ACTIVITY 2: Reflection of Light

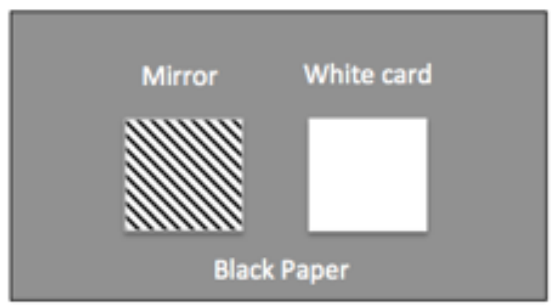
Purpose

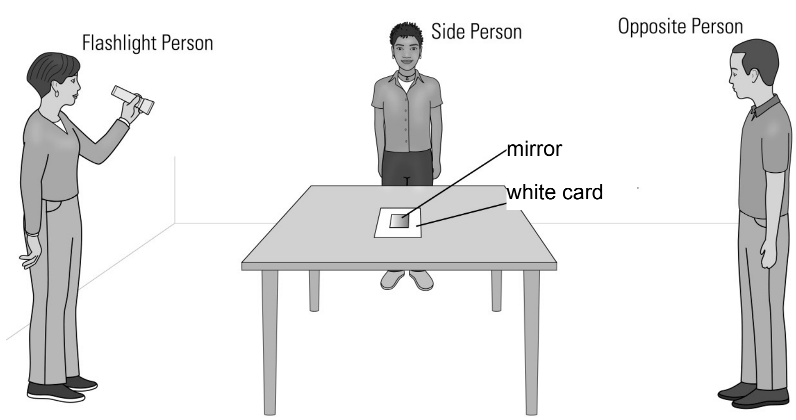
Most people realize that light is necessary to see things, like images in mirrors, and various kinds of objects. But how does that happen? In this activity you will investigate how light behaves when interacting with shiny objects like mirrors and non-shiny objects like paper. You will also consider how you see your image in a plane mirror. The key questions are:

1. ***How does light reflect from shiny and non-shiny surfaces?***
2. ***How do you see your image in a flat mirror?***

Initial Ideas

You instructor will show you a black piece of paper with a mirror and piece of white card on it. Imagine that this is placed in the middle of a table and three people stand around the table as shown below. **<u>With the room lights turned off</u>**, one person holds a flashlight so that it illuminates both the white card and the mirror, as suggested in the picture.





Which of the three people (if any) standing around the table would perceive the illuminated card as being white? Why do you think so?

If you thought one or more of the people standing around the table would not see the card as white, what do you think it would look like to them and why?

You are likely familiar with the observation a mirror can dazzle you when a bright light shines on it. Which of the three people (if any) standing around the table do you think might be dazzled when looking at the mirror in this arrangement? Why do you think so?

If you thought the mirror would not dazzle one or more of the people standing around the table, what do you think the mirror would look like to them and why?

Participate in a whole class discussion. Make a note of any predictions or reasoning that are different from your own.

You instructor will now lead the class in carrying out this experiment. Record the results in the table below. For simplicity, limit your entries to one of 'Dazzled', 'White', or 'Black'.

What each person observed	Appearance of mirror	Appearance of white card
Flashlight person		
Side person		
Opposite person		

You will now perform some investigations to help understand these results.

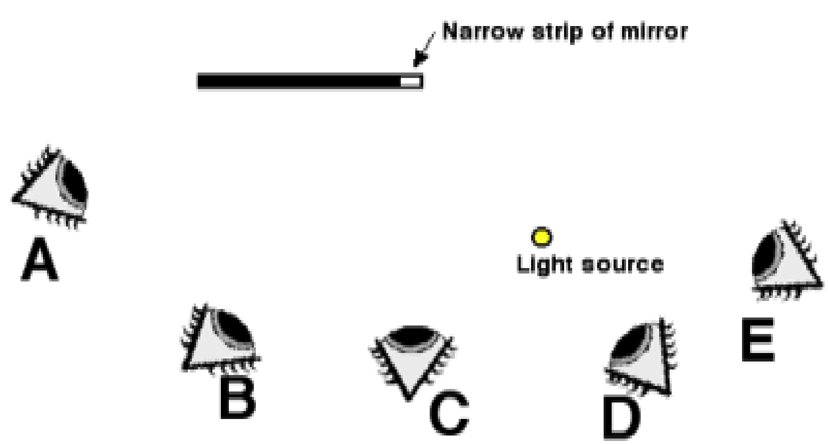
Collecting and Interpreting Evidence

You will need

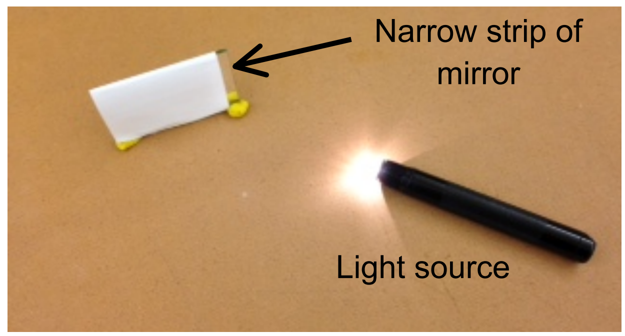
- Mini-Maglite™ flashlight
- Plane (flat) mirror
- Piece of clay
- Tape

Exploration #1: What happens when light strikes a shiny surface?

STEP 1. Suppose you had a small, flat mirror and covered up all of it except for a narrow strip. Imagine that you put a point source (tip of Maglite™) on the table as shown below in this **top view** diagram.



From which of the positions shown (A, B, C, D, E) do you think you would be able to see the image of the light source when looking at the narrow strip of mirror? (Choose as many as you think apply.) Show your thinking by drawing light rays on the diagram.



Now try it! Tape an index card to the mirror, leaving only a very thin strip of mirror exposed (about a ¼ inch or less) at the right end. Stand the mirror and card upright on the table (using the clay for support). Lay the Maglite™ on the table as shown in the picture to the right.

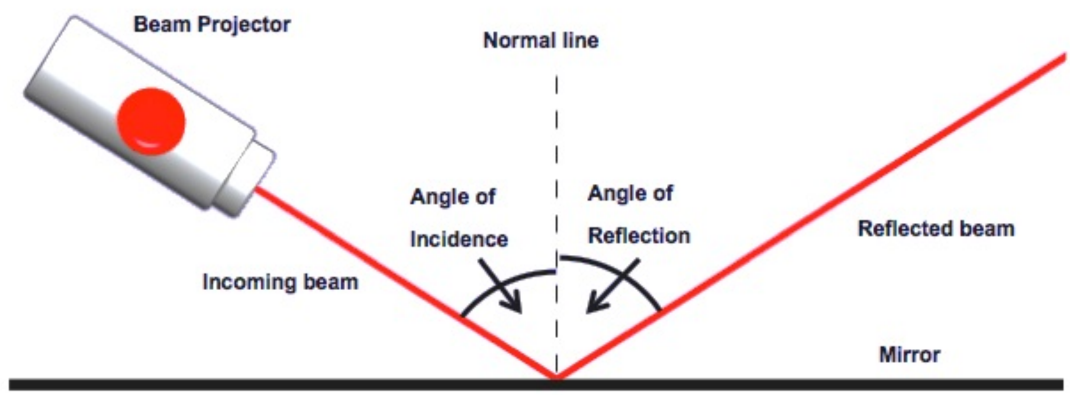
Now, bend down so your eye is at tabletop level and use one eye to look at the strip of mirror from the five positions suggested in the diagram on the previous page.

From which of the positions can you see an image of the light source **<u>when looking at the strip of mirror</u>**? Why do you think this is?

STEP 3. In order to 'see' the image of an object in a mirror, at least some light coming from the object must reflect from the mirror and come into your eye. That raises the question, how does light reflect from a shiny surface like a mirror?

Do you think there is any particular rule for how light reflects from a shiny surface and, if so, what do you think it is?

In a moment, you will check your thinking by watching a movie of a simulation. The setup is shown below, in which a narrow beam of light (red line) from a projector is aimed toward a mirror and reflects from it. (The narrow beam effectively shows us how a single light ray behaves.)



Before you watch the movie, we need to define some terms.

Normal line: This is a line drawn perpendicular (at right angles) to the mirror at the point where the light beam strikes the surface of the mirror. [It is the dashed line in the picture above, which is vertical only because the mirror surface is horizontal. In general, the direction of the normal line will depend on the orientation of the mirror surface.]

Angle of Incidence: This is the angle between the incoming beam (often also called the 'incident' beam) and the normal line.

Angle of Reflection This is the angle between the normal line and the reflected light beam.

Now watch ***UL-A2 – Movie 1***, which shows the angle of incidence of the incoming beam being changed. A protractor is included so that you can observe the angles of incidence and reflection, and see how they compare.

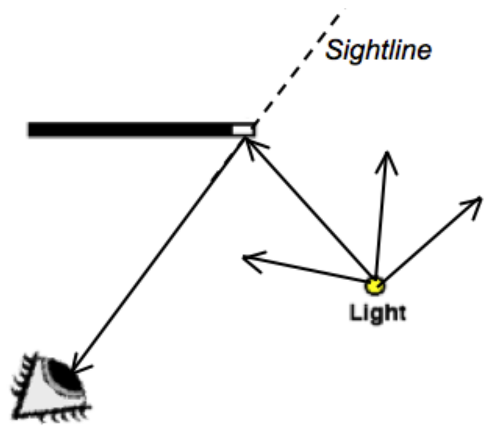
For all cases, how does the angle of reflection compare to the angle of incidence?

STEP 4. A statement of how light behaves when it strikes a shiny surface, like a mirror, is called the **Law of Reflection**. When drawing light ray diagrams involving a mirror, you should always be careful to draw the reflected light ray so that the angle of reflection is as close to being equal to the angle of incidence as you can.

(Note that you may have already seen this behavior when examining the reflection of waves from a boundary in Unit WS. Since light is also a form of wave (as will be discussed later in this unit), it is no surprise that it should obey the same Law of Reflection as other waves.)

If light from an object strikes a mirror and then enters your eye, you will see the image of the object in the mirror. When the light enters the eye, your eye-brain system determines where the reflected light 'seems' to have come from, and it is in this direction that the eye 'sees' the image of the object. To determine which direction this is, we extend a light ray entering the eye backwards behind the mirror. This backward extended line is called a *sightline*.

For example, in the diagram to the right, many light rays leave the source, only one of which reflects from the small strip of mirror into the eye.

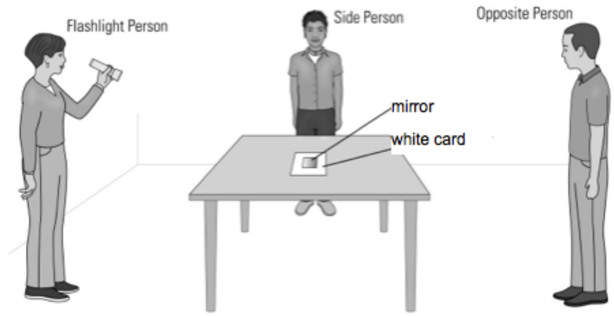


To draw the sightline lay a straight edge along the single light ray that actually enters the eye. Now extend this same line backward, behind the mirror, by drawing a dashed line, as shown in the diagram.

Because the light entering the eye comes from this direction, the eye-brain system 'sees' the image of the light source somewhere along this dashed sightline. However, if your eye is positioned so that no light from the object reflecting from the mirror can enter your eye, then you will not see its image in the mirror.

Furthermore, if no light from any other nearby objects reflect off the mirror and enter your eye, the mirror surface should then appear very dark (strictly it should appear black) when you look at it.

Draw light rays on this diagram to show why the opposite person is dazzled when looking at the mirror. Also draw a *sightline* to show in what direction this person sees the image of the flashlight.



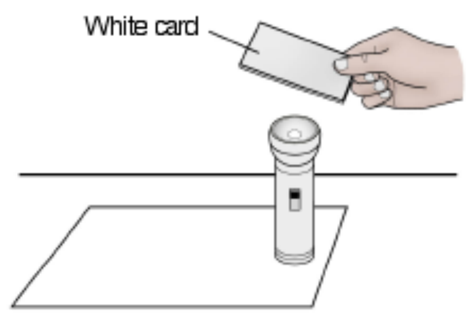
Assuming there are no other lights in the room, explain why the flashlight and side person see the mirror as being a 'black' surface.

Exploration #2: What happens when light strikes a non-shiny surface?

STEP 1. You have now seen that when a beam of light strikes a shiny surface (such as mirror), it is reflected in one particular direction. However, most objects are not shiny. For example, consider a white card.

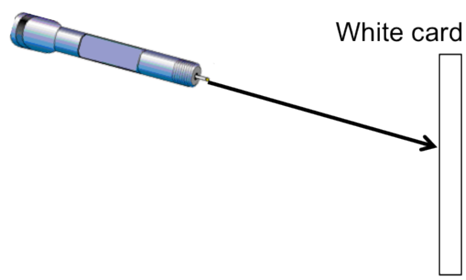
What do think happens when a beam of light strikes a white card? Do you think it reflects in one particular direction (like it would from a mirror), or does something else happen? If so, what?

STEP 2. Turn on the flashlight and stand it upright at one end of the paper. Hold the white card as shown in the picture, so the flashlight beam strikes the card. Move the card in and out of the beam of light and observe what happens on the sheet of paper.



Is light being reflected from the card and, if so, is it only in one direction, or in many different directions at the same time? How do you know?

Below is part of a light ray diagram representing light from a Maglite™ striking a white card. Draw one or more light rays being reflected from the card to show that it reflects in many different directions.



Now draw some eyes at different positions on the flashlight side of the diagram and explain why they would **all** see the card as white, no matter where they were.

Writing explanations using the ray model of light

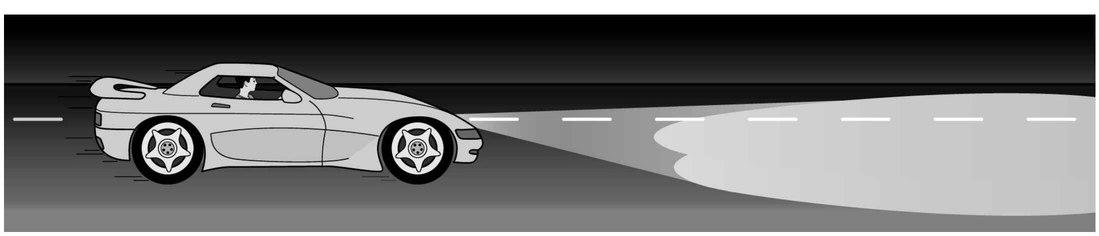
Now that we have established some of the behaviors of light when it reflects from both shiny and non-shiny surfaces, we will use the light ray model to explain some phenomena using these ideas. To construct a scientific explanation using the ray model, you should first draw a light ray diagram of the situation showing all the relevant behaviors of some of the light rays involved, and then write a narrative, keeping in mind that both should satisfy the usual criteria:

- Your explanation should be **well-constructed**. Your light ray diagram should be clear and easy to read, and your narrative should be well written and easy to follow. (In particular, normal lines and sightlines should be easily distinguishable from light rays.) Also, the diagram and narrative should be consistent with each other.

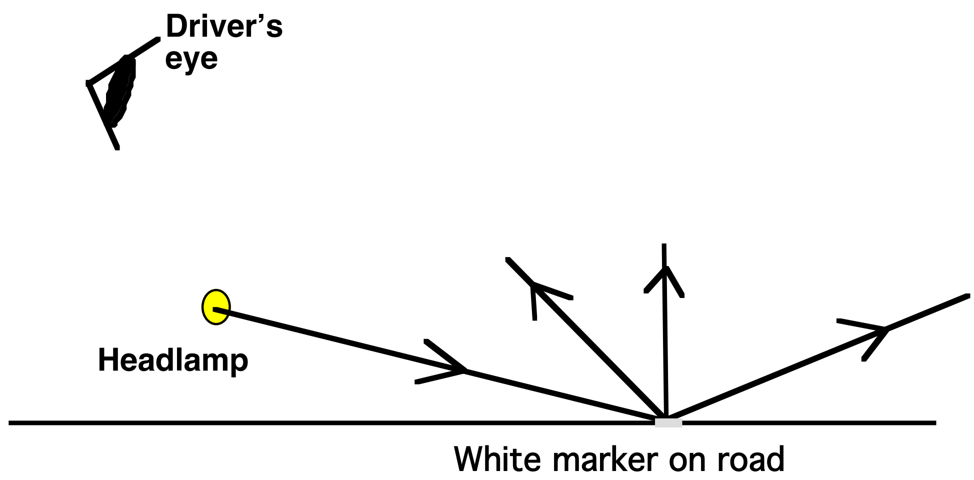
- Your explanation should be **accurate**. The diagram and narrative should use one or more relevant ideas about the behavior of light that are consistent with those we have established from the evidence gathered in class. (It is particularly important to use a straight edge when drawing light rays.)

- Your explanation should be **well reasoned**. Reasons should be given for why the light behaved as it did. (Currently, this would be based around a relevant general statement about how light reflects from a particular surface and what happens to it after it does so.)

When you drive at night, your headlamps shine on the road in front of the car. If there are white lines on the road (and the road is dry), then as you sit in the car behind the headlamps you can see these white lines quite easily. Bear the above criteria in mind as you consider the following explanation of ***how you can see the white lines on the road surface when you drive at night***.



Describe the model using a diagram:



Write the narrative:

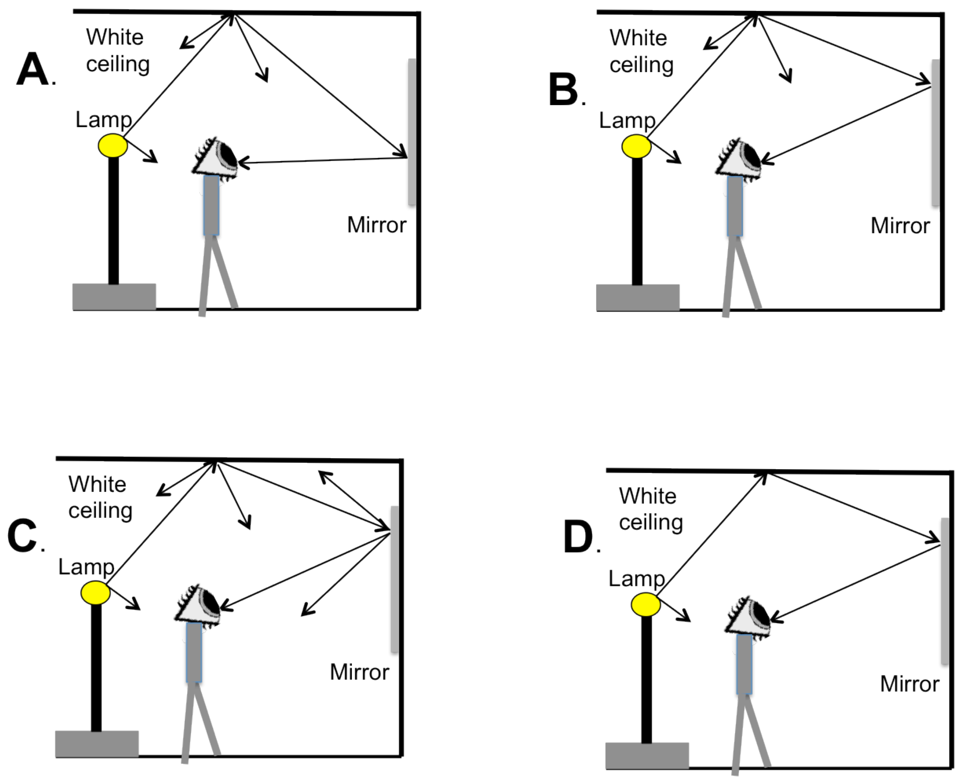
The driver can see a white marker on the road ahead because light from the headlamp goes to the marker. Since the marker is a white, non-shiny surface, the light from the headlamp reflects from it in all directions. Because the driver is looking at the marker where the light is reflecting, he can see the marker.

Do you think this explanation is 'good' or 'problematic'? Why do you think so? If you think either the diagram or narrative is poor, make appropriate corrections.

Summarizing Questions

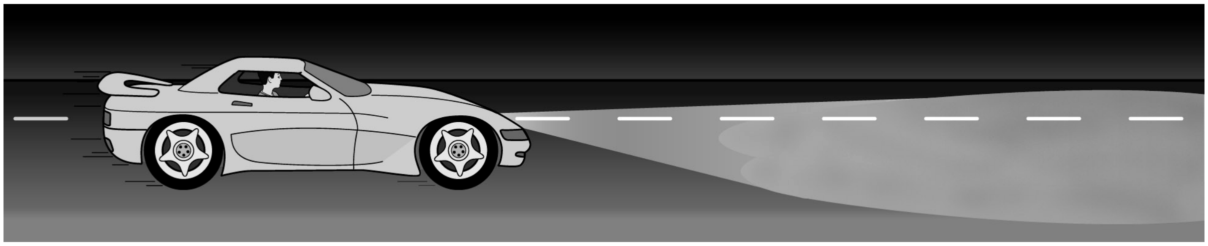
S1. On the next page are four possible light ray diagrams showing light going from a lamp to a white, non-shiny ceiling, to a mirror on the wall, and then to an observer. The observer can see an image of the ceiling in the mirror.

a) Which light ray diagram best represents how light behaves in this situation? What is problematic about the other three light ray diagrams?



b) On the appropriate diagram, draw a sightline to show in which direction the person sees the image of the ceiling.

S2. When driving at night after it rains, and the road is very wet, it is very hard to see the white markings on the road ahead of you. This is because they look almost black to you, just like the rest of the road surface. Write an explanation as to why this is.



Describe the model using a diagram:

Write the narrative: