1 Units and Measurements

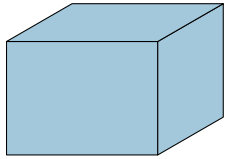
1.1 Units

Usually physical quantities are expressed with of values and units. Standard unit system for most scientist is **SI units** which has 7 base units.

SI base quantities	SI base units	Symbol
mass	kilogram	
length	metre	
time	second	
temperature	Kelvin	
electric current	ampere	
amount of substance	mole	mol
luminous intensity	candela	cd

These 7 quantities are called **base SI quantities**. For other physical quantities, their SI units can be considered by using their equations. The combination of base SI units is called **derived SI units**

Ex 1 Find SI unit of *area* and *volume*



Ex 2 Find SI unit of *density*

Ex 3 Find SI unit of *force*

Ex 4 Unit of a force is Newton, N.

(a) is Newton SI unit?

(b) is Newton base SI unit?

1.2 Prefixes

It is used to change value of units by placing in front of a unit. For example, km, cm and mm where m is unit of length but k, c and m are prefixes. The table below shows the list of prefixes.

Prefix	Symbol	Value
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}

Note - prefixes cannot stand alone

To change prefixes of a unit of a quantity, it can be done by the steps below:

- multiplying the value of the quantity by original prefix(s)
- dividing the value of the quantity by new prefix(s)

Note - This rule is always work no matter the changed prefixes are making the value greater or smaller.

Ex 1 Change the quantities below

1 km ⟶ ?m 5 dm ⟶ ?m 800 ms ⟶ ?s

Ex 2 Change the quantities below

1 g ⟶ ?kg 3.25 m ⟶ ?mm 6.5×10^{-4} s ⟶ ?ns

Ex 3 Change the quantities below

1 cm^2 ⟶ ?m^2 0.41 km^3 ⟶ ?m^3

Ex 4 Change the quantities below

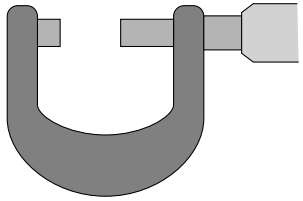
2 m^2 ⟶ ?nm^2 9.2×10^{-2} m^3 ⟶ ?mm^3

1.3 Measurement Apparatus

Different physical quantities can be measured be different apparatus.

Quantity	Measuring apparatus
Length	
mass	
time	
temperature	
volume of liquid	
electric current	
voltage	

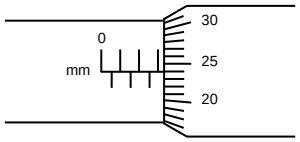
Micrometer consists of 2 scales:

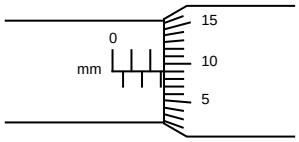


- fixed scale (1 div = 0.5 mm)
- revolving scale, 50 divisions
  (1 complete turn (50 div) = 0.5 mm –> 1 div = 0.05 mm)

Reading micrometer can be done by

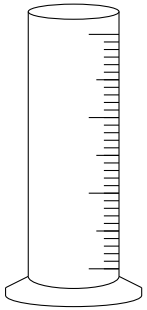
- read fixed scale
- read revolving scale and **divided the reading by 100**
- sum both readings from 2 scales





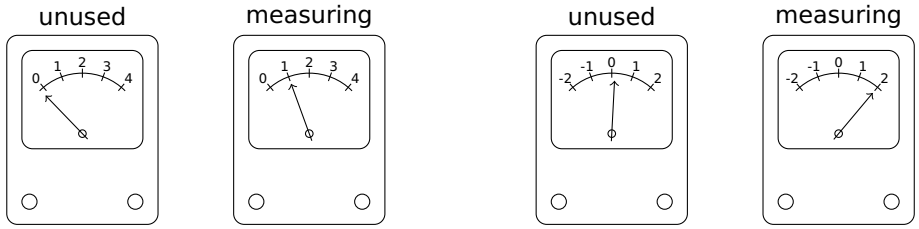
1.4 Errors

To accurately read a scale of a apparatus, you have to avoid an error called **parallax error**. This type of error occurs because the eyesight of reader is not perpendicular to the reading scale.



When (liquid) thermometer or measuring cylinder is used, the scale is read from level of liquid in the apparatus. Unfortunately, the level of liquid does not lay horizontally. The correct reading have to take at the **bottom of meniscus** of liquids.

When analogue stopwatch, ammeter or voltmeter is used, we have to make sure that its display value is started from zero. This process is called **check for zero error**.

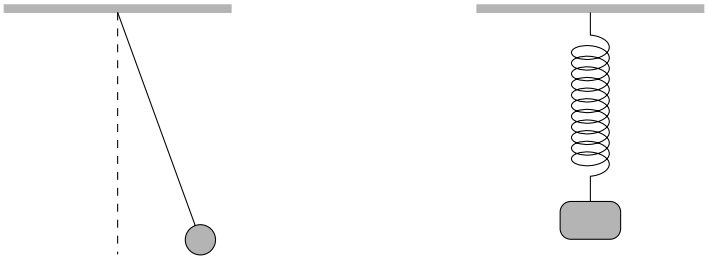


Note - repeating reading and finding the average will make you reading more accurate and reliable.

1.5 Measuring Time

Measuring small interval of time such as pendulum, vibrating of a mass attached to spring or moving piston is very difficult to be done accurately because of **human reaction time**. These problems can be overcame by:

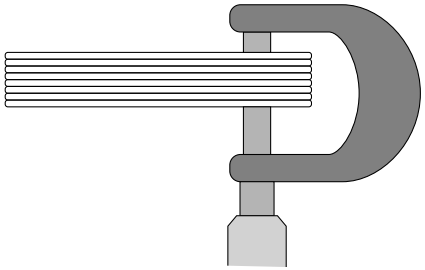
- measure time of 10 swings or oscillations rather than one
- divide the measuring time by 10 to get time of 1 swing or oscillation



1.6 Measure Small Length

It can be done accurately by a device called **micrometer**.

Measuring very small things such as thickness of a sheet of paper can be done more accurate by measure many sheet of paper (rather than 1 sheet) and then divide the result by number of sheets.

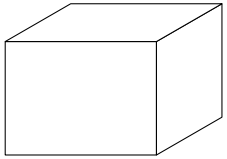


Note - repeating measuring thickness of sheets of paper in many different position will give more accurate average thickness value

1.7 Finding Volume

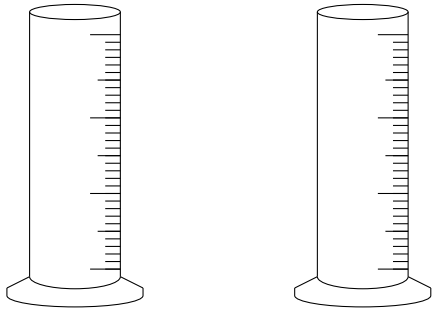
Liquids - pour the liquid into measuring cylinder then read the scale.

Regular solids - measure lengths and calculate by mathematics formula



Irregular solids - use water displacement method. For example, To find volume of a rock, it can be done by following steps below

- pour water into measuring cylinder and read volume (V_1)
- put the rock into the water and read the new volume (V_2)
- subtract both readings ($V_2 - V_1$) to get volume of the rock



1.8 Density

The density is defined as

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

$$\rho = \frac{m}{V}$$

The physical meaning of density is mass per unit volume. Density can be used to:

- classify type of material because objects with the same material will have the same density no matter how large or how heavy they are
- consider sink or float
  - if object's density is more than density of surrounding, it will sink
  - if object's density is less than density of surrounding, it will rise

Ex 1 A bottle contains 650 cm^3 of water. The water in the bottle has mass 650 g. Find

(a) density of water in unit of g/cm^3
(b) density of water in unit of kg/m^3
(c) volume of 200 kg of water
(d) mass of 450 cm^3 of water

Ex 2 An object has mass 0.8 g and volume 0.78 cm^3. By using density, predict that this object will sink or float in seawater with density 1029 kg/m^3.

Ex 3 The liquid A of 50 cm^3 is mixed with the liquid B of 150 cm^3. The density of liquid A and B are 2.4 g/cm^3 and 1.5 g/cm^3, respectively. Find the density of the mixed liquid.