Phys 112 2019

Lecture 31

Tues: Discussion / quiz

Supp 110, [illegible], 112, 113, 114

Ch 18 Q 19

Ch 18 Prob 20, 21

Weds lab – prelab

Image formation: convex/converging lenses

We saw that we can determine the location in which a lens forms by tracing two rays:

① parallel to the optical axis and through the far focal point

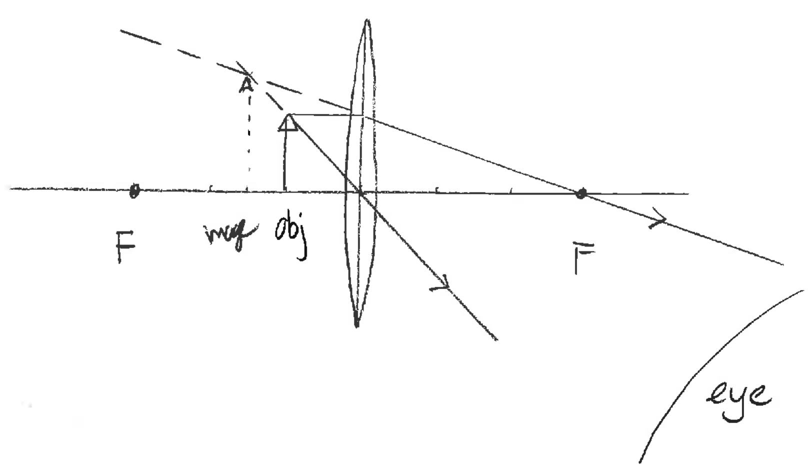
② directly through the center of the lens.

For a convex lens where the object was beyond the lens focal point, we find that the lens produces:

1) an inverted image beyond the far focal point

2) the image is real - i.e. light rays actually reach the image.

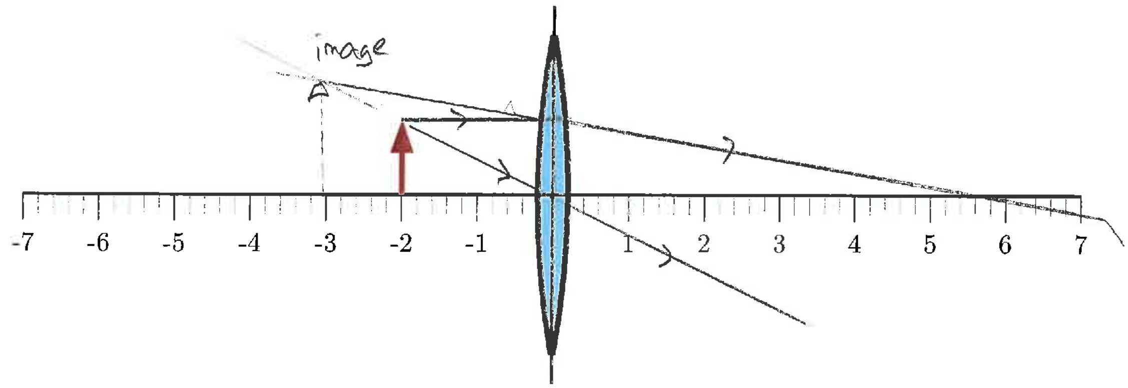
Now suppose the object is between the lens and the focal point. We trace the same rays but find that they diverge. However they appear to emerge from a point behind the lens. This is the image location



Warm Up!

108 Image formation by a convex lens: object between lens and focal point

A convex lens has focal length 6.0 cm. An arrow with height 1.0 cm is placed 2.0 cm left of the lens.



a) Trace two rays from the tip of the arrow to determine where the image of the tip is produced.

b) Determine the distance from the lens plane to the image of the arrow.

c) Determine the height of the image of the arrow. Determine the magnification

$$m := \frac{h'}{h}$$

where h is the height of the object and h' is the height of the image.

The thin lens equation relates the positions of the object and the image via

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$$

where s is the distance from the lens to the object and s' is the distance from the lens to the image.

d) Use the thin lens equation to predict the location of the image. Check this against your diagram.

e) The magnification equation predicts

$$m = -\frac{s'}{s}.$$

Use this to predict the magnification and the height of the image. Check this against your diagram.

a) By measuring image is at $-3.0\,cm$

b) " " height is $1.5\,cm$

c) $m = \frac{h'}{h} = \frac{1.5\,cm}{1.0\,cm} \Rightarrow m = 1.5$

d) $\frac{1}{s} + \frac{1}{s'} = \frac{1}{f} \Rightarrow \frac{1}{2\,cm} + \frac{1}{s'} = \frac{1}{6\,cm} \Rightarrow \frac{1}{s'} = \frac{1}{6\,cm} - \frac{1}{2\,cm}$

$\Rightarrow \frac{1}{s'} = \frac{1-3}{6\,cm} = \frac{-2}{6\,cm}$

$\Rightarrow \boxed{s' = -3\,cm}$ agrees

e) $m = -\frac{s'}{s} = -\left(\frac{-3\,cm}{2\,cm}\right) = 1.5$

So $\frac{h'}{h} = m \Rightarrow h' = mh = 1.5 \times 1.0\,cm = 1.5\,cm \Rightarrow \boxed{h' = 1.5\,cm}$

agrees

This is how a magnifier operates. We see that

If an object is between a convex/converging lens and its focal point then

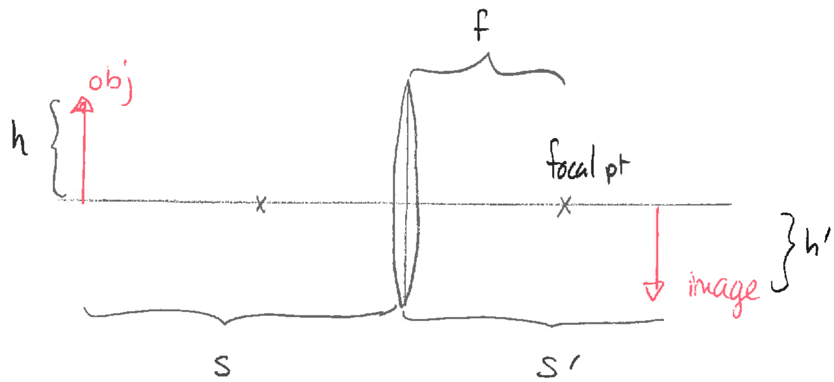
1) the image is on the same side as the lens
2) the image is upright and larger than the object
3) the image is virtual

Warm Up 2

<u>Demo</u> Show this with PhET Geometric Optics....

<u>Thin lens equation</u>

We can predict precisely how a convex lens will form images. We use the illustrated set up with variables "s" used to indicate positions and "h" heights. The following signs apply



variable	symbol	sign
focal length	f	$f > 0$ for convex & $f < 0$ for concave
object location	s	$s > 0$ for objects left of lens
image location	s'	$s' > 0$ for image right & $s' < 0$ for image left
object height	h	$h > 0$
image height	h'	$h' > 0$ for upright & $h' < 0$ for inverted

Then we can use the thin lens equation to predict the image location:

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$$

Separately we can determine the height in two stages. First we note that the magnification is:

$$M = \frac{h'}{h}$$

Then we can show

$$m = -\,s'/s$$

So we get:

Quiz 1 50% → 90%