

# Delta, Delta, Delta: Teacher Lesson Plan

## Introduction

In this experiment, students construct an equilateral triangle using graph paper, pencil, protractor, and a ruler. They also make a “laser triangle” using a laser pointer and front-silvered mirrors. Students can use the geometric properties of an equilateral triangle, combined with their understanding of the Law of Reflection, to decide how to place the mirrors at each vertex so that the “laser triangle” fits their equilateral triangle.

**Texas Essential Knowledge and Skills, Grades 9-12:**

### Astronomy

112.33(c)-2(I) use astronomical technology such as telescopes, binoculars, sextants, computers, and software.

### Integrated Physics and Chemistry

112.38(c)-5(G) explore the characteristics and behaviors of energy transferred by waves, including acoustic, seismic, light, and waves on water as they superpose on one another, bend around corners, reflect off surfaces, are absorbed by materials, and change direction when entering new materials.

### Physics

112.39(c)-7(D): investigate behaviors of waves, including reflection, refraction, diffraction, interference, resonance, and the Doppler effect.

**Warning:** Students should exercise extreme caution when using the laser pointers, since direct laser light entering the eye could cause retina damage.

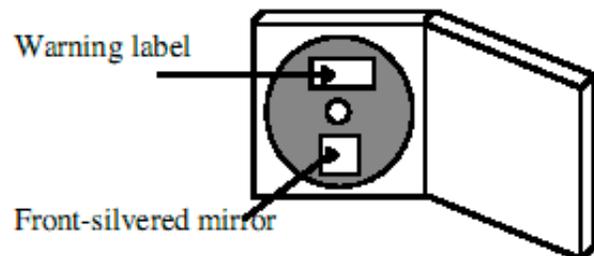
## Objective

Students produce an equilateral triangle, ray-tracing of a retro-reflector, and build a retroreflector using front-silvered mirrors.

## Materials:

Laser pointer, half-inch binder clip, 8.5 x 11-inch graph paper, protractor, ruler, and three front silvered mirrors.

Optional: Three CD jewel boxes to hold the mirrors in a vertical position



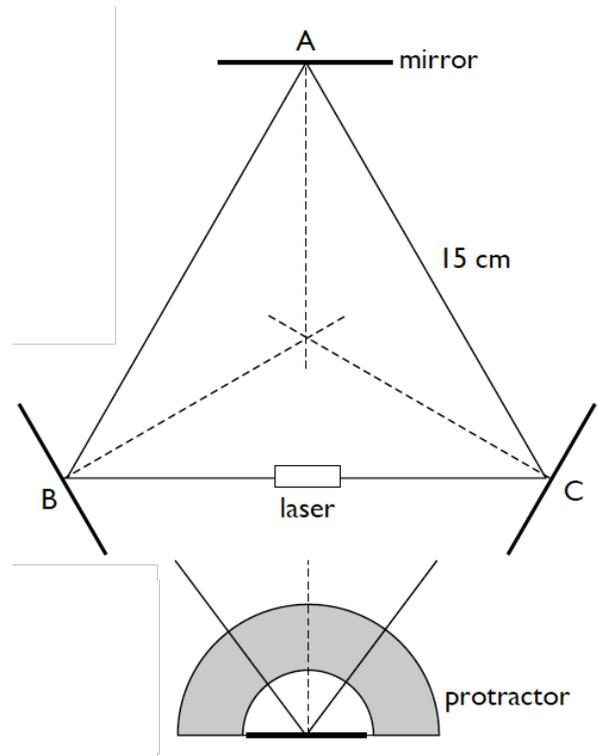
## Engage

Ask students to describe what they think the law of reflection means.

## Explore

1. Using the protractor, ruler, and a pencil, ask students to construct an equilateral triangle, with sides at least 15 centimeters long. Students should check that the sides are equal in length, and that the angles are all the same (each should be 60 degrees). Students should also label each vertex (A, B, C).

2. Draw a rectangle to represent the laser's placement along one of the sides of the triangle. The laser should point (as if firing the beam) toward a vertex.



3. At each vertex, students draw a line that represents where they think the mirror should stand so that the laser beam will complete the equilateral triangle. This is called the "mirror line." Student may use their protractors to mark and measure angles for their mirror line. As they choose their mirror line, remind them about the law of reflection: angle of incidence = angle of reflection with respect to the normal.

4. Place the mirrors along the mirror lines, so that they stand vertically on each line.

5. With the binder clip holding the laser horizontally and in the "on" position, place the laser on the triangle in the rectangle you drew in step 2.

6. The "laser triangle" is complete when the beam strikes the backside of the laser pointer. Sprinkle chalk dust or baby powder along the laser beam's path to make the beam show up. However, exercise caution with students who are sensitive to dust or powder. Instead, try inserting tracing paper or transparency film in the laser beam path to see scattered light from the beam. Also, try "skimming" the beam

along the surface of the graph paper.

7. Adjust the mirror angles and/or the laser pointer until the laser completes the equilateral triangle. Mark the final positions of the mirrors on the graph paper. Note that any triangle will work, but in this case, students are building an equilateral triangle. The equilateral triangle acts as a guide for properly aligning the mirrors to guide the laser light along the sides of the triangle.

## **Explain**

Students' equilateral triangle:

1. What are the lengths of the equilateral triangle sides?

*The lengths will vary from triangle to triangle; but for any equilateral triangle, the sides are equal length.*

2. What are the angles between each side?

*Each angle should be 60 degrees.*

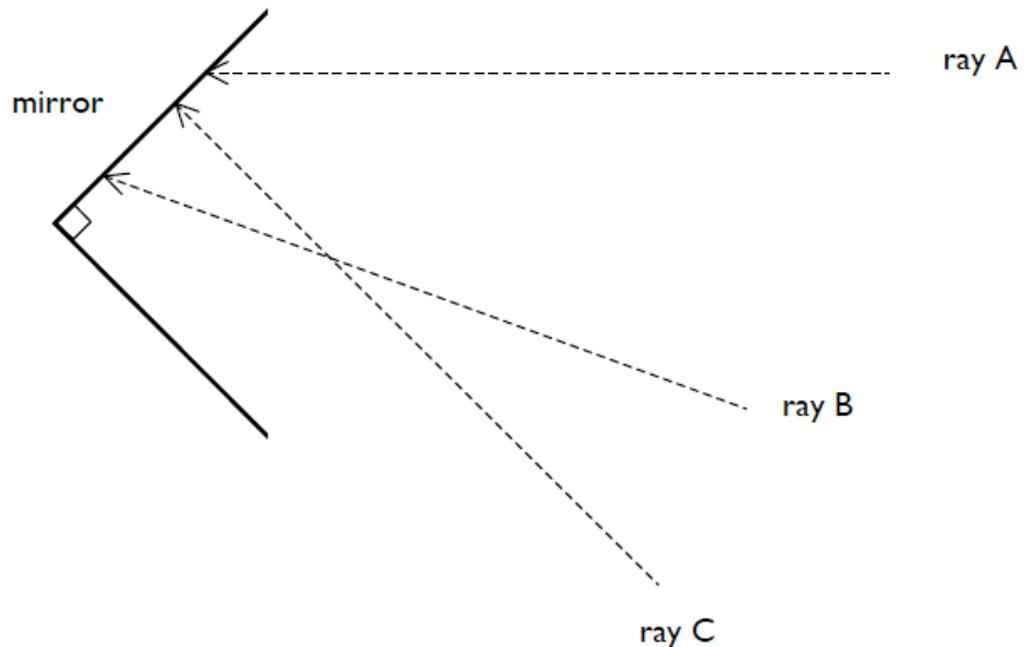
Mirrors

3. What is the angle between the mirrors and the sides of the triangle at vertex A? Vertex B? Vertex C?

*Each angle should be 60 degrees.*

## Elaborate: Make a Retro-Reflector

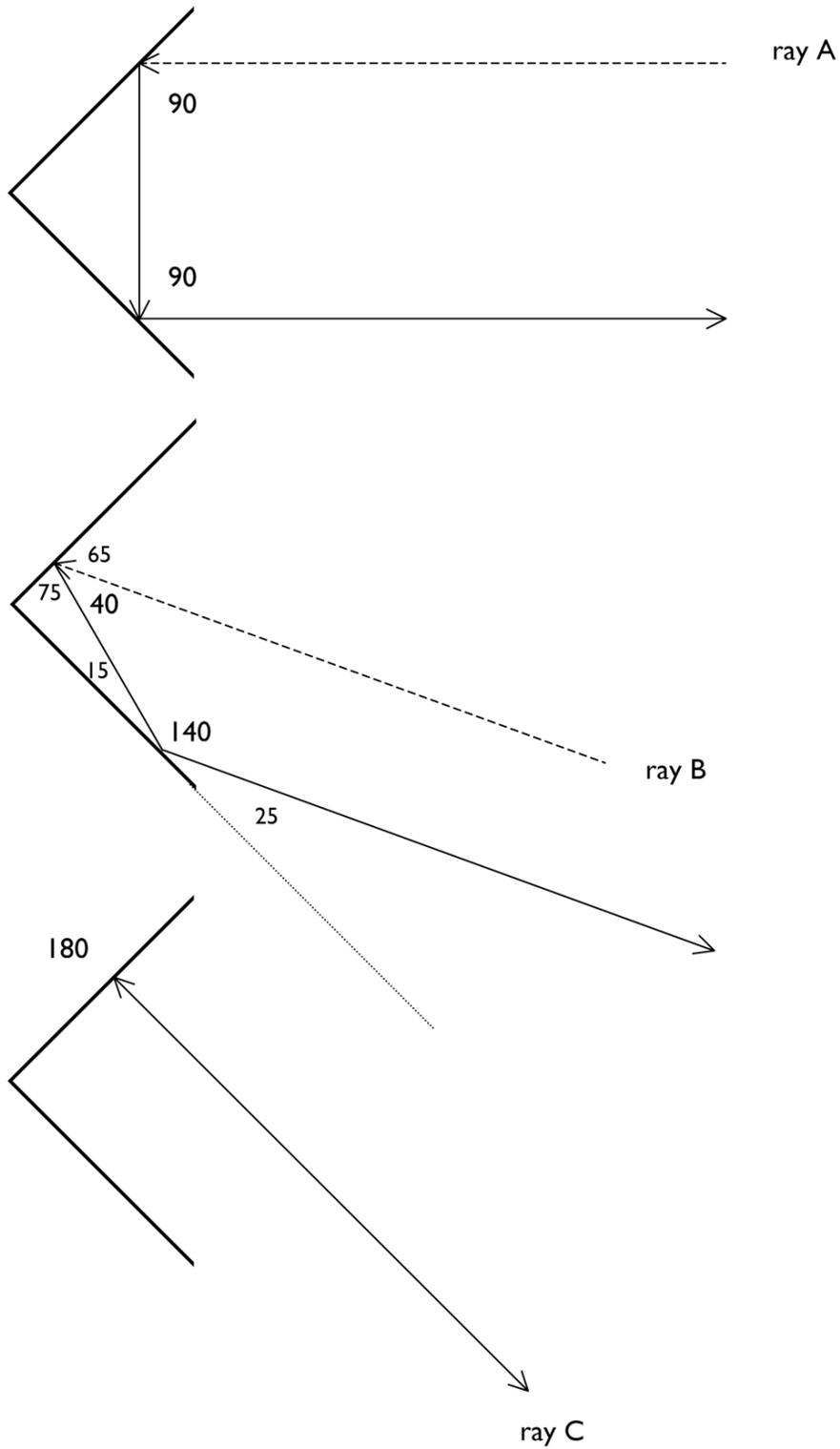
1. Ask students to read the StarDate script "Receding Moon." They may also explore the McDonald Laser Ranging Station web site (<http://www.csr.utexas.edu/mlrs/>).
2. Have students study the diagram of a retro-reflector (below). Have them label the incident rays and the mirrors.
3. Ask students to predict the reflection path of each incident ray after it strikes the mirror. What do the reflected rays have in common?
4. Once they predict the paths of the reflection rays, ask them to make a retro-reflector with their three front-silvered mirrors and test it using their laser pointer or a flashlight.



Retro-reflectors, also called "corner cubes," reflect incident light back toward the source. That is, the light ray makes a 180-degree turn. To make a retro-reflector with the front-silvered mirrors, students must place them 90 degrees apart, or perpendicular to each other. Along the path of the ray through the retro-reflector, the sum of the interior angles is always 180 degrees.

### Elaborate: Key

The solid lines represent the ray's path after striking the retro-reflector. The mirrors are perpendicular.



Corner cube

