Chapter 1 - Measurement

Measurements } Science & Engineering, based on Comparisons }

So, how things are measured and compared?
⇒ experiments to establish the units for those measurements and comparisons.

measure the quantities: such as length, time, mass, temperature, pressure, electric current
↓
in their own units (by comparison with a standard)

i.e.
- meter (m) for the quantity length.
- standard for the length (1.0 m)
⇒ distance traveled by light in a vacuum during a certain fraction of a second.

- standard corresponds to exactly 1.0 units of the quantity

So many physical quantities!! { not all independent } speed ~ $\frac{\text{length}}{\text{time}}$ ratio } Becomes small number of physical quantities.
⇓
(Seven) Base quantities
Base standards

Units for three SI Base Quantities [L] [M] [T]

Quantity	Unit Name	Unit Symbol
length	meter	m
Time	second	s
Mass	kilogram	kg

SI Units ≡ Metric system

Derived Units:
Units are defined in terms of base units.

i.e.
SI unit for power, Watt
$1 \text{ Watt} = 1 \text{ W} = 1 \text{ kg} \frac{m^2}{s^3}$

Example: Find the distance that light travels in one year.

$c = 2.998 \times 10^8$ m/s light year, ly

Base Unit: time $1 = \frac{60 \text{ sec}}{1 \text{ min}}$, $1 = \frac{365.25 \text{ day}}{1 \text{ year}}$, $1 \text{ ly} = (2.998 \times 10^8 \text{ m/s})(\text{year})$

$1 \text{ ly} = (2.998 \times 10^8 \text{ m/s})(1 \text{ year})\left(\frac{365.25 \text{ day}}{1 \text{ year}}\right)\left(\frac{24 \text{ hours}}{1 \text{ day}}\right)\left(\frac{60 \text{ min}}{1 \text{ hour}}\right)\left(\frac{60 \text{ sec}}{1 \text{ min}}\right)$

$= 9.461 \times 10^{15}$ m

Very large
Very small quantities ; we need scientific notation ⇒ powers of 10

2 ~ # of significant figures

0.00035 $\xrightarrow{2}$ 3.5×10^{-4} or 3.5E-4 ; exponent of ten

0.000325400 $\xrightarrow{6}$ 3.25400×10^{-4}

2500 $\xrightarrow{2}$ 2.5×10^{3}

3560000000 $\xrightarrow{3}$ 3.56×10^{9}

} 10 sf ? Do we know the quantity so accurate? Solution is the scientific notation.

See Table 1.2 for Prefixes for SI Units.

1.27×10^{9} watts = 1.27 gigawatts = 1.27 GW

2.35×10^{-9} s = 2.35 nanosecond = 2.35 ns

See lecture notes for "Changing Units". Chain-link conversion

Example: Uncertainity, How accurate?

Page width? a measure : 1 mm divisions (accuracy)

21.6 cm

0.1 cm

21.6 ± 0.1 cm plus minus 0.1 : Error in measurement

Percentage error in measurement : $\left(\frac{0.1}{21.6}\right) \times 100 = 0.5\ \%$

Page area?

21.6 cm (±0.1)
27.9 cm (±0.1)
(0.4%) what is the percentage error in measurement?

} (21.6 cm) * (27.6 cm) = 603 cm²
what about uncertainity in measurement of area?
(0.4 + 0.5) addition 0.9 → 0.9 %
(0.9) * (603 cm²) = 5 cm² ⇒ 603 ± 5 cm²

Example: Significant figures. (sf) Physical properties → uncertain

2.00 m (3 sf) < 1.995 m OR 2.005 m ?

2.000 m (4 sf) < 1.9995 m / 2.0005 m

603 cm² (3 sf) < 602.5 cm² / 603.5 cm²

0.00035 (2 sf, not 6 sf)

mass of earth 5.98×10^{24} kg (3 sf)
6.0×10^{24} kg (2 sf)

In calculations, in exams!

2sf $\frac{3.0}{11.0}$ 3sf = 0.27272727... with calculator

what should be the answer?!

⇒ least number of sf!

⇒ 0.27 ✓