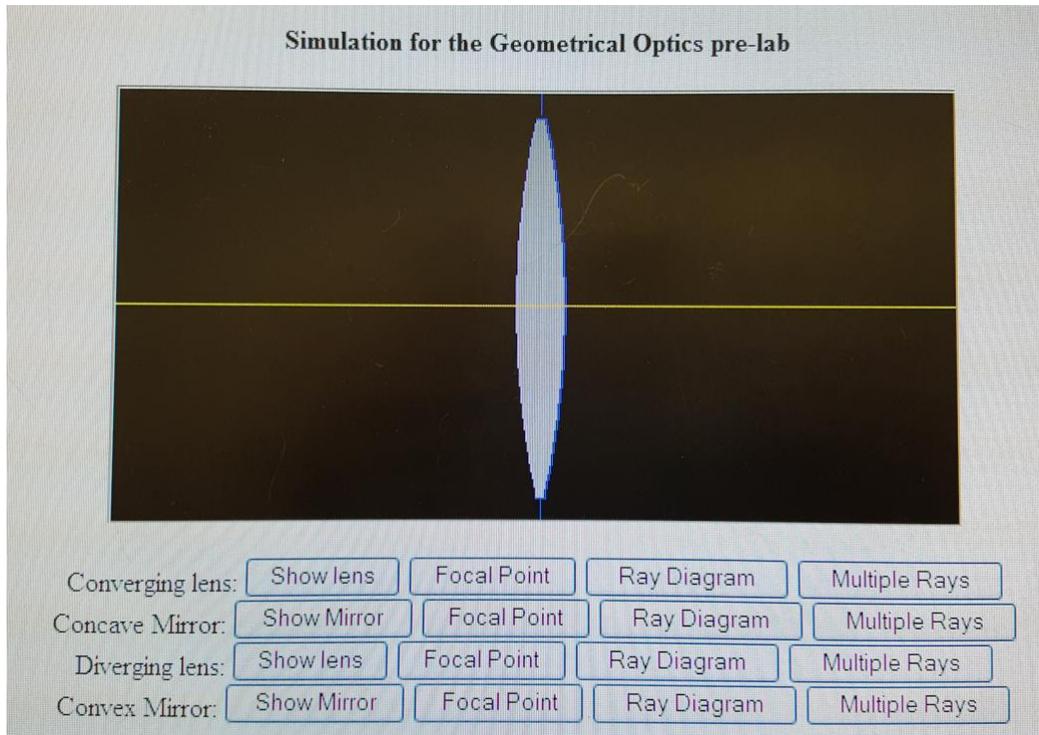


Section: _____ Name: _____ BU ID: _____

Partner: _____ Name: _____ BU ID: _____

Lab 7: Properties of Light I (geometrical optics)

Part I: Open the link http://physics.bu.edu/ulab/prelabs/prelab_geo_optics.html and click on Simulation button (if asked, OK all security prompts).



When the app opens first time you should see a lens, if not – change the browser. The app allows you to assemble different optical devices and observe the ray diagrams they produce. Your goal is to draw ray diagrams for different situations and then check your diagrams using the app.

1. We start from a Concave Mirror; click on Show Mirror

What kind of a mirror is it? converging diverging

Is the focal point of the mirror real or virtual? _____

Click on Focal Point. Check your answer.

If you would move the mirror, what would happen to the focal point?

Use a mouse and drag the mirror to the right. Observe.

For this mirror, draw a ray diagram for an object placed far from the mirror (farther than the doubled focal point distance).



According to your ray diagram, what are the properties of the image (underline the correct feature)?

- a) real or virtual
- b) upright or inverted
- c) enlarged or reduced

Click on Ray Diagram and drag the mirror to the right. Compare your ray diagram with the one on the screen. Then click on Multiple Rays, move the mirror and observe how the diagram changes; also move an object (represented by an arrow), and a point source (represented by a red square).

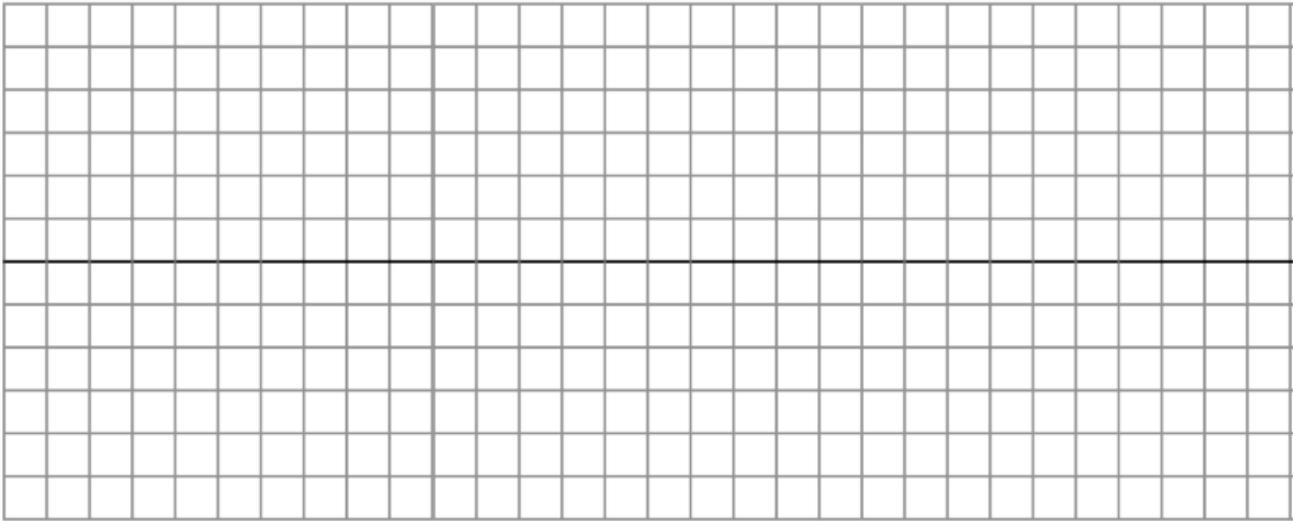
2. Draw below a ray diagram for an object placed between the focal point and doubled focal point.



According to your ray diagram, what are the properties of the image (underline the correct feature)?

- a) real or virtual
- b) upright or inverted
- c) enlarged or reduced

3. Draw below a ray diagram for an object placed between the mirror and the focal point.



According to your ray diagram, what are the properties of the image (underline the correct feature)?

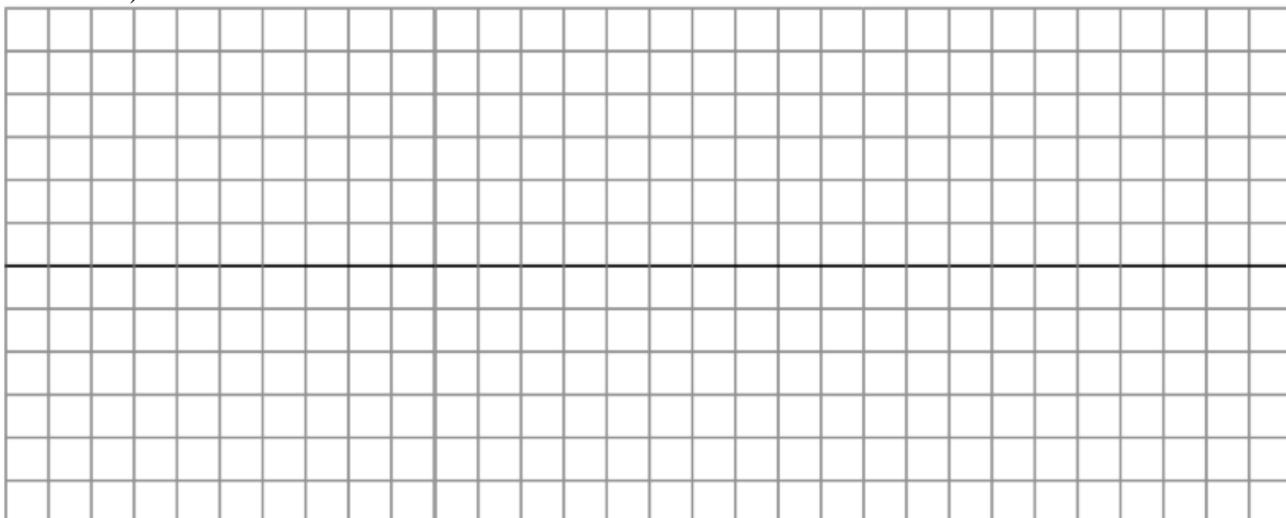
- a) real or virtual
- b) upright or inverted
- c) enlarged or reduced

According to your diagrams, predict what will happen to the image if you drag the mirror closer to the object; what will happen to the image if you drag the object toward the mirror. Use the applet to check your predictions.

4. Click again Show Mirror for Concave mirror. Click on the mirror. Two small dots show the focal points of this mirror. Click on the focal point located **to the left to the mirror**, hold the left button of the mouse and drag the focal point on the other side of the mirror.

What kind of a mirror is it? _____ What can you say about its focal point?

For this mirror, draw a ray diagram for an object placed far from the mirror (farther than the doubled focal point distance).



According to your ray diagram, what are the properties of the image (underline the correct feature)?

- a) real or virtual
- b) upright or inverted
- c) enlarged or reduced

Click on Focal point for Convex Mirror and compare with your answers.

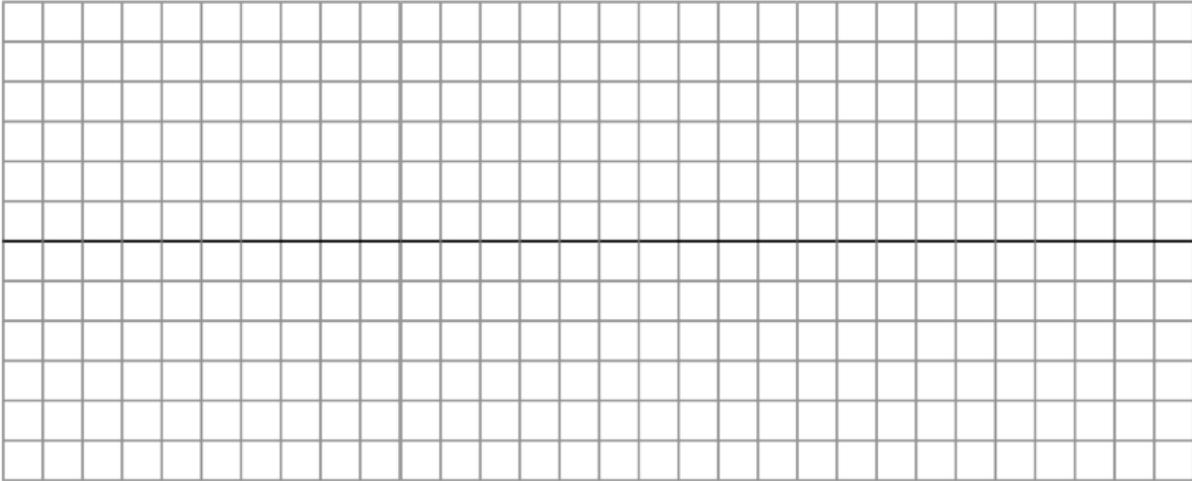
Click on Ray Diagram for Convex Mirror. Compare with your diagram.

Predict what will happen to the image if you drag the mirror closer to the object; farther from the object, if you move the object toward or away from the mirror.

Click on the mirror in the simulation. Holding the left button of the mouse, drag the mirror toward the object. Compare your observations with your prediction. Explain all the differences (if any). Then move the object and compare the result with your predications.

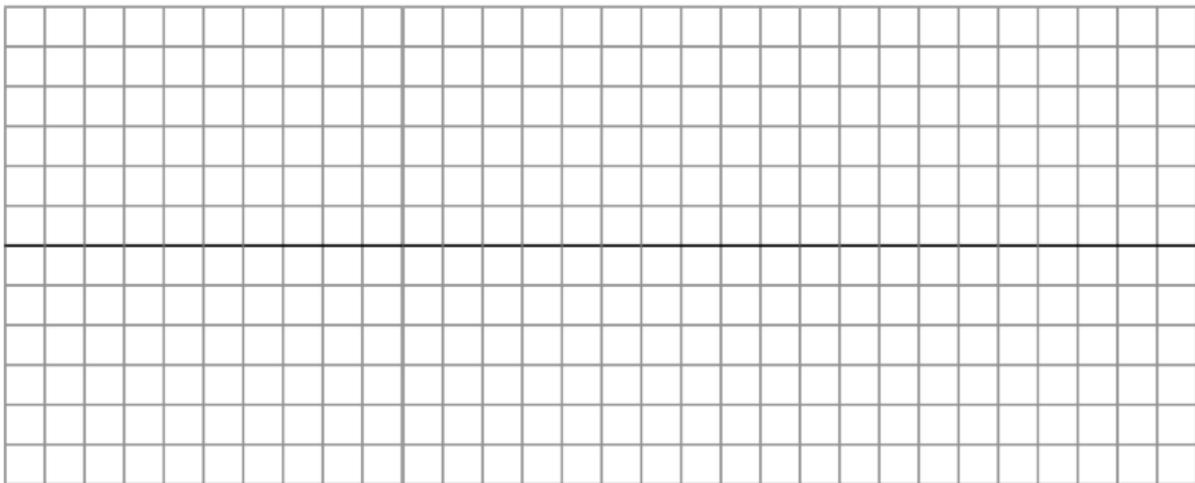
Now let us play with lenses.

5. Draw a ray diagram for a *beam* of parallel rays passing through a converging lens (parallel to the principle axis).



Click on Focal Point for Converging lens and compare with your diagram.

6. Draw a ray diagram for an object placed farther from the lens than its focal distance.

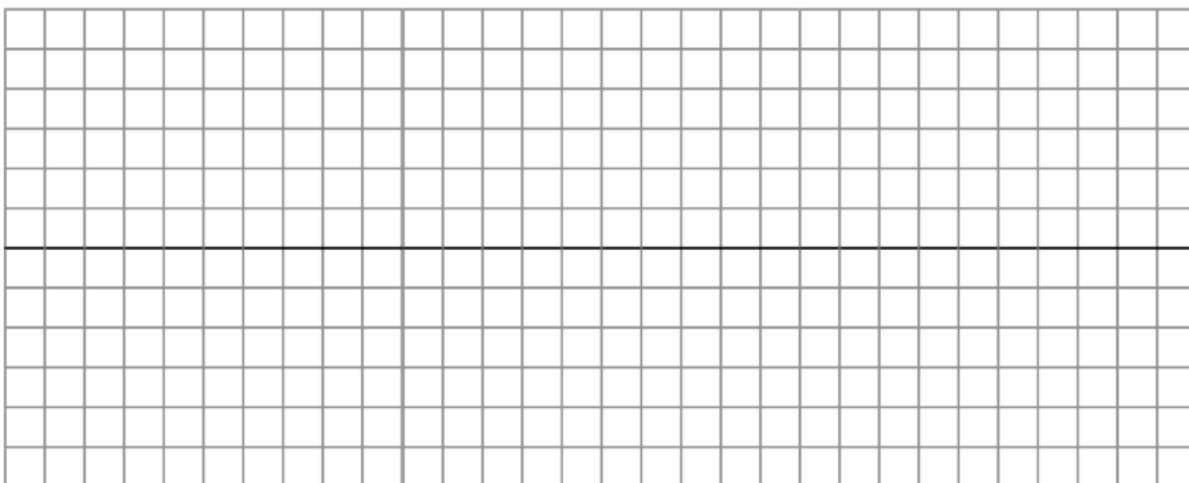


According to your ray diagram, what are the properties of the image (underline the correct feature)?

- a) real or virtual
- b) upright or inverted
- c) enlarged or reduced

Predict what will happen to the image if you start moving the lens or an object; check your predictions.

7. Draw a ray diagram for an object placed between the lens and its focal point.



According to your ray diagram, what are the properties of the image (underline the correct feature)?

- a) real or virtual
- b) upright or inverted
- c) enlarged or reduced

Predict what will happen to the image if you start moving the lens or an object; use the app and check your predictions for parts 6 and 7.

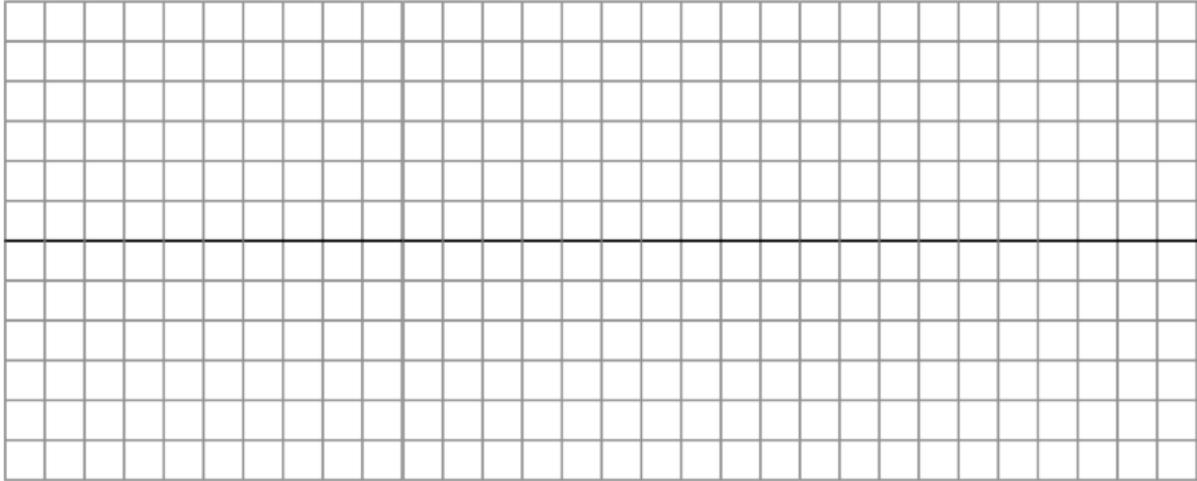
Click again on Show lens for Converging lens. Click on the lens. Drag the *left* focal point *to the right* to the lens. The new lens is _____

8. Draw a ray diagram for a beam of parallel rays passing through a diverging lens.



Click on Focal Point for Diverging lens and compare.

9. Draw a ray diagram for an object placed nearby a diverging lens.



According to your ray diagram, what are the properties of the image (underline the correct feature)?

- a) real or virtual
- b) upright or inverted
- c) enlarged or reduced

Predict what will happen if you move an object or a lens. Using the applet check your ray diagram and predictions.

Part II: Making images of an object.

In this part you will explore images you can make using a convex (converging) lens. You have a lens with a focal length of 100 mm, and a lens with a focal length of 200 mm (another lens would work, too, if the focal distance does not exceed 30 – 35 cm). You also have two light sources, each of which you can use as an object (a bulb with a long filament, and a bulb with an + - shaped slit, choose the source with you think fits the best the particular task, be creative, try both). You can use some additional equipment like a screen (sometimes just a sheet of paper is good enough).

- Optical bench with 4 rod holders • 2 Lens clamps • Object light source (a bulb with an + - shaped slit)
- Rod mounted lamp (a bulb with a long filament) • Ground glass screen • 1 meter stick • Paper

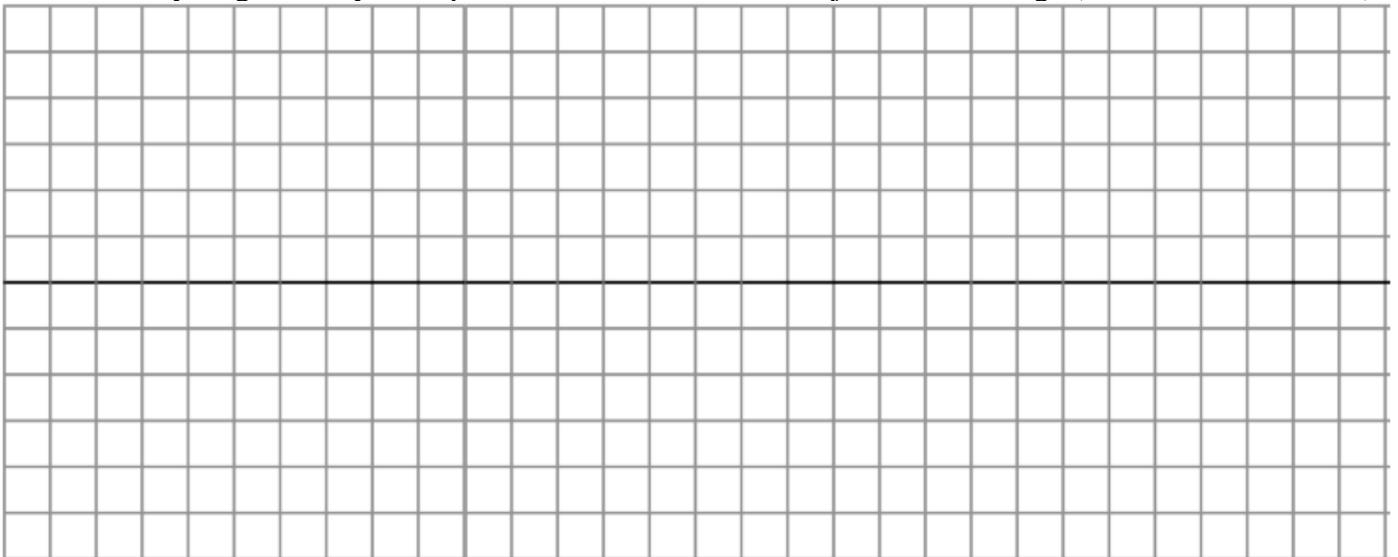
Your goal in this activity is to form and observe a real image created by a lens.

1. Select one of the lenses. What kind of a lens did you take and why? Make a sketch of your lens. When you feel it with your fingers, what is thicker, the center or the edge of the lens? How do we call a lens like that?

2. Write the thin lens equation.

3. Explain the meaning of each term in the thin lens equation.

4. Sketch a ray diagram for your experiment, label the lens, an object, and its image (it has to be a real one!).



5. List the properties of the image you want to make in your experiment (underline the correct feature).

a) real or virtual

b) upright or inverted

c) enlarged or reduced

6. Use the optical bench; place a light source (“an object” – you have two options for it, a bulb with a long filament, and a bulb with an \oplus - shaped slit; you can try both), a lens, and a screen on the bench. Make adjustments needed to observe a clear real image of the source on the screen.

7. Make sure you see a clear image of the object on the screen.

Measure the object distance d_o and the image distance d_i .

$d_o =$ _____

$d_i =$ _____

8. Calculate the focal distance of the lens f . Is it in an agreement with the color coding of the lenses in the lab?

$f =$ _____

9. Predict, what will happen with the image if you take a piece of paper and cover the top half of *the object*.

10. Cover the top half of *the object* and describe what you observe. Does your observation agree with your prediction?

11. Predict what would happen to the image if you were to cover the top half of the lens with a piece of paper.

12. Cover the top half of the lens and describe what you observe. Does your observation agree with your prediction?

13. Predict what would happen to the image if you were to cover the left half of the object with a piece of paper?

14. Cover the left half of the object and describe what you observe. Does your observation agree with your prediction?

15. Predict what would happen to the image if you were to cover the left half of the lens with a piece of paper

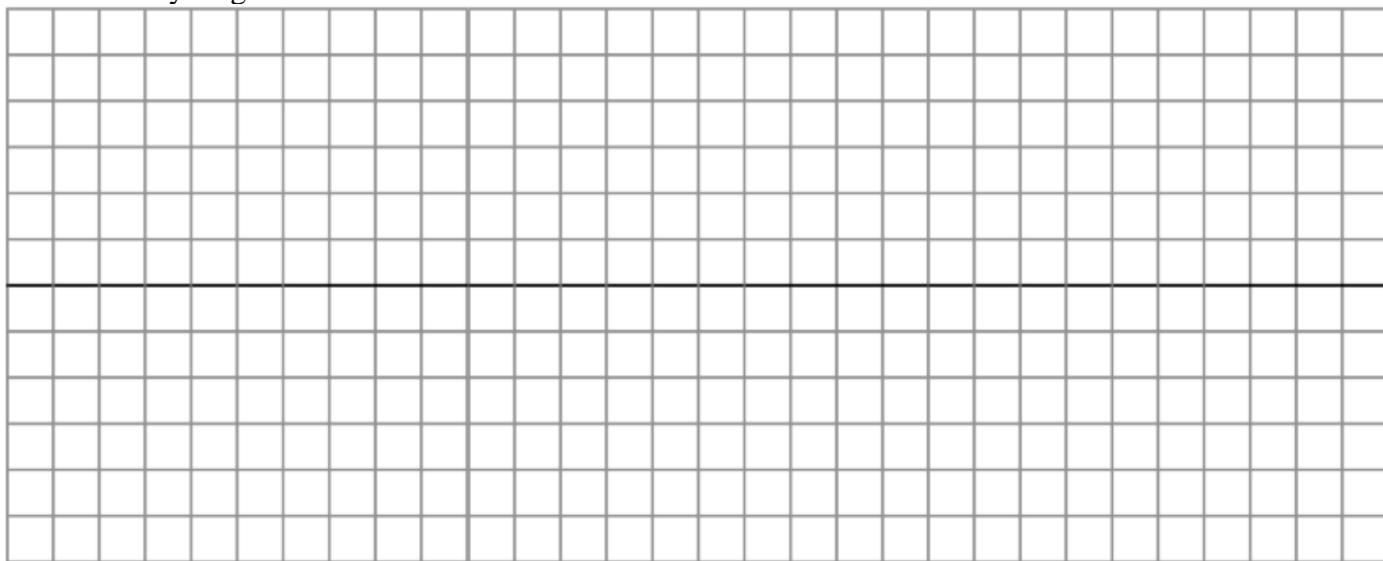
16. Cover the left half of the lens and describe what you observe. Does your observation agree with your prediction?

17. Write an expression for the magnification of the lens. Calculate the *actual value* and the *magnitude* of the magnification for the values you measured in part 7. What is the difference (and why) between the *actual value* and the *magnitude* of the magnification?

18. Your goal is to make the *smallest* possible focused on a screen image of an object within the limits of the lab setup (and using one of the lenses). Think about how should you arrange the object, the lens, and the screen? Look at the size of the clear (focused) image for different distances between the object and the lens. Describe your observations.

Finally, build the set-up which gives you the image of the *smallest* size.

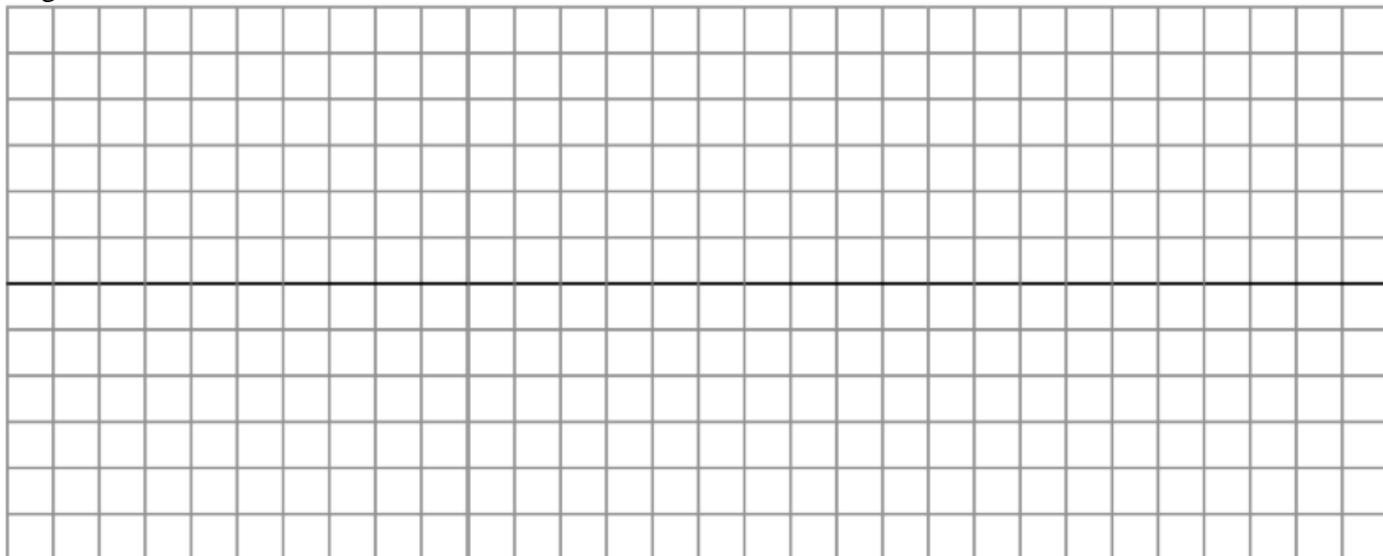
Sketch the ray diagram.



19. Measure the object distance and the image distance and calculate the magnification for your arrangement.

20. Now, try to measure the actual size of the object and of the image (think, which light source would be the most useful as the object), and calculate the magnification again. Compare your results.

21. Where should you place an object so that the *same* lens forms its virtual image? Draw a possible ray diagram for this situation.

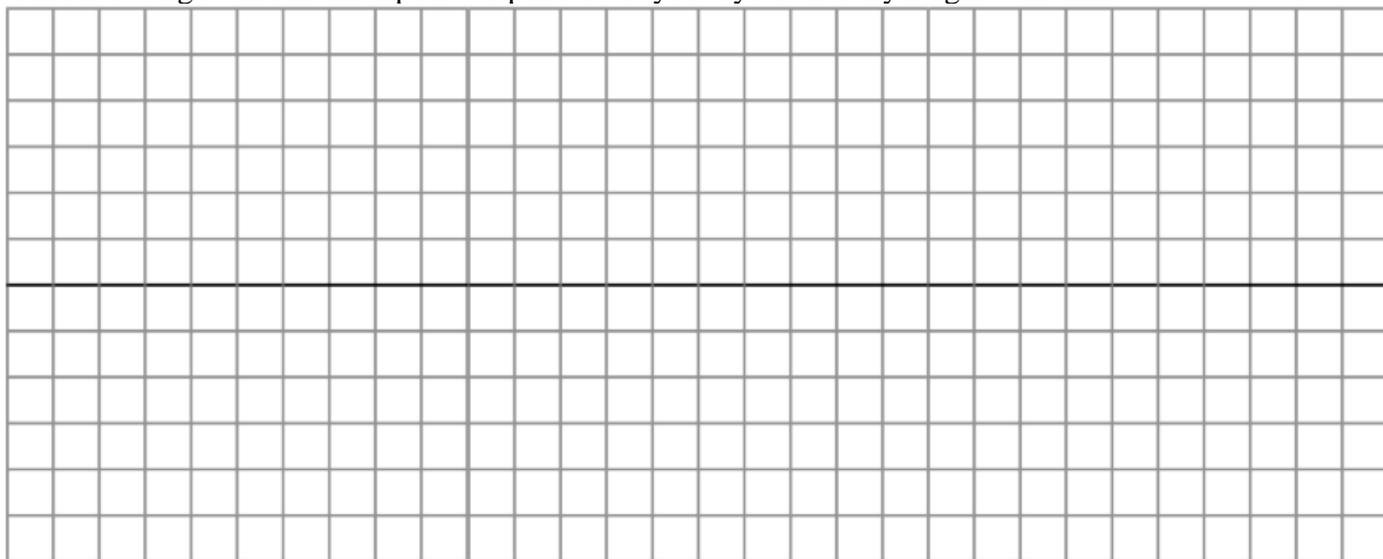


22. List the properties of the image (underline the correct feature).

- a) real or virtual
- b) upright or inverted
- c) enlarged or reduced

23. Build this set-up with the equipment you have in the lab. Can you see this image on the screen and, if not, how could you see it?

24. Replace the lens with another one which is *thinner in the middle than at the edge*. Can you make an image seen on a screen? Why? Remove the screen. Predict where you would have to place your eye in order to see the image now? Show a possible position of your eye on the ray diagram below.



25. Try to observe the object according to your prediction. Comment on how it went.

Equipment

Lab 7

Part I (12 tables): **Computers**

Part II (12 tables): • **Optical bench with 4 rod holders** • **2 Lens clamps** • **Object light source**
• **Rod mounted lamp** • **Ground glass screen** • **Meter stick** • **Paper**

Unit layout

L7: 140 min

PI: 70 min

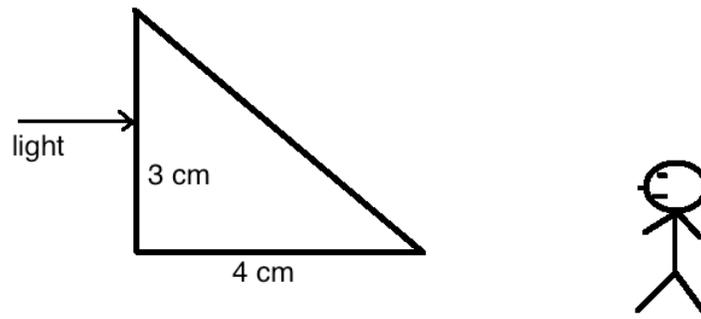
PII: 70 min

PE7: 60 min

Breakes when needed.

Practice Exercise 7

(A) In the picture below, will the observer see any light coming out of the prism if the prism is in the air ($n=1$) and its index of refraction is 1.5? Use the law of refraction (the *Snell's Law*) to prove your answer (think of how this law is applied to the *total internal reflection* phenomenon at the longest side of the prism).



(B) Keeping the prism in the air, what should be done to the index of refraction of the *prism* (should it be increased or decreased) in order for the observer to start seeing light coming through the prism? Find the critical index of refraction of the prism in the air for this to happen.

(C) Starting from the original situation (case (A)), keeping the index of refraction of the prism equal to 1.5, what should be done to the index of refraction of the *medium* around it (should it be increased or decreased by replacing the air with another substance) in order for the observer to start seeing light coming through the prism? Find the critical index of refraction of the medium for this to happen.