Lecture 2: Some Fundamentals

- Introduction
- Units
- Uncertainty

Credits

Some Slides and material were taken from Richard Wright and they were slightly modified

Introduction

In this lecture, you will…

- we define what is physics.
- Perform unit conversions.
- Explain the most common prefixes in the SI units.
- Determine the number of significant figures in calculations.
- Calculate the percent uncertainty of a measurement.

Introduction

- Physics is the study of the rules by which the physical world operates.
- These rules describe “how” things happen - Laws of Nature
- These rules don’t say “why” things happen. Physicists are most interested in being able to predict what will happen. Many physicists think that because they can say how things happen, they have answered the why.
- Why does gravity pull things together? Newton described the effects over 100 years before anyone asked why gravity happened. Einstein suggested that mass bends space-time, but that is just a model.
- Physics deals with “how”. But “Why” is philosophy.

Introduction

- There is a superpower behind the laws of physics.
- When the effect of laws stops this is called miracle- Miracles exist
- I believe being able to describe these intricate, interrelated laws shows the wisdom and might in nature.
- Laws of nature don’t change, neither do other laws like, “Treat others how you would like to be treated” or any other.
- Following natural laws makes everything work better.

Units

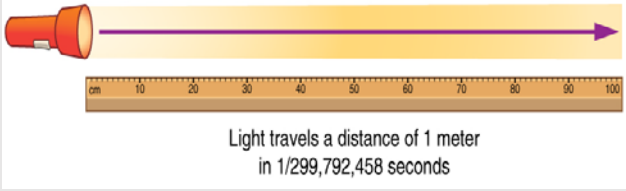
Scientific Method

- Can be used to solve many types of problems, not just science

  - Usually begins with observation and question about the phenomenon to be studied
  - Next preliminary research is done and an hypothesis is developed
  - Then experiments are performed to test the hypothesis
  - Finally the tests are analyzed and a conclusion is drawn

Units

- Units
- Meter is defined based on distance light travels in a vacuum in 1/299,792,458 of a second
- Second based on time it takes for 9,192,631,770 vibrations of Cesium atoms
- Mass based on mass of a platinum-iridium cylinder kept with the old meter standard at the International Bureau of Weights and Measures near Paris



  - USA uses English system as was used by the British Empire
  - Rest of world uses SI system (International System or Metric System)
  - Some places still use unusual units
- **Fundamental Units**
  - Time = second (s)
  - Distance = meter (m)
  - Mass = kilogram (kg)
  - ~~Electric Current = ampere (A)~~ not used in this course

- All other units are derived from these 4

Units

- Metric Prefixes
  - SI system based on powers of ten

Prefix	Symbol	Value	Prefix	Symbol	Value
exa	E	10^{18}	deci	d	10^{-1}
peta	P	10^{15}	centi	c	10^{-2}
tera	T	10^{12}	milli	m	10^{-3}
giga	G	10^{9}	micro	µ	10^{-6}
mega	M	10^{6}	nano	n	10^{-9}
kilo	k	10^{3}	pico	p	10^{-12}
hecto	h	10^{2}	femto	f	10^{-15}
decka	da	10^{1}	atto	a	10^{-18}

Units _ simple conversions

Old Magic Tables

length

km	hm	dam	m	dm	cm	mm
1	0	0	0			

1 km = 1000 **m**

Area

km^2		hm^2		dam^2		m^2		dm^2		cm^2		mm^2	
	1	0	0	0	0	0	0						

$1\ km^2 = 1000000\ m^2$

Volume

km^3			hm^3			dam^3			m^3			dm^3			cm^3			mm^3		
		1	0	0	0	0	0	0	0	0	0									

$1\ km^3 = 1000000000\ m^3$

Units _ combined conversions

- Unit conversions
- Multiply by conversion factors so that the unwanted unit cancels out

See details in class

- Convert 20 Gm to m
  - $\frac{20\ Gm}{} \cdot \left(\frac{1\times10^{9}\ m}{1\ Gm}\right)$
  - $2 \times 10^{10}\ m$

Example

- Convert 5 cg to kg
  - $\frac{5\ \cancel{cg}}{} \cdot \left(\frac{1\times10^{-2}\ \cancel{g}}{1\ \cancel{cg}}\right) \cdot \left(\frac{1\ kg}{1\times10^{3}\ \cancel{g}}\right)$
  - $\frac{5\times10^{-2}\ kg}{1\times10^{3}}$
  - $5 \times 10^{-5}\ kg$

Example

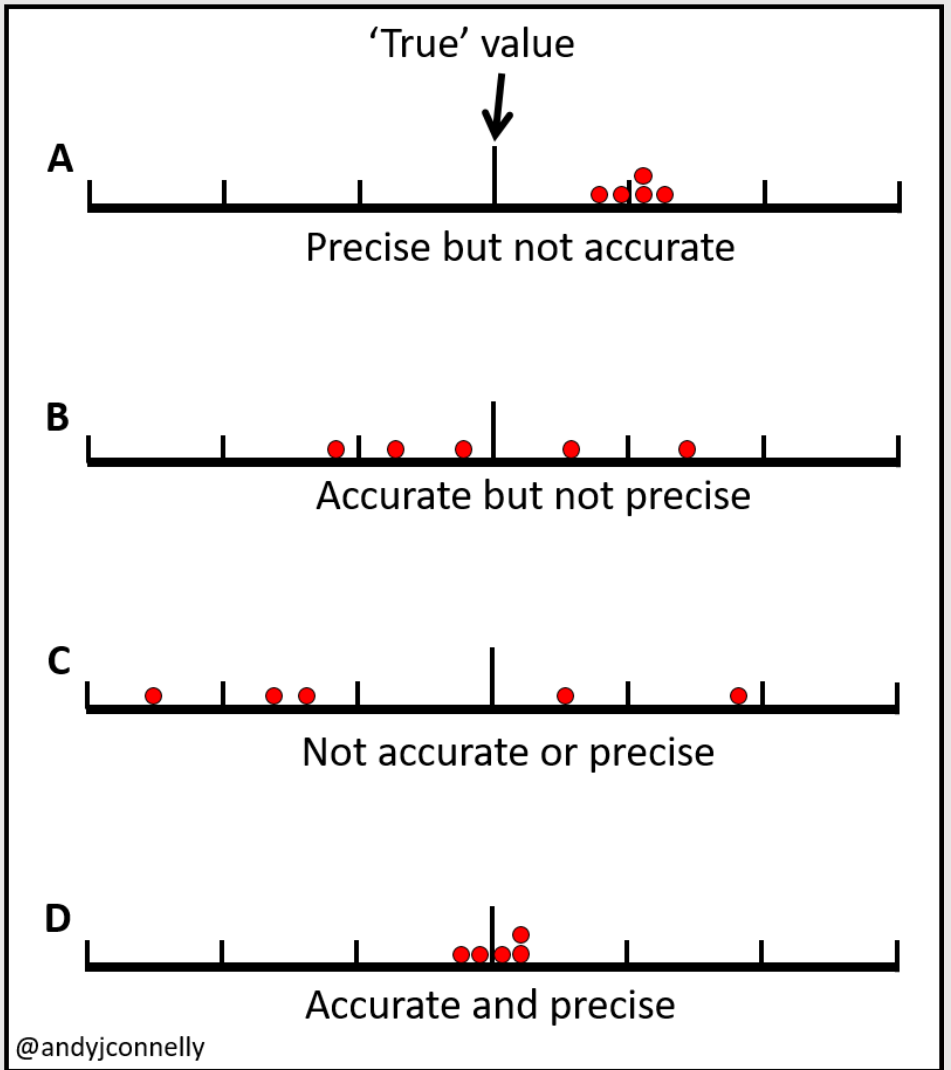
- Convert 25 km/h to m/s
  - $\frac{25\ \cancel{km}}{1\ \cancel{h}} \cdot \left(\frac{1\times10^{3}\ m}{1\ \cancel{km}}\right) \cdot \left(\frac{1\ \cancel{h}}{60\ \cancel{min}}\right) \cdot \left(\frac{1\ \cancel{min}}{60\ s}\right)$
  - $\frac{2.5\times10^{4}\ m}{3600\ s}$
  - $6.94\ m/s$

- Convert 2km/min to m/s

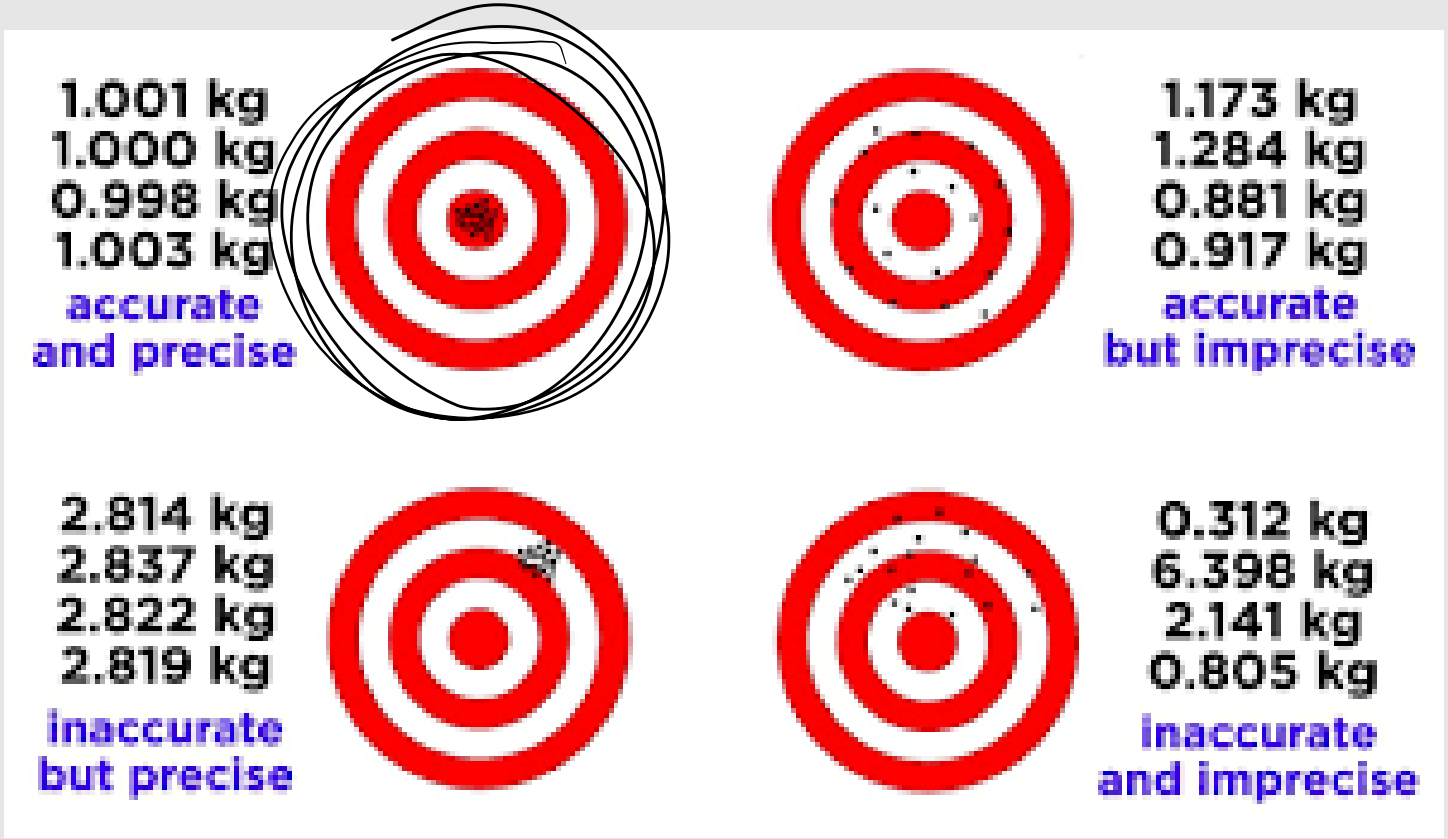
Uncertainty

- Accuracy is how close a measurement is to the correct value for that measurement.

- Precision of a measurement system is refers to how close the agreement is between repeated measurements.



Uncertainty- continued



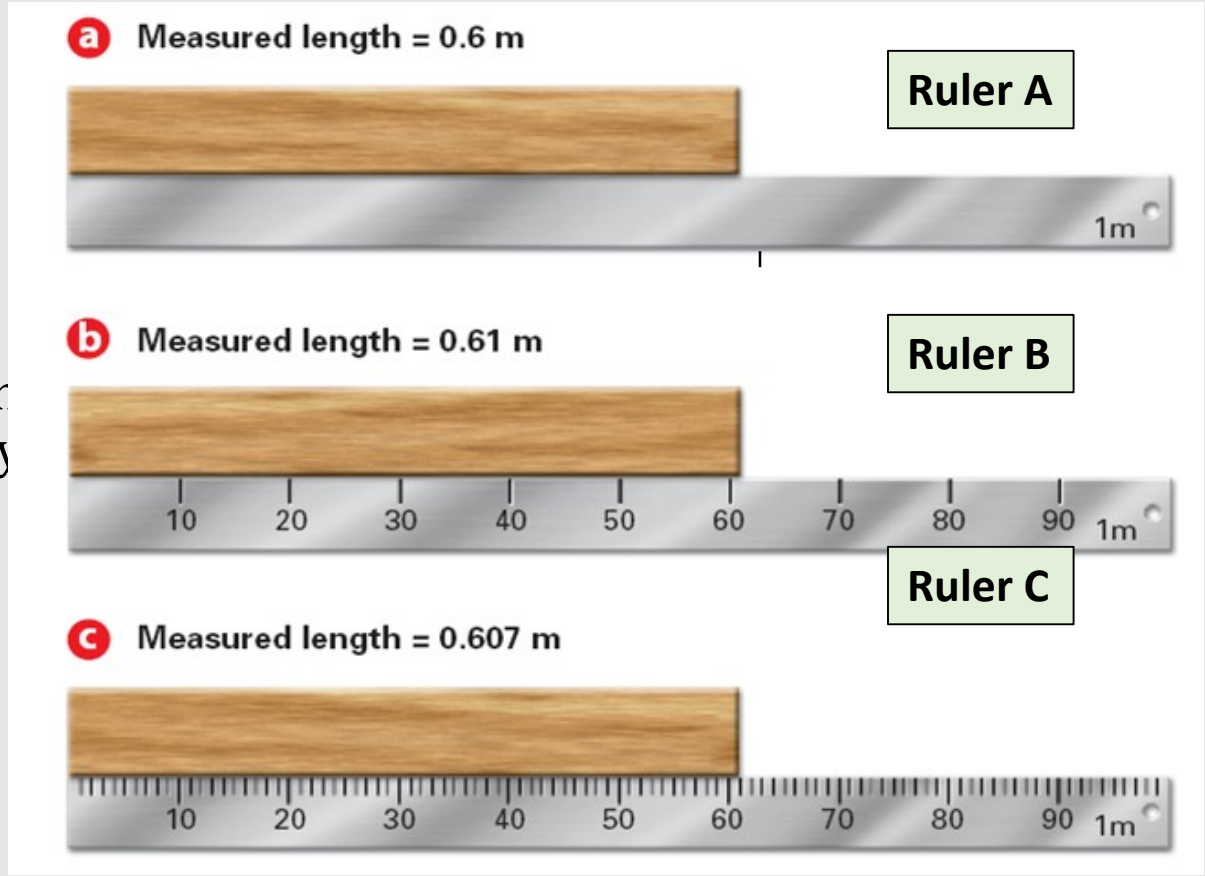
Uncertainty

- The accuracy and precision of a measuring system leads to uncertainty i.e. how far from the true value you are.

- A device can repeated get the same measurement (precise), but always be wrong (not accurate).

Uncertainty- Significant Figures

- Significant Figures
  - Used to reflect uncertainty in measurements
- Each measuring device can only measure so accurately
- The last digit is always an estimate



Uncertainty _ Significant Figures

- To find significant figures
  - Ignore placeholder zeros between the decimal point and the first nonzero digit
  - Count the number of other digits
- 0.000000602
  - 3 sig figs
- 1032000
  - 4 sig figs
- 1.023
  - 4 sig figs

Uncertainty _ Significant Figures

- Rules for combining significant figures
  - Addition or subtraction
    - The answer can contain no more decimal places than the least precise measurement.
    - $1.02 + 2.0223 = 3.04$
  - Multiplication or division
    - The result should have the same number of significant figures as the quantity having the least significant figures entering into the calculation.
    - $1.002 \cdot 2.0223 = 2.026$