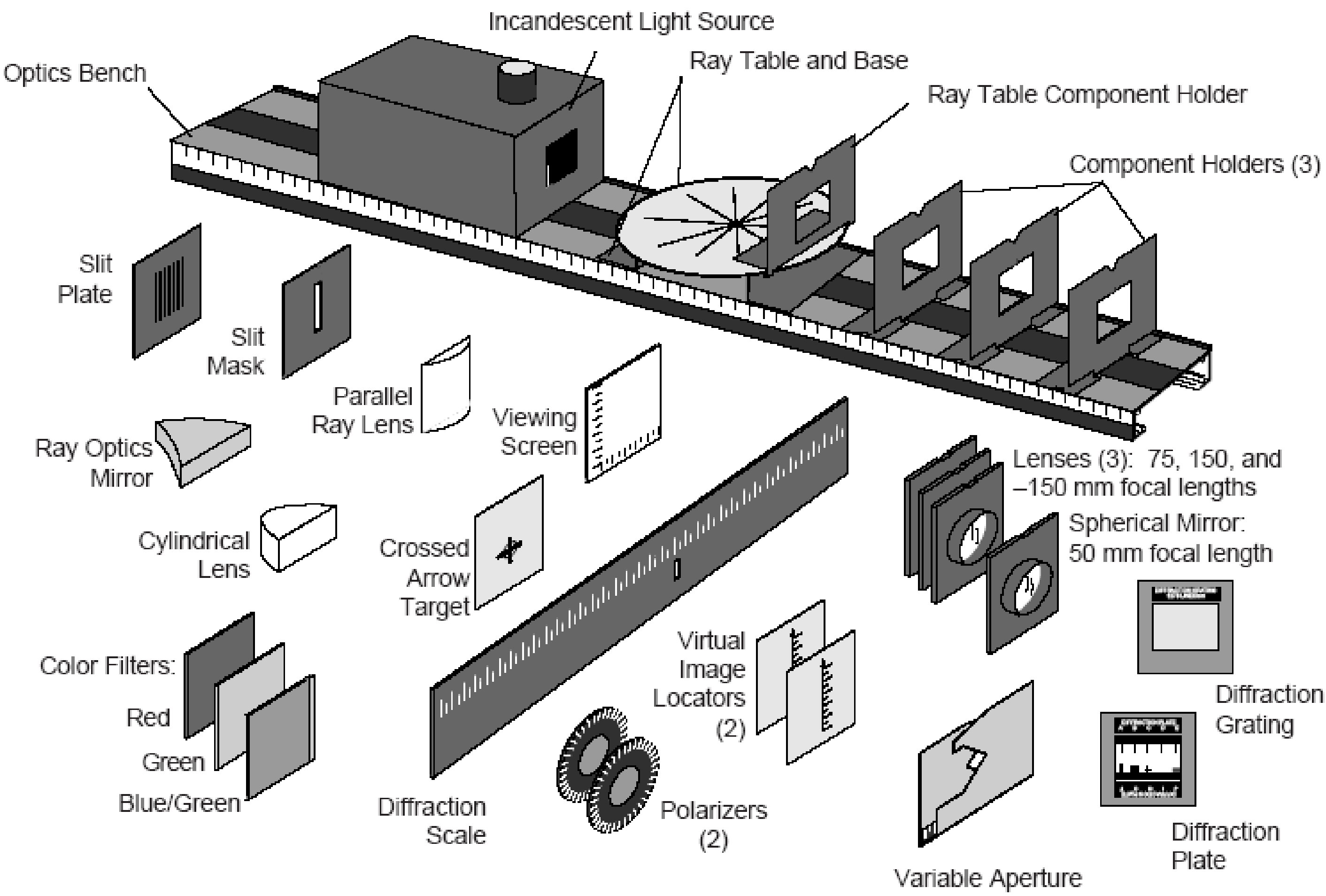
Lab 2L
Mirrors and Lenses

Equipment



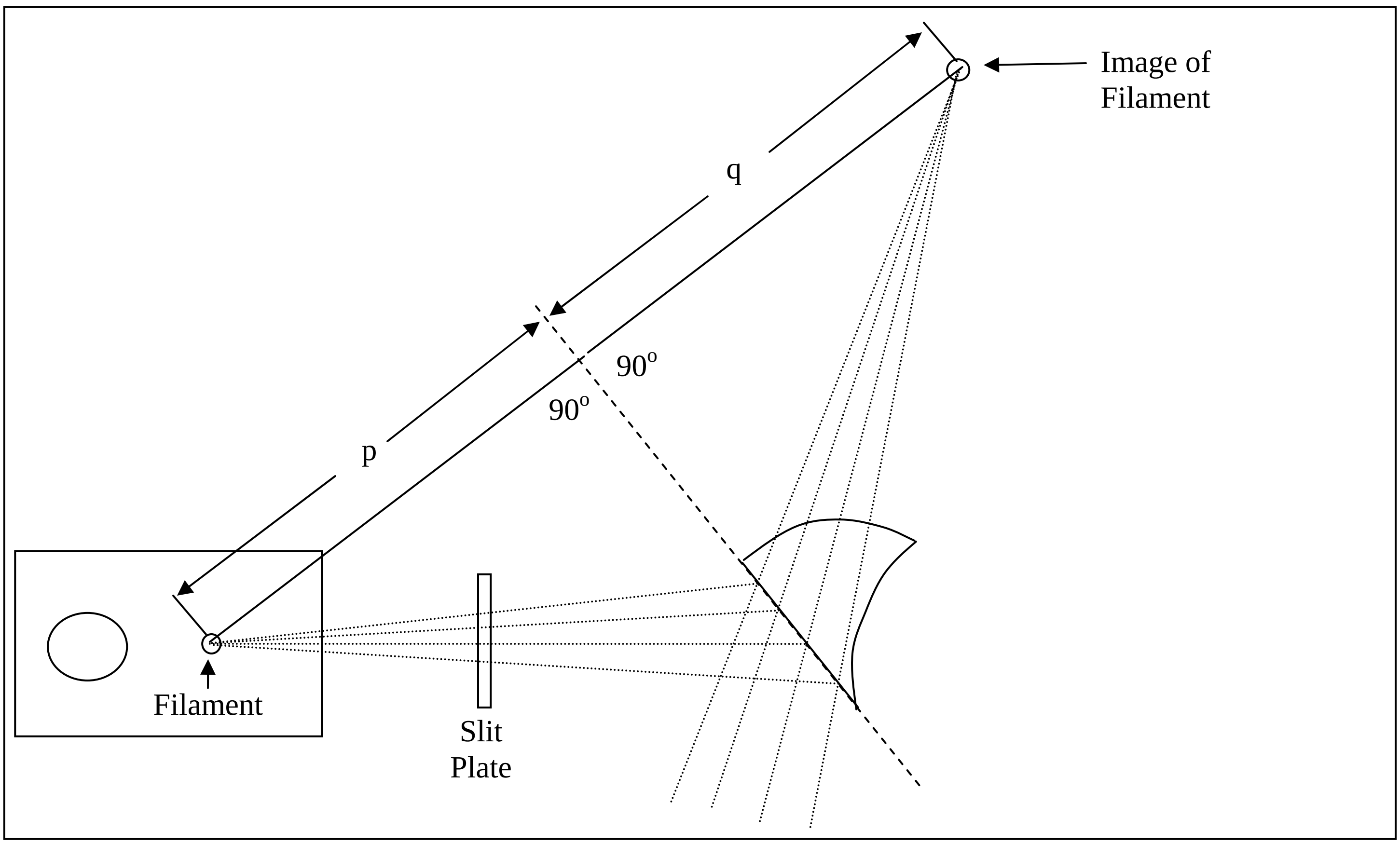
Not all of the equipment shown above will be used during the activities outlined in this procedure.

Image Formation in a Plane Mirror

Place the light source, slit plate (mounted on a component holder), and the ray optics mirror on a large piece of paper such that the slit plate forms rays of light that strike the plane (flat) side of the ray optics mirror at an angle. Note that the filament of the light source must be on the paper. Adjust the components such that you have sharp, easily visible incident and reflected rays.

While firmly holding the mirror in place, use a sharp pencil to draw a line where the flat edge of the mirror is located on the paper. Now mark where each incident ray strikes the mirror. A couple inches away from the mirror, draw a small line on each incident ray. Also draw a small line on each of the reflected rays a couple of inches away from the mirror. These marks will be used to recreate each incident and reflected ray after the light source is removed.

Turn-off the light source and remove it from the paper. Remove the mirror. Carefully extend the line that indicated where the flat edge of the mirror was located on the paper using a straight edge. Using the mark where an incident ray struck the mirror and the individual line drawn on the same incident ray, recreate each incident ray using a straight edge. Make sure to extend the lines representing each incident ray from the mirror to where the filament was located. Each incident ray should intersect where the filament was located. Now, using the mark where an incident ray struck the mirror and the individual line drawn on each reflected ray, recreate each reflected ray using a straight edge. When these lines are extended through the flat edge of the mirror, they should intersect where the *image* of the filament was located. Draw a straight line from the filament and the image of the filament. This line should be perpendicular to the line that was extended from the flat edge of the mirror. At this point you should have a diagram that looks similar to the diagram below without the light source, slit plate, or mirror.



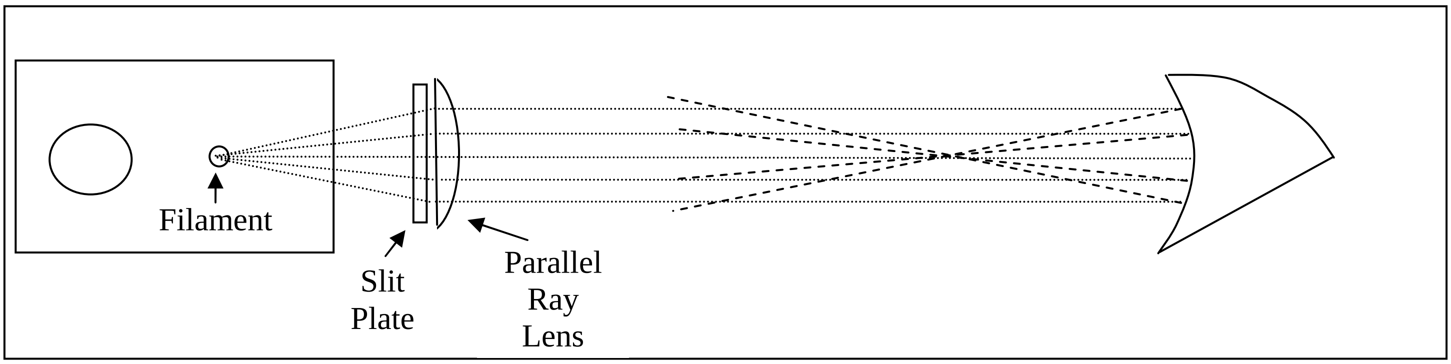
Answer the questions on the Data Sheet under the section *Image Formation in a Plane Mirror*.

Focal Lengths of Cylindrical Mirrors

Ray Tracing techniques can be used to determine the focal length of any mirror of known shape. If parallel light rays hit the mirror parallel to the optical axis, the focal point can be easily located. If the reflected rays intersect at a point, a focal length can be measured at that point. If the reflected rays do not intersect, but would if they were extended back beyond the mirror, a virtual focal length can be measured by tracing the rays back to the point of intersection. A virtual focal length such as this is denoted by using a negative sign.

Concave Mirror

Using the opposite side of your large piece of paper, position the light source, parallel ray lens and slit plate to form clear parallel rays. (Note: the slit plate and Parallel Ray Lens should be mounted on the same component holder.) Use the grid on the Ray Table to ensure that your incident rays are as near parallel as possible. After you have adjusted the Slit Plate/Parallel Ray Lens to form clear parallel incident rays, remove the Ray Table and place the concave mirror such that the parallel rays are parallel to the optical axis of the concave mirror as shown below. Trace the surface of the mirror, the incident rays, and the reflected rays as before. Determine and record the focal length on your Data Sheet.

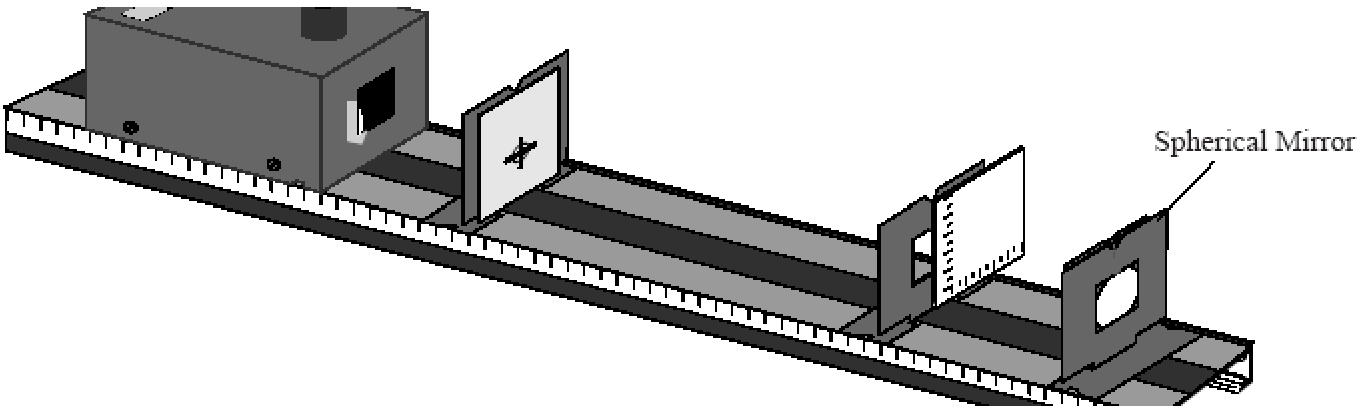


Convex Mirror

Reposition the light source, parallel ray lens, slit plate and <u>convex</u> mirror on the large piece of paper such that it will not interfere with your previous ray diagrams. Adjust the Slit Plate/Parallel Ray Lens and Convex Mirror such that you have clear parallel incident rays that are all parallel to the optical axis of the convex mirror. Trace the surface of the mirror, the incident rays, and the reflected rays as before. Remove the convex mirror and extend the reflected rays back to their point of intersection. Determine and record the focal length on your Data Sheet.

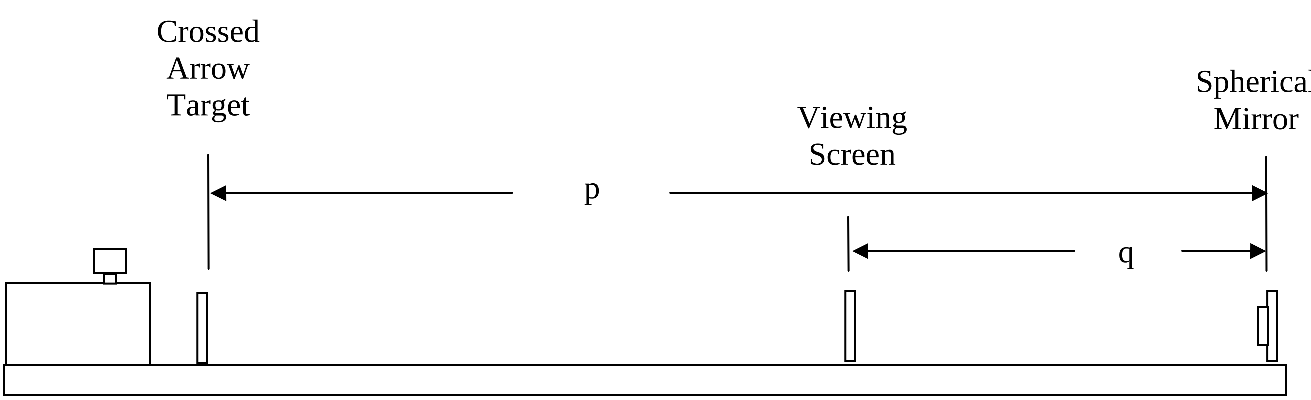
Image Formation from Spherical Mirrors

Position the light source and the Cross Arrow Target as far away as possible from the Spherical Mirror with the concave side of the Spherical Mirror facing the light source. Adjust the position of the viewing screen to form a focused image. Note that the viewing screen should be positioned on the component holder such that only half of the hole is covered. You may have to finesse the viewing screen by placing it at a slight angle or adjusting the amount of the hole that is exposed to find the image. Once you have a focused image, measure q (the distance of the image from the mirror) and record the value and answer the question on the Data Sheet under <u>Image Formation from Spherical Mirrors</u>.



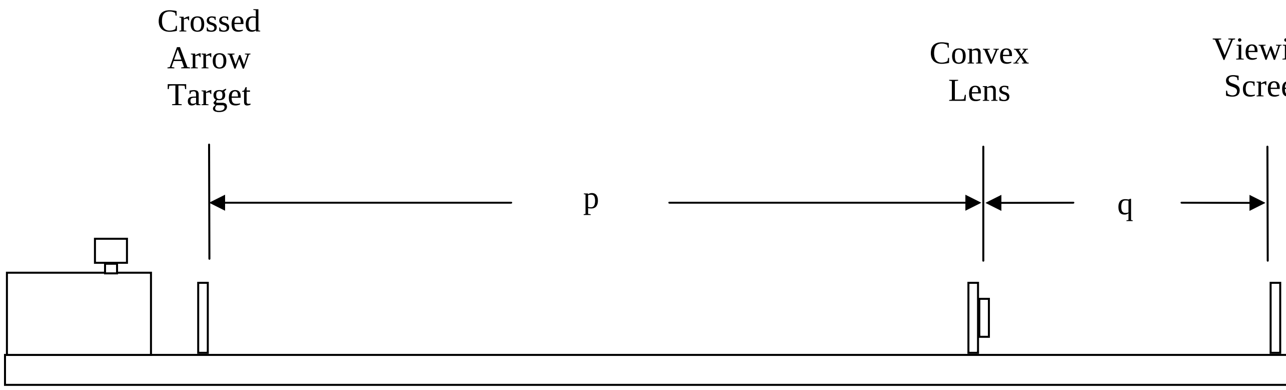
Complete the table on The Data Sheet. Using the data and the Fundamental Lens Equation determine a more accurate focal length of the spherical mirror. Also determine the magnification of the mirror.

Fundamental Lens Equation $\frac{1}{f}=\frac{1}{p}+\frac{1}{q}$ Magnification $m=\frac{-q}{p}=\frac{h_i}{h_o}$



Converging Lenses: Image and Object Relationships

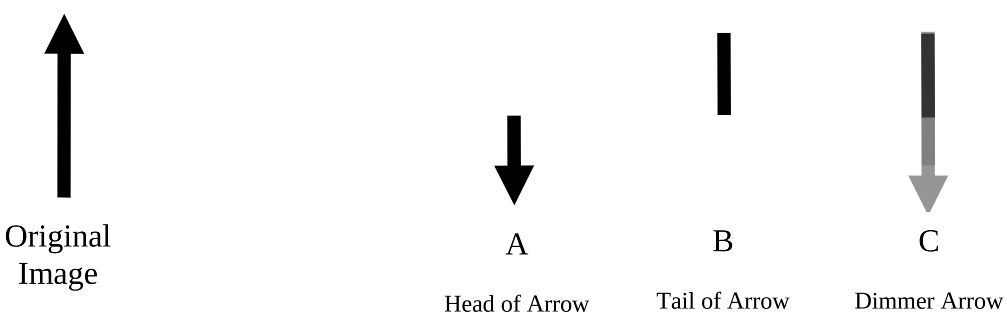
With the optics components configured as below, estimate the focal length of the lens in a similar fashion as with the spherical mirror. Record your estimate and answer the questions on the Data Sheet in the section Converging Lenses: Image and Object Relationships.



Complete the table on The Data Sheet. Using the data and the Fundamental Lens Equation determine a more accurate focal length of the Convex Lens. Also determine the magnification of the lens.

Fundamental Lens Equation $\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$ Magnification $m = \frac{-q}{p} = \frac{h_i}{h_o}$

Adjust the components such that the image on the viewing screen is focused and is as large as possible. If you slowly lower a card or piece of paper directly in front of the lens so that half of the lens is covered, how would you expect your image to change? Record your guess on the Data Sheet before trying it.



Now actually try covering half of the lens, and record the actual result on the Data Sheet and explain the result with a ray Diagram. Note that the card/paper needs to be held directly in front of the lens.

Name: ________________________________ Name: ___________________________________

Name: ________________________________ Name: ___________________________________

Data Sheet

Lab 2L

Mirrors and Lenses

Image Formation in a Plane Mirror

Do the rays seem to follow a straight line into the mirror? ____

What is the perpendicular distance from the filament to the plane of the mirror (p)? ______________________

What is the perpendicular distance from the image of the filament to the plane of the mirror (q)?____________

What is the relationship between the object and image location for reflection in a plane mirror? ____________
____
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Focal Lengths of Cylindrical Mirrors

Focal length of concave mirror ____

Focal length of convex mirror ____

What can you conclude about the radii of the Convex and Concave mirrors? How do they compare? _________
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Ask to borrow the Ray Optics Mirror from a neighboring station, and use two Ray optics Mirrors to compare the radii of the Convex and Concave mirrors by “nesting” them together. Now comment on the radii based on the focal lengths you determined above and the “nesting” procedure:_________________________________
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Image Formation from Spherical Mirrors

Value of q: ______________________________

Using the Fundamental Lens Equation, mathematically explain why q is a good estimate of the focal length of the concave mirror:____

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p (mm)	q (mm)	Focal Length (mm)	h_i (mm)	h_o (mm)	Magnification based on h_i/h_o	Magnification based on $-q/p$
400			N/A	N/A	N/A	N/A
300			N/A	N/A	N/A	N/A
200			N/A	N/A	N/A	N/A
150						
Average Focal Length						

Determine a percent difference of the focal length using the known value of the focal length. _______________

Determine a percent difference between the magnifications determined by h_i/h_o and $-q/p$.

Are there any significant discrepancies?   If, so what do you attribute these discrepancies? ________________

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Converging Lenses: Image and Object Relationships

Estimate of the focal length of the Convex Lens: ____________________________

Using the Fundamental Lens Equation, mathematically explain why your estimate is valid for a convex lens.

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Is the image magnified or reduced? ____

Is the image upright or inverted? ____

p (mm)	q (mm)	Focal Length (mm)	h_i (mm)	h_o (mm)	Magnification based on h_i/h_o	Magnification based on $-q/p$
300			N/A	N/A	N/A	N/A
200			N/A	N/A	N/A	N/A
150						
100						
Average Focal Length						

Determine a percent difference of the focal length using the known value of the focal length. ______________

Determine a percent difference between the magnifications determined by h_i/h_o and -q/p. (two percent difference calculations should be made).

Are there any significant discrepancies? If, so what do you attribute these discrepancies? _________________

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Guess on how the image will change by covering half of the lens (A, B, or C): __________________________

How did the image actually change by covering half of the lens (A, B, or C): ___________________________

Explain why the image changed as it did using a ray diagram: