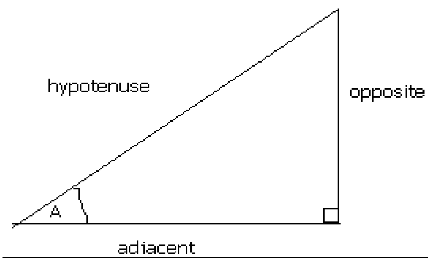
Saturday Math Club Topics

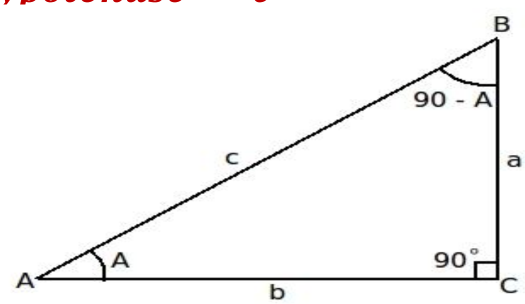
Class Activities

Class activity #1: The Sine Function

- In a right angle triangle, the sine of an angle is equal to the ratio between the length of the side of the triangle opposite that angle and the length of the hypotenuse:

$$sinA = \frac{length\ of\ opposite\ side}{length\ of\ hypotenuse} = \frac{a}{c}$$





- Step 1: Draw a right triangle with an acute angle A and measure the length of the opposite side of angle A and the length of the hypotenuse and evaluate the ratio and record it. Record your data in the table below:

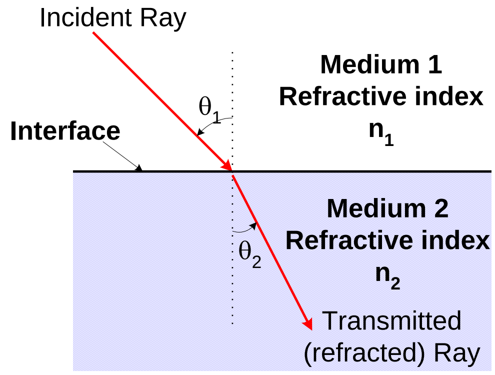
- Step 2: Now, use a protractor and measure angle A. Use a calculator to compute sin A. Compare this result with the one found in Step 1.

- Step 3: Extend both the base and the hypotenuse of your triangle obtaining in this way a new triangle. Repeat Step 1 and 2 on this new triangle. Did you obtain a different value for sin A when using the measurements of this new triangle? Is the result consistent with your expectation?

- Repeat step 3 one more time

Triangle # 1	Length of opposite side, a (cm)	Length of hypotenuse, c (cm)	Ratio $\frac{a}{c}$	Calculator Computed $\sin A$	Compare $\frac{a}{c}$ to $\sin A$	Comments

Class activity #2: The law of Refraction (Snell's Law)



$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

Step 1: Place the glass half cylinder on the template provided in Figure 1-1.

Step 2: Align the light ray produced by the ray box with the line that makes a 10 degree angle with the perpendicular (also called ***the normal***) to the glass surface.

Step 3: Mark the point where the light ray emerging from the glass half cylinder intersects the circle.

Step 4: Repeat steps 1 through 3 for incident angles of incidence of 20, 30, 40 and 50 degrees.

Step 5: Remove the glass cylinder and connect the center of the cylinder (the point where the incident light meets the cylinder) with the points you marked on the circle.

Step 6: Measure the angles made by the refracted ray (i.e. by the lines you just draw in step 5) with the normal to the surface. Record your values in the data table provided.

Step 7: Use a calculator to compute $\sin\theta_1$, $\sin\theta_2$ and record the values in the data table.

Step 8. Use $\sin\theta_1$ and, $\sin\theta_2$ to find the index of refraction of the glass cylinder.

Angle of Incidence, θ_1(degrees)	Angle of refraction, θ_2(degrees)	$\sin\theta_1$	$\sin\theta_2$	$\frac{\sin\theta_1}{\sin\theta_2}$	Index of Refraction, n	Comments

Repeat Steps 1 through 8 for refraction from glass to air using the template provided in Figure 1-2 and record the data in the table below:

Angle of Incidence, θ_1(degrees)	Angle of refraction, θ_2(degrees)	$\sin\theta_1$	$\sin\theta_2$	$\frac{\sin\theta_1}{\sin\theta_2}$	Index of Refraction, n	Comments

Class activity #3: Measuring the focal length of a converging (convex) lens

Use the templates provided in figures 2-1 and 2-2 to measure the focal length of a converging lens.

Step 1: Place the double convex lens on the template provided in Figure 2-1.

Step 2: Align the light rays produced by the ray box with the line marks the optical axis of the lens

Step 3: Mark the point where the light rays emerging from the lens intersect

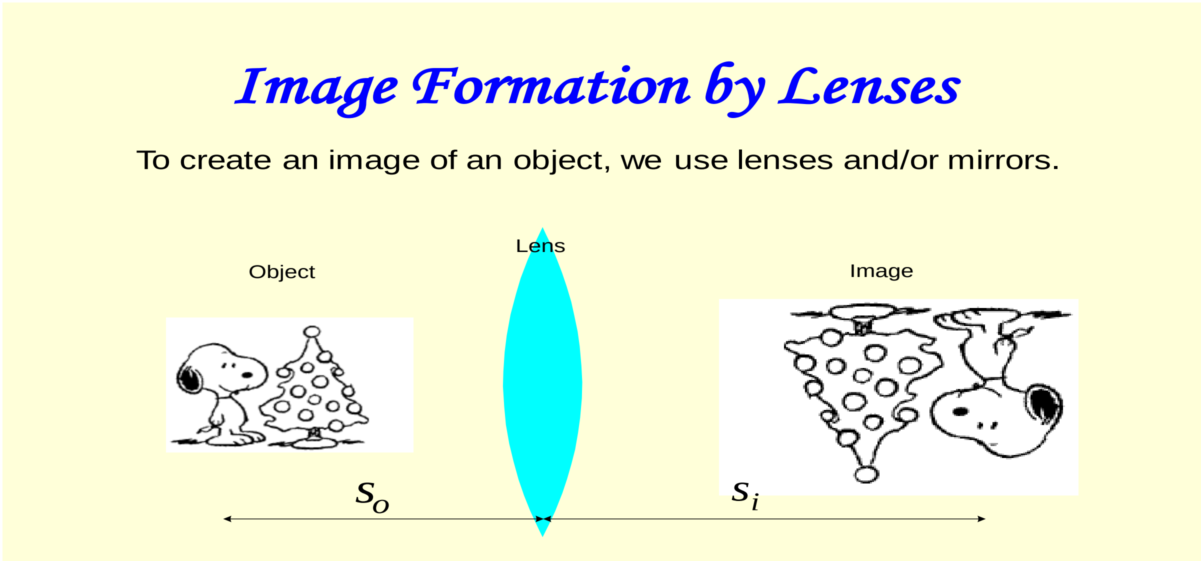
Step 4: Use a ruler to measure the focal length of the lens and record it below:

$$f_{double\ convex\ lens} =$$

Step 5: Repeat steps 1 through 4 for the plano-convex lens by using the template in Figure 2-2.

$$f_{plano-\ convex\ lens} =$$

Class activity #4: Image Formation through Convex (converging) Lenses



The thin-lens equation is used to calculate the position (distance) of the image when we know the position (distance) of the object:

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f} \qquad\qquad s_i = \frac{s_o \cdot f}{s_o - f}$$

In class you have solved this equation for several object distances (expressed as multiples of the focal length *f*) and you found the corresponding image distances (again, expressed in terms of the focal length *f*):

Object distance, s_o	*4f*	*3f*	*2f*	*1.5f*	*1.05f*	*0.95f*	*0.5f*
Image Distance, s_i							

Table 1: Theoretically predicted image distances for known object distances

You will now use an optical rail, place a luminous object at those distances from a converging lens of known focal length, measure the corresponding image distance and verify if your experimental findings confirm the theoretical calculations you did based on the thin lens equation.

Step 1: Place the luminous object at one end of the optical rail

Step 2: Place the white screen at the other end of the optical rail

Step 3: Place the converging lens with a nominal focal length of 10 cm at a distance of 15 cm from the screen.

Step 4: Slowly slide the lens along the rail toward the screen until the image of the luminous object appears in clear focus.

Step 5 Record your experimentally measured value of the focal length

$$f_{experimental} =$$

Step 6: Place the converging lens at a distance from the luminous object equal to 3 times its experimentally measured focal length.

Step 7: Move the white screen on the optical rail until the image of the luminous object is in clear focus.

Step 8: Record the object distance and the image distance and calculate the data in the table below:

Step 9: Repeat steps 6 and 7 for

Focal length, f (cm)	Object distance, s_o (cm)	Image Distance, s_i (cm)	$\frac{s_o}{f}$	$\frac{s_i}{f}$	Theoretically predicted image distance from table 1