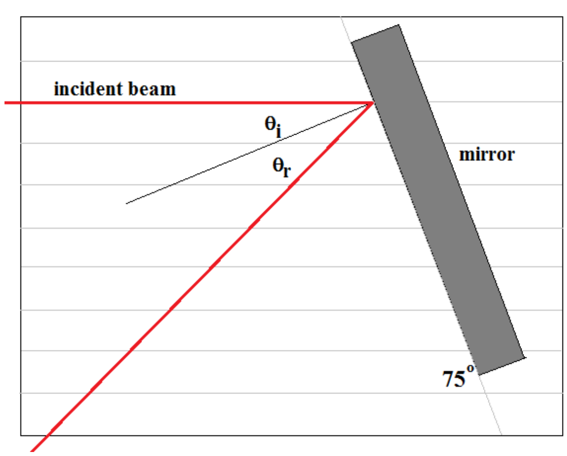
Geometric Optics

Equipment	
Laser Level	1
Rectangular Lucite Block	1
Triangular Lucite Block	1
Convex Lens Lucite Block	1
Concave Lens Lucite Block	1
Flat Mirror	1
Concave/Convex Mirror	1
Rulers	2
Protractors	2

Terms:

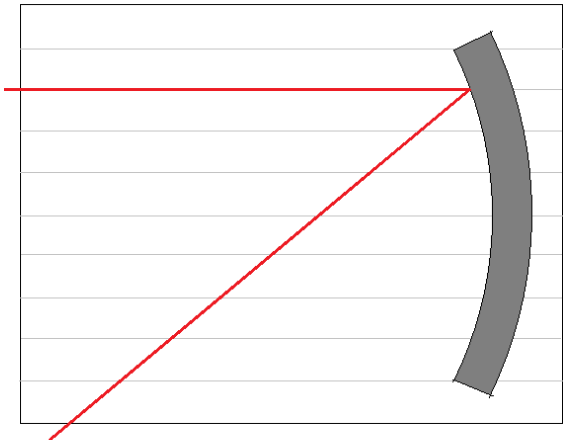
Reflection	Total Internal Reflection
Refraction	Critical Angle
Angle of Incidence	Radius of Curvature
Angle of Reflection	Focal Length
Angle of Refraction	Concave/Convex mirrors
Snell's Law	Concave/Convex lenses
Index of Refraction	

This exercise investigates some basic principles of geometric optics, principles that are useful in understanding reflection, refraction, and imaging systems.



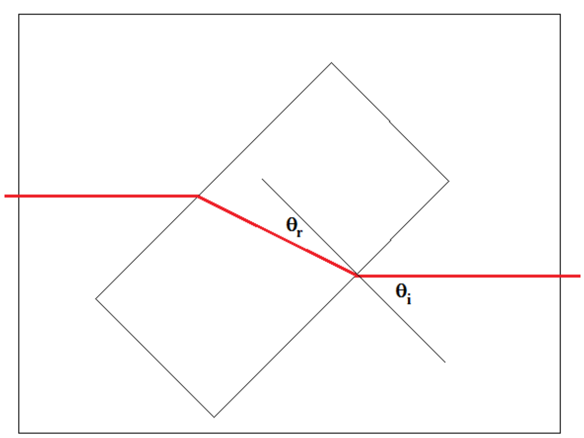
Plane Mirror

1. Draw at least 5 parallel lines on a sheet of paper.
2. Draw another line that crosses the parallel lines at an angle of 75^o.
3. Place the flat mirror on the paper with its mirrored surface along the 75^o line.
4. Trace a line around the mirror to record its location on the paper. You can use this to reposition the mirror if it's moved during the procedure.
5. Shine the laser beam along one of the parallel lines.
6. Trace the reflected beam using a ruler.
7. Shine the laser along the other parallel lines and trace their reflected beams in the same manner.
8. Draw arrowheads on the lines to indicate direction of light propagation.
9. On another sheet of paper repeat this process with a 50^o mirror line.
10. On another sheet of paper repeat this process with a 15^o mirror line.
11. For each sheet, use a protractor to measure the angles of incidence for all the rays and record in the data table an average incidence angle. The figure indicates the angles of incidence and reflection, θ_i & θ_r
12. For each sheet, measure the angles of reflection for each of the rays and record their averages in the table.



Concave and convex mirrors

1. Make another page of parallel lines and place the curved mirror on it so that the laser beam will reflect on the concave side.
2. Trace around the mirror to record its location on the paper.
3. Draw reflected beam lines the way you did for the flat mirror. In this case, they should converge.
4. Locate the point of convergence of the beam lines. This is the focal point of the mirror.
5. Measure the distance from the focal point to the closest point on the mirror. This is the focal length of the mirror.



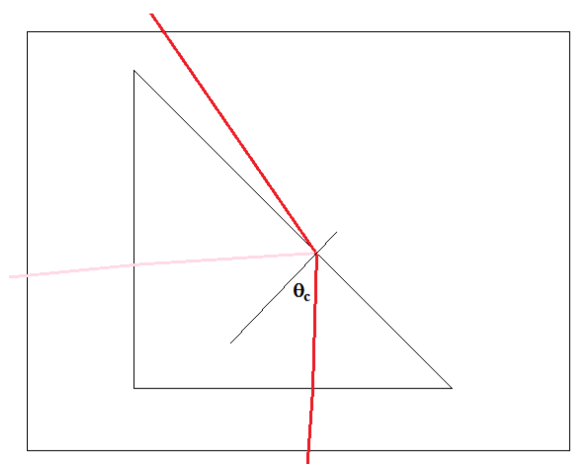
Snell's Law

Now you'll measure the index of refraction of the Lucite. The index of refraction of a transparent material is defined as

$$n = \frac{\sin\theta_i}{\sin\theta_r}$$

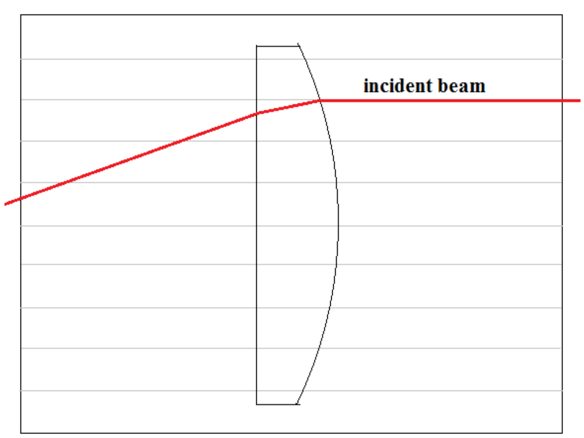
Where the angles of incidence and refraction are θ_i and θ_r. You'll measure each of these and calculate the index.

1. Place the rectangular block on a piece of paper and trace its edge.
2. Shine the laser as in the figure so that it refracts in the block.
3. Using the ruler, trace the beams entering and leaving the block.
4. Remove the block and connect the two beams so that you have a line representing the beam through the block.
5. Measure θ_i and θ_r and calculate the index of refraction of the material.
6. Repeat this procedure for two other angles of incidence. The index of refraction is a property of the material and so the result should be about the same for each θ_i



Total Internal Reflection

1. Place the triangular block on a blank piece of paper and trace its edge.
2. Shine the laser so that the beam exiting the block is nearly parallel to the side, as in the figure. Notice that some of the beam reflects off the inside surface through which the exiting beam passes (faint line in figure).
3. Move the laser so that the beam exiting the block becomes closer and closer to parallel with the side of the block.
4. Stop when the exiting beam disappears. All of the beam is now internally reflecting. The angle of incidence of the internal beam is called the critical angle θ_c.
5. Mark the 3 points where the beam meets the edge of the block.
6. Remove the block and connect the 3 points to indicate the path of the beam inside the block.
7. From these lines, determine the critical angle.



Concave and Convex Lenses

1. Make another page with parallel lines and place the convex lens on a line that's perpendicular to the parallel lines.
2. Trace the edge of the lens.
3. Using a ruler, trace the beam path for numerous lines.
4. Tape another piece of paper to the end of the page in order to trace the beams to the point at which they converge (the focal point). Since the shape of this lens is only roughly a circle, the beams will not all converge on the same spot, but an approximate location can be determined.
5. Measure the focal length of the lens, the distance from the focal point to the near side of the lens.
6. Repeat this procedure for the concave lens. In this case, the beam will diverge instead of converging.
7. After you've traced the beams, remove the lens and trace the beams backward to the point where they will converge.
8. Measure the focal length. In this case, the value will be negative.
9. Use the drawing that you made with the convex lens to find the radius of curvature of the lens. This can be done using a drawing compass and a straightedge. Ask the instructor for assistance if you don't know how to do this.
10. Do the same to find the radius of curvature of the concave cylindrical mirror.

Data Table 1: Plane Mirror

Average Angle of Incidence	Average Angle of Reflection

Data Table 2: Cylindrical Mirrors

	Concave Mirror	Convex Mirror
Focal length		
Radius of Curvature		
Radius/Focal Length		

Data Table 3: Snell's Law

θ_i	θ_r	n
	Average n	

Data Table 4: Total Internal Reflection

Measured θ_c	
Theoretical θ_c	
Percent Difference	

Data Table 5: Cylindrical Lenses

	Convex	Concave
Focal Length		
Radius of Curvature		