PHYSICS CLASS-XII –RAY OPTICS

Unit VI: Optics 27 Periods

Chapter–9: Ray Optics and Optical Instruments

Ray Optics: Reflection of light, spherical mirrors, mirror formula, refraction of light, total internal reflection and its applications, optical fibers, refraction at spherical surfaces, lenses, thin lens formula, lensmaker's formula, magnification, power of a lens, combination of thin lenses in contact, refraction of light through a prism.

Scattering of light - blue colour of sky and reddish appearance of the sun at sunrise and sunset.

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

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601. When a wave is propagating from a rarer to a denser medium, which characteristic of the wave does not change and why ?
   [**Ans**. frequency, as frequency is a characteristic of the source of waves   **CBSE (AI)-2015**

   OR

   When monochromatic light travels from one medium to another, its wavelength changes but its frequency remains same. Why ?
   [**Ans**. frequency is a characteristic of the source of waves. That is why it remains the same.   **CBSE (AI)-2011**
      But wavelength is characteristic of medium. So wavelength and velocity both change.

602. When monochromatic light is incident on a surface separating two media, the reflected and refracted light both have the same frequency as the incident frequency. Why ?   **CBSE (AI)-2016,2010,(D)-2011**
   [**Ans**. Reflection and refraction arise through interaction of incident light with atomic constituents of matter which vibrate with the same frequency as that of incident light. Hence frequency remains unchanged.

603. When light travels from a rarer to a denser medium, the speed decreases. Does this decrease in speed imply a reduction in the energy carried by the wave ?   **CBSE (AI)-2016,2010**
   [**Ans**. **No**. Energy carried out by a wave depends on the amplitude of the wave, not on the speed of wave propagation.

604. In the wave picture of light, intensity of light is determined by the square of the amplitude of the wave. What determine the intensity in the photon picture of light ?   **CBSE (AI)-2016**
   [**Ans**. In photon picture, intensity is determined by the number of photons incident normally on a unit area per unit time

605. When light comes from air to glass, the refracted ray is bent towards the normal. Why ?   **CBSE (DC)-2004**
   [**Ans**. $\mu = \dfrac{\sin i}{\sin r} = \dfrac{3}{2}$
   $\Rightarrow \sin r = \dfrac{2}{3} \sin i$ $\Rightarrow \sin r < \sin i$ $\Rightarrow r < i$ hence, refracted ray is bent towards the normal

606. For the same angle of incidence, the angle of refraction in to two media A and B are 25^0 and 35^0 respectively. In which medium is the speed of light less ?   **CBSE (AI)-2015,2012**
   [**Ans**. **In medium A speed of light is less**

      Reason : $\mu = \dfrac{\sin i}{\sin r} = \dfrac{c}{v}$ $\Rightarrow$ $v = \dfrac{c \times \sin r}{\sin i}$ $\Rightarrow$ $v \propto \sin r$ [∵ angle of incidence is same

      But $r_A < r_B$ $\Rightarrow$ $v_A < v_B$

607. Define refractive index of a transparent medium. What is the minimum and maximum value of refractive index ?
   [**Ans**. **Refractive index** :   **CBSE (AIC)-2017,(AI)-2009**
         Refractive index of a medium is defined as the ratio of velocity of light in vacuum to the velocity of light in that medium
   i,e, $\mu = \dfrac{c}{v}$ Minimum value of refractive index is 1 for air and maximum is 2.42 for diamond

608. What is the ratio of the velocity of the wave in the two media of refractive indices μ_1 and μ_2 **CBSE (AI)-2015**
   [**Ans**. $\dfrac{v_1}{v_2} = \dfrac{\mu_2}{\mu_1}$

609. How does the refractive index of a transparent medium depend on wavelength of light used ?   **CBSE (F)-2015**
   [**Ans**. $\mu = a + \dfrac{b}{\lambda^2}$

610. When a glass slab is placed on an ink dot, ink dot appears to be raised. Why ?   **BSE (AIC)-2010**
   [**Ans**. due to refraction of light

611. By how much would an ink dot appear to be raised, when covered by a glass plate of thickness $6.0\ cm$. Refractive index of glass is 1.5.   **CBSE (AIC)-2010**
   [**Ans**. $\Delta y = t\left(1 - \dfrac{1}{\mu}\right) = 6\left(1 - \dfrac{1}{1.5}\right) = 6\left(\dfrac{0.5}{1.5}\right) = 2.0\ cm$

612. The line AB in the ray diagram represents a lens. State whether the lens is convex or concave ?   **CBSE (AI)-2015**
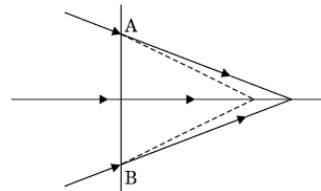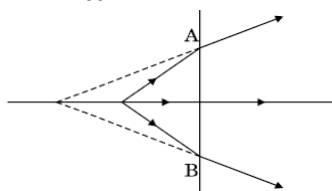
   [**Ans**. (i) **Convex lens**,   **Reason** : refracted ray is bending towards the principal axis
      (ii) **Concave lens**,   **Reason** : refracted ray is bending away from the principal axis

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613. What is total internal reflection of light ?   **CBSE (AI)-2016,2001**
    [Ans. **Total internal reflection** : When a ray of light travelling from denser to a rarer medium is incident on the interface at an angle greater than the critical angle, it is totally reflected back in to the denser medium. This phenomenon is called total internal reflection of light.

614. State the conditions for the phenomenon of total internal reflection to occur.   **BSE (AI)-2016,(D)-2010**
    [Ans. **Conditions for TIR** :
    (i) light ray must travel from denser to a rarer medium
    (ii) angle of incidence must be greater than the critical angle ($i > i_c$)

615. Name one phenomenon which is based on total internal reflection.   **CBSE (AI)-2016**
    [**Ans**. Mirage/ sparkling of diamond/ optical fibre/ totally reflecting prisms

616. Can total internal reflection occur when light goes from rarer to a denser medium ?   **CBSE (D)-2007**
    [Ans. No

617. Define critical angle.What is the relationbetween refractive index & critical angle for a given pair of optical media ?
    [Ans. **Critical angle** : The angle of incidence in the denser medium for which the angle of refraction in the rarer medium is 90^0 is called critical angle.   **CBSE (AI)-2009**

    Relation : $\mu = \dfrac{1}{\sin i_c}$

618. When light travels from an optically denser medium to a rarer medium, why does the critical angle of incidence depend on the colour/wavelength of light ?   **CBSE (AI)-2015,2009**
    [Ans. $\mu = \dfrac{1}{\sin i_c} \quad \Rightarrow \quad i_c = \sin^{-1}\left(\dfrac{1}{\mu}\right)$

    As $\mu = a + \dfrac{b}{\lambda^2}$. Hence critical angle would also be different for different colours/wavelengths of light

619. What is the critical angle for a material of refractive index $\sqrt{2}$?   **CBSE (AI)-2010**
    [Ans. $\sin i_c = \dfrac{1}{\mu} = \dfrac{1}{\sqrt{2}} \quad \Rightarrow \quad i_c = 45^0$ 620. Velocity of light in glass is 2×10^8 m/s and in air is 3×10^8 m/s.

    If the ray of light passes from glass to air, calculate the value of critical angle.   **CBSE (F)-2015**
    [Ans. $\mu = \dfrac{c}{v} = \dfrac{3 \times 10^8}{2 \times 10^8} = 1.5$

    $\mu = \dfrac{1}{\sin i_c} \quad \Rightarrow \quad i_c = \sin^{-1}\left(\dfrac{1}{\mu}\right) = \sin^{-1}\left(\dfrac{1}{1.5}\right) == \sin^{-1}\left(\dfrac{2}{3}\right) = 41.8^0$

621 Calculate the speed of light in a medium whose critical angle is 30^0.   **CBSE (AI)-2012,2010**
    [Ans. $\mu = \dfrac{1}{\sin i_c} = \dfrac{1}{\sin 30} = \dfrac{1}{1/2} = 2 \qquad$ Now, $\mu = \dfrac{c}{v} \quad \Rightarrow \quad v = \dfrac{c}{\mu} = \dfrac{3 \times 10^8}{2} = 1.5 \times 10^8$ m/s
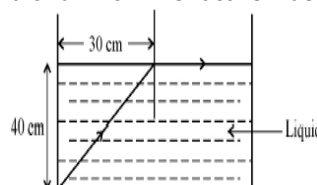
622. In the following ray diagram, calculate the speed of light in the liquid of unknown refractive index.   **CBSE (AIC)-2017**
    [**Ans.** $\mu = \dfrac{c}{v} = \dfrac{1}{\sin i_c}$
    $\Rightarrow \dfrac{3 \times 10^8}{v} = \dfrac{1}{30/50}$
    $\Rightarrow v = \dfrac{30}{50} \times 3 \times 10^8 = 1.8 \times 10^8$ m/s

623. Draw a ray diagram to show how a right angled isosceles prism can be used to-   **CBSE (AI)-2015,(DC)-2001**
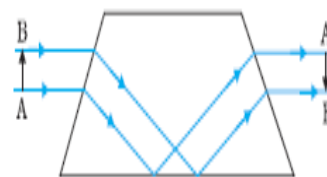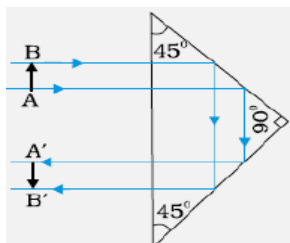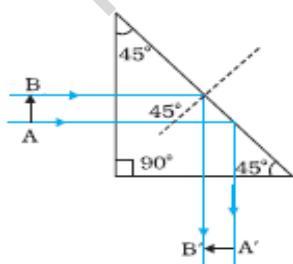   (i) deviate a light ray through (i) 90^0, (ii) deviate a light ray through 180^0/ to obtain the inverted image
    (iii) to invert an image without the deviation of the rays ?
    [**Ans**. (i)   (ii)   (iii)

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624. Why does a diamond sparkle ?   **CBSE (D)-2009,2002**

[**Ans.** The brilliance of diamond is due to total internal reflection of light

Refractive index of diamond is very large (2.42) so its critical angle is small (24.4^0). The faces of diamond are cut in such a manner that light entering diamond from any face suffers multiple total internal reflections and remains within the diamond but it comes out through only a few faces. Hence the diamond sparkles.

625. Find the relation between critical angle and refractive index.   **CBSE (AI)-2016**

[**Ans.** By Snell's law, $\dfrac{\sin i}{\sin r} = \dfrac{1}{\mu}$

But when $i = i_c, \ r = 90^0$

$\Rightarrow \quad \dfrac{\sin i_c}{\sin 90} = \dfrac{1}{\mu} \qquad \Rightarrow \qquad \mu = \dfrac{1}{\sin i_c}$

626. What is an optical fibre ? Name the phenomenon on which working of an optical fibre is based. Give any two uses of optical fibres.   **CBSE (AI)-2016,(D)-2011**

[**Ans. Optical fibre :** An optical fibre is a fine strand of quality glass/quartz surrounded by a glass coating of slightly lower refractive index called cladding.

Phenomenon : Total internal reflection of light

**Uses :** (a) in transmission of optical signals

(b) as light pipe in medical examination of stomach etc.

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627. Draw a labelled diagram of an optical fibre. Explain how light propagates through the optical fiber.

[**Ans. Phenomenon :** Total internal reflection   **CBSE (AI)-2016,(D)-2011**

Working :

When a signal in the form of light enters at one end of the fibre at suitable angle, it undergoes repeated total internal reflections and finally comes out at the other end.

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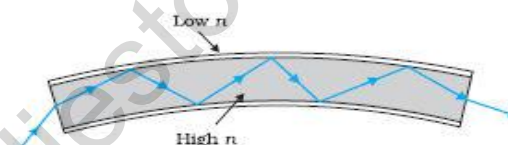
628 What is scattering light ? What is the condition for Rayleigh scattering to occur ?   **CBSE (AIC)-2010**

[**Ans. Scattering of light :** This is the phenomenon in which light is deflected from its path due to its interaction with the particles of the medium through which it passes.

Condition : size of scatterer $a \ll \lambda$

629. Why cannot we see clearly through fog ? Name the phenomenon responsible for it.   **CBSE (AI)-2016**

[**Ans.** Some light gets deviated/ scattered/ absorbed

Phenomenon- Scattering of light

630. Why does bluish colour predominate in the sky ?   **CBSE (AI)-2015,2008,(D)-2010**

[**Ans. due to most scattering of blue light**

as blue light has the smallest wavelength and as per Rayleigh's law of scattering, intensity of scattered light $I \propto \dfrac{1}{\lambda^4}$

631. Why does Sun appears red at sunrise and sunset ?   **CBSE (AI)-2016,(F)-2015**

[**Ans. due to least scattering of red light**

as red light has the longest wavelength and as per Rayleigh's law of scattering, intensity of scattered light $I \propto \dfrac{1}{\lambda^4}$

632. Clouds appear white. Why ?   **CBSE (AIC)-2010**

[**Ans. due to equal scattering of all colours of light**

Large particles such as dust, raindrops, ice particle do not scatter light in accordance with Raleigh's law but scatters light of all colours almost equally

633 Give reasons for the following observations on the surface of the moon :   **CBSE (AI)-2000**

(a) Sunrise and sunset are abrupt.   (b) Sky appears dark   (c) a rainbow is never formed.

[**Ans. (a)** Moon has no atmosphere. There is no scattering of light. Sunlight reaches the moon straight covering the short distance. Hence sunrise and sunset are abrupt.

(b) Moon has no atmosphere. There is nothing to scatter sunlight towards the moon. No skylight reaches moon surface. Hence sky appears black in the day time as it does at night.

(c) No water vapours are present at moon surface. No clouds are formed. There are no rains on the moon, so rainbow is never formed

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634 Why is aperture of objective lens of a telescope is taken large ?   **CBSE (AI)-2013**
[**Ans.** to increase the light gathering capacity and hence brightness of the image

635. State two main considerations taken into account while choosing the objective in optical telescopes with large diameters.
[**Ans.** (i) better light gathering power   **CBSE (AI)-2015**
      (ii) high resolving power

636. The objective of a telescope is of larger focal length and of larger aperture (as compared to eye piece). Why ?
[**Ans.** (i) Objective of larger focal length increases magnification ($m = -\dfrac{f_o}{f_e}$)   **CBSE (AIC)-2013**
      (ii) Objective of larger aperture has large light gathering capacity and hence increases the brightness of image/ have a high resolving power

637. Why is eye piece of a telescope is of short focal length, while objective of large focal length ? Explain.
[**Ans.** $m = -\dfrac{f_o}{f_e}$ **CBSE (F)-2013**
   ⇨ for large angular magnification, $f_o \gg f_e$
      Hence, focal length of objective should be large, while focal length of eye piece should be small

638. State the condition under which a large magnification can be achieved in an astronomical telescope. **CBSE (F)-2017**
[Ans. $m = -\dfrac{f_o}{f_e}$
      (i) By increasing f_o /decreasing f_e or $f_o \gg f_e$
      (ii) Distance between two lenses $L > f_0 + f_e$

639. You are given the following three lenses. Which two lenses will you use as an eyepiece and as an objective to construct an astronomical telescope ? Give reason.   **CBSE (AI)-2017,(D)-2009**

Lenses	Power (D)	Aperture (cm)
L_1	3	8
L_2	6	1
L_3	10	1

[Ans. **Objective lens** : Lens L_1
      & **Eye piece** : Lens L_3
   Reason : $m = -\dfrac{f_o}{f_e}$
   ⇨ for higher magnification & brighter image, objective should have large aperture and large focal length
      & eye piece should have small aperture and small focal length

640. You are given three lenses of power $0.5\ D, 4\ D$ and $10\ D$ to design a telescope. Which lenses should you use as an objective and eyepiece of an astronomical telescope ? Justify your answer.   **CBSE (AI)-2016**
[Ans. **Objective lens** : $0.5\ D$
      & **Eye piece** : $10\ D$
   Justification : $m = -\dfrac{f_o}{f_e}$
   ⇨ for higher magnification, objective should have large focal length & eye piece should have small focal length

641. Write two main limitations of refracting telescopes. Explain how these can be minimized in a reflecting telescope.
[**Ans.** **Limitations of refracting telescope:**   **CBSE (F)-2016,2015,(AI)-2013**
      (i) Suffers from spherical aberration . It can be corrected by using parabolic mirror objective
      (ii) Suffers from chromatic aberration. It can be corrected by using mirror objective instead of spherical lens
      (iii) Image is less bright/ small magnifying power/small resolving power
            In reflecting telescope image is bright due to reflection and has high resolving power due to large aperture

642. Give two reasons to explain why a reflecting telescope is preferred over a refracting telescope. **CBSE (F)-2017**
OR
State the advantages of reflecting telescope over refracting telescope.   **CBSE (AI)-2016,2015,(D)-2016,2009**
[**Ans.** (i) No chromatic/spherical aberration as mirror is used as objective in reflecting telescope
      (ii) Brighter image/ high resolving power as mirror of large aperture is used as objective in reflecting telescope

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643. (i) Draw a schematic diagram of a reflecting telescope. State the advantages of reflecting telescope over refracting telescope.
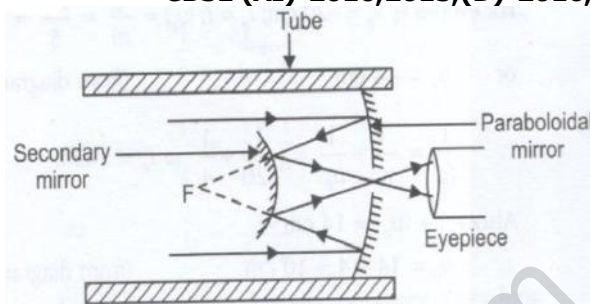
(ii) What is its magnifying power ? **CBSE (AI)-2016,2015,(D)-2016,2009**

[**Ans.** **Advantages of reflecting telescope**

(i) No chromatic aberration

(ii) No spherical aberration

(iii) Brighter image

(iv) large magnifying power

(v) High resolving power

$$m = \frac{angle\ subtended\ at\ the\ eye\ by\ image}{angle\ subtended\ at\ the\ eye\ by\ object} = \frac{f_o}{f_e}$$

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644. Does the magnifying power of a microscope depend on the colour of the light used ? Justify your answer.

[**Ans.** **Yes** **Justification** : $m \propto \frac{1}{f_o f_e}$ & focal length depends on colour/μ **CBSE (F)-2017**

645. Explain, why must both the objective and the eye piece of a compound microscope have short focal lengths ?

[**Ans.** $m = \frac{L}{f_o} \times \frac{D}{f_e}$ **CBSE (D)-2017,(D)-2009**

⇨ to increase magnifying power both the objective and the eye piece must have short focal lengths

646. Explain, why is the objective of a compound microscope be of short aperture ? **CBSE (AIC)-2014**

[**Ans.** to minimize spherical aberration and to collect all the reflected light from object to produce brighter image

647. Explain, While viewing through a compound microscope, why should our eyes be positioned not on the eye piece but a short distance away from it for best viewing ? **NCERT-2017**

[**Ans.** To collect complete light refracted by the objective and to increase field of view

648. You are given the following three lenses. Which two lenses will you use as an eyepiece and as an objective to construct a compound microscope ? Give reason. **CBSE (AI)-2017**

Lenses	Power (D)	Aperture (cm)
L_1	3	8
L_2	6	1
L_3	10	1

[**Ans.** **Objective lens** : Lens L_3 **Eye piece** : Lens L_2

Reason : Objective of a microscope should have small aperture and smallest focal length eye piece of a microscope should have small aperture and small focal length (but longer focal length than aperture)

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649. What is dispersion of light ? What is its cause ? **CBSE (D)-2016**

[**Ans.** **Dispersion of light** : When a ray of white light is incident on a glass prism, it splits into its seven constituent Colours. This phenomenon is called dispersion of light.

Cause of dispersion : Refractive index of material of prism is different for different colours of light. Hence from $\delta = (\mu - 1)A$, different colour will deviate through different angles

650. How does the angle of minimum deviation of a glass prism vary, if the incident violet light is replaced by red light ? Give reason.

[**Ans. Decreases,** **Reason** : $\delta = (\mu - 1)A$ & $\mu_{red} < \mu_{Violet}$ or $\lambda_{red} > \lambda_{Violet}$ **CBSE (AI)-2017**

651. Violet colour is seen at the bottom of the spectrum when white light is dispersed by a prism. Give reason

[**Ans.** $\delta = (\mu - 1)A$ & $\mu_{Violet} > \mu_{red}$ ⇨ $\delta_{Violet} > \delta_{red}$ **CBSE (D)-2010**

Hence, Violet colour is seen at the bottom of the spectrum when white light is dispersed by a prism

652. Out of blue and red light which is more deviate by prism ? Give reason. **CBSE (D)-2010**

[**Ans.** $\delta = (\mu - 1)A$ & $\mu_{blue} > \mu_{red}$ ⇨ $\delta_{blue} > \delta_{red}$ Hence, blue light deviates more than red light by a prism

653. For which colour the refractive index of prism material is maximum and minimum ? **CBSE (D)-2010**

[**Ans.** $\mu = a + \frac{b}{\lambda^2}$ & $\lambda_{Violet} < \lambda_{red}$ ⇨ $\mu_{Violet} > \mu_{red}$

Hence, refractive index of prism material is maximum for violet and minimum for red colour

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654. How is the focal length of a spherical mirror affected, when the wavelength of light used is increased ?
[Ans. No change as focal length of a spherical mirror does not depend on wavelength   **CBSE (AI)-2000**

655. How is the focal length of a spherical mirror is affected, when it is immersed in water/Glycerin ? **CBSE (F)-2010**
[Ans. No change as focal length of a spherical mirror does not depend on medium

657. How is the focal length of a spherical lens affected, when the wavelength of light used is increased ?
[Ans. Focal length of the lens increases   **CBSE (AI)-2016,(F)-2010**
Reason : $\frac{1}{f}$ = $(\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ & $\mu = a + \frac{b}{\lambda^2}$

658. How does focal length of a convex lens change, if violet light is used instead of red light ?
[Ans. Focal length of the lens decreases   **CBSE (F)-2012,(AI)-2010**
Reason : $\frac{1}{f}$ = $(\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ & $\mu = a + \frac{b}{\lambda^2}$
As $\lambda_{Violet} < \lambda_{red}$ $\Rightarrow$ $\mu_{Violet} > \mu_{red}$ $\Rightarrow$ $f_{Violet} < f_{red}$

659. Explain with reason, how the power of a diverging lens changes when incident red light is replaced by violet light.
[Ans. Power of the lens will increases   **CBSE (AIC)-2017**
Reason : $P = \frac{1}{f}$ = $(\mu - 1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$ & $\mu = a + \frac{b}{\lambda^2}$
As $\lambda_{Violet} < \lambda_{red}$ $\Rightarrow$ $\mu_{Violet} > \mu_{red}$ $\Rightarrow$ $P_{Violet} > P_{red}$

660. What happens to the focal length of a convex lens when it is immersed in water ? Refractive index of the material of lens is greater than that of water .   **CBSE (AI)-2016**
[Ans. Focal length will increase hence power will decrease
$P = \frac{1}{f}$ = $\left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ As μ_1 increases f increases $(\mu_1 \, for \, water > \mu_1 \, for \, air)$

661. A lens of glass is immersed in water. What will be its effect on the power of lens ?   **CBSE (AI)-2003**
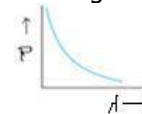**[Ans. Power of the lens will decrease**
$P = \frac{1}{f}$ = $\left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ As μ_1 increases P decreases $(\mu_1 \, for \, water > \mu_1 \, for \, air)$

662. Draw a plot showing the variation of power of a lens with the wavelength of incident ligh   **CBSE (D)-2008**
[Ans. Power of the lens decreases with increase in wavelength
Reason : $P = \frac{1}{f}$ = $(\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ & $\mu = a + \frac{b}{\lambda^2}$

663. A glass lens of refractive index 1.45 disappears when immersed in a liquid. What is the value of refractive index of the liquid ?   **CBSE (D)-2010**
[Ans. The refractive index of the liquid should be equal to that of the lens, i,e, 1.45

664. What should be the value of the refractive index of the medium in which the lens should be placed so that it acts as a plane sheet of glass ?   **CBSE (AI)-2015**
OR
Under what condition does a biconvex lens of glass having a certain refractive index acts as a plane glass sheet when immersed in a liquid ?   **CBSE (D)-2012**
[Ans. The refractive index of the medium/liquid should be equal to that of the lens

665. Explain with reason, how the power of a diverging lens changes when it is kept in a medium of refractive index greater than that of the lens.   **CBSE (AIC)-2017**
[Ans. Power will become positive, i,e, lens will behave as Converging lens.
Reason : $P = \frac{1}{f_m}$ = $-\left(\frac{\mu_g}{\mu_m} - 1\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$ As $\mu_m > \mu_g$ $\Rightarrow$ $P = \frac{1}{f_m}$ = +ve

666. A biconcave lens made of transparent material of refractive index 1.25 is immersed in water of refractive index 1.33. Will the lens behave a converging or diverging lens ? Give reason.   **CBSE (D)-2015,(AI)-2014**
[Ans. Converging lens.
Reason : $\frac{1}{f_m}$ = $-\left(\frac{\mu_g}{\mu_m} - 1\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$
As $\mu_m > \mu_g$ $\Rightarrow$ $\frac{1}{f_m}$ = +ve $\Rightarrow$ $f_m > 0$

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667. A biconvex lens made of transparent material of refractive index 1.25 is immersed in water of refractive index 1.33. Will the lens behave a converging or diverging lens ? Give reason. **CBSE (AI)-2014**

[Ans. **Diverging lens**.

Reason : $\frac{1}{f_m} = \left(\frac{\mu_g}{\mu_m} - 1\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$ As $\mu_m > \mu_g$ $\Rightarrow$ $\frac{1}{f_m} = -ve$ $\Rightarrow$ $f_m < 0$

668. A biconvex lens made of transparent material of refractive index 1.5 is immersed in water of refractive index 1.33. Will the lens behave a converging or diverging lens ? Give reason. **CBSE (AI)-2014**

[Ans. **Converging lens**.

Reason : $\frac{1}{f_m} = \left(\frac{\mu_g}{\mu_m} - 1\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$ As $\mu_m < \mu_g$ $\Rightarrow$ $\frac{1}{f_m} = +ve$ $\Rightarrow$ $f_m > 0$

669. A convex lens made up of glass of refractive index 1.5 is dipped, in turn, in **CBSE (AI)-2011**

(i) a medium of refractive index 1.65, (ii) a medium of refractive index 1.33

Will the lens behave a converging or diverging lens in the two cases ? Give reason.

[Ans. (i) **Diverging lens**.

Reason : $\frac{1}{f_m} = \left(\frac{\mu_g}{\mu_m} - 1\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$ As $\mu_m > \mu_g$ $\Rightarrow$ $\frac{1}{f_m} = -ve$ $\Rightarrow$ $f_m < 0$

(ii) **Converging lens**.

Reason : $\frac{1}{f_m} = \left(\frac{\mu_g}{\mu_m} - 1\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$ As $\mu_m < \mu_g$ $\Rightarrow$ $\frac{1}{f_m} = +ve$ $\Rightarrow$ $f_m > 0$

670. A converging lens is kept coaxially in contact with a diverging lens, both the lenses being of equal focal length. What is the focal length of the combination ? **CBSE (AI)-2016,2010**

[Ans. $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{f} + \frac{1}{-f} = 0$

$\Rightarrow$ $F = \infty$ hence the combination will act as a plane glass plate

671. Two thin lenses of power $+6\,D$ and $-2\,D$ are in contact. What is the focal length of this combination ?

[Ans. $P = P_1 + P_2 = +6 - 2 = +4\,D$ **CBSE (D)-2009**

$\Rightarrow$ $F = \frac{1}{P} = \frac{1}{4} = 0.25\,m = 25\,cm$

672. A convex lens of focal length $25\,cm$ is placed coaxially in contact with a concave lens of focal length $20\,cm$. Determine the power of the combination will the system be converging or diverging in nature ? **CBSE (AI)-2013**

[Ans. $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{25} + \frac{1}{-20} = \frac{4-5}{100} = -\frac{1}{100}$ $\Rightarrow$ $F = -100\,cm = -1\,m$

$\Rightarrow$ $P = \frac{1}{F} = \frac{1}{-1} = -1$ hence the combination will be diverging in nature

673. The focal length of a convex lens made of glass($\mu = 1.5$) is 22 cm. What will be its new focal length when placed in a medium of refractive index 4/3 ? **CBSE (F)-2017,2016,(AI)-2015**

[Ans. $f_{medium} = \frac{(a\,\mu_g - 1)}{\left(\frac{a\,\mu_g}{a\,\mu_w} - 1\right)} \times f_{air} = \frac{(3/2 - 1)}{\left(\frac{3/2}{4/3} - 1\right)} \times 22 = 4 \times 22 = 88\,cm$

674. A double convex lens is made of a glass of refractive index 1.55, with both faces of the same radius of curvature. Find the radius of curvature required, if the focal length is 20 cm. **CBSE (AI)-2017,NCERT-2017**

[Ans. For biconvex lens, $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$

$\Rightarrow$ $\frac{1}{20} = (1.55 - 1)\left(\frac{1}{R} + \frac{1}{R}\right)$ $\Rightarrow$ $\frac{1}{20} = (0.55)\left(\frac{2}{R}\right)$ $\Rightarrow$ $R = 2 \times 0.55 \times 20 = 22\,cm$

675. The focal length of an equiconvex lens is equal to the radius of curvature of either face. What is the refractive index of the material of the lens ? **CBSE (AI)-2015**

[Ans. $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R} + \frac{1}{R}\right) = (\mu - 1)\left(\frac{2}{R}\right)$

But $f = R_1 = R_2 = R$ $\Rightarrow$ $\frac{1}{R} = (\mu - 1)\left(\frac{2}{R}\right)$ $\Rightarrow$ $\frac{1}{2} = (\mu - 1)$ $\Rightarrow$ $\mu = \frac{1}{2} + 1 = \frac{3}{2}$

676. The radii of curvature of the faces of a double convex lens are $10\,cm$ and $15\,cm$. If the focal length of the lens is $12\,cm$, find the refractive index of the material of the lens ? **CBSE (D)-2010**

[Ans. $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$ $\Rightarrow$ $\frac{1}{12} = (\mu - 1)\left(\frac{1}{10} + \frac{1}{15}\right) = (\mu - 1)\left(\frac{3+2}{30}\right) = (\mu - 1)\left(\frac{1}{6}\right)$

$\Rightarrow$ $\mu - 1 = \frac{6}{12} = \frac{1}{2}$ $\Rightarrow$ $\mu = 1 + \frac{1}{2} = \frac{3}{2}$

PHYSICS CLASS-XII –RAY OPTICS

678. A concave mirror produces a real and magnified image of an object kept in front of it. Draw a ray diagram to show The image formation and use it to derive the mirror equation. **CBSE (AI)-2015**

[**Ans.** Derivation of mirror formula:

ΔABC and $\Delta A'B'C$ are similar

$\therefore \quad \dfrac{B'A'}{BA} = \dfrac{B'C}{CB} = \dfrac{PC - PB'}{PB - PC}$ -----------(1)

ΔABP and $\Delta A'B'P$ are also similar

$\therefore \quad \dfrac{B'A'}{BA} = \dfrac{PB'}{PB}$ ----------(2)

$\Rightarrow$ from equation (1) and (2)

$\dfrac{PC - PB'}{PB - PC} = \dfrac{PB'}{PB}$

$\Rightarrow \quad \dfrac{-2f - (-v)}{-u - (-2f)} = \dfrac{-v}{-u} \quad \Rightarrow \quad \dfrac{v - 2f}{2f - u} = \dfrac{v}{u} \quad \Rightarrow \quad uv - 2uf = 2vf - uv$

$\Rightarrow \quad 2uv = 2vf + 2uf$

Dividing by $2uvf$ on both sides we get, $\quad \dfrac{2uv}{2uvf} = \dfrac{2vf}{2uvf} + \dfrac{2uf}{2uvf}$

$\Rightarrow \quad \boxed{\dfrac{1}{f} = \dfrac{1}{u} + \dfrac{1}{v}}$

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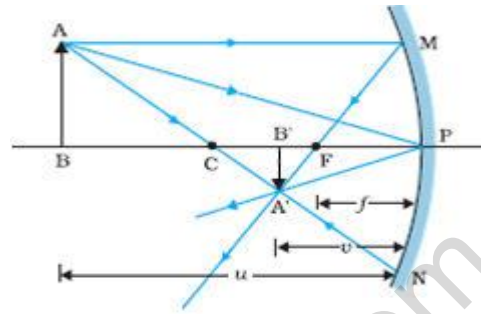
679. A point object O on the principal axis of a spherical surface of radius R separating two media of refractive indices μ_1 and μ_2 forms an image 1' as shown in the figure. **CBSE (F)-2017,(AI)-2015**

Prove that

$$\dfrac{\mu_2}{v} - \dfrac{\mu_1}{u} = \dfrac{(\mu_2 - \mu_1)}{R}$$

[**Ans.** By Snell's law, $\quad \dfrac{\sin i}{\sin r} = \dfrac{\mu_2}{\mu_1}$

For small angles, $\dfrac{i}{r} = \dfrac{\mu_2}{\mu_1}$

$\Rightarrow \quad \mu_1 i = \mu_2 r$ -----------(1)

In Δ OAC and Δ IAC,

$i = \alpha + \gamma \ \& \ \gamma = r + \beta$

$\Rightarrow$ from (1),

$\mu_1 (\alpha + \gamma) = \mu_2 (\gamma - \beta)$

$\Rightarrow \quad \mu_1 \alpha + \mu_2 \beta = (\mu_2 - \mu_1) \gamma$ ----------(2)

let the aperture of the surface is also very small then we have

$\alpha \approx \tan \alpha = \dfrac{AM}{MO} \approx \dfrac{AM}{PO}$

$\beta \approx \tan \beta = \dfrac{AM}{MI} \approx \dfrac{AM}{PI} \quad \& \quad \gamma \approx \tan \gamma = \dfrac{AM}{MC} \approx \dfrac{AM}{PC}$
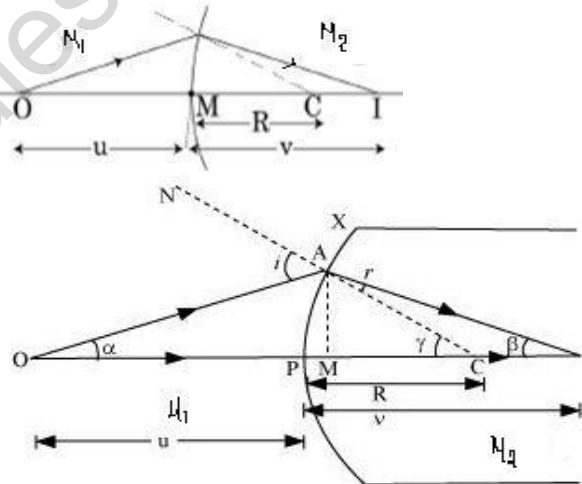
$\Rightarrow$ from equation (2)

$\mu_1 \left(\dfrac{AM}{PO}\right) + \mu_2 \left(\dfrac{AM}{PI}\right) = (\mu_2 - \mu_1) \left(\dfrac{AM}{PC}\right)$

$\Rightarrow \quad \dfrac{\mu_1}{-u} + \dfrac{\mu_2}{+v} = \dfrac{(\mu_2 - \mu_1)}{+R}$

$\boxed{\dfrac{\mu_2}{v} - \dfrac{\mu_1}{u} = \dfrac{(\mu_2 - \mu_1)}{R}}$ Or $\boxed{\dfrac{\mu}{v} - \dfrac{1}{u} = \dfrac{(\mu - 1)}{R}}$

PHYSICS CLASS-XII –RAY OPTICS

680. Derive expression for the lens maker's formula using necessary ray diagrams. **CBSE (AI)-2016,2014,2012,2011**
$$\frac{1}{f} = (\mu_{21} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

Also state the assumptions in deriving the above relation and the sign conventions used.

[Ans. For the refraction at the interface ABC,

$$\frac{\mu_2}{v\prime} - \frac{\mu_1}{u} = \frac{(\mu_2 - \mu_1)}{R_1} \qquad ---------(1)$$

For the refraction at ADC, image I_1 will act as an imaginary object and if the lens is very thin, then

$$\frac{\mu_1}{v} - \frac{\mu_2}{v\prime} = -\frac{(\mu_2 - \mu_1)}{R_2} \qquad ---------(2)$$

on adding (1) & (2) we get

$$\frac{\mu_1}{v} - \frac{\mu_1}{u} = (\mu_2 - \mu_1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\Rightarrow \quad \frac{1}{v} - \frac{1}{u} = \frac{(\mu_2 - \mu_1)}{\mu_1}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\Rightarrow \quad \frac{1}{v} - \frac{1}{u} = (\mu_{21} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

But when $u = -\infty$ then $v = f$

$$\Rightarrow \quad \frac{1}{f} - \frac{1}{-\infty} = (n_{21} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\boxed{\frac{1}{f} = (n_{21} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)}$$

Assumptions used :
(i) lens used is very thin.
(ii) Aperture of the lens is very small
(iii) Object is a point object placed at the principal axis.
(iv) All the rays are paraxial.

New Cartesian sign conventions used :
(i) All distances are measured from the optical centre of the lens
(ii) Distances measured in the direction of incident ray are positive
(iii) Distances measured in the opposite direction of incident ray are negative.

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681. Two thin convex lenses L_1 and L_2 of focal lengths f_1 and f_2 respectively, are placed coaxially in contact. An object is placed at a point beyond the focus of lens L_1. Draw a ray diagram to show the image formation and hence derive the expression for the focal length of the combined system. **CBSE (AI)-2017,2016,2014**

[Ans. For the refraction by lens L_1 we have

$$\frac{1}{v\prime} - \frac{1}{u} = \frac{1}{f_1} \qquad --------------(1)$$

For the refraction by lens L_2, $I\prime$ will act as an imaginary object,

$$\Rightarrow \quad \frac{1}{v} - \frac{1}{v\prime} = \frac{1}{f_2} \qquad -------------(2)$$

On adding equation (1) and (2) we get

$$\frac{1}{v\prime} - \frac{1}{u} + \frac{1}{v} - \frac{1}{v\prime} = \frac{1}{f_1} + \frac{1}{f_2}$$
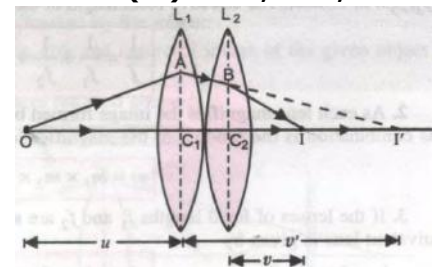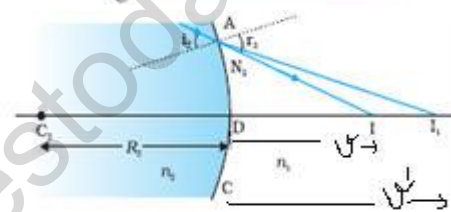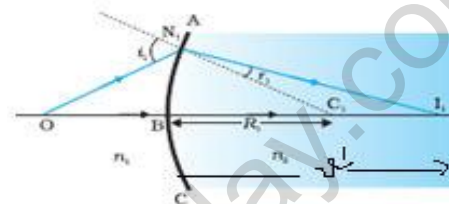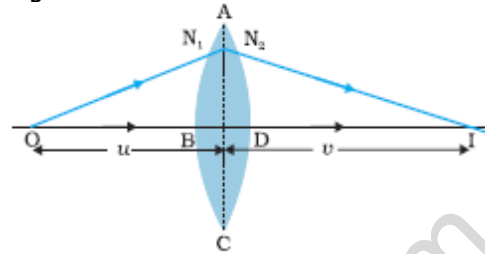
$$\Rightarrow \quad \frac{1}{v} - \frac{1}{u} = \frac{1}{f_1} + \frac{1}{f_2} \qquad -----------(3)$$

Let F be the focal length of this lens combination then we have

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{F} \qquad ------------(4)$$

From (3) and (4),

$$\boxed{\frac{1}{F} \quad \frac{1}{f_1} \quad \frac{1}{f_2}}$$

682. Draw a ray diagram to show the refraction of light through a glass prism. Hence derive the relation

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

CBSE (F)-2017,(AI)-2016,(D)-2016

[Ans. Refraction through a glass prism :

Let a light ray is incident on the principal section

ABC of a glass prism as shown

In quadrilateral AQNR,

$\angle A + 90^0 + \angle QNR + 90^0 = 360^0$

⇒ $\angle A + \angle QNR = 180^0$ ----------(1)

In triangle QNR,

$r_1 + r_2 + \angle QNR = 180^0$ ----------(2)

From (1) and (2)

$r_1 + r_2 = A$ --------(3)

Now, total deviation

$\delta = (i - r_1) + (e - r_2) = (i + e) - (r_1 + r_2)$

⇒ $\delta = i + e - A$ ---------(4)

But when $\delta = \delta_m$, $i = e$ hence $r_1 = r_2$

⇒ from (3), $2r = A$ ⇒ $r = A/2$

From (4), $\delta_m = 2i - A$ ⇒ $i = (A + \delta_m)/2$

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

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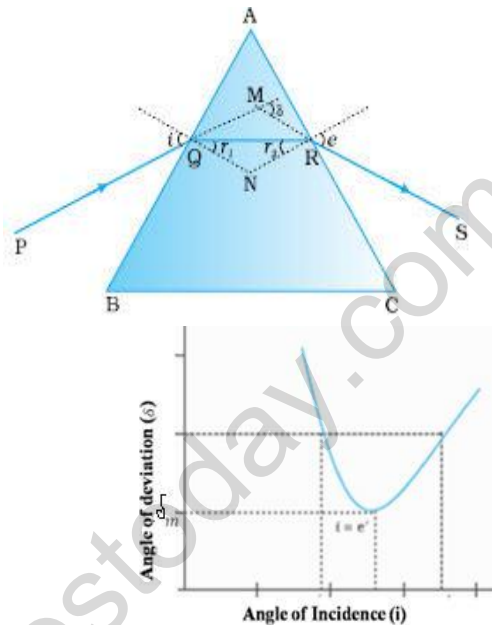
683. A ray of light incident on an equilateral glass prism propagates parallel to the base line of the prism inside it. Find the angle of incidence of this ray. Given refractive index of material of glass prism is $\sqrt{3}$. **CBSE (AI)-2016,2015**

[Ans. **Given :** $\mu_g = \sqrt{3}$, $A = 60^0$, i = ?

If the ray moves parallel to the base line, it means that, $r_1 = r_2 = r$

As $r_1 + r_2 = A$ ⇒ $2r = 60^0$ ⇒ $r = 30^0$

$\mu_g = \frac{\sin i}{\sin r}$ ⇒ $\sqrt{3} = \frac{\sin i}{\sin 30^0}$ ⇒ $\sin i = \sqrt{3} \times \sin 30^0 = \sqrt{3} \times 1/2 = \sqrt{3}/2$ ⇒ $i = 60^0$

==

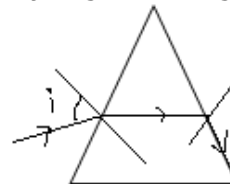**684.** Determine the value of the angle of incidence for a ray of light travelling from a medium of refractive index $\mu_1 = \sqrt{2}$ into the medium of refractive index $\mu_2 = 1$, so that it just grazes along the surface of separation. CBSE (F)-2017

[Ans. From Snell's law,

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

⇒ $\frac{\sin i}{\sin 90} = \frac{1}{\sqrt{2}}$

⇒ $\sin i = \frac{1}{\sqrt{2}}$ ⇒ $i = 45^0$

==

685. A ray of light passing from air through an equilateral glass prism undergoes minimum deviation when the angle of incidence is 3/4 th of the angle of prism. Calculate the speed of light in the prism. **CBSE (AI)-2017**

[Ans. Given : $A = 60^0$, & $i = \frac{3}{4} A$ ⇒ $i = \frac{3}{4} \times 60 = 45^0$

At minimum deviation, $r = A/2 = 60/2 = 30^0$

⇒ $\mu = \frac{\sin i}{\sin r} = \frac{\sin 45}{\sin 30} = \frac{1/\sqrt{2}}{1/2} = \frac{2}{\sqrt{2}} = \sqrt{2}$

But, $\mu = \frac{c}{v}$ ⇒ $v = \frac{c}{\mu} = \frac{3 \times 10^8}{\sqrt{2}} = 2.1 \times 10^8 \ m/s$

PHYSICS CLASS-XII –RAY OPTICS

686. (i) Draw a labelled ray diagram to show the image formation by an astronomical telescope in normal adjustment.
    (ii) Define magnifying power of an astronomical telescope in normal adjustment (i,e, when the final image is formed at infinity).
    (iii) Derive the expression for its magnifying power in normal adjustment.

[Ans.   **CBSE (AI)-2017,2016,(F)-2016,2009**
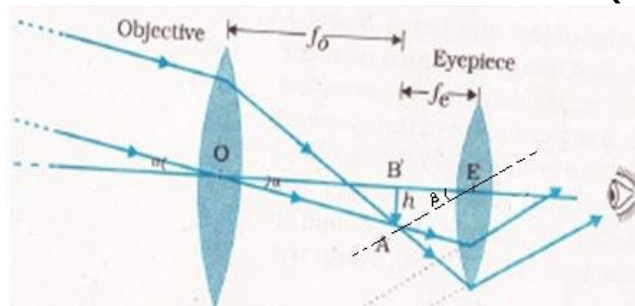
Magnifying power : It is defined as the ratio of the angle subtended at the eye by the final image to the angle subtended at the eye by the object, when both are at infinity
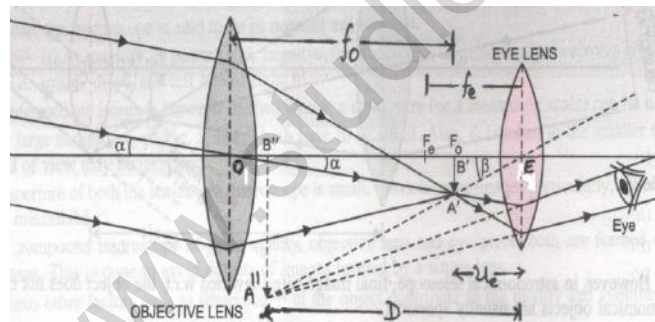
$$m = \frac{\beta}{\alpha} \approx \frac{\tan\beta}{\tan\alpha} = \frac{B'A'/EB'}{B'A'/OB'} = \frac{OB'}{EB'} = \frac{f_0}{-f_e}$$

$$\Rightarrow \quad m = -\frac{f_0}{f_e}$$

==

687. (i) Draw a labelled ray diagram of an astronomical telescope when the final image is formed at least distance of distinct vision.
    (ii) Define its magnifying power and deduce the expression for the magnifying power of telescope.

[Ans.   **CBSE (F)-2015,2014,(AI)-2013**

Magnifying power : It is defined as the ratio of the angle subtended at the eye by the image at the least distance of the distinct vision to the angle subtended at the eye by the object at infinity, when seen directly

$$m = \frac{\beta}{\alpha} = \frac{\tan\beta}{\tan\alpha} = \frac{A'B'/EB'}{A'B'/OB'} = \frac{OB'}{EB'} = -\frac{f_0}{u_e} \quad \text{-------(1)}$$

But for eye lens,

$$\frac{1}{f_e} = \frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{-D} - \frac{1}{-u_e} = \frac{1}{-D} + \frac{1}{u_e}$$

$$\Rightarrow \quad \frac{1}{u_e} = \frac{1}{f_e} + \frac{1}{D} = \frac{1}{f_e}\left(1 + \frac{f_e}{D}\right)$$

$$\Rightarrow \quad \text{from (1),} \quad m = -\frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$$

688. Write the main considerations required in selecting the objective and eye piece lenses in order to have large magnifying power and high resolution of the telescope   **CBSE (AI)-2014**

[Ans. $m = -\frac{f_0}{f_e}$ & $R.P. = \frac{D}{1.22\,\lambda}$

(i) to have large magnifying power $f_o \gg f_e$
   Hence, focal length of objective should be large, while focal length of eye piece should be small

(ii) to have high resolving power D should be large. Hence aperture of objective should be large

PHYSICS CLASS-XII –RAY OPTICS

689. Draw a labelled ray diagram of a compound microscope when image is formed at least distance of distinct vision. Define its magnifying power and deduce the expression for the magnifying power of the microscope.

CBSE (AI)-2016,2010,(F)-2015,2013,(D)-2014

[Ans. ray diagram of a compound microscope when the final image is at least distance of distinct vision:
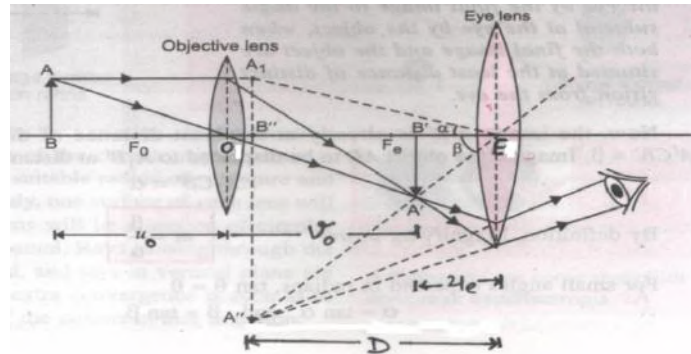
Magnifying power : It is defined as the ratio of the angle subtended at the eye by the image to the angle subtended at the eye by the object, when both lie at the least distance of distinct vision.

$$m = \frac{\beta}{\alpha} \approx \frac{\tan \beta}{\tan \alpha} = \frac{B'A'/EB'}{BA/EB} = \left(\frac{B'A'}{BA}\right)\left(\frac{EB}{EB'}\right) = \left(\frac{v_0}{-u_o}\right)\left(\frac{-D}{-u_e}\right)$$

$$\Rightarrow \quad m = -\frac{v_0}{u_o}\left(\frac{D}{u_e}\right) \qquad \text{-----------(1)}$$

But for eye lens,

$$\frac{1}{f_e} = \frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{-D} - \frac{1}{-u_e} = \frac{1}{-D} + \frac{1}{u_e}$$

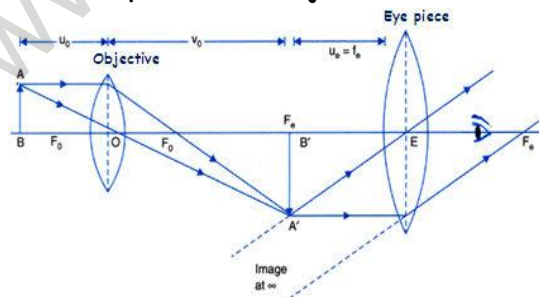$$\Rightarrow \quad \frac{1}{u_e} = \frac{1}{f_e} + \frac{1}{D} = \frac{1}{D}\left(1 + \frac{D}{f_e}\right)$$

$$\Rightarrow \quad \text{from (1),} \quad \boxed{m = \frac{v_0}{u_o}\left(1 + \frac{D}{f_e}\right) = -\frac{L}{f_o}\left(1 + \frac{D}{f_e}\right)}$$

==

690. (i) Draw a labelled ray diagram for the formation of image by a compound microscope in normal adjustment.

(ii) Define magnifying power of a compound microscope in normal adjustment and derive an expression for it.

[Ans. ray diagram of a compound microscope in normal adjustment   **CBSE (D)-2017,(AI)-2015**

[Ans. **Magnifying power** : Magnifying power of a compound microscope is defined as the angle subtended at the eye by the final image to the angle subtended (at the un aided eye) by the object

$$m = m_0 \text{ X } m_e = \frac{v_0}{u_0} \text{ X } \frac{D}{f_e}$$

When the object is very close to f_o, and the image formed is very close to eye lens, then

$u_o \simeq f_o$ and $v_o \simeq L$

$$\boxed{m = -\frac{L}{f_o} \text{ X } \frac{D}{f_e}}$$

PHYSICS CLASS-XII –RAY OPTICS

691. Three rays (1,2,3) of different colours fall normally on one of the sides of an isosceles right angled prism as shown.The refractive index of prism for these rays is 1.39, 1.47 and 1.52 respectively. Find which of these rays get internally reflected and which get only refracted from AC. Trace the path of rays. Justify your answer.

[Ans. For TIR, $i > i_c$ **CBSE (F)-2016,(AI)-2011,(D)-2009**

$\Rightarrow \quad \sin i > \sin i_c$

$\Rightarrow \quad \sin i > \frac{1}{\mu} \qquad [\because \mu = \frac{1}{\sin i_c}]$

$\Rightarrow \quad \mu > \frac{1}{\sin i} = \frac{1}{\sin 45} = \frac{1}{1/\sqrt{2}} = \sqrt{2}$

$\Rightarrow \quad \mu > \sqrt{2} = 1.414$

Hence rays (2) & (3) will go TIR

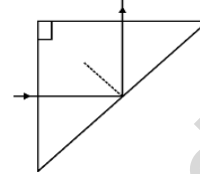===
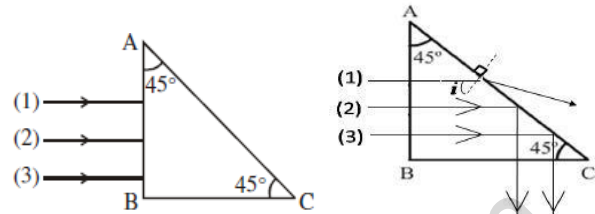
692. A ray of light incident normally on one face of a right isosceles prism is totally reflected as shown. What must be The minimum value of refractive index of glass ? Give relevant calculations.   **CBSE (D)-2016**

[Ans. For TIR, $i \geq i_c$

$\Rightarrow \quad \sin i \geq \sin i_c$

$\Rightarrow \quad \sin 45 \geq \frac{1}{\mu} \quad \Rightarrow \quad \frac{1}{\sqrt{2}} \geq \frac{1}{\mu}$

$\Rightarrow \quad \sqrt{2} \leq \mu \quad \Rightarrow \quad \mu \geq \sqrt{2}$

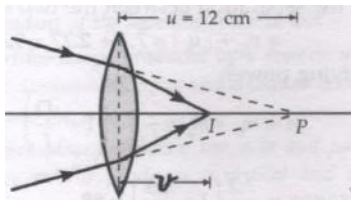===

693. A beam of light converges at a point P. Now a lens is placed in the path of the convergent beam 12 cm from P. At what point does the beam converge if the lens is   **CBSE (AI)-2015,NCERT-2017**
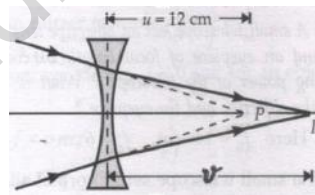(i) a convex lens of focal length 20 cm,
(ii) a concave lens of focal length 16 cm ?

[Ans. $u = + 12$ cm, $f = + 20$ cm $u = + 12$ cm, $f = - 16$ cm

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

$\Rightarrow \quad \frac{1}{20} = \frac{1}{v} - \frac{1}{12}$

$\Rightarrow \frac{1}{v} = \frac{1}{20} + \frac{1}{12} = \frac{3+5}{60} = \frac{8}{60} = \frac{2}{15}$

$\Rightarrow \quad v = + 7.5$ cm

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

$\Rightarrow \quad \frac{1}{-16} = \frac{1}{v} - \frac{1}{12}$

$\Rightarrow \quad \frac{1}{v} = \frac{1}{12} - \frac{1}{16} = \frac{4-3}{48} = \frac{1}{48}$

$\Rightarrow \quad v = + 48$ cm

===

694. A ray of light incident on one of the faces of a glass prism of angle 'A' has angle of incidence 2A. The refracted ray in the prism strikes the opposite face which is silvered, the reflected ray from it retracing its path. Trace the ray diagram and find the relation between the refractive index of the material of the prism and the angle of the prism.
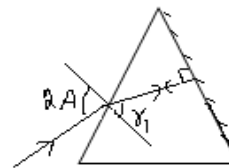
[Ans. We know   **CBSE (AI)-2015**

$r_1 + r_2 = A$

But here, $r_2 = 0$

$\Rightarrow \quad r_1 = A$

$\Rightarrow \quad \mu = \frac{\sin i}{\sin r} = \frac{\sin 2A}{\sin A} = \frac{2 \sin A \cos A}{\sin A} = 2 \cos A$

===

695. Using mirror formula, explain why does a convex mirror always produce a virtual image ? **CBSE (AI)-2016,2011**

[Ans. $\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \quad \Rightarrow \quad \frac{1}{v} = \frac{1}{f} - \frac{1}{u}$ -------(1)

Hence from (1) v is always positive, hence image is always virtual

PHYSICS CLASS-XII –RAY OPTICS

696. You are given two converging lenses of focal lengths 1.25 cm and 5 cm to design a compound microscope. If it is desired to have a magnification of 30, find out the separation between the objective and the eyepiece.

[**Ans.** $m = -\frac{L}{f_o}\left(1 + \frac{D}{f_e}\right)$ **CBSE (AI)-2015**

$\Rightarrow$ $-30 = -\frac{L}{1.25}\left(1 + \frac{25}{5}\right)$ $\Rightarrow$ $-30 \text{ X } 1.25 = L \text{ X } 6$ $\Rightarrow$ $L = 6.25 \, cm$

697. (i) A small telescope has an objective lens of focal length 150 cm and eyepiece of focal length 5 cm. What is the magnifying power of the telescope for viewing distant objects in normal adjustment ? **CBSE (AI)-2015**

(ii) If this telescope is used to view a 100 m tall tower 3 km away, what is the height of the image of the tower formed by the objective lens ? **CBSE (AI)-2015**

[**Ans.** (i) $m = -\frac{f_0}{f_e} = -\frac{150}{5} = -30$

(ii) For objective lens, $\frac{1}{f_o} = \frac{1}{v_o} - \frac{1}{u_o}$

$\Rightarrow$ $\frac{1}{1.5} = \frac{1}{v_o} - \frac{1}{-3000}$ $\Rightarrow$ $\frac{1}{v_o} = \frac{1}{1.5} - \frac{1}{3000} = \frac{2000 - 1}{3000} = \frac{1999}{3000}$

$\Rightarrow$ $v_o = \frac{3000}{1999} \approx 1.5 \, m$

$h_2 = \frac{v_o}{u_o} \text{ X } h_1 = \frac{1.5}{3000} \text{ X } 100 = 0.05 \, m$

698. (i) A giant refracting telescope has an objective lens of focal length 15 m. If an eye piece of focal length 1.0 cm is used, what is the angular magnification of the telescope ? **CBSE (D)-2015,(AI)-2011,NCERT-2017**

(ii) If this telescope is used to view the moon, what is the diameter of the image of the moon formed by the objective lens ? The diameter of the moon is $3.48 \times 10^6 \, m$ and the radius of lunar orbit is $3.8 \text{ X } 10^8 \, m$.

[**Ans.**(i) **Angular magnification**

$|m| = \frac{f_0}{f_e} = \frac{15}{1.0 \text{ X } 10^{-2}} = 1500$

(ii) Angle subtended by the moon

$\alpha = \frac{diameter \, of \, moon}{radius \, of \, lunar \, orbit} = \frac{3.48 \text{ X } 10^6}{3.8 \text{ X } 10^8} = \frac{3.48}{3.8} \text{ X } 10^{-2}$

Angle subtended by the image

$\alpha = \frac{diameter \, of \, image \, of \, moon}{f_0} = \frac{D}{f_0}$

$\Rightarrow$ $\frac{D}{f_0} = \frac{3.48}{3.8} \text{ X } 10^{-2}$ $\Rightarrow$ $D = \frac{3.48}{3.8} \text{ X } 10^{-2} \text{ X } f_0 = \frac{3.48}{3.8} \text{ X } 10^{-2} \text{ X } 15 = 13.73 \, cm$

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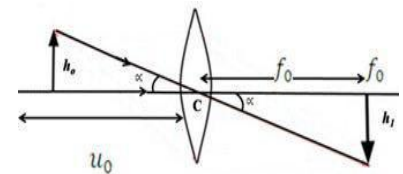
699. Monochromatic light of wavelength 589 nm is incident from air on a water surface. If μ for water is 1.33, find the wavelength, frequency and speed of the refracted light. **CBSE (AI)-2017,NCERT-2017**

[**Ans.** $\lambda' = \frac{\lambda}{\mu} = \frac{589}{1.33} = 442.89 \, nm$

$v = \frac{c}{\lambda} = \frac{3 \text{ X } 10^8}{589 \text{ X } 10^{-9}} = 5.09 \text{ X} 10^{12} \, Hz$

Speed $v' = \frac{c}{\mu} = \frac{3 \text{ X } 10^8}{1.33} = 2.25 \text{ X} 10^8 \, m/s$

699*. Calculate the distance of an object of height h from a concave mirror of radius of curvature $20 \, cm$, so as to obtain a real image of magnification 2. Also find the location of the image. **CBSE (D)-2016**

[**Ans. Given,** $R = -20 \, cm, f = \frac{R}{2} = \frac{-20}{2} = -10 \, cm, m = -2, u = ?, v = ?$

$m = -\frac{v}{u}$ $\Rightarrow$ $-2 = -\frac{v}{u}$ $\Rightarrow$ $v = 2u$ --------(1)

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ $\Rightarrow$ $\frac{1}{-10} = \frac{1}{u} + \frac{1}{u}$ $\Rightarrow$ $u = -15 \, cm$

From (1) $v = 2 \text{ X} - 15 = -30 \, cm$