PHYSICS 534

ANSWERS

EXERCISE-53 Lens Part-2 /2

POWELL

Cecil Powell was awarded the Nobel prize for physics in 1950 for his photographic nuclear methods.

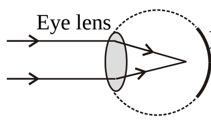
- **THE EYE**

The eye is an optical "instrument". It contains a converging lens used to focus images on the "retina" (a kind of screen at the back of the eye). Images on the retina are inverted.

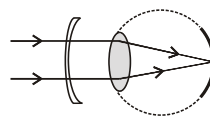
- **DEFECTS IN VISION**

NEARSIGHTEDNESS The ability to see objects clearly which are ***near*** but objects far away appear blurred. Nearsightedness, known as ***myopia***, is caused by the fact that rays of light focus ***in front*** of the retina of the eye. Myopia is corrected by using a diverging lens as illustrated in the diagram below.

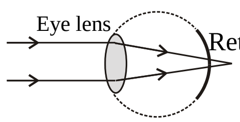
FARSIGHTEDNESS The ability to see objects clearly which are ***far*** but objects close to the eye appear blurred. Farsightedness, known as **hyperopia**, is caused by the fact that rays of light focus ***behind*** the retina of the eye. Hyperopia is corrected by using a converging lens as illustrated in the diagram below.



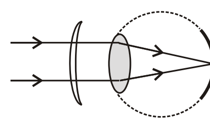
Myopia
(Nearsightedness)



Corrected with diverging lens



Hyperopia
(Farsightedness)



Corrected with converging lens

Reminder: In applying the lens equation, be sure to use the signs carefully.

d_o (the object distance) is always positive
f (the focal length) is positive for convex lenses and negative for concave lenses
d_i (the image distance) is positive for real images and negative for virtual images

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1. A lens forms an image 10 cm high. If the object is 4 cm in height and situated 8 cm away, what is the focal length of the lens? [13.3 cm]

$$\mathbf{h_i = 10\,cm \quad h_o = 4\,cm \quad d_o = 6.0\,cm \quad d_i = ? \quad f = ?}$$

$$\because \frac{h_i}{h_o} = \frac{-d_i}{h_o} \qquad \therefore d_i = \frac{-h_i d_o}{h_o} = \frac{-(10\,cm)(8\,cm)}{4\,cm} = -20\,cm$$

$$\because \frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \qquad \therefore \frac{1}{f} = \frac{1}{8\,cm} + \frac{1}{-20\,cm} \qquad \therefore f = 13.3\,cm$$

Reminder: Focal length is negative for concave lenses.

2. The focal length of a ***concave*** lens is 10 cm. An object, whose height is 2 cm, is placed 15 cm in front of the lens. Determine the characteristics of the image.

$$\because \ \frac{1}{f}=\frac{1}{d_o}+\frac{1}{d_i} \quad \text{or} \quad \frac{1}{d_i}=\frac{1}{f}-\frac{1}{d_o}=\frac{1}{-10\,cm}-\frac{1}{15\,cm}$$

$$\therefore d_i=-6\,cm$$

$$\because \ M=\frac{-d_i}{d_o}=\frac{-6\,cm}{15\,cm}=0.4$$

$$\text{Thus: } h_i=Mh_o=(0.4)(2\,cm)=0.8\,cm$$

ype: ***Virtual*** (real or virtual)

tion: ***6 cm***

tion: ***0.4***

ight: ***0.8 cm***

tude: ***Upright*** (upright or inverted)

3. An object whose height is 4 cm is placed 6 cm in front of a ***converging*** lens. If the focal length of the lens is 8 cm, determine the characteristics of the image.

$$h_o=4\,cm \quad h_i=16\,cm \quad d_o=6\,cm \quad d_i=-24\,cm \quad f=8\,cm$$

$$\because \ \frac{1}{f}=\frac{1}{d_o}+\frac{1}{d_i} \quad \text{or} \quad \frac{1}{d_i}=\frac{1}{f}-\frac{1}{d_o}=\frac{1}{8\,cm}-\frac{1}{6\,cm} \quad \therefore d_i=-24\,cm$$

$$\because \ \frac{h_i}{h_o}=\frac{-d_i}{d_o} \quad \therefore h_i=\frac{-d_ih_o}{d_o}=\frac{-(-24\,cm)(4\,cm)}{6\,cm}=16\,cm$$

pe: ***Virtual*** (real or virtual)

on: ***24 cm***

on: ***4***

ht: ***16 cm***

de: ***Upright*** (upright or inverted)

4. The focal length of a camera is 10 cm. The lens forms an image 4 cm high when the negative (film) is 12 cm from the lens.

a) What is the object distance? [60 cm]

$$\because \ \frac{1}{f}=\frac{1}{d_o}+\frac{1}{d_i} \quad \therefore \frac{1}{d_o}=\frac{1}{f}-\frac{1}{d_i}=\frac{1}{10\,cm}-\frac{1}{12\,cm} \quad \therefore d_o=60\,cm$$

b) What is the object height? [20 cm]

$$\because \ \frac{h_i}{h_o}=\frac{-d_i}{d_o} \quad \therefore h_o=\frac{h_ih_o}{-d_i}=\frac{(4\,cm)(60\,cm)}{-12\,cm}=-20\,cm$$

c) What is the magnification factor? [0.2]

$$M=\frac{h_i}{h_o}=\frac{4\,cm}{-20\,cm}=-0.2$$

Negative signs indicate inversion

5. A 35-mm slide (the object) is placed 8.2 cm from a projection lens whose focal length is 8 cm. Determine:

a) The image distance. [328 cm]

$$f = 8\,cm \qquad d_o = 8.2\,cm \qquad d_i = ?$$

$$\because \frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \quad \therefore \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{8\,cm} - \frac{1}{8.2\,cm} \quad \therefore d_i = 328\,cm$$

b) The image height. [140 cm]

$$\text{Note: } h_o = 35\,mm = 3.5\,cm$$

$$\because \frac{h_i}{h_o} = \frac{-d_i}{d_o} \quad \therefore h_i = \frac{-d_i h_o}{d_o} = \frac{-(328\,cm)(3.5\,cm)}{8.2\,cm} = -140\,cm$$

c) The magnification factor. [40]

$$M = \frac{h_i}{h_o} = \frac{-140\,cm}{3.5\,cm} = -40$$

Negative signs indicate inversion

6. The focal length of a magnifying glass is 10 cm. The lens is used to view a stamp that is 2.0 cm in height. If the stamp is placed 6.0 cm away from the magnifying glass, calculate the height of the image. [5.0 cm]

$$f = 10\,cm \qquad h_o = 2\,cm \qquad h_i = ? \qquad d_o = 6.0\,cm \qquad d_i = ?$$

$$\because \frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o} \quad \therefore \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{10\,cm} - \frac{1}{6.0\,cm} \quad \therefore d_i = -15\,cm$$

$$\because \frac{h_i}{h_o} = -\frac{d_i}{d_o} \quad \therefore h_i = \frac{-d_i h_o}{d_o} = \frac{-(-15\,cm)(2\,cm)}{6\,cm} = 5.0\,cm$$

7. An object is 4 cm from a ***concave*** lens whose focal length is 12 cm. Where will the image be located? [-3 cm]

The focal length of concave (diverging) lenses is negative.

$$f = -12\,cm \qquad d_o = 4\,cm \qquad d_i = ?$$

$$\because \frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \quad \therefore \frac{1}{d_i} = \frac{1}{-f} - \frac{1}{d_o} = \frac{1}{-12\,cm} - \frac{1}{4\,cm} \quad \therefore d_i = -3\,cm$$

Indicates a virtual image

8. An object 3 cm high is located 30 cm from a concave lens whose focal length is 15 cm. Determine:

NOTE
The focal length of concave (diverging) lenses is negative.

a) The image distance. [10 cm]

$$\mathbf{f = -15\,cm \qquad d_o = 30\,cm \qquad d_i = ?}$$

$$\because \frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \qquad \therefore \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{-15\,cm} - \frac{1}{30\,cm} \qquad \therefore d_i = -10\,cm$$

Negative sign indicates a virtual image

b) The magnification. [0.3]

$$M = \frac{-d_i}{d_o} = \frac{-(-10\,cm)}{30\,cm} = 0.3$$

c) The size of the image. [1 cm]

$$\because \frac{h_i}{h_o} = \frac{-d_i}{d_o} \qquad \therefore h_i = \frac{-(-10\,cm)(3\,cm)}{30\,cm} = 1\,cm$$

d) The type of image: ***Virtual***

e) The attitude of the image: ***Upright***

9. Define each of the following terms:

a) Myopia

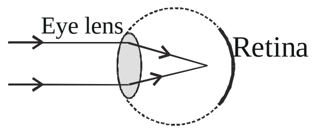
The problem of seeing far objects clearly.

b) Hyperopia

The problem of seeing near objects clearly.

10. Illustrated below are two common eye problems or ***defects***. State the name of each defect and draw the appropriate lens in order to correct the problem.

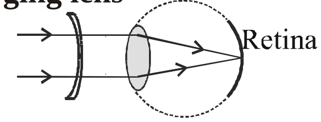
a)



Myopia

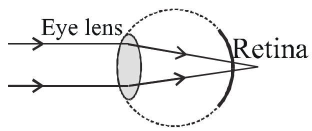
Defect name

Diverging lens



Correction

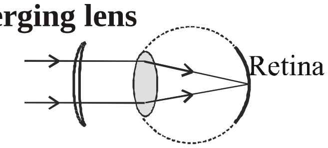
b)



Hyperopia

Defect name

Converging lens



Correction

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