# Teacher Notes: Squared for High School

## Introduction

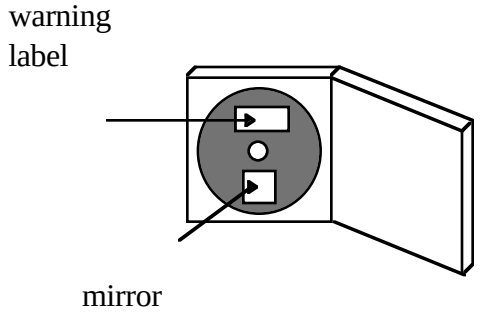
Light has many interesting aspects. An example is **reflection**. Reflection occurs when light bounces off a surface. Think about what happens when you look in a mirror. Whether you realize it or not, you are reflecting light. This light travels to the mirror, then bounces back to your eyes. This is how you see your reflection.

A guideline to working with mirrors is the **Law of Reflection:** The angle light hits a mirror will be the same angle light leaves the mirror.

You can use this principle to make a square. In this experiment you are going to use a laser and several mirrors to bounce the light around until it forms a square.

In most household mirrors, the reflective surface is placed behind the glass. These are called **back silvered mirrors**. Back silvered mirrors don't work as well for this lab. The glass that the light must pass through before can contain imperfections, which will skew the angles. If you do use these mirrors, you must correct for the thickness of the glass and measure all angles from the back of the mirror rather than the front.

To eliminate this adjustment, we recommend **front silvered** mirrors for this lab. As the name implies, the reflective surface is actually placed on the front of the mirrors. **Do NOT touch the mirror surface!** One way to protect the mirror is to secure them in a CD case. You may wish to add a warning label to the case. The mirrors can also be attached to blocks of wood so that they will stand vertically. Be careful when you store them. We do not recommend cleaning, but if you must, do so with a soft brush or cloth. Every wipe removes some of the reflective coating.




A suitable size for the square has sides of 25 cm. You may wish to encourage different groups to use different sizes. The final results should be the same. Students may also be challenged to move as few mirrors as possible to complete the activity.

## Materials (per group)

laser pointer
binder clip
white paper (8.5 x 11 inch)
protractor
ruler (one foot)
4 front-silvered mirrors
4 CD-cases (optional)

Procedure

1. Draw a square on the paper. Use a protractor to be sure the angles are all the same. Use a ruler to be sure all the sides are the same length. A length of 25 cm works well, and all angles should be 90°.

2. Draw a laser-shaped space in the center of the square. It should point to one of the corners. The eventual mirror it points to is defined as the first mirror.

3. At each corner, draw where you think the mirror should go so that the laser light will complete the square. Keep in mind the following:

- your laser is going to be in the center of the square, so the first angle will be a little tricky
- use a protractor to measure the angle between the laser and mirror exactly
- remember, the incoming angle is the same as the outgoing angle.

4. Ask your teacher how to correctly position the mirror vertically. Front-silvered mirrors are easily damaged. **Do not touch the front of the mirror**. Do not let groups use the mirrors until they have drawn where they go. Some students will try to short cut by putting the mirrors in place before they make the predictions.

5. Line up the mirror exactly on the line you drew for it. If you are using a CD-case, set the mirror down so that it is close to the table and the front of the mirror is directly over the indicated line.

6. Turn the laser on. **Never look directly at the laser beam or allow it to shine in someone's eyes.** Use the binder clip to maintain the laser pointer in the ON position.

7. Place the laser and binder clip in the middle of the square.

8. If you need help seeing the laser beam, ask your teacher for assistance. Some methods of making the laser beam show up include a water spray bottle, dry ice (to make this really work put a small chunk of dry ice into hot water), or a commercial fogger. Baby powder or chalk dust will work too, but be careful if you have students with asthma or other respiratory problems and they add dust to the mirrors.

9. If your angles were measured properly, you should be able to see the laser bounce off each mirror and end up back at the first mirror. If they are not, then move one to three mirrors until the square is complete. Mark the new mirror placement positions and measure any new angles. Turn the laser off.

## Questions

1. How long is one side of your square?
*Answers will vary, but around 25 cm works well.*

2. What are the angles in your square?
*The angles were 90°.*

3. What is the angle between the laser and the first mirror?
*Answer: It should be 90°.*

4. What were the final measurements of the angles for mirrors 2, 3, and 4??
*Answer: The angles for these mirrors should be 45° and 45°.*

5. What pattern did you notice about all of the angles you measured?
*Answer: These angles are all the same.*

## Conclusion

Does the incoming angle equal the outgoing angle? Use evidence from your lab to backup your claim.

*Yes, the incoming angle equals the outgoing angle. All of the angles (except the one between the laser and the first mirror) were 45°.*