Recitation 7: Intro to Light

Equipment:

- light box
- assortment of lenses: plano-convex, bi-convex, bi-concave
- curved mirror
- small LED light boxes emitting different colors of light
- white board with markers
- meter stick
- ruler
- butcher paper

Part A: How does light travel?

1) For now, set up the light box with the plano-convex lens (flat on one side, bulging outward on the other) pressed with the flat-side against the light slits.

What do you see?

How can you represent the light coming out of the box? Draw what you see in the space below.

What happens to the light coming out of the box when the plano-convex lens is removed (taken away)? Draw what you see in the space below.

One of these set-ups is called a "Parallel ray" arrangement and the other is called a "Point source" arrangement. Which is which? Why?

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Part B: Focusing light

2) Set up the light box to emit parallel rays of light. Use the mirror to block all but two of these light rays. With the two remaining rays, place the bi-convex lens (bulging outward on both sides) in the path of the light. What happens to these two light rays because of the lens?

Move the mirror to allow a third ray to hit the bi-convex lens. What happens when this third ray is allowed to reach the lens? Draw what you see in the space below.

What do you think will happen if all of the rays from the light box are allowed to reach the lens? Draw your prediction on the whiteboard/butcher paper and then check your prediction with the equipment. If your prediction was incorrect, discuss what you saw and why you might have been mistaken.

3) Let's explore what happens if we use other optical elements besides the bi-convex lens. Still using the parallel ray set-up, try replacing the bi-convex lens with the bi-concave lens (both sides pushed inward) or the curved mirror. Try mixing and matching these elements. You should see that some arrangements spread the light out as it passes through the lens/reflects from the mirror and other arrangements bring the light together as it passes through the lens/reflects from the mirror. The "spreading out" of the light is referred to as *diverging*. The "bringing together" of the light is referred to as *converging*. Make small sketches of the possible combinations that produce diverging/converging in the appropriate box below.

Converging	**Diverging**

For the mirrors, it is fairly self-evident that this diverging/converging happens when the light bounces off of the mirror (i.e., when it *reflects* from the mirror's surface). When does the diverging/converging happen for light traveling through the lenses? Pick a lens, set it up with the light box emitting parallel rays, and examine how the incoming parallel rays are changed as they enter, travel through, and then leave the lens. Draw what you see in the space below.

When *does* the diverging/converging happen for the light traveling through the lens? This bending of the light is called *refraction*. From what you can see, when do you think refraction occurs?

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Part C: Effect of rays emitted by a light source—Parallel rays or Point source?

4) For incoming parallel rays, the light passed through a bi-convex lens focuses together at the 'focal point' of the lens. We say that these "parallel incident rays converge on the focal point of the lens." The distance from the center of the lens to this 'focal point' is called the *focal length* of the lens. Look at the focal length of your lens. Does this focal length change when the lens is brought closer to/farther from the parallel ray light source? Do you think it should change? Why or why not? Draw what you see in the space below and carefully label the focal length, *f*, of your lens.

The effects you see for the bi-convex, 'converging' lens should hold true for the converging mirror, too. Does the focal length of the converging mirror change when the mirror is brought closer to/farther from the parallel ray light source? Draw what you see in the space below and label the focal length, *f*, of your converging mirror.

What do you see when you try using the 'diverging' arrangements? Where do you think the focal point is for the bi-concave, 'diverging' lens or for the diverging mirror? Draw your ideas in the space below.

By convention, we say that the converging lenses/mirrors have positive focal lengths and that the diverging lenses/mirrors have negative focal lengths. How do you reconcile this convention with the diagrams/pictures that you have drawn for the converging and diverging lenses and mirrors?

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5) Now set up the light box as a 'Point source.' When light rays from a point source interact with a lens, the place where the rays overlap is called the *image location*[1]. Using the bi-convex, converging lens, move the lens closer to/farther from the point source and observe the image location relative to the lens position. Do you see a pattern? If so, describe the pattern in the space below. If not, call a TA/LA to your group and show them what you do see.

The effects that you observe should hold true for the converging mirror, too. Using the converging mirror, move the mirror closer to/farther from the point source and observe the image location relative to the mirror position. Do you see a pattern? Is this the same pattern that you saw for the converging lens? If so, describe the pattern in the space below. If not, describe how the pattern is different in the space below.

[1]Actually, any time the light rays overlap an *image* is formed. So what we really see with a parallel ray source is that the image is formed on top of the focal point of the lens. For rays from a point source, the image is not formed on top of the focal point of the lens.

6) Now let's compare the parallel ray light source to the point source. (For this part, it may be helpful to use only three light rays from the light source; you can block the remaining rays using the mirror.) Using the converging lens, place the lens at a <u>known distance</u> from the light source. With the light source emitting parallel rays, note the focal point and focal length of the lens. Now remove the plano-convex lens to create a point source. How did the light rays shift when the plano-convex lens was removed? Where is the image formed with respect to the focal length of the lens? Draw the point source ("after") picture below and carefully label the image location as well as the focal length of the lens.

What happens when you perform this same investigation for the converging lens (comparing parallel rays to point source light) at a CLOSER distance to the light source? What happens at a FARTHER distance? Draw what you observe for both in the space below. Write a sentence or two to summarize the relationship that you observe between the distance of the lens from the light source (the object distance, *o*), the distance of the image from the lens (the image distance, *i*), and the focal length, *f*, of the lens.

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Do this same set of investigations for the converging mirror and draw the point source ("after") picture below, carefully labeling the image locations and the focal length of the lens in each of the distances to the light source (closer, middle distance, and farther).

Does the trend you saw for the converging lens hold for the converging mirror?

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Part D: Light rays of multiple colors/narrow and wide bands of light

7) Using the LED light boxes, note that the light can either be emitted from a slit in the end-cap as a bar of light, or as a wide band of light if the end-cap is removed. Explore how these light sources, individually or in combination, interact with the various lenses and mirrors available to you. If you find anything particularly interesting, describe your findings below. You will be asked to share one or two 'neat' discoveries with the class as a whole, so keep track of the interesting things that you see.