M6b: Physics Tools – Instruments, Measurements and Analyses

Introduction:

Precise and accurate measurements are the cornerstone not just of physics experiments, but also of physics itself, and the sciences in general. In order to make accurate measurements, it is necessary to take those measurements using the proper instrument. Being familiar with the appropriate use of the equipment is also important. If the correct equipment is being used incorrectly or inaccurately, then the measurements will be flawed. In either case, with incorrect measurements, the results of any experiment will be inaccurate, and the experiment may need to be repeated, resulting in more time spent in the lab.

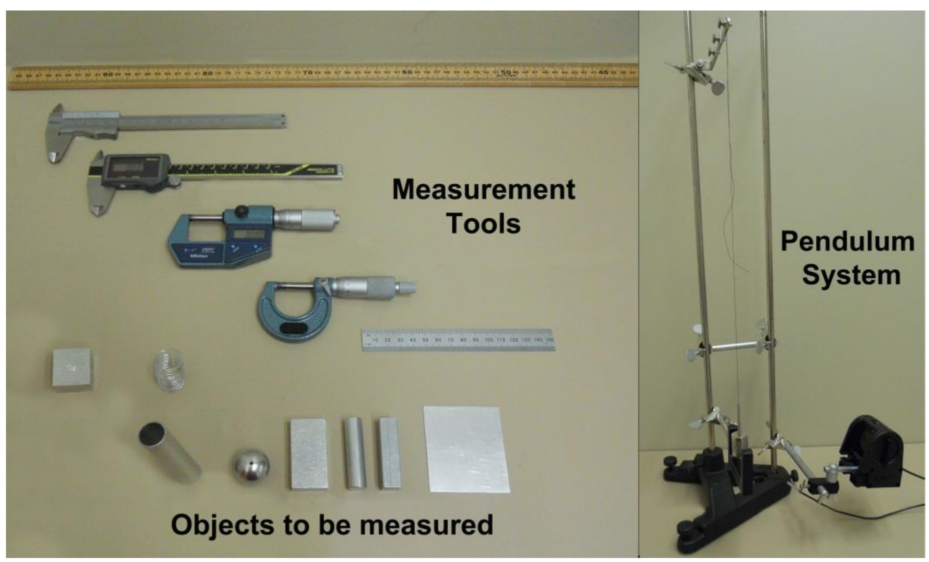
The focus of this current experiment is on learning how to use the different tools of measurement properly, and also on learning how to select the correct measuring tool for the task. By taking several different measurements of mass, length, and time for different objects in different situations, it becomes possible to familiarize one's self with the West Campus Physics Laboratory's measuring apparatuses. This familiarity will prove to be extremely important for all future physics experiments performed throughout the semester.

After collecting the different measurements, those values will be used to calculate the volume and density of the material. Part of the calculations will involve statistical analyses of the data. Finally two statistical graphs of the data will be developed, using excel, to demonstrate additional analyses techniques often required to determine appropriate conclusions.

Remember, when collecting data and taking measurements, and also when performing calculations, to pay careful attention to the units of measurement; units of measurement must be consistent. Also, all measurements used for experiments performed here in the lab should be made in the metric system (usually **SI -** meters, kilograms, and seconds; sometimes **CGS** – centimeters, grams, and seconds), unless explicitly stated otherwise.

Apparatus:

- 1 metal cube
- 1 thin metal sheet
- 1 solid metal cylinder
- 1 metal tube
- 1 lengths of wire
- 1 metal sphere
- 2 metal rectangular parallelepiped
- 1 meter stick
- 1 metal rule
- 1 each vernier caliper & digital calipers
- 1 each micrometer & digital micrometer
- 5 electronic mass scales
- 1 mechanical mass scale
- Complete Pendulum System (includes support structure, pendulum bob, photogate, rangefinder)



Procedures:

This lab consists of four parts, all of which are related to the central concept of measurement, and all of which are geared to providing the understanding necessary in order to operate the different measuring apparatuses in the physics laboratory. Be sure to follow the instructions to each of the different parts of this experiment exactly. **Also, please be sure to seek assistance from a lab instructor before beginning any experiment this semester.**

PART I Complete Table 1 and Table 2

1. Measure the dimensions of the cube using all of the available tools provided with the apparatus: meter stick, metal rule, vernier caliper, digital caliper, micrometer, digital micrometer. In the table include all of the following information:
    a. The range each tool can measure
    b. The precision of the measurement each tool can make and the amount of error in the measurement
    c. The units of measurement for the tool
2. Measure the mass of the cube using all of the available mass scales available in the lab. Be certain to include scale resolutions to 1-gram, .1-gram, .01-gram, .001-gram and .0001-gram. Also in the table include all of the following information:
    a. The range each tool can measure
    b. The precision of the measurement each tool can make and the amount of error in the measurement
    c. The units of measurement for the tool

PART II Complete Table 3

1. Using the most precise measurements from **PART I** calculate the volume of the cube. Now calculate the mass per unit volume of the cube.
2. Select the thin metal sheet and measure its mass and dimensions using the most precise tools available. Calculate the surface area of the sheet. Now calculate the mass per unit area of the metal sheet.
3. Select the thin metal wire and measure its mass using the most precise mass scale available. Carefully extend the wire and measure its length as precise as possible. Calculate the mass per unit length of the wire.
4. Measure the diameter of the wire carefully using the most precise tool available. Repeat the measurement at different locations along the wire for a total of seven measurements. Calculate the mean for the measurement. Also calculate the standard deviation for the measurement. Note: It's suggested to use Excel for these statistical calculations.

Part III Complete Table 4

1. Measure as precisely as possible the dimensions of each of the following items: the sphere, the cylinder, the tube and both rectangular parallelepipeds.
2. Measure the mass of each item also as precisely as possible.
3. Calculate the volume of each item.

4. Construct a graph using Excel to determine the mass per unit volume (density) of the material. Hint: mass on y-axis and volume on x-axis. Determine statistically the slope and the standard deviation.

PART IV Complete Table 5

1. Adjust the length of the pendulum arm, for a length of .600 meters. Note: this is the distance from where the string is tied on to the upper rod to the center of mass of the pendulum bob. While conducting these time measurements with each tool also include the following information:
   a. The range each tool can measure
   b. The precision of the measurement each tool can make and the amount of error in the measurement
   c. The units of measurement for the tool
2. Pull the pendulum bob back approximately 10 cm from its hanging position and release it so that it swings back and forth through the photogate. Using the analog clock, count the number of pendulum swings that occur in one minute. One swing may also be called one complete cycle and is from the position of the pendulum bob at its peak height position on one side until it returns back to the same position. Calculate the time for one cycle.
3. Using a similar technique with the pendulum as step-2 now measure the time for the pendulum to complete 25 cycles with the digital stopwatch. Calculate the time for one cycle.
4. Adjust the pendulum bob's position so that it is aligned with the range-finder. Start the DataStudio software and load the routine labeled M6b. The program should self–initialize once loaded, indicated by an active start button. Start the pendulum swinging as before and then click on the start button. Collect 20 seconds of data. Using the software's smart tool measure the time for ten cycles. Calculate the time for one cycle.
5. Have one of the lab assistants demonstrate the curve fitting features built into the software.
6. Adjust the pendulum bob's position so that it is now aligned with the photogate. Again start the pendulum swinging as before and then click on the start button. Collect data for 25 cycles. Record the mean and standard deviation of the measured time.
7. Adjust the length of the pendulum arm to .550 meters. Check the alignment of the pendulum bob with the photogate. Again start the pendulum swinging as before and then click on the start button. Collect data for 25 cycles. Record the mean and standard deviation of the measured time.
8. Repeat the sequence in step-7 for an additional 8 trials using pendulum arm lengths of: .500 meters, .450 meters, .400 meters, .350 meters, .300 meters, .250 meters, .200 meters, .150 meters.
9. Using the data collected with the pendulum and photogate construct a graph of: the time for one cycle as a function of the pendulum arm length. Use Excel to construct the graph. This graph is not a linear relationship. Fit the graph with the appropriate type of trendline and include the equation with statistics.

Experiment M6b: Physics Tools

Student Name____

*Lab Partner Name*____

*Lab Partner Name*____

Physics Course____

Physics Professor______________________________________

Experiment Start Date__________________________________

Lab Assistant Name	*Date*	*Time In*	*Time Out*

Experiment Stamped Completed

Data Sheet 1: M6b: Physics Tools

Table 1: Dimension Measurements of Cube

Measuring Tool	Range	Precision & Error	Units	Measurement Length, Width, Height

Data Sheet 2: M6b: Physics Tools

Table 2: Mass Measurement of Cube

Measuring Tool	Range	Precision & Error	Units	Measurement

Data Sheet 3: M6b: Physics Tools

Table 3: Mass, Dimensions & Density: 3-Dimensionsal, 2-Dimensional, 1-Dimensional

Volume of Cube	
Mass per unit Volume of Cube (mass volume density)	
Mass of Sheet	
Dimensions of Sheet Length, Width, Thickness	
Surface Area of Sheet	
Mass per unit Area of Sheet (mass surface density)	
Mass of Wire	
Length of Wire	
Mass per unit Length of Wire (mass linear density)	

Diameter of Wire						
Mean Diameter of Wire				Standard Deviation		

Data Sheet 4: M6b: Physics Tools

Table 4: Mass, Dimensions, Volume

Item Description	Mass	Dimensions	Volume

Data Sheet 5: M6b: Physics Tools

Table 5: Time Measurements

Measuring Tool	Range	Precision & Error	Units	Measured Time & Number of Cycles	Time for 1 Cycle	Measured Length
Analog Clock						
Digital Stopwatch						
Computer Rangefinder						
Computer Photogate						