Geometrical Optics

1st year physics laboratories

University of Ottawa

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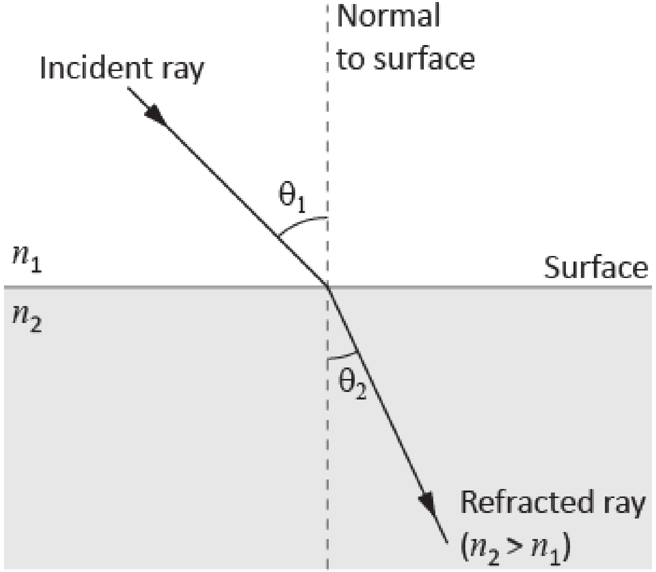
INTRODUCTION

- **Geometrical optics** deals with light as a ray that can be bounced (reflected) or bent (refracted) by different mechanisms.
- **Refraction** is the bending of light when it goes from one medium to another if the two media have different **refractive indices**.
- **Dispersion** (index of refraction depends on wavelength) is demonstrated by the spatial separation of light into the different colours that it is composed of.
- **Lenses** can be used to focus (**converge**) or defocus (**diverge**) light rays.
- Simple optical devices, such as a **microscope**, can be fabricated using optical components as simple as a pair of lenses.

REFRACTION

- When light crosses the interface between two media having different refractive indices (ie. between air and water), a light ray will change its direction of travel.
- **Snell's law** tells us the amount the light will bend and depends on the angle of incidence (θ_1), the refractive index of the first material (n_1), and the refractive index of the second material (n_2).

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$



DISPERSION

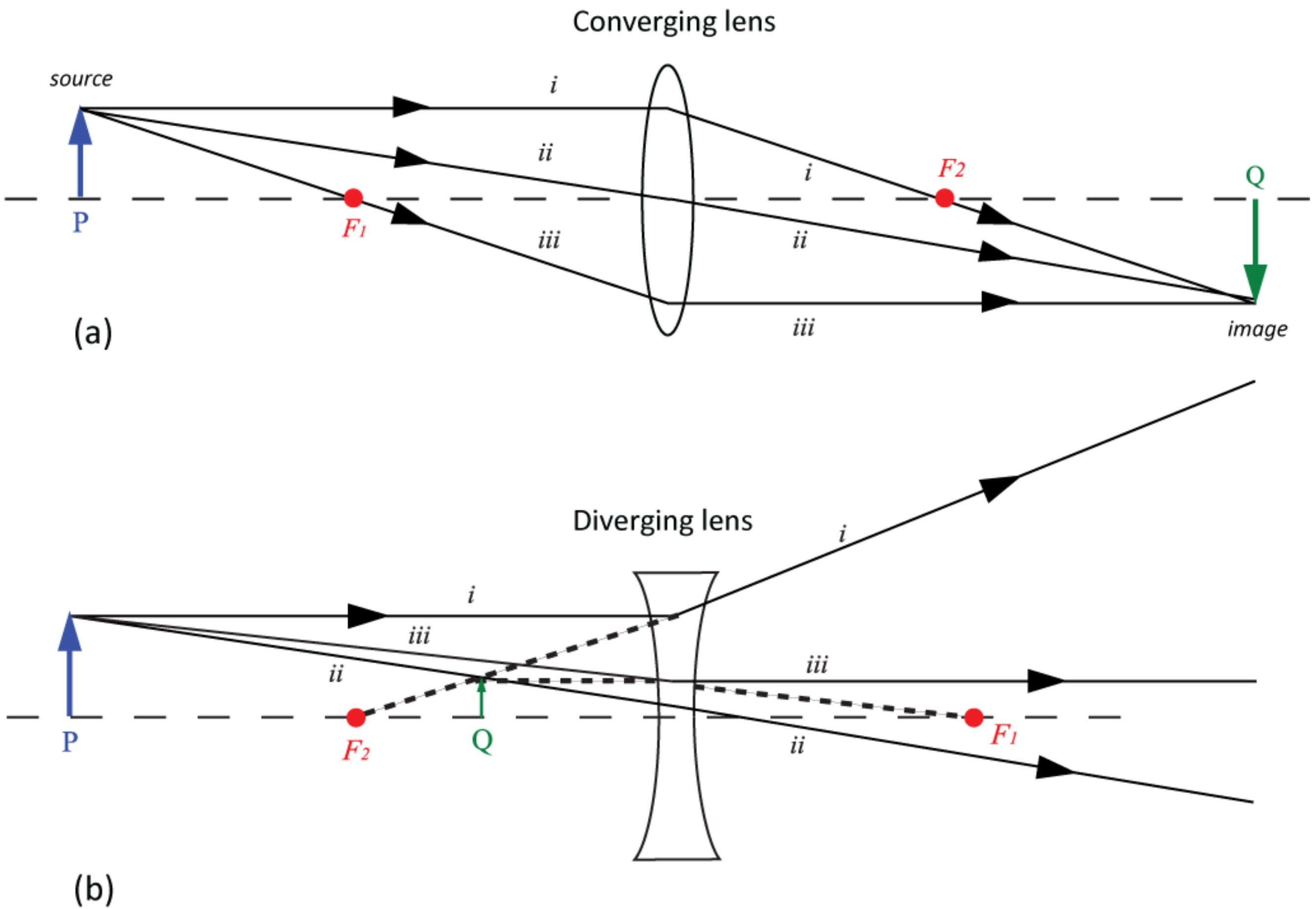
- The index of refraction for light varies with the wavelength (colour) of the light. The index is **lower for longer wavelengths** and **higher for shorter wavelengths**.
- White light is made up of a spectrum of different colours and when it enters a material at an angle, each colour will spatially separate because it will bend by a slightly different amount.
- When we send white light through a prism, the double bending in the same direction will cause enough spatial separation of colours so that you'll see a rainbow pattern.

LENSES

- A lens can be used to converge or diverge light that is incident on its surface.
- We can use the thin lens equation to connect the object (p) and image (q) distances with the focal length (f) of the lens:

$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$$

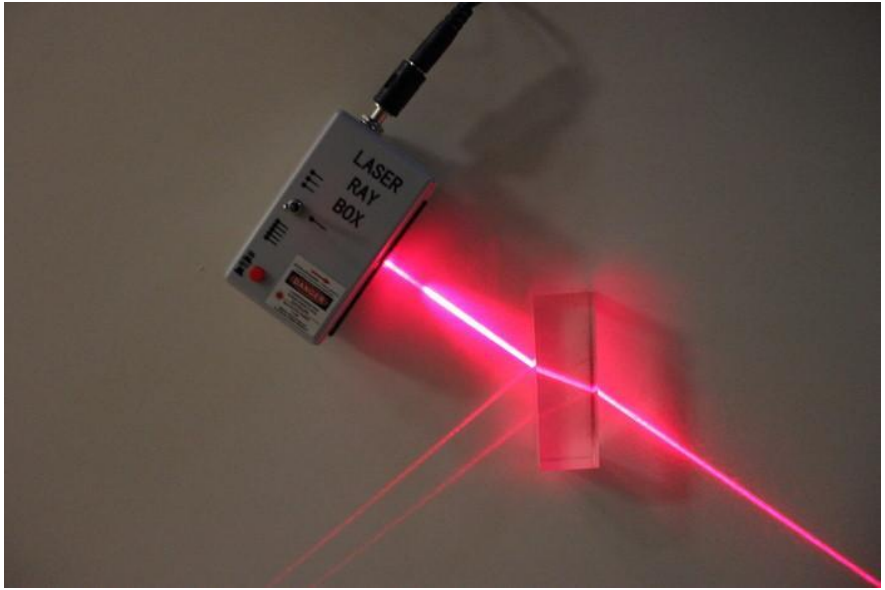
RAY DIAGRAMS



- We can construct ray diagrams using three simple rules.
- F_1 and F_2 are the focal points.

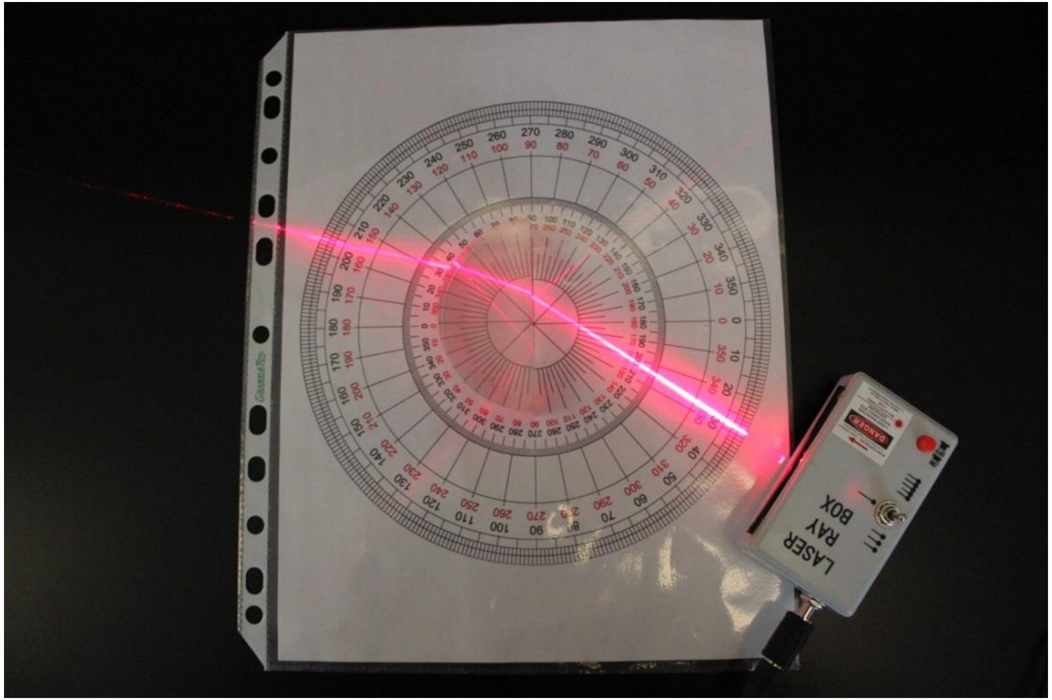
REFRACTION

- Use a single beam from the laser ray box to demonstrate reflection and refraction of light.

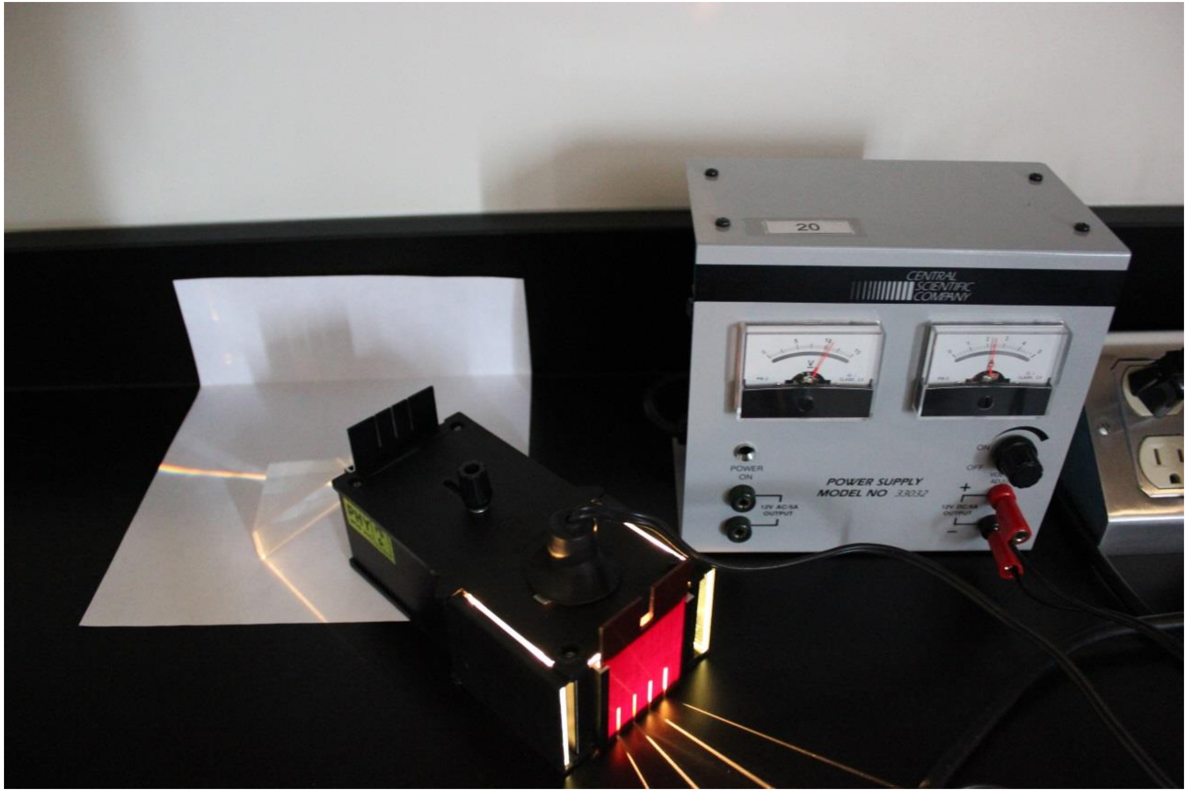


REFRACTION OF LIGHT

- You will use Snell’s law the experimentally determine the index of refraction of a piece of acrylic.
- Method 1 by calculation (see previous slide).
- Method 2 by making a graph of incident angle *vs*. refracted angle (setup shown to the right).



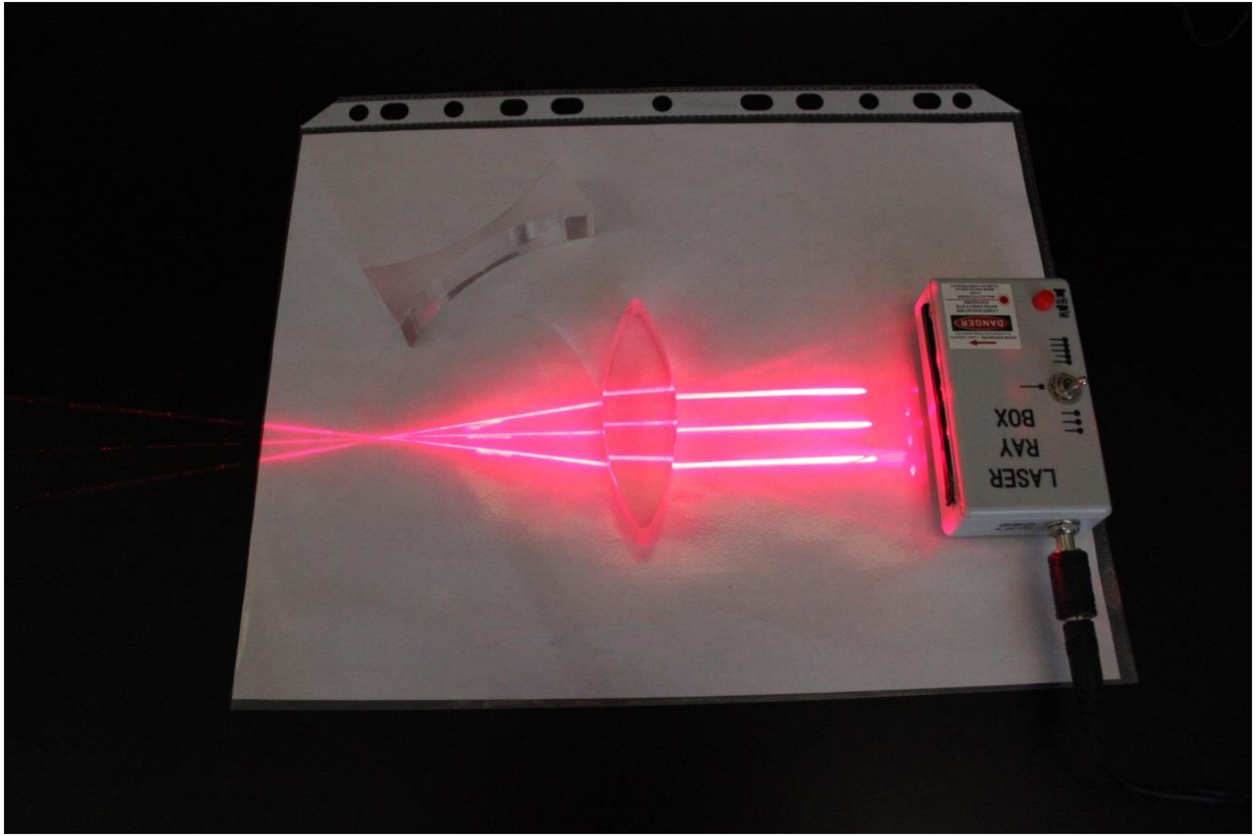
DISPERSION SETUP



- Investigate the dispersion of white light as you shoot it through a prism.
- Which colour has the largest refraction angle?

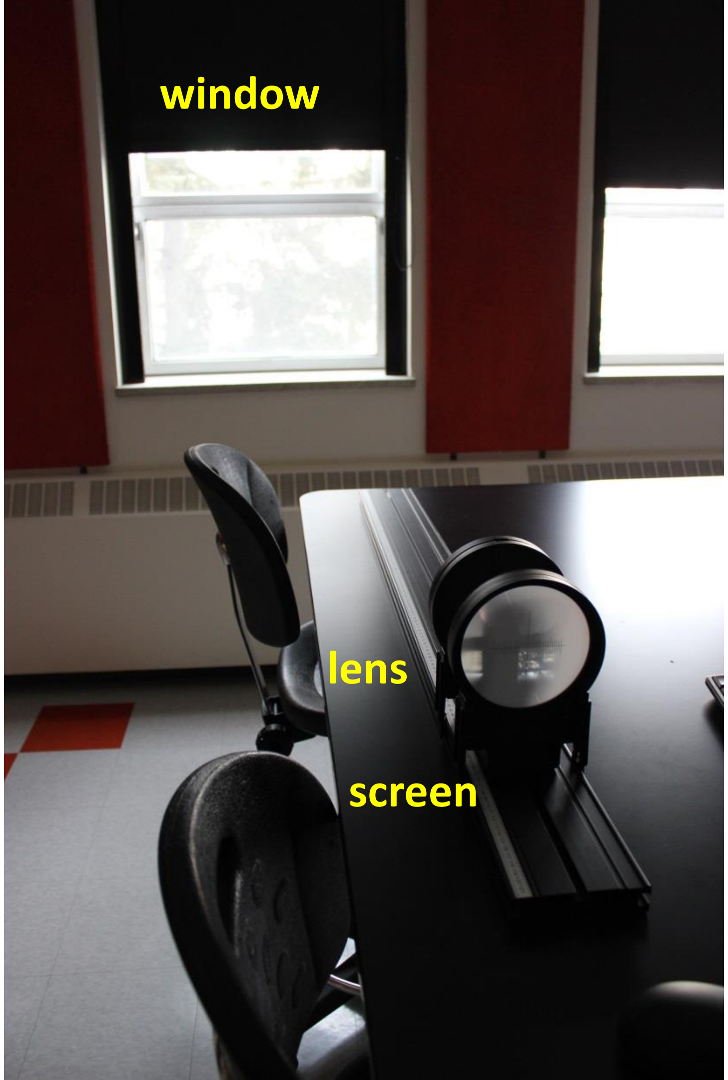
FOCUSING LENS SETUP

- You can directly measure the focal length of the double concave and double convex acrylic lenses using three beams from the laser ray box.

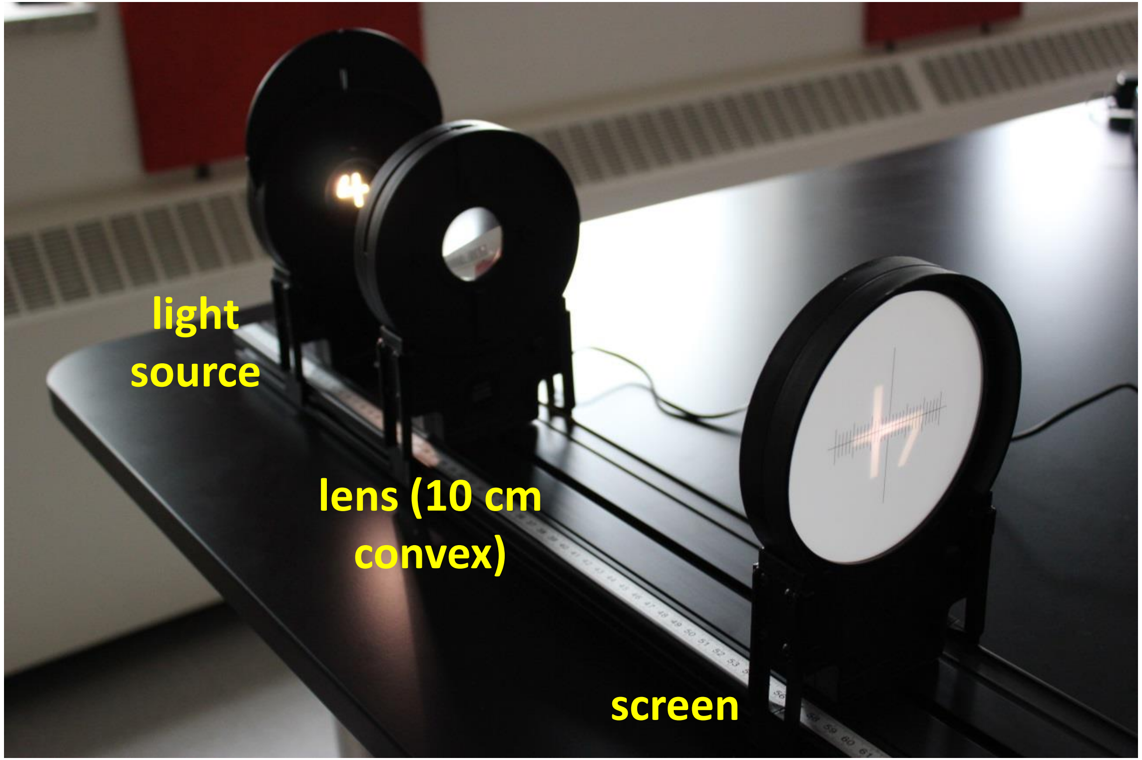


FOCUSING AN OBJECT AT INFINITY

- A very distant object ($p \to \infty$) will have a real image at the focal point of a converging lens ($q \approx f$).



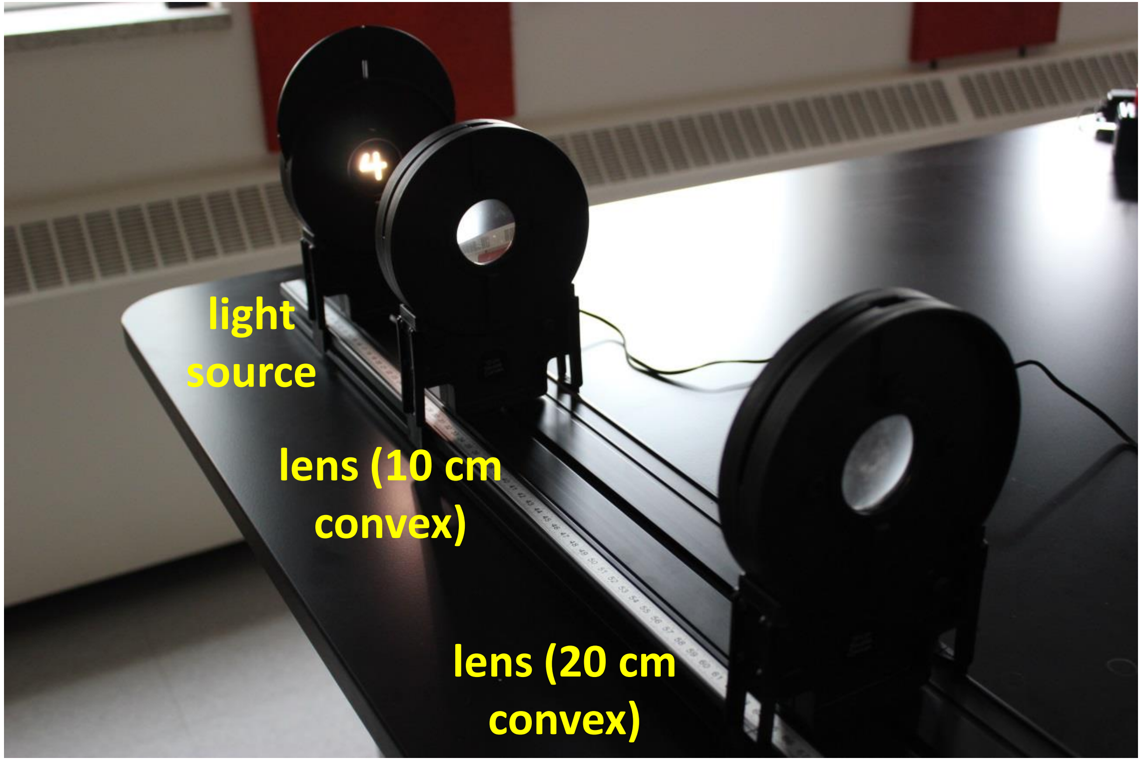
OBJECT CLOSER THAN INFINITY



- Record a series of p and q measurements and graphically determine the focal length of the lens.

MICROSCOPE SETUP

- Use two lenses to assemble a microscope to magnify an image.
- Determine the magnification, *M*.



CLEAN UP

- Turn off the computer and **don’t forget to take your USB key.**
- Make sure the laser ray box is turned off. Put back the 4 acrylic pieces and the 360° protractor.
- Make sure the white light source is turned off. Put the light source, the two lenses, and the screen back on the optical track.
- Please recycle scrap paper and throw away any garbage. Please leave your station as clean as you can.
- Push back the monitor, keyboard, and mouse. Please push your chair back under the table.

- Thank you!

DUE DATE

The report is due at the end of the lab session.

PRE-LAB

Don’t forget to do your pre-lab for the next experiment!