

Name: _____

Skill Sheet 15-A

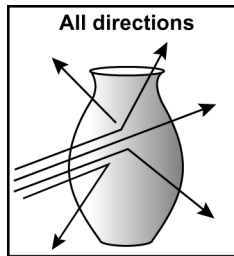
Ray Diagrams



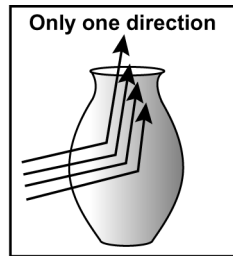
This skill sheet will give you practice in making ray diagrams. A ray diagrams helps you determine where an image produced by a lens will form and whether the image will be upside down or right side up. For each question, read the directions carefully and plot your ray diagram in the space provided.

1. Getting started

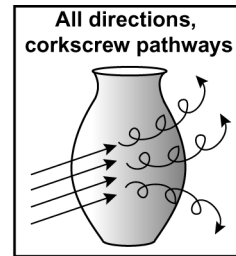
1. Of the diagrams below, which one correctly illustrates how light rays come off of an object? Explain your answer.



A.



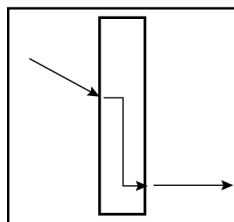
B.



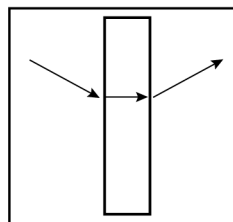
C.

2. Of the diagrams below, which one correctly illustrates how a light ray enters and exits a piece of thick glass?

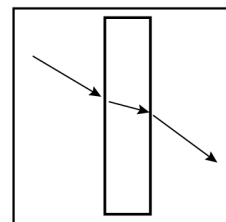
Light through thick glass



A.



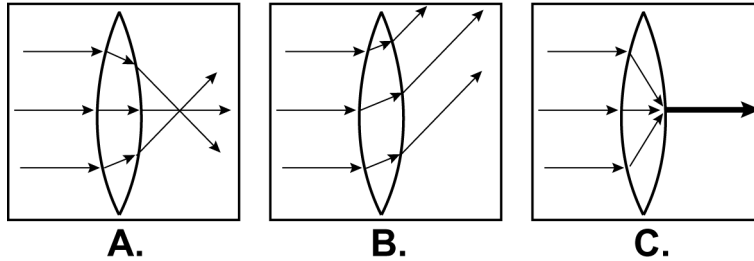
B.



C.

3. In your own words, explain what happens to light as it enters glass from the air. Why does this happen? Use the terms *refraction* and *index of refraction* in your answer.

4. Of the diagrams below, which one correctly illustrates how parallel light rays enter and exit a converging lens? Explain your answer.



5. Draw a diagram of a converging lens that has a focal point of 10 centimeters. In your diagram, show three parallel lines entering the lens and exiting the lens. Show the light rays passing through the focal point of the lens. Be detailed in your diagram and provide labels.

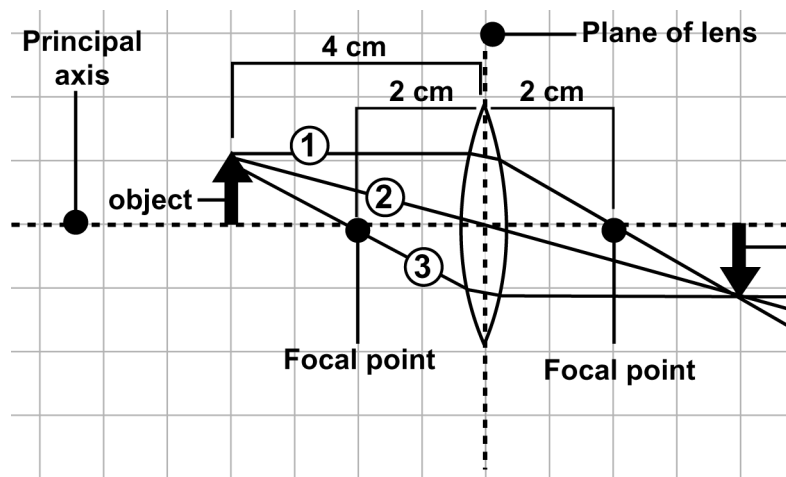
2. How to draw ray diagrams

A ray diagram helps you see where the image produced by a lens appears. The components of the diagram include the lens, the principal axis, the focal point, the object, and three lines drawn from the tip of the object and through the lens. These light rays meet at a point and intersect on the other side of the lens. Where the light rays meet indicates where the image of the object appears.

Example: A lens has a focal length of 2 centimeters. An object is placed 4 centimeters to the left of the lens. Follow the steps to make a ray diagram using this information. Trace the rays and predict where the image will form.

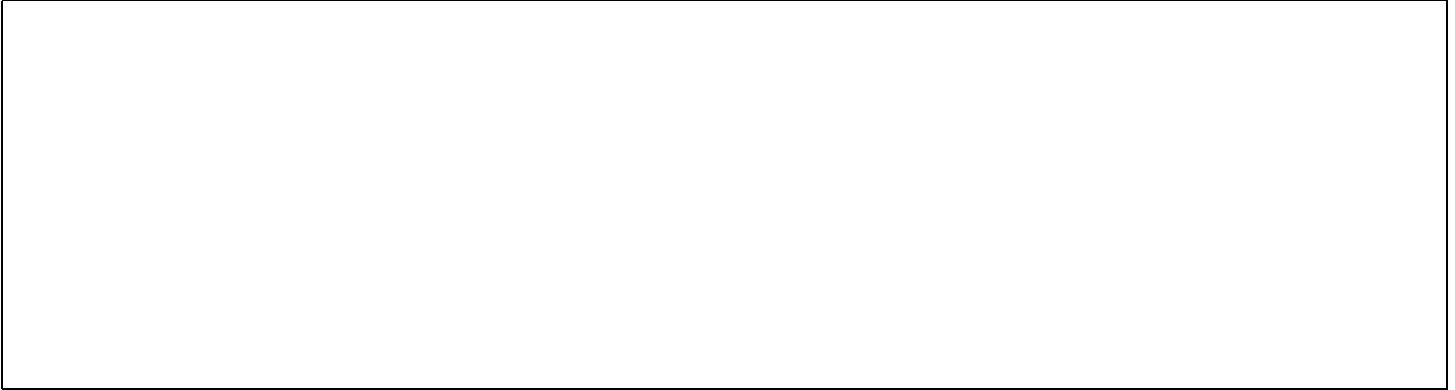
Steps:

- Draw a lens and show the principal axis.
- Draw a line that shows the plane of the lens.
- Make a dot at the focal point of the lens on the right and left side of the lens.
- Place an arrow (pointing upward and perpendicular to the principle axis) at 4 centimeters on the left side of the lens.
- **Line 1:** Draw a line from the tip of the arrow that is parallel to the principal axis on the left, and that goes through the focal point on the right of the lens.
- **Line 2:** Draw a line from the tip of the arrow that goes through the center of the lens (where the plane and the principal axis cross).
- **Line 3:** Draw a line from the tip of the arrow that goes through the focal point on the left side of the lens, through the lens, and parallel to the principal axis on the right side of the lens.
- Lines 1, 2, and 3 converge on the right side of the lens where the tip of the image of the arrow appears.
- The image is upside down compared to the object.

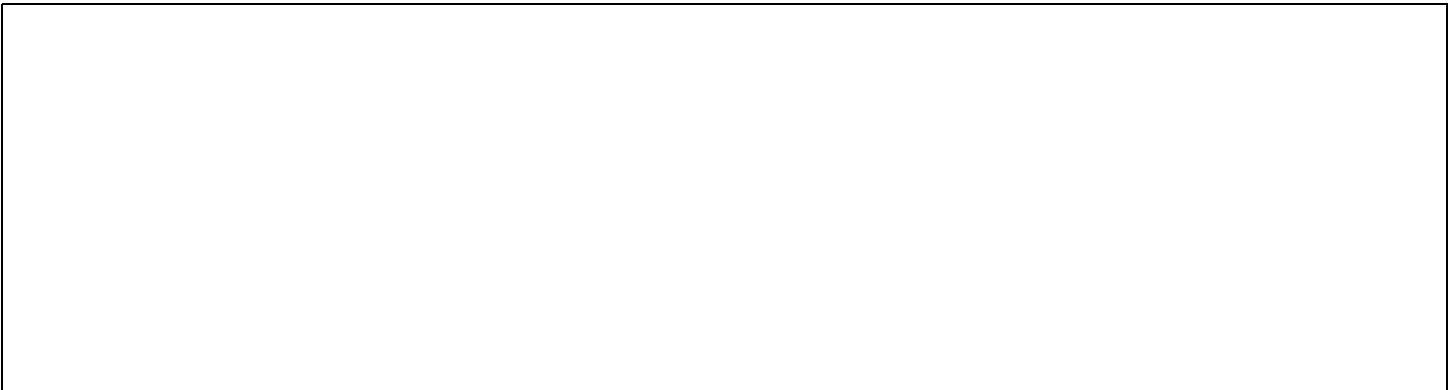


3. Drawing ray diagrams

1. A lens has a focal length of 4 centimeters. An object is placed 8 centimeters to the left of the lens. Trace the rays and predict where the image will form. Is the image bigger, smaller, or inverted as compared to the object?



2. **Challenge question:** An arrow is placed at 3 centimeters to the left of a converging lens. The image appears at 3 centimeters to the right of the lens. What is the focal length of this lens? (Hint: Place a dot to the right of the lens where the image of the tip of the arrow will appear. You will only be able to draw lines 1 and 2. Where does line 1 cross the principal axis if the image appears at 3 centimeters?)



3. What happens when an object is placed at a distance from the lens that is less than the focal length? Use the term *virtual image* in your answer.

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Skill Sheet 15-B

The Law of Reflection



The law of reflection works perfectly with light and the smooth surface of a mirror. However, you can apply this law to other situations. For example, how would the law of reflection help you win a game of pool or pass a basketball to a friend on the court?

In this skill sheet you will review the law of reflection and perform practice problems that utilize this law. Use a protractor to make your angles correct in your diagrams.

1. What is the law of reflection?

The law of reflection states that when an object hits a surface, its angle of incidence will equal the angle of reflection. This is true when the object is light and the surface is a flat, smooth mirror. When the object and the surface are larger and lack smooth surfaces, the angles of incidence and reflection are close but not always exact. Nevertheless, this law is very helpful in performing activities like bouncing a ball to someone or in playing pool.

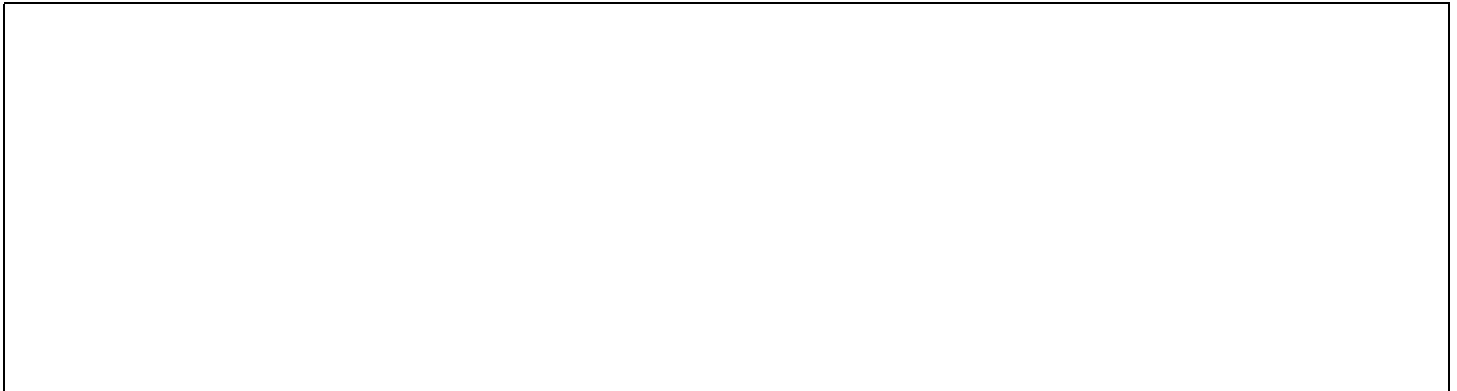
1. When we talk about angles of incidence and reflection, we often talk about the normal. The normal to a surface is an imaginary line that is perpendicular to the surface.
 - a. Draw a diagram that shows a surface, with a normal line, and a ray of light hitting the surface at an angle of incidence of 60 degrees.

- b. In the diagram above, label the angle of reflection. How many degrees is this angle of reflection?
-

2. Light strikes a mirror's surface at 30 degrees to the normal. What will the angle of reflection be?
-

3. The angle between the angle of incidence and angle of reflection for a light ray of light hitting a mirror is measured to be 90 degrees. What is the measurement for each of these angles?
-

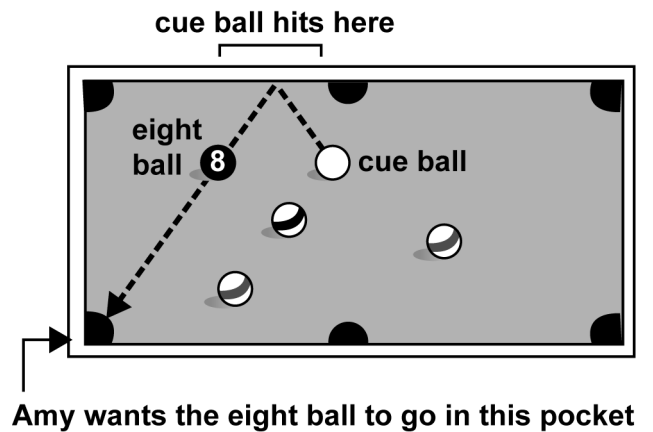
4. In a game of basketball, the ball is bounced (with no spin) toward a player at an angle of 40 degrees to the normal. What will the angle of reflection be? Draw a diagram that shows this play. Label the angles of incidence and reflection and the normal.



2. Playing pool

Use a protractor to figure out the angles of incidence and reflection for the following problems.

1. Because her opponent's balls are in the way for a straight shot, Amy is planning to hit the cue ball off the side of the pool table so that it will hit the 8-ball into the corner pocket. In the diagram, show the angles of incidence and reflection for the path of the cue ball. How many degrees does each angle measure?



2. You and a friend are playing pool. You are playing solids and he is playing stripes. You have one ball left before you can try for the eight ball. Stripe balls are in the way. You plan on hitting the cue ball behind one of the stripe balls so that it will hit a solid ball and force it to follow the pathway shown in the diagram. Use your protractor to figure out what angles of incidence and reflection are needed at points A and B to get the solid ball into the far side pocket.

