Lecture 8

Fri: Read 3.1 → 3.3

HW by 5pm

Note office Hr Issue - these will shift
- 10am - 10:45am
- 3pm ~~-4pm~~ - 4pm.

Metric Units

Physical quantities are always measured in some system of units. In the sciences the units used are the metric system.

Quantity	Basic Unit	Symbol
time	second	s
distance/length	meter	m
mass	kilogram	kg

These are not always convenient. For example if one measured distances or lengths of objects.

DEMO : Slide with distances

There is a system of derived units to manage this. These are related to the basic unit via multiples of 10. For example

1 kilometer = 1000 meters $\langle\approx\rangle$ 1km = 1000m

To convert we multiply or divide.

distance (km) = 1000 × distance (m)

distance (m) = $\frac{\text{distance}}{1000}$ (km)

DEMO: Second slide with distances.

The system extends as follows

1 kilo unit = 1000 unit

1 centi unit = $\frac{1}{100}$ unit = 0.01 unit

1 milli unit = $\frac{1}{1000}$ unit = 0.001 unit $\Rightarrow$ 1000 milli unit = 1 unit

Quiz 1

Example The width of a letter sheet is 21.6 cm. Convert this to a) meters, b) millimeters and c) kilometers.

Answer a) $21.6\text{cm} = 21.6 \times 1\text{cm} = 21.6 \times 0.01\text{m} = 0.216\text{m}$

b) (Alternative strategy) $1000\text{mm} = 1\text{m} \Rightarrow 1 = \frac{1000\text{mm}}{1\text{m}}$

$$0.216\text{m} = 0.216\text{m} \times 1 = 0.216\text{m} \times \frac{1000\text{mm}}{1\text{m}} = 216\text{mm}$$

c) $$0.216\text{m} = 0.216\text{m} \times \frac{1\text{km}}{1000\text{m}} = 0.000216\text{m}$$ ∎

Powers of Ten

Quantities that are very large or very small in standard units can be expressed in a more compact form using powers of ten. First the mathematics is:

$$\underbrace{10 \times 10 \times 10}_{} = \underbrace{1000}_{\text{number of zeroes}}$$

$$= 10^3$$ → number of multiples of 10 → these are equal.

In general:

$$10^n = \underbrace{10 \times 10 \times \dots \times 10}_{n \text{ factors}} = \underbrace{100\dots00}_{n \text{ zeroes}}$$

Then

$$10^{\text{first power}} \times 10^{\text{second power}} = 10^{\text{first + second powers}}$$

This will help manage larger numbers. For smaller numbers:

$$10^{-n} = \frac{1}{10^n} = \frac{1}{\underbrace{10 \times 10 \times \dots \times 10}_{\text{divide by } n \text{ factors}}} = 0.\underbrace{00\dots01}_{n-1 \text{ zeroes}}$$

and a special definition is

$$10^0 = 1$$

Then

$$\frac{10^{\text{first power}}}{10^{\text{second power}}} = 10^{\text{first - second power}}$$

Quiz 2 -90% $\quad 0.0001 = \frac{1}{10 \times 10 \times 10 \times 10} = 10^{-4}$

Quiz 3 -70% → 90% $\quad 10^3 \times 10^2 = 10^{3+2} = 10^5$

flip ↓

Quiz 4 90% $\quad \frac{10^5 \times 10^{-2}}{10^4} = \frac{10^{5+(-2)}}{10^4} = \frac{10^3}{10^4} = 10^{3-4} = 10^{-1}$

$= \frac{1}{10} = 0.1$

Scientific Notation

We aim to represent measured quantities in a standard form using powes of 10. We will get

$$\text{measurement} = \boxed{\square}.\boxed{\square}\boxed{\square} \times 10^{\boxed{\square}}$$

single digit number

For example

$$400 = 4 \times 100 = 4 \times 10^2$$

Example Express 62830 in this notation

Answer:

$$\begin{aligned} 62830 &= 6283 \times 10 \\ &= 628.3 \times 10 \times 10 \\ &= 62.83 \times 10 \times 10 \times 10 \\ &\vdots \\ &= 6.283 \times 10 \times 10 \times 10 \times 10 \\ &= 6.283 \times 10^4 \end{aligned}$$

Another way to see this is

$$62830 = 62830.0$$

Shift decimal 4 to left

$$= 6.2830 \times 10^4$$

Quiz 5

Quiz 6 ~> 80%

We use these in more general calculations.

Example An electron has mass 9.11×10^{-31} kg

A proton has mass 1.67×10^{-27} kg

These are 3.5×10^{-10} m apart

Calculate

$$\frac{\text{mass electron} \times \text{mass proton}}{\text{distance apart}}$$

Answer

$$\frac{9.11 \times 10^{-31}\,\text{kg} \times 1.67 \times 10^{-27}\,\text{kg}}{3.5 \times 10^{-10}\,\text{m}}$$

$$= \frac{9.11 \times 1.67 \times 10^{-31} \times 10^{-27}}{3.5 \times 10^{-10}} \quad \frac{\text{kg}^2}{\text{m}}$$

$$= \frac{9.11 \times 1.67}{3.5} \times \frac{10^{-31-27}}{10^{-10}}$$

$$= 4.34 \times 10^{-58-(-10)}$$

$$= 4.34 \times 10^{-48}$$

If time: New Powers of Ten