PHYSICS 203

Measurement Lab

Materials: Ruler and stopwatch (cell phone has stopwatch function), coin (quarter, penny etc.), book or ream of paper.

Introduction

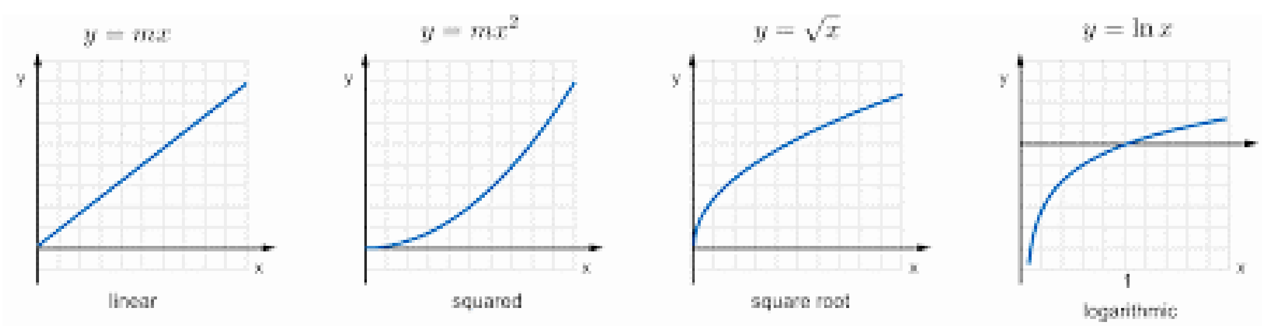
Any physical science requires measurement. This lab involves making several measurements of some fundamental units of measure: length and time.

Also, in physics, we often use functional relationships to understand how one quantity varies as a function of another. For example, if you apply a constant force to an object, the acceleration of the object will be directly proportional to this force: $a \propto F$

This is an example of a *linear* relationship. This lab will explore other relationships in the context of physical measurements.

Below in Fig. 1, are several different *functional relationships* between x and y which are likely to come up in physics.

Figure 1: Graphs of some functional relationships



Part I – Time measurement:

Use stopwatch to measure the time between your heartbeats. Record this information for use in your lab report. *<u>*Note: this is not the beats per minute, but rather, how many seconds pass between each heartbeat.</u>*

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Part II - Use google maps to estimate the value of Pi:

Using Google Maps, find three circular features each having a different diameter. Then, measure circumference and diameter of each one using the maps interface. (Here's how if you're not familiar) In your lab report, indicate which features you've recorded the information on and place your measurements of circumference and diameter in Table 1 below. Plot a graph with circumference on the Y-axis and Diameter on the X-axis. Determine the slope of this graph.

Table 1. Data from circular objects on Google Maps

Object Number/Name	Diameter, d (m)	Circumference, C (m)
1		
2		
3		

Here is url for Google maps, use ctrl + click to follow link:
http://maps.google.com/

Hint 1: You will need to find either a geological or man-made feature that is large and circular.

Hint 2: Usually, when a meteor strikes the earth, it leaves a large crater behind that is generally circular. Can you find any of those? Also, there are very large circular tanks near many cities for storing things.

Hint 3: Okay. If you have not found any circles yet, here are some -

A crater in Quebec

Storage tanks in New Jersey

Painted circles at Newark Airport

Industry Pond, Queens

Houston Astrodome

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[Epcot Center]

[Stadium in Washington DC]

[Weird Neighborhoods in Arizona]

[The largest circular racetrack, Italy.]

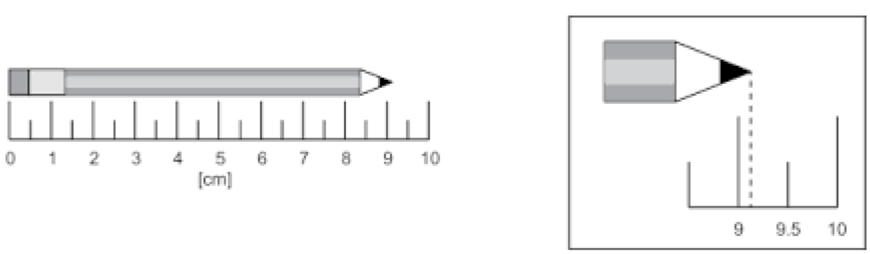
What is your estimate of Pi from this exercise?

Uncertainty in Measurements

From the above measurement, you've probably discovered that your value of π differs from the accepted value of 3.14159... It might be a little higher, or a little lower depending on how good your measurement was. This degree of 'goodness' will be determined by many factors: the quality of the instruments, their inherent resolution, your skill as an experimentalist, etc. We can quantify this 'goodness' by considering the **error** associated with the measurement. In science, *error* does not mean a mistake, or mess-up, or incorrect answer, as it does in common speech. In science measurements, error specifically refers to how confident we are in our measurement. The bigger the error, the less confident we can be about our measurements. Our measurement can still be correct, we just are less certain about it.

We will consider the error associated with a simple length measurement first. Below is a picture of a pencil being measured by a ruler.

Figure 2: Measurement of length of Pencil



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We can see that the pencil is greater than 9 centimeters long, but less than 9.5. Because of the spacing of the marks on the ruler, we can only be so certain about this measurement. We can of course see that the pencil is kind of close to 9.25 centimeters. Thus, generally, we'll say that the uncertainty in this measurement is equal to one half of the smallest spacing on the ruler, which, on this ruler is 0.5 centimeters.

$\delta L = 0.5/2 = 0.25$cm

Thus, the measurement we'll report for this pencil is: 9.25±0.25 cm.

Part III – Linear measurement:

Use your ruler to measure items listed in Table 2. Include measurement error of ruler. This section includes conversion of metric units.

List exact name of object you used in your experiment activity.

Table 2: Linear measurement of objects

Object	millimeter (mm)	centimeter (cm)	meter (m)	kilometer (km)	Error in Ruler, δL
Diameter of coin					
Width of one of your thumbs					
Length of book/ream of paper					
Height of book/ream of paper					
Width of book/ream of paper					
Length of pen/writing instrument					

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Part IV – Measure your walking step length:

Use a piece or tape, edge of a tile, shoe, book or other item to mark starting point on the floor. Walk three normal paces forward from your starting point. Place an object to mark this end point. Measure distance between start and end points. Divide this distance by three to get average distance covered during one walking step. Record data in Table 3. Alternatively, you can measure one step as shown in Figure 3. However, because it is just one step you are consciously taking for a measurement, you tend to have a longer step.

Figure 3: Measuring one step.

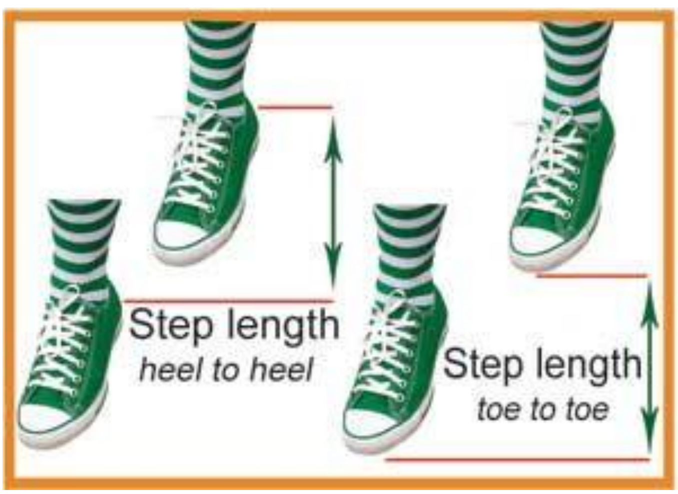

Table 3: Walking distance data

Distance	Centimeters (cm)	Meters (m)	Kilometers (km)
Distance covered with three steps			
Average distance covered with one step			

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On average, how many steps do you need to take to walk one kilometer?

Use your stopwatch to time yourself walking ten steps. Time for ten steps - ____

Determine how long it takes you to walk one step. Time for one step - ___

What is your average rate of walking in cm/s, m/s and km/h?

Record all your data for submission in your lab report.