Quiz 10 Solutions

1. A converging lens with focal length $f$ is placed between a light source and a screen. The distance between the light source and the screen is $D$.

   a) Find the two locations of the converging lens such that the image is formed at the screen.

   b) What happens if $D < 4f$? Can you still get an image on the screen?

Solution

a)

\[
\text{The distance between the source and the screen is fixed as } D. \text{ Let the lens be a distance } d_o \text{ from the source then we have the image distance } d_i = D - d_o. \text{ Using the lens’ equation, we get}
\]

\[
\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{d_o} + \frac{1}{D - d_o} = \frac{1}{f}
\]

(1)

Using the second equality we get a quadratic equation for $d_o$,

\[
d_o^2 - Dd_o + fD = 0
\]

(2)

which gives the two possible locations of the lens

\[
d_o = \frac{D \pm \sqrt{D^2 - 4fD}}{2}
\]

(3)

Notice that the two possible locations of the lens are symmetric about the center at $D/2$. 
b) If \( D < 4f \) then the discriminant (the expression below the square root sign) becomes negative and we get imaginary \( d_o \). Thus it is no longer possible to get a focused image on the screen if \( D < 4f \).

2. A magnifying glass is a convex lens.
   a) Why do we use a convex lens for the magnifying glass?
   b) If the focal length of the convex lens is 10cm, find the distance at which an object is magnified 10 times and the image is upright (not inverted).

Solution

a) A concave lens always gives a smaller image whereas convex lens can give magnification \(|m| > 1\). Thus we use a convex lens for a magnifying glass.

b) Since the image is upright, magnification \( m \) is positive. Thus \( m = -d_i/d_o \) gives \( d_i = -10d_o \) (note the negative sign). Using the lens’ equation we get

\[
\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{d_o} + \frac{1}{(-10d_o)} = \frac{9}{10d_o} = \frac{1}{f}
\]

which gives \( d_o = 9f/10 = 9\text{cm} \).