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Simple Lens Equation Problems

The following examples can be done without a calculator, using common denominators. In preparation you need to know which devices are convergent and divergent and when the focal length is negative. Notes: "Optics Basics" and "Lens/ Mirror Equations".

1. A thin convergent lens has a focal length of 10 cm. An 8 cm object is placed 30 cm to the left of the lens. Calculate the distance to the image.

f h p

$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$ $\frac{1}{30cm} + \frac{1}{q} = \frac{1}{10cm}$ $\frac{1}{q} = \frac{1}{10} - \frac{1}{30}$ $q = 15cm$

$\frac{1}{q} = \frac{3}{30} - \frac{1}{30} = \frac{2}{30}$ $\frac{1}{15}$

2. A 2 cm tall object is 4 cm in front of a concave mirror that has a focal length of 5 cm.

h p f

A. Calculate the distance to the image.

$\frac{1}{4} + \frac{1}{q} = \frac{1}{5}$ $\frac{1}{q} = \frac{1}{5} - \frac{1}{4}$ $= \frac{4}{20} - \frac{5}{20} = \frac{-1}{20}$ $q = -20cm$

B. Describe the image (real, virtual, magnified, reduced).

Virtual, since q is negative, magnified since q > p

3. A 4 cm object is 2 cm to the left of a divergent mirror. The image is seen 1.5 cm to the right of the mirror.

h p q

A. Before you calculate, describe the image.

Divergent so f is neg. Image for div devices are always virtual, reduced & on right side of mirror

B. Calculate the focal length of the mirror.

$\frac{1}{2} + \frac{1}{-1.5} = \frac{1}{f}$ $\frac{1.5-2}{3.0} = \frac{-5}{3.0} = \frac{-1}{6}$ $f = -6cm$

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4. A concave mirror has an 8 cm focal length. A 20 cm real image is projected 40 cm to the left of the mirror.

A. Calculate the distance to the object.

$q = 40cm$, $f = 8cm$

$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$ $\quad \frac{1}{p} + \frac{1}{40cm} = \frac{1}{8cm}$ $\quad p = 10cm$

B. Calculate the magnification of the mirror.

$M = -\frac{q}{p} = \frac{-40cm}{10cm} = -4$

C. Calculate the height of the object.

$M = \frac{h'}{h}$ $\quad -4 = \frac{-20cm}{h}$ $\quad h = 5cm$

5. A 4 cm object is 6 cm to the left of a concave lens. The image is 1.5 cm on the left side of the lens.

A. Calculate the focal length of the lens.

$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$ $\quad \frac{1}{6cm} + \frac{1}{-1.5cm} = \frac{1}{f}$ $\quad f = -2cm$

B. Calculate the height of the image.

$\frac{-q}{p} = \frac{h'}{h}$ $\quad \frac{-(1.5cm)}{6cm} = \frac{h'}{4cm}$ $\quad h' = 1cm$

6. A 0.08 m object is 0.12 m in front of a convergent mirror. The image focuses on a screen 0.24 m to the left of the mirror. Calculate the height of the image.

$h = 8cm$, $p = 12cm$, $q = 24cm$

$\frac{-q}{p} = \frac{h'}{h}$ $\quad \frac{-24cm}{12cm} = \frac{h'}{8cm}$ $\quad h' = -16cm$

7. A 4 cm object is 10 cm in front of a convex lens. The image is found to be 6 cm tall and inverted. Calculate the focal length of the lens.

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7. A 4 cm object is 10 cm in front of a convex lens. The image is found to be 6 cm tall and inverted. Calculate the focal length of the lens.

$h = 4\text{cm}$ $p = 10\text{cm}$ $h' = -6\text{cm}$

$\frac{h'}{h} = \frac{-q}{p}$ $\frac{-6\text{cm}}{4\text{cm}} = \frac{-q}{10\text{cm}}$ $q = 15\text{cm}$

$\frac{1}{10\text{cm}} + \frac{1}{15\text{cm}} = \frac{1}{F}$ $f = 6\text{cm}$

8. A convex mirror has a focal length of 4 cm. A 6 cm object is 12 cm to the left of the mirror. Calculate the distance to and height of the image.

$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$ $\frac{1}{12\text{cm}} + \frac{1}{q} = \frac{1}{-4\text{cm}}$ $q = -3\text{cm}$

$\frac{-q}{p} = \frac{h'}{h}$ $\frac{-(-3\text{cm})}{12\text{cm}} = \frac{h'}{6\text{cm}}$ $h' = 1.5\text{cm}$

9. A convex lens has a focal length of 4 cm. The 2 cm object is 3 cm to the left of the lens. Calculate the magnification of the lens.

$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$ $\frac{1}{3\text{cm}} + \frac{1}{q} = \frac{1}{4\text{cm}}$ $q = -12\text{cm}$

$M = \frac{-q}{p} = \frac{-(-12\text{cm})}{3\text{cm}}$ $M = 4$

10. A concave lens has a focal length of 3 cm. The object is 6 cm to the left of the lens and is 4 cm tall. Calculate the height of the image.

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10. A concave lens has a focal length of 3 cm. The object is 6 cm to the left of the lens and is 4 cm tall. Calculate the height of the image.

$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$

$\frac{1}{6cm} + \frac{1}{q} = \frac{1}{-3cm}$

$q = -2cm$

$\frac{-q}{p} = \frac{h'}{h}$ $\frac{-(-2cm)}{6cm} = \frac{h'}{4cm}$ $h' = 1.33cm$

11. A 3 cm tall object is 8 cm from a concave mirror. The image is 9 cm tall and projected. Calculate the distance to the image and the focal length of the mirror.

$\frac{-q}{p} = \frac{h'}{h}$ $q = \frac{-ph'}{h} = \frac{-8(-3)}{3}$

$q = 24cm$

$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$ $F = 6cm$

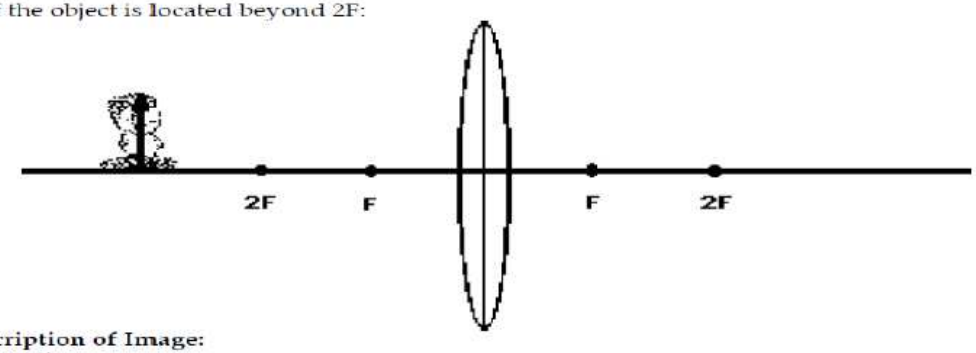
12. An 0.03 m object is 0.20 m in front of a convergent mirror that has a 0.10 m focal length. Calculate the height and distance to the image.

$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$

$\frac{1}{20cm} + \frac{1}{q} = \frac{1}{10cm}$

$q = 20cm$ $h' = 3cm$

Case 1: If the object is located beyond 2F:



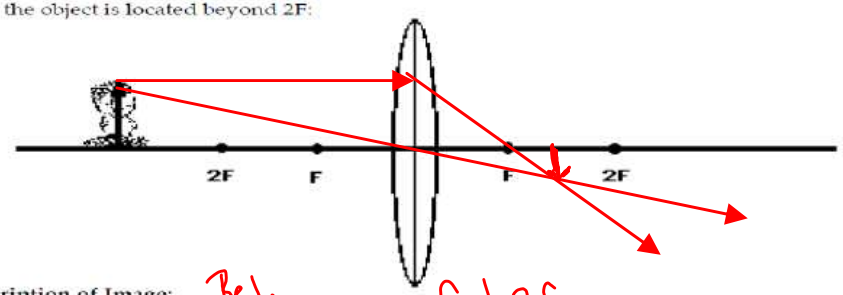
Description of Image:

Location: _____

O: Upright or Inverted S: Magnified or Reduced T: Real or Virtual

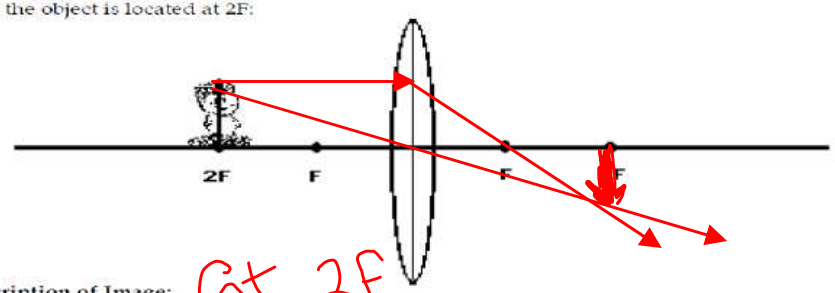
8.50 x 11.00 in

Case 1: If the object is located beyond 2F:



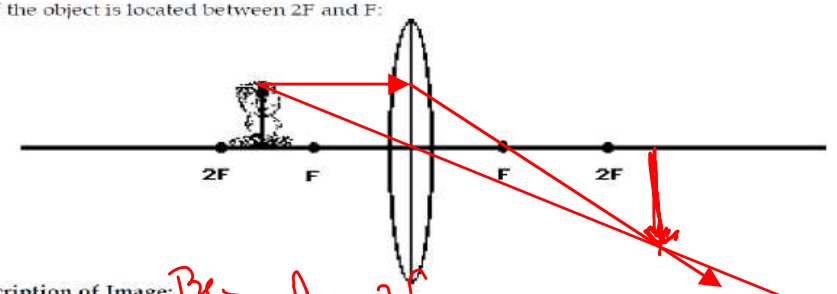
Description of Image: Between f & 2f
Location: _____
O: Upright or Inverted S: Magnified or Reduced T: Real or Virtual

Case 2: If the object is located at 2F:



Description of Image: At 2F
Location: _____
O: Upright or Inverted S: Magnified or Reduced T: Real or Virtual

Case 3: If the object is located between 2F and F:



Description of Image: Beyond 2F
Location: _____
O: Upright or Inverted S: Magnified or Reduced T: Real or Virtual