Name: **Physics Optics Experiments**

Hi! You will perform three experiments (found in this packet) during the time when Mr. Ayton is gone on the Senior Trip. You will also complete this packet answering all questions, filling in data tables, sketching data and graphs, and determining relationships for optics. At the culmination of the three days, you will turn in your Physics Optics Experiment Packet. I hope you can "see" an A in your future!

Experiment #1 - Light, Brightness, and Distance

In your everyday life, you may have noticed that a light source appears to be brighter when you are close to it and dimmer when you are farther away from it. This happens because the amount of the light that enters your eye increases as you move closer to the light source. There are several ways to measure the brightness of light. In this experiment, you will use a Light Sensor to measure the illumination detected by the sensor in lux (unit of illuminance). You will observe how illumination varies with distance and compare the results to a mathematical model.

Online students: You must interact with a group in class in order to perform this laboratory.

Objective: Determine the mathematical relationship between illumination and distance from a light source.

Materials: LabQuest, dynamics track, and light source (light box or light source assembly)

Experiment Set-Up:

- Use the LabQuest to access the light sensor: Turn on the LabQuest and select the sensor button towards the top left of the screen. Then, select the sensor set up button. Next, find the check box that says, "light sensor" and click it so it is checked. Then press ok. Now an illumination (lux) measuring should be on your screen.
- On the 10 cm mark on dynamics track, attach the light source assembly/light box so that the light (the big hole with the light) is facing along the length of the Dynamics Track.
- Turn on the light source assembly/box using the switch on it. The brightness of the LED light source varies when it is first turned on. Make a note of the current time so that you can ensure a few minutes have passed before you begin making the measurements during the Procedure.
- Turn the lights off to darken the room. A very dark room is critical to obtaining the most accurate results. There should be no reflective surfaces behind, beside, or below the bulb.

Procedure:

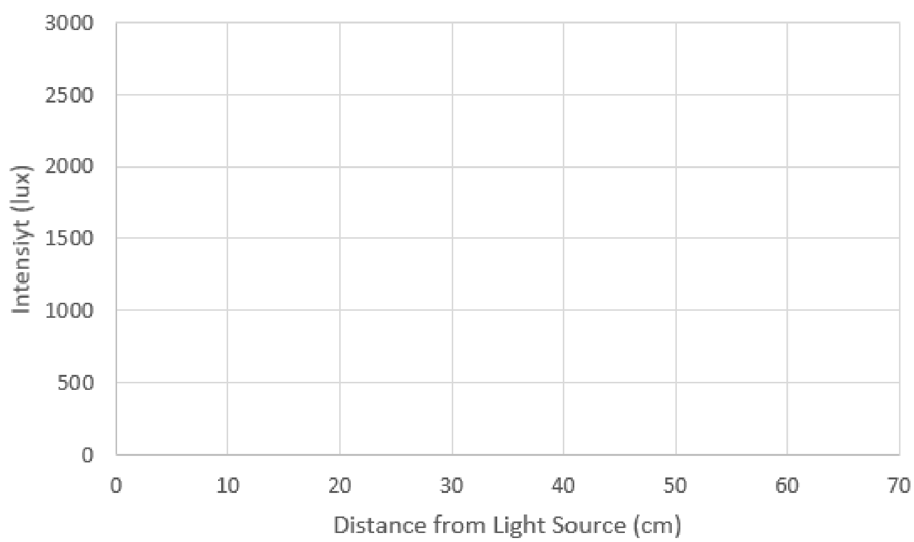
- With the Light Source assembly/box at the 10 cm mark, have one group member take the LabQuest with the illumination measurement ready, and place it at the 30 cm mark on the track(it should be 20cm from the light source assembly/box). In order to record accurately, hold the LabQuest vertically (up and down, so it is more tall than short) so the screen is facing the light. There is a small sensor at the top of the LabQuest. Identify it and make sure it is on top, facing the light.
- Then, record the distance between the light source assembly/box and the LabQuest Sensor and the Intensity measured in lux found on the LabQuest.
- Move the Light Sensor in 10 cm increments until it reaches the 70 cm mark on the track. There should be at the least five data points (you have the ability to take more data as you see fit).

Data:

- Record all data in a table of distance (cm) and Intensity (lux).
- Graph your data in the graph provided.

Experiment 1

Distance from light source(cm)	Intensity (lux)



Analysis:

1. Is the Intensity of the Light Source increasing or decreasing as distance from the Light Source increases? Circle your answer – Increasing or Decreasing
2. Identify the independent variable (what you changed in the experiment) and dependent variable (what changed in response) in this experiment.

   Independent Variable: ______________________ Dependent Variable: ______________________
3. What is the relationship of distance and light intensity?
   Circle your answer – Directly Proportional, Inversely Proportional, Squared

Experiment #2 - Real Images and the Thin Lens Equation

In this investigation, you will explore the formation of real images with convex lenses. You will have the opportunity to project images in various configurations, and explore the variables that affect the formation of a real image. After exploring the phenomena, you will formalize your explanations and learn mathematical relationships governing the behavior you have observed.

Online students: Use either of the following simulations to investigate:

- **https://www.physicsclassroom.com/Physics-Interactives/Refraction-and-Lenses/Optics-Bench/Optics-Bench-Refraction-Interactive**
- **https://simpop.org/convex-lens/convex-lens.htm**

Objectives:

- Use lenses to produce real images.
- Explore the appearance, orientation, and magnification of real images.
- Explore the relationship between object distance, image distance and focal length in **real** images produced by convex lenses.

Materials: Dynamics track, light source assembly/box, Screen assembly, 10 cm double convex lens, 20 cm double convex lens, 15 cm double concave lens

Experiment Notes:

- Be careful handling the lenses, as they are very fragile and expensive. Be sure that the lenses are locked into place in the lens holders. Teacher may have the lens you are looking for.

Procedure A (Thick Convex Lens):

Use the light source (light assembly/box) and a lens to project an image:

a. Attach the light source near the end of the track at the 10 cm mark, facing toward the higher distance markings.

b. Place the thick double convex lens on the track, at 50 cm(the lens and the light source should be 40 cm apart)

c. Attach the screen to the track and position it so that light from the light source passes through the lens and strikes the screen.

d. If you have a light box, turn the light source wheel until the "cross" is visible in the opening. If you have a light source assembly, turn the light source wheel until the "4" is visible in the opening. This will be your "object" for this investigation.

e. Adjust the position of the lens and the screen until you see a clear image on the screen. This may require some trial-and-error.

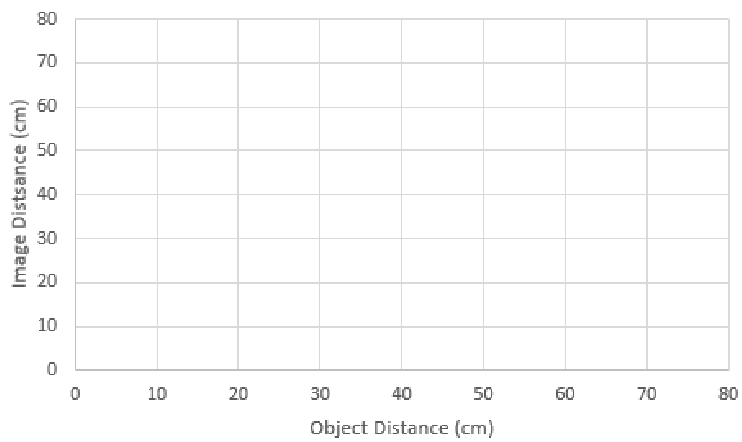
Continue adjusting the position of the lens by 10 cm increments toward and away from the light and each time adjust the screen to find different configurations that yield sharp images. Record 5 pairs of values for "Object distance" and "Image distance" in the data table provided.

Data:

- Record the distance between the light source and the lens as “Object distance” and the distance between the lens and the screen as “Image distance” in a data table.
- Graph your data in the graph provided.

Experiment 2- Procedure A

Object Distance (cm)	Image Distance (cm)



Analysis of Experiment A (Thick Convex Lens):

1. What is your independent variable and dependent variable in this experiment?

   Independent Variable: ______________________ Dependent Variable: ______________________

2. Is this graph of distance of object vs distance of image a linear (directly proportional) relationship?

   Circle your answer – Yes or No

3. Take one of your points and enter it into the following equation to calculate the focal length (f) for the lens.

   Focal Point of the Lens = __________________

$$(Thin\ Lens\ Equation)\ \frac{1}{s_i} + \frac{1}{s_0} = \frac{1}{f}$$

Where S_i = image distance, S_o is the object distance, and *f* is the focal length of the lens.

4. Is the image a real or virtual image? Is the image upright or inverted?

   Circle you answer – Real or Virtual

   Circle your answer – Upright or Inverted

Procedure B (Thin Convex Lens):

Use the light source (light box) and a lens to project an image:

a. Attach the light source near one end of the track at the 10 cm mark, facing toward the higher distance markings.

b. Place the thin double convex lens on the track, at about 50 cm.

c. Attach the screen to the track and position it so that light from the light source passes through the lens and strikes the screen.

d. Turn the light source wheel until the "**hole**" is visible in the opening. This will be your "object" for this investigation.

e. Adjust the position of the lens and the screen until you see a focused dot on the screen. This may require some trial-and-error.

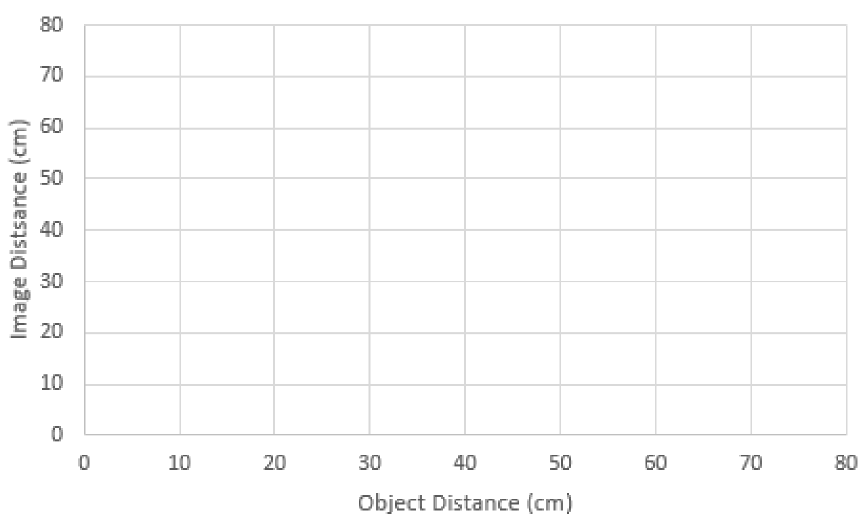
Continue adjusting the position of the lens by 10 cm increments toward and away from the light and each time adjust the screen to find different configurations that yield sharp images. Record 5 pairs of values for "Object distance" and "Image distance" in a **data table titled Experiment #2B**.

Data:

- Record the distance between the light source and the lens as "Object distance" and the distance between the lens and the screen as "Image distance" in a data table.
- Graph your data in the graph provided.

Experiment 2- Procedure B

Object Distance (cm)	Image Distance (cm)



Analysis of Experiment B (Thin Convex Lens):

1. What is your independent variable and dependent variable in this experiment?

   Independent Variable: ______________________ Dependent Variable: ______________________

2. Is this graph of distance of object vs distance of image a linear (directly proportional) relationship?

   Circle your answer – Yes or No

3. Take one of your points and enter it into the following equation to calculate the focal length (f) for the lens.

   Focal Point of the Lens = __________________

   $$(Thin\ Lens\ Equation)\ \frac{1}{s_i} + \frac{1}{s_0} = \frac{1}{f}$$

   Where S_i = image distance, S_o is the object distance, and *f* is the focal length of the lens.

4. Is the image a real or virtual image? Is the image upright or inverted?

   Circle you answer – Real or Virtual

   Circle your answer – Upright or Inverted

Experiment #3 - Virtual Images and the Telescope

The telescope is an example of the usefulness of lenses in producing images. One of the many claims to fame of Galileo Galilei is his work refining the design of a refracting optical telescope. Telescopes use combinations of lenses to produce a magnified image.

Online students: You must interact with a group in class in order to perform this laboratory.

Objectives:

- Build a refracting optical telescope.
- Discuss the characteristics of real and virtual images.

Materials: Dynamics track, window, screen assembly, 10 cm double convex lens, 20 cm double convex lens, 15 cm double concave lens, and lens holder.

Procedure:

Part A: The Magnifying Lens

In this investigation, we will experiment with the use of a double convex lens as a magnifying glass.

- Attach the screen to the track.
- Attach the thick double convex lens to the track.
- Look through the double convex lens at the screen. Adjust the distance between the two until you clearly see a magnified image of the screen and its scale markers. Continue to adjust the distance to maximize the magnification of the image.

1. Is the image produced by a magnifying glass real or virtual?

   Circle your answer – Real or Virtual

2. About what distance is your eyes from the lens to result in the maximized magnification of the image?

   Distance of your face from the lens = ____________________

Part B: The Telescope

Now we will make a telescope.

- Set up the 10 cm (thick) double convex lens and the screen in the position from Part B that yielded maximum magnification. Be sure to leave space on the opposite side of the screen for steps that follow.
- Use a 20 cm (thin) double convex lens to project the image of a distant object on the "back" side of the screen, as you did in "Real Image Formation."
- Adjust the lens position until the projected image is in sharp focus.
- The final arrangement of the track should be: Window, 20 cm lens (thin), Screen, 10 cm lens (thick). The arrangement is demonstrated in the figure at the bottom of the page.
- Now remove the screen. You have made a telescope. The lens that was a magnifying lens is now the eyepiece, and the lens producing the real image is the objective lens.

1. Describe the image you see when looking through the eyepiece. Is it upright or inverted? Bigger (magnified) or smaller (reduced)? Real or virtual?

   Circle your answer – Upright or Inverted

   Circle your answer – Bigger or Smaller

   Circle your answer – Real or Virtual

2. What is the distance between the two lenses?

   Distance = ___________________