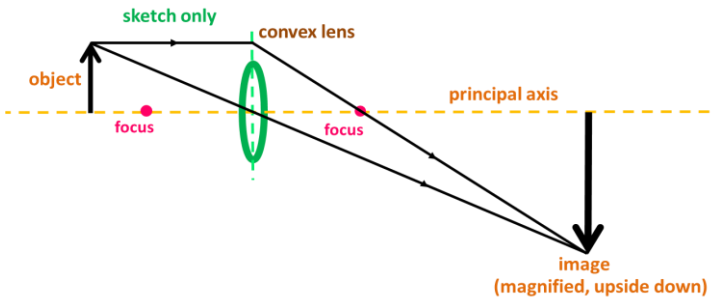
Shedding Light on Lenses: Bonus Feature 2 – The Mathematics of Lenses and Image Formation
Name: _____

u = distance of object to lens, **v = distance of image to lens** **f = focal length**
H_i = Height of Image **H_o = Height of Object**

$v = (f^{-1} - u^{-1})^{-1}$ $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ $f^{-1} = u^{-1} + v^{-1}$ $f = (u^{-1} + v^{-1})^{-1}$

Magnification, $M = H_i / H_o$ $M = \frac{Hi}{Ho} = \frac{v}{u}$ H_i = magnification x height of object $H_i = M \times H_o$

Eg 1. An object is placed 35 cm away from a convex lens of focal length 30 cm. How far is the image from the lens, and what is its magnification?



f = 30cm u = 35cm

$v = (f^{-1} - u^{-1})^{-1}$
$v = (30^{-1} - 35^{-1})^{-1}$
v = 210cm

$M = \frac{Hi}{Ho} = \frac{v}{u}$
$M = \frac{210}{35} = 6$

Eg 2. Calculate the image height if the object is 10cm tall.
$M = H_i / H_o$, so $Hi = M \times H_o = 6 \times 10cm = 60cm$

1. (a) A 2cm-tall object stands 4cm from a convex lens of focal length 3cm. Determine the position of the image, the magnification produced and its height.
f = _____ u = _____ H_o = _____ v = ? M = ? H_i = ?

(b) Compare your answers above to your answers to Question 10 from the Shedding Light on Lenses Worksheet.

Quantity	Results from Ray Diagram	Results from Calculations	% difference $\frac{ray\ diagram\ results - calculation\ results}{calculation\ results} \times 100\%$
Distance of image to lens (v)			
Magnification			
Height of Image (H_i)			

2. (a) A 2cm-tall object stands 6cm from a convex lens of focal length 3cm. Determine the position of the image, the magnification produced and its height.

f = _____ u = _____ H_o = _____ v = ? M = ? H_i = ?

(b) Compare your answers above to your answers to Question 14 from the Shedding Light on Lenses Worksheet.

Quantity	Results from Ray Diagram	Results from Calculations	% difference $\frac{ray\ diagram\ results - calculation\ results}{calculation\ results} \times 100\%$
Distance of image to lens (v)			
Magnification			
Height of Image (H_i)			

3. (a) A 2cm-tall object stands 9cm from a convex lens of focal length 3cm. Determine the height of the image, its position, and the magnification produced.

f = _____ u = _____ H_o = _____ v = ? M = ? H_i = ?

(b) Comment on the accuracy of your diagram from Question 15 of the Shedding Light on Lenses Worksheet.

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4. (a) A 2cm-tall object is 2cm away from a convex lens of focal length 6cm. Calculate the position of the image, its magnification, and its height.

f = _____ u = _____ H_o = _____ v = ? M = ? H_i = ?

(b) Compare your answers above to your answers to Question 6 from the Shedding Light on Lenses Worksheet. (Use only the actual values and ignore the negatives)

Quantity	Results from Ray Diagram	Results from Calculations	% difference $\frac{ray\ diagram\ results - calculation\ results}{calculation\ results} \times 100\%$
Distance of image to lens (v)		(ignore the negatives)	
Magnification			
Height of Image (H_i)			

5. (a) The same 2cm tall object is now 3.6cm away from a convex lens of focal length 6cm. Determine the position of the image, the magnification produced and its height.

f = _____ u = _____ H_o = _____ v = ? M = ? H_i = ?

(b) Compare your answers above to your answers to Question 7 from the Shedding Light on Lenses Worksheet. (Use only the values and ignore the negatives)

Quantity	Results from Ray Diagram	Results from Calculations	% difference $\frac{ray\ diagram\ results - calculation\ results}{calculation\ results} \times 100\%$
Distance of image to lens (v)			
Magnification			
Height of Image (H_i)			

6. (a) A 2cm-tall object stands 6cm from a concave lens of focal length 3cm. Determine the height of the image, its position, and the magnification produced.
Remember, mathematically, the focal length of a concave lens is negative, so f = -3cm.
f = _____ u = _____ H_o = _____ v = ? M = ? H_i = ?

(b) Comment on the accuracy of your diagram from Question 23 of the Shedding Light on Lenses Worksheet.
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7. A typical human eye has a diameter of about 2.5cm. Assuming that the focussed image forms on the retina at the back of the eye (2.5 cm from the lens/cornea), calculate:
   (a) the focal length of the lens/cornea when you are focussing on something that is 20cm away.
   u = 20.0cm v = 2.50cm f = ?

   (b) the focal length of the lens/cornea when you are focussing on something that is 1m (100cm) away.
   u = _____ v = _____ f = ?

   (c) the focal length of the lens/cornea when you are focussing on something that is 100m away.
   u = _____ metres = _____ centimetres v = _____ f = ?

(d) Comment on your findings and, in particular, the way the eye's lens changes shape as you look from a nearby object to a distant object.
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