Chapter 1: Introduction

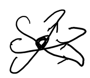
Monday, June 7, 2021 12:35

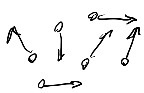
Physics – study of how the universe works

energy, matter, space, time

- chemistry - biology - weather
- architecture - astronomy
- engineering - medicine - music

models

- description of things we can't see directly
- ease of understanding
- not always 100% accurate
- e.g.: - Planetary Model of the Atom 
  - Atomic Model of Gasses (Molecular)



  - Standard Model of Particle Physics

    quarks photons
    electrons Higgs boson

theories

- explanation of nature
- may come with a model.
- verified by experiment
- e.g. Theory of Relativity
  - Mechanics

laws

- short explanation of a common event.
- often a single mathematic equation
- verified by experiment
- e.g. Newton's Laws
  - $F = ma$
  - every action has an equal + opposite reaction.

Scientific Method

1. think of possible explanations
2. test that explanation with a experiment.
   "hypothesis"
3. see if results are consistent.
   - ↳ not consistent. hypothesis = WRONG! (goto 1)
   - ↳ consistent. more likely true. (goto 2)

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classical physics

~~before~~ the 20th century

"slow" (< ~%1 speed of light)

"big" (can see with a microscope)

"light" (< massive then the earth)

modern physics

- quantum mechanics
- relativity

"light" (< massive then the earth)

Ch 1.2 physical quantaties - can be measured or calculated from other physical quantaties.

HAVE UNITS! might have DIRECTION!

scalar - no direction

vector - direction

US customary (imperial)

feet inches miles
pounds ounces
cups

metric system (SI) — Système Internationalè

meter, seconds, Newtons, liter

Fundamental units

(m) meter - measures length
(s) second - measures time
(kg) kilogram - measures mass
(A) ampere - measures electric current

derived units: m/s (velocity), m/s^2 (acceleration), $kg \cdot m/s^2 = N$ (force), $kg \cdot m^2/s^2 = J$ (energy), $kL = m^3$ (volume)

giga	G	10^9
mega	M	10^6
kilo	k	10^3
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ (u)	10^{-6}
nano	n	10^{-9}

$$GHz = 10^9\ Hz = 10^9 \frac{1}{s}$$

$$mm = 10^{-3}\ m = \frac{1}{1000}\ m$$

2.54 cm ≈ in

$33\ m/s \rightarrow km/hr$

$$33 \frac{m}{\cancel{s}} \times \frac{km}{1000\ \cancel{m}} \times \frac{3600\ \cancel{s}}{hr} = 118.8\ km/hr$$

$$6'8'' = 80\ \cancel{in} \times \frac{2.54\ \cancel{cm}}{\cancel{in}} \times \frac{1\ m}{100\ \cancel{cm}} = 2.032\ m$$

12

1 km = 3,281 ft

29,024 ft → km

$\boxed{8.846\ km}$

$$29024\ \cancel{ft} \times \frac{1\ km}{3281\ \cancel{ft}} = 8.846\ km$$

$6'8'' = 80\,\cancel{in} \times \frac{\quad}{\cancel{in}} \times \frac{\quad}{100\,\cancel{cm}} = 2.\_\_ m$

$6\,\cancel{ft} \times \frac{12\,in}{\cancel{ft}} = 72\,in$

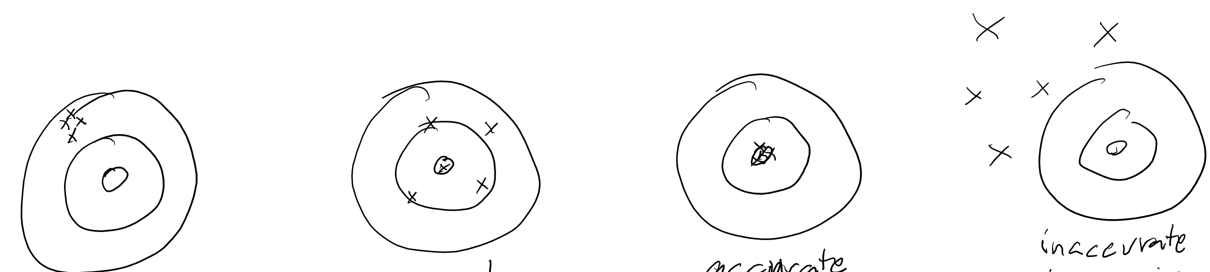
$29024\,\cancel{ft} \times \frac{1\,km}{3281\,\cancel{ft}} = \underline{8.846\,km}$

$$\left[\begin{array}{l} 10\,Mg = 10^6\,g \neq 10^6\,kg \\ \qquad\quad = 10^3\,kg \end{array}\right]$$

Section 1.3 – Accuracy + Precision

accuracy – how close the measurement is to the "true" or "standard" value

precision – how close repeated measurements are to each other



inaccurate precise — accurate imprecise — accurate precise — inaccurate imprecise

uncertainty – "measure" of how accurate + precise a measurement is

how far is the measurement from it's actual "true" value

$3000\,mi \pm 50\,mi$ = between 2950 mi and 3050 mi

$20\,s\ {}^{+10\,s}_{-2\,s}$ = between 18 s + 30 s

$24\,s \pm 6\,s$ //

- limitations of your measuring device
- skill of the person measuring
- irrelugarity in what you are measuring
- anything else effecting the measurement

% uncertainty $= \frac{\delta A}{A} \times 100\%$

$A \pm \delta A$

$\frac{50\,mi}{3000\,mi} \times 100\% = 1.67\%$

$5\,lb \pm 0.4\,lb$

$5\,lb \pm 8\%$

$0.4\,lb$ ... 8%

$A \pm \delta A$

3000 mi ±50 mi

$\frac{50\,mi}{3000\,mi} \times 100\% = 1.67\%$

3000 mi ± 1.67%

$\frac{0.4\,lb}{5\,lb} \times 100\% = 8\%$

- addition or subtraction – add absolute uncertainty

$5m \pm 1m - 2m \pm 0.5m = 3m \pm 1.5m$

(4m to 6m) (1.5m to 2.5m) (1.5m to 4.5m)

- multiplication + division – add precent uncertainty

$(5m \pm 1\%) / (5s \pm 7\%) = 1\,m/s \pm 8\%$

$(8kg \pm 6\%) \times (1\,m/s \pm 8\%) = (8kg \times 1\,m/s) \pm (6\% + 8\%)$

$= \boxed{8\,kg \cdot m/s \pm 14\%}$

4,567,821.637 m ± 20,000 m

NEVER WRITE THIS

4,570,000 m ± 20,000 m

Last digit that you write is the first with uncertainty

"3 significant figures"
"3 sig. figs."

0.000312 s – 3 sig figs

21000 m – 2 to 5 sig. figs.

21000 m ± 1000 m   21000 m ± 1 m

scientific notation – decimal between 1 and 10 times a power of 10

$2.1 \times 10^{+4}\,m$ $3.12 \times 10^{-4}\,s$

2 sig figs
$\pm 10^3$

$2.1000 \times 10^4\,m$
5 sig figs
±1

(2.1 e4 m)(3.12 e-4 s)

means the same thing

multiplily or dividing – same # of sig figs as least precise

$1.2m / 3.74s = 0.320855615\,m/s = 0.32\,m/s$

2 sig figs

$$\underbrace{1.2\,m}_{2\text{ sig figs}} / \underbrace{3.74\,s}_{3\text{ sig figs}} = 0.320855615\ m/s = \underbrace{0.32\ m/s}_{2\text{ sig figs}}$$

$$\pi(3.2\,m)^2 = 32.16990877\,m^2 = \underline{32\,m^2}$$

adding or subtracting - no more decimal places then least precise

$$7.54\,kg + 32.1\,kg = 39.6\,kg$$

$$\underbrace{5.13\,m}_{3\text{ sig figs}} - \underbrace{5.03\,m}_{} = \underbrace{0.10\,m}_{2\text{ sig figs}}$$

$$\begin{array}{r} 12.7\,m \\ +\ 4.82\,m \\ +\ 32\ \ \ m \\ \hline 50.\ m \end{array}$$

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section 1.4 - approximization = a "good guess"

- how many generations have there been since 0AD?

generation ~ 1/3 lifetime
lifetime ~ 100 years

$$2020\,\cancel{years} \times \frac{\cancel{lifetime}}{100\,\cancel{years}} \times \frac{generation}{1/3\,\cancel{lifetime}} \approx \underline{60\ generations}$$

- how many atoms are in a bacterium?

mass of atom in bacteria ~ 10 × mass of hydrogen ~ 10^{-26} kg
mass of hydrogen ~ 10^{-27} kg
mass of bacterium ~ 10^{-15} kg

$$\#\ atoms = \frac{mass\ of\ bacteria}{mass\ of\ atom} = \frac{10^{-15}\,kg}{10^{-26}\,kg} = \boxed{10^{11}}$$