UNIT 5

Refraction of Light

03/01/2021 – Class 47

Assignment Answer

When an object is placed at a distance of 30 cm from a convex lens, a real image is formed at a distance of 60 cm. What is the focal length of lens?

Distance to the object from the lens **(u) = - 30 cm**
Distance to the image from the lens **(v) = + 60 cm** (real image, so v is positive)
Focal length **(f) = uv / (u-v)**
= (-30 X +60) / (-30 - +60)
= - 1800 / -90 = + 20 cm

Activity 1

Is there any relation between the height of an object and the height of its image? Can it be related to the ratio between the distance to the object and that to the image?

Discussion

- When an object is placed at different positions in front of a lens, isn't there a change in the height of the image? **Yes.**
- The ratio of the height of the image to the height of the object is called? **Magnification**.

Magnification(m)

Magnification is the ratio of the height of the image to the height of the object. It shows how many times the image is larger than the object.

Magnification (m) = Height of the image(hi) / Height of the object (ho)

If the distance of object is taken as **u** and that of the image as **v,**
Magnification (m) = v / u

Activity 2

When an object of height 5 cm is placed at a distance of 15 cm from a lens a real image is formed at a distance of 30 cm. Find the height of the image?

Distance to the object from the lens **(u) = -15 cm**
Distance to the image from the lens **(v) = +30 cm** (for real image v is positive)
Height of the object **(ho) = +5cm** (distance upwards from X axis is positive)
Magnification **(m) = v/u = 30 / -15 = - 2**

We have also, **m = hi/ho**
hi = m X ho = -2 X 5 = **-10 cm**
Height of the image (hi) = **- 10 cm**

Height of the image is negative (downwards from X axis). So the image is real and inverted.

Activity 3

If an object with a height of 6 cm is placed 60 cm away from a lens and the actual image is formed at a distance of 1.2 m, what is the height of the image formed when the object is placed at a distance of 30 cm from the same lens?

Distance to the object from the lens **(u) = -60 cm**
Distance to the image from the lens **(v) = +1.2 m = 120 cm** (for real image v is positive)
Height of the object **(ho) = + 6 cm**
Focal length of the lens (f) = uv / (u-v)
= -60 X +120 / (-60 - +120)
= -7200 / - 180 = **+ 40 cm**

When, the distance to the object **(u) = - 30 cm**
Distance to the image from the lens **(v) = uf / (u+f)**
= -30 X +40 / (-30 + 40)
= - 1200 / +10 = **-120 cm**

Magnification **(m) = v/u**
= -120 / - 30 = + 4
We have, m = hi / ho
So, height of the image **(hi) = m X ho**
= +4 X +6 = + 24 cm

Height of the image is positive (upwards from X axis). So the image is virtual and erect.

Inference

- ➔ If the magnification is **negative**, the image will be **real and inverted.**
- ➔ When the magnification is **positive**, image will be **virtual and erect.**

Activity 4

We have now understood the different types of lenses and the characteristics of images formed by them.

Devices in which lenses are used.

- ➔ In telescope.
- ➔ In spectacles.
- ➔ In camera.
- ➔ In microscope.
- ➔ In projector.

Activity 5

Discussion

- Does, same kind of lenses are used in the spectacles? **No.**
- Doses, the power of the lenses used in the spectacles are same? **No.**
- What you mean by the power of a lens? **Power of a lens is the reciprocal of focal length expressed in metres.**

Inference

- ➔ **Power** is a term related to the **focal length** of a lens.
- ➔ Power of a lens is the **reciprocal of focal length expressed in metres.**
- ➔ Power **(p) = 1 / f**
- ➔ Unit of power is **dioptre**. It is represented by **D.**
- ➔ Power of a **convex lens is positive** and that of a **concave lens is negative.**

Activity 6

What is the focal length of a lens of power +2D?

Power **(p) = + 2 D**

p = 1 / f

f = 1/p = 1/+2 = +0.5 m = **+50 cm**

Focal length of the lens = **+50 cm**

Activity 7

You might have seen the twinkling of stars at night. What may be the reason?

Discussion

- Does the temperature of different layers of atmosphere are same? **No.**
- Due to this difference in temperature, what happens to the optical density of different layers of atmosphere? **There optical densities are also different.**
- What happens to the light when it travels through media of different optical densities? **It undergoes successive refractions.**

Reason for the twinkling of stars.

➔ Light coming from distant stars passes through different layers of air.

➔ Each layer differs from the other in their optical densities.

➔ Hence **light undergoes successive refraction.**

➔ Since stars at a greater distance they appear like a **point source.**

➔ The rays of **light appear to come from different points** on reaching the eye after **refraction.**

Let us assess

1. Refractive indices of different materials are given. Find out the medium through which light passes with maximum speed?

Medium	Refractive index
Glass	1.52
Glycerine	1.47
Sun flower oil	1.47
Water	1.33
Flint glass	1.62

From the table **water** has **lowest refractive index**. So its **optical density also less**. Hence light passes with maximum speed through the **water.**

2. The nature of images formed by two lenses are given.

(i) An erect and magnified virtual image. - **Convex lens**

(ii) An erect and diminished virtual image. - **Concave lens.**

(a) What type of lens is used in each case?

(b) By using which type of lens will we get an image having the same size as the object? What is the position of the object?

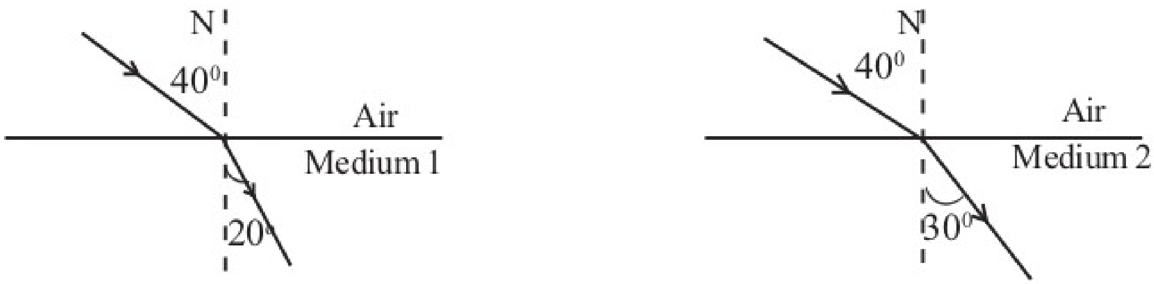
Convex lens. Object at 2F

4. What do you mean by power of a lens? What is the SI unit of the power of a lens? Calculate the power of a concave lens of focal length 25 cm?

- **Power of a lens is the reciprocal of focal length expressed in metres.**
- SI unit of power of a lens – **Dioptre (D).**

Focal length **(f) = -25 cm = - 0.25 m**
- Power **(p) = 1/f = 1/ -0.25 = - 4 D**

5) Observe the figure. Light falling on two different media are shown.



(a) Which medium has greater optical density? Why?

***Medium 1*. Light is incident with the same angle (40^0) on the same medium (air). But the angles of refraction are different. The medium, with the lesser angle of refraction has greater optical density.**

(b) Which medium has greater refractive index?

Medium 1, medium with greater optical density has greater refractive index.

6) An object of height 3 cm is placed in front of a convex lens of focal length 20 cm at a distance of 30 cm.

(a) What is the distance to the image formed?

Focal length **(f) = + 20 cm**
Distance to the object from the lens **(u) = - 30 cm**
Distance to the image **(v) = uf / (u+f)**
= -30 X +20 / (-30 +20)
= -600 / -10 = **+60 cm**

(b) What is the nature of the image? **Real, Inverted, magnified.**

(c) What is the height of the image?

Magnification **(m) = v/u = 60/ -30 = -2**
Height of the object (ho) = **+3 cm**
m = hi/ho
Height of image (hi) = **m X ho = -2 X +3 = - 6 cm**

7) In the table the absolute refractive indices of certain transparent media are given.

Medium	Refractive index
Air	1.0003
Water	1.33
Kerosene	1.44
Turpentine oil	1.47
Crown glass	1.52
Diamond	2.42

(a) Find out from the table the medium of highest and lowest optical densities.

Highest – Diamond, Lowest – Air.

(b) If the speed of light in air is 3×10^8 m/s, what will be the speed of light through kerosene?

Speed of light in air **(c) = 3×10^8 m/s**
Refractive index of kerosene **(n) = 1.44**
Refractive index **(n) = c / v**
Speed of light through kerosene **(v) = c/n = $3X10^8$ / 1.44 = $2.08X\ 10^8$ m/s**

(c) Will a ray of light deviate towards the normal or away from the normal when it enters from air to diamond obliquely?

Deviates towards the normal. The medium with greater refractive index has greater optical density also. Here light enters from a medium of lower optical density (air) to a medium of greater optical density (diamond). So it deviates towards the normal.

(d) The refractive index of diamond is 2.42. What do you mean by this? Calculate the speed of light through diamond.

Light travels through the air with a velocity of 2.42 times, than the velocity through the diamond.

Speed of light in air **(c) = 3×10^8 m/s**
Refractive index of diamond **(n) = 2.42**
Refractive index **(n) = c / v**
Speed of light through diamond **(v) = c/n = $3X10^8$ / 2.42 = $1.24X\ 10^8$ m/s**