#419308

Topic: Optical Instruments

A student measures the thickness of a human hair by looking at it through a microscope of magnification 100. He makes 20 observations and finds that the average width of the hair in the field of view of the microscope is $3.5\ mm$. What is the estimate on the thickness of hair?

A $0.035 mm$

B $0.007 mm$

C $3.5 mm$

D None of the above

Solution

Magnification= 100.

Avg. width in Microscope =3.5 mm

So,

Original width = $\dfrac{3.5\ mm}{100} = 0.035\ mm$

#419313

Topic: Thin Lenses

The photograph of a house occupies an area of $1.75 cm^2$ on a slide. The slide is projected on to a screen, and the area of the house on the screen is $1.55 m^2$. What is the linear magnification of the projector-screen arrangement.

Solution

Arial Magnification = Area of image / Area of object

$= 1.55/1.75 \times 10^4$

$= 8857$

Linear Magnification = $\sqrt{8857} = 94.11$

#421246

Topic: Spherical Mirrors

A small candle, 2.5 cm in size is placed at 27 cm in front of a concave mirror of radius of curvature 36 cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image? Describe the nature and size of the image. If the candle is moved closer to the mirror, how would the screen have to be moved?

Solution

Object distance $u = -27cm$

Radius of curvature of the concave mirror, $R = -36cm$

focal length of mirror $f = R/2 = -18cm$

The image distance can be obtained using the mirror formula,

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

From above equation, $v = -54cm$.

Therefore, the screen should be placed 54 cm away from the mirror to obtain a sharp image. The magnification of the image is given as,

$$m = \frac{h'}{h} = -\frac{v}{u}$$

$$\therefore h' = -5cm$$

The height of the candle's image is 5 cm. The negative sign indicates that the image is inverted and virtual. If the candle is moved closer to the mirror, then the screen will have to be moved away from the mirror in order to obtain the image.

#421247

Topic: Spherical Mirrors

A 4.5 cm needle is placed 12 cm away from a convex mirror of focal length 15 cm. Give the location of the image and the magnification. Describe what happens as the needle is moved farther from the mirror.

Solution

Height of the needle, $h_1 = 4.5cm$. Object distance, $u = -12cm$ Focal length of the convex mirror, $f = 15cm$, Image distance $= v$ The value of v can be obtained using the mirror formula.

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

$\therefore v = 6.7cm$

Hence, the image of the needle is 6.7 cm away from the mirror. Also, it is on the other side of the mirror.

The image size is given by the magnification formula.

$$m = \frac{h'}{h} = -\frac{v}{u}$$

$\Rightarrow h' = +2.5cm$

$m = 0.56$

The height of the image is 2.5 cm. The positive sign indicates that the image is erect, virtual, and diminished. If the needle is moved farther from the mirror, the size of the image will reduce gradually.

#421248

Topic: Refraction at Plane Surfaces

A tank is filled with water to a height of 12.5 cm. The apparent depth of a needle lying at the bottom of the tank is measured by a microscope to be 9.4 cm. What is the refractive index of water? If water is replaced by a liquid of refractive index 1.63 up to the same height, by what distance would the microscope have to be moved to focus on the needle again?

Solution

$h_1 = 12.5cm;\ h_2 = 9.4cm$

$\mu = h_1/h_2 = 1.33$

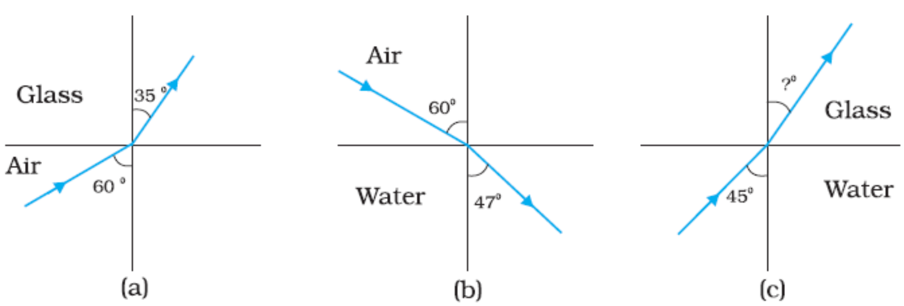
now water is replaced by $\mu' = 1.63$

$\mu' = h/y \Rightarrow y = 7.67cm$

distance by which microscope should be moved up is $9.4 - 7.67 = 1.73\ cm$

#421256

Topic: Refraction at Plane Surfaces



Figures (a) and (b) show refraction of a ray in air incident at 60^o with the normal to a glass-air and water - air interface, respectively. Predict the angle of refraction in glass when the angle of incidence in water is 45^o with the normal to a water-glass interface [Fig. (c)].

Solution

Refractive index of glass $\mu_g = sin60^o/sin35^o = 1.51$

For water $\mu_w = sin60^o/sin47^o = 1.184$

So, refractive index of glass wrt to water can be $\mu_r = \mu_g/\mu_w = 1.275$

now,

$\mu_r = sin45^o/sinr = 1.275 \Rightarrow r = 36.68^o \approx 37^o$

#421261

Topic: Total Internal Reflection

A small bulb is placed at the bottom of a tank containing water to a depth of 80 cm. What is the area of the surface of water through which light from the bulb can emerge out? Refractive index of water is 1.33. (Consider the bulb to be a point source.)

Solution

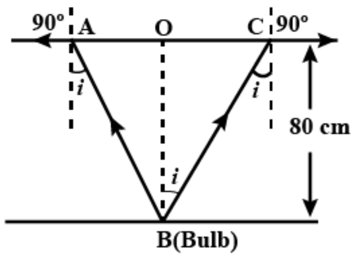
Actual depth $d_1 = 0.8m$; $\mu = 1.33$

Circle radius, $R = AC/2$

$\mu = sin90^o / sini \Rightarrow i = 48.75^o$

$tani = OC/OB = R/d_1 \Rightarrow R = 0.91m$

Area, $\pi R^2 = 2.61m^2$



#421265

Topic: Prism

A prism is made of glass of unknown refractive index. A parallel beam of light is incident on a face of the prism. The angle of minimum deviation is measured to be 40^o. What is the refractive index of the material of the prism? The refracting angle of the prism is 60^o. If the prism is placed in water (refractive index 1.33), predict the new angle of minimum deviation of a parallel beam of light.

Solution

Angle of prism, 60^o, minimum deviation $\delta = 40^o$

μ' is the refractive index of the material of prism.

$\mu' = sin(\frac{A + \delta m}{2}) / sin(\frac{A}{2}) = 1.5321$

Let δ_1 be new minimum deviation, now it is put under water $\mu = 1.33$

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

$\Rightarrow \delta_1 = 10.32^o$

#421272

Topic: Thin Lenses

Double-convex lenses are to be manufactured from a glass of refractive index 1.55, with both faces of the same radius of curvature. What is the radius of curvature required if the focal length is to be 20 cm?

Solution

$f = 20cm$, R_1 is the radius of curvature of one face, R_2 is the radius of curvature of other face., R is the radius of curvature of double convex.

$R_1 = R$; $R_2 = -R$

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

$R = 22cm$

#421274

Topic: Thin Lenses

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 (a) a convex lens of focal length 20 cm, and (b) a concave lens of focal length 16 cm?

Solution

According to the given case, object is virtual, $u = +12\ cm$

Using lens equation, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$v = 7.5\ cm$

now the focal length of the concave lens, $f = -16\ cm$

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

$v = 48\ cm$

#421292

Topic: Thin Lenses

An object of size 3.0 cm is placed 14cm in front of a concave lens of focal length 21cm. Describe the image produced by the lens. What happens if the object is moved further away from the lens?

Solution

$h_1 = 3cm; u = -14cm; f = -21cm$

by lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$v = -8.4cm$

Magnification formula for lens,

$m = \frac{h'}{h} = \frac{v}{u} \Rightarrow h_2 = 1.8cm$

#421296

Topic: Combination of Lenses and Mirrors

What is the focal length of a convex lens of focal length 30 cm in contact with a concave lens of focal length 20cm? Is the system a converging or a diverging lens? Ignore thickness of the lenses.

Solution

Focal length of convex lenses, $f_1 = 30cm$

Focal length of concave lenses, $f_2 = -20cm$

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

$f = -60cm$. Therefore diverging lens .

#421298

Topic: Optical Instruments

A compound microscope consists of an objective lens of focal length $2.0cm$ and an eyepiece of focal length $6.25cm$ separated by a distance of $15cm$. How far from the objective should an object be placed in order to obtain the final image at (a) the least distance of distinct vision $(25cm)$, and (b) at infinity? What is the magnifying power of the microscope in each case?

Solution

Focal length of the objective lens $f_1 = 2cm$

Focal length of the eyepiece,$f_2 = 6.25cm$

Distance between the objective lens and the eyepiece,$d = 15cm$

Least distance of distinct vision,$d^{'} = 25cm$

Image distance for the eyepiece,$v_2 = -25cm$

bject distance for the eyepiece = u_2

According to the lens formula

$$\frac{1}{f_2} = \frac{1}{v_2} - \frac{1}{u_2}$$
$$\frac{1}{6.25} = \frac{1}{-25} - \frac{1}{u_2}$$

$u_2 = -5cm$

Image distance for the objective lens $v_1 = d + u_2 = 15 - 5 = 10cm$

According to the lens formula

$$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u_1}$$
$$\frac{1}{2} = \frac{1}{10} - \frac{1}{u_1}$$

$u_2 = -2.5cm$

The magnifying power of a compound microscope is given by the relation

$$m = \frac{v_1}{|u_1|}(1 + \frac{d^{'}}{f_2})$$
$$m = \frac{10}{2.5}(1 + \frac{25}{6.25}) = 20$$

b)The final image is formed at infinity

Image distance for the eyepiece $v_2 = \infty$

According to the lens formula

$$\frac{1}{f_2} = \frac{1}{v_2} - \frac{1}{u_2}$$

According to the lens formula

$$\frac{1}{6.25} = \frac{1}{\infty} - \frac{1}{u_2}$$

$u_2 = -6.25cm$

Image distance for the objective lens $v_1 = d + u_2 = 10 - 6.25 = 8.75$

Object distance for the objective len =u_2

According to the lens formula

$$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u_1}$$

$$\frac{1}{2} = \frac{1}{8.75} - \frac{1}{u_1}$$

$u_2 = -2.59cm$

The magnifying power of a compound microscope is given by the relation:

$$\frac{v_1}{|u_1|}(\frac{d^{'}}{|u_2|}) = 13.51$$

#421303

Topic: Optical Instruments

A person with a normal near point (25 cm) using a compound microscope with objective of focal length 8.0 mm and an eyepiece of focal length 2.5 cm can bring an object placed at 9.0 mm from the objective in sharp focus. What is the separation between the two lenses? Calculate the magnifying power of the microscope.

Solution

Focal length of the objective lens, $f_o = 8mm = .8cm$

Focal length of the eyepiece; $f_e = 2.5cm$

Object distance for the objective lens, $\mu_o = -9mm = -.9cm$

Least distance of distant vision $d = 25cm$

Image distance for the eyepiece, $v_e = -d = -25cm$

Object distance for the eyepiece $= u_e$

Using the lens formula, we can obtain the value of u_e

$$\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e}$$
$$\frac{1}{-25} - \frac{1}{u_e} = \frac{1}{2.5}$$

So, $u_e = -2.27cm$

We can also obtain the value of the image distance for the objective lens v_o using the lens formula.

$$\frac{1}{v_o} - \frac{1}{u_o} = \frac{1}{f_o}$$
$$\frac{1}{v_o} - \frac{1}{-0.9} = \frac{1}{0.8}$$

distance between the objective lens and the eye piece is $|u_e| + v_o$

so separation is $2.27 + 7.2 = 9.47cm$

The magnifying power of the microscope is calculated as

$$m = \frac{v_o}{|u_o|}(1 + d/f_e) = 88$$

#421305

Topic: Optical Instruments

A small telescope has an objective lens of focal length 144cm and an eyepiece of focal length 6.0 cm. What is the magnifying power of the telescope? What is the separation between the objective and the eyepiece?

Solution

$f_o = 144cm; f_e = 6cm$

for telescope, $m = f_o/f_e = 24$

The separation between the objective lens and the eyepiece is $f_o + f_e = 150cm$

#421309

Topic: Optical Instruments

(a) A giant refracting telescope at an observatory has an objective lens of focal length 15 m. If an eyepiece of focal length 1.0 cm is used, what is the angular magnification of the telescope?

(b) 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 $3.8 \times 10^8 m$.

Solution

(a) Angular magnification of a telescope is

$m = f_o/f_e = 1500$

(b) Let d be diameter of moon and r_o be radius of lunar orbit.

Let d' be the diameter of image of moon.

The angle subtended by the diameter of moon is equal to the angle subtended by the image.

$d/r_o = d'/f_o \Rightarrow d' = 13.74cm$

#421310

Topic: Spherical Mirrors

Use the mirror equation to deduce that:

(a) an object placed between f and $2f$ of a concave mirror produces a real image beyond $2f$.

(b) a convex mirror always produces a virtual image independent of the location of the object.

(c) the virtual image produced by a convex mirror is always diminished in size and is located between the focus and the pole.

(d) an object placed between the pole and focus of a concave mirror produces a virtual and enlarged image.

[Note: This exercise helps you deduce algebraically properties of images that one obtains from explicit ray diagrams.]

Solution

a)For a concave mirror, the focal length (f) is negative.

When the object is placed on the left side of the mirror, the object distance (u) is negative

For image distance v we can write

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

$$\frac{1}{v}=\frac{1}{f}-\frac{1}{u} \quad ...(1)$$

The object lies between f and $2f$.

$$2f < u < f$$

$$\frac{1}{2f} > \frac{1}{u} > \frac{1}{f}$$

$$\frac{-1}{2f} < \frac{-1}{u} < \frac{-1}{f}$$

$$\frac{1}{f}-\frac{1}{2f} < \frac{1}{f}-\frac{1}{u} \quad ....(2)$$

from eq. 1

$$\frac{1}{2f} < \frac{1}{v} < 0 \text{ ; } v \text{ is negative}$$

$$2f > v$$

$$-v > -2f$$

Therefore, the image lies beyond $2f$.

b) For a convex mirror, the focal length (f) is positive

When the object is placed on the left side of the mirror, the object distance (u) is negative

For image distance v, we have the mirror formula

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

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

Using eq (2)

$$\frac{1}{v} < 0$$

$$v > 0$$

Thus, the image is formed on the back side of the mirror.

Hence, a convex mirror always produces a virtual image, regardless of the object distance.

c)For a convex mirror, the focal length (f) is positive

When the object is placed on the left side of the mirror, the object distance (u) is negative

For image distance v, we have the mirror formula

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

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

but $u < 0$

therefore $\frac{1}{v} > \frac{1}{f}$

$$v < f$$

Hence, the image formed is diminished and is located between the focus (f) and the pole

d)For a concave mirror, the focal length (f) is negative

When the object is placed on the left side of the mirror, the object distance (u) is negative

It is placed between the focus (f) and the pole

therefore $f > u > 0$

$\frac{1}{f} < \frac{1}{u} < 0$

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

For image distance v, we have the mirror formula

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

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

$\frac{1}{v} < 0$

$v > 0$

The image is formed on the right side of the mirror. Hence, it is a virtual image

For $u < 0$ and $v > 0$, we can write:

$\frac{1}{u} > \frac{1}{v}$ so $v > u$

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

Hence, the formed image is enlarged.

#421311
Topic: Refraction at Plane Surfaces

A small pin fixed on a table top is viewed from above from a distance of 50 cm. By what distance would the pin appear to be raised if it is viewed from the same point through a 15 cm thick glass slab held parallel to the table? Refractive index of glass $=$ 1.5. Does the answer depend on the location of the slab?

Solution

Actual depth of the pin , $d = 15cm$

Apparent dept of the pin = d'

Refractive index of glass is $\mu = 1.5$

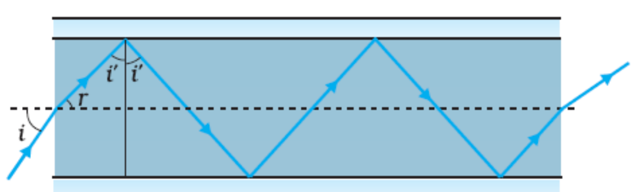
Ratio of actual depth to the apparent depth is equal to the refractive index of the glass i.e.

$\mu = \frac{d}{d'} \Rightarrow d' = 10cm$

The distance at which the pin appears to be raised = $d' - d = 15 - 10 = 5cm$

For a small angle of incidence, this distance does not depend upon the location of the slab.

#421320
Topic: Total Internal Reflection



(a) Figure shows a cross-section of a light pipe made of a glass fibre of refractive index 1.68. The outer covering of the pipe is made of a material of refractive index 1.44. What is the range of the angles of the incident rays with the axis of the pipe for which total reflections inside the pipe take place, as shown in the figure.

(b) What is the answer if there is no outer covering of the pipe?

Solution

(a)

$\mu_1 = 1.68, \mu_2 = 1.44$

$\mu_1/\mu_2 = 1/\sin i_1 \Rightarrow i_1 = 59^o$

For critical angle, total internal reflection takes place when $i > i_1$

maximum angle of reflection is $90 - i_1 = 31^o = r_{max}$

Let i_{max} be the maximum angle of incidence.

$\mu_1 = \sin i_{max}/\sin r_{max} \Rightarrow i_{max} = 60^o$

Thus all the ray between $0^o < i < 60^o$ will suffer TIR.

(b)

Now, $\mu_1 = 1$ (air)

$\sin i/\sin r = \mu_2/\mu_1 \Rightarrow r = 36.5^o$

$i = 90 - 36.5 = 53.5^o$

Since $i > r$, all incident ray will suffer TIR

#421339

Topic: Total Internal Reflection

Answer the following questions:

(a) You have learnt that plane and convex mirrors produce virtual images of objects. Can they produce real images under some circumstances? Explain.

(b) A virtual image, we always say, cannot be caught on a screen. Yet when we see a virtual image, we are obviously bringing it on to the screen (i.e., the retina) of our eye. Is there a contradiction?

(c) A diver under water, looks obliquely at a fisherman standing on the bank of a lake. Would the fisherman look taller or shorter to the diver than what he actually is?

(d) Does the apparent depth of a tank of water change if viewed obliquely? If so, does the apparent depth increase or decrease?

(e) The refractive index of diamond is much greater than that of ordinary glass. Is this fact of some use to a diamond cutter?

Solution

(a)

Plane and convex mirrors can produce real images as well. If the object is virtual, i.e., if the light rays converging at a point behind a plane mirror (or a convex mirror) are reflected to a point on a screen placed in front of the mirror, then a real image will be formed.

(b)

A virtual image is formed when light rays diverge. The convex lens of the eye causes these divergent rays to converge at the retina. In this case, the virtual image serves as an object for the lens to produce a real image.

(c)

The diver is in the water and the fisherman is on land (i.e., in air). Water is a denser medium than air. It is given that the diver is viewing the fisherman. This indicates that the light rays are travelling from a denser medium to a rarer medium. Hence, the refracted rays will move away from the normal. As a result, the fisherman will appear to be taller.

(d)

Yes, it Decreases.

The apparent depth of a tank of water changes when viewed obliquely. This is because light bends on travelling from one medium to another. The apparent depth of the tank when viewed obliquely is less than the near-normal viewing.

(e)

The refractive index of diamond (2.42) is more than that of ordinary glass (1.5). The critical angle for diamond is less than that for glass. A diamond cutter uses a large angle of incidence to ensure that the light entering the diamond is totally reflected from its faces. This is the reason for the sparkling effect of a diamond.

#421350

Topic: Refraction at Plane Surfaces

(a) The refractive index of glass is 1.5. What is the speed of light in glass? (Speed of light in vacuum is $3.0 \times 10^8 ms^{-1}$)

(b) Is the speed of light in glass independent of the colour of light? If not, which of the two colours red and violet travels slower in a glass prism?

Solution

(a) Speed of light in glass is $c/\mu = 2 \times 10^8 m/s$

(b) The speed of light in glass is not independent of the colour of light. The refractive index of a violet component of white light is greater than the refractive index of a red component. Hence, the speed of violet light is less than the speed of red light in glass. Hence, violet light travels slower than red light in a glass prism.

#421357

Topic: Combination of Lenses and Mirrors

The image of a small electric bulb fixed on the wall of a room is to be obtained on the opposite wall 3m away by means of a large convex lens. What is the maximum possible focal length of the lens required for the purpose?

Solution

$d = 3m$

For real image, maximum focal length is given as $f_{max} = d/4 = 0.75m$

#421360

Topic: Thin Lenses

A screen is placed 90 cm from an object. The image of the object on the screen is formed by a convex lens at two different locations separated by 20 cm. Determine the focal length of the lens.

Solution

Distance between screen and the object $D = 90cm$.

Distance between two location of convex lens, $d = 20cm$

$$f = \frac{D^2 - d^2}{4D} = 21.39cm$$

#421369

Topic: Combination of Lenses and Mirrors

(a) Determine the effective focal length of the combination of the two lenses, if they are placed 8.0 cm apart with their principal axes coincident. Does the answer depend on which side of the combination a beam of parallel light is incident? Is the notion of effective focal length of this system useful at all?

(b) An object 1.5 cm in size is placed on the side of the convex lens in the arrangement (a) above. The distance between the object and the convex lens is 40cm. Determine the magnification produced by the two-lens system, and the size of the image.

Solution

(a)

(i) Let a parallel beam be the incident from the left on the convexlens first.

$f_1 = 30\ cm$ and $u_1 = \infty$, give $v_1 = +30\ cm$. This image becomes a virtual object for the second lens.

$f_2 = 20\ cm$, $u_2 = +(308)cm = +22\ cm$ which gives, $v_2 = 220\ cm$. The parallel incident beam appears to diverge from a point 216 cm from the centre of the two - lens system.

(ii) Let the parallel beam be incident from the left on the concavelens first:

$f_1 = 20\ cm$, $u_1 = \infty$, give $v_1 = 20\ cm$.

This image becomes a real object for the second lens:

$f_2 = +30\ cm$, $u_2 = (20 + 8)cm = 28\ cm$ which gives, $v_2 = 420\ cm$. The paralle lincident beam appears to diverge from a point 416 cm on the left of the centre of the two - lens system.

Clearly, the answer depends on which side of the lens system the parallel beam is incident. Further we do not have a simple lens equation true for all u (and v) in terms of a definite constant of the system (the constant being determined by f_1 and f_2, and the separation between the lenses). The notion of effective focal length, therefore, does not seem to be meaningful for this system.

(b)

$u_1 = 40\ cm$, $f_1 = 30\ cm$, gives $v_1 = 120\ cm$.

Magnitude of magnification due to the first (convex) lens is 3.

$u_2 = +(120)cm = +112\ cm$ (object virtual);

$f_2 = 20\ cm$ which gives $v_2 = -\dfrac{112 \times 20}{92}$

Magnitude of magnification due to the second (concave) lens = 20/92.

Net magnitude of magnification = 0.652

Size of the image = 0.98 cm

#421376
Topic: Prism

At what angle should a ray of light be incident on the face of a prism of refracting angle 60° so that it just suffers total internal reflection at the other face? The refractive index of the material of the prism is 1.524.

Solution

Angle of prism A is 60^o; $\mu = 1.524$

i is angle of incidence.

r_1 is angle of refraction.

r_2 is angle of incidence during exit from other end.

e is 90^o angle of convergent.

$\mu = sine / sinr_2 \Rightarrow r_2 = 41^o$

$r_1 = A - r_2 = 19^o$

$\Rightarrow \mu = sini / sinr_1 \Rightarrow i = 29.75^o$

#421378
Topic: Prism

You are given prisms made of crown glass and flint glass with a wide variety of angles. Suggest a combination of prisms which will

(a) deviate a pencil of white light without much dispersion,

(b) disperse (and displace) a pencil of white light without much deviation.

Solution

(a)Place the two prisms beside each other. Make sure that their bases are on the opposite sides of the incident white light, with their faces touching each other. When the white light is incident on the first prism, it will get dispersed. When this dispersed light is incident on the second prism, it will recombine and white light will emerge from the combination of the two prisms.

(b)Take the system of the two prisms as suggested in answer (a). Adjust (increase) the angle of the flint-glass-prism so that the deviations due to the combination of the prisms become equal. This combination will disperse the pencil of white light without much deviation.

#421384

Topic: Human Eye

For a normal eye, the far point is at infinity and the near point of distinct vision is about 25cm in front of the eye. The cornea of the eye provides a converging power of about 40 dioptres, and the least converging power of the eye - lens behind the cornea is about 20 dioptres. From this rough data estimate the range of accommodation (i.e., the range of converging power of the eye-lens) of a normal eye.

Solution

To see object at infinity, eye uses its least converging power.

Power of eye lens, $P = 40 + 20 = 60D$

Power of eye lens is $1/f \Rightarrow f = 5/3cm$

To focus on object at the near point, object distance $u = -d = -25$ cm

Focal length of eye lens is distance between the cornea and the retina.

Image distance, $v = 5/3\ cm$

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f_1} \Rightarrow f_1 = 16/25cm^{-1}$

Power is $100/f_1 = 64D$

power of eye lens is $64 - 40 = 24D$.

#421387

Topic: Human Eye

Does short-sightedness (myopia) or long-sightedness (hypermetropia) imply necessarily that the eye has partially lost its ability of accommodation? If not, what might cause these defects of vision?

Solution

A myopic or hypermetropic person can also possess the normal ability of accommodation of the eye-lens. Myopia occurs when the eye-balls get elongated from front to back. Hypermetropia occurs when the eye-balls get shortened. When the eye-lens loses its ability of accommodation, the defect is called presbyopia.

#421394

Topic: Human Eye

A myopic person has been using spectacles of power 1.0 dioptre for distant vision. During old age he also needs to use separate reading glass of power + 2.0 dioptres. Explain what may have happened.

Solution

The power of the spectacles used by the myopic person, $P = -1D$

Focal length of the spectacles, $f = 1/P = -1m = -100cm$

Hence, the far point of the person is 100cm. He might have a normal near point of 25 cm. When he uses the spectacles, the objects placed at infinity produce virtual images at 100 cm. He uses the ability of accommodation of the eye-lens to see the objects placed 100cm and 25cm.

During old age, the person uses reading glasses of power, $P = +2D$

The ability of accommodation is lost in old age. This defect is called presbyopia. As a result, he is unable to see clearly the objects placed at 25 cm.

#421401

Topic: Human Eye

A person is looking at another person wearing a shirt with a pattern comprising of vertical and horizontal lines. He is able to see the vertical lines more distinctly than the horizontal ones. What is this defect due to? How is such a defect of vision corrected?

Solution

The person is suffering from Astigmatism. It is a defect caused due to the imperfection in the curvature of cornea. In this defect, a person is able to focus objects with in one direction only and is unable to do so in its perpendicular direction.

Astigmatism is corrected with the use of a cylindrical lens.

#421407

Topic: Optical Instruments

A man with normal near point (25 cm) reads a book with small print using a magnifying glass: a thin convex lens of focal length 5 cm.

(a) What is the closest and the farthest distance at which he should keep the lens from the page so that he can read the book when viewing through the magnifying glass?

(b) What is the maximum and the minimum angular magnification (magnifying power) possible using the above simple microscope?

Solution

(a)

$f = 25\ cm$

least distance of distance vision, $d = 25\ cm$

closed object distance is u.

Image distance $v = -d = -25cm$.

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow u = -4.167 \approx -4.2$

Hence closest distance to resd book is 4.2 cm

for the farthest distance, $v = \infty$

$\frac{1}{v} - \frac{1}{u_1} = \frac{1}{f} \Rightarrow u_1 = -5$

Hence the farthest distance at which person can read the book is $5cm$.

(b)

maximum angular magnification,

$\alpha = d/|u| = 25/|-4.167| = 6$

minimum angular magnification,

$\alpha = d/|u_1| = 25/|5| = 5$

#421426

Topic: Optical Instruments

A card sheet divided into squares each of size $1\ mm^2$ is being viewed at a distance of 9 cm through a magnifying glass (a converging lens of focal length 9 cm) held close to the eye.

(a) What is the magnification produced by the lens? How much is the area of each square in the virtual image?

(b) What is the angular magnification (magnifying power) of the lens?

(c) Is the magnification in (a) equal to the magnifying power in (b)? Explain

Solution

(a)

Area of each square, $A = 1mm^2$

$u = -9,\ f = 10$

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow v = -90cm$

Magnification, $m = v/u = -90/(-9) = 10$

Area of each square is $10^2 \times A = 100mm^2$

(b)

Magnifying power of the lens is $d/|u| = 25/9 = 2.8$

(c)

No, magnification of an image by a lens and angular magnification (or magnifying power) of an optical instrument are two separate things. The latter is the ratio of the angular size of the object (which is equal to the angular size of the image even if the image is magnified) to the angular size of the object if placed at the near point (25 cm). Thus, magnification magnitude is $|(v/u)|$ and magnifying power is $(25/|u|)$. Only when the image is located at the near point $|v| = 25\ cm$, are the two quantities equal.

#421445

Topic: Optical Instruments

A card sheet divided into squares each of size $1\ mm^2$ is being viewed at a distance of $9\ cm$ through a magnifying glass (a converging lens of focal length $9\ cm$) held close to the eye.

In order to view the squares distinctly with the maximum possible magnifying power.

(a) What is the magnification produced by the lens? How much is the area of each square in the virtual image?

(b) What is the angular magnification (magnifying power) of the lens?

(c) Is the magnification in (a) equal to the magnifying power in (b)?

Explain:

Solution

(a) Area of each square , $A = 1 mm^2$

Object distance $u = -9 cm$

Focal length of the converging lens , $f = 10 cm$

For image distance v, the lens formula can be written as

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

By putting the values we get $v = -90 cm$

Now magnification,

$$m = \frac{u}{v} = \frac{-60}{-9} = 10$$

$\therefore$ Area of each square in the virtual image = $10^2 A = 10^2 \times 1 = 100 mm^2$

(b) Magnifying power of the lens

$$\frac{d}{|u|} = \frac{25}{9} = 2.8$$

(c) The magnification in (a) is not same as the magnifying power in (b).

The ,magnification magnitude is

$(|\frac{v}{u}|)$ and the magnifying power is $(\frac{d}{|u|})$

The two quantities will be equal when the image is formed at the near point (25cm).

#421461

Topic: Optical Instruments

A card sheet divided into squares each of size $1\ mm^2$ is being viewed at a distance of 9 cm through a magnifying glass (a converging lens of focal length 9 cm) held close to the eye and the magnifying glass if the virtual image of each square is to have an area of $6.25 mm^2$. Would you be able to see the squares distinctly with your eyes very close to the magnifier?

Solution

Area of virtual image $A = 6.25 mm^2$

$A_o = 1 mm^2$

Linear magnification $m = \sqrt{A/A_o} = 2.5$

But $m = v/u \Rightarrow v = 2.5u$

also, $f = 10 cm$

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

so, $v = -15\ cm;\ u = -6\ cm$

Virtual image is formed at 15cm which is less than 25cm. Hence, it can not be seen.

#421467

Topic: Refraction at Plane Surfaces

Explain how Corpuscular theory predicts the speed of light in a medium, say, water, to be greater than the speed of light in vacuum. Is the prediction confirmed by experimental determination of the speed of light in water? If not, which alternative picture of light is consistent with experiment?

Solution

No; Wave theory

Newton's corpuscular theory of light states that when light corpus

of two media moves from a rarer (air) to a denser (water) medium, the particles experience forces of attraction normal to the surface. Hence, the normal component of velocity increases while the component along the surface remains unchanged.

Hence, $c\sin i = v\sin r$

i = Angle of incidence

r= Angle of reflection

c= Velocity of light in air

v= Velocity of light in water

We have the relation for relative refractive index of water with respect to air as $\mu = v/c$

Thus, $v/c = \sin i/\sin r = \mu$

Hence, it can be inferred that $v > c$. This is not possible since this prediction is opposite to the experimental results of $c > v$.

The wave picture of light is consistent with the experimental results.

#421475

Topic: Optical Instruments

Answer the following questions:

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

(b) In viewing through a magnifying glass, one usually positions ones eyes very close to the lens. Does angular magnification change if the eye is moved back?

(c) Magnifying power of a simple microscope is inversely proportional to the focal length of the lens. What then stops us from using a convex lens of smaller and smaller focal length and achieving greater and greater magnifying power?

(d) Why must both the objective and the eyepiece of a compound microscope have short focal lengths?

(e) When viewing through a compound microscope, our eyes should be positioned not on the eyepiece but a short distance away from it for best viewing. Why? How much should be that short distance between the eye and eyepiece?

Solution

(a) Though the image size is bigger than the object, the angular size of the image is equal to the angular size of the object. A magnifying glass helps one see the objects placed closer than the least distance of distinct vision (i.e., 25cm). A closer object causes a larger angular size. A magnifying glass provides angular magnification. Without magnification, the object cannot be placed closer to the eye. With magnification, the object can be placed much closer to the eye.

(b) Yes, the angular magnification changes. When the distance between the eye and a magnifying glass is increased, the angular magnification decreases a little. This is because the angle subtended at the eye is slightly less than the angle subtended at the lens. Image distance does not have any effect on angular magnification.

(c) The focal length of a convex lens cannot be decreased by a greater amount. This is because making lenses having very small focal lengths is not easy. Spherical and chromatic aberrations are produced by a convex lens having a very small focal length.

(d) Angular magnification of eye-piece is $[(25/f_e)+1]$ (f_e in cm) which increases if f_e is smaller. Further, magnification of the objective is given by $\frac{V_o}{|u_o|} = \frac{1}{\left(|u_o|/f_o\right)-1}$

which is large when $|u_O|$ is slightly greater than f_O. The microscope is used for viewing very close object. So $|u_o|$ is small, and so is f_O.

(e) When we place our eyes too close to the eyepiece of a compound microscope, we are unable to collect much refracted light. As a result, the field of view decreases substantially. Hence, the clarity of the image gets blurred.

The best position of the eye for viewing through a compound microscope is at the eye-ring attached to the eyepiece. The precise location of the eye depends on the separation between the objective lens and the eyepiece.

#421535

Topic: Optical Instruments

An angular magnification (magnifying power) of 30X is desired using an objective of focal length 1.25cm and an eyepiece of focal length 5cm. How will you set up the compound microscope?

Solution

Focal length of the objective lens, $f_o = 1.25 cm$

Focal length of the eyepiece, $f_e = 5cm$

Least distance of distinct vision, $d = 25cm$

Angular magnification of the compound microscope = $30X$

Total magnifying power of the compound microscope, $m = 30$

The angular magnification of the eyepiece is given by the relation-

$m_e = (1 + d/f_e) = 6$

The angular magnification of the objective lens (m_o) is calculated as-

$m_o m_e = m \Rightarrow m_o = 5$

Now, $m_o = -v_o/u_o \Rightarrow v_o = -5u_o$

Using lens formula,

$$\frac{1}{v_o} - \frac{1}{u_o} = \frac{1}{f_o}$$

Using above two equations, $u_o = -1.5cm \text{ and } v_o = 7.5cm$

So, The object should be placed 1.5 cm away from the objective lens to obtain the desired magnification.

Now, Image distance for the eyepiece is $v_e = -d = -25cm$

Using lens formula,

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

$u_e = -4.17cm$

Separation between the objective lens and the eyepiece, $|u_e| + |v_o| = 11.67cm$

Therefore, the separation between the objective lens and the eyepiece should be 11.67cm.

#421542
Topic: Optical Instruments

A small telescope has an objective lens of focal length 140cm and an eyepiece of focal length 5.0cm. What is the magnifying power of the telescope for viewing distant objects when

(a)the telescope is in normal adjustment (i.e., when the final image is at infinity)?

(b) the final image is formed at the least distance of distinct vision (25cm)?

Solution

(a) Focal length of the objective lens, $f_o = 140cm$

Focal length of the eyepiece, $f_e = 5cm$

Least distance of distinct vision, $d = 25cm$

When the telescope is in normal adjustment, its magnifying power is given as-

$m = f_o/f_e = 28$

(b) Focal length of the objective lens, $f_o = 140cm$

Focal length of the eyepiece, $f_e = 5cm$

Least distance of distinct vision, $d = 25cm$

When the final image is formed at d, its magnifying power is given as-

$m = f_o/f_e(1 + f_e/d) = 33.6$

#421547
Topic: Optical Instruments

Answer the following questions:

(a) For the telescope described in Exercise (a)[A small telescope has an objective lens of focal length $140cm$ and an eyepiece of focal length $5.0cm$. What is the magnifying power of the telescope for viewing distant objects when

(a) the telescope is in normal adjustment (i.e., when the final image is at infinity)?],

What is the separation between the objective lens and the eyepiece?

(b) If this telescope is used to view a $100m$ tall tower $3km$ away, what is the height of the image of the tower formed by the objective lens?

(c) What is the height of the final image of the tower if it is formed at $25cm$?

Solution

(a) Focal length of objective lens is $f_o = 140cm$

Focal length of an eyepiece is $f_e = 5cm$

At normal adjustment, the separation between the objective lens and the eyepiece is $f_e + f_o = 145cm$

(b) Distance of tower is $3000m$; $h_1 = 100m$

angle subtended by tower at telescope is $\theta_1 = h_1/u = 1/30\ rad$

angle subtended by image, $\theta_2 = h_2/f_o = h_2/140rad$

as two angles are equal, $h_2 = 4.7cm$

(c) Image formed at $d = 25cm$.

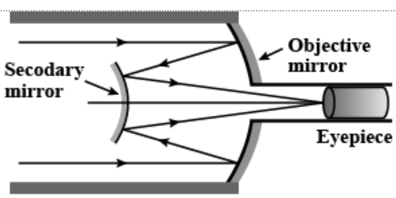
$m = 1 + d/f = 6$

f_e is focal length of eyepiece.

Height of the image is $m \times h_2 = 6 \times 4.7 = 28.2cm$

#421595

Topic: Optical Instruments



Schematic digram of a reflecting telescope (Cassegrain).

A Cassegrain telescope uses two mirrors as shown in above figure. Such a telescope is built with the mirrors $20\ mm$ apart. If the radius of curvature of the large mirror is $220\ mm$ and the small mirror is $140\ mm$, where will the final image of an object at infinity be?

Solution

Distance between the objective mirror and the secondary mirror, $d = 20mm$

Radius of curvature of the objective mirror, $R_1 = 220mm$

Hence, focal length of the objective mirror, $f_1 = R_1/2 = 110mm$

Radius of curvature of the secondary mirror, $R_2 = 140mm$

Hence, focal length of the secondary mirror, $f_2 = R_2/2 = 70mm$

The image of an object placed at infinity, formed by the objective mirror, will act as a virtual object for the secondary mirror.

Hence, the virtual object distance for the secondary mirror, $u = f_1 - d = 110 - 20 = 90mm$

Applying the mirror formula for the secondary mirror,

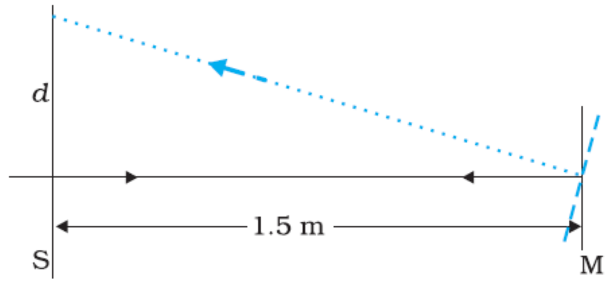
$1/v + 1/u = 1/f_2$

$\Rightarrow v = 315mm$

Hence, the final image will be formed $315mm$ away from the secondary mirror.

#421608

Topic: Spherical Mirrors



Light incident normally on a plane mirror attached to a galvanometer coil retraces backwards as shown in Fig. A current in the coil produces a deflection of 3.5^o of the mirror. What is the displacement of the reflected spot of light on a screen placed 1.5 m away?

Solution

$\theta = 3.5^o$, $D = 1.5m$

Reflected rays get deflected by an amount twice the angle of deflection, i.e., $2\theta = 7^o$

d is the displacement of reflected spot of light on screen.

$tan 2\theta = d/1.5 \Rightarrow d = 18.4cm$

#421612
Topic: Thin Lenses

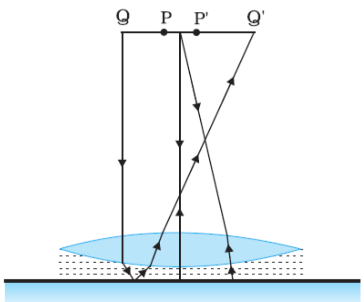


Figure shows an equiconvex lens (of refractive index 1.50) in contact with a liquid layer on top of a plane mirror. A small needle with its tip on the principal axis is moved along the axis until its inverted image is found at the position of the needle. The distance of the needle from the lens is measured to be 45.0cm. The liquid is removed and the experiment is repeated. The new distance is measured to be 30.0cm. What is the refractive index of the liquid?

Solution

Focal length of the convex lens, $f_1 = 30cm$

The liquid acts as a mirror. Focal length of the liquid $= f_2$

Focal length of the system (convex lens + liquid), $f = 45cm$

For a pair of optical systems placed in contact, the equivalent focal length is given as:

$1/f = 1/f_1 + 1/f_2$

$\Rightarrow f_2 = -90cm$

Let the refractive index of the lens be μ_1 and the radius of curvature of one surface be R. Hence, the radius of curvature of the other surface is $-R$.

R can be obtained using the relation:

$1/f_1 = (\mu_1 - 1)(1/R - 1/(-R)) \Rightarrow R = 30cm$

Let μ_2 be the refractive index of the liquid.

Radius of curvature of the liquid on the side of the plane mirror $= \infty$

Radius of curvature of the liquid on the side of the lens $R = -30cm$

The value of μ_2 can be calculated using the relation:

$1/f_2 = (\mu_2 - 1)(1/(-R) - 1/\infty) \Rightarrow \mu_2 - 1 = 0.33$

$\mu_2 = 1.33$.

Hence, the refractive index of the liquid is 1.33

#463239

Topic: Human Eye

Fill in the blanks in the following:

(a) A person 1m in front of a plane mirror seems to be ___________ m from his image.

(b) If you touch your ________ ear with right hand in front of a plane mirror it will be seen in the mirror that your right ear is touched with ___________.

(c) The size of the pupil becomes ___________ when you see in dim light.

(d) Night birds have __________ cones than rods in their eyes.

Solution

(a) A person 1m in front of a plane mirror seems to be $2\ m$ from his image.

Distance between mirror and object $d_1 = 1\ m$

Hence, distance between mirror and image $d_2 = 1\ m$

Image formed by the plane mirror is behind the mirror. Hence, distance between object and image, $d = d_1 + d_2$

$d = 1 + 1 = 2\ m$

(b)

If you touch your **left** ear with right hand in front of a plane mirror it will be seen in the mirror that your right ear is touched with **left hand**.

Image formed in the plane mirror is laterally inverted. Hence right ear appears as left ear in the image and the left hand appears as right hand in the image.

(c)

The size of the pupil becomes **large** when you see in dim light.

The eye pupil adjusts itself to capture more light in the dark and increases its size.

(d)

Night birds have **less** cones than rods in their eyes.

Rods are sensitive to dim light and cones are sensitive to bright light. Since the night birds can see in the night, they have more rods.

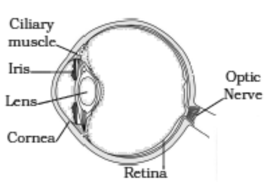
#463257

Topic: Human Eye

Draw a labeled sketch of the human eye.

Solution

The figure shows a labelled sketch of the human eye.



#464782

Topic: Spherical Mirrors

The image formed by a concave mirror is observed to be virtual, erect and larger than the object. Where should be the position of the object?

A Between the principal focus and centre of curvature

B At the centre of curvature

C Beyond the centre of curvature

$\boxed{\text{D}}$ Between the pole of mirror and its principal focus

Solution

When the position of object is between the pole of mirror and its principal focus, the image formed by a concave mirror is observed to be virtual, erect and larger than the object.

#464783
Topic: Thin Lenses

Where should an object be placed in front of convex lens to get a real image of the size of the object?

A At the principal focus of the lens

B At twice the focal length

C At infinity

D Between the optical centre of the lens and its principal focus

Solution

When object is kept at twice the focal length, image is formed at twice the focal length on the opposite side. In such a scenario, magnification is -1 and hence the image size is same as object size.

#464784
Topic: Thin Lenses

A spherical mirror and a thin spherical lens have each a focal length of -15 cm. The mirror and lens are likely to be :

A both concave

B both Convex

C the mirror is concave and lens is convex

D the mirror is convex but lens is concave

Solution

Negative focal length is a characteristic of concave mirror and concave lens. Hence, both mirror and the lens are concave.

#464785
Topic: Spherical Mirrors

No matter how far you stand from a mirror, your image appears erect. The mirror is likely to be

A plane

B concave

C convex

D either plane or convex

Solution

Plane mirror and convex mirror forms a virtual image irrespective of the position of the object.

#464786
Topic: Optical Instruments

Which of the following lenses would you prefer to use while reading small letters found in a dictionary?

A A convex lens of focal length 50 cm

B A concave lens of focal length 50 cm

C A convex lens of focal length 5 cm

D A concave lens of focal length 5 cm

Solution

A convex lens is also used as a simple microscope. The object is kept between the focal length and mirror so that a virtual, erect and magnified image is formed. Smaller focal length has more power and is suitable for larger magnification. Hence, convex lens of focal length 5 cm is preferred.

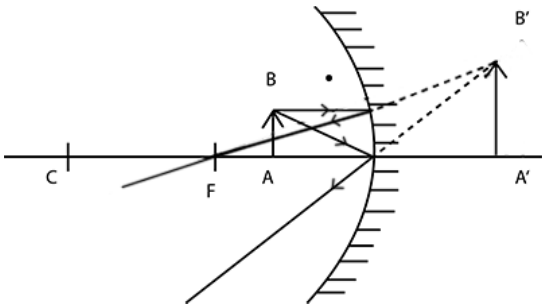
#464787

Topic: Spherical Mirrors

We wish to obtain an erect image of an object, using a concave mirror of focal length 15 cm. What should be the range of distance of the object from the mirror? What is the nature of the image? Is the image larger or smaller than the object? Draw a ray diagram to show the image formation in this case.

Solution

Object distance should be less than the focal length for the formation of an erect image. Hence, the range of distance of object from the mirror should be less than 15 cm i.e. from 0 to 15 cm in the front of mirror from the pole. The nature of image so formed will be virtual and erect. The size of the image will be larger than object. Ray diagram is attached as image to the question.



#464790

Topic: Spherical Mirrors

An object 5 cm in length is held 25 cm away from converging lens of focal length 10 cm. Draw the ray diagram and find the position, size and nature of the image formed.

Solution

$(1/v) - (1/u) = 1/f$

$(1/v) = (1/10) - (1/25)$

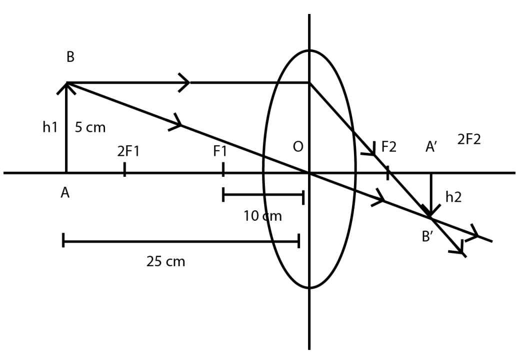
$v = 50/3 = 16.66\ cm$

$m = v/u$

$h_2/h_1 = 16.66/(-25)$

$h_2 = -3.33\ cm$

An inverted , 3.33 cm high image will be formed.



#464791

Topic: Spherical Mirrors

A concave lens of focal length 15cm forms an image 10 cm from the lens . How far is the object placed from the lens? Draw the ray diagram.

Solution

Given: $f = -15$

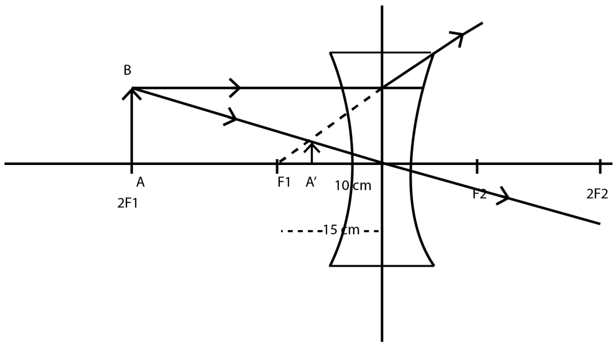
$v = -10$

From mirror formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{-10} - \frac{1}{u} = \frac{1}{-15}$

$\frac{1}{u} = \frac{1}{15} - \frac{1}{10}$

$u = -30\ cm$



#464792

Topic: Spherical Mirrors

An object is placed at a distance of 10 cm from a convex mirror of focal length 15 cm. Find the position and nature of the image.

Solution

Given: $f = 15$

$u = -10$

From mirror formula, $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

$\frac{1}{-10} + \frac{1}{v} = \frac{1}{15}$

$v = 6\ cm$

Image is formed 6 cm to the right of the mirror. Image formed is virtual and erect.

#464793

Topic: Spherical Mirrors

The magnification produced by a plane mirror is +1. What does this mean?

Solution

The magnification produced by a plane mirror is +1 means that the image formed is virtual, erect and of the same size as that of object.

#464794

Topic: Spherical Mirrors

An object 5.0 cm in length is placed at a distance of 20 cm in front of a convex mirror of radius of curvature 30 cm. Find the position of the image, its nature and size.

Solution

Given: $u = -20\ cm$

$f = R/2 = 15\ cm$

Size of image, $h = 5\ cm$

Let size of image be $h^{'}$

From mirror formula, $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

$\frac{1}{-20} + \frac{1}{v} = \frac{1}{15}$

$v = \frac{60}{7} = 8.57\ cm$

Image is formed 8 cm behind the mirror. It is virtual and erect.

Magnification, $m = -v/u = 8.57/20 = 0.428$

Also, $m = h^{'}/h = h^{'}/5$

From above, $h^{'}/5 = 0.428$

$h^{'} = 2.14\ cm$

#464795

Topic: Spherical Mirrors

An object of size 7.0 cm is placed at 27cm in front of concave mirror of focal length 18 cm. At what distance from the mirror should a screen be placed, so that a sharp focused image can be obtained? Find the size and nature of the image.

Solution

Given: Size of object, $h = 7\ cm$

$u = -27\ cm$

$f = -18\ cm$

Let position and size of image be $v\ \&\ h^{'}$ respectively.

From mirror formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{v} - \frac{1}{-27} = \frac{1}{-18}$

$v = -54\ cm$

Magnification, $m = -v/u = h^{'}/h$

$m = -2 = h^{'}/7$

$\implies h^{'} = -14\ cm$

Image is of size 14 cm. It is real and inverted. It is formed 54 cm on the same side of mirror as object and hence, mirror should be placed at the same point.

#464796

Topic: Thin Lenses

Find the focal length of a lens of power (-2.0)D. What type of lens is this?

Solution

$P = \frac{1}{f}$

$= \frac{1}{-2}$

$= -0.5\ m$

Since focal length is negative, it is concave lens.

#464797

Topic: Thin Lenses

A doctor has prescribed a corrective lens of power +1.5D. Find the focal length of the lens. Is the prescribed lens diverging or converging?

Solution

Power, $P = 1/f = 1/1.5$

$f = 0.67\ m$

Since, focal length is positive it is convex lens i.e. converging lens.

#464823

Topic: Human Eye

The human eye can focus objects at different distances by adjusting the focal length of the eye lens. This is due to

A presbyopia

B accomodation

C near-sightedness

D far-sightedness

Solution

The human eye can focus objects at different distances by adjusting the focal length of eye lens due to the power of accomodation of human eye.

#464825

Topic: Human Eye

The least distance of distinct vision for a young adult with normal vision is about:

A 25 m

B 2.5cm

C 25cm

D 2.5m

Solution

The least distance of distinct vision for a young adult with normal vision is about is 25 cm. It is the least distance of distinct vision of an object to see clear and distinct image.

#464827

Topic: Human Eye

A person needs a lens of power -5.5 diopters for correcting his distant vision. For correcting his near vision he needs a lens of power +1.5 diopters. What is the focal length of the lens required for correcting (i) distant vision (ii) near vision?

Solution

(i) Correcting distant vision

$$f = \frac{1}{P} = 1/(-5.5) = -0.18\ m$$

(ii) Correcting near vision

$$f = \frac{1}{P} = \frac{1}{1.5} = 0.67\ m$$

#464828

Topic: Human Eye

The far point of a myopic person is 80 cm in front of the eye. What is the nature and power of lens required to correct the problem?

Solution

The person is suffering from myopia and hence need a concave lens to correct the defect. The lens should be such that an object at infinity must form its image at the far point.

Hence, $f = -80\ cm = -0.8\ m$

$P = 1/f = 1/(-0.8) = -1.25$ D

#464830

Topic: Human Eye

Make a diagram to show how hypermetropia is corrected. The near point of hypermetropic eye is 1 m. What is the power of lens required to correct this defect? Assume that the near point of the normal eye is 25 cm.

Solution

Hypermetropia can be corrected by using a convex lens. A convex lens converges the incoming light such that the image is formed on the retina.

An object at 25 cm forms an image at the near point of the hypermetropic eye. Here, near point is 1 m.

Given: $u = -25\ cm$

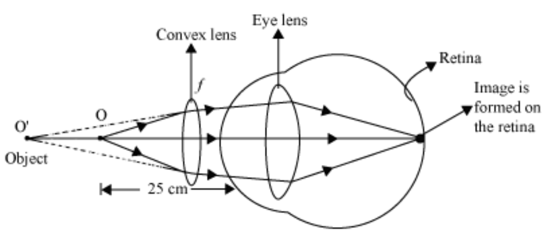
$v = -100\ cm$

From lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{-100} - \frac{1}{-25} = \frac{1}{f}$$

$f = 100/3\ cm = 1/3\ m$

$P = \frac{1}{f} = \frac{1}{1/3} = 3\ D$



#464835

Topic: Human Eye

Why is a normal eye not able to see clearly the objects placed closer than 25 cm?

Solution

Ciliary muscles contract and expand to change the focal length of eye lens so that it is able to see objects at variable distances. However, too much contraction lays a lot of stress on the eye muscles and when objects are closer than the near point(25 cm), the eye is unable to focus its image on retina. Hence, a normal eye cannot see objects closer than 25 cm clearly.