8 mins. Lecture / Demonstration; 12 mins. Student Practice

Lecture #1: Triple-beam Balance

Explain terms: (mass) rider
beam
adjustment screw
pan
pointer

A. Move all mass riders to zero.
B. Zero the balance with the adjustment knob. Do this *each time* you use the balance!
C. Pointer settles at zero or swings equal amounts above and below zero mark.
D. Place object to be measured on the pan.
D. Move *only* one mass rider along the beam at a time, moving from the most to least massive.
E. When the pointer drops down below the zero mark, move the mass rider *backward* to the next notch on the beam.
F. Continue moving one mass rider at a time until you get to the smallest mass.
G. Move the smallest mass until the pointer settles at zero or swings equal amounts above and below zero mark. There are *no notches* on the least massive rider.
H. Tap the smallest rider gently with a pencil tip for better control.
I. Read the measurement by looking ***directly*** at it (*not* from an angle), ***estimating*** the last digit and including the *unit of measurement*.
J. FYI's:
   1. Never put a hot object directly on the pan. Air currents developing around the hot object may cause massing errors.
   2. Never pour chemicals directly on a balance pan. Dry chemicals should be placed on paper or in a glass container. Liquid chemicals should be placed in glass containers.
   3. If using a container, obtain its mass first and then deduct that from the total to obtain the mass of the material it contains.
   4. ONLY pick it up by holding the base.
K. ***Miscellaneous:*** Show how to remove an electrical plug from an outlet.

Lecture #2: Meter Stick

Explain markings: meter
decimeter
centimeter
millimeter

Explain relationship among various markings, including *powers of ten* (the logical base of the metric system) and how to *move the decimal* when *converting* between units.

A. Set the ruler on the thinnest edge.
B. Set the ruler so that the beginning of the object being measured is lined up with a *visible* mark.
C. If the zero mark is not visible, use the one, two, or ten centimeter mark.
D. Subtract the initial mark from the ending mark to get the correct length.
E. Read the measurement by looking ***directly*** at it (*not* from an angle), ***estimating*** the last digit and including the *unit of measurement*.

Lecture #3: Graduated Cylinders

Explain terms: graduation line, cylinder, meniscus, pipette

Equipment: graduated cylinders, various sizes; various solid cubes (multiples of cm^3); beaker of vinegar; goggles

A. Determine what each graduation indicates in units. Select cylinder size for most accurate measure.
B. Demonstrate filling a graduated cylinder to a certain measure, finishing with a pipette.
C. Demonstrate ***how*** to read the meniscus.
D. Demonstrate how to measure the volume of an irregularly-shaped object by noting the liquid amount both before and after inserting the object, which must be completely covered by the liquid for a correct reading.
E. Explain the uncertainty of guessing any amount of liquid that rises above the last graduation line.
F. Show how to read the measurement by looking ***directly*** at it (*not* from an angle), ***estimating*** the last digit and including the *unit of measurement*.
G. FYI's:
   1. Show how to measure the volume of a regular solid (length x width x height). Note L, W, & H are arbitrary.
   2. Note that cm^3 (cc) & ml (mL) are equal amounts; one is a solid, the other a liquid.
   3. Compare 1 ml cubes with 10 ml graduated cylinder.

J. ***Miscellaneous:*** Demonstrate how to safely determine the odor of a chemical (with **goggles** on).

Lecture #4: Thermometers and Temperature Conversions

History Lesson:

The first to seal mercury in a glass rod was Daniel Fahrenheit in Germany (1709). He had to build a scale from scrap : zero was allocated to the temperature of a salty mixture, assuming that nothing could ever be colder and 96 was his estimate of the human body. With such a scale, water would freeze at 32 and boil at 212.

In 1730, in France, Rene Antoine Ferchault de Reaumur built the first alcohol thermometer. He allocated 0 to freezing water and 80 to boiling water.

In 1742, in Sweden, the astronomer Anders Celsius used a scale allocating 100 to freezing water and 0 (!) to boiling water. His scale was later inverted (0 to freezing water and 100 for boiling) and long known as "centigrade".

Comparing the scales: 9 ° Fahrenheit = 4 ° Reaumur = 5 ° Celsius

° C = (F - 32) x 5/9   ° F = 32 + C x 9/5

The two scales meet at - 40: - 40°F is the same as - 40°C

Starting from the absolute zero (at -273.15 C or -459.67 F), it was tempting to follow the old idea of Fahrenheit and have only a positive scale. This was done by Sir William Thomson, Lord Kelvin, from the Celsius scale. Thus the ° C + 273.15 equals ° K.

Water is freezing at 273.15 K, and boiling at 373.15 K

The SI uses the Kelvin scale, defined by the triple point of water (at 273.16 K or 0.01?C) and absolute zero.

Triple point of water

The single combination of pressure and temperature at which water, ice, and water vapour can coexist in a stable equilibrium occurs at exactly 273.16 K (0.01 °C) and a partial vapour pressure of 611.73 pascals (ca. 6.1173 millibars, 0.0060373057 atm). At that point, it is possible to change all of the substance to ice, water, or vapor by making arbitrarily small changes in pressure and temperature.

Water has an unusual and complex phase diagram, although this does not affect general comments about the triple point. At high temperatures, increasing pressure results first in liquid and then solid water. (Above around 10^9 Pa a crystalline form of ice forms that is denser than liquid water.) At lower temperatures under compression, the liquid state ceases to appear, and water passes directly from gas to solid.

At constant pressures above the triple point, heating ice causes it to pass from solid to liquid to gas, or steam, also known as water vapor. At pressures below the triple point, such as those that occur in outer space, where the pressure is near zero, liquid water cannot exist. In a process known as sublimation, ice skips the liquid stage and becomes steam when heated.

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A. Explain the difference between the Celsius, Fahrenheit, and Kelvin scales.
B. Demonstrate immersing the thermometer bulb into the *center* of the liquid.
C. Do not stir with the thermometer.
D. Read the measurement while the thermometer is still immersed or it will start to change as it begins to read the air temperature.
E. Do not "shake down" the thermometer when finished.
F. Read the measurement by looking ***directly*** at it (*not* from an angle), ***estimating*** the last digit and including the *unit of measurement*.

Physics is the science of measurement.

When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind. It may be the beginning of knowledge, but you have scarcely advanced to the state of science.

Lord Kelvin (1824 - 1907)

German chemist Emil Erlenmeyer created the **Erlenmeyer flask** in 1861. The narrow neck allows it to be stoppered using rubber bungs or cotton wool. The conical shape allows the contents to be swirled or stirred during an experiment (as in titration); the narrow neck keeps the contents from spilling. The smaller neck also slows evaporative loss better than a beaker. The flat bottom makes it unlikely to tip over, unlike the round-bottomed Florence flask. A wire gauze mesh or pad is placed between the ring and the flask to prevent flames from directly touching the glass.