Name: _____

Lab 16. Measurement

Introduction

Overview

Science describes the physical world through measurement. Almost all scientific experiments involve measurement, the assignment of numbers to certain properties. A fundamental assumption of science is that some of these properties are meaningful, and that the numbers associated with them are meaningful as well.

Measuring Instruments

Here is an overview of the measuring instruments you will be using in this lab:

RULER: Simple as it is, the ruler or meter stick is often used incorrectly. Your eye must be positioned directly over the ruler when taking a reading, so that the ruler is perpendicular to your line of sight. If you try to read the ruler at an angle, your measurement will be too high or too low. (This is a common error called **parallax**.)

VERNIER CALIPERS: Many metric scales have one millimeter as their smallest division. You need to estimate the tenths of a division for a best measurement. A vernier allows you to estimate this fractional part precisely. It has a main scale and alongside of this, a vernier scale. The vernier scale has 10 marks in the length of 9 marks on the main scale. The left-most mark on the vernier scale is the zero marker. Use it to read the whole number of divisions. Then obtain the fractional part of one division by observing which of the ten vernier marks lines up best with a mark on the main scale. The number of this mark is the fractional digit of the measurement.

TRIPLE-BEAM BALANCE: Follow these steps when using this balance:

1. Slide all sliders to the left. The pointer at the right should point exactly at the center of the indicator mark. If not, adjust the screw to the left of the pan.
2. Place the object to be weighed on the pan.
3. Advance the heaviest slider, one notch at a time, until the pointer swings below the indicator mark. Then slide it back one notch.
4. Repeat for each lighter slider in succession until balance is obtained. The lowest bar does not have notches. Report the last digit estimated between the closest marks on the scale.

HANGING SPRING SCALE: This measures the extension of the internal spring in response to tension on the hook. To get a stable reading, the body of the scale must be held firm. Hang the scale from a stable support, and hang its load from the hook. Allow the length of the spring to stabilize without interference. Report the last digit between the closest marks on the scale.

GRADUATED CYLINDER: You will notice that the surface of the liquid is not flat and level, but instead is curved, lower in the middle and higher at the edges of the tube. This curved surface is the **meniscus**. Read the position of the *bottom* of the meniscus. Since the meniscus is

at the center of the tube and not right next to the marked scale, you must position your eyes at the level with the meniscus.

Materials and supplies

Mass: Triple beam balance, spring force meters, disk weights, density cubes

Length: Ruler, meter stick, measuring tape, Vernier calipers, pencil, penny, lacrosse ball

Volume: 100-ml Volumetric flask, 100-ml graduated cylinder, 100-mL beaker, plastic wash bottle, pipet, sponge, stopwatch

Mass: aluminum track, tape, support block, rolling cylinder, stopwatch or phone with timer app

Measuring

The activities in this lab do not need to be done in order, so if an apparatus that you have not used is free, step up and use it.

Mass

Although this lab is essentially an individual lab, you may, to save time on the balance, perform there measurements as a group, as long as **every group member** performs **at least one** of the measurements with the triple beam balance.

Use the triple beam balance to find the masses of the disk weights.

Description	Mass

Use the triple beam balance to find the masses of the density cubes.

Description	Mass

Use the spring force meter to find the masses of the density cubes.

Description	Mass

Length

Look at the meter stick, the ruler, the measuring tape, and the calipers. Where does the scale begin (where is the zero mark or setting) for each one?

Meter stick _____

Ruler _____

Measuring tape _____

Calipers _____

Measure the length of the pencil with the meter stick. _____

Measure the length of the pencil with the ruler. _____

Measure the length of the pencil with the measuring tape. _____

Measure the width of a pencil (smallest or largest width?) with the Vernier calipers.

_____

Measure a side of a density cube with the ruler. _____

Measure a side of a density cube with the calipers. _____

Examine the lacrosse ball. Imagine trying to measure the diameter of the lacrosse ball. What difficulties would you encounter if you tried to find the ball's diameter with the ruler, meter stick, measuring tape, or Vernier calipers?

Propose a device that would allow you to accurately find the radius of the lacrosse ball. How would it operate?

Time

Place the cylinder at the 10-cm mark of the inclined aluminum track. Release it from rest and allow it to roll down. Catch the cylinder before it rolls off the table. Time how long it takes for the cylinder to reach the 110-cm mark. Repeat for five independent measurements.

_____ _____ _____ _____ _____

Are the five measurements similar to each other? _____

_____

Volume

Put some water into the volumetric flask so that the bulb is completely full. Pour the water from the flask into the beaker. It is awkward, so practice until you become accustomed to the process.

Practice pouring from the beaker back into the volumetric flask. This should be easier, because beakers are designed for pouring.

Fill the volumetric flask exactly to the mark with water. Show it to your instructor for approval.

_____

Pour the contents of the volumetric flask into the graduated cylinder.

What is the volume reading on the graduated cylinder? _____

What is the appearance of the drained volumetric flask? _____

_____

Pour the contents of the graduated cylinder back into the volumetric flask. Use care; you should be able to pour cleanly without using a funnel. Is the liquid exactly to the mark? _____

Fill the beaker to its 100-mL mark with water. Pour this water into the graduated cylinder. What is the volume reading on the graduated cylinder? _____

You might wonder how we can deliver precise volumes of liquid. There are devices for accomplishing that, but they do not include graduated cylinders or volumetric flasks!