Scaling & Daily Motion

Science Speak

- Approximation
- Assumption
- Extrapolation
- Goes up/falls off like/with
- Models/Theories

Performing Experiments

- Experiments must be repeatable – requires careful control over variables
- Possible outcomes of an experiment:
  - The experiment may support the theory
    - We then continue to make predictions and test them
  - The experiment may falsify the theory
    - We need a new theory that describes both the original data and the results of the new experiment
- Since we cannot do every possible experiment, a theory can never be proven true; it can only be proven false

Making Measurements

- Errors
  - Random
  - Systematic
- With every measurement, it is essential to provide an estimate of the uncertainty – the likely range of errors
- Example:
  - Using a ruler marked in mm, we round to the nearest marking – at most off by half a division, or 0.5 mm
  - Cite a measurement of 15 mm as **15 ± 0.5 mm** to indicate that the real value of the length is likely to be anywhere between 14.5 mm and 15.5 mm
  - If a theory predicts a value of **15. 2 mm,** then a reading of **15 ± 0.5 mm** is in agreement with the theory but a reading of **15 ± 0.1 mm** is probably not

Relative Uncertainty

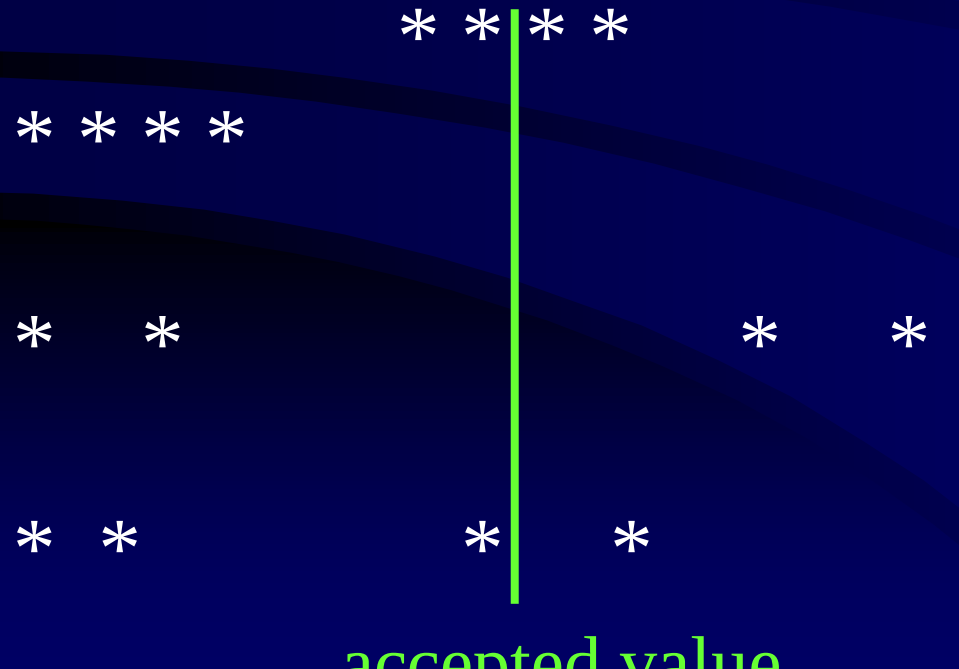
- If you have a small error and the measured length is also small, you might have a huge error!

- Use percentages:
  - Percent error = (estimated error)/(result) x 100%
  - Example: **51.3 cm ± 0.2 cm** gives
  - Percent error = (0.2 cm)/(51.3cm) x 100 % = **0.4 %**

    (This is a pretty small error)

Is our result precise or accurate or what?

- Two different concepts: precision and accuracy!
- High precision means small error
- High accuracy means close to an accepted value
- Examples:



high precision, high accuracy

high precision, low accuracy

low precision, high accuracy

low precision, low accuracy

When Do Results Agree?

- Results agree, if they are within the error margins of each other
- Examples:

values very different, but errors large: agreement!

values closer, but errors smaller: no agreement!

Scaling

- Often one is interested in how quantities change when an object or a system is enlarged or shortened
- Different quantities will change by different factors!
- Typical example: how does the circumference, surface, volume of a sphere change when its radius changes?

How does it scale?

- Properties of objects scale like the perimeter, the area or the volume
  - Mass scales like the volume (“more of the same stuff”)
  - A roof will collect rain water proportional to its surface area