

REFRACTION WORKSHEET

“Triangle” Diagram: On other pages in this set you will find a large triangle that represents a triangular prism. We want to follow the path of a light ray striking one of the surfaces as it passes through the prism and exits one of the other surfaces. Assume that $n = 1.5$ in the prism.

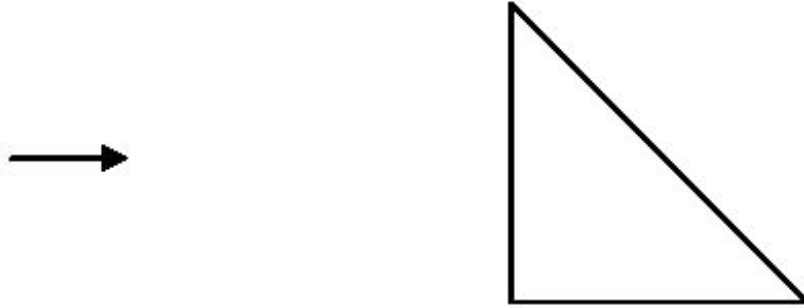
1. Draw an incident ray which strikes the surface of the prism, on the side marked by the asterisk, at an angle of incidence of 60° . Use a protractor to do this carefully. Include an arrow on the ray to indicate its direction of travel. (Use a blue pen or pencil if you have one.) The ray should enter the side of the prism indicated with the asterisk.
2. Use Snell’s law to find the path of the ray as it passes into the prism, and then as it exits out one of the other surfaces. Put arrows on the ray as it passes through the other regions as well.

You will have to draw a normal line at the surfaces where the light ray meets the surface. Use colored pencil or pen or draw a dashed line for the normal lines; it will then be easier to distinguish them from the rays.

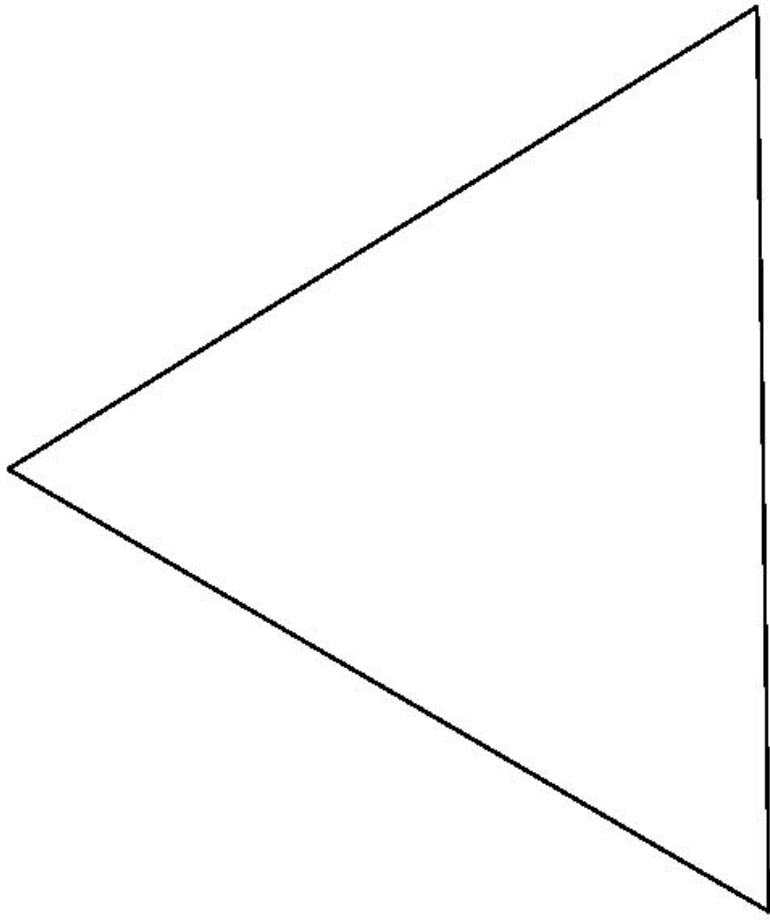
3. The index of refraction actually depends on the wavelength of the light, so the path you have drawn is accurate only for one particular wavelength. Assume that this is blue light. Then the index of refraction for red light will be less. Assume (unrealistically) that the index of refraction for red light is 1.0. (It would actually be about 1.48, and wavelengths between those of red and blue would have indices of refraction between the two extreme values; we are choosing a very low value of n for red light to exaggerate the difference in paths and make the difference very clear.) Draw the path the red light will take, if it comes in along the same path as the blue light when it strikes the first surface.
4. Suppose white light – a mixture of many different wavelengths of light – entered the prism along the original path. What type of pattern would you see as the light rays exited the prism? Explain in the space below. (Note: The creation of this pattern from white light is called dispersion.)

5. On the second copy of the prism diagram, draw a ray incident on the same side as before but this time with an angle of incidence of 20° . Follow this ray through the prism as before. Describe how the path differs from that of the two previous rays. What is the term used to describe this phenomenon?

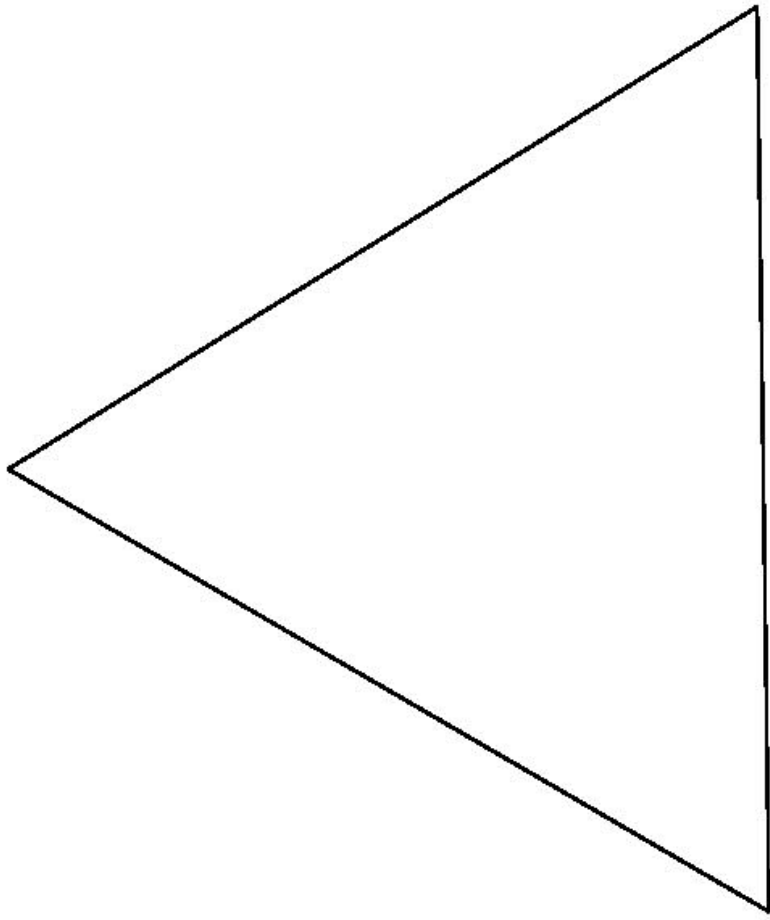
6. A $45^\circ - 45^\circ - 90^\circ$ prism of the type below ($n \approx 1.5$) is often used in place of a mirror in devices such as binoculars, periscopes, etc. Draw the path followed by light passing through the prism, starting along the arrow on the left, until the ray has exited the prism. Explain why this prism can be used to replace a mirror. Relate this to what you observed in #5.



7. [optional] Find another light path (with a different incoming direction) for the prism in #6 that would result in the light ray returning back, after passing through the prism, in the same direction from which it came.



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“Thick Lens” Diagram: In this assignment you are to follow some light rays from the arrow (the “object”) as they go through the lens, and find out where the “image” of the object is. Essentially, you follow the light ray as it encounters two different surfaces and refracts at each surface. The first surface is air to glass and the second surface is glass to air.

In your calculation use $n = 2.0$ for the glass making up this lens.

There will be many different lines, counting incident rays, normals, and refracted rays, to draw in this diagram, and it will get very confusing. It will help if you do the following:

- 1) Always put arrows on the light rays to show their direction of travel, both inside the lens and outside.
- 2) When you draw the path of the ray traveling inside the lens, extend a dotted line outside the lens in exactly the opposite direction, to help in measuring angles. (Or, use a smaller protractor.)
- 3) Use colored pencil or pens for the normal lines. You might use blue for the normal lines on the left surface, and red for the normals on the right surface. Extend the normals far enough to be able to measure all necessary angles. The normals should be dashed lines rather than solid to distinguish them from the light rays.

How do you determine the normals? The centers of curvature of each lens surface are represented with dots; that is, the dot on the right is the center of the circle of which the left lens surface forms a part, etc. A straight line drawn from the center of curvature, to the surface of the respective circle, will be perpendicular (“normal”) to the circle at that point. That is how you can most easily draw the normal lines.

General Instructions:

- 1) Follow the path of two different rays incident on the left surface: (a) a ray from the arrowhead that travels approximately parallel to the principal axis, and (b) a ray from the arrowhead that strikes the left surface at the vertex (the point where the surface meets the axis).
- 2) Follow each ray through to the other side, and find where rays (a) and (b) intersect; that will be where the image of the arrowhead is formed. Where will the arrow’s tail be imaged?

