PAM1014
Introduction to Radiation Physics

"Numbers, Physical Quantities, and Units"

Objectives

- Introduce
  - Numbers
  - Physical quantities
  - Symbols
  - Units

Numbers

- Can be…
  - Real e.g. 1, 0.01, 1.5, -12
  - Imaginary e.g. 3i, -2i (where i = √-1)
  - Complex e.g. 1+2i, -12+4i
  - Integer e.g. 100, 9, -87
  - Positive e.g. 1, 4, 123
  - Negative e.g. -12, -1, -0.001

Numbers

- Decimal places:
  - ONE decimal place: 0.1
  - TWO decimal place: 0.01
  - THREE decimal place: 0.001
  - etc

Numbers

- Rounding to nearest decimal place:
  - π = 3.14159265358979
    - ONE decimal place: π = 3.1
    - THREE decimal place: π = 3.142
    - SIX decimal place: π = 3.141593
    - Etc
  - If the next decimal value is equal or greater than 5, round up
  - Else, round down!

Examples

- 100.13567
- 1.9957342
- 12.1368

Numbers

- Rounding to significant figures:
  - π = 3.14159265358979
    - ONE significant figure: $\pi = 3$
    - THREE significant figure : $\pi = 3.1$
    - SIX significant figure : $\pi = 3.14159$
    - Etc
  - If the next decimal value is equal or greater than 5, round up
  - Else, round down!

Examples

- 100.13567
- 1.9957342
- 12.1368

Numbers

- Big & small numbers
- 1 million: 1,000,000
- 1 billion: 1,000,000,000,000
- 1 millionth: 0.000001
- 1 billionth: 0.000000000001

Numbers

- Big & small numbers
- 1 million: 1,000,000 = 10^6
- 1 billion: 1,000,000,000,000 = 10^{12}
- 1 millionth: 0.000001 = 10^{-6}
- 1 billionth: 0.000000000001 = 10^{-12}

Physical Quantities

- Numbers are used to describe experimental results

<u>Fundamental Quantities</u> (Operational Definitions)

- Only defined by measurement
- Other physical quantities can be describe by the way they are calculated from measurements

<u>Derived Quantities</u>

- Calculated quantities

Physical Quantities

<u>Example</u>

- Use a ruler to measure distance [m]
- Use stop watch to measure time [s]
- Speed
- Speed = distance/time [ms^{-1}]

Physical Quantities

Example

- Use a ruler to measure distance [m]
- Use stop watch to measure time [s]
- Acceleration
- Acceleration = speed/time [ms^{-2}]

Physical Quantities

- When measuring quantity, we always compare it to a reference standard
- Example: If we say someone is 1.8 m tall, we mean that they are 1.8 times as tall as a metre stick – which we define as 1 m long
- Such a standard defines a **unit**

Physical Quantities

Units

- To make precise measurements, we need units of measure that…
  - Do not change
  - Can be duplicated

Physical Quantities

SI Units

Système International (International System)

- Time – seconds [s]
  - Atomic Clock
- Length – metres [m]
  - Atomic: Wavelength of light emitted by ^{86}Kr
- Mass – kilograms [kg]
  - Mass of a cylinder of platinum-irradium alloy

Physical Quantities

- Force

$$\text{Force} = \text{mass} \times \text{acceleration}$$
$$F = m\,a$$

- SI Units: Newtons [N]
- 1 Newton = 1 Kg ms^{-2}
- Physical quantity or Operational definition?

Physical Quantities

- Work and Energy

$$\text{Work} = \text{Force} \times \text{distance}$$
$$W = F\,d$$

- SI Units: joule [J]
- 1 joule = 1 N m
- Physical quantity or Operational definition?

Physical Quantities

Prefixes

- Larger & smaller units for the same PQ
- Metric system
  - Always multiples of 10 or 1/10th

Physical Quantities

Prefixes

- Length
- SI unit: metre

1 nanometre	1 nm	10^{-9} m	Size of a few atoms
1 micrometre	1μm	10^{-6} m	Size of a cells
1 millimetre	1 mm	10^{-3} m	Size of a pen tip
1 centimetre	1 cm	10^{-2} m	
1 metre	1 m	10^{0} m	
1 kilometre	1 km	10^{3} m	Ten min walk

Physical Quantities

Prefixes

- Time
- SI unit: second

1 femtosecond	1 fs	10^{-15} s
1 picosecond	1ps	10^{-12} s
1 nanosecond	1 ns	10^{-9} s
1 microsecond	1 μs	10^{-6} s
1 millisecond	1 ms	10^{-3} s
1 second	1 s	1 s

Physical Quantities

Prefixes

- Mass
- SI unit: kilogram

1 microgram	1 μg	10^{-9} kg	Mass of a dust particle
1milligram	1 mg	10^{-6} kg	Mass of a grain of salt
1 gram	1 g	10^{-3} kg	Mass of a paper clip
1 kilogram	1 kg	1 kg	Mass a of a bag of flour

Unit Conversion

- When calculating *derived quantities* from *fundamental quantities* correct units MUST be used
- Symbols represent physical quantities including units which must be substituted in a consistent manner

Unit Conversion

Example:

- Calculating the volume of a cube from the length of it's sides
- Measure side to be 1 cm
- Volume in cubic metres [m^3]

$$volume = (length)^3 = (1[cm])^3 = (1[cm] \times 0.01[m\ cm^{-1}])^3$$
$$= 0.01\ m^3$$

Unit Conversion

FLAP: M1.2
Section 3.3

Example:

- Kinetic energy = ½mv^2
- Calculate the KE of a 100g mass with a velocity of 10 cm/s
- SI units ?

$$Kinetic\ Energy = \frac{1}{2}mv^2 = \frac{1}{2}\times 100[g]\times\left(10[cms^{-1}]\right)^2$$
$$= \frac{1}{2}\times 100[g][0.001\,kg\ g^{-1}]\times\left(10[cms^{-1}][0.01m\ cm^{-1}]\right)^2$$
$$= \frac{1}{2}\times 0.1[kg]\times\left(0.1[ms^{-1}]\right)^2 = 0.05[kg]\times 0.01\left[m^2s^{-2}\right]$$
$$= 0.0005\left[kg\ m^2s^{-2}\right]$$

Summary

- Numbers
- Physical quantities
- Symbols
- Units

Background Reading

- FLAP Module M 1.2