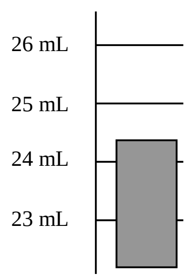
Introduction: Measurements and Significant Figures

ESTIMATING BETWEEN MARKED DIVISIONS

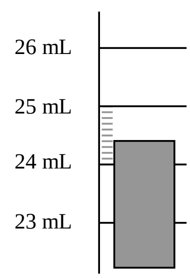
Many measurements that you make in the laboratory or in a clinical setting require you to read a value from an analog scale. It is important to report all measurements to the proper decimal place to convey the level of precision of the measurement. Whenever you read a marked scale, the last digit you report as significant is the one you estimate. (Record all the values associated with the marked scale + go out one more decimal place for the estimated digit.) Follow the steps below and the accompanying examples to properly record measurements read from an analog scale.

1. determine the value associated with marked divisions on the scale
2. decide to what level of precision you can estimate values between the marks and mentally divide the space between markings
    a. a general rule of thumb is to estimate to $1/10^{th}$ of the marked divisions
    b. sometimes it makes more sense to estimate to a half, fourths or fifths depending on how close the markings are together and what the scale is
3. read the measurement by reading the scale and the est. digit based on your imagined scale
4. record the measurement and its associated precision (the last decimal place of the measurement should be the same decimal place as the ± precision)

Example A:

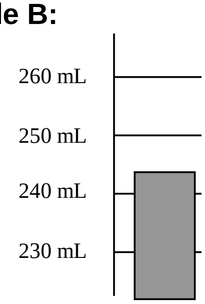


1. In this example, the markings are 1 mL
2. Mentally divide the space between mark 24 and 25 into 10 spaces as shown below

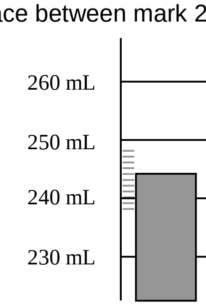


3. the bar is 24 and 4 additional “tenths”—in this case each imagined line is $1/10^{th}$ of 1 mL or 0.1 mL
4. this measurement should be recorded as 24.4 mL ± 0.1 mL

Example B:

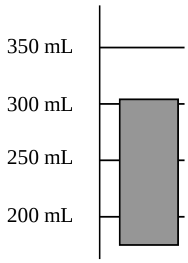


1. In this example, the markings are 10 mL
2. Mentally divide the space between mark 240 and 250 into 10 spaces as shown below

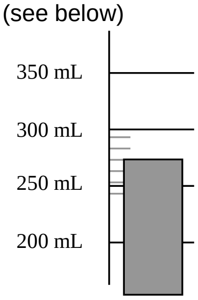


3. the bar is 240 and 4 additional “tenths”—in this case each imagined line is $1/10^{th}$ of 10 mL or 1 mL
4. this measurement should be recorded as 244 mL ± 1 mL

Example C:

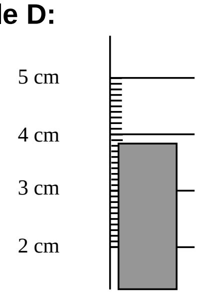


1. In example C, the markings are 50 mL apart
2. In this case, it probably makes more sense to imagine 5 spaces between marked divisions so that each imagined division is $1/5^{th}$ of 50mL or 10 mL (see below)

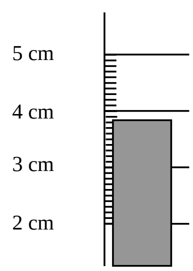


3. the bar is 250 and 3 additional “fifths”—in this case each imagined line is $1/5^{th}$ of 50 mL or 10 mL—so 250 + 3 x 10 = 280
4. this measurement should be recorded as 280 mL ± 10 mL

Example D:



1. In example D, the markings are 0.1 cm or 1 mm apart
2. Because the markings on this ruler are so close together, the best you can probably do is to imagine 2 divisions between the marks. The object would then either be “on a line” or “between” lines

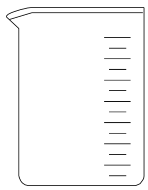


3. the bar is between the 3.8 and 3.9 cm markings
4. this measurement should be recorded as 3.85 cm ± 0.05 cm

MEASURING THE VOLUME OF A LIQUID

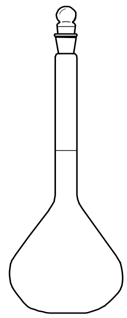
In the laboratory, liquid volumes are measured with different pieces of glassware depending on the size of the sample, the required precision of the measurement, and whether one is "containing" or "transferring" the liquid. Examples of glassware and their associated uses are shown below. In this lab, we will use graduated cylinders to measure the volume of a liquid and to measure the volume of an irregular solid by displacement (the volume of the added solid equals the volume of liquid it displaces.)

Glassware that contain a specified volume of liquid :



Beakers

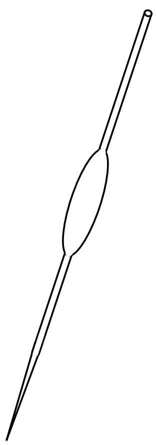
- come in various sizes
- markings allow measurement of different volumes
- not very precise



Volumetric Flasks

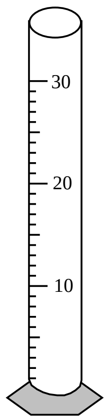
- come in various sizes
- single calibration mark so each flask measures only one volume
- very precise

Glassware that transfer a specified volume of liquid:



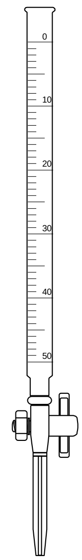
Volumetric Pipets

- come in various sizes
- single calibration mark allows delivery of only one specified volume
- very precise



Graduated Cylinders

- come in various sizes
- calibration markings allow measurement of different volumes

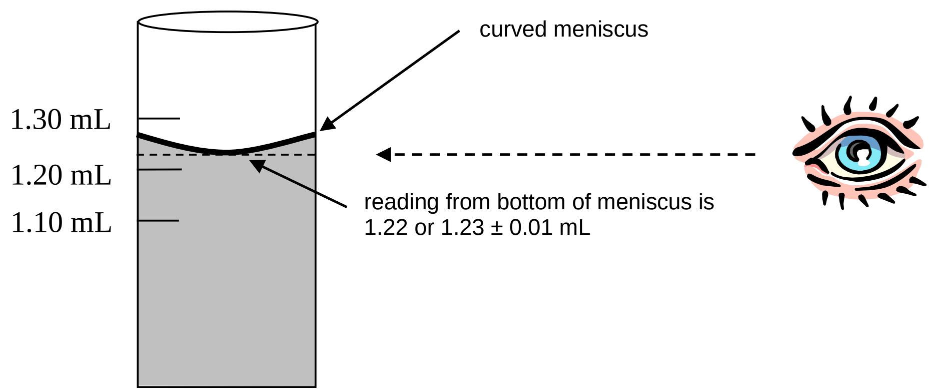


Burets

- come in various sizes
- calibration markings allow delivery of any desired volume within calibration range

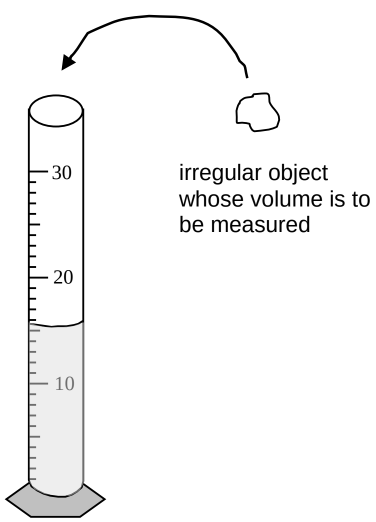
How to read liquid volumes:

When a liquid such as water contacts glass, it forms a curved surface called a “meniscus.” To properly read the level of liquid in glassware, view the meniscus with your eye at the same level as the liquid and read from the bottom of the meniscus.

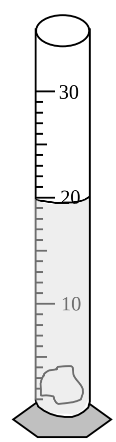


Volume by Displacement:

To measure the volume of an irregular solid, you can immerse the solid in a graduated cylinder containing water. The volume of the solid is calculated by subtracting the initial volume level of the water from the final volume level of the water and solid in the cylinder.



graduated cylinder with 15.2 mL water



graduated cylinder with irregular object immersed in water

volume of object :

final volume reading	19.4 mL
– initial volume reading	– 15.2 mL
volume of object =	4.2 mL

MEASURING THE MASS OF A SAMPLE

In the laboratory, masses are measured using balances. Balances come in different sizes and have different levels of precision. In chem 3, we will be using “top-loading” balances that can weigh samples up to 210 grams and have a precision of ± 0.001 g.

Rules for Using Top-Loading Balances:

1. Use the TARE (or Re-Zero) button to set the balance to 0.000 g.
   Always record masses to ±0.001 g.
2. Do not put chemicals directly on the balance pan—use a weighing paper or flask.
   a. the mass of the chemical is the difference between the mass of the weighing paper with the substance and the mass of the weighing paper alone
   b. alternatively, the balance can be tared with the paper or flask on the pan if desired so that the mass displayed is just that of the added sample. (make sure mass does not exceed 210 g !)
3. Always clean up any spills immediately. Notify your instructor if anything spills under the pans of the top-loading balances.
4. Only weigh items that are at room temperature.