**Optics Simulation (remote)**

# Notes:

1. ***This is a one-week lab that can be done at home.***
2. Only a **summary** must be submitted. Please check 'Summary\_template.docx' for a template of the summary.
3. This lab can be done in several ways. On a laptop or desktop (Win or Mac) you can download the simulation or run it in a web browser (free). You can also run it through an app on an iOS or android smartphone or tablet (but it will cost you 99 cents).
4. We strongly recommend doing the lab early in the week, rather than waiting until it is almost due. If you have trouble, you will want to have plenty of time to fix it before the deadline. No excuses!
5. Turning in your report:
   1. Collaborate with your partner(s) on data collection, analysis and report.
   2. Turn in only one report but be sure it lists all partners as authors.
   3. Lab reports should be uploaded to Canvas in pdf format by the deadline in the course calendar.
   4. You don’t need to upload or include any spreadsheets. You may want to use figures in your report that can contain screenshots of spreadsheet(s) or graphs copied and pasted from them.
6. Getting help:
   1. Your lab TA can answer questions by email or during their office hours listed in the syllabus.
   2. You should also seek advice from one another on in person or on CN.

# Objectives of this lab:

These are things you will address in your report

1. You will do some experiments in a simulated environment to measure the focal length of a concave lens, convex lens, concave mirror and convex mirror.
2. Identify the errors that can occur in your experiment.
3. Identify the sources of noise in your experiment.
4. Minimize the noise in your experiment.

# What you will learn:

Please review the learning goals for the semester in lab in the “Lab Overview” document (look in the Syllabus Task on CN). In addition, this lab has several specific goals:

1. You will practice keeping lab notes in a paper notebook, computer file, or other format.
2. You will enhance the data analysis skills you learned previously, by applying them to real data.
3. You will learn to distinguish between two types of errors that occur in data: systematic errors and random errors.
4. You will enhance your understanding of how noise arises in data, and how to account for that noise when interpreting experimental results.

# Equipment:

* Excel, Numbers, or other graphing software
* A web browser to run the simulation. Alternatively, you can run the simulation on a smartphone or tablet.

# Background:

This lab is focused on a few equations that are central to the study of lenses and mirrors. For an object at a distance p from a lens of focal length of f, the image is formed at a distance q. The relation between these quantities is given by

1/f = 1/p + 1/q

where is f is positive for a convex lens and negative for a concave lens.

The same equation can be used for mirrors with the recognition that f is positive for a concave mirror and negative for a convex mirror.

**Sign Conventions:**

1. Remember that f > 0 for a convex lens and a concave mirror, and f < 0 for a concave lens and convex mirror.

2. All object distances are positive.

3. For lenses, if the image is on the opposite side of the lens compared the object, the image distance is positive. If image is on the same side as object, image distance is negative.

4. For mirrors, if the image is on the opposite side of the mirror compared to the object, the image distance is negative. If image is on same side as object, image distance is positive.

# ACTIVITY 1: Lens

To get started, you need to get the app running. Here are the options:

1. Browser: Navigate to https://phet.colorado.edu/en/simulations/geometric-optics. You can use the simulation there by clicking on the image (it has a triangular play symbol like a video).
2. Graphical user interface, application, icon

   Description automatically generatedMobile: Download the PhET app from the App Store or Google Play (99 cents). Once you have the app, you can search for Geometric Optics.
3. When you click on the video, you get a page that allows you to select between Lenses and Mirrors.
4. Click on Lens and you should see a ray optics diagram.
5. At the top, you can select either a convex or a concave lens. You will use both.
6. Choose a concave lens with radius of curvature (R) between 50 and 60 cm, index of refraction of 1.5, and diameter of 80 cm.
7. For 10 different object distances, ranging from 150 cm to minimum distance permitted by the simulation, determine corresponding image distances.
8. Plot graph of 1/q vs 1/p.
9. Determine focal length from your plot.
10. Repeat for a convex lens.

# ACTIVITY 2: Mirrors

1. Go back to step 3 of Activity 1 and now select Mirror.
2. You will be able to select concave or convex mirror; we won’t be using the plane mirror.
3. Choose a concave mirror with radius of curvature (R) between 150 and 160 cm, refractive index of 1.5 and diameter of 80 cm.
4. For 10 different object distances, ranging from 200 cm to minimum permitted by the simulation, determine corresponding image distances.
5. Plot graph of 1/q vs 1/p.
6. Determine focal length from your plot.
7. Repeat for a convex mirror.

Submit your lab notes and graphs for grading; full report not required for this lab.