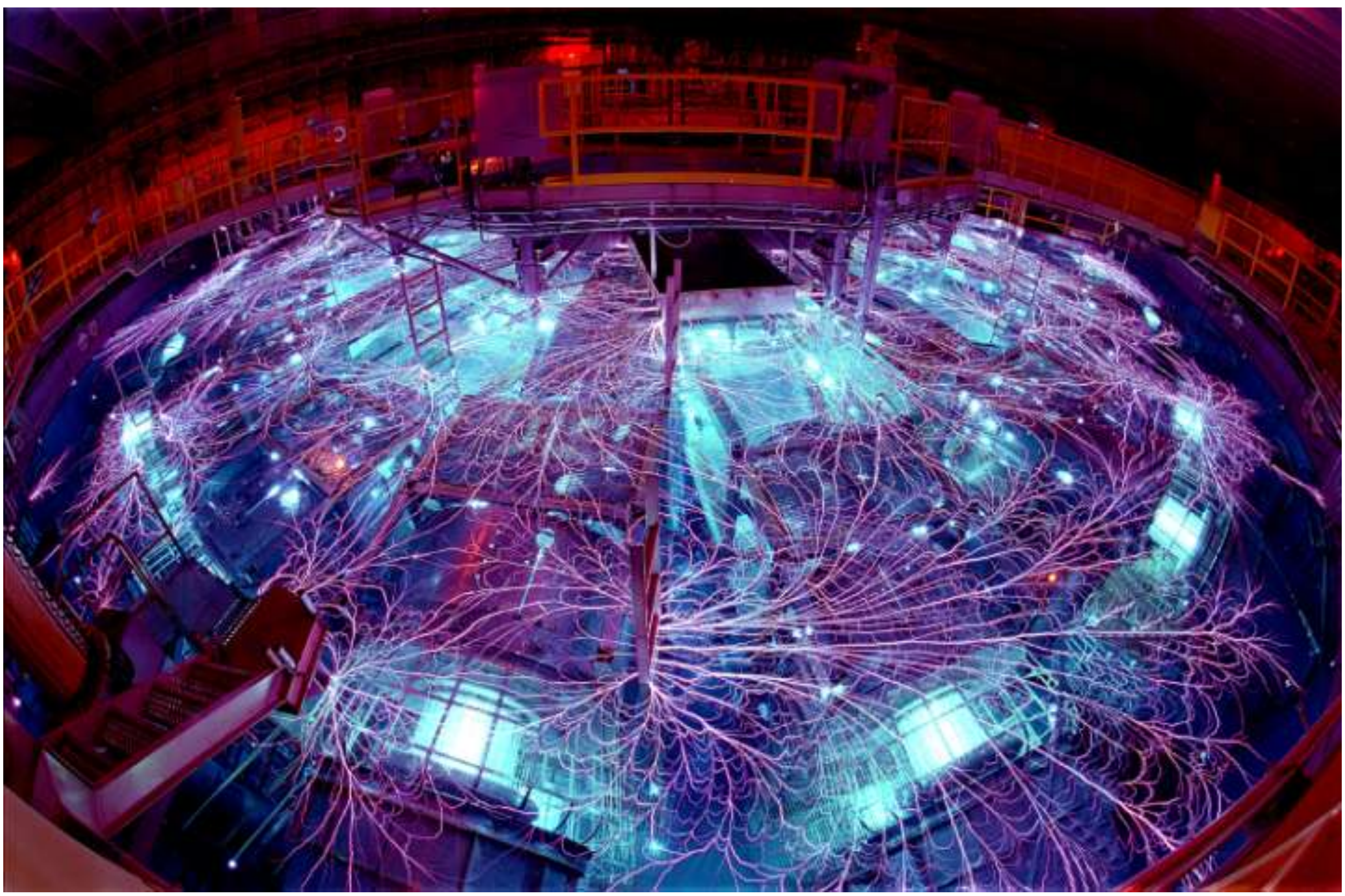
James M. Hill
Physics 112
Laboratory Manual
2012 – 2013



Mr. P. MacDonald

Laboratory Outline

Heading: Name, Date, Group members

Title

Introduction

Students will highlight the problem that is being solved and how they will go about solving this problem. This section should be 2-3 sentences maximum. Third-person speech is to be used.

Experimental Procedure

Students will keep a running log of what they did during the lab. All **data** and **measurements** are included in this section. All data should be specific to each individual experiment! Third-person speech is used. All **observations** are also included in this section. This section is normally kept in point form.

Calculations

This section includes all mathematical calculations that are performed as part of the experiment. No conclusions should be stated. Work should be organized appropriately, with the use of tables encouraged. All tables should be numbered, and titled correctly.

Discussion

Students will report the main findings of the lab. As well, students must discuss any possible errors that may have occurred during the procedure, and how these errors may have affected the final results. This must be covered in full detail! It is important that the issue highlighted in the 'Introduction' is addressed.

Notes:

- First page in notebook should be an index, including titles and page numbers.
- Only the right-hand side of the book will be marked. Any scrap work can be done on the left-hand side. Number pages on right-hand side only.
- All work must be done in blue or black ink. Pencil or coloured pen will not be accepted!
- All sections should be separated by the proper heading.
- Any graphs or attachments should be stapled into the proper place in the book.

Physics Lab Report Rubric

Criteria	1	2	3	4	5
Purpose	• Purpose is not identified • Relevant variables are not described	• Purpose is somewhat vague • Relevant variables are not described	• Purpose is identified • Relevant variables are described in somewhat unclear manner	• Purpose is identified • Relevant variables are described	• Purpose is clearly identified • Relevant variables are described
Hypothesis	• Predicted results and hypothesized relationship between variables not stated	• Predicted results and hypothesized relationship between variables are unclear	• Predicted results and hypothesized relationship between variables stated and appear reasonable	• Predicted results and hypothesized relationship between variables stated	• Predicted results and hypothesized relationship between variables clearly stated and reasonable
Materials	• There is not a list of the necessary lab materials	• Most lab materials included	• All necessary lab materials included but not listed in any particular order	• All necessary lab materials included and listed	• All necessary lab materials included and listed in an organized manner
Procedure	• Procedures are not listed	• Procedures are listed but not in clear steps	• Procedures are listed in clear steps but not numbered and/or in complete sentences	• Procedures are listed in clear steps • Each step is numbered and in a complete sentence	• Procedures are listed in clear steps • Each step is numbered and in a complete sentence • Diagrams are included to describe the set-up
Data	• Data is not represented or is not accurate	• Data lacks precision • Greater than 20% difference with accepted values	• Good representation of the data using tables and/or graphs • Less than 15% difference with accepted values • Precision is acceptable	• Accurate representation of the data using tables and/or graphs • Data is fairly precise • Less than 10% difference with accepted values	• Accurate representation of the data using tables and/or graphs • Graphs and tables are labeled and titled • Less than 5% difference with accepted values • Data is precise
Analysis	• Trends/patterns are not analyzed • Questions are not answered • Analysis is not relevant	• Trends/patterns are not analyzed • Answers to questions are incomplete • Analysis is inconsistent	• Trends/patterns are logically analyzed for the most part • Questions are answered in complete sentences • Analysis is general	• Trends/patterns are logically analyzed • Questions are answered in complete sentences • Analysis is thoughtful	• Trends/patterns are logically analyzed • Questions are answered thoroughly and in complete sentences • Analysis is insightful
Error Analysis	• There is no discussion of experimental errors	• Some experimental errors are identified	• Experimental errors and their effects are discussed	• Experimental errors are determined • Their effects are discussed	• Experimental errors are determined • Their effect and ways to reduce errors are discussed
Conclusion	• No conclusion was included or shows little effort and reflection on the lab	• A statement of the results is incomplete with little reflection on the lab	• A statement of the results of the lab indicates whether results support the hypothesis	• Accurate statement of the results of the lab indicates whether results support the hypothesis • Possible sources of error identified	• Accurate statement of the results of lab indicates whether results support hypothesis • Possible sources of error and what was learned from the lab discussed

Physics 112 Lab - Displacement #1

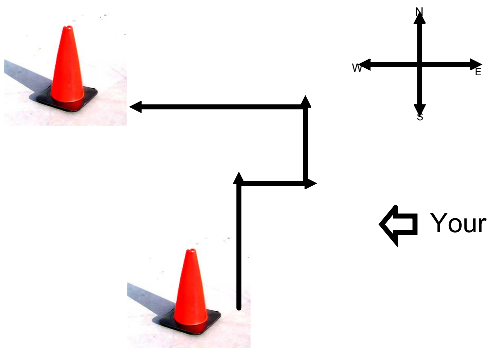
Purpose: Find the displacement, ***d***, of a person.

Materials: Compass, metre stick, calculator, pylons.

Part 1

Experimental Procedure:

- Groups of three or four
- From origin walk due North 8.0 metres (be sure to mark the location of your starting point!)
- walk due East 4.0 m.
- then North 3.0 m.
- lastly due West 14.0 m and marks that location.
- Measure the distance between the two pylons and the direction of the last pylon from the first one. (Be sure to record all of this data as each group member will need it.



⇦ Your path should look something like this.

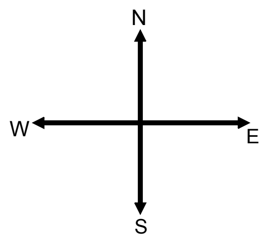
Calculations:

- Produce a scale diagram of the path traced out by your group to determine the resultant displacement.
- Label the resultant R (with an arrow over it) on your diagram.

Discussion:

- Compare the experiment data with the theoretical (calculated). Are there differences?
- Write a short note to explain why the experiment results would differ from calculations.

Physics 112 Lab Displacement #2



Purpose: Find the displacement, ***d***, of a person.

Materials: Compass, metre stick, calculator

Procedure:

- Mark it the origin.
- walk 6.0 m [N60°E] .
- then walk due West 10.0 m.
- walk 7.0 m [S40°W].
- finally walk 12.5 m [N20°E] and mark that location.
- Measure the displacement of the final location relative to the first.

Calculations

- Produce a scale diagram of the path traced out by your group to determine the resultant displacement.
- Label the resultant R (with an arrow over it) on your diagram.

Discussion

- Compare the experiment data with the theoretical (calculated by the scale diagram). Are there differences?
- Write a short note to explain why the experiment results would differ from calculations.

-


Calculate the straight line distance from the gym doors to the Canada flagpole.
Flagpole
Gym doors

Static and Kinetic Friction

Purpose: To study static and kinetic friction.

Materials: Spring scales, wood, various surfaces

Part I – Overcoming Static Friction

- Obtain a flat-sided object (e.g. a block of wood) and attach it to a spring scale to one of them.
- Record the normal force (data will be easier to record if the normal force large).
- Slowly pull the spring scale, keeping the scale as parallel to the surface as possible) watching the value carefully as you pull.
- Record the force just before the object begins to move.
- Calculate the coefficient of static friction.
- Repeat once more with a different normal force.
- Calculate the coefficient of static friction for each trial and take an average.
- Repeat the experiment for a different surface.

Part II – Kinetic Friction

- Record the normal force of an object.
- Slide the object along a surface at a constant speed (the scale should read a constant value; you can use the surfaces from Part I).
- Calculate the coefficient of kinetic friction.
- Repeat once more with a different normal force.
- Calculate the average coefficient of kinetic friction.
- Repeat the experiment for a different surface.

Physics 112 Lab: Spring Oscillations and Force

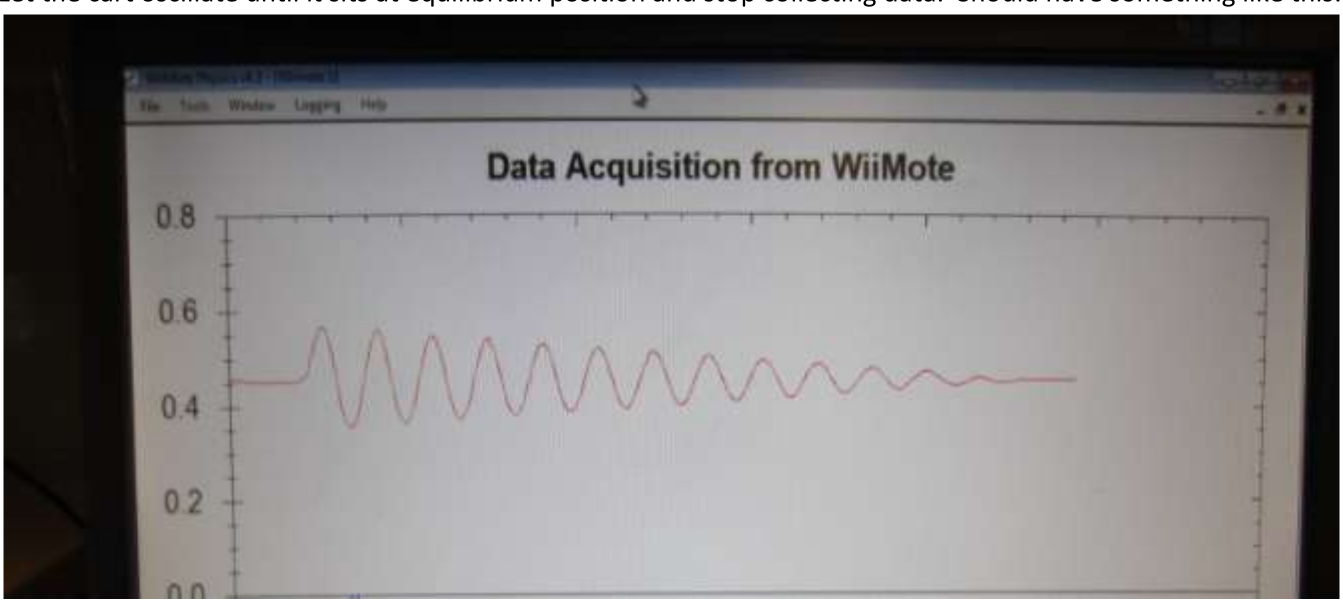
Purpose: To analyze the changes in amplitude on an object suspended by a spring on an incline.

Materials: Wiimote, WiiPhysics software, track and cart. (Your own SD card or memory stick)

Procedure

1) Setup the lab as shown in the image below (you can copy this image into your lab report)

2) Connect the wiimote to the computer (see the Wii Physics Instructions), start the Wii Physics program and set the collection mode to 1-D, and only have the Distance option checked.
3) On the WiiPhysics screen right-click the mouse and select “show point values”.
4) Attach the cart to the black stopper with the spring and let the cart hang there (this is its equilibrium position)
5) Stretch the spring about 10 - 15 cm and hold the cart in place until someone turns on data collection for the WiiPhysics program (ctrl+F5).
6) Let the cart oscillate until it sits at equilibrium position and stop collecting data. Should have something like this:



7) The red line is the distance from the sensor bar in meters.
   a) Right click and select “Save Image As…” You will need to save it to a memory stick/SD card for use in your report.

b) Record the initial distance from the sensor bar (in the above image it is about 0.45 m) by placing your mouse above the initial flat line.
c) Place the mouse over each red peak and record the distance and time ordered pair to four decimal places.
d) This data will be inputted into the Excel spreadsheet program provided. The program will automatically calculate the magnitude of the amplitude for the data and graph it with respect to time.
e) Record the total mass of the cart, wiimote, and the blue putty in kg.

8) Input the data from (7) into the Excel spreadsheet named Spring_Oscillations_Ramp_Lab.xlsx. Delete or add rows of data and be sure to make the appropriate changes to your graphs as well (ask if you are unsure how to do this). You will need to include your data tables and graphs into your report.
9) Place the two silver masses on the cart and repeat the experiment.

Discussion/Analysis (be sure to answer the following – they do not have to be answered in the order below)

1) The Excel graph shows the equation of best fit for the linear relationship. What does that slope represent? What force is responsible for bringing the oscillations to a stop?
2) What affect did adding the masses have on the values of your results?
3) What affect would increasing or decreasing the angle have on the data?

Physics 112: Roller Coaster Motion Lab

Purpose:

- To study and observe the motion of an object through a vertical circle and around a corner.
- To compare theoretical and experimental conservation of energy.

Materials: Hot Wheels ™ tracks and cars, slow motion camera, Tracker analysis program.

Procedure Part 1 – Making the Loop:

1. Using the components available, construct a track consisting of a loop and a corner (spaced apart using one straight section). Don't use the slingshot to launch the car, rather attach a few straight sections together and tilt it up to make an incline the car will travel down to gain speed.
    a. Experimentally determine the minimum height *above the base of the loop* the car must start to not crash.
    b. Rearrange the track to that the car goes down the loop, hits one straight section, then the corner, one straight section, and finally the loop. Then repeat section *a*.
    c. Theoretically, assuming no friction, no matter where the loop is the minimum starting height is given by the formula: $h_o = 2.5r$ where *r* is the radius of the loop. Calculate your theoretical starting height and be sure to compare that result with your experimental results in your discussion section.

Procedure Part 2 – Analyzing the loop with Tracker:

1. Set up the track with a loop.
2. Release the car from a height that will result in the car just making the loop. Record the car going through the loop in super slow motion.
3. Analyze the video with the Tracker program and generate a plot of position vs. time and velocity vs. time.
    a. What was the speed of the car as it entered the loop? ¼ the way up? ½ way (at the top) ¾ the loop? exiting the loop?
    b. How would using a larger radius change your starting height? How would it change your values from *a*?
4. In physics, problems like this are analyzed by studying the change in energy of the object. Just before you let go of the car it has stored gravitational potential energy. As it moves down the track that energy changes to kinetic (energy from being in motion). In an ideal situation (no friction, air resistance, etc.) the potential energy before release should exactly equal the kinetic energy at the bottom no matter the shape of the track or how many loops the car goes through. Answer the following at the end of your calculations section (use handbook for formulas).
    a. Calculate the gravitational potential energy before releasing the car, E_g.
    b. Calculate the kinetic energy just before entering and exiting the loop, E_k.
    c. Calculate the energy loss due to friction and other non-conservative forces for the car traveling from release to exiting the loop, W_{nc}.

Physics 112: Oscillations – Wiimote on a Spring

Objective: To learn about how different springs affect the motion of a mass attached to it.

Materials: Wiimote, springs, ruler (or metre stick).

Be careful to not overstretch the spring!

Procedure:

1. Connect the Wii remote to the PC (click on the CPU Devices shortcut on the desktop then click add a device)
2. Start *Wii Physics* and change the collection mode to measure the 1D motion, y-acceleration only.
3. Right click on the blank Wii Physics screen and select *Show Point Values*.
4. Attach the wiimote to the spring and let it hang so it is not moving. This is its equilibrium position.
5. Stretch the spring 5 .0 cm past equilibrium position and let it oscillate.
6. Collecting data by pressing ctrl+F5. Let the program run for about 8 to 10 seconds (you should see about 10 peaks).
7. Right-click on the graph and save it as an image file.
8. Repeat for a stretch length of 10.0 cm.
9. Repeat the above for two springs attached to the wiimote.

Analysis Questions

1. From your graph determine the period and frequency of the vibrations.
2. For all parts of the lab calculate the average speed of the wiimote as it oscillates. Remember: $V_{sp} = \frac{distance}{Time}$
3. What affect did stretching the spring have on its period, frequency, and average velocity?
4. What affect did adding a second spring have on its period, frequency, and average velocity?

Summarize all your data and calculations in a table.

Waves Lab

Purpose

- To study and analyze the wave properties of a spring and determine the relationship between tension and waves speed.

Materials

- Tension springs
- Slinky/spring
- Meter stick
- Timer/stopwatch

Procedure

1. Measure the mass of your spring in kg.
2. Stretch the spring. Record the distance of the stretched spring. Be as precise as possible.
3. Record the tension in the spring.
4. Send a pulse down the spring three times and record how long it takes for each trip. Take an average to obtain t_{avg}.
5. Repeat steps 1 – 4 to have a total of ten distances that cover a wide range of tensions (you should be able to increment tensions at regular intervals).
6. Take general notes on what happens to the wave as it propagates. (Does the velocity or amplitude change as the pulse travels along the spring?

Calculations

1. Place the data into then Excel file named Waves_Lab_Results_2012.xlsx. Copy the table into your lab report.
2. What do you notice about the relationship between stretch distance and time it takes the wave to travel that distance?
3. Looking at your data, does the wave speed increase or decrease as the tension is increased?
4. Include the graph from the Excel file. Theoretically that slope should equal one. Calculate your percent error using:

$$\%\ error = \frac{|Theoretical - Experimental|}{Theoretical} \times 100\%$$

Physics 112: Standing Waves Lab

Purpose: To analyze standing waves and their properties in a known string.

Part 1: Changing the Tension on the String (fixed length)

- Place a mass on the holder (max of 300 g). The tension, *T* = total mass in kg x 9.81.
- Record the length of the string, in metres, that will be vibrated.
- Turn on the power source.
- Slowly increase the voltage until you observe f_1.
- Note: You may not observe the fundamental frequency in this part as it is a low voltage; if you do not you can calculate it from your data.
- Continue increasing the voltage until standing waves are observed and record the voltage at each harmonic.
- Double the total mass and repeat.

Part 2: Changing the Length of the String (fixed tension)

- Increase the length of the vibrating string and repeat the experiment using your initial total mass from Part 1.

Calculations

- Enter your data into Excel (the formulas and graphs are pre-programmed).

Discussion Questions

1. What effect did increasing tension have on the harmonic frequency?
2. What effect did decreasing the length of the spring have on the harmonic frequency?
3. What combination of tension and length gives rise to the lowest harmonic frequencies? Highest?
4. Does the data support the theory that each harmonic is an integer multiple of the fundamental frequency (f_1), support your answer?
5. What is the rate of frequency increase (of the machine) as voltage is increased?
6. What voltage and frequency is necessary to see the 10^{th} harmonic for each part?
7. When you doubled the tension, by what factor did the frequency change?

Physics 112: Standing Waves Lab

Part 1a: Tension, T (N) = _________ L (m) = __________ Part 2a: Tension, T (N) = _________ L (m) = __________

Part 1b: Tension, T (N) = _________ L (m) = __________ Part 2b: Tension, T (N) = _________ L (m) = __________

Part 1a

Harmonic (N)	V (volts)
1	
2	
3	
4	
5	
6	
7	
8	

Part 1b

Harmonic (N)	V (volts)
1	
2	
3	
4	
5	
6	
7	
8	

Part 2a

Harmonic (N)	V (volts)
1	
2	
3	
4	
5	
6	
7	

Part 2b

Harmonic (N)	V (volts)
1	
2	
3	
4	
5	
6	

Physics 112 MacDonald

Refraction Lab

Purpose: To calculate the speed of light in a certain type of glass and tap water by first determining the index of refraction of each substance.

Materials: ray box with single slit (or a red laser)
Protractor
ruler

Procedure:

1. Place the Plexiglas on the ray.
2. With the ray box, shine a ray of light at about 5°.
3. Mark the angle of refraction (and angle of incidence if required).
4. Do steps 2 & 3 in 5° increments (should have 6 to 8 angles).
5. Repeat the experiment for tap water.
6. Measure the critical angle for each as light goes into the air.
7. Open the "Snell's Law Lab" Excel file and enter your data.
8. Use Excel to create a line of best fit.

Analysis Questions

1. Use a line of best fit to determine the slope of the graph. Use that slope to determine the index of refraction for glass and the tap water.
2. Use *your calculation* of n_i to determine the speed of light in the glass and water.
3. Calculate the critical angle for your piece of glass and water. Does it agree with your measurement?
4. Be sure to summarize the answers to the analysis questions in your discussion.

Not a Question, just some information for you:

The light coming from your ray box (and the Sun) is white light (light made up of all the colours). Technically, blue light and red light will slow down to different speeds in Plexiglas (remember, they will keep their initial frequencies), and thus have different angles of refraction when they exit the glass and enter air. For example, in Plexiglas the index of refraction for red light is 1.51 and the index of refraction for blue light is 1.54.

Images in a Converging Mirror Lab

Part I – Experimental Measurements.

Purpose: To study/test the properties of images formed by a converging mirror.

Materials: Concave mirror, mirror holder, candle and Petri dish, meter stick, and index card.

Procedure

1. Secure the mirror on a meter stick at the 0.0 cm mark using the mirror holder.
2. Find the focal length of the mirror by setting the index card beside the candle and moving the mirror back and forth until a clear image is projected on the card. This distance is 2F. Determine F and record it in table 1.
3. Do step 2 three times (total) to determine the average focal length. Record in table 1. (use excel)
4. Record in table 2 the distances that the object will be placed (do) for 2.50f, 2.00f, and 1.50f.
5. Place the burning candle at 2.50f. The flame will be the object.
6. Move the index card back and forth until a clear image is formed. Measure the image distance, image height, and flame height and record them in the table.
7. Repeat steps 6 and 7 for 2.00f and 1.50f.
8. Calculate the theoretical value for d_i using the magnification equation.
9. Perform a %Error analysis for d_i.

Table 1.

Focal Length 1	Focal Length 2	Focal Length 3

Table 2.

Object Distance	Observed			Theoretical	
	di	hi	ho	di	%Error
2.50f					
2.00f					
1.50f					

Part II – Graphical Analysis of the Mirror Equation

1. Using the same mirror, generate a total of 25 data points of d_o and d_i. Six of these d_o values should be close to your focal point. Record your data in the excel spreadsheet. Remember to give your table a name and include this table in your results section.

Analysis Questions (answer them in your lab report)

1. Excel will plot Observed d_i versus d_o and Theoretical d_i vs d_o on the same graph. Comment on the closeness of the two graphs (ideally the two graphs should overlap – what does it mean if they do not?).

2. Solve the mirror equation, algebraically, for d_i. Show your work.
   a. What are the restrictions on d_o?

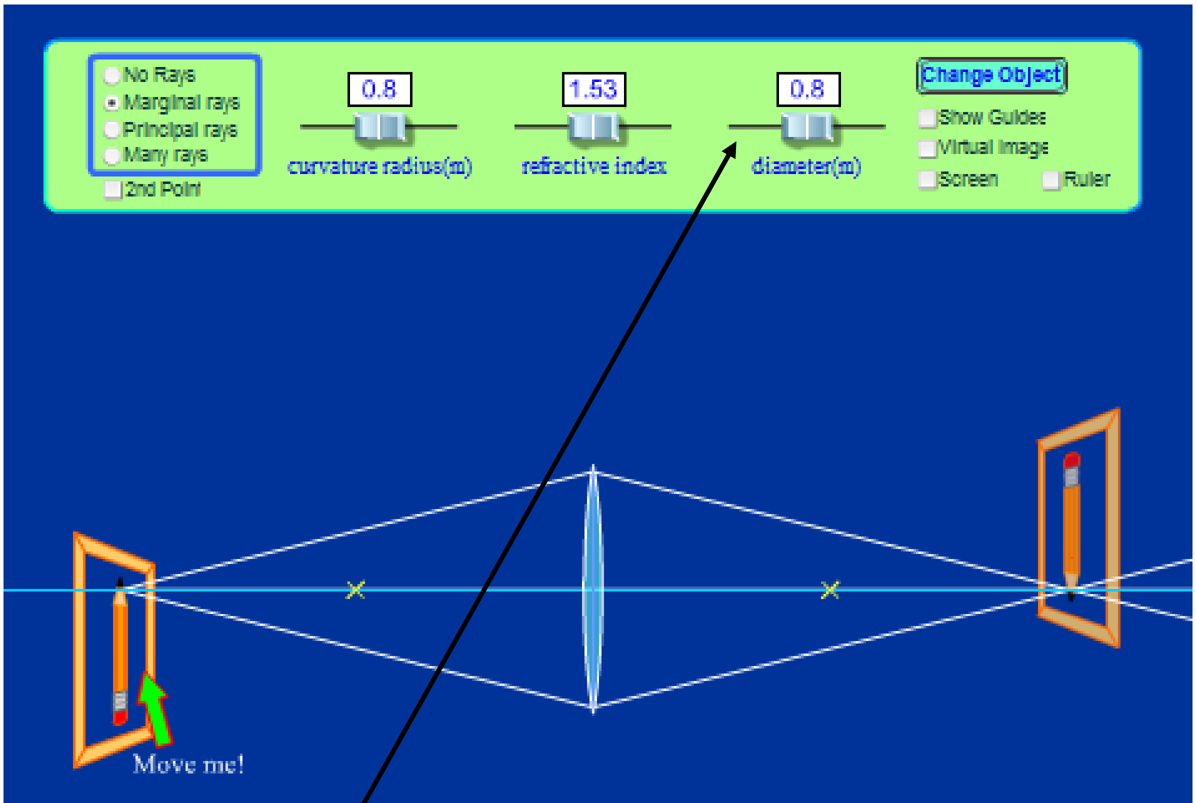
3. Use your graph from 1 to determine what value d_i converges to as d_o gets larger and larger. (theoretically this value should be your focal length, but record what you observe)
   a. Describe/show that this must be the focal length by analyzing your answer that you determined in question 2. (Think about/describe how the numerator and denominator change as $d_o \rightarrow \infty$).

4. By analyzing your graph, how can the magnification at each d_o be calculated?
   a. Provide an example calculation for a d_o value or your choosing.
   b. How does *M* change as d_o decreases? Increases?

Physics 112: Geometric Optics Virtual Lab

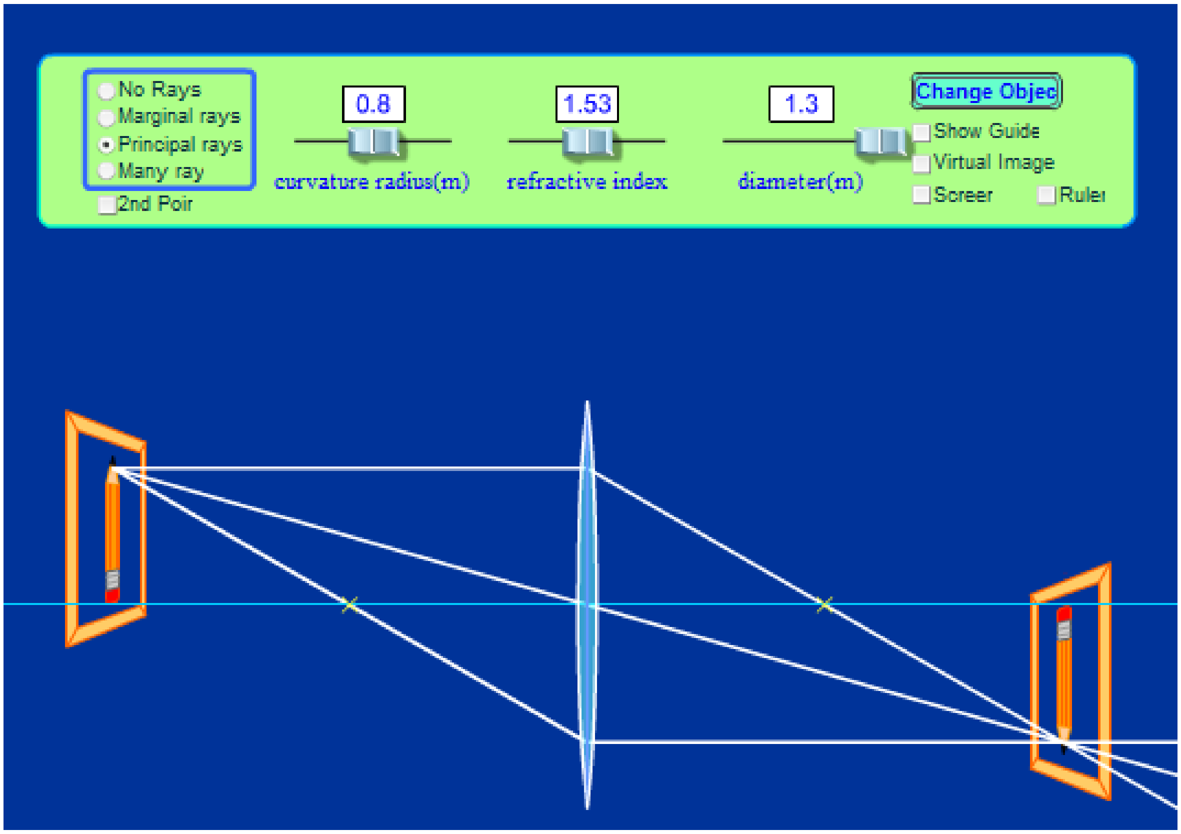
This is a program that simulates were an image forms depending on the structure of a lens. This worksheet will guide you through the different properties of refractive lenses.

1. When the program starts you should see:



2. The object is on the left and the image is on the right. First, change the diameter by sliding the button left and right. How does the diameter of a lens affect the image?

3. Move the object so that the bottom of the pencil is on the blue line. Click the principle rays button and increase the diameter to the maximum size. It should look like the image on the next page.



4. Images form where the refracted light rays meet. We will always consider light coming from the top of the object – that enables us to locate the top of the image and get an idea of its size. The lens inverts the object to make it appear upside down – our eyes do this as well. Now is a good time to introduce the terminology associated with lenses:
    - The centre of gravity (geometric centre) of the lens is called the optical centre or vertex.
    - The horizontal line that cuts through the optical centre is called the principle axis.
    - The x's on either side of the lens is the principle focus, F (the lens is symmetric so there is a principle focus on either side).

5. There are a few options for viewing how light leaves the pencil, refracts, and then forms an image. What you are viewing is called the principle rays – these are the rays we will use in our course to sketch where an image will form and how big (or small) it is. There are three principle rays:
    - A ray that leaves the pencil (object) parallel to the principle axis ←This ray will refract and pass through the principle focus on the other side.
    - A ray that is directed through V will not change direction.

- A ray that leave the pencil and passes through (or appears to have come from) the principle focus ←This ray emerges from the lens parallel to the principle axis.
- Since all three light rays came from top of the pencil the emerging light rays all pass meet at the top of the image.
- Each lens is unique. Depending on its shape and material each lens has its own principle focus (focal point).

6. How does moving the object left change the size of the image? Right? What happens to the image if the pencil is between the principle focus and the lens?

7. Change the curvature of the lens. What affect does it have?

8. Change the refractive index. What affect does it have?

9. Make the lens to your choosing. What happens to the image as you move the object farther away from the principle focus? Towards the principle focus?

10. Near the top right select the "virtual Image" box. Move your object around in the space between F and V, where is the image?
    - When an image forms on the same side of a lens as the object that image is called virtual (like a magnifying glass) because our eyes are fooled into thinking that is where the light is emanating from.
    - Images that form on the opposite side of a lens are called real images because we could put a piece of paper there and see the image.

11. Place the object at F, what do you notice about the lines on the other side of the lens? Could an image form?

12. Where can an image never form?

Mr. MacDonald **_Lenses Lab_**

Purpose

- To study the image properties of converging lenses.
- Determine the focal length of a converging lens.

Procedure

1. Place the light source (your object) a distance, *do*, from the lens and record the image distance, *di*.
2. Use the formula below to calculate the focal length f.

$$f = \frac{d_o d_i}{do + di}$$

3. Repeat steps 1 and 2 (using different object distances). Take an average of your three calculations and use that as the focal length of the lens.
4. Place your object 2 cm from your focal point and record the image distance.
5. Increase *do* by 2 cm and record *di*. Continue until you have a total 25 data points (you can use your three measurements from steps 1 – 3).

Within your discussion answer the following:

1. Your graph has a vertical and horizontal asymptote at what values?
2. The Excel file also graphs the theoretical values (based on your focal length calculation). Compare your observed values to the theoretical calculations.

Physics 112: Diffraction Lab

Purpose: To observe how the diffraction pattern depends on wavelength and distance between the diffraction grating slits. The wavelength of red and green lasers will be determined. The line spacing of a CD and DVD will be calculated.

******These laser can damage your eyes! Do not point them at people even if they are off!******

Materials: Red and green laser pointer, metre stick, known diffraction gratings, DVD, CD, and Blu-Ray

Part I: Determining the wavelength of the red and green lasers.

I. Setup the diffraction grating and record its distance to the wall and how many lines per inch on the grating.
II. Tape/secure your blank paper on the wall. Ensure that it is not too far from your grating (you should see the middle dot and at least three dots on one side. This paper is to be included in your report so label it correctly (all parts of the lab should be on one piece of paper).
III. Shine the laser through the grating and trace the pattern on the paper.
IV. Measure the distance from the centre dot to the first, second, and third dots on the right (or left).
V. Replace the diffraction grating with a different one and repeat steps I through IV.
VI. Record your numbers on the Excel file called Diffraction Lab Results (be sure to save it as a different name).

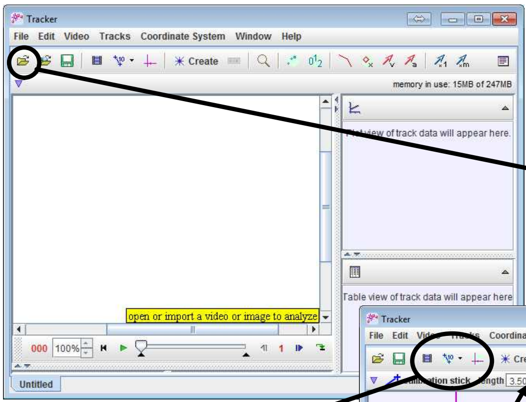
Part II: Determine the spacing between CD, DVD, and Blu-Ray tracks. (we will use factory wavelength values)

I. Set up the apparatus such that you will shine a red laser through the CD.
II. Shine the laser and trace the pattern (should see a middle dot and one dot to the right and left).
III. Repeat with the green laser.
IV. Repeat for the DVD and Blu-Ray disc.

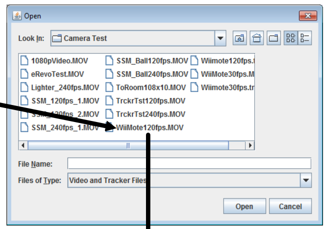
Discussion/Conclusion

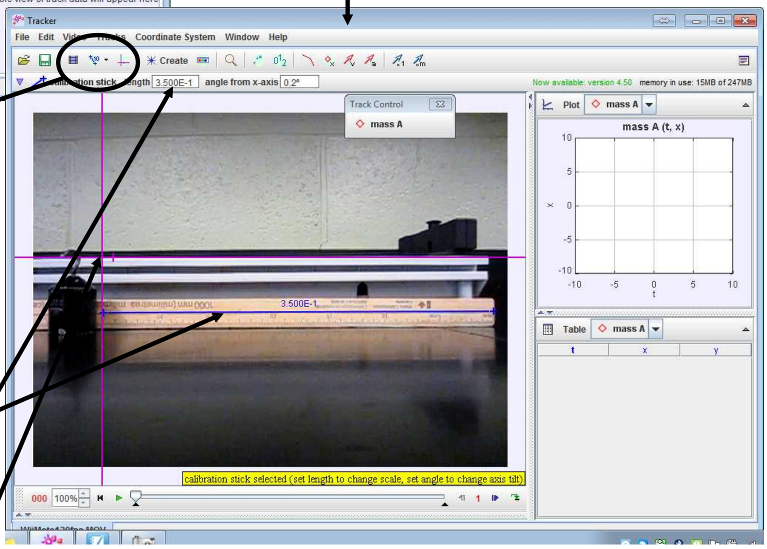
- Remember to restate the purpose of the lab.
- Be sure to include a summary of your findings and sources of error.
- Did you successfully determine the wavelength of the laser to within factory value?
- Write a few sentences concluding the lab report.
  a) Why are your findings for part II important for recording data on discs?
- I will print your data table for you or you can copy it into your lab book.

Tracker: Quick Start Guide



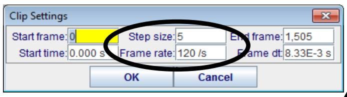
Click to load a file or video.



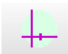


Before collecting data you need to adjust the frame rate information, scale, and set up a coordinate system.

Change frame rate to read the amount of fps setting of the camera and make the step size 5.



Click to set up the **calibration stick**. This is the relative scale of the video. In the yellow box type the scale.

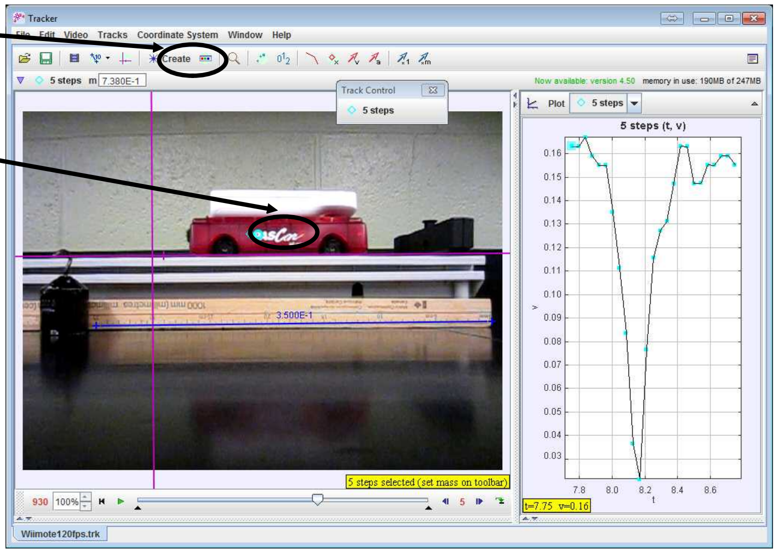


Click this to set up your coordinate system. The origin (0,0) is where the lines cross.

You are almost ready to collect data!

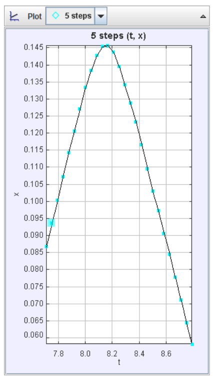
Next hit "create" and select point mass. When you click on the track control you should change its name to represent the object you are tracking.

Now, hold the shift key. The mouse cursor will turn into a square with a cross-hairs in it. Move it to the point you want to track and click the left mouse button. The program will automatically skip to the next frame. Repeat the process to track the same point on the object as it moves in the video.



Your data will automatically be stored and displayed in a graph. Note that when first started you may see your raw data displayed in a table below your graph.

In the image above it is graphing the objects velocity as a function of time. By default you will see distance vs. time. Using the data from this video we get the graph to the right:



Clicking on the "x" or "t" allows you to change the data displayed in the graph. Each graph can be printed, copied, or saved as a separate image to include in reports. The raw data can also be exported to a spreadsheet program like Microsoft Excel.