b) Refracted light
c) Both reflected as well as refracted light
d) Neither reflected nor refracted light

50. Which of the following phenomenon confirms the transverse nature of the light waves ?
a) Interference b) Diffraction
c) Polarisation d) None of the above

51. The refractive index is equal to the tangent of the angle of polarisation. It is called :
a) Brewster's law b) Malu's law
c) Bragg's law d) Grimaldi's law

52. Which of the following material may be used for manufacturing polaroids ?
a) Calcite b) Quartz
c) Tourmaline d) Quinine iodosulphate

53. What is the angle between the direction of oscillation of the light waves and the direction of propagation ?
a) 0^0 b) $\frac{\pi}{4}$
c) $\frac{\pi}{2}$ d) π

54. What is the angle between the plane of polarisation and the direction of propagation of the polarised light ?
a) 0 b) $\frac{\pi}{4}$
c) $\frac{\pi}{2}$ d) π

55. From the Brewster's law it follows that the angle of polarisation depends on :
a) wavelength b) frequency
c) plane of polarisation
d) plane of vibration

56. A beam of light of intensity I_1 is incident on a tourmaline crystal and then on another tourmaline crystal. The transmission axes of both crystals are parallel to each other. If the intensity of light transmitted through the second crystal be I_2, then :
a) $I_1 = I_2$ b) $I_1 = 2\ I_2$
c) $I_1 = 4\ I_2$ d) $2\ I_1 = I_2$

57. For a double refracting crystal, the refractive indices for the ordinary and extraordinary rays are denoted by μ_0 and μ_e. Which of the following relations is valid along the optical axis of the crystal ?
a) $\mu_0 = \mu_e$ b) $\mu_0 < \mu_e$
c) $\mu_0 > \mu_e$ d) $\mu_0 \gtrless \mu_e$

58. The line along which the light travels and the plane of polarisation are inclined to each other at :
a) $\frac{\pi}{4}$ b) $\frac{\pi}{2}$
c) $\frac{3\pi}{4}$ d) none of the above

59. A ray of light is incident on the surface of glass plate at an angle of incidence equal to Brewster's angle ϕ. If μ represents the refractive index of glass with respect to air, then the angle between the reflected and the refracted rays is :
a) $90 + \phi$ b) $\sin^{-1}(\mu \cos\phi)$
c) 90^0 d) $90^0 - \sin^{-1}\frac{(\sin\phi)}{\mu}$

60. The polariser and analyser are inclined to each other at 60^0. The intensity of the polarised light emerging from the polariser is I. What is the intensity of the unpolarised light incident on the polariser ?
a) 8 I b) 4 I
c) 2 I d) I

61. We prefer polaroid sunglasses because they :
a) reduce the intensity of light
b) have soothing colours
c) are cheaper
d) can change colours

62. A ray of light is incident on the glass plate at an angle of incidence equal to the Brewster's angle (θ_b). Let μ be the refractive index of the glass slab. If the grazing angle for the incident ray be 30^0, then the angle of refraction will be :
a) 30^0 b) 60^0
c) $\tan^{-1}\mu$ d) $\frac{\theta_b}{2}$

63. An unpolarised beam of intensity 2 I^2 passes through a thin polaroid. Assuming that no light is absorbed by the polaroid, the amplitude of the emergent beam will be :

a) 2 I^2 b) I^2

c) 2 I d) I

64. An unpolarised beam of intensity I_0 is incident on a polariser and analyser placed in contact. The angle betwen the transmission axes of the polariser and analyser is θ. What is the intensity of the light emerging out of the analyser ?

a) I_0 b) $I_0 \cos\theta$

c) $I_0 \cos^2\theta$ d) $\frac{(I_0 \cos^2\theta)}{2}$

65. When the analyser is rotated, one observes :

a) One extinction and two brightnesses

b) One brightness and two extinctions

c) Two extinctions and two brightnesses

d) None of the above

66. Which of the following cannot be polarised ?

a) Radio waves b) Sound waves

c) Transverse waves d) X-rays

67. In the light polarised by reflection, the angle between reflected and refracted ray is :

a) 0 b) $\frac{\pi}{6}$

c) $\frac{\pi}{3}$ d) $\frac{\pi}{2}$

68. When a polaroid is rotated, the intensity of light varies and ultimately reduces for a particular orientation to zero. It shows that the incident light is :

a) completely plane polarised

b) partially plane polarised

c) unpolarised

d) none of the above

69. A rotating calcite crystal is placed over an ink dot. On seeing through the crystal one finds :

a) Two stationary dots

b) Two dots moving along straight lines

c) One dot rotating about the other

d) Both dots rotating about a common axis

Numerical Bank

70. A ray of light strikes a glass plate at an angle of 60^0. If the reflected and refracted rays are perpendicular to each other, the index of refraction of glass is :

a) $\frac{\sqrt{3}}{2}$ b) $\frac{3}{2}$

c) $\frac{1}{2}$ d) $\sqrt{3}$

71. Two nicol prisms are inclined to each other at 30^0. If I be the intensity of the light incident on the first prism, then what will be the intensity of the light emerging from the second prism ?

a) $\frac{3}{4}I$ b) $\frac{1}{2}I$

c) $\frac{1}{4}I$ d) $\frac{3}{8}I$

72. The amplitude of the unpolarised light incident on the polariser is a. What will be the amplitude of the polarised light transmitted through it ?

a) $\frac{a}{2}$ b) $\frac{a}{\sqrt{2}}$

c) $\frac{\sqrt{3}}{2}a$ d) $\frac{3}{4}a$

73. The axes of the polariser and analyser are inclined to each other at 45^0. If the amplitude of the unpolarised light incident on the polariser is a, then what is the amplitude of the light transmitted through the analyser ?

a) $\frac{a}{2}$ b) $\frac{a}{\sqrt{2}}$

c) $\frac{\sqrt{3}}{2}a$ d) $\frac{3}{4}a$

74. A beam of unpolarised light is incident on a tourmaline crystal. The intensity of the emergent light is I_0, The emergent light is incident on another tourmaline crystal. It is found that no light emerges out of the second crystal. If now, the fIrst crystal is rotated through 45^0, the intensity of the light emerging through the second crystal will be :

a) zero b) 0.25 I_0

c) 0.50 I_0 d) 0.75 I_0

75. Two polaroid sheets are placed one over the other with their axes inclined to each other at 30^0. The ratio of the intensity of the unpolarised incident light and the polarised emergent light is :

a) $\frac{1}{2}$ b) $\frac{3}{4}$

c) $\frac{8}{3}$ d) $\frac{3}{1}$

76. Unpolarized light of intensity 32 W/m^2 is incident on the combination of three polaroids. The first and last polaroids are crossed. If the intensity of the light transmitted through the combination be 3 W/m^2, then what is the angle between the transmission axes of firsr two polaroids ?

a) 0° b) 30°

c) 45° d) 60°

77. Three polaroids are placed one above the other, such that the first and the last polaroids are crossed with each other. If the angle between the transmission axis of the fust two polaroids is 45^0, then what is the percentage of incident light transmitted through the combination of three polaroids ?

a) 0 % b) 12.5 %

c) 50 % d) 100 %

78. Two nicol prisms are placed with their principal planes at 60^0. What percentage of light incident on the combination is transmitted ?

a) 75 % b) 60 %

c) 25 % d) 12.5 %

79. Three similar polaroids are placed one above the other. The angle between the transmission axes of first and second is θ_1 and that between the transmission axes of second and third is θ_2. If $\theta_1 + \theta_2 = 90^0$, then what should be the values of θ_1 and θ_2 for the intensity of transmitted light to be maximum ?

a) $\theta_1 = 30^0, \theta_2 = 60^0$ b) $\theta_1 = \theta_2 = 45^0$

c) $\theta_1 = 60^0, \theta_2 = 30^0$ d) $\theta_1 = 90^0$ and $\theta_2 = 0^0$

Recent Questions from MH -CET Exams :

80. The wavelength of green light in air is 5400 AU. Its wavelength in the glass of refractive index 3/2 is :

a) 2700 A.U. b) 8100 A.U.

c) 5400 A.U. d) 3600 A.U.

81. Light is incident from air on a flat face of a flint glass block (μ = 1.60). The reflected and the refracted beams are at right angles to each other. The ratio of the wavelengths of the reflected and refracted light is :

a) 0.599 b) 0.625

c) 1.60 d) 1.67

82. Light of wavelength 6000 Å is reflected at nearly normal incidence from a soap film of refractive index 1.4. The least thickness of the film that will be black is :

a) infinity b) 200 Å

c) 1000 Å d) 2000 Å

83. If wavelength of a wave is λ = 6000 Å. Then wave number will be :

a) 166×10^3 per m b) 16.6×10^{-1} per m

c) 1.66×10^6 per m d) 1.66×10^7 per m

84. Time taken by sunlight to penetrate 2 mm glass slab is of order (μ = 1.5) :

a) 10^{-7} sec b) 10^{-16} sec

c) 10^{-19} sec d) 10^{-11} sec

85. Refractive index of water is 1.5 and velocity of light in air is 3×10^8 m/s. Then time taken to travel a distance of 4×10^8 m is :

a) 2 s b) 4 s

c) 6 s d) none of these

86. According to corpuscular theory of light velocity of light :

a) In rarer medium > denser medium

b) In rarer medium < denser medium

c) Same in both media

d) None of these

87. When light enters water from the vaccum, then the wavelength of light :

a) decreases b) increases

c) remains constant d) becomes zero

88. The frequency of light in air is 5×10^{14} Hz. What will be the frequency of light when it enters in the water ?

a) 2.5×10^{14} Hz b) 5×10^{14} Hz

c) 10^{15} Hz d) 2.5×10^{12} Hz

89. What is the time taken by light to cross a glass 2 mm thick ? [Refractive index of glass = 1.5]

a) 10^{-10} second b) 10^{-12} second

c) 10^{-11} second d) 10^{-9} second

90. The refractive index of water is $\frac{4}{3}$ and that of glass slab is $\frac{5}{3}$. The critical angle for the ray of light tending to go from water to glass is :

a) $\sin^{-1}\left(\frac{4}{5}\right)$ b) $\sin^{-1}\left(\frac{5}{4}\right)$

c) $\sin^{-1}\left(\frac{1}{2}\right)$ d) $\sin^{-1}\left(\frac{2}{1}\right)$

91. Light appears to travel in a straight line, since it :

a) is reflected by atmosphere
b) has very small wavelength
c) has high velocity
d) all of the above

92. Wave theory of light does not explain :

a) refraction of light
b) reflection of light
c) photoelectric effect
d) interference of light

93. The refractive index of glass w.r.t. water is $\frac{9}{8}$, velocity of light in glass is 2×10^8 m/s, then velocity of light in water should be :

a) 2.25×10^8 m/s
b) 0.42×10^8 m/s
c) 4.2×10^8 m/s d) 9×10^8 m/s

94. Frequency of light in air is 4×10^{14} Hz. When it passes through a medium of refractive index 1.5. The percentage change in wavelength of light is :

a) 11.11 % b) 22.22 %
b) 33.33 % b) 44.44 %

95. A ray of light takes same time of travel through air and glass. If thickness of glass is 5 cm and $\mu = 1.5$, then distance travelled through air is :

a) 5 cm b) 7.5 cm
c) 6 cm d) 8 cm

96. Light enters glass from water, then :

a) wavelength remains same
b) wavelength decreases
c) frequency increases
d) wavelength increases

97. Light is incident on a substance of refractive index $\sqrt{2}$ at an angle to 45^0. What is the ratio of width of beam in air to the medium ?

a) $\sqrt{3}:\sqrt{2}$ b) $1:\sqrt{1.5}$
c) $1:2\sqrt{2}$ d) $\sqrt{2}:\sqrt{3}$

98. Huygen's Wave Theory of Light could not explain :

a) reflection b) refraction
c) interference
d) photoelectric effect

99. If the polarising angle for a given medium is 60^0, then the refractive index of the medium is :

a) $\frac{1}{\sqrt{3}}$ b) 1

c) $\frac{\sqrt{3}}{3}$ d) $\sqrt{3}$

100. The refractive indices of glass and diamond with respect to air are 1.5 and 2.4 respectively. The refractive index of diamond with respect to glass is :

a) 0.62 b) 0.9
c) 1.95 d) 1.6

101. A glass slab of thickness t and refractive index μ. Calculate the time taken by light to travel this thickness :

a) $t \mu c$ b) $\frac{tc}{\mu}$

c) $\frac{t}{\mu c}$ d) $\frac{\mu t}{c}$

102. Light is incident at an angle i on a glass slab. The reflected ray is completely polarised. The angle of refraction is :

a) $90^0 - i$ b) $180^0 - i$
c) $90^0 + i$ d) i

103. The tourmaline crystal :

a) absorbs ordinary light and transmits extra ordinary
b) absorbs extra ordinary light and transmits ordinary
c) both absorb ordinary light and extra ordinary
d) both transmit ordinary light and extra ordinary

104. The angle of refraction is found to be half the angle of refraction. Then refractive index of medium is :

a) $2\cos^{-1}\left(\frac{\mu}{2}\right)$ b) $\cos^{-1}(\mu)$

c) $2\sin^{-1}(\mu)$ d) $2\cos^{-1}$

105. In Nicol prism Canada balsam acts as an ...... medium for the extra ordinary ray :

a) optically rarer b) optically denser

c) opaque d) none of these

106. A light ray is travelling from air to medium, c is velocity of light in air and v is velocity of light in medium. The reflected and refracted rays are perpendicular to each other. The angle of polarisation is :

a) $\theta = \tan^{-1}\left(\frac{\nu}{c}\right)$ b) $\theta = \cos^{-1}\left(\frac{\nu}{c}\right)$

c) $\theta = \cot^{-1}\left(\frac{\nu}{c}\right)$ d) $\theta = \sin^{-1}\left(\frac{\nu}{c}\right)$

107. The equiconvex lens has focal length 'f'. If it is cut perpendicular to the principal axis passing through optical centre, then focal length of each half is :

a) $\frac{f}{2}$ b) f

c) $\frac{3f}{2}$ d) 2 f

108. In vacuum, to travel distance 'd', light takes time 't' and in medium to travel distance '5d' , it takes time 'T'. The critical angle of the medium is :

a) $\sin^{-1}\left(\frac{5T}{t}\right)$ b) $\sin^{-1}\left(\frac{5t}{3T}\right)$

c) $\sin^{-1}\left(\frac{5t}{T}\right)$ d) $\sin^{-1}\left(\frac{3t}{5T}\right)$

109. The distance of a point on the screen from two slits in biprism experiment is 1.8×10^{-5} m and 1.23×10^{-5} m. If wavelength of light used is 6000 Å, the fringe formed at that point is :

a) 10^{th} bright b) 10^{th} dark

c) 9^{th} bright d) 9^{th} dark

110. In Young's double slit experiment, the ratio of intensities of bright and dark bands is 16 which means :

a) the ratio of their amplitudes is 5

b) intensities of individual sources are 25 and 9 units respectively

c) the ratio of their amplitudes is 4

d) intensities of individual sources are 4 and 3 units respectively

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REVISION OUESTIONS

from Competitive Exams

1. Which of the following does not change, when a photon enters glass from air ?
   a) Momentum b) Velocity
   c) Wavelength d) Energy
2. One cannot see through fog because :
   a) fog absorbs light
   b) the refractive index of fog is infinity
   c) light suffers total reflection at the droplet in a fog
   d) light is scattered by the droplets in fog
3. The twinkling of stars is due to :
   a) The fact that stars do not emit light continuously
   b) The refractive index of the earth's atmosphere fluctuates
   c) Intermittent absorption of star light by its own atmosphere
   d) None of these
4. A fly is sitting on the objective of a telescope pointed towards the moon. What effect is expected on the photograph of the moon taken through the telescope ?
   a) The entire field of view is blocked
   b) There is an image of the fly on the photograph
   c) There is no effect at all
   d) There is a reduction in the intensity of the image
5. Light appears to travel in straight lines since :
   a) it is not absorbed by the atmosphere
   b) it is reflected by the atmosphere
   c) its wavelength is very small
   d) its velocity is very large
6. Which one of the following phenomena is not explained by Huygen's construction of wavefront ?
   a) Refraction b) Reflection
   c) Diffraction d) Origin of spectra
7. Huygen's wave theory of light cannot explain :
   a) Diffraction b) Interference
   c) Polarization d) Photoelectric effect
8. The sky appears blue because :
   a) red light is absorbed
   b) blue light is scattered the most
   c) blue light is absorbed
   d) it is its natural colour
9. Ratio of intensities of two waves are given by 4 : 1. Then ratio of the amplitudes of the two waves is :
   a) 2 : 1 b) 1 : 2
   c) 4 : 1 d) 1 : 4
10. The frequency of e.m. wave which best suited to observe a particle of radii 3×10^{-4} cm is of the order of :
    a) 10^{15} b) 10^{13}
    c) 10^{14} d) 10^{12}
11. When light travels from one medium to another, which are separated by a sharp boundary, the characteristic which does not change is :
    a) velocity b) wavelength
    c) frequency d) amplitude
12. Ray optics is valid, when characteristic dimensions are :
    a) of the same order as the wavelength of light
    b) much smaller than the wavelength of light
    c) of the order of one millimetre
    d) much larger than the wavelength of light
13. The refractive index of water is 1.33. What will be the speed of light in water ?
    a) 3×10^8 m/s b) 2.25×10^8 m/s
    c) 4×10^8 m/s d) 1.33×10^8 m/s
14. Electromagnetic radiation of frequency n, wave-length λ, travelling with velocity υ in air, enters a glass slab of refractive index μ. The frequency, wavelength and velocity of light in the glass slab will be respectively :
    a) $\frac{n}{\mu}, \frac{\lambda}{\mu}, \frac{\upsilon}{\mu}$ b) $n, \frac{\lambda}{\mu}, \frac{\upsilon}{\mu}$
    c) $n, \lambda, \frac{\upsilon}{\mu}$ d) $\frac{n}{\mu}, \frac{\lambda}{\mu}, \upsilon$
15. If ϵ_0 & μ_0 are respectively the electric permittivity and magnetic permeability of free space, ϵ and μ are the corresponding quantities in a medium, the index of refraction of the medium is :
    a) $\sqrt{\frac{\epsilon}{\epsilon_0}}$ b) $\sqrt{\frac{\epsilon_0 \mu}{\epsilon \mu_0}}$

c) $\sqrt{\frac{\in\mu}{\in_0\mu_0}}$ d) $\sqrt{\frac{\in_0\mu_0}{\in\mu}}$

16. Soap bubble looks coloured due to :
a) dispersion b) reflection
c) interference d) anyone of these

17. According to the modem theory for nature of light, the light has :
a) Wave nature only
b) Particle nature only
c) Both wave and particle (dual) nature.
d) Neither particle nature nor wave nature

18. Wavelength of light of frequency 100 Hz is :
a) 2×10^6 m b) 3×10^6 m
c) 4×10^6 m d) 5×10^6 m

19. Frequency of radio waves corresponding to 10 m wavelength :
a) 3.4×10^{-8} Hz b) 3.4×10^{-7} Hz
c) 3×10^7 Hz d) 3×10^9 Hz

20. The velocity of light in vacuum can be changed by changing :
a) frequency b) amplitude
c) wavelength d) none of these

21. Rainbow is formed due to :
a) reflection b) refraction
c) scattering d) dispersion

22. Rainbow is formed due to a combination of :
a) Refraction and absorption
b) Dispersion and total internal reflection
c) Dispersion and focussing
d) Refraction and scattering

23. Which of the following cannot be polarized ?
a) Radiowaves b) Ultra-violet rays
c) Infra-red rays d) X-rays
e) Ultrasonic waves

24. When an unpolarised light passes through a prism, then which of the following will not occur ?
a) Polarisation b) Double Refraction
c) Reflection d) Refraction

25. When a plane polarised light is passed through an analyser and analyser is rotated through 90^0, the intensity of the emerging light :
a) varies between a maximum and minimum
b) becomes zero
c) does not vary
d) varies between a maximum and zero

26. υ_0 and υ_E represent the velocities, μ_0 and μ_E the reflactive indices of ordinary and extraordinary rays for a doubly refracting crystals. Then :
a) $\upsilon_0 \le \upsilon_E$, $\mu_0 \le \mu_E$ if the crystal is quartz
b) $\upsilon_0 \ge \upsilon_E$, $\mu_0 \le \mu_E$ if the crystal is calcite
c) $\upsilon_0 \ge \upsilon_E$, $\mu_0 \ge \mu_E$ if the crystal is quartz
d) $\upsilon_0 \le \upsilon_E$, $\mu_0 \ge \mu_E$ if the crystal is calcite

27. The phenomenon of rotation of plane of plane palarised light is called :
a) optical activity b) dichroism
c) Kerr effect d) double refraction

28. Two polaroids are kept crossed to each other. Now one of them is rotated through an angle of 45^0. The percentage of incident light now transmitted through the system is :
a) 15 % b) 25 %
c) 50 % d) 60 %
e) 75 %

29. Polarization of light takes place due to many processes. Which of the following will not cause polarization ?
a) Reflection b) Double refraction
c) Scattering d) Diffraction
e) Absorption

30. A nicol prism is based on the action of :
a) double refraction b) refraction
c) dichroism d) both (a) and (c)

31. The angle of incidence at which reflected light in totally polarised for reflection from air to glass (refractive index n) is :
a) $\sin^{-1}(n)$ b) $\sin^{-1}\left(\frac{1}{n}\right)$
c) $\tan^{-1}\left(\frac{1}{n}\right)$ d) $\tan^{-1}(n)$

32. H-polarized is prepared by :
a) orienting herapathite crystal in the same direction in nitrocellulose
b) using thin tourmaline crystals

c) stretching polyvinyl alcohol and then heated with dehydrating agent

d) stretching polyvinyl alcohol & then impregnating with iodine

33. Specific rotation of sugar solution is 0.01 SI units. 200 kgm^{-3} of impure sugar solution is taken in a polarimeter tube of length 0.25 m and an optical rotation of 0.4 rad is observed. The percentage of purity of sugar in the sample is :

a) 11 % b) 20 %
c) 80 % d) 89 %

34. The speed of light in media M_1 and M_2 are 1.5×10^8 m/s and 2.0×10^8 m/s respectively. A ray of light enters from medium M_1 and M_2 at an incidence angle i. If the ray suffers total internal reflection, the value of i is :

a) Equal to $\sin^{-1}\left(\frac{2}{3}\right)$

b) Equal to or less than $\sin^{-1}\left(\frac{3}{5}\right)$

c) Equal to or greater than $\sin^{-1}\left(\frac{3}{4}\right)$

d) Less than $\sin^{-1}\left(\frac{2}{3}\right)$

35. A ray of light is incident on a 60^0 prism at the minimum deviation position. The angle of refraction at the first face (i.e. incident face) of the prism is :

a) zero b) 30°
b) 45° d) 60°

36. Which of the following is not due to total internal reflection ?

a) Working of optical fibre

b) Difference between apparent and real depth of a pond

c) Mirage on hot summer days

d) Brilliance of diamond

37. A biconvex lens has a radius of curvature of magnitude 20 cm. Which one of the following options describe best the image formed of an object of height 2 cm placed 30 cm from the lens ?

a) Virtual, upright, height = 1 cm

b) Virtual, upright, height = 0.5 cm

c) Real, inverted, height = 4 cm

d) Real, inverted, height = 1 cm

38. A car is fitted with a convex side-view mirror of focal length 20 cm. A second car 2.8 m behind the first car is overtaking the first car at a relative speed of 15 m/s. The speed of the image of the second car as seen in the mirror of the first one is :

a) 15 m/s b) $\frac{1}{10}$ m/s

c) $\frac{1}{15}$ m/s d) 10 m/s

39. **Direction :**

The question has a paragraph followed by two statements, Statement-1 and Statement-2. Of the given four alternatives after the statements, choose the one that describes the statements

A thin air film is formed by putting the convex surface of a plane convex lens over a plane glass plate. With monochromatic light, this film gives an interference pattern due to light reflected from the top (convex) surface and the bottom (glass plate) surface of the film.

Statement-1 :

When light reflects from the air-glass plate interface, the reflected wave suffers a phase change of π.

Statement-2 :

The centre of the interference pattern is dark.

a) Statement-1 is false, Statement-2 is true

b) Statement-1 is true, Statement-2 is false

c) Statement-1 is true, Statement-2 is true and Statement-2 is the correct explanation of Statement-1

d) Statement-1 is true, Statement-2 is true and Statement-2 is the not correct explanation of Statement-1

40. A 200 W sodium street lamp emits yellow light of wavelength 0.6 µm. Assuming it to be 25% efficient in converting electrical energy to light, the number of photons of yellow light it emits per second is :

a) 6×10^{18} b) 62×10^{20}
c) 3×10^{19} d) 1.5×10^{20}

41. The magnifying power of a telescope is 9. When it is adjusted for parallel rays the distance between the objective and eyepiece is 20 cm. The focal length of lenses are :

a) 15 cm, 5 cm

b) 18 cm, 2 cm

c) 11 cm, 9 cm d) 10 cm, 10 cm

42. A ray of light is incident at an angle of incidence, i on one face of a angle A (assumed to be small) and emerges normally from the opposite face. If the refractive index of the prism is μ, the angle of incidence i, is nearly equal to :

a) $\frac{\mu A}{2}$ b) $\frac{A}{\mu}$

c) $\frac{A}{2\mu}$ d) μA

43. A concave mirror of focal length 'f_1' is placed at a distance of 'd' from a convex lens of focal length 'f_2' . A beam of light coming from infinity and falling on this convex lens-concave mirror combination returns to infinity. The distance 'd' must equal :

a) $-f_1 + f_2$ b) $2f_1 + f_2$

c) $-2f_1 + f_2$ d) $f_1 + f_2$

44. When a biconvex lens of glass having refractive index is dipped in a liquid, it acts as a plane sheet of glass. This implies that the liquid must have refractive index :

a) Less than one

b) Greater than that of glass

c) Less than that of glass

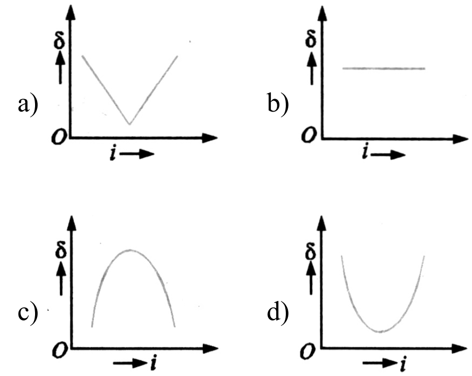
d) Equal to that of glass

45. An object 2.4 m in front of a lens forms a sharp image on a film 12 cm behind the lens. A glass plate 1 cm thick, of refractive index 1.50 is interposed between lens and· film with its plane faces parallel to film. At what distance (from lens) should object be shifted to be in sharp focus on film ?

a) 5.6 m b) 7.2 m

c) 2.4 m d) 3.2 m

46. The graph between angle of deviation (δ) and angle of incidence (i) for a triangular prism is represented by :



47. A beam of unpolarised light of intensity I_0 is passed through a polaroid A and then through another polaroid B which is oriented so that its principal plane makes an angle of 45^0 relative to that of A. The intensity of the emergent light is :

a) $\frac{I_0}{8}$ b) I_0

c) $\frac{I_0}{2}$ d) $\frac{I_0}{4}$

48. Diameter of a plano-convex lens is 6 cm and thickness at the centre is 3 mm. If speed of light in material of lens is 2×10^8 m/s, the focal length of the lens is :

a) 10 cm b) 15 cm

c) 20 cm d) 30 cm

49. A ray of light travelling in the direction $\frac{1}{2}(\hat{i} + \sqrt{3}\hat{j})$ is incident on a plane mirror, after reflection, it travels along the direction $\frac{1}{2}(\hat{i} - \sqrt{3}\hat{j})$. The angle of incidence is :

a) 30° b) 45°

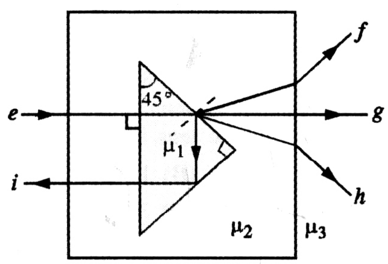
c) 60° d) 75°

50. The image of an object, formed by a plano-convex lens at a distance of 8 m behind the lens, is real and is one-third the size of the object. The wavelength of light inside the lens is $\frac{2}{3}$ times the wavelength in free space. The radius of the curved surface of the lens is :

a) 1 m b) 2 m

c) 3 m d) 6 m

51. A right angled prism of refractive index μ_1 is placed in a rectangular block of refractive index μ_2, which is surrounded by a medium of refractive index μ_3, as shown in the figure. A ray of light 'e' enters the rectangular block at normal incidence. Depending upon the relationships between μ_1, μ_2 and μ_3, it takes one of the four possible paths 'ef', 'eg', 'eh' or 'ei'.



Match the paths in List-I with conditions of refractive indices in List-II and select the correct answer using the codes given below the lists :

	List-I		List-II
P.	$e \to f$	1.	$\mu_1 > \sqrt{2\mu_2}$
Q.	$e \to g$	2.	$\mu_2 > \mu_1$ and $\mu_2 > \mu_3$
R.	$e \to h$	3.	$\mu_1 = \mu_2$
S.	$e \to i$	4.	$\mu_2 < \mu_1 < \sqrt{2\mu_2}$ and $\mu_2 > \mu_3$

Codes :

	P	Q	R	S
a)	2	3	1	4
b)	1	2	4	3
c)	4	1	2	3
d)	2	3	4	1

52. A plano-convex lens fits exactly into a plano concave lens. Their plane surfaces are parallel to each other. If lenses are made of different materials of refractive indices μ_1 and μ_2 and R is the radius of curvature of the curved surface of the lenses, then the focal length of the combination is :

a) $\dfrac{R}{(\mu_1 - \mu_2)}$ b) $\dfrac{2R}{(\mu_2 - \mu_1)}$

c) $\dfrac{R}{2(\mu_1 + \mu_2)}$ d) $\dfrac{R}{2(\mu_1 - \mu_2)}$

53. For a normal eye, the cornea of eye provides a converging power of 40 D & the least converging power of the eye lens behind the cornea is 20 D. Using this information, the distance between the retina and the cornea-eye lens can be estimated to be :

a) 1.67 cm b) 1.5 cm

c) 5 cm d) 2.5 cm

54. Light with an energy flux of 25×10^4 Wm^{-2} falls on a perfectly reflecting surface at normal incidence. If the surface area is 15 cm^2, the average force exerted on the surface is :

a) 3.0×10^{-6} N b) 1.25×10^{-6} N

c) 2.50×10^{-6} N d) 1.20×10^{-6} N

55. If the focal length of objective lens is increased then magnifying power of :

a) microscope will decrease but that of telescope will increase

b) microscope will increase but that of telescope decrease

c) microscope and telescope both will increase

d) microscope and telescope both will decrease

56. The angle of a prism is 'A' . One of its refracting surfaces is silvered. Light rays falling at an angle of incidence 2A on the first surface returns back through the same path after suffering reflection at the silvered surface. The refractive index μ, of the prism is :

a) tan A b) 2 sin A

c) 2 cos A d) $\dfrac{1}{2}\cos A$

57. A thin convex lens made from crown glass $\left(\mu = \dfrac{3}{2}\right)$ has focal length f. When it is measured in two different liquids having refractive indices $\dfrac{4}{3}$ and $\dfrac{5}{3}$, it has the focal lengths f_1 and f_2 respectively. The correct relation between the focal lengths is :

a) $f_1 = f_2 < f$

b) $f_1 > f$ and f_2 becomes negative

c) $f_2 > f$ and f_1 becomes negative

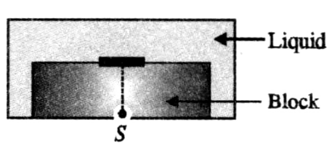
d) f_1 and f_2 both become negative

58. A green light is incident from the water to the air-water interface at the critical angle (θ). Select the correct statement :
   a) The entire spectrum of visible light will come out of the water at an angle of 90^0 to the normal.
   b) The spectrum of visible light whose frequency is less than that of green light will come out to the air medium.
   c) The spectrum of visible light whose frequency is more than that of green light will come out to the air medium.
   d) The entire spectrum of visible light will come out of the water at various angles to the normal.

59. Two beams, A & B, of plane polarized light with mutually perpendicular planes of polarization are seen through a polaroid. From the position when the beam A has maximum intensity (and beam B has zero intensity), a rotation of polaroid through 30^0 makes the two beams appear equally bright. If the initial intensities of the two beams are I_A and I_B respectively, then $\frac{I_A}{I_B}$ equals :

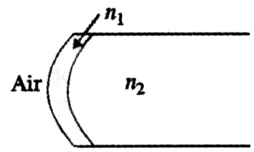
   a) 3 b) $\frac{3}{2}$
   c) 1 d) $\frac{1}{3}$

60. A point source S is placed at the bottom of a transparent block of height 10 mm and refractive index 2.72. It is immersed in a lower refractive index liquid as shown in the figure, It is found that the light emerging from the block to the liquid forms a circular bright spot of diameter 11.54 mm on the top of the block. The refractive index of the liquid is :



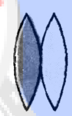
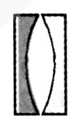
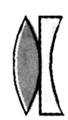
   a) 1.21 b) 1.30
   c) 1.36 d) 1.42

61. A transparent thin film of uniform thickness and refractive index $n_1 = 1.4$ is coated on the convex spherical surface of radius R at one end of a long solid glass cylinder of refractive index $n_2 = 1.5$, as shown in the figure. Rays of light parallel to the axis of the cylinder traversing through the film from air to glass get focused at distance f_1 from the film, while rays of light traversing from glass to air get focused at distance f_2 from the film. Then :



   a) $|f_1| = 3R$ b) $|f_1| = 2.8R$
   c) $|f_2| = 2R$ d) $|f_2| = 1.4R$

62. Four combinations of two thin lenses are given in List-I. The radius of curvature of all curved surfaces is r and the refractive index of all the the lenses is 1.5. Match lens combinations in List-I with their focal length in List-II and select the correct answer using the code given below the lists.

List-I		List-II	
P.		1.	2 r
Q.		2.	r / 2
R.		3.	– r
S.		4.	r

Code :
   a) P – 1, Q – 2, R – 3, S – 4
   b) P – 2, Q – 4, R – 3, S – 1
   c) P – 4, Q – 1, R – 2, S – 3
   d) P – 2, Q – 1, R – 3, S – 4

63. Two identical thin plano-convex glass lenses (refractive index 1.5) each having radius of curvature of 20 cm are placed with their convex surfaces in contact at the centre. The intervening space is filled with oil of refractive index 1.7. The focal length of the combination is :

a) – 50 cm b) 50 cm

c) – 20 cm d) – 25 cm

64. The refracting angle of a prism is A, and refractive index of the material of the prism is $\cot\left(\frac{A}{2}\right)$.

The angle of minimum deviation is :

a) $90^0 - A$

b) $180^0 + 2A$

c) $180^0 - 3A$

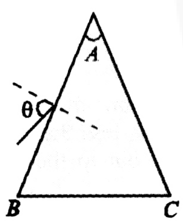
d) $180^0 - 2A$

65. Assuming human pupil to have a radius of 0.25 cm and a comfortable viewing distance of 25 cm, the minimum separation between two objects that human eye can resolve at 500 nm wavelength is :

a) 100 μm b) 300 μm

c) 1 μm d) 30 μm

66. Monochromatic light is incident on a glass prism of angle A. If the refractive index of the material of the prism is μ, a ray, incident at an angle θ, on the face AB would get transmitted through the face A C of the prism provided :



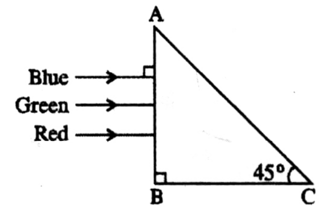
a) $\theta > \cos^{-1}\left[\mu \sin\left(A + \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

b) $\theta < \cos^{-1}\left[\mu \sin\left(A + \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

c) $\theta > \sin^{-1}\left[\mu \sin\left(A - \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

d) $\theta < \sin^{-1}\left[\mu \sin\left(A - \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

67. A beam of light consisting of red, green and blue colours is incident on a right angled prism. The refractive index of the material of the prism for the above red, green and blue wavelengths are 1.39, 1.44 and 1.47, respectively :



The prism will :

a) not separate the three colours at all

b) separate the red colour part from the green and blue colours

c) separate the blue colour part from the red and green colours

d) separate all the three colours from one another

68. In an astronomical telescope in normal adjustment a straight black line of length L is drawn on inside part of objective lens. The eye-piece forms a real image of this line. The length of this image is I. The magnification of the telescope is :

a) $\frac{L+I}{L-I}$ b) $\frac{L}{I}$

c) $\frac{L}{I}+1$ d) $\frac{L}{I}-1$

• • •

Brain Teasers

1. A person with normal vision can just resolve two poles separated by a distance of 10 m. If the limit of resolution be 1 second, then the distance of the poles from the person is :

   a) 36 km b) 3.6 km
   c) 36 m d) 3.6 m

2. If μ_r be the relative permeability and ε_r the relative permittivity of a medium then its refractive index is given by :

   a) $\frac{1}{\sqrt{\mu_r \varepsilon_r}}$ b) $\sqrt{\mu_r \varepsilon_r}$
   c) $\sqrt{\frac{\mu_r}{\varepsilon_r}}$ d) $\sqrt{\frac{\varepsilon_r}{\mu_r}}$

3. A perfectly reflecting mirror has an area of 0.5 cm^2. Light energy is allowed to fallon it for one hour at the rate of 20 W/cm^2. The force that acts on the mirror is :

   a) 3.33×10^{-8} N
   b) 6.7×10^{-8} N
   c) 1.65×10^{-8} N
   d) 0.82×10^{-8} N

4. The resolution limit of the eye is 1 minute. At a distance of *x* km from the eye, two persons stand with a lateral separation of 3 metres. For the two persons to be just resolved by the naked eye, *x* should be :

   a) 10 km b) 15 km
   c) 20 km d) 30 km

5. Yellow light has wavelength 600 nm in air. What is the wavelength of yellow light in water ?

   Refractive Index of water $\frac{4}{3}$.

   a) 600 nm b) 450 nm
   c) 300 nm d) 800 nm

6. Minimum light intensity that can be perceived by normal human eye is about 10^{-10} Wm^{-2}. What is the minimum number of photons of wavelength 660 nm that must enter the pupil in one second, for one to see the object ?

   Area of cross-section of the pupil is 10^{-4} m^2 ?

   a) 33×10^{-2} b) 33×10^{3}
   c) 33×10^{4} d) 33×10^{5}

7. 5% of the energy supplied to a lamp is radiated as a visible light. How many quanta of light are emitted per second by 100 watt lamp. Assume the average wavelength of visible light at 555 nm ?

   a) 0.7×10^{19} b) 1.4×10^{19}
   c) 2.1×10^{19} d) 2.8×10^{19}

8. What is the momentum of a photon having frequency 1.5×10^{13} Hz ?

   a) 3.3×10^{-29} kg m/s b) 3.3×10^{-34} kg m/s
   c) 6.6×10^{-34} kg m/s d) 6.6×10^{-30} kg m/s

9. The energy of a photon of light of wavelength 450 nm is :

   a) 4.4×10^{-19} J b) 2.5×10^{-19} J
   c) 1.25×10^{-17} J d) 2.5×10^{-17} J

10. Frequency of photon having energy 66 eV is :

    a) 8×10^{-15} Hz b) 12×10^{-15} Hz
    c) 16×10^{15} Hz d) none

11. The wavelength of a 1 keV photon is 1.24×10^{-9}. What is the frequency of 1 MeV photon ?

    a) 1.24×10^{15} b) 2.4×10^{20}
    c) 1.24×10^{18} d) 2.4×10^{23}

12. The eye can detect 5×10^{4} photons/ms^2 of light of wavelength 500 nm. The ear can detect 10^{-13} W/m^2. As a power detector, which is more sensitive ?

    a) Sensitivity of eye is one fifth of the ear
    b) Sensitivity of eye is five times that of ear
    c) Both are equally sensitive
    d) Eye cannot be used as power detector

13. What is rate of emission of photons if light source of 100 watt emits radiations of 5000 Å wave-length ?

    a) 2.5×10^{5} b) 2.5×10^{10}
    c) 2.5×10^{20} d) 2.5×10^{25}

14. Check the order (increasing) of velocity of light in diamond (V_d), in glass (V_g) and in water (V_w).

    a) $V_w > V_d > V_g$ b) $V_d > V_w > V_g$
    c) $V_d > V_g > V_w$ d) $V_w > V_g > V_d$

15. What is the K.E. in joule for a photon possessing wavelength 0.016 A^0 ?

    a) 12×10^{-13} b) 0.12×10^{-13}
    c) 12.75×10^{-13} d) 1.2375×10^{-13}

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Answer Key

MH Text Book Based MCQ's

01. (a)	17. (b)	33. (a)	49. (a)	65. (c)	81. (c)	97. (d)
02. (c)	18. (c)	34. (d)	50. (c)	66. (b)	82. (d)	98. (d)
03. (d)	19. (b)	35. (d)	51. (a)	67. (d)	83. (c)	99. (d)
04. (b)	20. (c)	36. (a)	52. (d)	68. (a)	84. (d)	100. (d)
05. (c)	21. (c)	37. (a)	53. (c)	69. (c)	85. (a)	101. (d)
06. (c)	22. (a)	38. (c)	54. (a)	70. (d)	86. (b)	102. (a)
07. (b)	23. (b)	39. (b)	55. (a)	71. (d)	87. (a)	103. (a)
08. (b)	24. (b)	40. (a)	56. (b)	72. (b)	88. (b)	104. (a)
09. (d)	25. (d)	41. (d)	57. (a)	73. (a)	89. (c)	105. (a)
10. (c)	26. (a)	42. (a)	58. (d)	74. (c)	90. (a)	106. (c)
11. (d)	27. (d)	43. (c)	59. (c)	75. (c)	91. (b)	107. (d)
12. (b)	28. (b)	44. (d)	60. (a)	76. (b)	92. (c)	108. (c)
13. (b)	29. (d)	45. (b)	61. (a)	77. (b)	93. (a)	109. (b)
14. (a)	30. (c)	46. (c)	62. (a)	78. (d)	94. (c)	110. (b)
15. (d)	31. (a)	47. (c)	63. (d)	79. (b)	95. (b)	
16. (b)	32. (a)	48. (a)	64. (d)	80. (d)	96. (b)	

REVISION QUESTIONS from Competitive Exams.

01. (d)	11. (c)	21. (d)	31. (b)	41. (b)	51. (d)	61. (a,c)
02. (d)	12. (d)	22. (b)	32. (d)	42. (d)	52. (a)	62. (b)
03. (b)	13. (b)	23. (e)	33. (c)	43. (b)	53. (a)	63. (a)
04. (d)	14. (b)	24. (c)	34. (c)	44. (d)	54. (c)	64. (d)
05. (c)	15. (c)	25. (d)	35. (b)	45. (a)	55. (c)	65. (d)
06. (d)	16. (c)	26. (d)	36. (b)	46. (d)	56. (c)	66. (c)
07. (d)	17. (c)	27. (a)	37. (c)	47. (d)	57. (b)	67. (b)
08. (b)	18. (b)	28. (b)	38. (c)	48. (d)	58. (b)	68. (b)
09. (a)	19. (c)	29. (d)	39. (b)	49. (a)	59. (d)	
10. (a)	20. (d)	30. (d)	40. (d)	50. (c)	60. (c)	

BRAIN TEASERS

01. (a)	03. (b)	05. (b)	07. (b)	09. (a)	11. (b)	13. (c)
02. (b)	04. (a)	06. (b)	08. (a)	10. (c)	12. (b)	14. (d)
						15. (d)

Hints and Explanations

1-9. Knowledge based questions.

10. Laser can be used to produce intense beam of monochromatic light.

11. The laser beams donot diverge or converge.

12. Due to Doppler's effect blue shift will occur gradually.

13. Wavelength of X-ray = 0·1 nm.

14. Mean wave length of the visible photon is 500 nm.

15. White colour is mixture of all colours.

16. Light can travel even in vacuum.

17. Corpuscular theory of light suggests that light should travel faster in the denser medium.

18. Geometrical optics deals with the formation of images using the concepts of light rays travelling along straight lines.

19. Both Einstein as well as Newton predicted the deflection of light rays by the gravitational field. However, Einstein's prediction very much agrees with the experimental results.

20-22 $mc^2 = h\nu$, Hence $m = h\nu/c^2 = h/c\lambda$ and $p = h/\lambda$

23. $E = h\nu = hc/\lambda$.

24. $p = \dfrac{h\nu}{c} = \dfrac{6 \cdot 62 \times 10^{-34} \times 10^{19}}{3 \times 10^{8}}$

$= 2 \cdot 21 \times 10^{-23}$ kg m/s

25. $p = h/\lambda = h/10^{-9}$ m.

26. $m = \dfrac{h}{c\lambda} = \dfrac{6 \cdot 62 \times 10^{-34}}{3 \times 10^{8} \times 10^{-10}} = 2 \cdot 21 \times 10^{-32}$ kg

27. $p = h/\lambda$

28. λ_{max} for light $\cong$ 800 nm. $E = hc/\lambda$

29. $p = \dfrac{h}{\lambda}$ and $\nu = c\,\lambda = \dfrac{pc}{h}$.

30. $n = \dfrac{P\lambda}{hc}$.

31-32. Rest mass of photon is zero.

33. $\lambda = \frac{h}{m\upsilon} = \frac{6\cdot 62 \times 10^{-34} \times 10}{1\cdot 67 \times 10^{-27}}$.

34. Photons exert pressure on the surface on which they fall.

35. Photons always travel with constant speed. Therefore, their rest mass is zero.

36-40. Knowledge based questions.

41. Photoelectric effect can be explained on the basis of quantum theory of light.

42. Both points will lie on the same spherical wave front.

43. The γ-rays are em waves.

44. None of sources generate plane wave front. It can be artificially produced by reflection from a mirror or by refraction through a lens.

45. $E/p = h\nu/(h/\lambda) = \nu\lambda = c$.

46-52. Knowledge based questions.

53. $\vec{E} \perp \vec{c}$.

54. The light ray lies in the plane of polarisation.

55. $\tan\theta = \mu = \frac{c}{\upsilon} = \frac{\lambda_0}{\lambda}$

56. $I_2 = \frac{I_1}{2}\cos^2\theta = \frac{I_1}{2}$.

57. It is the statement of fact.

58. Both the plane of polarisation as well as the plane of oscillation contain the line of propagation of light.

59. When the light is incident at Brewster's angle, the angle between the refracted ray and reflected ray is 90°, irrespective of the value of refractive index.

60. Light incident on the analyser has intensity $I/\cos^2 60° = 4I$ and that on the polariser is $4I \times 2 = 8I$.

61. The polaroids reduce the intensity of light due to polarisation.

62. Here $i + r = 90°$. Also grazing angle + i = 90° Hence r = grazing angle.

63. $(\text{Amplitude})^2 \propto$ Intensity.

64. Only 50% light passes through the polariser due to polarisation.

65. Light is extinguished when the polariser and analyser are crossed. That is the angle between their axes is 90°.

66. Sound waves are longitudinal and so they cannot be polarised.

67. Electric and magnetic field vectors oscillate in the same phase but they are oriented perpendicular to each other.

68. Polaroid cuts off plane polarised light for one orientation.

69. Light suffers double refraction through calcite.

70. $\mu = \tan i$.

71. Intensity of the light transmitted through the first prism is $I/2$ and that through the second is $(I/2)\cos^2 30° = (I/2)(3/4) = 3I/8$.

72. Intensity of the light transmitted through polariser is $I/2$ and so its amplitude is $\sqrt{I}/\sqrt{2} = a/\sqrt{2}$.

73. Angle of polarisation is 60°. Hence $n = \tan 60°$.

74. $I = I_0\cos^2\theta$. Here $\theta = 45°$.

75. $I = \frac{I_0}{2}\cos^2 30° = \frac{I_0}{2}\left(\frac{\sqrt{3}}{2}\right)^2 = \frac{3}{8}I_0$

Hence $\frac{I_0}{I} = \frac{8}{3}$.

76. $I = \frac{I_i}{2}\cos^2\theta\sin^2\theta$

Here $\frac{2I}{I_i} = \frac{2\times 3}{32} = \frac{\sin^2 2\theta}{4}$

Hence $\sin 2\theta = \frac{\sqrt{3}}{2}$

That is $\theta = 30°$

77. $I = \frac{I_i}{2}\cos^2 45° \times \cos^2 45° = \frac{I_i}{2} \times \frac{1}{2} \times \frac{1}{2}$

Hence $\frac{I}{I_i} = \frac{1}{8} = 12\cdot 5\%$.

78. $I = \frac{I_i}{2}\cos^2 60° = \frac{I_i}{2\times 4}$

Hence $\frac{I}{I_i} = \frac{1}{8} = 12\cdot 5\%$.

79. $I = \frac{I_0}{2}\cos^2\theta_1\cos^2\theta_2 \Rightarrow I \propto \cos^2\theta_1 . \cos^2\theta_2$

i.e., I to be Max.

$\theta_1 = \theta_2 = 45°$

80. We know that

$\mu = \frac{c}{\upsilon} = \frac{\nu\lambda}{\nu\lambda'}$ (λ – wavelength in air)

(λ' – wavelength in glass)

Therefore, $\mu = \frac{\lambda}{\lambda'}$

Hence $\lambda' = \frac{\lambda}{\mu} = \frac{5400 \text{ A.U.}}{3/2} = 3600$ A.U.

81. We know that

$\mu = \frac{c}{\upsilon} = \frac{\lambda}{\lambda'}$

(λ – wavelength of reflected beam or wavelength in air and λ' – wavelength of refracted beam or wavelength in glass).

Hence ratio of wavelength is equal to refractive index.

82. For minima in reflected light the relation is $2\mu t\cos r = n\lambda$

Or $$t = \frac{n\lambda}{2\mu\cos r}$$

$$t_{\min} = \frac{\lambda}{2\mu} = \frac{6000\text{ Å}}{2\times 1\cdot 4} = 2000\text{ Å}$$

83. We know that

$$\text{Wave number} = \frac{1}{\text{Wavelength}} = \frac{1}{600\times 10^{-10}} = 1\cdot 66\times 10^{6}\text{ per m.}$$

84. Time taken by light to travel a glass slab of thickness 2 mm is

$$= \frac{\mu t}{c} = \frac{1\cdot 5\times 2\times 10^{-3}}{3\times 10^{8}} = 10^{-11}\text{ second.}$$

85. Refractive index is given by :

$$\mu = \frac{\text{Velocity of light in air}}{\text{Velocity of light in medium}}$$

that is, $\mu = \frac{C}{\upsilon}$

$\Rightarrow \upsilon = \frac{C}{\mu}$

Substituting $C = 3\times 10^{8}\text{ ms}^{-1}$; $\mu = 1\cdot 5$, we get

$$\upsilon = 2\times 10^{8}\text{ m s}^{-1}$$

Now, time taken to travel a distance $x = 4\times 10^{8}$ m is given by :

$$t = \frac{x}{\upsilon} = \frac{4\times 10^{8}}{2\times 10^{8}} = 2\text{ s}$$

86. Knowledge based question.

87. When the light enters from rarer to denser medium, the wavelength of light decreases

$$\lambda' = \frac{\lambda}{\mu}$$

where λ' is wavelength of light in denser medium.

88. Frequency of light does not change, when light enter from one medium to another medium.

89. $$\text{Time taken} = \frac{\text{thickness of glass plate}}{\text{velocity of light}} = \frac{2\times 10^{-3}}{3\times 10^{8}/1\cdot 5} = \frac{3\times 10^{-3}}{3\times 10^{8}} = 10^{-11}\text{ second.}$$

90. According to Snell's law we have :

$$\frac{\sin i}{\sin r} = \mu = \frac{\mu_2}{\mu_1}$$

Here $\mu_1 = \mu_G = \frac{5}{3}$

and $\mu_2 = \mu_W = 4/3$

$\angle r = 90°$

$\angle i = C$

$\therefore \sin C = \frac{4/3}{5/3}$

or $C = \sin^{-1}\left(\frac{4}{5}\right)$

91. Because of very small wavelength it bends only at very-very small obstacles.

92. Wave theory of light does not explain photoelectric effect.

93. $${}^{w}\mu_g = \frac{V_w}{V_g}, \text{ so, } V_\omega = V_g\times {}^{w}\mu_g$$

$$\Rightarrow \frac{9}{8} = \frac{x}{2\times 10^{8}}$$

$$x = \frac{2\times 10^{8}\times 9}{8} = 2\cdot 25\times 10^{8}\text{m s}^{-1}$$

94. $$\lambda_a = \frac{C}{f_a} = \frac{3\times 10^{8}}{4\times 10^{14}} = 7500\text{ Å}$$

$$\lambda_g = \frac{\lambda_a}{{}_a\mu^g} = \frac{7500}{1\cdot 5} = 5000\text{ Å}$$

$\therefore \Delta\lambda = 7500 - 5000 = 2500$ Å

$$\therefore \frac{\Delta\lambda}{\lambda}\times 100\% = \frac{2500}{7500}\times 100\% = 33\cdot 33\%$$

95. $t_a = t_g$, where t = time

$\therefore \frac{d_a}{\upsilon_a} = \frac{d_g}{\upsilon_g}$, where d = distance, υ = velocity

$$\Rightarrow d_a = \left(\frac{\upsilon_a}{\upsilon_g}\right)\times d_g$$

$$\Rightarrow d_a = {}_a\mu^g\times d = 1\cdot 5\times 5 = 7\cdot 5\text{ cms.}$$

96. $\upsilon = \nu\lambda$

In water, velocity 'υ' decreases and hence λ decreases.

97. $$\mu = \frac{\sin i}{\sin r} \Rightarrow \sin r = \frac{\sin i}{\mu} = \frac{1}{\sqrt{2}}\times\frac{1}{\sqrt{2}} = \frac{1}{2}$$

$$\Rightarrow r = \sin^{-1}\frac{1}{2} = 30°$$

Now, $\dfrac{\text{width of beam in air}}{\text{width of beam in water}} = \dfrac{\cos i}{\cos r} = \dfrac{\cos 45^\circ}{\cos 30^\circ}$

$$= \frac{1}{\sqrt{2}\times\sqrt{\frac{3}{2}}} = \frac{2}{\sqrt{2}\times\sqrt{3}} = \frac{\sqrt{2}\times\sqrt{2}}{\sqrt{2}\times\sqrt{3}} = \sqrt{2} : \sqrt{3}.$$

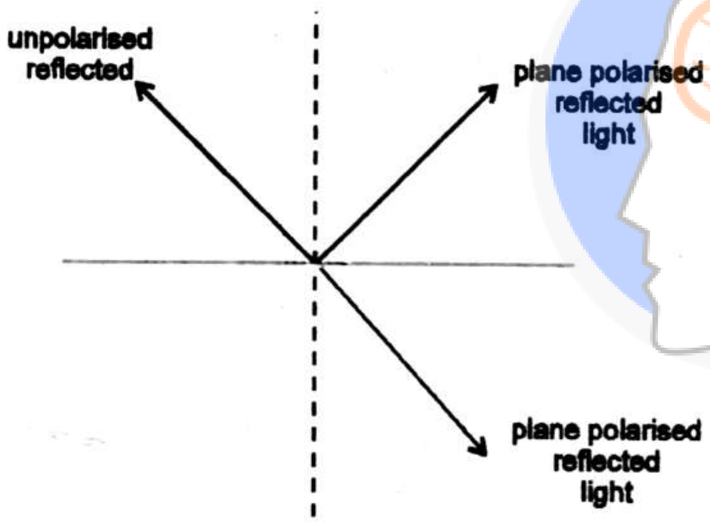
98. Huygein's wave theory of light could not explain photoelectric effect.

99. $\mu = \tan i_p = \tan 60^\circ = \sqrt{3}$.

100. $\dfrac{\mu d}{\mu g} = \dfrac{\mu d}{\mu a} \times \dfrac{\mu a}{\mu g} = \dfrac{2\cdot 4}{1\cdot 5} = 1\cdot 6.$

101. Times taken by the ray of light to pass through glass slab $= \dfrac{\mu t}{c}$, where μt = optical path.

102. According to Brewster, when a beam of unpolarised light is reflected from a transparent medium of refractive index μ then the reflected light is completely plane polarised at a certain angle of incidence called as angle of polarisation (i)



$\therefore \quad i + r = 90^\circ$

$r = 90^\circ - i$

103. Knowledge based question.

104. Given that $r = \dfrac{i}{2}$

or $i = 2r$

We know that $\mu = \dfrac{\sin i}{\sin r} = \dfrac{\sin 2r}{\sin r} = \dfrac{2\sin r\cos r}{\sin r}$

$(\because \sin 2\theta = 2\sin\theta\cos\theta)$

$\therefore \quad \mu = 2\cos r$

or $\quad r = \cos^{-1}\left(\dfrac{\mu}{2}\right)$

$\dfrac{i}{2} = \cos^{-1}\left(\dfrac{\mu}{2}\right) \quad \left(\because r = \dfrac{i}{2}\right)$

or $\quad i = 2\cos^{-1}\left(\dfrac{\mu}{2}\right)$

105. Knowledge based question.

106. We know that, $\mu = \tan\theta_p$

$\dfrac{C}{v} = \tan^{-1}\theta_p$

or $\quad \theta_p = \tan^{-1}\left(\dfrac{C}{v}\right)$

We can also write, $\theta_\pi = \cot^{-1}\left(\dfrac{v}{C}\right)$

107. When the equiconvex lens is cut along optical axis *i.e.* perpendicular to principal axis then focal length of each piece becomes double the focal length of original lens.

i.e. $f' = 2f$

108. We know that, ${}_m\mu_a = \sin C$

$\therefore \quad \dfrac{\mu_a}{\mu_m} = \sin C$

$\dfrac{v_m}{v_a} = \sin C \qquad \left(\because \mu = \dfrac{1}{v}\right)$

$\dfrac{\frac{d_m}{t_m}}{\frac{d_a}{t_a}} = \sin C \qquad \left(\because v = \dfrac{d}{t} = \dfrac{\text{distance}}{\text{time}}\right)$

$\dfrac{\frac{5d}{T}}{\frac{d}{t}} = \sin C$

$\dfrac{5d}{T} \times \dfrac{t}{d} = \sin C$

or $\quad \sin C = \dfrac{5t}{T}$

or $\quad C = \sin^{-1}\left(\dfrac{5t}{T}\right)$

109. $\Delta x = 1\cdot 8 \times 10^{-5} - 1\cdot 23 \times 10^{-5}$

$= (1\cdot 8 - 1\cdot 23) \times 10^{-5} = 0\cdot 57 \times 10^{-5}$

Let $\Delta x = (2n-1)\dfrac{\lambda}{2}$ (for dark fringe)

or, $0\cdot 57 \times 10^{-5} = (2n-1) \times \dfrac{6000}{2} \times 10^{-10}$

or, $\quad 2n - 1 = 19$

or, $\quad 2n = 20 \Rightarrow n = 10$

110. $\dfrac{I_{max.}}{I_{min}} = \dfrac{16}{1} = \dfrac{(\sqrt{I_1} + \sqrt{I})^2}{(\sqrt{I_1} - \sqrt{I_2})^2}$

or, $\dfrac{I_{max}}{I_{min}} = \dfrac{(\sqrt{25} + \sqrt{9})^2}{(\sqrt{25} - \sqrt{9})^2} = \dfrac{(5+3)^2}{(5-3)^2}$

$= \dfrac{64}{4} = \dfrac{16}{1}$

So, option (B) is the right option.

REVISION QUESTIONS from Competitive Exams.

1. $E = h\nu$. The ν does not change on refraction.

2-3. Knowledge based questions.

4. Less light will enter the telescope.

5. Because of short wavelength it bends only at very very small obstacles or apertures.

6. Origin of spectra cannot be explained by Huygen's principle.

7. Photo electric effect can be explained on the basis of quantum theory.

8. Scattering of light increases when the wavelength decreases. Wavelength of blue light is much smaller as compared to the red and green colours.

9. Amplitude $\propto$ (Intensity)$^{1/2}$.

10. The resolving power of microscope is higher for smaller wavelengths. The wavelength should be of the order of the radii of the particle. Hence

$$\nu = \frac{3 \times 10^8}{3 \times 10^{-4} \times 10^{-2}} = 10^{14}\text{ Hz}.$$

However when frequency is more than 10^{14} Hz, the wavelength is still smaller and resolving power is higher.

11. Frequency does not change during refraction.

12. If wave optics is valid when size of the objects is of the order of wavelength of light.

13. $\mu = \frac{c}{\upsilon}$. Hence $\upsilon = \frac{c}{\mu} = \frac{3 \times 10^8 \text{ m/s}}{1 \cdot 33}$.

14. Frequency does not change with medium and wavelength as well as velocity decrease with the increase in refractive index.

15. Refractive index

$$= \sqrt{\frac{c}{\upsilon}} = \sqrt{\frac{1/\epsilon_0\mu_0}{1/\epsilon\mu}} = \sqrt{\frac{\epsilon\mu}{\epsilon_0\mu_0}}.$$

16. Interference at thin films.

17. Knowledge based question.

18. $\lambda = \frac{c}{f} = \frac{3 \times 10^8}{100} = 3 \times 10^6\text{ m}.$

19. $f = \frac{c}{\lambda} = \frac{3 \times 10^8}{10} = 3 \times 10^7\text{ Hz}.$

20. Velocity of light in vacuum is a natural constant.

21. Knowledge based question.

22. Knowledge based question.

23. Ultrasonic waves are longitudinal, so they cannot be polarised.

24-27. Knowledge based questions.

28. According to the Malus law

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

When light passes through a polaroid, only 50% light is able to pass through it.

% of incident light transmitted

$$= \frac{\frac{I}{2}\cos^2 45}{I} \times 100$$

$$= \frac{I/4}{I} \times 100 = 25\%$$

29-30. Knowledge based questions.

31. For total internal reflection, we have :

$$i > C \qquad \text{...(1)}$$

where C is the critical angle.

Equation (1), can be written as ;

$$\sin i > \sin C$$

Since $\sin C = \frac{1}{\mu}$, therefore, we have :

$$\sin i > \frac{1}{\mu}$$

Substituting $i = 45°$, we get :

$$\sin 45° > \frac{1}{\mu}$$

or $\frac{1}{\sqrt{2}} > \frac{1}{\mu}$

or $\mu > \sqrt{2}$

32. Knowledge based question.

33. Specific rotation is given by :

$$\alpha = \frac{\text{angle of rotation (in rad)}}{\text{length of tube} \times \text{concentration}} = \frac{\theta}{l \times c}$$

$$\Rightarrow c = \frac{\theta}{\alpha \times l}$$

Substituting $\theta = 0 \cdot 4$; $\alpha = 0 \cdot 01$; $l = 0 \cdot 25$ m, we get :

$$c = 160 \text{ kg m}^{-3}$$

Hence, percentage purity of sugar in the sample

$$= \frac{160}{200} \times 100 = 80\%$$

34. $\mu_1 = \frac{C}{\upsilon_1} = \frac{3 \times 10^8}{1.5 \times 10^8} = 2$

$\mu_2 = \frac{C}{\upsilon_2} = \frac{3 \times 10^8}{2 \times 10^8} = \frac{3}{2}$

Now $\sin C = \frac{\mu_2}{\mu_1}$ for total internal reflection

$\sin i \geq \sin C$

$\therefore \sin i \geq \frac{\mu_2}{\mu_1} \geq \frac{3/2}{2}$

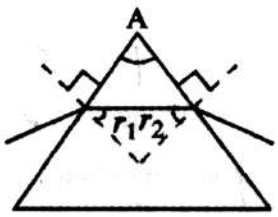
or $i \geq \sin^{-1} \frac{3}{4}$

35. $A = r_1 + r_2$

For deviation to be minimum,

$r_1 = r_2 = r \therefore A = 2r$

$A = 60^\circ \therefore r = \frac{A}{2} = \frac{60^\circ}{2} = 30^\circ$



36. The difference between apparent depth and real depth based on the phenomenon of refraction.

37. We know that, $\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

By using sign convention : $R_1 = +VE$
$R_2 = -VE$

$\frac{1}{f} = \left(\frac{3}{2} - 1\right)\left[\frac{1}{20} + \frac{1}{20}\right]$

$\frac{1}{f} = \frac{1}{2}\left[\frac{2}{20}\right] = \frac{1}{20}$

$\Rightarrow f = 20$

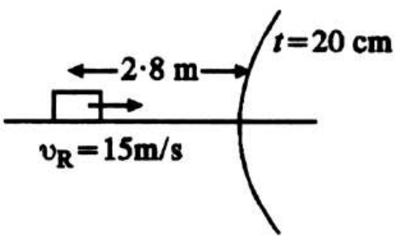
$f = \frac{u\upsilon}{u - \upsilon} = +20 = \frac{-30 + \upsilon}{-30 - \upsilon}$

$\Rightarrow \upsilon = 60$ cm (Real)

$m = \frac{\upsilon}{u} = \frac{60}{-30} = \frac{h_1}{h_0} = \frac{h_1}{h_2}$

$\Rightarrow h_1 = -4$ cm. (inverted)

38. By using mirror formula



$\upsilon = \frac{f \times u}{f - u} = \frac{280 \times 20}{300}$ [f = VE, $u = -u$]

$\upsilon = \frac{-56}{3}$ cm

The velocity of image seen through the mirror is given by

$\upsilon_I = -\left(\frac{\upsilon}{u}\right)^2 \upsilon_R$

$= -\left(\frac{-56}{3 \times 280}\right) \times 15 = \frac{1}{15}$ m/s.

39. The statement-I is true, statement-II is false. The centre maxima and minima depends on the thickness of glass.

40. We know that

$E = h\nu = h\frac{C}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{0.6 \times 10^{-6}}$

$= 33 \times 10^{-30}$ J

$\therefore$ Number of protons, $N = \frac{25\%\ P}{E}$

or $N = \frac{25 \times 200}{100 \times 33 \times 10^{-20}} = 1.5 \times 10^{10}$

41. We know that magnifying power of a telescope is given by :

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

or $9 = \frac{f_o}{f_e} \Rightarrow f_o = 9f_e$

Given, $f_o + f_e = 20$ cm

or $9f_e + f_e = 20$ cm

or $10f_e = 20$ cm $\Rightarrow f_e = \frac{20}{10} = 2$ cm

and $f_o = 9f_e = 9 \times 2 = 18$ cm

42. Here $\angle e = 0$, $\angle r_2 = 0$, because the emergent ray emerges normally from the opposite face.

But, $r_1 + r_2 = A \Rightarrow r_1 + 0 = A \Rightarrow r_1 = A$

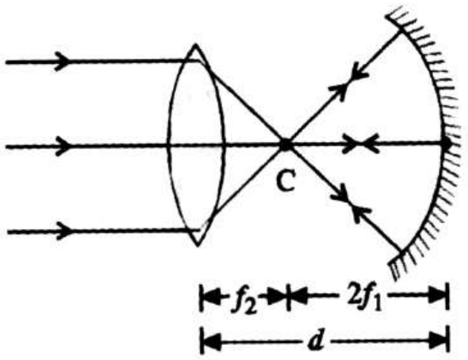
Also, $\frac{\sin i}{\sin r_1} = \mu$ (Snell's law)

or, $\frac{\sin i}{\sin A} = \mu$

or $\frac{i}{A} = \mu$ [$\because$ the angles are very-very small]

$\therefore i = \mu A$

43.



Here , $d = f_2 + 2f_1$

or $\quad d = 2f_1 + f_2$

44. Use lens maker's formula

$$\frac{1}{f} = \left(\frac{\mu_g}{\mu_L} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

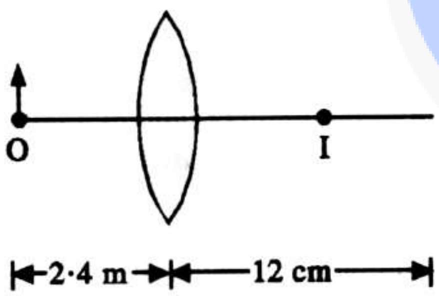
When biconvex lens is dipped in a liquid, then it acts as a plane sheet of glass,

$\therefore \quad f = \infty \Rightarrow \frac{1}{f} = 0$

$\therefore \quad 0 = \frac{\mu_g}{\mu_L} - 1 \Rightarrow \frac{\mu_g}{\mu_L} = 1$

$\Rightarrow \quad \mu_g = \mu_L$

45.



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

or $\quad \frac{1}{f} = \frac{1}{12} - \frac{1}{-240}$

$\Rightarrow \quad \frac{1}{f} = \frac{20+1}{240} = \frac{21}{240}$

or $\quad f = \frac{240}{21} = \frac{80}{7}$ cm

Normal shifting when slab is inserted.

$$\Delta t = t\left(1 - \frac{1}{\mu}\right) = 1\left(1 - \frac{2}{3}\right) = \frac{1}{3} \text{ cm}$$

Now, to form the image at the same position, due to lens only the image should be formed at,

$$v' = \left(12 - \frac{1}{3}\right) = \frac{35}{3} \text{ cm}$$

Also, $f = \frac{80}{7}$ cm

Now, $\frac{1}{f} = \frac{1}{v'} - \frac{1}{u'}$

or $\quad \frac{7}{80} = \frac{3}{35} - \frac{1}{u'}$

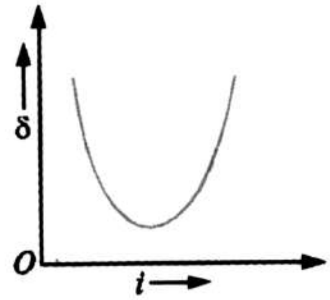
$\Rightarrow \quad \frac{1}{u'} = \frac{3}{35} - \frac{7}{80} = \frac{240-245}{2800}$

or $\quad \frac{1}{u'} = \frac{-5}{2800}$

$\Rightarrow \quad u' = -\frac{2800}{5} = -560 \text{ cm} = -5{\cdot}6 \text{ m}$

Thus, shifting of object $= 5{\cdot}6 - 2{\cdot}4 = 3{\cdot}2$ m

46.



47. After passing through polaroid A, the intensity of light as :

$$I_1 = \frac{I_0}{2}$$

Now, intensity of light emerging from polaroid B as per Malus law is given by :

$$I_2 = I_1 \cos^2 45°$$

$$= \left(\frac{I_0}{2}\right)\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{I_0}{4}.$$

48. As per lens maker's formula.

$$\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

For plano-convex lens,

$$R_1 = R \text{ and } R_2 = \infty$$

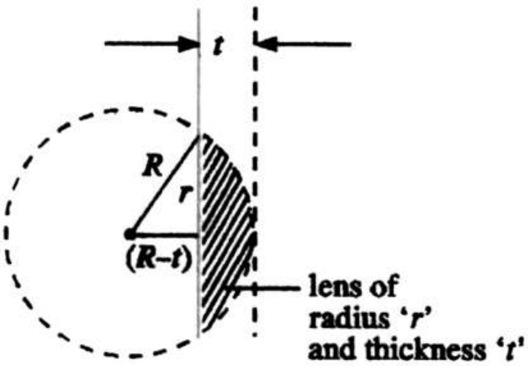
$\therefore \quad \frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{\infty}\right]$

$\therefore \quad \frac{1}{f} = \frac{\mu - 1}{R} \Rightarrow f = \frac{R}{\mu - 1} \quad$ ...(*i*)

Now, $\mu = \frac{c}{v} = \frac{3 \times 10^8}{2 \times 10^8} = \frac{3}{2} = 1{\cdot}5$

From fig. radius of curvature (R) of the curved surface is :

$$R^2 = r^2 + (R - t)^2$$



or $\quad R^2 = r^2 + R^2 + t^2 - 2Rt$

or $\quad 2Rt = r^2 + t^2 \Rightarrow R = \dfrac{r^2 + t^2}{2t}$

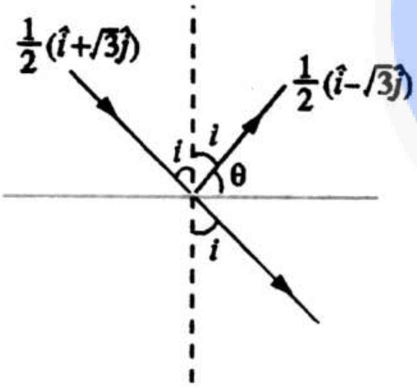
$\because r >> t \therefore r^2 + t^2 \cong r^2$

Hence, $R = \dfrac{r^2}{2t} = \dfrac{(3)^2}{2 \times 0 \cdot 3} = 15$ cm

Now, from eqn. (*i*)

$$f = \frac{R}{\mu - 1} = \frac{15}{1 \cdot 5 - 1} = \frac{15}{0 \cdot 5} = 30 \text{ cm}$$

49.



$$\cos\theta = \frac{\left(\frac{\hat{i} + \sqrt{3}\hat{j}}{2}\right)\cdot\left(\frac{\hat{i} - \sqrt{3}\hat{j}}{2}\right)}{\left|\frac{\hat{i} + \sqrt{3}\hat{j}}{2}\right|\left|\frac{\hat{i} - \sqrt{3}\hat{j}}{2}\right|}$$

or $\cos\theta = \dfrac{\frac{1-3}{4}}{1} = \dfrac{-2}{4} = \dfrac{-1}{2}$

or $\quad \theta = \cos^{-1}\left(-\dfrac{1}{2}\right) = 120^\circ$

Thus, angle of incidence

$$i = \frac{180^\circ - \theta}{2}$$

$$= \frac{180^\circ - 120^\circ}{2} = 30^\circ$$

50. Here $v = +8$ m (as image is formed behind the lens)

$$m = \frac{I}{O} = \frac{v}{u} = -\frac{1}{3} \Rightarrow u = -3v$$

$$= -3 \times 8 = -24 \text{ m}$$

Use lens formula : $\dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{f}$

or $\quad \dfrac{1}{8} - \dfrac{1}{-24} = \dfrac{1}{f}$

$\Rightarrow \quad \dfrac{1}{f} = \dfrac{1}{8} + \dfrac{1}{24} = \dfrac{1}{f} = \dfrac{3+1}{24}$

or $\quad \dfrac{1}{f} = \dfrac{4}{24} = \dfrac{1}{6} \Rightarrow f = 6$ m

$$\mu = \frac{\lambda_{vac}}{\lambda_{\text{inside the lens}}} = \frac{\lambda_0}{\frac{2}{3}\lambda_0} = \frac{3}{2}$$

$$= 1 \cdot 5$$

Now, according to lens maker's formula

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

For plano convex lens, $R_1 = R$ and $R_2 = \infty$

$\therefore \quad \dfrac{1}{f} = \dfrac{\mu - 1}{R} \Rightarrow R = f(\mu - 1)$

or $\quad R = 6(1 \cdot 5 - 1) = 6 \times 0 \cdot 5 = 3$ m

51. (*i*) $e \to f$, the ray bends towards the normal, so $\mu_2 > \mu_1$

and $\mu_2 > \mu_3 \to$ ray bends away from the normal

$\therefore P \to 2$

(*ii*) $e \to g$,

since there is no deviation, therefore $\mu_1 = \mu_2$ hence $Q \to 3$

(*iii*) $e \to h$,

$\mu_1 > \mu_2$ *i.e.*, the ray bends away from the norm or $\mu_2 < \mu_1$.

Also, $\mu_2 > \mu_3 \to$ ray bends away from the normal $\mu_1 < \sqrt{2\mu_2}$ as no total internal reflection takes place

$\therefore R \to 4$

(*iv*) $e \to i$

here, the total internal reflection takes place

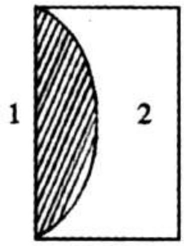
$\therefore \sin 45^\circ > \sin C$

Also, $\sin C = \dfrac{\mu_2}{\mu_1}$

$\therefore \quad \dfrac{1}{\sqrt{2}} > \dfrac{\mu_2}{\mu_1} \Rightarrow \mu_1 > \sqrt{2}\mu_2$

so, $S \to 1$.

52. Here, $\frac{1}{f_1} = (\mu_1 - 1)\left(\frac{1}{\infty} - \frac{1}{R}\right)$



or $\frac{1}{f_1} = \frac{\mu_1 - 1}{R}$

Similarly,

$$\frac{1}{f_2} = (\mu_2 - 1)\left(\frac{1}{-R} - \frac{1}{\infty}\right)$$

or $\frac{1}{f_2} = -\frac{(\mu_2 - 1)}{R}$

Now, $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$

or $\frac{1}{f} = \frac{(\mu_1 - 1)}{R} - \frac{(\mu_2 - 1)}{R} = \frac{\mu_1 - \mu_2}{R}$

or $f = \frac{R}{\mu_1 - \mu_2}$

53. $P_c = +40\,D$

$P_e = +20\,D$

$\therefore$ Power of eye lens, $P = P_c + P_e = 40D + 20D = 60D$

Also, Power of the eye lens,

$$P = \frac{1}{\text{focal length } (f)}$$

$\therefore f = \frac{1}{P} = \frac{1}{60\,D} = \frac{1}{60}\text{ m} = \frac{100}{60}\text{ cm} = \frac{5}{3}\text{ cm}$

Hence, distance between the retina and cornea-eye lens = focal length of eye lens = $\frac{5}{3}$ cm = 1·67 cm.

54. Average force acting on the surface

$$F = \frac{2E}{c \times t} = \frac{2I}{c} \times A$$

$$= \frac{2 \times 25 \times 10^4 \times 15 \times 10^{-4}}{3 \times 10^8}$$

$$F = 2{\cdot}5 \times 10^{-6} N.$$

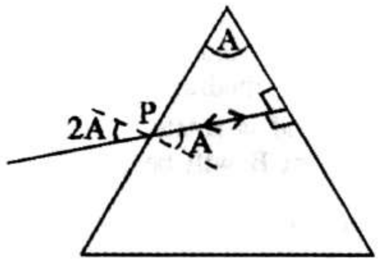
55. We know that,

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

Hence f_o increases, m also increases.

Same formula hold good for telescope also.

56. According to given diagram



We know that, $r_2 = 0$

$\Rightarrow r_1 = A - r_2$

$\Rightarrow r_1 = A$ $\qquad (\because A = r_2 + r_1)$

Hence Applying Snell's law at A

$$\mu = \frac{\sin 2A}{\sin A} = \frac{2\sin A \cos A}{\sin A}$$

$\mu = 2\cos A$.

57. $\frac{1}{f_1} = \left(\frac{\mu}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

or $\frac{1}{f_1} = \left(\frac{3/2}{4/3} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

or $\frac{1}{f_1} = \frac{1}{8}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Similarly, $\frac{1}{f_2} = \left(\frac{\mu}{\mu_2} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

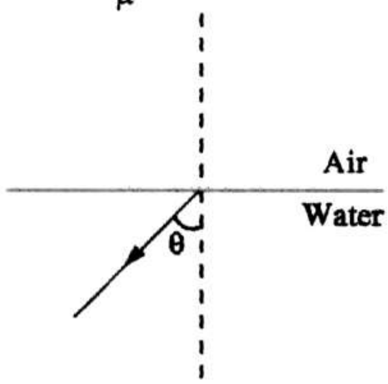
or $\frac{1}{f_2} = \left(\frac{3/2}{5/3} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

or $\frac{1}{f_2} = -\frac{1}{10}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$\frac{1}{f} = \left(\frac{3}{2} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) = \frac{1}{2}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Hence, $f_1 = 4f$ and $f_2 = -5f$.

58. Since, $\sin\theta = \frac{1}{\mu}$



The refractive index (μ) of the medium depends on the wavelength of light. μ is less for greater wavelength.

Therefore, θ will be more for less frequency of light.

Hence, the spectrum of visible light whose frequency is less than that of green light will come out of the air medium.

59. If the polaroid is rotated through 30° w.r.t. beam A, then beam B will be at 60°

$$\therefore I_A \cos^2 30^\circ = I_B \cos^2 60^\circ$$

or $$I_A\left(\frac{3}{4}\right) = I_B\left(\frac{1}{4}\right)$$

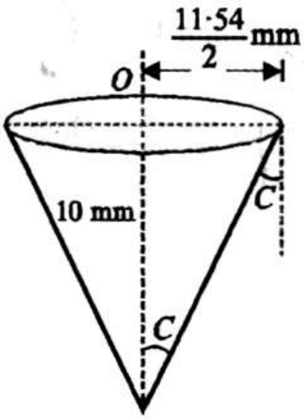
or $$\frac{I_A}{I_B} = \frac{1}{3}.$$

60. $\sin C = \dfrac{\mu_l}{\mu_b} = \dfrac{\mu_l}{2.72}$ ...(*i*)

Where, μ_l = refractive index of liquid

μ_b = refractive index of block

Also, from figure



$$\sin C = \frac{11.54/2}{\sqrt{\left(\frac{11.54}{2}\right)^2 + 10^2}} = \frac{5.77}{11.545}$$

$$\therefore \frac{\mu_l}{2.72} = \frac{5.77}{11.545}$$

or $\mu_l = 1.36$.

61. $\dfrac{1}{f_{film}} = (n_1 - 1)\left(\dfrac{1}{R} - \dfrac{1}{R}\right) = 0$

$\Rightarrow f_{film} = \infty$

So, no effect of presence of film

Now, from air to glass

$$\frac{n_2}{v} - \frac{1}{u} = \frac{n_2 - 1}{R}$$

or $$\frac{1.5}{v} - \frac{1}{\infty} = \frac{1.5 - 1}{R}$$

or $$\frac{1.5}{v} = \frac{0.5}{R}$$

or $$v = 3R$$

$$f_1 = 3R$$

From glass to air

$$\frac{1}{v} - \frac{n_2}{u} = \frac{1 - n_2}{-R}$$

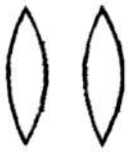
or $$\frac{1}{v} - \frac{1.5}{\infty} = \frac{1 - 1.5}{-R}$$

or $$\frac{1}{v} = \frac{0.5}{R}$$

or $$v = \frac{R}{0.5} = 2R \Rightarrow f_2 = 2R.$$

62. (P)  $\dfrac{1}{f} = \left(\dfrac{3}{2} - 1\right)\left(\dfrac{1}{r} + \dfrac{1}{r}\right) = \dfrac{1}{r}$

$\Rightarrow f = r$

 $\dfrac{1}{f_{eq}} = \dfrac{1}{f} + \dfrac{1}{f} = \dfrac{2}{f} = \dfrac{2}{r}$

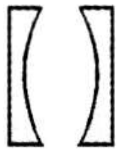
$\Rightarrow f_{eq} = \dfrac{r}{2}$

(Q)  $\dfrac{1}{f} = \left(\dfrac{3}{2} - 1\right)\left(\dfrac{1}{r}\right) \Rightarrow f = 2r$

 $\dfrac{1}{f_{eq}} = \dfrac{1}{f} + \dfrac{1}{f} = \dfrac{2}{f} = \dfrac{2}{2r} \Rightarrow f_{eq} = r$

(R)  $\dfrac{1}{f} = \left(\dfrac{3}{2} - 1\right)\left(-\dfrac{1}{r}\right) = -\dfrac{1}{2r}$

$\Rightarrow f = -2r$

 $\dfrac{1}{f_{eq}} = \dfrac{1}{f} + \dfrac{1}{f} = \dfrac{2}{f} = \dfrac{2}{-2r}$

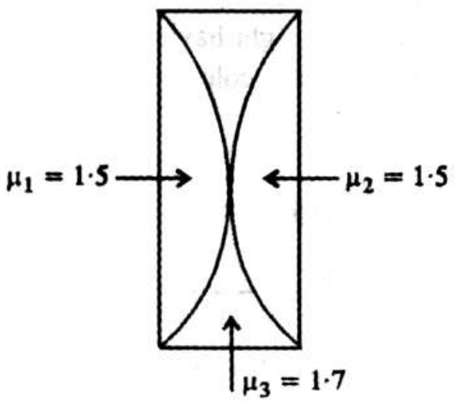
$\Rightarrow f = -r$

(S)  $\dfrac{1}{f_{eq}} = \dfrac{1}{r} + \dfrac{1}{-2r} = \dfrac{1}{2r}$

$\Rightarrow f_{eq} = 2r$

Thus, P – 2, Q – 4, R – 3, S – 1.

63.



This combination is equivalent to three lenses as shown in the figure.

use, $\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

For plano-convex lens, $R_1 = \infty$, $R_2 = -20$ cm

$\therefore \frac{1}{f_1} = \frac{1}{f_2} = (1.5 - 1)\left[\frac{1}{\infty} - \frac{1}{-20}\right] = \frac{0.5}{20} = \frac{1}{40}$

or, $f_1 = f_2 = 40$ cm.

For concave lens, $\mu = 1.7$, $R_1 = -20$ cm, $R_2 = 20$ cm

$\therefore \quad \frac{1}{f_3} = (1.7 - 1)\left(\frac{1}{-20} - \frac{1}{20}\right) = \frac{-7}{100}$

or, $f_3 = \frac{-100}{7}$ cm

Now, $\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$

$= \frac{1}{40} + \frac{1}{40} + \frac{1}{-100/7} = -\frac{1}{50}$

or, $f_{eq} = 50$ cm.

64. $\mu = \dfrac{\sin\left(\frac{A+\delta}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

or, $\cot\frac{A}{2} = \dfrac{\sin\left(\frac{A+\delta}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

or, $\dfrac{\cos\frac{A}{2}}{\sin\frac{A}{2}} = \dfrac{\sin\left(\frac{A+\delta}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

or, $\sin\left(\frac{\pi}{2} - \frac{A}{2}\right) = \sin\left(\frac{A}{2} + \frac{\delta}{2}\right)$

or, $\frac{\pi}{2} - \frac{A}{2} = \frac{A}{2} + \frac{\delta}{2}$

or, $\delta = \pi - 2A = 180^\circ - 2A$.

65. Here, $r = 0.25$ cm

$\therefore d = 2r = 2 \times 0.25 = 0.50$ cm

$= 0.50 \times 10^{-2}$ m

$\Delta\theta = \frac{1.22\lambda}{d} = \frac{1.22 \times 500 \times 10^{-9}}{0.50 \times 10^{-2}}$

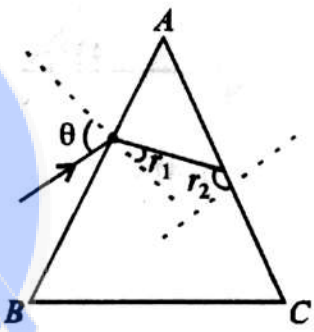
$= 1.22 \times 10^{-4}$ rad.

Hence, minimum separation that eye can resolve,

$x = D\,\Delta\theta = 25 \times 10^{-2} \times 1.22 \times 10^{-4}$

$= 30.5 \times 10^{-6}$ m $= 30.5$ μm $\cong 30$ μm.

66. $\mu = \frac{\sin\theta}{\sin r_1} \Rightarrow \sin r_1 = \frac{\sin\theta}{\mu}$



or, $r_1 = \sin^{-1}\left[\frac{\sin\theta}{\mu}\right]$

Also, $A = r_1 + r_2$

or, $r_2 = A - r_1 = A - \sin^{-1}\left[\frac{\sin\theta}{\mu}\right]$

Now, r_2 must be less than critical angle for the ray to get transmitted from face AC.

i.e. $r_2 < \sin^{-1}\left(\frac{1}{\mu}\right)$

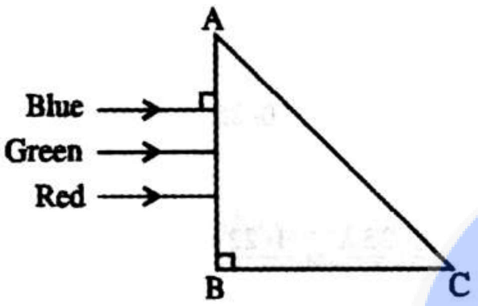
or, $A - \sin^{-1}\left[\frac{\sin\theta}{\mu}\right] < \sin^{-1}\left(\frac{1}{\mu}\right)$

$\Rightarrow \sin^{-1}\left[\frac{\sin\theta}{\sin\mu}\right] > A - \sin^{-1}\left(\frac{1}{\mu}\right)$

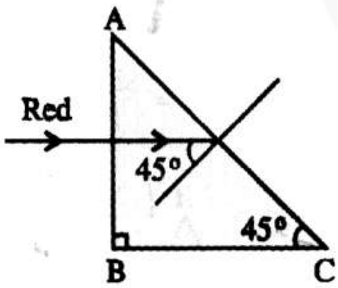
$\Rightarrow \frac{\sin\theta}{\mu} > \sin\left[A - \sin^{-1}\left(\frac{1}{\mu}\right)\right]$

or, $\theta > \sin^{-1}\left[\mu \sin\left(A - \sin^{-1}\frac{1}{\mu}\right)\right]$

67.



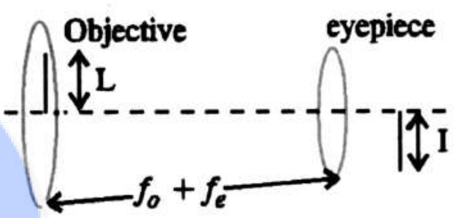
Refractive index of light rays that can just pass through the prism at grazing energence at 2nd second surface is



$$\mu = \frac{1}{\sin 45^\circ} = 1 \cdot 414$$

So, Light having refractive index < $1 \cdot 414$ takes refraction but light having $\mu > 1 \cdot 414$ suffers TIR.
$\therefore$ only only red colour light will come out of the prism.

68.



Magnification of telescope, $m = \frac{f_o}{f_e}$

here $\frac{f_e}{f_e + \mu} = \frac{-I}{L}$

$$\Rightarrow \frac{f_e}{f_e - (f_o + f_e)} = \frac{-I}{L}$$

$$\frac{f_e}{f_o} = \frac{I}{L}$$

$$\therefore m = \frac{L}{I}.$$

Hints and Explanations

1. Here $\frac{1}{3600} = \frac{10\text{ m}}{x}$.

Hence x = 36000 m = 36 km.

2. Refractive index $= \frac{c}{\upsilon} = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} / \frac{1}{\sqrt{\mu \varepsilon}}$

$$= \sqrt{\frac{\mu \varepsilon}{\mu_0 \varepsilon_0}} = \sqrt{\mu_r \varepsilon_r}.$$

3. Amount of energy falling on the surface in one second = 10 J. Momentum of the photons $p = \frac{h}{\lambda} = \frac{h\nu}{c} = \frac{E}{c}$, where E is the energy. On reflection, change of momentum = $2p$. Force = change in momentum per second = $2p/1$ = $2p$ = $2E/c$ = $(2 \times 10/3 \times 10^8)$ N = 6.67×10^{-8} N.

4. $\theta = l/r$. Here θ = 1 minute = $\left(\frac{1}{60} \times \frac{\pi}{180}\right)$ rad

And l = 3m. Hence $r = 3/[\pi/(60 \times 180)]$

$$= \frac{3 \times 60 \times 180}{\pi} \text{ m} = 10.3 \text{ km} \cong 10 \text{ km}.$$

5. $\lambda_m = \frac{\lambda_{air}}{\mu} = \frac{600 \text{ nm}}{4/3} = 450$ nm.

6. I = 10^{-10} Wm^{-2} = 10^{-10} Js^{-1} m^2. Let the number of photons required be n. Then

$n\,h\nu/10^{-4} = 10^{-10}$

Hence $n = 10^{-10} \times 10^{-4}/h\nu = 10^{-14}\lambda/hc$

$$= \frac{10^{-14} \times 660 \times 10^{-9}}{6.6 \times 10^{-34} \times 3 \times 3 \times 10^8}$$

$= 3.3 \times 10^4 = 33 \times 10^3$.

7. Energy radiated as visible light $= \frac{5}{100} \times 100 \text{ Js}^{-1} = 5 \text{ Js}^{-1}$. Let n be number of photons emitted per second. Then $n\,h\nu$ $= n\,hc/\lambda = 5$

Therefore $n = 5\lambda/hc = 1.4 \times 10^{19}$

8. $P = nC = \frac{h\nu}{C} = \frac{6.62 \times 10^{-34} \times 1.5 \times 10^{13}}{3 \times 108}$

$= 3.3 \times 10^{-29}$ kg m/s.

9. $E = h\nu = \frac{hC}{\lambda} = \frac{6.62 \times 10^{-34} \times 3 \times 10^8}{450 \times 10^{-9}}$

$= 4.4 \times 10^{-19}$ J.

10. $E = h\nu$

$\nu = \frac{E}{h} = \frac{6.6 \times 1.6 \times 10^{-19}\text{ J}}{6.6 \times 10^{-34}}$

$= 16 \times 10^{15}$ Hz.

11. $\frac{hc}{\lambda} = 10^3$ ev and $h\nu = 10^6$ eV

Hence $\nu = \frac{10^3\,C}{\lambda} = \frac{10^3 \times 3 \times 10^8}{1.24 \times 10^{-9}}$

$= 2.4 \times 10^{20}$ Hz.

12. Power of the eye

$$= \frac{5 \times 10^4 \times 6.67 \times 10^{34} \times 3 \times 10^8}{500 \times 10^{-9}}$$

$$= 0.2 \times 10^{-13} \text{ W/m}^2.$$

13. Energy of each photon

$$= \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{5000 \times 10^{-10}}$$

$$= 3.96 \times 10^{-19} \text{ J}$$

Total energy/second = 100 watt

= 100 J/s

Therefore number of photons/second.

$$= \frac{100}{3.96 \times 10^{-19}} = 2.5 \times 10^{20}$$

14. We know $C = \mu V$.

$V = C/\mu$

Since $\mu_w/\mu_g < \mu_d$

Therefore $V_w > V_g > V_d$

15. $$K.E. = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{0.016 \times 10^{-10}}$$

$$= \frac{6.6 \times 3 \times 10^{-13}}{16}$$

$$= 1.2375 \times 10^{-13} \text{ Joule.}$$