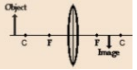
Wave Refraction: Lenses

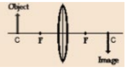
Definitions

Convex Lenses

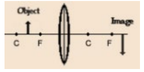
The object is beyond C: image will be an inverted image/reduced in size/real



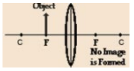
The object is at C: image will be inverted/equal to the object size/real.



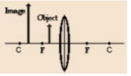
The object is between C & F: image will be inverted/larger/real.



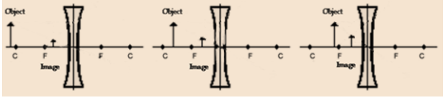
The object is at F: When the object is located at the focal point, no image is formed.



The object is in front of F: image will be upright/magnified/virtual. The image is located on the object's side of the lens.



Concave Lenses



Regardless of the position of the object the image will always be virtual/upright/ reduced in size. The image is located on the object's side of the lens by tracing the rays back to where they appear to come from.

Equations

$\frac{1}{f}=\frac{1}{d_o}+\frac{1}{d_i}$	Focal length	f	m
	Object distance	d_o	m
	Image distance	d_i	m
$m=\frac{d_i}{d_o}=\frac{h_i}{h_o}$	magnification	m	-
	Image distance	d_i	m
	Object distance	d_o	m
	Image height	h_i	m
	Object height	h_o	m

f: Distance between f and pole of lens.
d_o: Distance from the lens to the object.
d_i: Distance from the lens to the image
h_o: Height of the object.
h_i: Height of the image.
m: Magnification – the ratio of height of object, h_o to height of image, h_i

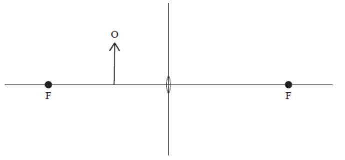
- If d_i is the same side as the object it is negative
- The image height, h_i for a virtual image is negative
- The focal length for a concave lens is negative

Questions

THE ENLARGED EYE (2018;1)

Sophie and her friend John were investigating magnifying glasses (convex lenses). Sophie laughed at the size that John's eye appeared when he placed the lens over his eye.

(a) Complete the following ray diagram to show how John's eye (the object) appears enlarged, as in the photo. Clearly indicate its size and position.



(b) The lens has a focal length of 12 cm. John holds the lens 5 cm from his eye. Calculate the distance the image is from the lens and state the nature of the image produced.

(c) If the eye (object) has a height of 2.0 cm, calculate the magnification AND the height of the image of the eye.

Terms

F: the focal length
C: the centre of curvature (where C = 2f)

Real image: An image generated by a lens that can be projected onto a screen
Virtual image: An image where light rays appear to originate from a lens; this image cannot be projected on a screen

Tips

Ray diagrams for convex lenses

1. A ray parallel to the principal axis will be refracted through F behind the lens.
2. A ray that passes through F in front of the lens will be refracted parallel to the principal axis.
3. A ray that passes through the centre of lens (the pole) will continue with no change in direction.

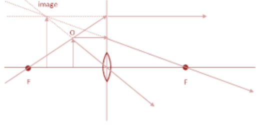
Ray diagrams for convex lenses

1. A ray parallel to the principal axis will be refracted away from as if it has come from the focal point F in front of the lens.
2. A ray that heading towards F behind the lens will be refracted parallel to the principal axis.
3. A ray that passes through the centre of lens (the pole) will continue with no change in direction.

REMEMBER – you do not need to draw all 3 rays. The first two are enough, and then you can use the 3rd ray as a check.

Answers

(a)



(b)

$$\frac{1}{d_o}+\frac{1}{d_i}=\frac{1}{f}$$

$d_o = 5$ cm
$f = 12$ cm

$$d_i=\left(\frac{1}{12}-\frac{1}{5}\right)^{-1}=(0.117)^{-1}$$

$d_i = -8.6$ cm

Properties: upright, magnified and virtual.

(c)

$$\frac{h_i}{h_o}=\frac{d_i}{d_o}$$

$$m=\frac{d_i}{d_o}=-\frac{8.6}{5}=-1.71$$

$$\frac{h_i}{h_o}=m$$

$$h_i=m\times h_o=-1.71\times 2=-3.43\text{ cm}$$