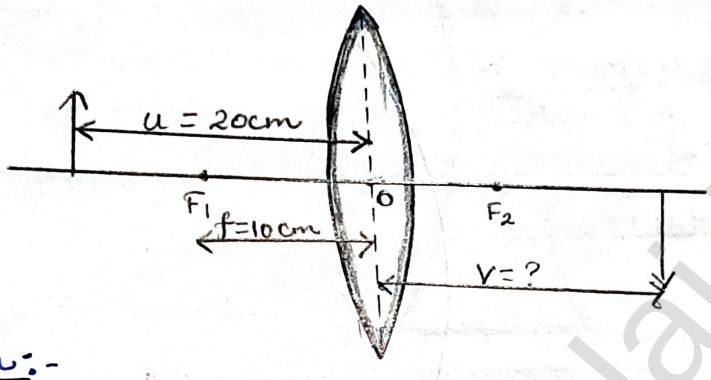
Date: 25/03/2022 | Unit -2

Day: Friday | Optics

Numerical Problems

1. An object is placed at a distance 20cm from a convex lens of focal length 10cm. Find the image distance and nature of image?

Solution



Given:-

Object distance (u) = -20cm

focal length of convex lens (f) = 10 cm

Image distance (v) = ?

Nature of the image = ?

Soln

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \quad \therefore \text{Lens formula.}$$

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

$$\frac{1}{v} = \frac{1}{10} + \frac{1}{-20}$$

$$\frac{1}{v} = \frac{1}{10} - \frac{1}{20}$$

$$\frac{1}{v} = \frac{20-10}{200}$$

$$\frac{1}{v} = \frac{10}{200}$$

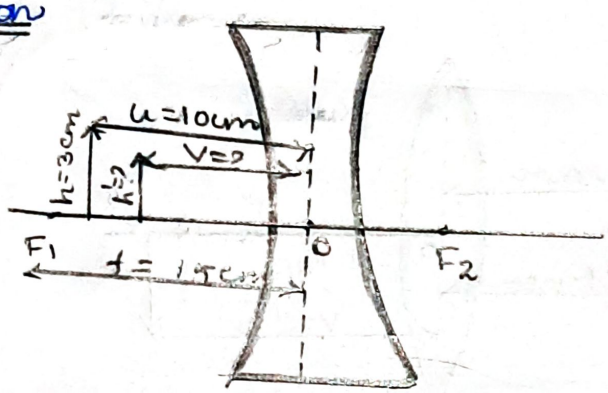
$V = 20\,cm$

∴ The image distance is 20 cm

The nature of image is real and inverted

2. An object of height 3cm is placed at 10cm from a concave lens of focal length 15cm. Find the size of the image.

Solution



Given:

The height of the object $(h) = 3cm$

focal length of concave lens $(f) = -15cm$

Object distance $(u) = -10cm$

The height of the image $(h') = ?$

Soln

Lens formula: $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

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

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

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

$$\frac{1}{v} = \frac{10+15}{-150}$$

$$\frac{1}{v} = \frac{25}{-150}$$

$$V = \frac{-6}{1}$$

$$\boxed{V = -6\,cm}$$

Magnification of lens: $m = \frac{v}{u}$

$$m = \frac{-6}{-10}$$

$$\boxed{m = 0.6 \text{ (no unit)}}$$

∴ To find 'h'

$$\boxed{\text{Magnification of lens: } m = \frac{h'}{h}}$$

$$h' = m \times h$$

$$h' = 0.6 \times 3$$

$$\boxed{h' = 1.8\,cm}$$

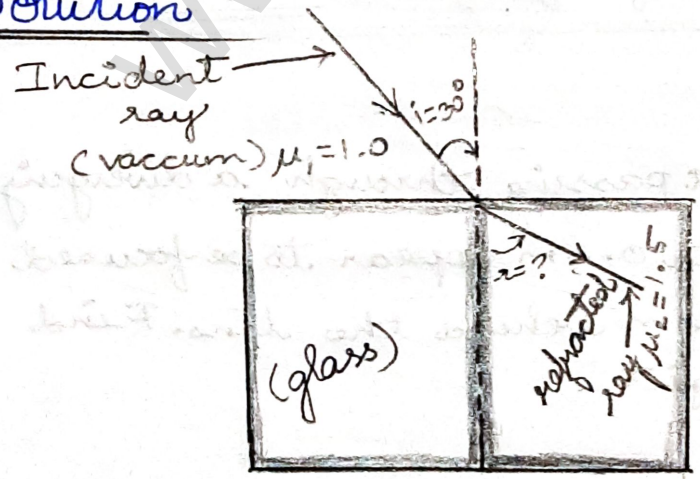
∴ The height of the image is 1.8 cm.

Solved Problems :-

Problem - 1

1. Light rays travel from vaccum into a glass whose refractive index is 1.5. If the angle of incidence is 30°, calculate the angle of refraction inside the glass.

Solution



Given :-

The angle of incidence (i) = 30°

The refractive index of vaccum (μ_1) = 1.0

The refractive index of glass (μ_2) = 1.5

The angle of refraction (r) = ?

Soln

According to snell's law

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

$\mu_1 \sin i = \mu_2 \sin r$

$(1.0) \times \sin 30° = 1.5 \sin r$

$(1.0) \times \sin 30° = 1.5 \times \sin r$

$(1.0) \times \frac{1}{2} = 1.5 \times \sin r$

$\therefore \sin r = \frac{1}{2 \times 1.5}$

$\sin r = \frac{1}{3}$

$\sin r = 0.333$

$r = \sin^{-1}(0.333)$

$r = 19.45°$

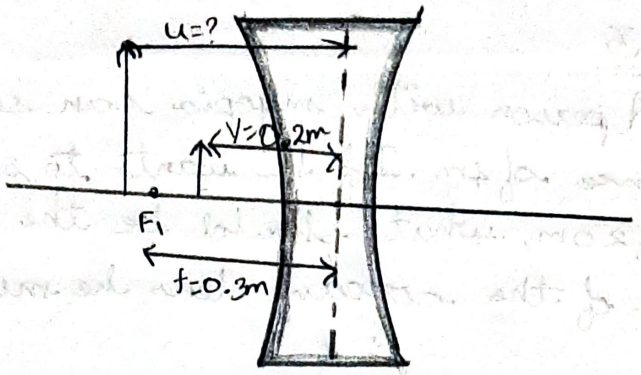
$\therefore$ The angle of refraction is 19.45°

0.3
3 | 10
9
10

Problem-2

A beam of light passing through a diverging lens of focal length 0.3m appear to be focused at a distance 0.2m behind the lens. Find the position of the object.

Solution:-



Given

Focal length of diverging lens (concave) (f) = -0.3m.

Image Distance (v) = -0.2m.

Position of the object (u) = ?

Soln

Lens formula: $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

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

$$\frac{1}{u} = \frac{1}{-0.2} - \frac{1}{-0.3}$$

$$\frac{1}{u} = \frac{1}{-0.2} + \frac{1}{0.3}.$$

$$\frac{1}{u} = \left(\frac{1}{-0.2} \times \frac{10}{10}\right) + \left(\frac{1}{0.3} \times \frac{10}{10}\right)$$

$$\frac{1}{u} = \frac{10}{-2} + \frac{10}{3}$$

$$\frac{1}{u} = \frac{30 - 20}{-6}$$

$$\frac{1}{u} = \frac{10}{-6}$$

$$u = \frac{-6}{10}$$

$u = -0.6\,m$

∴ The Position of object is -0.6m

Problem-3

A person with myopia can see object placed at a distance of 4m. If he wants to see object at a distance of 20m, what should be the focal length and power of the concave lens he must wear?

Solution

Given:- $x = 4\,m$

$y = 20\,m$

$f = ?$

$P = ?$

Solv:-

Focal length of the correction lens is $\boxed{f = \frac{xy}{x-y}}$

$$f = \frac{4 \times 20}{4-20}$$

$$f = \frac{80}{-16}$$

$$\boxed{f = -5m}$$

Power of the correction lens is $\boxed{P = \frac{1}{f}}$

$$P = \frac{1}{-5}$$

$$\boxed{P = -0.2D}$$

∴ The power of the correction of lens is $-0.2D$

Problem-4

For a person with hypermeteropia, the near point has moved to 1.5m. Calculate the focal length of the correction lens is order to make his eyes normal.

Solution

Given

$d = 1.5m.$

$D = \frac{25}{100}$ m

$D = 0.25$ m.

$f = ?$

Soln

Focal length of the correction of lens $\boxed{f = \frac{dD}{d-D}}$

$$f = \frac{1.5 \times 0.25}{1.5 - 0.25}$$

$$f = \frac{0.375}{1.25}$$

$$f = \frac{0.375}{1.25} \times \frac{1000}{1000}$$

$$f = \frac{375}{1250}$$

$$\boxed{f = 0.3\text{m}}$$

∴ The focal length of the correction of lens is 0.3m.

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