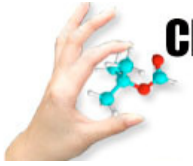
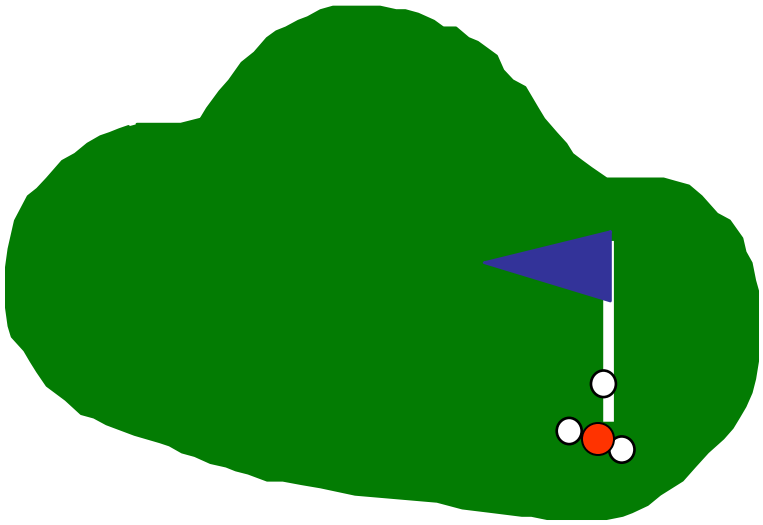
CHAPTER 1 : MEASUREMENTS

1.3
Uncertainty in Measurement



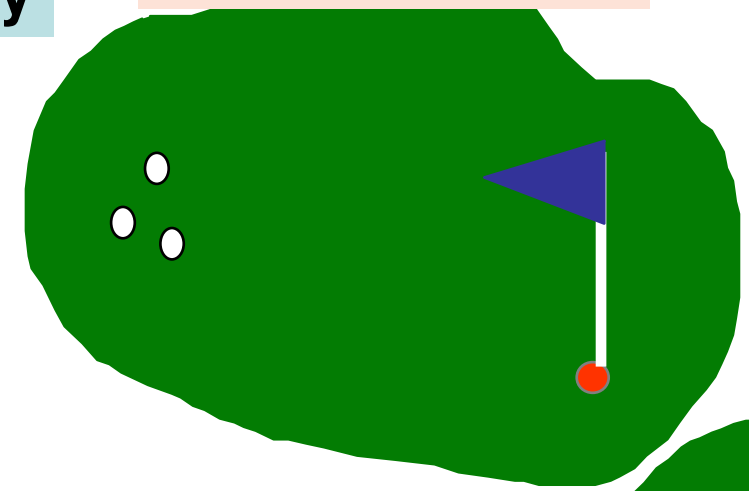
1.3
Uncertainty in Measurement

Let's use a golf analogy

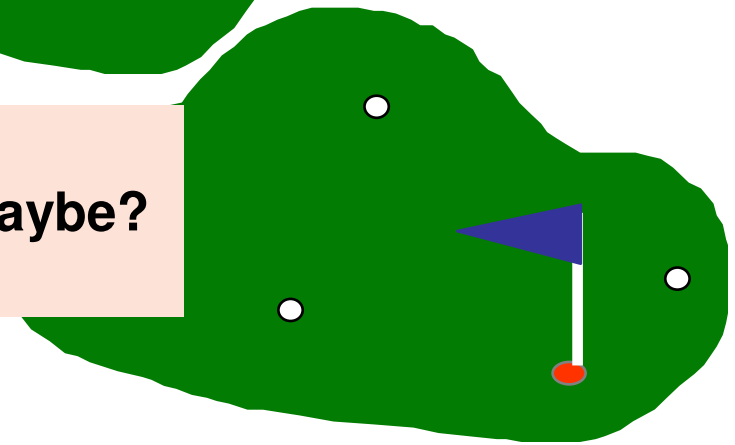


Precise?-Yes
Accurate? Yes

Precise?-Yes
Accurate? No



Precise?-no
Accurate? Maybe?

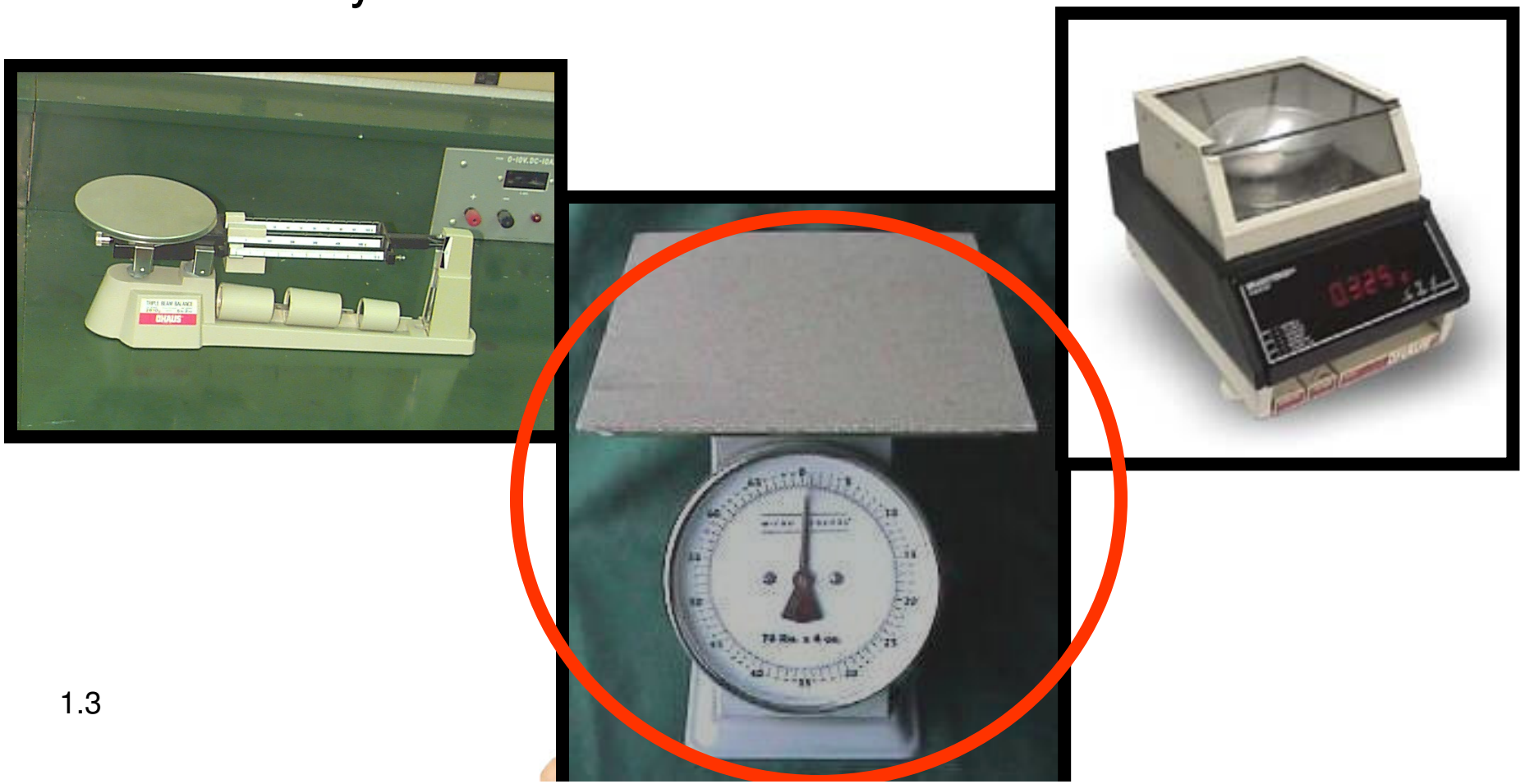


Why Is there Uncertainty?

- **A digit that must be estimated is called uncertain. A measurement always has some degree of uncertainty.**
- Measurements are performed with instruments, and no instrument can read to an infinite number of decimal places

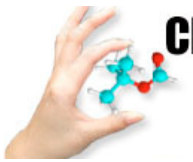
Uncertainty in Measurement

- *Which of the balances below* has the greatest uncertainty in measurement?

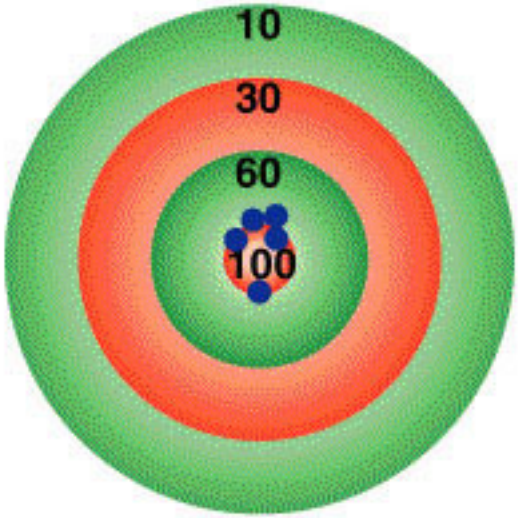


How good are the measurements?

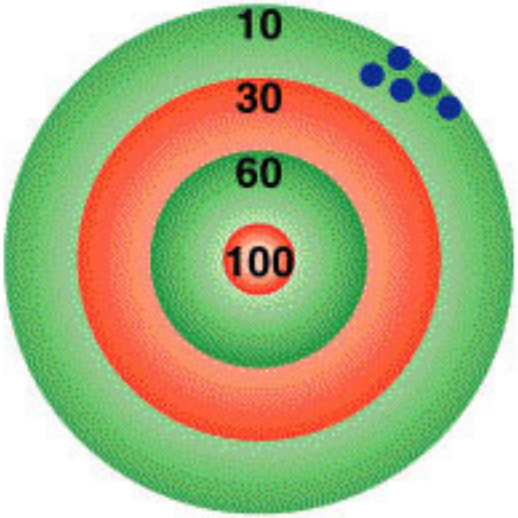
- Scientists use two word to describe how good the measurements are-
- Accuracy- how close the measurement is to the actual value.
- Precision- how well can the measurement be repeated.
- Accuracy can be true of an individual measurement or the average of several.
- Precision requires several measurements before anything can be said about it.



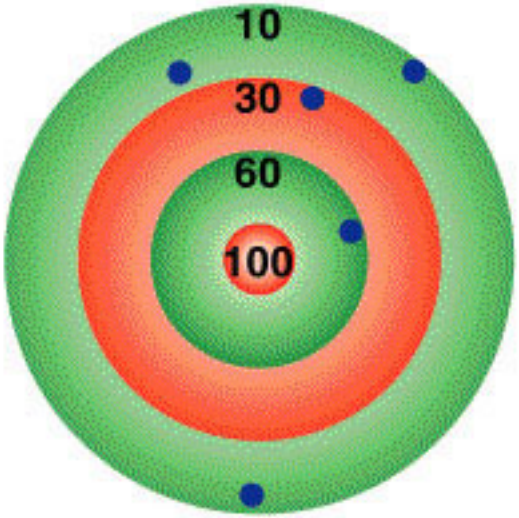
Accuracy vs *Precision*



accurate
&
precise

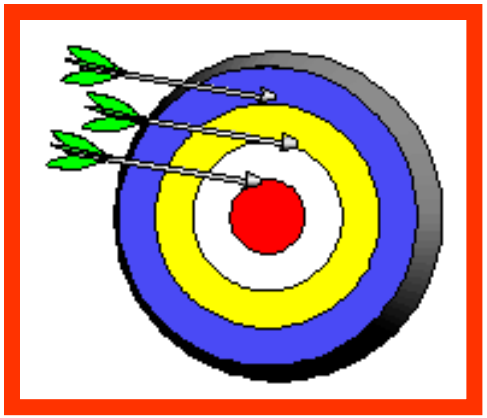


precise
but
not accurate

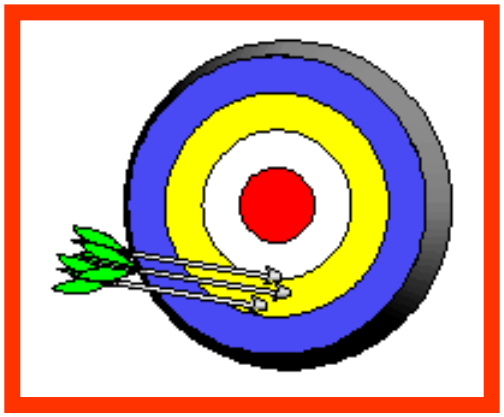


not accurate
&
not precise

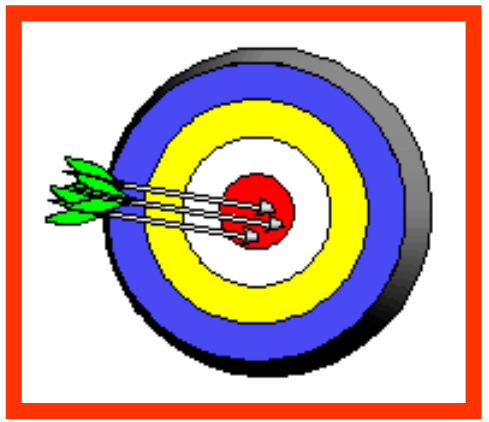
Precision and Accuracy



Neither accurate nor precise



Precise, but not accurate

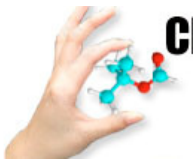


Precise AND accurate

Accuracy, Precision, and Error

- **Accepted value = the correct value based on reliable references**
- **Experimental value = the value measured in the lab**
- **Error = accepted value – exp. value**
  - **Can be positive or negative**
- **Percent error = the *absolute value* of the error divided by the accepted value, then multiplied by 100%**

$$\% \text{ error} = \frac{|\text{ error }|}{\text{accepted value}} \times 100\%$$



Types of Error

- **Random Error (Indeterminate Error) - measurement has an equal probability of being high or low.**

Systematic Error (Determinate Error) - Occurs in the same direction each time (high or low), often resulting from poor technique or incorrect calibration. This can result in measurements that are precise, but not accurate.

Practice problems

1 Three students measure the volume to be 10.2 ml, 10.3 ml and 10.4 ml .

- If the actual value of volume is 10.5ml
- Were they precise? No
- Were they accurate? No

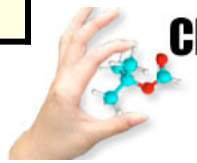
weighing	Result
1	2.486g
2	2.487g
3	2.487g
4	2.487g
5	2.487g

1.3

2 Are these values precise?

Yes

High precision among several measurements is an indication of accuracy only if systematic error is absent .



Practice problem

To check the accuracy of a graduated cylinder , a student filled the cylinder to the mark of 25ml Using a buret.following are the results of five trail :

Trial	Volume shown by graduated cylinder	Volume shown by the Buret
1	25ml	26.54ml
2	25ml	26.51ml
3	25ml	26.49ml
4	25ml	26.60ml
5	25ml	26.57ml
Average	25ml	26.54ml

Is the graduated cylinder accurate?

The results are very good in precision. However ,the average value of the buret is very different from the 25ml .

Thus the graduated cylinder is not very accurate.

Percent Error vs. Percent Difference

- Percent Error:
  - Measures the accuracy of an experiment
  - Can have + or – value

$$\frac{\text{accepted} - \text{experimetal}}{\text{accepted}} \times 100\%$$

  - Percent Difference:
  - Used when one isn't "right"
  - Compare two values
  - Measures precision

$$\frac{|\text{value 1} - \text{value 2}|}{\text{average of value 1 and 2}} \times 100\%$$

Practice problems

1 Measured density from lab experiment is 1.40 g/mL. The correct density is 1.36 g/mL.

$$\%\ \text{error} = \frac{1.36 - 1.40}{1.36} \times 100 = -2.94\%$$

- Find the percent error.

2 Two students measured the density of a substance. Sally got 1.40 g/mL and Bob got 1.36 g/mL.

$$\%\ \text{difference} = \frac{|1.40 - 1.36|}{\frac{1.40 + 1.36}{2}} \times 100 = 2.90\%$$

- Find the percent difference