RAY OPTICS AND OPTICAL INSTRUMENTS

- Light is a form of energy. Light propagates in the form of electro-magnetic waves and photons
- Different theories are proposed to explain the nature of light and method of propagation of light energy.

NEWTON'S CORPUSCULAR THEORY:

- It proposes that a source emits light in the form of small, tiny elastic particles called "CORPUSCLES"
- Corpuscles travel in straight line paths.
- It proposes that speed of light is more in denser medium
- Different colours of light are due to the difference in size of corpuscles.
- Corpuscular theory succeeded in explaining reflection and refraction but failed to explain interference, diffraction and polarization.

HUYGEN'S WAVE THEORY:

- It proposes that entire universe is pervaded with invisible, low density, highly elastic hypothetical medium called ether.
- Every luminous body propagates light energy in the form of longitudinal,mechanical waves through ether medium
- The colour of light depends on the wavelength of these waves.
- It proposes that speed of light is more in rarer medium
- Wave theory succeeded in explaining reflection, refraction, interference and diffraction phenomenon
- Wave theory failed to explain polarization, photo electric effect, Compton effect.

MAXWELL'S ELECTRO MAGNETIC THEORY :

- It proposes that light propagates in the form of transverse electro-magnetic waves.
- These waves carry electromagnetic energy but not mechanical energy.
- In an electro magnetic wave, the electric and magnetic fields oscillate in mutually perpendicular directions and perpendicular to the direction of propagation of the wave.
- Em waves travel with a velocity of 3×10^8 m/s in vacuum.
- The velocity of these waves in vacuum is given by $C = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$ where

  μ_0 = permeability of free space

  ϵ_0 = permittivity of free space
- The electric field of an electro magnetic wave is responsible for optical effects.
- The theory explained the phenomena including polarization connected with wave nature of light.
- It failed to explain the black body radiation, photo electric effect, Compton effect.

MAX PLANK'S QUANTUM THEORY :

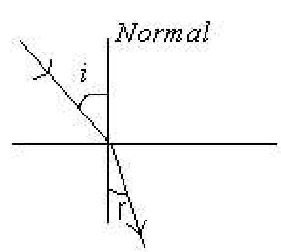
- It is proposed from the results of black body radiation experiment.
- It proposes that light radiation from a source travels through space in the form of discrete energy packets called quanta.
- Each quanta carry an energy of $E = h\nu$
- A quantum of light is called photon (name proposed by Einstein).
- Quantum theory explains photo electric effect, scattering, emission and absorption of radiation successfully.
- It fails to explain the phenomenon like Interference, diffraction and polarization

DUAL NATURE OF LIGHT :

- Light is to be considered as wave when it interacts with Light.
- Light is to be considered as photon when interacts with matter (such as electrons, protons).
- As light exhibits both wave and particle characters, light is said to be exhibiting "Dual nature".
- Eddington termed the nature of light as "Wavicle" (Wave + particle)

REFRACTION:

- The phenomenon of bending of light ray when it travels from one medium to another medium is called refraction.
- Refraction is due to change in the speed of light with medium.



- When a light ray suffers refraction its frequency remains same but wavelength and speed changes

- **LAWS OF REFRACTION:**
  - The incident ray, the refracted ray and the normal at the point of incidence are coplanar.
  - The ratio of **sine** of angle of incidence to **sine** of angle of refraction is a constant for a given pair of media and for a given colour of light.

$$\frac{\sin i}{\sin r} = \mu = \text{ constant}$$

μ = refractive index

- The "second law of refraction" is also called "law of sines " (or) **snell's law.**
- The value of "μ"is independent of i and r. It depends on the pair of media and colour of light.
- The value of μ is maximum for violet and minimum for red.
- As the temperature of medium increases, the refractive index decreases.
- The refractive index of any medium with reference to vacuum is called its absolute refractive index.

$$\mu_{\text{absolute}} = \frac{\text{velocity of light in vacuum}}{\text{velocity of light in the medium}}$$

$$\mu = \frac{C_o}{C_m} = \frac{\lambda_o}{\lambda m}$$

Since $C_m < C_o$, The absolute refractive index is always greater than one.

eg: μ_{water} = 1.33, μ_{glass} = 1.5

$\mu_{diamond}$ = 2.4

- When a ray of light passes from medium 1 to medium 2, the ratio of refractive index of medium 2 to that of medium 1 is called relative refractive index of medium 2 with respect to medium 1.

$$_1\mu_2 = \frac{\mu_2}{\mu_1} = \frac{C_1}{C_2} = \frac{\lambda_1}{\lambda_2} = \frac{\sin i}{\sin r}$$

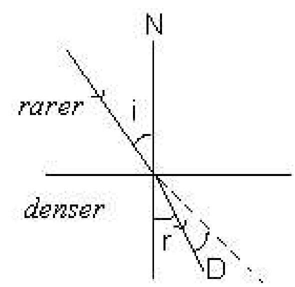
eg: Refractive index of glass with respect to water

is $_w\mu_g = \frac{\mu_g}{\mu_w} = \frac{9}{8} = 1.125$

- $1\mu_2 \times 2\mu_1$ = 1, represents principle of reversibilty
- If a light ray final path is reversed, it travels back along the same path in opposite direction. It is called "principle of reversibility"
- If a ray of light travels from a medium "a" to medium "b" then into another medium "C" and finally again into medium "a" then

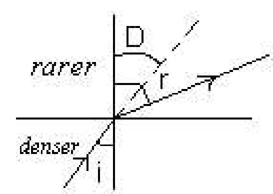
$$_a\mu_b \times _b\mu_c = _b\mu_c$$

- If light travels a distance x in a medium of refractive index μ the equivalent path in vacuum it would travel in the same time is μx. It is called optical path
- If 'c' is the velocity of light in vacuum, then the time taken by light to travel a distance 'x' in a medium of refractive index μ is given by t= $\frac{\mu x}{c}$
- When a ray of light travels from a rarer medium into a denser medium



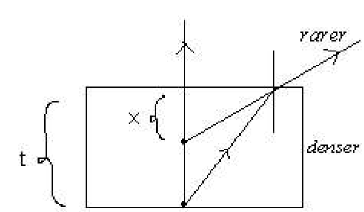
a) Its velocity and wavelength decreases
b) It bends towards normal. (i>r)
c) Angle of Deviation D=(i – r)

- When a ray of light travels from a denser medium into rarer medium



a)Its velocity and wavelenght increase
b)It bends away from the normal.(i < r).
c) Angle of deviation D = (r – i)

- The apparent depth of ponds and beakers filled with water and such liquids is always less than their real depth.
- When looking from a rarer medium (air) into a denser medium object appear to be nearer due to refraction.



$$\mu = \frac{\text{real depth}}{\text{apparent depth}}$$

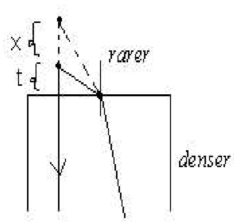
- The shift produced by a denser medium of thickness "t" is "x"

  $x=t(1-\frac{1}{\mu})$, It is independent of a height from which it is viewed
- When a point object is seen through a glass slab of thickness "t", it appears as if it is moved towards glass slab by distance, $\text{"x"} = t(1-\frac{1}{\mu})$
- If a glass slab is kept in the path of converging rays, the point of convergence moves away from the slab by distance

  $\text{"x"} = t(1-\frac{1}{\mu})$

- If the denser medium contains multiple layers of thickness t_1, t_2, t_3 ... and μ_1, μ_2 and μ_3 ... are refractive indices of different layers.

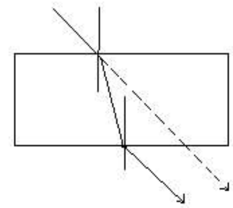
  apparent depth = $\frac{t_1}{\mu_1}+\frac{t_2}{\mu_2}+$............
- When looking from a denser medium into a rarer medium objects appear to be farther away.



$$\mu = \frac{\textbf{apparent depth}}{\textbf{real depth}}$$

When an object in rarer medium is seen from denser medium it appears to be farther and shift is $x=t(\mu-1)$

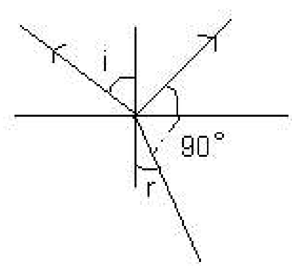
- Whenever a light ray passes through a glass slab the incident and emergent rays will be parallel to each other. But the emergent ray is displaced laterally.



The lateral displacement=x= $\frac{\mathbf{t}}{\mathbf{Cos\,r}}\mathbf{\sin(i-r)}.$

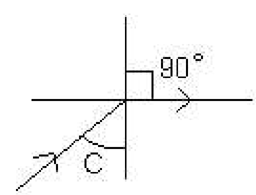
The length of the path travelled by light inside the glass slab = $\frac{t}{\text{Cos}\,r}$

- A ray of light travels from rarer medium and strikes a denser medium. If reflected and refracted rays are perpendicular to each other then the refractive index of denser medium is $\mu = \text{Tan}\,i$



- Critical Angle(C): when a ray of light enters a rarer medium from a denser medium the angle of incidence for which the angle of refraction becomes 90^0 is called critical angle (c).

$$\mu = \frac{\mathbf{1}}{\mathbf{sin\,c}}$$



As refractive index increases critical angle decreases.

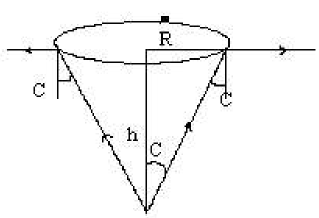
Critical angle for

1) diamond = $23^o35^|$ 2) for glass = $41^o49^|$

3) for ice = $50^o18^|$ 4) for water= $48^o36^|$

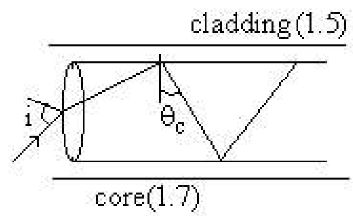
If C_1 and C_2 are the velocities of light in two media of refractive indices μ_1 and μ_2 ($\mu_2 > \mu_1$) then the critical angle for the pair of the media is given by Sin c = $\frac{\mu_1}{\mu_2} = \frac{C_2}{C_1} = \frac{\lambda_2}{\lambda_1}$

- Critical angle depends on the wave length and nature of given pair of medium.
- Critical angle depends on colour of light.
- The critical angle for violet is minimum.
- The maximum angle of refraction is possible in a medium only at the critical angle.
- In a medium, if the angle of incidence is just less than its critical angle, the ray undergoes refraction.
- In a medium if the angle of incidence is just equal to its critical angle, the ray of light grazes the surface of separation.
- In a medium, if the angle of incidence is greater than its critical angle, it undergoes "total internal reflection".
- For total internal reflection(TIR)
  - the ray of light travels from denser to rarer medium
  - the angle of incidence must be greater than the critical angle.
  - For a fish or diver under water the outside world appears to be within a cone of vertex angle 2C ($\approx 98^0$)
  - If "h" is the depth of the fish from the surface of the water of refractive index μ, the radius of the circle on the surface of the water through which it can see the outer world is R = h Tan C = $\frac{h}{\sqrt{\mu^2 - 1}}$



- **APPLICATIONS OF TIR :**
  - Brilliancy of a diamond
  - Mirages seen in deserts
  - A metal sphere coated with lamp black held in water appears bright.
  - Shining of small air bubble in water.
  - Total internal reflecting prisms (porroprisms) are right angled isosceles prisms which are used in binoculars, periscopes, range finders, cameras etc...
  - formation of looming in cold countries.
  - Fibre optics is developed basing on TIR. Gastroscope, Endoscope, bronchoscope and cystoscope work on this principle. They are used to observe the inaccessible internal parts of the human body.

OPTICAL FIBRE:



- An optical fibre is a long cylindrical transparent structure with a circular cross section.
- It consists of a thin fibre made of quartz or glass of high quality $(\mu = 1.7)$ which is called light guiding "core". It is about 10^{-6} m in thickness
- The coating applied on core with a material of less refractive index $(\mu = 1.6)$ is called "cladding".
- The core-cladding structure is enclosed by poly urathane foam jacket in order to safeguard it from chemical reactions and abrasion

r+c = 90^0 ; r = 90^0-c

$$\frac{\mu_2}{\mu_1} = \frac{1}{\sin C}$$

$$\mu_2 = \frac{\sin i}{\sin r}\ ;\ \sin i = \mu_2 \sin r = \mu_2 \cos C$$

$$= \sqrt{\mu_2^2 - \mu_1^2}$$

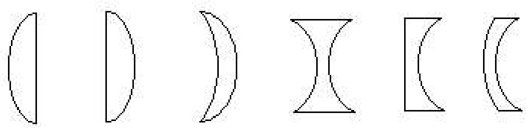
$$i = \sin^{-1}\left(\sqrt{\mu_2^2 - \mu_1^2}\right)$$

- Optical fibre works on the principle of total internal reflection.
- Light undergoes total internal reflection in the optical fibre if angle of incidence at the surface of core-cladding interface is more than critical angle of core material.
- Optical fibres are used
  - as light pipes in decorative lamps
  - to illuminate and examine the inside parts of human body (laproscopy, endoscopy)

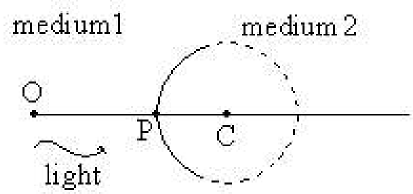
- in telephone industry
- in digital video transmission and in computers
- in under sea communication network
- to transmit and receive electrical signals which are converted into light
- to determine the refractive indices of liquids
- the optical fibre sensors are used to measure temperatures and pressures

LENS:

- Lens is a piece of transparent material with at least one curved surface and the refractive index of it is different from that of the surroundings.
- Lenses give both real and virtual images
- The nature of the image formed by a lens depends on the position of object and nature of lens.



- **SIGN CONVENTION:**



P : Pole = PC = Radius of curvature

  - Object distance, image distance and radius of curvature are measured from the pole of the curved surface
  - If Object distance, image distance and radius of curvature are measured in the direction of the incident ray, they are taken positive otherwise negative

Lens Maker's Formula :

- The focal length "f" of a lens in air or vaccum depends on
  - refractive index μ of its material
  - radii of curvature R_1,R_2 of its surface.

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

- When a lens is immersed in a liquid

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

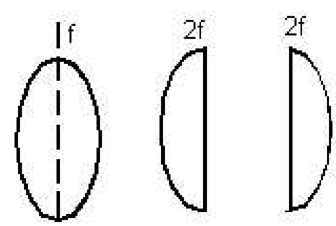
where μ_g = refractive index of lens

μ_l = refractive index of liquid.

When a glass lens of focal length 'f' and refractive index μ_g is placed in a liquid of refractive index μ_1 then new focal length f^1 is given by

$$\frac{f^1}{f}=\frac{(\mu_g-1)}{\left(\frac{\mu_g}{\mu_l}-1\right)}$$

- When the lens of focal length "f" made of glass (μ = 1.5) is immersed in water, $\left(\mu=\frac{4}{3}\right)$, its focal length becomes 4f.
- A lens immersed in a liquid whose refractive index is equal to that of the lens. The lens will have infinite focal length .Its focal power becomes zero.
- An air bubble in water behaves as a diverging lens.
  A liquid drop or a soap bubble in air behaves as a converging lens
- A convex lens immersed in a liquid of refractive index greater than that of the lens makes it behave like a concave lens and vice versa. ($\mu_g < \mu_1$)
- If a convex lens of focal length f is broken into two equal parts along principal axis the focal length of each part becomes "f".
- If an equiconvex lens of focal lengths 'f' is split into plano convex lenses perpendicular to principal axis the focal length of each becomes 2f.



- **LENS EQUATION:**
  - $\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$; f = $\frac{uv}{u+v}$
  - For a converging lens, the focal length is positive.
  - For a diverging lens, the focal length is negative.

- magnification $m = \frac{v}{u} = \frac{\text{size of image}}{\text{size of object}}$
- $u = f\left[1+\frac{1}{m}\right]$ for real image produced by convex lens
- $v = f(1+m)$
- The reciprocal value of focal length of a lens expressed in terms of meter is called its "focal power"(p)

  $P = \frac{1}{f}$ Where f is in meter

  $P = \frac{100}{f}$ where f is in centimeter
- The unit of focal power is Dioptre(D). If focal length of a lens is 1 meter then its power is said to be one diopter.
- The focal power is positive for converging lens and negative for diverging lens
- **THIN LENSES IN CONTACT**: If number of thin lenses of focal lengths f_1, f_2, f_3... are in contact with each other, the equivalent focal length "f" is given by $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} + ...$

  The equivalent focal power is $P = P_1 + P_2 + P_3 + ..$
- Lenses Separated by a Distance: When two lenses of focal lengths f_1 and f_2 are kept apart by a distance d , the effective focal length f is given by $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$

  The combined focal power 'P' of the system is

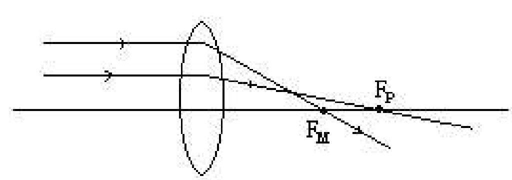
  $P = P_1 + P_2 - dP_1P_2$

  If a convex lens and a concave lens of equal focal lengths are combined, the focal length of combination is f = infinity and its focal power is zero.
  - Two convex lenses of focal lengths f_1 and f_2 are separated by a distance d such that a parallel beem incident on one lens emerges parallel from the other lens, then $d = f_1 + f_2$
  - In the above case if the second lens is concave then $d = f_1 - f_2$
- The positions of the object and the real image on the principal axis of a convex lens can be interchanged. The interchangeable points are called conjugate foci.
- The focal length of convex lens in conjugate foci method is $f = \frac{l^2 - d^2}{4l}$
- If I_1 and I_2 are the sizes of images formed in conjugate foci or lens displacement method, the size of object used is given by $OJ = \sqrt{I_1 I_2}$
  - If m_1 and m_2 are the magnifications of magnified and diminished images in two positions of conjugate foci method, then
    - $m_1 \times m_2 = 1$
    - $\frac{m_1}{m_2} = \left(\frac{L+d}{L-d}\right)^2$
    - $f = \frac{d}{m_1 - m_2}$

DEFECTS OF IMAGES:

- The defects and imperfections developed in images are known as aberrations
- The monochromatic aberrations are of five types
  1) spherical aberration 2) coma
  3) Astigmatism 4) Curvature
  5) Distortion
- The aberrations formed by a lens with white light or composite light producing coloured images are called chromatic aberrations.
- The light rays that are incident near the principal axis of a lens with large aperture are called paraxial rays
- The light rays that are incident farthest from the principal axis of a lens of large aperture are called marginal or peripheral rays.
- The marginal rays after refraction through lens converge at a point called marginal focus (F_m).
- The paraxial rays after refraction through lens converge at a point called paraxial focus (F_p).

SPHERICAL ABERRATION:



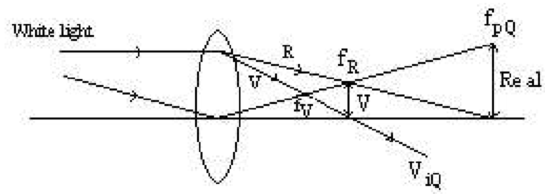
- The failure of lens to bring to focus all the marginal rays and paraxial rays at a single point is called "spherical aberration".
- The marginal rays deviate more than paraxial rays. The focus of marginal rays is closer to the lens than focus of paraxial rays.

- The focal length of lens is greater for paraxial rays than for marginal rays.
- The distance between the paraxial focus(F_P) and the marginal focus (F_m) is called longitudinal spherical aberration.
- The magnitude of longitudinal spherical aberration due to a lens depends on
  1. aperture of lens
  2. Radii of curvature of first and second surfaces (R_1,R_2) of lens and
  3. object distance
- The image of point object produced at focus of marginal rays (F_m) appears like a circular patch with non uniform intensity.
- The image produced at focus of paraxial rays (F_p) appears as a circular patch with maximum diameter. This image appears bright at centre and blurred at the edges.
- The position between F_m and F_p where the image has least area and appears like a bright disc is called "circle of least confusion"
- The position of circle of least confusion is the correct position of best image.
- The spherical aberration is positive for convex lens because F_p is to the right side of F_m and negative for concave lens because F_p is to the left side of F_m
- The spherical aberration is proportional to square of aperature

MINIMISING METHODS OF SPHERICAL ABERRATION:

- Usage of "stop" before the lens.
- Stops reduce the spherical aberration by limiting aperture of lens but they reduce the intensity of image.
- The crossed lens designed with the ratio of radii of curvatures of $\frac{R_1}{R_2} = -\frac{1}{6}$ can minimize the magnitude of spherical aberration.
- The crossed lens must be used so that incident light faces the surface of greater curvature of lens.
- The combination of two plano convex lenses separated by a distance equal to the difference between their focal lengths minimizes spherical aberration. $d = f_1 - f_2$

CHROMATIC ABERRATION:



- The failure of lens to converge light rays of different colours at the same point is called chromatic aberration.
- Chromatic aberration is due to dispersion of light in a lens.
- μ for violet colour is more than that of red, the focal length of lens for red colour is more than for violet colour $\mu_v > \mu_R \Rightarrow f_R > f_v$
- Due to prismatic action of lens violet colour undergoes greater deviation and converges nearer the optic center than red colour. So the image of a white object formed by a lens appears coloured and blurred
- The difference between the focal length of lens for red and violet colours gives the magnitude of longitudinal chromatic aberration($f_R - f_v$).
- The difference in magnifications between the images formed by red light and violet light is a measure of lateral chromatic aberration.
- Chromatic aberration is considered positive for convex lens because focus for red is the right side of the focus for violet and negative for concave lens because focus for red is to the left side of the focus for violet.

METHODS OF MINIMIZING CHROMATIC ABERRATION:

- By using thin lens
- A suitable combination of convex and concave lenses of different materials and focal length can be used as "Achromatic doublet" to minimize the chromatic aberration.

  The condition for achromatism of a doublet in contact is $\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0$

  Where ω_1 and ω_2 are dispersive powers of the lens and f_1, f_2 are their focal lengths.
- A lens combination of two lenses is used such that distance between lenses is eual to the average focal length $d = \frac{f_1 + f_2}{2}$

EYE-PIECES:

- The combination of two lenses used to increase field of view and to minimise aberrations is called Eye-piece
  In an eye piece the lens which is towards object is known as field lens and the lens nearer to the eye is called eye lens

RAMSDEN'S EYE-PIECE:

- It has two plano convex lenses (field lens and eye lens) of equal focal lengths "f".
- The separation between the lenses is $\frac{2}{3}$ of focal length of either lens.
- The convex surfaces of the two plano convex lenses must face each other.
- Its effective or equivalent focal lenghth is $\frac{3f}{4}$.
- The cross wires must be fixed at a distance of $\frac{f}{4}$ in front of field lens and at a distance $\frac{11}{12}f$ from the eye lens because the real image due to the objective forms at that position
- Cross wires can be placed with Ramsden's eye piece and hence it can be used for measurement.
- As it can not satisfy the conditions for spherical and chromatic aberrations ,it cannot produce clear image.
- It is called positive eye piece because the image due to the objective is fomed infront of the field lens.

HUYGEN'S EYE PIECE:

- It consists of two plano convex lenses, such that focal length of field lens is 3f and that of eye lens is f.
- The separation between two lenses is 2f and curved surfaces are towards object
- Its effective or equivalent focal length is $\frac{3f}{2}$ and the effective focal plane lies behind the field lens.Hence it is a negative eyepiece.
- The real image due to objective forms behind the field lens. So it is a negative eyepiece and cross wires cannot be fixed
- As it satisfies the conditions for minimum spherical and chromatic aberrations, it can produce clear image.
- As cross wires cannot be placed, it is not useful for measurements so it is preferred in biological microscopes for observation.

DISPERSION OF LIGHT:

- A prism whose apex angle is less than 10^0 can be cosidered as a thin prism
- For a thin prism with apex angle A and refractive index μ, the deviation produced is $d=(\mu-1)A$
- White light passing through prism not only deviates but also undergoes dispersion.
- The splitting of white light into seven constituent colours is called dispersion
- During dispersion deviation of red colour is minimum and that of violet colour is maximum [since $\lambda_R > \lambda_v \Rightarrow \mu_R < \mu_v$. Hence $d_R<d_v$].
- The difference in the deviations of any two colours is called angular dispersion. $\delta = d_v - d_R$
- For a thin prism $\delta = A(\mu_v - \mu_R)$. It depends on
  i) angle of the prism
  ii) the difference of the refractive indecies.
- The ratio of angular dispersion for two extreme colours to their mean deviation is called dispersive power of prism (ω)

  Dispersive power = $(\omega) = \frac{\text{Angular dispersion}}{\text{mean deviation}}$

  Dispersive power does not depend upon the angle of prism. It only depends upon material.
- The dispersive power of the material of a prism for red and violet colours is given by

  $\omega = \frac{d_v - d_R}{d}$ where $d = \frac{d_v + d_R}{2}$

  since angular dispersion $d_v - d_R = A(\mu_v - \mu_R)$

  $\omega = \frac{\mu_v - \mu_R}{\mu - 1}$ where $\mu = \frac{\mu_v + \mu_R}{2}$
- Dispersive power is the charecteristic property of the medium and it does not depend on the angle of prism.
- Dispersive power has no units and dimensions
- If A_1 and A_2 are the angles of prism then the condition for dispersion without deviation is
  i) $d_1 + d_2 = 0$ ii) $\delta_1 + \delta_2 \neq 0$
  iii) $A_1(\mu_1 - 1) + A_2(\mu_2 - 1) = 0$

$$\frac{A_1}{A_2} = \frac{-(\mu_2 - 1)}{(\mu_1 - 1)}$$

- If A_1 and A_2 are the angles of the prism then the condition for deviation without dispersion for mean ray (yellow ray) is
  - i) $\delta_1 + \delta_2 = 0$; $\omega_1.d_1 + \omega_2.d_2 = 0$
  - ii) $A_1(\mu_{V1} - \mu_{R1}) + A_2(\mu_{V2} - \mu_{R2}) = 0$
  - iii) $d_1 + d_2 \neq 0$

$$\frac{A_1}{A_2} = \frac{-(\mu_{V_2} - \mu_{R_2})}{(\mu_{V_1} - \mu_{R_1})}$$

- **VISIBLE SPECTRUM:**
  - Spectrum is the spread of colours "VIBGYOR" and it can be observed through a prism.
  - A spectrum of colours in which there is no overlapping and boundaries of colours are sharp is known as a pure spectrum.
  - To obtain a pure spectrum, we require
    - a narrow and parallel beam of composite light
    - a prism in minimum deviation position and
    - a lens or an astronomical telescope to focus the rays.
  - Spectro meter is used to get pure spectrum. Its essential parts are
    - collimator
    - prism table
    - telescope
    - circular scale and vernier arrangement
  - COLLIMATOR: It consists of a converging lens. If the distance between slit and convex lens is its focal length, it renders all the emerging rays narrow and parallel.
  - TELESCOPE: It is an astronomical telescope. It receives parallel rays of different colours. It is fitted with Ramsden's eye piece.
  - Adjustments of spectrometer in order
    - To focus cross wires
    - To focus the distant object with telescope
    - The slit is made narrow, and it is adjusted to give a parallel beam of light
    - The prism is in minimum deviation position

- Spectrometer is used to determine the refractive index of materials and wave length of different light waves.
- The spectra may be broadly divided into two types.
  1. Emission spectra
  2. Absorption spectra
- Emission spectra: It is the spectrum of light emitted by luminous objects
  eg: Vapour lamp, arc, bunsen flame give rise to emission spectrum.
  Emission spectra are of three types
  - Line spectra
  - Band spectra
  - Continuous spectra
- LINE SPECTRUM:
  It is the spectrum of light emitted by exited atoms in gaseous state
  eg: Hydrogen spectrum, Na vapour lamp
  - It consists of discrete coloured lines.
  - Each line represents the transition of electron from higher to lower energy level
  - Line spectra of no two elements look similar. Hence it is know as charecteristic spectra of elements
- **BAND SPECTRUM :**
  - It consists of discrete coloured bands with one edge sharp while the other edge gradually fades off followed by dark regions.
  - It is characteristic of molecular gases and chemical compounds.
  - It is also called molecular spectrum.
  - Nitrogen and cyanogen form band spectrum
- **CONTINUOUS SPECTRUM :**
  - The spectrum which extends from red to violet with overlapping of adjacent colours with no well defined boundaries is called continuous spectrum.
  - It is produced by incandescent solids, liquids and gases under high pressures.
  - Filament bulb, Flourescent light gives continuous spectrum crossed by a few lines. Candle flame, carbon arc lamp, hot charcoal, kerosene lamp are a few more examples.
- **ABSORPTION SPECTRUM:**
  - The spectrum of light emitted by a source formed due to the absorption of some of its component wave lengths by a transmitting medium is called absorption spectrum.

- A line absorption spectrum is produced when white light from a high temperature source is passed through a gas or vapour at comparatively low temperatures.

- **SOLAR SPECTRUM:**
  - It is a continuous spectrum crossed by a number of dark lines(absorption lines).
  - These dark lines are called Fraunhoffer lines.
  - Bunsen and Kirchoff explained the formation of these lines on the basis of the fact that "good absorbers are good radiators".
  - White light from interior of sun at 2×10^7 K passes through chromosphere at 6000 K. Then it undergoes selective absorption which results in the formation dark lines.
  - The element discovered with the help of Fraunhoffer lines is "Helium" (He).

CONCEPTUAL QUESTIONS

THEORIES OF LIGHT

1. Rectilinear propagation means
   1. Light travels in straight line path
   2. Light travels in curved path
   3. Light travels in parabolic path
   4. None of the above
2. The idea of quantum nature of light has emerged in an attempt to explain
   1. Interference 2. Diffraction
   3. Black body radiation
   4. Polarisation
3. According to Maxwell most of the optical properties of light depend on
   1. Magnetic vector 2. Electric vector
   3. Both electric and magnetic vectors
   4. Can not be decided.
4. According to Huygens the ether medium pervading entire universe is
   1. Less elastic and more denser
   2. Highly elastic and less denser
   3. Not elastic 4. Much heavier
5. According to Maxwell's theory the value of $\frac{1}{\sqrt{\mu_o \in_o}}$ for free space represents
   1. Wave length in any medium
   2. Frequency of light
   3. Velocity of light in vacuum
   4. Dual nature of light
6. Newton has postulated his corpuscular theory on the basis of
   1. Newton's rings 2. Colour due to thin film
   3. Dispersion of light
   4. Rectilinear propagation of light
7. According to corpuscular theory the colour of the light is given by
   1. speed of the corpuscule
   2. size of the corpuscule
   3. mass of the corpuscule 4. All the above
8. Huygen's wave theory could not explain
   1. reflection of light 2. refraction of light
   3. interference of light 4. double refraction
9. For the propagation of light wave, medium is required. This is according to
   1. Maxwell's theory 2. Huygen's theory
   3. Planck's theory 4. Newton's theory
10. Huygen's theory could not explain
    1. reflection of light 2. refraction of light
    3. Interference 4. polarisation
11. ASSERTION(A):Huygen's theory failed to explain polarization.
    REASON(R): According to Huygen's theory light is longitudinal wave
    1) A is correct, R is correct and it is the correct explanation
    2) A is correct, R is correct but it is not a correct explanation
    3) A is correct, R is wrong
    4) A is wrong , R is correct
12. (A) : Newton's corpuscular theory of light could not explain refraction of light.
    (B) : Huygens wave theory fails to explain polarization property of light.
    1) A is true B is false 2) A is false B is true
    3) A and B are true 4) A and B are false
13. Assertion (A) : Corpuscular theory fails in explaining the velocitiy of light in air to water.
    Reason (R) : According to corpuscular theory, light should travel faster in denser media than in rarer media.
    1) A and R are true R is correct explanation for A
    2) A and R are true R is not correct explanation for A
    3) A is true but R is false
    4) A is false but R is true
14. In case of theory of light nature of light match the following

List - I	**List - II**
a) Light is a collection of photons	e) Newton's theory
b) Light is a from of electro magnetic wave	f) Huygen's theory
c) Light is a longitudinal mechanical wave	g) Maxwell's theory
d) Light is a stream of corpuscles	h) Max plank's theory

1) a-h; b-g; c-f; d-g 2) a-e; b-f; c-g; d-h
3) a-g; b-h; c-g; d-f 4) a-f; b-e; c-h; d-g

15. Match the following :

Type - I	Type - II
Wave lengths	Colour
a) 450 to 500 nm	e) Red
b) 500 to 550 nm	f) Blue
c) 550 to 600 nm	g) Green
d) 650 to 700 nm	h) Yellow

1) a-f; b-g; c-h; d-e 2) a-e; b-f; c-g; d-h
3) a-h; b-g; c-f; d-e 4) a-g; b-f; c-e; d-h

16. Assertion (A) : Velocity of light is more in rarer medium than in denser medium
Reason (R) : Light waves are longitudinal mechanical waves
1) Statement A is correct R is wrong
2) Statement A is correct R is right
3) Statement A and R both are correct but R is not explaining A
4) Statement A and R both are correct and R is explaining A

REFRACTION & TOTAL INTERNAL REFLECTION

17. When light travels from one medium to the other of which the refractive index is different, then which of the following will change?
1. Frequency, wavelength and velocity
2. Frequency and wavelength
3. Frequency and velocity
4. Wavelength and velocity

18. Light of frequency n, wave length λ travelling with a velocity v enters into a glass slab of R.I. μ then frequency, wave length and velocity of the wave in glass slab respectively are
1. $\frac{n}{\mu}, \frac{\lambda}{\mu}, \frac{v}{\mu}$ 2. $n, \frac{\lambda}{\mu}, \frac{v}{\mu}$
3. $n, \lambda, \frac{v}{\mu}$ 4. $\frac{n}{\mu}, \frac{\lambda}{\mu}, v$

19. A hunter desires to shoot a fish whose image could be seen through clear water. His aim should be
1. Above the apparent image of fish
2. Below the apparent image of fish
3. In the line of sight of fish
4. Parallel to the surface of water

20. When a ray of light travels from denser into rarer medium
1. i = r 2. i < r 3. i > r 4. ir = 1

21. As temperature of medium increases the critical angle
1. Increases 2. Decreases
3. Remains same 4. None of the above

22. A rectangular solid piece is placed in a liquid whose refractive index is the same as that of the solid
1. The sides of the solid will appear to be bent inward
2. The sides of the solid will appear to be bent outward
3. The solid will not be seen at all
4. The solid will appear as in air

23. There are 4 coloured spots on a table. Their colours are red, blue, green and yellow respectively. When the same parallel sided glass-slab is placed on all of them, the colour that appears to be raised maximum is
1. red 2. blue 3. green 4. yellow

24. A ray of light strikes a glass slab of thickness t if the refractive index of the slab is μ, the lateral displacement for small angles of incidence is
1. $t(\mu-1)$ 2. $\left(1+\frac{1}{\mu}\right)t$ 3. $\left(1-\frac{1}{\mu}\right)t$ 4. $(1+\mu)t$

25. If a distance X_1, in a rarer medium and a distance X_2 in a denser medium contain the same number of waves of a given monochromatic light, the refractive index of the rarer medium relative to the denser medium is
1. $\frac{x_1}{x_1-x_2}$ 2. $1-\frac{x_2}{x_1}$ 3. $\frac{x_2}{x_1}$ 4. $\frac{x_1}{x_2}$

26. Mirages are due to
1. Refraction of light
2. Total internal reflection of light
3. Dispersion of light 4. Scattering of light

27. Cause for the briliance of a well-cut diamond is
1. Diamond is colourless
2. Diamond is transparent
3. Light falling on the diamond is reflected back
4. Light which enters diamond is sent back by total internal reflection.

28. A ball coated with 'lamp black' put in a glass tank containing water appears silvery white due to
1. Refraction 2. Diffraction
3. Interference 4. Total internal reflection

29. In an optical fibre
1. Core region is transparent, cladding is opaque
2. Core region is opaque, cladding is transparent
3. Both core and cladding regions are transparent
4. Both core and cladding regions are opaque

30. In an optical fibre light undergoes total internal reflection whenever light is incident on core-cladding interface at an angle
1. Less than critical angle
2. More than critical angle
3. Equal to critical angle 4. 90^0

31. The inner region of an optical fibre
1. Acts like a denser medium
2. Acts like a rarer medium
3. Acts like medium with refractive index less than one
4. Acts like a diffracting substance

32. In an optical fibre during transmission of light
1. Energy increases 2. Energy decreases
3. Loss less propagation of energy takes place
4. None of the above

33. In an optical fibre
1. μ core = μ cladding 2. μ core > μ cladding
3. μ core < μ cladding 4.Can not be decided.

34. In an optical fibre the propagation light radiations are confined to
1. Cladding region
2. Supporting structure
3. Core region
4. Both core and cladding regions

35. Transmission of light through an optical fibre takes place due to
1. Interference 2. Diffraction
3. Photo electric effect
4. Total internal reflection

36. Optical fibres are used in medical equipment like
1. Stethescope 2. X-ray unit
3. Endoscope 4. Refractometer

37. Due to atmosphere refraction
1) The stars twinkle
2) The sun is seen before the actual sunrise and still seen after the sun set
3) The sun appears bigger during sunset or sun rise
4) All the above

38. A plane glass plate is placed over various coloured letters. The letter which appears to be raised least
1) violet 2) yellow 3) red 4) green

39. $\frac{\sin i}{\sin r}$ =constant, the value of constant depends upon
a) pair of media b) colour of incident light
c) wave length d) refracting nature of material
1) only on a 2) only on b
3) only on a, d 4) a, b, c, d

40. In case of refraction of light
a) frequency changes b) phase changes
c) speed changes d) wavelength changes
1) a is correct 2) c and d are correct
3) d, b, c are correct 4) a and b are correct

41. Assertion (A) : In optical fibre light is propagated by multiple total internal reflection.
Reason (R) : The refractive index of core of optical fibre is less than refractive index of cladding
1) A and R are true R is correct explanation for A
2) A and R are true R is not correct explanation for A
3) A is true but R is false
4) A is false but R is true

42. Assertion (A) : Formation of mirrages in hot deserts is a phenomina of total internal reflection.
Reason (R) : Air close to the land is hotter than the air far from the land in a hot desert.
a) Statement A is correct R is wrong
b) Statement A is correct R is right
c) Statement A and R both are correct but R is not explaining A
d) Statement A and R both are correct and R is explaining A
1) a 2) b 3) c 4) d

43. If μ_r be the relative permeability and $\in_r$ be the relative dielectric constant of a medium, its refractive index is (**IIT-90**)
1. $\frac{1}{\sqrt{\mu_r \in_r}}$ 2. $\frac{1}{\mu_r \in_r}$ 3. $\sqrt{\mu_r \in_r}$ 4. $\mu_r \in_r$

44. A ray of light from a denser medium strikes a rarer medium at an angle of incidence 'i' if the reflected and refracted rays are mutually perpendicular to each other then the critical angle is (**IIT 83**)
1. $\sin^{-1}$ (tan i) 2. $\cos^{-1}$ (tan i)
3. $\cot^{-1}$ (tan i) 4. cosec^{-1} (tan i)

45. If ${}_im_j$ represents refractive index when a light ray goes from medium i to medium j. Then the product ${}_2m_1 \times {}_3m_2 \times {}_4m_3$ is equals to (**CBSE 90**)
1. ${}_3m_1$ 2. ${}_3m_2$ 3. $1/{}_1m_4$ 4. ${}_4m_2$

LENSES AND LENS MAKER'S EQUATION

46. A spherical air bubble in water will act as
1. a convex lens 2. a concave lens
3. Plane glass plate 4. Plano-concave lens

47. A double convex lens of focal length f is cut into 4 equivalent parts. One cut is perpendicular to the axis and the other is parallel to the axis of the lens. The focal length of each part is
1. f/2 2. f 3. 2f 4. 4f

48. The focal length of a lens depends on
1. colour of light
2. radius of curvature of the lens
3. material of the lens 4. all the above

49. Out of a convex, a Plano convex and a concave The inner region of an optical fibreens of equal focal lengths, a sharp image can be produced by
1. Any lens 2. convex lens
3. Plano convex lens 4. concave lens

50. The spherical aberration in optical instruments is reduced by using
1. Plano convex lenses 2. Plane mirrors
3. Concave lenses 4. Spherical mirrors

51. The failure of the paraxial and marginal rays passing through the same point on reflection at a spherical mirror or refraction through a lens is known as

1. Chromatic aberraton
2. Spherical aberration
3. Astigmatism 4.Coma

52. If ω is the dispersive power and f is the mean focal length, then the longitudinal chromatic aberration is
1. $\frac{\omega}{f}$ 2. ωf 3. $\frac{\omega f}{2}$ 4. $2\omega f$

53. To minimise the spherical aberration choose the correct among the following
1. Using the combination of plano convex lenses with separaton equal to $\frac{f_1 + f_2}{2}$
2. Using crossed lens with condition $\frac{R_1}{R_2} = -\frac{1}{12}$
3. Focussing the incident light on more curved surface of plano convex lens
4. Focussing the incident light on plane surface of plano convex lens

54. A white object AB is kept before a convex lens. The lens produces the images of white object AB with sizes as $B_V A_V$ and $B_R A_R$ with respect to violent and red colours. Then.
1. Size of $B_V A_V$ = Size of $B_R A_R$
2. Size of $B_V A_V$ > size of $B_R A_R$
3. Size of $B_R A_R$> size of $B_V A_V$
4. Size of $B_R A_R$ = $\sqrt{B_V A_V}$

55. The circle of least confusion is the position where
1. Marginal rays converge
2. Paraxial rays converge
3. Best image with least area can be seen
4. Blurred image with maximum area can be seen

56. If f_Y and f_B are the focal lengths of a convex lens for yellow and blue colours respectively, then
1. $f_Y = f_B$ 2. $f_Y > f_B$ 3. $f_Y < f_B$ 4. $\sqrt{f_Y} = f_B$

57. Ratio of the focal lengths of field lens and eye-lens in Ramsden's eyepiece is of
1. 3 : 1 2. 1 : 3 3. 1 : 1 4. 2 : 1

58. Huygen's eyepiece is useful where we want to
1. Eliminate spherical as well a chromatic-aberration
2. Eliminate chromatic aberration
3. Eliminate coma
4. Eliminate distortion

59. If the focal length of the eye lens in Ramsden's eye piece is f, then the focal length of the field lens and separation between the field lens and cross wires are respectively
1. 3f and f 2. f and f/4
3. 3f and 2 f 4. 2f and 3f

60. The ratio of the distance of the corss wire from field lens and distance between lenses in Ramsden's eye piece is
1. 2 : 3 2. 3 : 4 3. 3 : 8 4. 3 : 2

61. An eye piece is constructed so that spherical and chromatic aberrations are minimised to the maximum extent. If its equivalent focal length is 'P' then the focal length of the field lens is
1. 3P/2 2. 2P 3. 2P/3 4. 3P

62. Consider the following two statements A and B and identify the correct choice in the given answers **(2001)**
A. In Huygen's eye piece, the two plane surfaces of two plano - convex lenses face towards the eye
B. In Huygen's eye piece the focal length of the field lens is equal to the focal length of the eye lens
1. both A and B are true
2. A is true but B is flase
3. A is flase but B is true
4. Both A and B are false

63. The decrease in the aperture of the lens changes
1) The position of the image
2) The size of the image
3) The intensity of the image
4) Both the position and size of the image

64. f_B and f_R are focal lengths of a convex lens for blue and red light respectively and f_B and f_R are the focal lengths of the concave lens for blue and red light respectively. We must then have
1) $f_B > f_R$ and $f_B < f_R$
2) $f_B < f_R$ and $f_B > f_R$
3) $f_B > f_R$ and $f_B > f_R$
4) $f_B < f_R$ and $f_B < f_R$

65. If a convex lens is dipped in a liquid whose refractive index is equal to the refractive index of the lens, then lens acts like a
1) concave lens
2) plane parallel glass plate
3) plano convex lens 4) plano concave lens

66. Parallel rays of light are focussed by a thin convex lens. A thin concave lens of same focal length is then joined to the convex lens and the result is that
1) the focal point shifts away from the lens by a small distance
2) the focal point shifts towards the lens by a small distance
3) the focal point of lens does not shift at all
4) the focal point shifts to infinity

67. A real image is formed by a convex lens, when it is cemented with a concave lens, again the real image is formed. The real image
1) shifts towards the lens system
2) shifts away from the lens sytem
3) remain in its original position
4) shifts to infinity

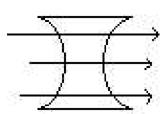
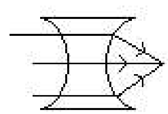
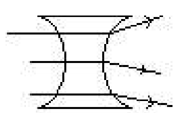
68. Acrossed lens is used to minimize the spherical aberration, in which ratio of radii of curvatures is the ratio of
1) 1/6 2) -1/6 3) 6/1 4) -6/1

69. What happens to the focal length of a thin convex lens if monochromatic red light is used instead of blue light to measure it ?
1) Increases 2) decreases
3) remains same 4) becomes zero

70. A wire gauge is illuminated with blue light and a convex lens forms a sharp image of it on a screen. If now the wire gauge is illuminated with red light, to get a sharp image again the screen must be
1) moved towards the lens
2) moved away from the lens
3) placed there itself
4) moved to infinity

71. To get real magnified image in convexlens, the object position is
1) in between lens and F 2) in between F and 2F
3) at 2F 4) beyond 2F

72. A concave lens made of R.I. μ_1 is immersed in a liquid of R.I. $\mu_2 (\mu_1 > \mu_2)$. When a parallel beam of white light incident on the lens, the correct diagram represents the phenomenon is

1) 
2) 
3) 
4) None

73. If the central portion of a convex lens is wrapped in black paper
1) no image is formed by the remaining portion of the lens
2) full image will be formed, but it will be less bright
3) the central portion of the image will be missing
4) there will be two images each produced by one of the eposed portions of the lens

74. Huygen's eye piece is called as -ve eye piece since
1) focal plane is on the negative side of the field lens
2) focal plane is on the positive side of the field lens
3) there will be no cross-wires
4) Focal length depends on colour of light

75. Consider the following statement & choose correct statement.
A) At polarised angle, the angle between reflected and refracted rays in 90
B) Above and below the polarized angle the reflected ray is not completely plane polarised
1) A and B is true 2) A and B false
3) A false, B true 4) A true, B false

76. Arrange the following combinations in the increasing order of critical angle
a) air, water interface
b) air, glass interface
c) water, glass interface
d) air, diamond interface
1) d, b, a, c 2) a, b, c, d
3) d, c, b, a 4) b, c, a, d

77. (A) : Huygen's eye piece cannot be used a telescope.
(B) : There is no provision of cross wires in case of a Huygens eye piece.
1) A true, B false 2) A false, B true
3) A false, B false 4) A true, B true

78. Assertion (A) : Ramsden eye piece is a positive eye piece.
Reason (R) : The focal plane of the Ramsden eye piece lies out side the combination
1) Statement A is correct R is wrong
2) Statement A is correct R is right
3) Statement A and R both are correct but R is not explaining A
4) Statement A and R both are correct and R is explaining A

79. 1) A convex lens always gives a real image
2) A concave lens always gives virtual image
3) A convex lens gives also magnified virtual image
4) A concave can be made as a convert lens with suitable medium
In the above statements, the true statements are
1) (1) and (2) 2) (1), (2) and (3)
3) (1), (3) and (4) 4) (2), (3) and (4)

80. Consider the following two statements A and B and identify the correct choice in the given answers. **(M2000)**
A. The curved surface of plano-convex lenses in Ramsden’s eye piece face each other
B. The focal length of field lens is 3 times the focal length of eye lens in Ramsden’s eye piece
1. Both A and B are true
2. Both A and B are flase
3. A is true and B is false
4. A is false and B is true

81. An achromatic combination of lenses produce
1. Image in black and white (**KARNATAKA-93**)
2. Coloured images
3. Image unaffected by variation of refractive index with wave length
4. highly enlarged images

82. A real image of a distant object is formed by a plano-convex lens on its principal axis. Spherical abberation (**IIT-98**)
1.is absent
2.is smaller if the curved surface of the lens faces object
3.is smaller if the plane surface of the lens faces the object
4.is the same whichever side of the lens faces the object

83. A converging lens is used to form an image on a screen. When the upper half of the lens is covered by an opaque screen. (**IIT 85**)
1. half of the image will disappear
2. completed image will be formed
3. Intensity of the image will increase
4. Intensity of the image will decrease

84. A convex lens of glass is immersed in water compared to its power in air, its power in water will
1. increase 2.decrease 3. not change
4. decrease for red light increase for violet light

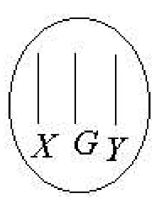
85. The graph drawn with object distance along abscissa and image distance along ordinate measuring the distance from the convex lens is
1. Straight line 2. Parabola
3. Circle 4. A hyperbola

86. In a Huygens eyepiece, with an eye-lens of focal length F the distance between eye-lens and field-lens should be **(1999)**
1. 2/3 F 2. F 3. 2F 4.3F

87. Which of the following is wrong about Huygens eye-piece **(1997)**
a.cross wires can be arranged
b.It can be used in biological instruments
c.Condition for achromatism is satisfied
d.Condition for chromatic abberation is satisfied
1) a, b 2) a, c 3) b, d 4) c, d

SPECTRA

88. The adjoining diagram shows the view through the eye-piece of a prism spectrometer with its slit illuminated by the source of light emitting three wavelengths corresponding to yellow (Y), Green (G) and unknown colour (X). The colour at X may be



1. Red 2. Orange 3. Pink 4. Blue

89. The order which has decreasing deviations
1. blue, green, red 2. red, blue, green
3. green, red, blue 4. green, blue, red

90. Wave front formed by the collimator of a spectrometer
1. Plane 2. Spherical
3. Cylindrical 4. paraboloidal

91. First adjustment of a spectrometer is
1. Focussing the distant object
2. Focussing the cross wires
3. Focussing the slit 4. Any one of the above

92. In a direct vision spectroscope, light undergoes.
1. Deviation without dispersion
2. Dispersion without deviation
3. Both dispersion and deviation
4.Neither dispersion nor deviation

93. Check the wrong statement
1. Line spectrum is characterstic of the element
2. Absorption spectrum is characteristic of the element
3. Continuous spectrum is characterstic of the source of light
4. There are two prominent yellow lines in the spectrum of sodium

94. At the time of total solar eclipse, Fraunhoffer lines in solar spectrum appear as
1. Black (dark) lines on a bright background
2. Bright coloured lines on dull background
3. Bright and dark bands
4. No spectrum is formed

95. The following spectrum can be obtained by iron in molten state
1. band 2. Line 3.Continuous 4.Solar

96. In the collimator of a spectroscope to obtain parallel beam of light, the distance between slit and convex lens must be equal to
1. Radius of curvature of lens
2. Refractive index of lens
3. Focal length of lens 4. none of the above

97. Light from a tungsten filament lamp give
1. Line spectrum 2. Absorption spectrum
3. Atomic spectrum 4. Continuous spectrum

98. The spectra used to identify the elements in the mixture is
1. emission 2. absorption
3. emission and absorption
4. molecular spectrum

99. A hollow glass prism gives
1. a dim spectrum 2. bright spectrum
3. no spectrum
4. only continuous spectrum

100. In the visible region the dispersive powers and the mean angular deviations for crown glass and flint glass prism are ω, ω^1 and d, d^1 respectively. The condition for getting dispersion with zero deviation when the two prisms are combined is. **(2001)**

1. $\sqrt{\omega d}+\sqrt{\omega^1 d^1}\#0$ 2. $\omega^1 d+\omega d^1\#0$

3. $\omega d+\omega^1 d^1\#0$ 4. $(\omega d)^2+\left(\omega^1 d^1\right)^2\#0$

101. Fraunhoffer lines are due to **(2001)**
1. The diffraction effects in the atmosphere
2. The absorption of sun's radiation by the earth's atmosphere
3. The absorption of sun's radiation by sun's atmosphere
4. The characteristic emission of sun'sradiation

102. Consider the following two statements A and B and identify the correct choice in the given answers **(2000)**
A. Line spectra is due to atoms in gaseous state
B. Band spectra is due to molecules
1. Both A and B are false
2. A is true but B is false
3. A is false but B is true
4. Both A and B are true.

103. In the achromatic prism, we have **(1998)**
1. deviation without dispersion
2. dispersion without deviation
3. refraction without deviation
4. deviation and dispersion

104. The element which was observed in solar spectrum is **(1996)**
1. Helium 2. Xenon 3. Neon 4. Argon

105. An incandescent filament emits a spectrum which is **(1996)**
1. line spectrum 2. Band spectrum
3. continuous spectrum
4. characterisitc spectrum

106. Dark lines in solar spectrum are due to **(1995)**
1. Lack of certain elements
2. Black body radiation
3. Absorption of certain wave length by chromosphere
4. Scattering

107. Match the following :

Type - I	**Type - II**
a) Continuous emission spectrum	e) Tungsten filament of a bulb
b) Line emission spectrum	f) CO_2 gas
c) Band emission spectrum	g) Sodium vapour lamp
d) Line absorption spectrum	h) Chromosphere of sun

1) a-e; b-f; c-g; d-h 2) a-f; b-e; c-h; d-e
3) a-e; b-g; c-f; d-h 4) a-h; b-g; c-f; d-e

108. Assertion (A) : The dark lines in solar-spectrum are called Fraun hoffer lines.
Reason (R) : The elements in the chromosphere of the sun absorb the light of their characteristic wavelengths commons from its photosphere
1) Statement A is correct R is wrong
2) Statement A is correct R is right
3) Statement A and R both are correct but R is not explaining A
4) Statement A and R both are correct and R is explaining A

109. Assertion (A) : An achromatic combination of lens is needed for the uninimisation of chromatic abberation.
Reason (R) : A single lens alone cannot satisfy the condition of minimisation of chromatic abberation
1) Statement A is correct R is wrong
2) Statement A is correct R is right
3) Statement A and R both are correct but R is not explaining A
4) Statement A and R both are correct and R is explaining A

110. A convex lens, glass slab, a glass prism, and a spherical solid ball have been prepared from the same optically transparent material. Dispersive power will be posessed only by
1. The glass slab and prism
2. lens and solid ball
3. The prism only 4.All the above

KEY

1) 1	2) 3	3) 2	4) 2	5) 3
6) 4	7) 2	8) 4	9) 2	10) 4
11) 1	12) 2	13) 1	14)	15) 1
16) 1	17) 4	18) 2	19) 2	20) 2
21) 1	22) 3	23) 1	24) 3	25) 3
26) 2	27) 4	28) 4	29) 3	30) 2
31) 1	32) 3	33) 2	34) 3	35) 4
36) 3	37) 4	38) 1	39) 4	40) 2
41) 1	42) 4	43) 3	44) 1	45) 3
46) 2	47) 3	48) 4	49) 3	50) 1
51) 2	52) 2	53) 3	54) 3	55) 3
56) 2	57) 3	58) 1	59) 2	60) 3
61) 2	62) 2	63) 3	64) 4	65) 2
66) 4	67) 2	68) 4	69) 1	70) 2
71) 2	72) 2	73) 1	74) 1	75) 3
76) 2	77) 4	78) 3	79) 3	80) 3
81) 3	82) 4	83) 2	84) 2	85) 3
86) 2	87) 4	88) 1	89) 1	90) 2
91) 2	92) 3	93) 2	94) 3	95) 3
96) 4	97) 1	98) 3	99) 3	100) 3
101) 4	102) 1	103) 1	104) 3	105) 3
106) 3	107) 4	108) 4	109) 4	110) 4

LEVEL - I

REFRACTION & SNELL'S LAW

1. Frequency of light is 5×10^{14}Hz. Its wavelength is
1. 6m 2.600 nm 3.6000nm 4.60 nm

2. Velocity of light in ice is 2.3×10^{8} m/s. Its refractive index is
1.1.5 2.2.5 3.1.305 4.2.3

3. The refractive indices of glass and water are 3/2 and 4/3 respectively. The refractive index of glass with respect to water is
1) 2 2) 8/9 3) 9/8 4) 5/3

4. When a ray of light traveling from vaccum to a medium of refractive index μ, the angle of incidence is twice the angle of refraction. The incident angle is
1) $\cos^{-1}\frac{\mu}{2}$ 2) $2\cos^{-1}\frac{\mu}{2}$
3) $2\sin^{-1}(\mu)$ 4) $2\sin^{-1}\frac{\mu}{2}$

5. Speed of light in vacuum is $3x10^8$ m/s. If refractive index of glass is 1.5, find the time taken by the light to travel 400 m in glass
1. $4\sqrt{3}s$ 2. $8\mu s$ 3. $2\mu s$ 4. $3\mu s$

6. The R.I. of water is 4/3. If ray travels 24 cm. in air in a given time t, the distance travelled by light in water in the same time t is
1. 32 cm 2. 24 cm 3. 18 cm 4. none

7. The time taken by a monochromatic light ray to travel a certain distance in air is 9×10^{-6} sec. The time taken by the light ray to travel the same distance in water of R.I. 4/3 is
1. 9μ sec 2. $12\ \mu$ sec.
3. $27/4\ \mu$ sec. 4. $1/12\ \mu$ sec.

8. The speed of light in water is three - fourth that in air. If wavelength of same light in air is 6000^{O}A, its wavelength in water is
1. 6000^{O}A 2. 6500^{O}A
3. 4000^{O}A 4. 4500^{O}A

9. Time taken by sun light to pass through a window of thickness 4 mm with refractive index 1.5 is [speed of light in vaccum= 3×10^8 m/s]
1. $2 \times 10^{-3}s$ 2. $2 \times 10^{5}s$
3. $2 \times 10^{-11}s$ 4. $2 \times 10^{-5}s$

10. To travel through the same distance in two different media, a light ray of certain frequency takes different times whichare in the ratio 3: 5, the relative refractive index is
1) 5/3 2) 3/2 3) 5/2 4) 7/5

MNR 87

11. The index of refraction of diamond is 2. velocity of light in cm per second is nearly **NCERT 79**
1. $6x10^{10}$ 2. $3x10^{10}$ 3. $2x10^{10}$ 4. $1.5x10^{10}$

12. Light of wave length 7200 A^{O} in air has a wave length in glass (μ=1.5) equal to
1. 7200 A^{O} 2. 4800A^{O}
3. 10800A^{O} 3. 7201.5A^{O}

13. If μ_r be the relative permeability and $\in_r$ be the relative dielectric constant of a medium, its refractive index is
1. $\frac{1}{\sqrt{\mu_r \in_r}}$ 2. $\frac{1}{\mu_r \in_r}$ 3. $\sqrt{\mu_r \in_r}$ 4. $\mu_r \in_r$

CPMT- 78

14. The velocity of light in glass whose refractive index with respect to air is 1.5 is $2x10^8$ ms^{-1}. In a certain liquid the velocity of light is found to be $2.5x10^8 ms^{-1}$. The refractive index of the liquid with respect to air is
1. 0.64 2. 0.80 3. 1.20 4. 1.44

AFMC - 92

15. Light passes from air into a liquid. The angle of incidence is 60^{O}. The deviation produced is 15^{O}. The refractive index of liquid is
1. 1.5 2. 1.33 3. 1.22 4. 1.63

CBSE - 90

16. If ${}_i\mu_j$ represents refractive index when a light ray goes from medium i to medium j. Then the product ${}_2\mu_1 \times {}_3\mu_2 \times {}_4\mu_3$ is equals to
1. ${}_3\mu_1$ 2. ${}_3\mu_2$ 3. $1/{}_1\mu_4$ 4. ${}_4\mu_2$

CRITICAL ANGLE AND TOTAL INTERNAL REFLECTION

17. The refractive index of a meium is 2. The critical angle for the medium is
1) 30^0 2) 60^0 3) 45^0 4) 37^0

18. The critical angle of a medium w.r.t. to vacuum is 30^0, velocity of light in this medium in m/s is
1) 3×10^8 2) 6×10^8
3) 1.5×10^8 4) $\sqrt{2} \times 10^8$

19. The velocity of lightin air is 3×10^8 m s^{-1} and the velocity of light in a medium is 2×10^8 m s^{-1}. The critical angle for the pair is SIN^{-1}
1) 2/3 2) 1/2 3) 1/3 4) 3/2

20. A fish under water at a depth of 20 cm can see the outer atmosphere through an aperture of radius of [critical angle of water is 45^{O}]
1.5 cm 2.20 cm 3.10 cm 4. $\frac{20}{\sqrt{3}}$

21. critical angles of two different media are 45^{O} and 60^{O} respectively. The ratio of velocities of light in those two media is
1. 2 : 3 2. $\sqrt{3}:\sqrt{2}$ 3. $\sqrt{2}:\sqrt{3}$ 4. $2:\sqrt{3}$

22. If the critical angle of the medium is 30^{O}. The velocity of light in that medium is [velocity of light in air 3×10^8 m/s]

1. $3\times10^8 m/s$ 2. $\frac{2}{10^8} m/s$

3. $1.5\times10^8 m/s$ 4. $\frac{4}{10^8} m/s$

23. Which the following pair is suitable to make core and cladding of an optical fibre

1) 1.6, 1.3   2) 1.6, 1.7
3) 1.3, 1.6   4) 1.24, 1.14

24. The critical angle for a pair a-b is 30^0, then the polarizing angle for the pair is

1) $\tan^{-1}(1/2)$ 2) $\tan^{-1}(2)$
3) $\tan^{-1}(3)$ 4) $\tan^{-1}(1/3)$

25. If the refractive index of water is 4/3, the velocity of light in vacuum is 3×10^{10} cm/sec. the time required to travel a distance of 450 cm in water will be **(1993)**

1. $0.2\mu s$ 2. $0.02\mu s$ 3. $2\mu s$ 4. $2000\mu s$

26. If "C" is the velocity of light in free space, the time taken by light to travel a distance x in medium of refractive index μ is given by **(1991)**

1. μxc 2. $\mu x/c$ 3. $\mu c/x$ 4. $x/\mu c$

27. Light takes t_1 sec to travel a distance x cm in vacuum and takes t_2 sec to travel 10x cm in a medium. The critical angle corresponding to the media is **(1994)**

1. $\sin^{-1}(10t_1/t_2)$ 2. $\sin^{-1}(t_2/10t_1)$
3. $\sin^{-1}(10t_2/t_1)$ 4. $\sin^{-1}(t_1/10t_2)$

28. Light wave of frequency 4×10^{14} Hz and λ = 5×10^{-7} m passes through a medium. The refractrive index of the medium is **(1990)**

1. 2/3 2. 4/3 3. 3/2 4. 1.414

29. The colour of light which travels with maximum speed in glass is **(1987)**

1. blue 2. green 3. red 4. violet

30. A glass slab is placed in the path of beam of convergent light. The point of convergence of light **(1986)**

1. moves towards the glass slab
2. moves away from the glass slab
3. remains at the same point
4. undergoes a lateral shift

35. The refractive index of a certain glass is 1.50 for light of wavelength 6000 A^{O}. When the light passes through this glass, its wave length will be (velocity of light in vacuum c = 3×10^8 m/s) **(1985)**

1. 6000 A^{O} 2. 4000 A^{O}
3. 9000 A^{O} 4. 7500 A^{O}

CPMT-93

31. The critical angle for light going from a medium in which wave length is 4000A^{O} to medium in which its wavelength is 6000A^{O} is

1. 30^{O} 2. 45^{O} 3. 60^{O} 4. $\sin^{-1}\left(\frac{2}{3}\right)$

IIT-98

32. A ray of light travelling in a transparent medium falls on a surface separating the medium from air at an angle of incidence 45^{O}. The ray undergoes total internal reflection. The possible value of refractive index of the medium with respect to air is

1. 1 2. 1.2 3. 1.4 4. 1.5

IIT 83

33. A ray of light from a denser medium strikes a rarer medium at an angle of incidence 'i' if the reflected and refracted rays are mutually perpendicular to each other then the critical angle is

1. $\sin^{-1}(\tan i)$ 2. $\cos^{-1}(\tan i)$
3. $\cot^{-1}(\tan i)$ 4. $\mathrm{cosec}^{-1}(\tan i)$

APPARENT SHIFT AND LATERAL SHIFT

34. A vessel of depth d filled with a liquid of refractive index μ_1 up to half its depth and the remaining space is filled with a liquid of refractive index μ_2. The apparent depth while seeing normal to the free surface of the liquid is

1) $d\left(\frac{1}{\mu_1}+\frac{1}{\mu_2}\right)$ 2) $d(\mu_1+\mu_2)$

3) $\frac{d}{2}\left(\frac{1}{\mu_1}+\frac{1}{\mu_2}\right)$ 4) $\frac{d}{2}(\mu_1+\mu_2)$

35. A bird in air is at a height Y from the surface of water. A fish is at a depth x below the surface of water. The refractive index of water is μ_1. The apparent distance of fish from the bird is

1) $x+\frac{y}{\mu}$ 2) $\mu x+y$

3) $\frac{x}{\mu}+y$ 4) $\frac{x}{\mu}+y$

36. A ray of light is travelling inside a rectangular glass block of refractive index $\sqrt{2}$ and incident on glass air interface at an angle of incidence 45^0. Under these conditions, the ray
1) will emerge into air with an angle of deviation 0
2) will be reflected back into the medium
3) will be absorbed
4) will just graze the surface of seperation of the two media

37. A plano convex lens of thickness 3 cm and radius of curvature 5 cm when seen normally through the flat surface, the thickness is found to be 2 cm. Then μ of material is **(1990)**
1. 3/2 2. 2/3 3. 6/5 4. 4/3

LENS MAKER'S FORMULA

38. A Glass lens has a focal length of 30 cm in air and its refractive index is 1.50. When it is dipped in carbon disulphide of refractive index 1.60, the lens behaves as
1. a convex lens of focal length 240 cm
2. a concave lens of focal length 240 cm
3. a transparent glass plate
4. None of the above.

39. A plano convex lens with radius of curvature 10 cm and refractive index 1.5 is pressed with another identical plano convex lens so that a double convex lens is formed. The focal length of resultant lens is
1. 20 cm 2. 10 cm 3. 5 cm 4. 30 cm

40. A convex lens, made of a material of refractive index 1.5 and having a focal length of 10 cm is immersed in a liquid of refractive index 3.0. The lens will behave as a
1. Converging lens of local length 10 cm
2. Diverging lens of focal length 10 cm
3. Converging lens of focal length 10/3 cm
4. Diverging lens of focal length 30 cm

41. A convex lens of focal length 20 cm is cut into two equal parts along the principal axis. The focal length of each part is
1. 40 cm 2. 20 cm 3. 10 cm 4. 5 cm

42. The radii of curvature of convexo - concave lens are 0.04 m and 0.05 m respectively. If its R.I. is 1.5. The focal length of the lens is
1) 0.4 m 2) -0.4 m 3) -0.2 m 4) 0.2 m

43. Focal length of a lens is 0.12 m and R.I. is 1.5. Focal length of the same lens for blue colour is 0.1175. Then R.I. of the lens for blue colour is
1) 1.51 2) 1 3) 1.49 4) 1.6

44. The focal length of an equiconvex lens of R.I. 1.5 is equal to
1) half of its radius of curvature
2) twice the radius of curvature
3) radius of curvature
4) $\frac{1}{4}$ th the radius of curvature

45. A double convex lens made of a material of refractive index 1.5 and having a focal length of 10 cm is immersed in a liquid of refractive index 3.0. The lens will behave as
1) converging lens of focal length 10 cm
2) diverging lens of focal length 10 cm
3) converging lens of focal length $\frac{10}{3}$ cm
4) converging lens of focal length 30 cm

46. A convex lens of focal length 0.15 m. is made of a material of refractive index $\frac{3}{2}$. When it is placed in a liquid its focal length is increased by 0.225m. The refractive index of the liquid is **E2002**
1. $\frac{7}{4}$ 2. $\frac{5}{4}$ 3. $\frac{9}{4}$ 4. $\frac{3}{2}$

47. A double convex lens of focal length 6 cm is made of glass of μ=1.5 the radius of one surface which is double that of other surface will be **(1991)**

48. The radii of curvature of an equi-convex lens, is each 30 cm, and the refractive index of the material of the lens is 1.5. Its focal length will be **(1985)**
1. 60 cm 2. 30 cm 3. 15 cm 4. 40 cm

49. The focal length of a biconvex lens of refractive index $\frac{3}{2}$ is 40 cm. Its focal length in m, when immersed in a liquid of refractive index $\frac{4}{3}$ is **(2002)**
1. 160 2. 16 3. 1.6 4. 0.8

50. A converging crown glass lens has a focal length 20 cm for the violet rays. Its focal length for red rays is (μ_V = 1.56, μ_R = 1.53) **(2001)**
1. 20.82 cm 2. 21.13 cm
3. 22.85 cm 4. 24.85 cm

51 A plano convex lens is made of a material of refractive index 1.6. The radius of curvature of the curved surface 60 cm. The focal length of the lens is **(1998)**
1. 50 cm 2. 100 cm 3. 200cm 4. 400 cm

52. A double convex lens of glass (μ=1.5) is immersed in water(μ=4/3). If the focal length in air is F, focal length in water is **(1995)**
1. F 2. F/2 3. 2F 4. 4F

53. A double convex lens of focal 30 cm is made of glass of refractive index 1.6. When it is immersed in a liquid, the focal length is found to be 126 cm. The refractive index of the liquid is **(1994)**
1. 1.4 2. 1.5 3. 1.33 4. 1.42

54. The refractive index of glass and water with respect to air are 3/2 and 4/3 respectively. The refractive index of gass with respect to water is **(1993)**
1. 8/9 2. 9/8 3. 1/2 4. 2

55. A double convex lens (μ = 3/2) of focal length 20 cm totally immersed in water (μ = 4/3). Its focallength will be **(1992)**
1. 20 cm 2. 80 cm 3. 40 cm 4. 10 cm

MNR 88

56. In a plano convex lens radius of curvature of the convex surface is 10cm and focal length of the lens is 30cm, the refractive index of the material of the lens is
1. 1.5 2. 1.66 3. 1.33 4. 3

CPMT-88

57. A double convex lens is made of glass which has refractive index 1.55 for violet rays and 1.50 for red rays. If the focal length of violet rays is 20 cm, the focal length for red rays is
1. 9 cm 2. 18 cm 3. 20 cm 4. 22 cm

LENS EQUATION, POWER AND COMBINTIONS

58. A convexlens of focal length produces a real image x times the size of an object, then the distance of the object from the lens is ....
1) (x-1)f 2) (x+1)f
3) $\left(\frac{x+1}{x}\right)f$ 4) $\left(\frac{x-1}{x}\right)f$

59. A plano-convex lens having radius of curvature 40 cm is made of glass of refractive index 1.5. The power of the lens is
1) zero 2) +5D 3)1.75D 4) 1.25D

60. The power of a double convex lens of radius of curvature R each is Y. The power of a plano convex lens of same material and of radius of curvature 2R is
1. Y/4 2. Y/2 3. 2Y 4. 4Y

61. The radius of curvature of the convex surface of a thin plano-convex lens is 15 cm and the refractive index of its material is 1. 6. The power of the lens is
1.+1D 2.-2D 3.+3D 4.+4D

62. Focal power of a plano-concave lens of refractive index 1.5 and of radius of curvature 50cm is
1.2D 2.-1D 3.1.5D 4.-1.5D

63. A lens forms a real image of an object on a screen placed at a distance of 100 cm from the screen. If the lens is moved by 20 cm towards the screen another image of the object is formed on the screen. The focal length of the lens is **(1989)**
1. 12 cm 2.24 cm 3. 36 cm 4. 48 cm

64. A convex lens of focal length 40 cm is in contact with a concave lens of focal length 25 cm. The power of the combination is **(1987)**
1. 1.5D 2. -1.5D 3. 6.5D 4. -2.5D

65. Two lenses of power +6 and -2 dioptres are placed in contact. The power of the combination will be **(1985)**
1. -12D 2.+4D 3.-4D 4.3D.

CPMT 83

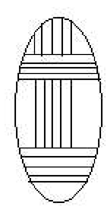
66. Two thin lenses when in contact produce a combination of power + 10D when they are 0.25m apart, the power reduces to +6D. The focal length of the lenses are
1. 20 cm, 30 cm 2. 30cm, 40cm
3. 12.5 cm, 50 cm 4. 25cm, 50cm

IIT-97

67. Two plano-concave lenses of glass of refractive index 1.5 have radii of curvatures 20 cm, 30 cm. They are placed in contact with curved surface towards each other and the space between them is filled with a liquid of refractive index 4/3. The focal length of the system is
1. 48 cm 2. 72 cm 3. 12 cm 4. 24 cm

IIT 75

68. The lens shown in the figure is made of two different materials. A point object is placed on the axis the number of images formed by the lens is



1. One 2. Two 3. Five 4.Three

ABERRATIONS AND EYEPIECES

69. Two plano convex lenses are adjusted so that the chromatic and spherical aberrations are reduced to minimum. The focal lengths of the lenses are in the ratio.
1. 1 : 1 2. 3 : 1 3. 1 : 3 4. 2 : 3

70. The magnitude of longitudinal chromatic aberration produced by a convex lens for the pair of violet and red colours is 0.353 cm. If the focal length of the lens with respect to violet colour is 15.295 cm, the focal length of lens for red coloured rays is
1. 14.942 cm 2. 15.648 cm
3. 15.295 cm 4. 15.118 cm

71. The focal length of eye lens of Ramsden's eye piece is 1.6 cm. The distance from corss wires to field lens is
1. 0.4 cm 2. 1.47cm
3. 1.07 cm 4. 3.2 cm

72. The focal length of field lens is 4.5 cm, Then theequivalent focal lengthof a Huygen's eye peice is
1) 2.25 cm 2) 1.5 cm
3) 3 cm 4) 2.5 cm

73. The effective focal length of Huygen's eyepiece is 3 cm. The focal power of field lens is
1. 6D 2. 16.7D 3. 3D 4. 10D

74. In Ramsden's eye piece the separation between field and eye lens is X cm. Its effective focal length is
1. $\frac{3}{4}x$ 2. $\frac{8x}{9}$ 3. $\frac{9}{8}x$ 4. $\frac{3}{2}x$

75. In a Huygens eyepiece, with an eye-lens of focal length F the distance between eye-lens and field-lens should be
(E1999)
1. 2/3 F 2. F 3. 2F 4. 3F

76. The lenses of focal lengths 75 cm and 25 cm will form a combination satisfying the condition with no chromtic aberration and minimum spherical aberration when they are placed at a distance of seperation of **(1993)**
1.125 cm 2. 60 cm 3 50 cm 4. 3 cm

DISPERSSIVE POWER AND SPECTRA

77. The focal lenths of thin lens are 50 cm and 46 cm for red and violet coloured rays respectively.
cm for red and violet coloured rays respectively. The dispersive power of the lens material is
1. 1/48 2. 4/98 3. 1/12 4. 1/96

78. In a prism, the refractive indices of different colours are $\mu_V = 1.6$; $\mu_R = 1.52$; $\mu_Y = 1.56$. The dispersive power of the prism is
1. $\frac{1}{56}$ 2. $\frac{1}{8}$ 3. $\frac{1}{7}$ 4. Infinite

79. The angles of minimum deviations are 53° and 51° for blue and red colours respectively produced in an equilateral glass prism. The dispersive power is
1. $\frac{51}{26}$ 2. $\frac{1}{26}$ 3. $\frac{1}{52}$ 4. $\frac{1}{51}$

80. A thin prism deviates blue and red rays through 10° and 6° respectively. Another prism deviates same colours through 8° and 4.5° respectively. The ratio of dispersive powers of the prisms is
1. 5 : 4 2. 4 : 5 3. 25 : 28 4. 5 : 28

81. The refractive indices of crown prism for violet and red lights are 1.523 and 1.513. Dispersive power of prism is
1. 0.19 2. 0.019 3. 0.0019 4. 19
MNR 88

82. A thin prism P_1 with angle 4° and made of glass of refractive index 1.54 is combined with another prism P_2 made of glass of refractive index 1.72 to produce dispersion without deviation. The angle of the prism P_2 is
1. 5.33° 2. 4° 3. 3° 4. 2.6°
ROORKEE - 79

83. While light is passed through a prism of angle 5°, If the refractive indices of red and blue colours are 1.641 and 1.659 respectively, the angle of dispersion between them is
1. 0.08° 2. 0.06° 3. 0.09° 4. 0.1°
CPMT 76

84. Two lenses of focal lengths +10 cm, and -15 cm when put in contact behave like a convex lens. They will have zero longitudinal chromatic aberration if their dispersive powers are in the ratio
1. + 3/2 2. + 2/3 3. - 3/2 4. - 2/4

KEY

1) 2	2)3	3)3	4) 2	5) 3
6) 3	7) 2	8) 3	9) 3	10)1
11)4	12) 2	13)3	14)3	15)3
16)3	17)1	18) 3	19)1	20)2
21)2	22) 3	23) 1	24) 2	25)2
26)2	27) 1	28) 3	29)3	30) 2
31) 2	32) 4	33) 3	34) 1	35) 3
36) 3	37) 4	38) 1	39) 2	40) 3
41)2	42)2	43) 2	44) 1	45) 3
46) 2	47) 2	48) 1	49) 2	50) 3
51)2	52) 2	53) 4	54) 1	55) 2
56) 2	57) 3	58) 4	59) 3	60) 4
61) 1	62) 4	63) 2	64) 2	65) 2
66) 2	67) 3	68) 1	69) 2	70) 2
71) 2	71) 2	72) 1	73) 2	74) 3
75) 3	76) 3	77) 3	78) 3	79) 2
80) 3	81) 2	82) 3	83) 3	84) 2

LEVEL - II

REFRACTION & SNELL'S LAW

1. A cube of side 15 cm is having an air bubble. The bubble appears at 6 cm from one face and at 4 cm from opposite face. The refractive index of cube is
1. 5/2 2. 3/2 3. 2/3 4. 2/5

2. A glass slab of thickness 4 cm contains the same number of waves as X cm of water column when both are traversed by the same monochromatic light. If the refractive indices of glass and water (for that light) are 5/3 and 4/3 respectively, the value of x will be

1. $\frac{9}{20}$cm 2. $\frac{20}{9}$cm 3. $\frac{5}{4}$cm 4. 5cm.

3. If incident ray vector is i is refracted ray vector and j is perpendicular vector to the surface of a medium of the refractive index μ then law of refraction is **(M1995)**

1. (ixn)= μ (nxr) 2. μ (ixn) = (nxr)
3. (i.n) = (μ n.r) 4. μ (i.n) = (n.r)

APPARENT SHIFT & LATERAL SHIFT

4. A layer of benzene (μ =1.50) 6 cm deep floats on water (μ =1.33) 4 cm deep. When viewed vertically through air, the apparent distance of the bottom of the vessel below the free surface of the benzene is

1. 14 cm 2. 5 cm 3. 7 cm 4. 3.5 cm

5. Refractive index of a rectangular glass slab is $\mu=\sqrt{3}$. A light ray incident at an angle 60^0 is displaced laterally through 2.5 cm. Distance travelled by light in the slab is

1. 4 cm 2. 5 cm
3. $2.5\sqrt{3}$ cm 4. Not possible to find out

6. A ray of light is incident upon a parallel sided transparent slab of thickness 9 cm at an angle of incidence 60°. If the angle of refraction is 30°, the lateral displacement of the light ray is

1. $\sqrt{3}$ cm 2. $3\sqrt{3}$ cm 3. 3 cm 4. $\frac{2}{\sqrt{3}}$ cm

7. A microscope is focussed on an ink dot on a white paper. A glass slab of thickness 0.03m with μ = 1.5 is placed on the paper. To focus the ink dot clearly the micorscope must be

1. Raised by 0.02m 2. Lowered by 0,02m
3. Raised by 0.01m 4. Lowered by 0.01m

8. A travelling microscope is focussed on a mark on a piece of paper and the scale reading is A. A rectangular block of glass is placed on the paper and the microscope is raised and focussed the mark on the paper. The microscope reading now is B, the paper is now placed on the block of glass.The reading now is C. The refractive index of the material of the block is

1. $\frac{C-B}{C-A}$ 2. $\frac{C-A}{C-B}$ 3. $\frac{C-A}{B-A}$ 4. $\frac{C}{C-A}$

9. A point source of light is placed at the bottom of a vessel containing a liquid of R.I. 5/3. A person is viewing the source from the above surface. There is an opaque disc of radius 1 cm floating on the surface. The centre of the disc lies vertically above the source. The liquid from the vessel is gradually drained out through a tap. The maximum height of the liquid for which the source cannot be seen at all from the above is ...... cm

1) 3/2 2) 4/3 3) 2/3 4) 3/4

10. After focusing the compound microscope to an ink spot on a paper, a glass slab of thickness 0.03 m and refractive index 1.5 is placed in between the paper and the instrument to see the same ink spot clearly the instrument should be

1) raised by 0.03 m
2) moved down by 0.03 m
3) raised by 0.01 m
4) moved down by 0.01 m

CRITICAL ANGL &TOTAL INTERNAL REFLECTION

11. The critical angle of light going from medium A into medium B is θ The speed of light in medium A is v. the speed of light in medium B is

1. $v/\sin\theta$ 2. $v\sin\theta$
3. $v/\tan\theta$ 4. $v\tan\theta$

12. Light ray is travelling from a denser medium into a rarer medium. The velocity of light in the denser and rarer medium is 2×10^8 m/sec. and 2.5×10^8 m/sec. The critical angle of the two media is

1. $\sin^{-1}5/4$ 2. $\sin^{-1}4/5$ 3. $\sin^{-1}1/2$ 4. $\sin^{-1}1/2.5$

13. A light source placed at the bottom of a water beaker 10 cm deep forms an illuminated circle of radius 11.3 cm at its surface. If the depth of the water in the beaker is increased to 20 cm, the radius of the illuminated circle will be

1. 16.8cm 2. 30.6 cm 3. 22.6cm 4. None

14. Ratio of wavelengths of light passing from one medium to another is 4:5. Ratio of the speeds of light in the two media is

1. 4:5 2. 5:4 3. $\sqrt{5}$:2 4. 2: $\sqrt{5}$

15. A ray of light falls on a transparent glass plate ($\mu=\sqrt{3}$) part of it is reflected and part is refracted. The reflected and refracted rays can be perpendicular to each other for.

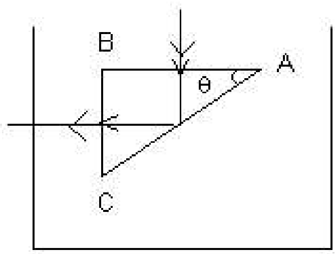
1. No Angle of incidence
2. Angle of incidence equal to 90°
3. Angle of incidence greater than 90°
4. Angle of incidence less than 90°

16. A point source of light is placed 4cm below the surface of water of refractive index 5/3. The minimum diameter of a disc, which should be placed over the source, on the surface of water to cut off all light coming out of water is
1. 2 cm 2. 6cm 3. 4m 4. 3m

17. The ray of light travels from an optically denser to rarer medium. The critical angle for the two media is C. The maximum possible deviation of the ray will be

1. $\frac{\pi}{2}$-C 2. π-2C 3. 2C 4. π/2+C

18. For the total internal reflection in the figure



1) sin μ <8/9, water must have greater μ.
2) sin θ>8/9, water must have less refractive index.
3) sin θ>8/9 the prism material must have less refractive index.
4) all are true
Which are of the above states are wrong
1) (1), (2) and (3) 2) (1), (3) and (4)
3) (2), (3) and (4) 4) (3), (4)

LENS MAKER'S FORMULA

19. A convex lens of focal length 25 cm is made of glass (μ = 1.5). If it is immersed in water (μ = 1.33), its focal power is...
1. 10D 2. 1D 3. 100D 4. 0.1D

20. A double convex thin lens made of glass (refractive index, μ=1.5) has both radii of curvature of magnitude 20 cm. Incident light rays parallel to the axis of the lens will converge at a distance d in cm, such that
1. d=10 2. d=20/3 3. d=40 4. d=20

21. A biconvex glass lens has a focal length of (f). It becomes equiconvex if R_1 is doubled and R_2 is halved. Then its focal length becomes
1. 1.25f 2. 0.8f 3. 2f 4. 2.2f

22. A double convex lens of focal length 30 cm is made of glass of R.I. 1.6 when it is immersed in a liquid, the focal length is found to be 126 cm. The R.I. of the liquid is
1) 1.33 2) 1.5 3) 1.4 4) 1.42

23. The focal length of a lens are in the ratio 13:8 when it is immersed in two different liquids of refractive indices 1.3 and 1.2 respectively. The refractive index of the material of the lens is
1) 1.25 2) 1.56 3) 1.5 4) 0.5

24. A thin convergent glass lens μ=1.5 has a power of +5D. When this lens is immersed in a liquid of refractive index μ it acts as a diverging lens of focal length 100 cm. The value of μ must be
1) 5/3 2) 4/3 3) 5/4 4) 6/5

LENS EQUATION, COMBINATIONS, POWER

25. The distance between an object and the screen is 100 cm. A lens produces an image on the screen when placed at either positions 40 cm apart. The power of the lens is
1. $\approx$3D 2. $\approx$5D 3. $\approx$7D 4. $\approx$9D

26. A plano convex lens has a thickness of 6 cm. Its radius of curvature is 25 cm. When its curved surface is kept on a horizontal surface and viewed from the top, its bottom appears to be raised by 2 cm. The focal power of lens is
1. 1 D 2. 4 D 3. 2D 4. None

27. A lens forms a sharp image on a screen. On inserting a paralle-sided slab of glass between the lens and the screen it is found necessary to move the screen a distance 'd' away from the lens in order for the image to be again sharply focussed. If the refractive index of glass relative to air is μ then the thickness of the slab is:

1. $\frac{d}{\mu}$ 2. $\frac{\mu}{d}$ 3. $\frac{\mu d}{(\mu-1)}$ 4. $\frac{(\mu-1)d}{\mu}$

28. The refractive index of the material of a plano convex lens is 1.5. Its radius of curvature is 30 cm. If the lens produces a real image of an object kept at 120 cm from it, the magnification produced is.
1. 3 2. 2 3. 1 4. 8

29. Two thin lenses of powers 2D and 3D are placed in contact. An object is placed at a distance of 30 cm from the combination. The distnce in cm of the image from the combination is
1. 30 2. 40 3. 50 4. 60

30. Two convex lenses of focal lengths 10 cm and 20 cms are kept apart. If the resultant focal length of such combination is 8 cm, the distance between the lenses is
1. 10 cm 2. 5 cm 3. 20 cm 4. 15 cm

31. Two thin lenses when in contact produce a combination of power +10 D. When they are 0.25 m apart the power is reduced to +6 D. The power of the lenses in diopters are
1. 1 & 9 2. 2 & 8 3. 4 & 6 4. 5 each

32. A parallel beam of monochromatic light falls on a combination of a convex lens and a concave lens of focal lengths 15 cm & 5 cm respectively. If the light emerges parallel from the concave lens. The distance between two lenses is
1. 20 cm 2. 3 cm 3. 10 cm 4. 45 cm

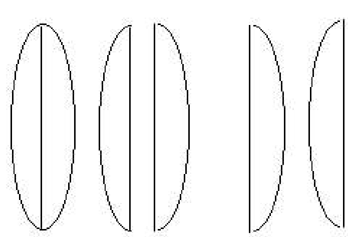
33. A symmetric double convex lens is cut into two equal parts by a plane perpendicular to the principal axis. If the power of the original lens was 4D, the power of a cut lens will be
1. 2D 2. 3D 3. 4D 4. 5D

34. A convex lens made of glass of refractive index 1.5 has a power of 10D in air. If it is immersed in a liquid of refractive index 1.5 the power of lens is
1. Infinity 2. 10D 3. 5D 4. Zero

35. An equibiconvex lens of focal power 10D is cut into two equal parts perpendicular to its axis. If its refractive index is 1.5, the radius of curvature of one of the parts is
1. 20 cm 2. 10 cm 3. 40 cm 4. 5 cm

36. If R_1 and R_2 are the radii of curvature of a double convex lens. Which of the following will have the largest power?
1. $R_1 = \infty$, $R_2 = 10$ cm
2. $R_1 = 10$ cm, $R_2 = \infty$
3. $R_1 = 10$ cm, $R_2 = 10$ cm
4. $R_1 = 5$ cm, $R_2 = 5$ cm

37. A convex lens of focal length 20 cm is cut into two equal parts so as to obtain two plano convex lenses as shown in the fig (a). The two parts are then put in contact as shown in fig(b) The focal length of the combination is



a *b*

1. zero 2. 5cm 3. 10cm 4.20cm

38. An equi convex lens of focal length 10 cm is cut into two equal halfs by cutting along a plane perpendicular to the principal axis. The two pieces are put 10 cm apart with curved surfaces facing each other. The focal length of the new combination is
1. 8 cm 2. 20 cm 3.40/3 cm 4.10 cm

39. Two identical plano convex lenses are arranged in three different combinations as
I) the plane surfaces touching each other
II) the curved surfaces touching each other
III) the plane surface of one lens touching the curved surface of the other. Then the focal lengths of the combinations are in the ratio
1. 1 : 2 : 3 2. 1 : 1 : 1
3. 3 : 2 : 1 4. 2 : 2 : 1

40. Three lens in contact have a combined focal length of 12 cm. When the third lens is removed, the combined focal length is 60/7 cm. The third lens is
1) a converging lens of focal the length 30 cm
2) a converging lens of focal the length 60 cm
3) a diverging lens of focal length 30 cm
4) a diverging lens of focal length 60 cm

41. A convex lens forms an image of a distant object at a distance of 20 cm from it. On keeping another lens in contact with the first, if the image is formed at a distance of 40/3 cm from the combination, then the focal length of the second lens is
1) -20 cm 2) -40 cm 3) 40 cm 4)13.33 cm

42. The distance between two point sources of light is 24 cm. Find out where would you place a converging lens of focal length 9 cm, so that the images of both sources are formed at the same point
1) 6 cm 2) 18 cm
3)18 cm or 6 cm 4) 24 cm

ABERRATIONS, DISPERSSION AND EYEPIECES

43. A convex lens of focal length 15 cm is combined with a concave lens of focal length 30 cm to obtain an achoromatic combination. If the dispersive power of the material of the convex lens is 0.02, then the magnitude of dispersive power of the material of the concave lens is
1. 0.02 2. 0.01 3. 0.04 4. 2.02

44. An achromatic convergent lens of equivalent focal length +20cm is made of two lenses (in contact) of materials having dispersive powers in the ratio of 1:2 and having focal lengths f_1 and f_2. Which of the followisng is true
1. f_1 = 10cm, f_2 = 20cm
2. f_1 = 20cm, f_2 = 10cm
3. f_1 = 10cm, f_2 = -20cm
4. f_1 = 20cm, f_2 = -10cm

45. Two plano convex lenses of focal lengths f_1 and f_2 set for minimising spherical aberration are kept apart by 2 cm. If the equivalent focal length of combination is 10 cm, the values of f_1 and f_2 are
1. 18 cm, 16 cm 2.18 cm, 20 cm
2. 20 cm, 22 cm 4.14 cm, 20 cm

46. Two plano convex lenses of same material and of focal lengths 20 cm. & 5 cm should be arranged such that the combination is free from chromatic abberation. Then effective focal length of the combination will be
1. 20 cm 2. 4 cm 3. 12.5 cm 4. 8 cm

47. A convex lens of focal length 63 cm and dispersive power 0.21 is kept in contact with another lens of dispersive power 0.50 in order to make an achromatic doublet. The focal length of second lens is
1. 150cm 2. 63 cm 3. -126cm 4. -150 cm

48. The dispersive powers of the materials of the two lenses are in the ratio 4/3. If the achromatic combination of these two lenses in contact is a convex lens of focal length 60cm, then the focal length of the component lenses are :
1. -20 cm and +25 cm 2.-20 cm and -25 cm
3. -15 cm and +20 cm 4.15 cm and -20 cm

49. The ratio of the distance of the image formed due to the objective to field lens to the efective focal length in Huygen's eye piece is
1. 1 : 1 2. 2 : 1 3. 2 : 3 4. 3 : 1
1. 1 : 4 2. 1 : 2 3. 1 : 8 4. 1 : 3

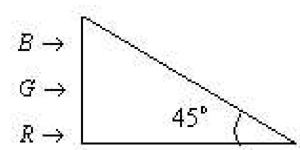
50. The respective angles of a flint glass prism and a crown glass prism are A and A' and n and n' represent the refractive indices for the mean ray. If these prisms are to be combined to produce dispersion without deviation of the mean ray, then $\frac{A}{A^1}$ should be

1. $\frac{n-1}{n^1-1}$ 2. $\frac{n^1-1}{n-1}$ 3. $\frac{n+1}{n^1+1}$ 4. $\frac{n^1+1}{n+1}$

51. A crown glass prism of angle 6.2^O is to be combined with a flint glass prism in such a way that the mean ray passes undeviated. What is the angle of the flint glass prism needed if the refractive indices of crown glass and flint glass for yellow light are 1.517 and 1.620 respectively
1. 1.5^O 2. 5.17^O 3. 51.7^O 4. None

52. A crown glass prism of angle 5^O is to be combined with a flint glass prism in a such a way that the dispersion is zero. The refractive indices for violet and red lights are 1.523 and 1.514 respectively for crown glass and for flint glass are 1.632 and 1.614, then the angle of the flint glass prism is
1. 10^O 2 2.5^O 3. 2^O 4. 5.45^O

53. The fig shows a mixture of blue, green and red colour ray incident on the right angled prism. The critical angles of the material of prism for red, green and blue colours are 46^0, $44^0$and 43^0 respectively. The arrangement will separate.



1. Red colour from green and blue
2. Blue colour from green and red
3. Green colour from red and blue
4. All the three colours

54. In a spectrometer experiment prisms A, B, C with same angle of prism but of different materials of refractive indices μ_A=1.33,μ_B=1.55, μ_C=1.44 are used. The corresponding angles of minimum deviation D_A, D_B, D_C measured will be such that. **(M1999)**
1. $D_A>D_B>D_C$ 2. $D_A<D_B<D_C$
2. $D_A>D_C>D_B$ 4. $D_A<D_C<D_B$

LEVEL 2 KEY

1) 2	2) 4	3) 1	4) 3	5) 2
6) 2	7) 3	8) 2	9) 2	10) 3
11) 1	12) 2	13) 3	14) 1	15) 4
16) 2	17) 1	18) 1	19) 2	20) 4
21) 1	22) 3	23) 3	24) 1	25) 2
26) 3	27) 4	28) 3	29) 4	30) 2
31) 2	32) 3	33) 1	34) 4	35) 2
36) 4	37) 4	38) 3	39) 2	40) 3
41) 3	42) 3	43) 3	44) 3	45) 2
46) 4	47) 4	48) 4	49) 1	50) 2
51) 2	52) 3	53) 1	54) 4	

LEVEL - III

REFRACTION & TOTAL INTERNAL REFLECTION

1. When monochromatic light is refracted from a medium of refractive index 1.72 into vacuum, its wavelength
1. increases by 72% 2. decreases by 72%
3. increases by 28% 4. decreases by 28%

2. A ray of light falls on the surface of a spherical glass paper weight making an angle α with the normal and is refracted in the medium at angle β. The angle of deviation of the emergent ray from the direction of incident ray is
1. $\alpha-\beta$ 2. $2(\alpha-\beta)$ 3. $(\alpha-\beta)/2$ 4. $\beta-\alpha$

3. A ray of light from denser medium strikes a rarer medium at an angle of incidence i. The reflected and refracted rays make an angle of 90^{O} with each other. Angle of reflection and refraction are r & r^1. The critical angle is

1. $\sin^{-1}(\tan r)$ 2. $\sin^{-1}(\tan i)$
3. $\sin^{-1}(\tan r^1)$ 4. 1 & 2

4. The difference in the number of wavelengths, when yellow light propagates through air and vacuum columns of the same thickness is one. The thickness of the air column is (Refractive index of air μ_a=1.0003 ; Wavelength of yellow light in vacuum = 6000A^{O})

1. 1.8 mm 2. 2 mm 3. 2 cm 4. 2.2 cm

5. A rectangular slab ABCD of refractive index μ_1 is immersed in a liquid of refractive index μ_2 ($\mu_2 < \mu_1$). A ray of light is incident on the surface AB of the slab as shown in te figure.The maximum value of incidence such that the ray comes out only from the surface CD is given by

1. $\sin^{-1}\left[\frac{\mu_1}{\mu_2}\cos(\sin^{-1}\frac{\mu_1}{\mu_2})\right]$

2. $\sin^{-1}\left[\mu_1\cos(\sin^{-1}\frac{1}{\mu_2})\right]$

3. $\sin^{-1}\left(\frac{\mu_1}{\mu_2}\right)$ 4. $\sin^{-1}\left(\frac{\mu_2}{\mu_1}\right)$

6. From a point light source S a beam of light with diverging angle α is produced.The light is allowed to fall symmetrically on a parallel sided glass slab of thickness 't' and refractive index 'n'. The diverging angle of the emergent beam is

1) Zero 2) α
3) $\sin^{-1}\left(\frac{1}{n}\right)$ 4) $2\sin^{-1}\left(\frac{1}{n}\right)$

7. A beaker of height 3h has a radius h. A thin rod of height h is placed to the wall of the beaker. A person can see the top end of the rod from the opposite edge of the beaker through a pin hole. When the beaker is filled with a liquid up to a height 2h, the person can see the bottom end of the rod. The refractive index of the liquid is

1. $\frac{3}{2}$ 2. $\frac{\sqrt{3}}{2}$ 3. $\frac{5}{2}$ 4. $\sqrt{\frac{5}{2}}$

8. Alight ray is incident at an angle 45^0 on parallel sided glass slaband emerges out grazing the veritical surface. The refractive index of the slab is

1. $\sqrt{\frac{3}{2}}$ 2. $\sqrt{\frac{5}{2}}$ 3. $\frac{\sqrt{3}}{2}$ 4. $\frac{\sqrt{5}}{2}$

LENSES AND
LENS MAKER'S FORMULA

9. A denser medium of refractive index 1.5 has concave surface of radius of curvature 12 cm. An object is situated in the denser medium at a distance of 9 cm from the pole of the surface. Locate the image due to refraction in air.

1. A real image at 8 cm
2. A virtual image at 8 cm
3. A real image at 4.8 cm
4. A virtual image at 4.8 cm.

10. Three lenses in contact have a combined focal length of 12 cm. When the third lens is removed the combined focal length is 60/7 cm. The third lens is

1. A converging lens of focal length 30 cm
2. A converging lens of focal length 60 cm
3. A diverging lens of focal length 30 cm
4. A diverging lens of focal length 60 cm

11. The plane side of a thin plano-convex lens with radius of curvature 20 cm is silvered to obtain a concave mirror. An object is located at a distance 25 cm infront of this mirror. The distance of the image from the mirror is (μ_g= 1.5)

1. 100 cm 2. 100/11 cm
2. 6.25 cm 4. 100/9 cm

12. The convex side of a thin plano-convex lens with radius of curvature 60 cm is silvered to obtain a concave mirror. An object is located at a distance of 30 cm in front of this mirror. The distance of the image from the mirror is (μ_8= 1.5)

1. 12 cm 2. -60 cm 3. 60 cm 4. 20 cm

13. Two thin lenses of same material separated by certain distance have an equivalent focal length of 50 cm. The combination satisfies the

condition for no chromatic abberation and minimum spherical abberation. The focal length of the two lenses are

1. 200/3cm, 100/3cm 2. 100 cm, 100/3 cm
3. 50 cm, 100 cm 4. None

14. Two convex lenses each of focal lengths 20 cm and refractive index 1.5 are placed in contact and space between them is filled with water of refractive index 4/3. The combination works as
1. converging lens of focal length 30 cm.
2. diverging lens of focal length 15 cm
3. converging lens of focal length 15 cm
4. diverging lens of focal length 40 cm

KEY

1) 1	2) 2	3) 4	4) 2	5) 2
6) 3	7) 4	8) 1	9) 4	10) 3
11) 1	12) 3	13) 2	14) 3	

LEVEL 4

NEW MODEL QUESTIONS

15. Arrange the following combinations in the increasing order of focal length
a) Plano convex lens of focal lengths 20 cm and 30 cm in contact
b) convex lens of focal lengths 20 cm and 10 cm in contact
c) two convex lenses of focal length 25 cm separated by 5 cm
1) a, b, c 2) b, a, c 3) a, c, b 4) c, a, b

16. Arrange the following data according to the increasing order of Radius of cerrature of the given plano convex lenses
a) plano convex lens of f=40 cm and μ=1.5
b) plano convex lens of f=20 cm and μ=1.6
c) plano convex lens with curved surface silvered f=20 cm and μ=1.5
d) plano convex lens with plane surface silvered f=25 cm and μ=1.5
1) b, a, d, c 2) a, b, c, d
3) d, c, b, a 4) a, b, d, c

17. Arrange the following data according to the increasing order of its focal length given Radius of curvature of the curved surfaces and corresponding refractive index of the material
a) R1=R2 = 2 cm, μ=1.5
b) R1=20 cm, R2= μ=1.5
c) R1=20 cm, R2=30 cm, μ=1.6
d) R1=20 cm, R2=40 cm, μ=1.5
1) c, b, a, d 2) a, b, c, d
3) b, c, d, a 4) d, c, b, a

18. A concave lens of focal length 40 cm and refractive index 3/2 is placed in a medium of refractive index 5/2, then
1) It will act as a divergent lens
2) It will act as a divergent lens of focal length 50cm
3) It will act as a divergent lens of focal length 80 cm
4) It will act as a convergent lens of focal length 160 cm
The following statements are true
1) (1), (2) and (3) 2) (2), (3) and (4)
3) (1) and (3) 4) (1) and (2)

19. A mono chromatic light passing through several media having different thickness(t), and different refractive indces(μ) identify the increasing order of apparent depths in different media. (asssure that the ray is falling normally)
1) t = 2 cm, μ = 1.5
2) t = 3 cm, μ = 1.2
3) t = 1 cm, μ = 1.4
4) t = 2.5 cm, μ = 1.1
1) 1, 2, 3 and 4 2) 3, 1, 2, 4
3) 1, 2, 4, 3 4) 3, 1, 4, 2

20. Identify the increasing order of the power of the lens in the following cases
1) lens of focal length 10 cm
2) lens of focal length 10 m
3) lens of focal length 2 m
4) lens of focal length 50 m
1) 3, 2, 4, 1 2) 4, 2, 3, 1
3) 2, 3, 1, 4 4) 1, 4, 3, 2

KEY

15) 2 16) 3 17) 2 18) 4 19) 4
20) 2