1 QUANTITIES, UNITS AND MEASUREMENTS

WHAT IS PHYSICS?

OBJECTIVES

At the end of the topic, students should be able to:

- define physics;
- classify measurements in physics into fundamental or basic quantities/units and derived quantities/units;
- express the derived quantities using the dimensions of fundamental units;
- explain the term uncertainty or accuracy in measurements of physical quantities and state how it should be expressed.

Physics is the science that studies the link between matter and energy.
This definition of physics shows the connection between two important quantities in science – **matter** and **energy.**

Matter

It is defined as anything that has mass and occupies space.
Matter is the material substance that makes up our physical world. The stuff that makes matter is known as **mass.** The three states of matter are **solid, liquid** and **gas.** A solid has definite shape and volume. A liquid has definite volume but no definite shape, it assumes the shape of the containing vessel. A gas has neither definite volume nor shape; it takes the shape and volume of the vessel that encloses it.

Matter can change from one state to another, for example, when you heat a cube of ice (solid) it becomes water (liquid). Further heating changes water to vapour (gas). Energy is the ability to do work. Energy exists in different forms. For example, you get energy from the chemical energy in the food you eat. Cars, lorries and motorcycles get chemical energy from petrol. When you light a banger during Christmas, it converts heat energy (also called thermal energy) to light and sound energy when it explodes. Due to the danger that may accompany such energy release, the use of banger has been prohibited.

Principle of conservation of energy

In a closed system, the sum total of energy is always constant, however, the energy can be converted from one form to another. For example, when you use coal to cook, chemical energy in the coal is converted to heat energy which heats up the food. When you start the engine of a car, chemical energy in the petrol of the car is converted to heat energy and kinetic energy.

Energy can be converted from one form to another. Anything that can perform work has energy stored in it. A stone (solid) can smash a glass; flood (liquid) can carry heavy objects and wind (gas) can uproot trees or remove the roof of a house. All these prove that each state of matter possesses energy which can be exploited for the benefit of man.

Physics, as a science that tends to find the link between **matter** and **energy,** discovers the laws of nature, and provides answers to the behaviour of matter in the universe. Physicists use the measurement of physical quantities and mathematics as tools to find the laws which govern the universe, and to provide answers to some observable facts.

Measurements in physics

To study and establish the link between **matter** and **energy,** we measure physical quantities. The quantities measured in physics are divided into two parts: a **number,** which states the size of the quantity measured, and a **unit,** which identifies the quantity being measured. For example, the length of a book is 0.50 metres. **Metre** (m) is the unit of **length,** it tells us that what is measured is length and not mass. The measured quantity will be meaningless if no unit is assigned to it.

Basic (fundamental) units and derived units

Basic (fundamental) units

The units of quantities measured in science are of two types: **the basic units or the derived units.** The **basic units** are also called **fundamental** units because they are the foundation of other units in science. The derived units rely on the basic units for their definition. The seven basic units and the quantities they indicate are shown in Table 1.1 below.

S/N	Quantity	Basic Unit	Abbreviation	Dimensional Symbol
1.	Length	Metre	m	L
2.	Mass	Kilogram	Kg	M
3.	Time	Second	s	T
4.	Electric current	Ampere	A	A
5.	Temperature	Kelvin	K	θ
6.	Amount of substance	Mole	Mol	-
7.	Luminous intensity	Candela	cd	

Table 1.1 Fundamental quantities or basic units, abbreviations and dimensional symbols

The basic units shown in table 1.1 are stated in the internationally accepted units i.e. System International units (SI units).

The derived units

The derived units are got by combining basic units either by multiplication, division or by a combination of multiplication and division of the basic units.

Example: Volume = Length Ã— Breadth Ã— Height

The **unit** of **volume** is **cubic metre** (m^3). This is obtained by multiplying the length by itself three times.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

The **unit** of **density** is **kilogram per cubic metre** (kg / m^3), obtained by dividing the unit of mass by the unit of volume.

$$\text{Force} = \frac{\text{Mass} \times \text{Velocity}}{\text{Time}}$$

$$\text{Force} = \frac{\text{Mass} \times \text{Displacement}}{\text{Time} \times \text{Time}}$$

The **unit** of **force** is **Newton** (N) obtained by multiplication and division of the basic units of mass, length (displacement) and time. The basic unit of force is *kilogram metre per second per second (kg m s^{-2})*. Table 1.2 shows derived units and their definitions using their basic units.

Multiples and sub-multiples of units

S/N	Quantity	Unit	Al b.	Definition	Derived unit
1.	Area (A)	Metre squared	m^2	Length x Length	m^2
2.	Velocity or speed (v)	Metre per second	m s^{-1}	$\frac{\text{Displacement}}{\text{Time}}$	m s^{-1}
3.	Acceleration (a)	Metre per second per second	m s^{-2}	$\frac{\text{Metre}}{\text{Second x Second}}$	m s^{-2}
4.	Pressure (P)	Pascal	Pa	$\frac{\text{Force}}{\text{Area}}$	N m^{-2}
5.	Work (W)	Joule	J	Force x Displacement	Nm
6.	Electric charge (Q)	Coulomb	C	Current x Time	As
7.	Resistance (R)	Ohm	Ω	$\frac{\text{Potential difference}}{\text{Current}}$	kg m^2 s^{-3} A^{-2}
8.	Force (F)	Newton	N	Mass x Acceleration	kg ms^{-2}
9.	Heat	Joule	J	Mass x Specific heat capacity x Change in temperature	
10.	Density	Gram per cubic centimetre	g/cm^3	$\frac{\text{Mass}}{\text{Volume}}$	gcm^{-3}
11.	Momentum	Newton second		Mass x Velocity	$Kgms^{-1}$

Table 1.2 Derived quantities and their definitions using basic units

The basic units can be expressed in higher units called multiples or lower units called sub-multiples. Prefixes are used to represent multiples and sub-multiples of units in physics. Table 1.3 shows the prefix, their symbols and meaning.

Prefix	Abbreviation	Meaning	Prefix	Abbreviation	Meaning
Exa.	E	10^{18}	deci.	d	10^{-1}
Peta.	P	10^{15}	centi.	c	10^{-2}
Tetra.	T	10^{12}	milli	m	10^{-3}
Giga.	G	10^{9}	micro.	μ	10^{-6}
Mega.	M	10^{6}	nano.	n	10^{-9}
Kilo.	K	10^{3}	pico.	p	10^{-12}
Hecto.	H	10^{2}	femto.	f	10^{-15}
Deca.	D	10^{1}	atto.	a	10^{-18}

Table 1.3 Prefixes, symbols and meaning

Dimensional Analysis

Most derived units are obtained by combining one or more of these basic units; *length, mass, time, electric current and temperature*. These basic units are called **dimensions.** The dimension of a quantity is written inside a square bracket. **[Length]** is the dimension of length and [L] is the **dimensional symbol.** The dimensions and the dimensional symbols of other basic units are shown in table 1.1. By using the dimensions of the basic units, it is possible to express the derived units in terms of these basic units without referring to their units or sizes. The process of doing this is called **dimensional analysis.**

Volume = Length Ã— Breadth Ã— Height = For a cube, [Volume] = L Ã— L Ã— L = L^3

The dimension of speed or velocity,

$$\text{Velocity} = \frac{\text{Distance}}{\text{Time}} = \frac{L}{T}$$

$$[\text{Velocity}] = \frac{\text{Distance (Length)}}{\text{Time}} = \frac{L}{T} = LT^{-1}$$

$$\text{acceleration} = \frac{\text{velocity}}{\text{time}}$$

The dimension of acceleration = [a]

$$\therefore \quad [a] \ \frac{\text{velocity}}{\text{time}} = \frac{\text{Distance / time}}{\text{Time}} = \frac{LT^{-1}}{T}$$

$$\therefore \quad [a] = LT^{-2}$$

The dimension of force [F] = MLT^{-2}

[Force] = (mass) Ã— (acceleration) = MLT^{-2}

Table 1.4 shows the dimensions of some derived quantities and their corresponding dimensions.

Dimension	**Quantity**
$ML^{-1} T^{-2}$	Pressure
$ML^2 T^{-2}$	Energy/Work
ML^{-3}	Density
$ML T^{-1}$	Momentum
ML^2T^{-3}	Power

Table 1.4 Dimension and quantity

Worked examples

1. Use the dimensional analysis to prove the correctness of the following formulae.
   (a) Kinetic energy = $\frac{1}{2}mv^2$
   (b) Potential energy = mgh
   (c) Work done = Force Ã— distance

Solution

The dimension of energy = $ML^2 T^{-2}$

(a) [K.E] = $M (LT^{-1})^2 = ML^2 T^2$

(b) [P.E] = $M (LT^{-2}) L = ML^2 T^{-2}$

(c) [W] = $(MLT^{-2})L = ML^2T^{-2}$

The three formulae are dimensionally correct. Note that constants and numbers are dimensionless and are not considered.

2. Given that $M^x L^y T^z$ is the dimension of pressure, what are the values of x, y and z?

Solution

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

$$= \frac{\text{Mass x Acceleration}}{\text{Area}}$$

$$= \frac{MLT^{-2}}{L^2} = ML^{-1}T^{-2}$$

$$\therefore x = 1,\ y = -1\ and\ z = -2.$$

3. The period of oscillation of a simple pendulum is related to its length (l) and acceleration due to gravity (g) by T = 2Ï€$l^x g^y$. Where Ã— and y are constants, find the values Ã— and y.

Solution

Period = [Time] = T, [Length] = L and [g] = acceleration due to gravity = LT^{-2}

$$T = 2\pi l^x g^y$$

Since $M^0L^0 = 1$ then, $T = M^0L^0T^1$

$$\therefore M^0L^0T^1 = 2\pi L^x (LT^{-2})^y$$

$$\therefore M^0L^0T^1 = 2\pi L^x L^y T^{-2y}$$

$$\therefore M^0L^0T^1 = 2\pi L^{x+y} T^{-2y}$$

$\therefore$ Equating the index of each dimension yields:

0 = x + y and –2y = 1.

Solving the two equations above gives $y = -\frac{1}{2}\ and\ x = \frac{1}{2}$

$$\therefore T = 2\pi l^{\frac{1}{2}} g^{-\frac{1}{2}} = 2\pi\sqrt{\frac{l}{g}}$$

Uncertainties in measurement

The **precision** or **accuracy** of any measuring instrument depends on the skill of the user in using the instrument and the sensitivity of the instrument. If the same measurement is taken many times by the same observer or by different observers, their observations may vary. There is always an uncertainty in every measurement. For this reason, all measurements in physics are stated within a range that contains the correct value.

This is added or subtracted to give the range of the accepted measurement. The uncertainty of a metre rule is 0.05cm or 0.1cm to 1 decimal place; therefore, when the measurement of length is stated as 43 it means that the length measured is correct within a range of 42.9 cm and 43.1 cm. Uncertainty is sometimes called **accuracy of the measuring instrument**.

The uncertainty of an instrument is the least measurement it can determine. Usually, this is half of the smallest division on its scale.

Summary

- Physics is the science that studies the link between **matter** and **energy.**
- The **basic units** are also called **fundamental** units because they are the foundation of other units in science.
- The **derived units** are got by combining basic units either by multiplication, division or a combination of multiplication and division of basic units.
- The **uncertainty** of an instrument is the least measurement it can determine. Usually, this is half of the smallest division on its scale.

Practice questions

(1) Why do we take measurements in physics?

(2) Make a list of quantities that can be measured in physics.

(3) What is dimension? Give the dimensions of the following quantities in physics: **pressure, work, momentum,** and **power**.

MEASUREMENT OF LENGTH

OBJECTIVES

At the end of the topic, students should be able to:

- state the units of length and be able to convert other units of length to metres;
- name some length measuring instruments and state their accuracy or uncertainty;
- obtain readings from the scales of metre rule, vernier calliper and micrometer screw gauge.

Length is the distance between two points. The standard or the SI unit of **length** is **metre** (m). The sub-multiple units of length are **centimetre** (cm), **millimetre** (mm), **micrometre** (Î¼), etc. These sub-units are related to the SI unit as follows:

1 cm = 0.01m = $1.0\text{x}10^{-2}$ m 1 mm = 0.001m. = 1.0 Ã— 10^{-3} m or 1 mm = 0.000001m = $1.0\text{x}10^{-6}$ *m.*	1m = 100 cm. or 1m= 1000 mm. or 1m = 1,000,000Î¼m

The higher multiples of length are **kilometre** (km), **megametre** (Mm) etc.
1km = 1000 m and 1 Mm = 1,000,000 m.

1 m = 0.001 or 10^{-3} km and 1m = 0.000001 or 10^{-6} Mm.

Length measuring instruments

The length of an object can be measured with any of the following instruments depending on the size of the object to be measured:

(a) ***The metre rule*** (b) ***The vernier calipers***

(c) ***The micrometre screw gauge*** (d) ***The tape rule***

The metre rule

The metre rule is suitable for measuring lengths that lie between a few centimetres and few metres long. It can be made from wood, plastic or metal. The length of a metre rule is 1 metre or 100 cm. Each centimetre is subdivided into 10 equal parts (10 mm). The smallest division on a metre rule is 1mm (0.1 cm).

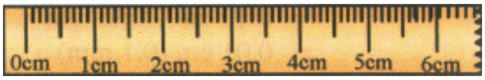


Figure 1.1 Part of a metre rule

The uncertainty (accuracy) of the metre rule

The least measurement that a metre rule can measure is 0.5 mm (0.05 cm). This is the **uncertainty** or **accuracy** of the metre rule. The uncertainty of a metre rule is half the smallest division on its scale. Every direct measurement made with a metre rule is recorded correct to the number of decimal places of its uncertainty. For example, the length of a physics textbook 50.50 cm.

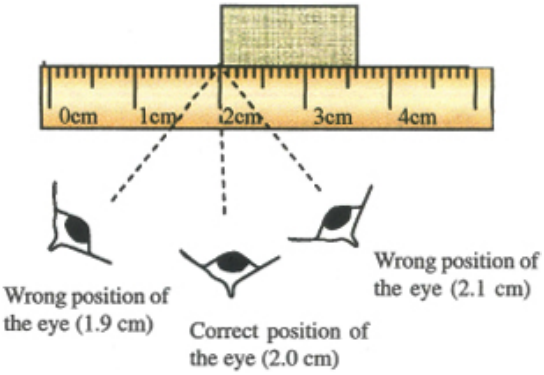


Figure 1.2 Correct method of measuring length with metre rule

Sources of errors and precautions that can be observed when using metre rule

Source I: Zero error due to worn out scales at the edges.

Precaution: Measurement of length should not begin from the edge of the metre rule to avoid zero (systematic) error due to worn out edges.

Source II: Parallax error is due to wrong positioning of the eye when taking the reading with the metre rule: this is a random error (the mistake of the observer).

Precaution

The eye should be vertically above the mark measured to avoid error due to parallax. Parallax error is caused by the thickness of the metre rule as in Figure 1.2.

The vernier calipers

The vernier calipers measures length with greater precision than the metre rule. The uncertainty or accuracy of vernier calipers is 0.01 cm, which is smaller than that of the metre rule. It has two scales:

(i) the main (M) scale and

(ii) the vernier (V) scale.

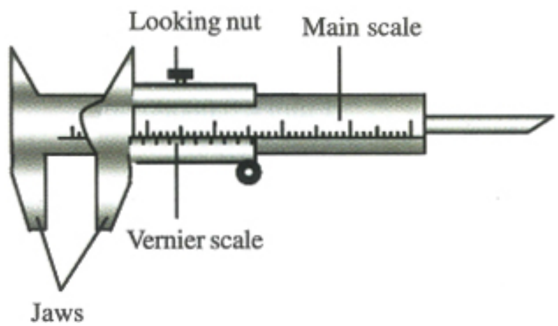


Figure 1.2 Vernier calipers

The main (M) scale: The main scale of the vernier calipers is the same as that of metre rule. It is divided into centimetres and millimetres. Each division on the main scale represents 0.1 cm (1.0 mm).

The vernier (V) scale: The vernier or moving scale slides beside the main scale. It is constructed by dividing 0.9 cm (9.0 mm) into ten equal parts such that one division on the vernier scale is 0.09 cm (0.9 mm). The addition of the main scale and the vernier scale reading gives the total length of the object whose dimension is measured.

The uncertainty (accuracy) of the vernier calipers is the smallest length it can measure. It is the difference between one division on the M-scale and one division on the V-scale.

Uncertainty = One division on the M-scale – One division on the V-scale

= 0.10 cm – 0.09 cm

= 0.01 cm (0.1 mm)

Vernier calipers can measure lengths correctly to 2 decimal places in centimetres. Any length measured with the vernier calipers is correct within the range of its uncertainty or Â± 0.01 *cm*.

Uses of vernier calipers

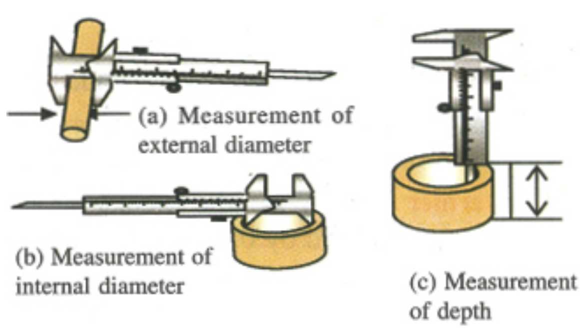
The vernier calipers are used to measure:

(a) the external diameters of a pipe;

(b) the internal diameter of a pipe or hollow tube;

(c) the depth or cavity of a hollow object like test tube;

(d) the thickness of a disc (e.g. a coin)



How to use vernier calipers

- **To check for zero error,** close the jaws of the caliper, if the zeros on the M- and V-scales coincide, the vernier caliper is good and can be used. If they do not coincide, their difference (known as zero error) is added or subtracted from the final reading of the callipers.
- **To find the M-scale reading,** look for the last reading on the M-scale before the zero on the V-scale. This is the M-scale reading.
- **To find the V-scale reading,** count the number of divisions on the V-scale, up to the division that coincides with a division on the M-scale. This number is multiplied by 0.01 cm to give the reading of the V-scale.
- **The final reading of the vernier calipers** is sum of the M-scale and V-scale readings.

Worked example

Obtain the reading of the vernier calipers scale shown in Figure 1.13 below.

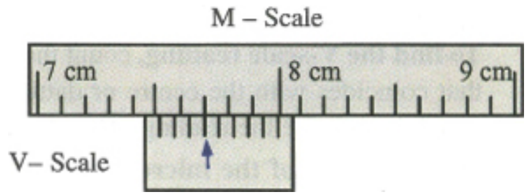


Figure 1.3 Scales of vernier calipers

Solution

The M-scale reading	=	7.40 cm
The V-scale reading	=	+ 0.04 c
Final reading of micrometer	=	7.44 cm.

The Micrometre Screw Gauge

A = Anvil, *S* = Spindle, *F* = Frame, *L* = Locking nut, *M* = Main scale, *V* = Vernier scale, *T* = Thimble and *R* = Ratchet.

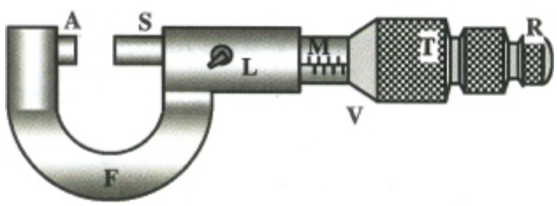


Figure 1.4 The micrometre screw gauge

The micrometer screw gauge is used to measure very small lengths with greater precision than the vernier calipers. The uncertainty or the accuracy is 0.001 cm (0.01 mm). Like the vernier calipers, it has two scales:

(a) The main scale or the sleeve *(M)*

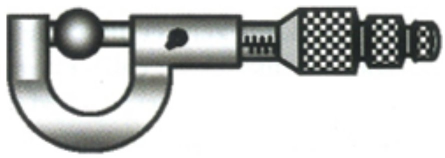
(b) The circular vernier scale *(V)*

The main scale: The main scale is divided into millimetre (mm) and half millimetre (0.5mm). The smallest division on the main scale is 0.5 mm or 0.05 cm; this corresponds to the distance the spindle moves when the circular vernier scale is turned round once.

The vernier scale: When the circular vernier scale is turned round once, the spindle moves forward or backward by 0.5 mm (0.05 cm). The number divisions on the vernier scale is 50, therefore, one division on the vernier scale represents 0.01 mm (0.001 cm). This is the smallest length a micrometer screw gauge can measure. The micrometer screw gauge can give an accurate measurement of small lengths such as:

(i) external diameters of pipes;

(ii) thickness of very thin wires, metal sheets, sheet of paper, discs and pendulum bob.



How to use micrometre screw gauge

- **To check for zero error,** turn the thimble using the ratchet until the spindle touches the anvil. If the zero on the vernier scale does not match the datum or the centre line on the sleeve, the difference (zero error) is noted and added or subtracted from the final reading of the micrometer.
- **To find the M-scale reading,** look for the last reading on the M-scale, which is clearly visible. This is the M-scale reading.
- **To find the V-scale reading,** count the number of divisions on the V-scale up to the division that coincides with the centre or datum line on the M-scale. This number is multiplied by 0.001 cm to give the reading of the V-scale.

The final reading of the micrometre is sum of the M-scale and V-scale readings.

Worked example

What is the reading of the micrometer screw gauge scales in Figure 1.15 (a) and (b)?

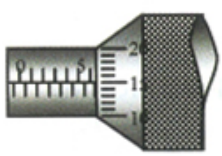


Figure 1.15a

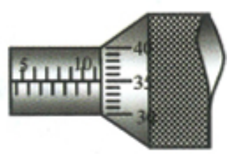


Figure 1.15b

Solution

(a)	The M-scale reading	=	6.50 cm
	The V-scale reading	=	+ 0.015 cm
	Final reading of micrometer	=	6.515 cm
(b)	The M-scale reading	=	11.00 cm
	The V-scale reading	=	+ 0.035 cm
	Final reading of micrometer	=	11.035 c

Summary

- Length is the distance between two points.

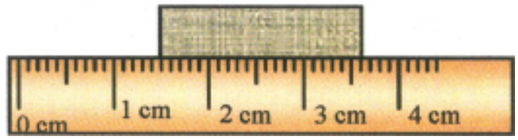
- The SI unit of length is *metre* (m).
- Length is measured with metre rule, tape rule, vernier calipers and micrometer screw gauge.
- The uncertainty or accuracy of the metre rule is 0.05 cm, vernier calipers, 0.01 cm and micrometer screw gauge, 0.001 cm.

Practice questions

1. Find the lengths of the objects measured with the metre rule as shown below:

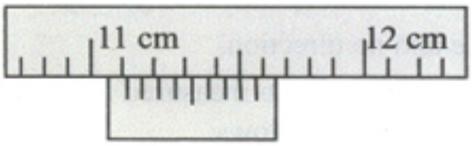
(a)

(b)

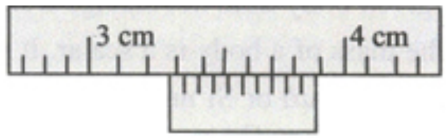


2. Obtain the reading of the following vernier caliper scales shown below.

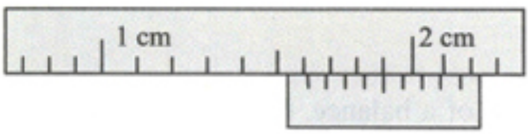
(a)



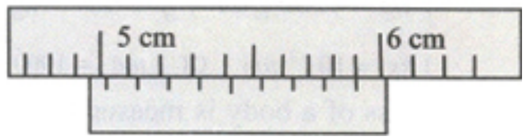
(b)



(c)

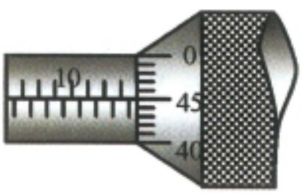


(d)

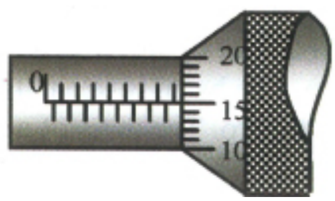


3. Draw a portion of a vernier caliper scale showing the following readings:
   (a) 3.86 cm (b) 5.15 cm (c) 12.08 cm.
   (b) State two uses of vernier calipers.
4. What is the reading of the following micrometer screw gauge scales shown in the diagrams below?

(a)



(b)



5. Draw a portion of a micrometer screw gauge scales showing the following readings:
   (a) 7.75 cm
   (b) 1.68 cm (c) 0.83 cm

MEASUREMENT OF MASS AND WEIGHT

OBJECTIVES

At the end of the topic, students should be able to:

- define mass and state its units;
- measure mass of a substance using balances;
- define weight of a body and state its unit;
- measure weight of bodies using spring balance;

- explain why the weight of a body varies on the earthâ€™s surface.

Mass

Mass is the quantity of matter in a body.

Two important facts about mass are:

(a) The mass of a body is the same anywhere in the universe. It is always constant. The mass of a given body does not change from place to place. It is independent of gravity.

(b) The mass of a body is a scalar. It has magnitude and no direction.

The standard or SI unit of mass is kilogram (kg). Mass is also measured in other units like gram(g) and tons. Gram and tons are related to the SI units as follows:

$1\ kg = 1000\ g$ or $1\ g = 10^{-3}\ kg$

$1\ kg = 10^{-3}\ ton$ or $1\ ton = 1000\ kg$

The mass of a body is measured with the aid of a balance. Different kinds of balances are used today to determine with greater precision, the mass of a body. All can be grouped into two: the analogue and digital balances. The analogue balances include:

- the chemical or beam balances
- the lever or burchart balances
- top scale pan balances.

The chemical or beam balance

The beam balance Figure 1.7 consists of a beam with two scale pans A and B attached at the ends of the beam. The beam is free to turn about a pivot at the centre. When the beam is balanced, the pointer reads zero. The mass of a given body is found as follows:

- Put the mass of the object to be measured on the scale pan A.
- Add standard weights (weights with known masses) on the scale pan B until the beam is balanced horizontally (i.e. the pointer reads zero on the scale).
- The mass of the object on the scale pan A is the total mass of the standard weights on the scale pan B.

The beam balance is a very sensitive instrument. Its uncertainty or accuracy varies depending on how sensitive the instrument is. A good beam balance can measure mass correctly to about 0.001 g.

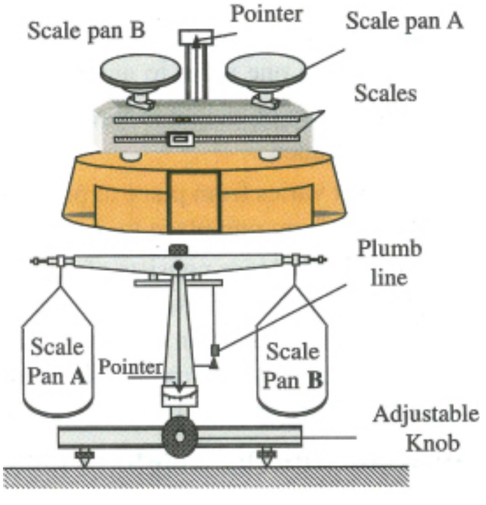


Figure 1.7 Different models of beam balance

The lever balance

The lever balance has a scale pan attached to a system of levers. When the mass of the object to be measured is placed on the top scale pan, it presses down the lever systems, which in turn lifts the fixed mass. The pointer which carries the fixed mass, moves on the scale to show the value of the mass in grams. The mass is read directly from the scale. The uncertainty or accuracy of a lever balance is about 0.1 g.

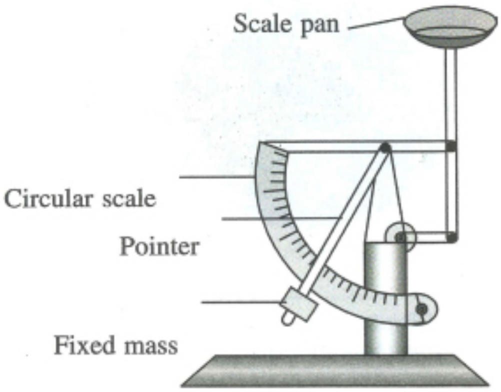


Figure 1.8 Lever balance

Weight

Weight is the gravitational force which attracts every object inside the earthâ€™s gravitational field towards the centre of the earth.

The weight of a body depends on:

- the mass of the body (m);
- the acceleration due to gravity (g).

Newton in 1687, showed that the weight of body is proportional to the mass of a body in a particular location.

Weight Î± mass of the body

Weight = mass Ã— acceleration due to gravity.

W = m Ã— g

The weight of a body is also called **gravitational mass** because its value depends on acceleration due to gravity.

Weight varies from place to place. This is because acceleration due to gravity is different from one place to another.

The SI unit of weight is Newton (N). The weight of a body is measured using a spring balance.

Weight varies from place to place. This is because acceleration due to gravity is different from one place to another.

A spring balance consists of a spiral spring whose force constant determines its sensitivity. The extension of the spring is proportional to the weight of the body to be determined. When the free end of the spring is fixed on the weight, the spring extends and it contracts when the weight is removed. The spring balance is calibrated in Newton (N) and sometimes in grams (g).

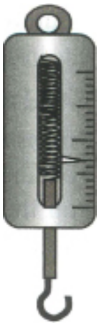


Figure 1.9 The spring balance

Reasons why the weight of a body varies on the earthâ€™s surface

â€¢ The shape of the earth

The weight of a body increases with latitude. This is because the earth is geoid (i.e. the earth is not completely round). It is flat at the poles and bulges at the equator. A body at the pole is nearer the centre of the earth and therefore weighs more than a body at any other location on the earthâ€™s surface. The reason is that the weight of a body decreases as its distance from the centre of the earth increases. Our weights are greatest at the north and south poles and least at the equator.

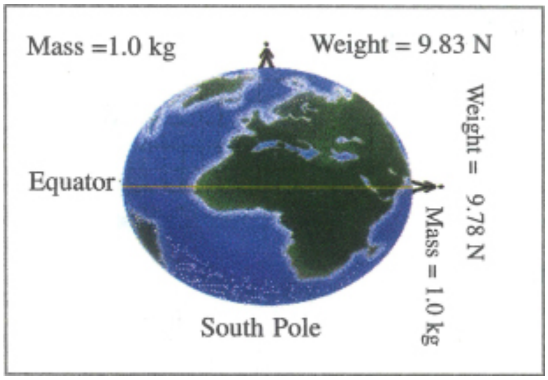


Figure 1.10 Weight is maximum at the poles and minimum at the equator

â€¢ The rotation of the earth

The earth spins about its own axis and rotates round the sun. Different locations on the earthâ€™s surface move at different speeds, (a) therefore, weight of a body varies from place to place.

Differences between mass and weight

	Mass	Weight
1.	Mass is the amount of matter in a body.	Weight is the gravitational force which attracts every object towards the centre of the earth.
2.	Mass is constant anywhere in the universe.	Weight varies from place to place depending on gravity.
3.	Mass is a scalar quantity.	Weight is a vector quantity.

4.	Mass is measured with a beam balance or other balances.	Weight is measured with a spring balance.
5.	The SI unit of mass is kilogram.	The SI unit of weight is Newton.

Summary

- Mass is the amount matter in a body. It is constant anywhere in the universe.
- Weight is the gravitational force which attracts every object inside the earthâ€™s gravitational field towards the centre of the earth. It depends on the acceleration due to gravity on a particular location.
- The weight of a body on the earthâ€™s surface depends on the latitude of the place and the speed of the earth.
- Weight is maximum at the poles (9.83 N) and minimum at the equator (9.78 N).

Practice question 1c

1. (a) What is mass? (b) How is it measured?
2. (a) What is 38.2 tones of rice in (i) grams (ii) kilograms?
   (b) Convert 4.8 g to (i) kilogram (ii) ton.
3. (a) What is weight? Why does it vary from place to place on the earthâ€™s surface?
   (b) Distinguish between weight and mass of a body.
1. The mass and weight of a body is weighed at the foot and top of mountain Everest. State with reason which of the two will vary slightly at the top of the mountain.
2. (a) Why is weight called *gravitational mass?*
   (b) What is the relationship between mass and weight of a body?
   (c) A mass of 5 g is weighed with a spring balance on earth and moon respectively, calculate the weights of the mass on the earth and moon if the gravity of the earth is 9.8 m s^{-2} and that of the moon is 1.7 m s^{-2}.

MEASUREMENT OF TIME

OBJECTIVES

At the end of the topic, students should be able to:

- define time and state its unit;
- state some of the properties of matter that can be used to measure time;
- name some time measuring devices;
- define some terms like frequency and period and state how they are related.

Time is measured in seconds (s)

The measurement of time is very important. The ancient men used different methods to measure time. This includes the use of water droplet dripping through a fine hole. The volume of water that passed through the hole at equal interval of time is the same, thus the volume of water is converted to time. This type of clock is called water clock. The vital question is what is time? **Time is the interval between two events.** The standard unit of time is second (s).

The units of time and their relation to second are shown in table 1.4.

Time measuring devices use regular vibrations of the following:

- Simple pendulum to measure time (e.g. pendulum clock). A simple pendulum consists of a mass swinging at the end of a string or rod. When a simple pendulum is slightly displaced from its equilibrium position, it vibrates to and fro about the equilibrium position. The time to complete one vibration is constant, thus the vibration of a simple pendulum can be used as a clock to measure time.

S/N	Unit	Second equivalent
1.	Nanosecond	1.0 Ã— 10^{-9}
2.	Microsecond	1.0 Ã— 10^{-6}
3.	Millisecond	1.0 Ã— 10^{-3}
4.	Second	1.0
5.	Minute	6.0 Ã— 10^{1}
6.	Hour	3.6 Ã— 10^{3}
7.	Day	8.64 Ã— 10^{4}
8.	Month	2.59 Ã— 10^{6}
9.	Year	3.11 Ã— 10^{7}
10.	Decade (10 years)	3.11 Ã— 10^{8}
11.	Century (100 years)	3.11 Ã— 10^{9}

Table 1.4 Units of time and their second equivalent

- A balance wheel to measure time as used in wrist and stopwatches. The vibratory motion of the balance wheel transfers energy through the gear systems to the hands of the watches to record time.
- Atoms in digital and atomic clocks. Quartz, a crystal with its atoms regularly spaced, is used to measure very small time intervals. Longer intervals of time are measured with radioactive clocks.

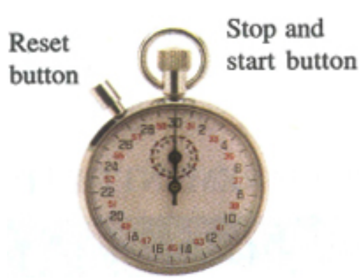


Figure 1.11a Stopwatch

Frequency and period of oscillation (vibration)

Frequency is the number of vibrations (oscillations) completed in one

second.* The unit of frequency is Hertz *(Hz). Period is the time it takes to complete one vibration (oscillation).

$$T = \frac{t}{N}$$

The unit of period is second (s).

T = period of oscillation or vibration, t = time to complete N vibrations and N = number of vibrations completed in t seconds.

The period of oscillation is related to frequency by

$$f = \frac{1}{T} \quad or \quad T = \frac{1}{f}$$

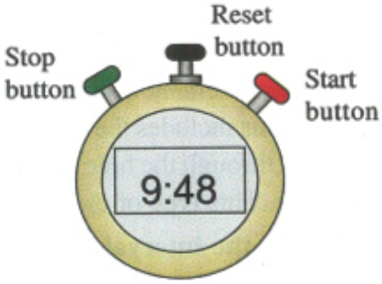
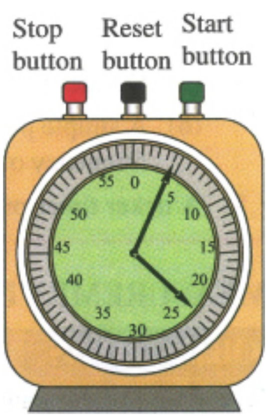


Figure 1.11b Digital stopwatch

Time measuring devices

The stop clock / watch

Stop clocks or watches are used to measure time during experiments in the school laboratory. There are different types and sizes of stop clocks or watches. Accuracy of stop clocks varies depending on the type; some can measure time correctly to 0.1, 0.2 and 0.5 seconds respectively. Digital stop clocks or watches give better accuracy.

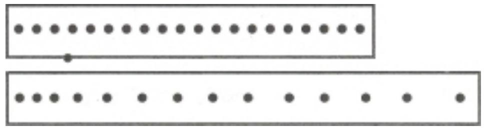


The ticker timer

Ticker timer is used to measure smaller time intervals between two positions of a moving body. The timer prints dots on a paper connected to the moving body. A timer prints 50 dots in one second; therefore, the interval between two dots is 0.02 seconds. The spacing of the dots describes the nature of the motion.

- The speed of the body is constant if the spacing of the dots is equal. Ten dots are printed on the paper in 0.2 seconds.
- The speed of the body is increasing if spacing of the dots is increasing.

- The speed of the body is decreasing if spacing of the dots is decreasing.



The multi- flash camera

Technology has advanced greatly that we can measure accurately very small time intervals. Pictures taken with multi-flash cameras can reveal the positions of a moving body at regular intervals of time during its motion. Measurements from such photographs are used to determine accurately the time for the body to change its position.

Regular flashing of light from the flasher in a dark room photographs the moving body at different positions during its motion.

The number of flashes per second or frequency produced by the flasher is used to find the time interval between two positions of the body. A multi-flash camera that flashes 50 times per second has a period of 0.02 seconds. Very fast moving bodies require flashers with high frequency.

Summary

- Time is defined as interval between two events. The standard unit of time is second (s).
- Time measuring devices use regular vibrations of simple pendulum, balance wheel and atoms of crystals to measure time.
- Frequency is the number of vibrations per second.
- Period of oscillation is the time to complete one vibration.

Practice question 1d

1. (a) What is time? State five examples of motion that can be used to determine time.
   (b) The earth is about 4.6 billon years old. State the age of the earth in seconds.
2. (a) Define frequency of a vibrating body.
   (b) A simple pendulum completes 50 vibrations in 42 seconds. Calculate the period and frequency of oscillation.
3. A ticker timer prints 80 dots per second. What is the time interval between two dots?

MEASUREMENT OF VOLUME

OBJECTIVES

At the end of the topic, students should be able to:

- determine the volumes of regular objects like cube, cone, sphere, etc;
- determine volumes of irregular objects by displacement of liquid using measuring cylinder and overflow can;
- measure volumes of liquids.

Volume is a measure of the amount of space occupied by matter. The standard unit of volume is cubic metre (m^3). The units of volume and their equivalent in cubic metre (m^3) are shown in table 1.5.

S/N	Unit	Equivalent in (m3)
1.	Cubic millimetre (mm^3)	1.0 Ã— 10^{-9}
2.	Cubic centimetre (cm3)	1.0 Ã— 10^{-6}
3.	Cubic decimetre (dm3)	1.0 Ã— 10^{-3}
4.	Cubic metre (m3)	1.0
5.	Litre (1)	1.0 Ã— 10^{-3}
6.	Millilitre(ml)	1.0 Ã— 10^{-6}

Table 1.5 Units of volume and their equivalents

A litre is the volume occupied by one kilogram of water which has maximum density at 4 Â°C. This is approximately 1000 cm^3.

Therefore, 1 cm^3 = 1 ml.

Conversion from cubic centimetre (cm^3) to cubic metre (m^3)

A cubic metre (m^3) is the volume occupied by matter with dimensions 1m each.

$$
\begin{aligned}
1\ m^3 &= 1\ m \times 1\ m \times 1\ m \\
&= 100\ cm \times 100\ cm \times 100\ cm \\
&= 1{,}000{,}000\ cm^3
\end{aligned}
$$

$$\Rightarrow \quad 1\ cm^3 = \frac{1}{1{,}000{,}000}\ m^3 = 10^{-6}\ m^3$$

Volume of regular objects

Volumes of solids with regular shapes are found by direct measurement of its dimensions (length, breadth, height, diameter or radius), and applying mathematical formulae to calculate their volumes. Table 1.6 illustrates different geometrical shapes and the formulae used in calculating their volumes.

S/N	Regular Solid	Geometric shape	Formula	Meaning of symbol
1.	Cube		$V = l^3$	l = length
2.	Cuboid		$V = l \times b \times h$	l = length b = breadth h = height
3.	Cylinder		$V = \pi r^2 h$ $V = \frac{\pi d^2 h}{4}$	d = diameter h = height
4.	Cone		$V = \frac{1}{3}\pi r^3$	r = radius
5.	Sphere		$V = \frac{4\pi r^3}{3}$	r = radius

Table 1.6 Regular solids, geometric shapes and formulae to calculate their volumes

Volumes of objects with irregular shapes

Two objects cannot take up the same space at the same time. This principle is used in finding the volumes of irregular objects. The irregular object is immersed in a liquid, which does not dissolve it. The solid displaces the liquid, causing its level to rise in a measuring cylinder. The rise in the volume of the liquid is measured and recorded as the volume of the solid. Two methods used include:

(i) displacement of liquid in measuring cylinder.

(ii) displacement of liquid in overflow (Eureka) vessel.

Activity 1

Apparatus: Measuring cylinder, thread, irregular object (stone) and water.

Procedure

(a) Pour water into a measuring cylinder and record the initial volume of water in the measuring cylinder.

(b) Gently lower the solid into the water until it is immersed completely.

(c) Measure and record the new volume of water in the measuring cylinder.

(d) Find the difference between the new volume and the initial volume.

When the solid is completely immersed, the level of water in the measuring cylinder rises. This is because the water displaced by the solid rises above the solid. The volume of solid immersed = $V_2 - V_1$

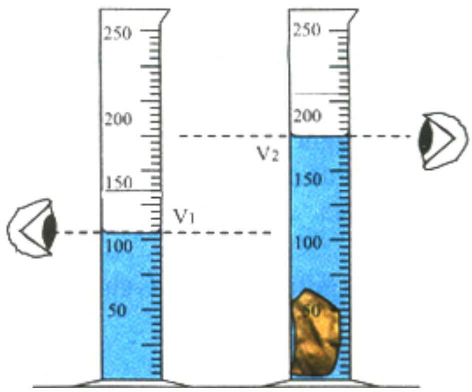


Figure 1.12 Measurement of volume by displacement of water in a measuring cylinder

Activity 2

Apparatus: Measuring cylinder, overflow (Eureka) vessel, water, solid and thread.

Procedure

(a) Fill the overflow (Eureka) vessel with water and allow it to stand until water stops dripping from the spout.

(b) Gently lower the solid until it is completely immersed in water.

(c) Collect the displaced water in a measuring cylinder.

(d) Read and record the volume of water collected in the measuring cylinder.

The volume of displaced water in the measuring cylinder is the volume of solid immersed.

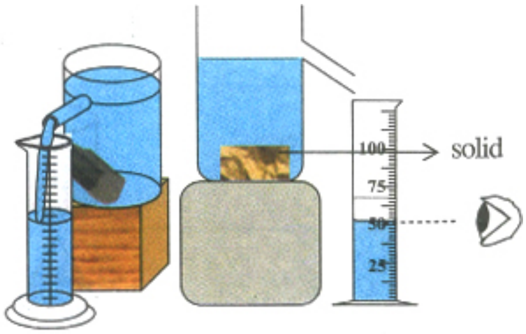


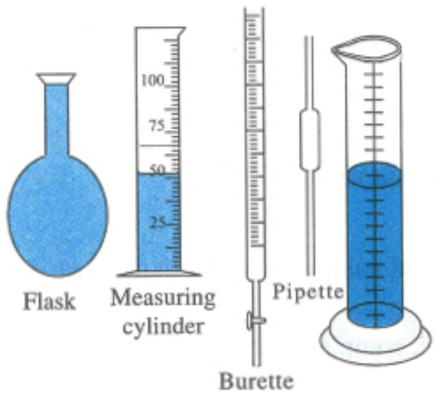
Figure 1.13 Measurement of volume by displacement of water in an overflow vessel

Precautions

(a) The solid should be immersed gently to avoid splashing of the liquid.

(b) The volume of liquid in the measuring cylinder is read with the eye directly on the concave meniscus of the liquid to avoid parallax error.

(c) No liquid should be dripping from the spout of the overflow vessel before the solid is immersed and at the time of taking the final reading of the liquid displaced.



Measurement of volume of liquids

Volume of liquids is measured with graduated vessels like measuring cylinders, flasks, pipettes and burettes. These instruments are graduated in cubic centimetres (cm^3) or millilitre (ml). They have different sizes for measuring different amount of liquid.

MEASUREMENT OF DENSITY

OBJECTIVES

At the end of the topic, students should be able to:

- define density and state its unit;
- determine the density of solids and liquids;
- define relative density of a substance;
- distinguish between density and relative density of a substance;
- measure the relative density of liquids and solids;
- solve simple problems on density and relative density of a substance.

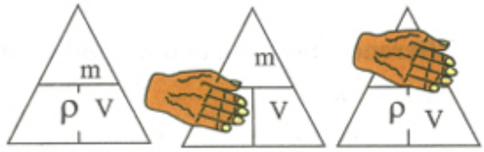
It is a common experience that iron is heavier than wood of the same volume. In physics, we say that iron is denser than wood (i.e. a given volume of iron contains more matter than the same volume of wood). Mass contained in a unit volume of a substance is called *density*.

Density is the mass per unit volume of a substance. Or, density is mass contained in a unit volume of a substance.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\rho = \frac{m}{V} \quad \Rightarrow \quad m = \rho \times V \quad \Rightarrow \quad V = \frac{m}{\rho}$$

where m = Mass, v = Volume, ρ = Density



If m is covered, the product Ï Ã— V gives the formula for mass of the substance. The same can be done for the density Ï and the volume V.

The units of density are kilogram per cubic metre (kgnr^{-3}) and gram per cubic centimetre 1gcm^{-3}.

$$1 \text{ g cm}^{-3} = 1000 \text{ kg m}^{-3}$$

The density of water is 1 g cm^{-3} or 1000 kg m^{-3} The density of gold is 19.3 g cm^{-3}, this means that gold is 19.3 times denser than water.

Table 1.7 shows the densities of some substances and the temperature at which they were measured.

Substance	State of substance	Density (g cm^{-3})	Tempe-rature (°C)
Hydrogen	Gas	0.00009	0
Air	Gas	0.00129	0
Alcohol	Liquid	0.79	20
Oil	Liquid	0.93	20
Pure water	Liquid	1.00	20
Aluminium	Solid	2.70	20
Iron	Solid	7.90	20
Copper	Solid	8.95	20
Brass	Solid	8.90	20
Mercury	Liquid	13.60	20
Gold	Solid	19.30	20

Table 1.7 Substances, states, densities temperature

Relative density (specific gravity)

Water is used as a standard to compare the density of other substances; therefore, it is assigned by convention, the density of 1g cm^{-3} is that of pure water.

Relative density is the density of other substances compared with the density of pure water.

$$\text{Relative density} = \frac{\text{Density of substance}}{\text{Density of water}}$$

$$\text{Relative density} = \frac{\text{Mass of substance}}{\text{Mass of the same volume of water}}$$

$$\text{Relative density} = \frac{\text{Weight of substance}}{\text{Weight of the same volume of water}}$$

The student should do well to recognize the following important facts about relative density of a substance.

- Relative density of a substance has no unit. It is the ratio of two densities.
- Density of substance = Relative density of substance/Density of water
- Relative density of substance is numerically equal to the density of the substance but has no unit.

Differences between density and relative density

S/N	Density	Relative density
1.	Density is mass per unit volume.	Relative density is the ratio of density of substance to density of water.
2.	The unit of density is kg m^{-3}or g cm^{-3}.	Relative density has no unit. It is the ratio of two densities.

The relative density bottle

The **relative density** or the density of a liquid is determined with the **density bottle.** The density bottle is a round glass flask flattened at the base with a stopper. The stopper has a fine capillary hole at the centre. When the stopper is replaced as shown in Figure 1.15, excess liquid flows out through the capillary hole and is dried with clean rag.

Figure 1.15 Relative density bottles

Measurement of relative density of liquid

Apparatus: Beam balance, relative density bottle, water, liquid, clean rag.

Procedure

(a) Clean the relative density bottle, weigh it with a beam balance, and record its mass (m).

(b) Fill the relative density bottle with liquid and replace the stopper. Wipe clean the density bottle with a clean rag and weigh again. Record the mass of the density bottle and liquid (m_1).

(c) Pour out the liquid; rinse the density bottle properly with water and refill with water. Clean the side of the density bottle properly and weigh the third time.

Record the mass of the density bottle and water (m_2).

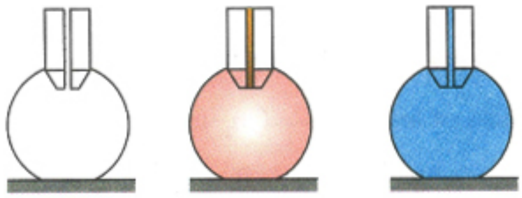


Figure 1.16 Determination of relative density of a liquid

Observation

- Mass of empty relative density bottle = m g
- Mass of relative density bottle filled with liquid = m_1 g
- Mass of relative density bottle filled with water = m_2g
  Calculation
- Mass of liquid – (m_1 -m) g
- Mass of water = (m_2 -m) g

$$\text{Relative density} = \frac{\text{Mass of liquid}}{\text{Mass of the same volume of water}}$$

$$\text{Relative density} = \frac{m_1 - m}{m_2 - m}$$

Measurement of relative density of insoluble particles (granular substances)

Procedure

(a) Clean the relative density bottle, weigh it with a beam balance. Record its mass (m_1).

(b) Carefully add some lead shots to the density bottle. Weigh the density bottle with the lead shots and record the mass (m).

(c) Top the density bottle containing lead shots with water, weigh and record the mass (m_2).

(d) Pour the lead shots and water out and fill the density bottle with water only, weigh and record the mass (m_3).

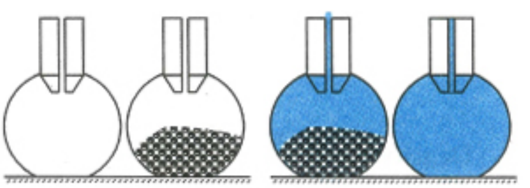


Figure 1.17 Determination of relative density of a granular solid

Observation

- Mass of empty relative density bottle = m
- Mass of relative density bottle with lead shots = m_1
- Mass of relative density bottle with lead shots and water = m_2
- Mass of relative density bottle with water only = m_3

Calculation

Mass of lead shots = (m_1 – m)

Mass of water topping the lead shots = m_2 – m_1

Mass of water = $m_3 - m$

Mass of water with the same volume as lead shots = $(m_3 - m) - (m_2 - m_1)$

$$\text{Relative desnsity of lead shots} = \frac{\text{mass of lead shots}}{\text{mass of equal volume of water}}$$

$$\text{Relative density of leadshots} = \frac{m_1 - m}{(m_3 - m) - (m_2 - m_1)}$$

Precautions

- Clean rag should be used to wipe the relative density bottle each time the stopper is replaced before weighing.
- The density bottle should be rinsed in water before it is filled with the water.
- Parallax error should be avoided when taking the reading from the beam balance.

Worked examples

1. An aluminium solid of mass 54.3 g has a volume of 20 cm^3. What is the density in:

   (i) g cm^{-3} (ii) kg m^{-3}?

Solution

(i) $$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{54.3\text{ g}}{20\text{ cm}^3} = 2.715\text{ g cm}^{-3}$$

(ii) 1 g cm^{-3} = 1000 kg m^{-3}

$\therefore$ 2.715 g cm^{-3} = 2.715 x 1000 kg m^{-3}

= 2 715 kg m^{-3}

2. A copper cube is melted and recast into a cylinder of base radius 3 cm and height 7 cm. Calculate the mass of the copper if the relative density is 9.0.

Solution

Volume of cylinder $= \pi r^2 h$

$$= \frac{22}{7} \times 3 \times 3 \times 7 = 198\ cm^3$$

Density of copper = relative density Ã— density of water

Density of copper = 9.0 Ã— 1 g cm^3 = 9.0 g cm^{-3}

Mass of copper = Density of Copper Ã— Volume

Mass of copper = 9.0 g cm^{-3} Ã— 198 cm^3

= 1782 g or 1.782 kg

3. 100g of water is mixed with 50g of tetraoxosulphate (VI) acid of relative density 1.25. What is the density of the dilute acid formed?
(Density of water = 1 g cm^3).

Solution

$$\text{Volume of acid} = \frac{\text{Mass of acid}}{\text{Density of acid}} = \frac{50\ g}{1.25\ g\ cm^{-3}} = 40\ cm^3$$

Density of acid = relative density of acid x density of water

$$\text{Volume of acid} = \frac{\text{Mass of acid}}{\text{Density of acid}} = \frac{50\ g}{1.25\ g\ cm^{-3}} = 40\ cm^3$$

Density of acid = 1.25 x 1 g cm^{-3} = 1.25 g cm^{-3}

Volume of dilute acid = 100 cm^3 + 40 cm^3 = 140 cm^3

Mass of dilute acid = 100 g + 50 g = 150 g

$$\text{Density of acid} = \frac{\text{Mass of dilute acid}}{\text{Volume of dilute acid}} = \frac{150\ g}{140\ cm^3} = 1.071\ g\ cm^{-3}$$

4. In an experiment to determine the relative density of lead shots, a student obtained the following results:
Mass of relative density bottle = 25.8 g
Mass of relative density bottle with lead shots only = 69.3 g
Mass of relative density bottle filled with water = 75.8 g
Mass of relative density bottle with lead shots and water = 115.4 g
Use the above data to find the density of lead shots given that the density of water = 1.0gcm^{-3}.

Solution

Mass of lead shots = 69.3 g – 25.8 g = 43.5 g

Mass of water topping the lead shots = 115.4 g – 69.3 g = 46.1 g

Mass of water filling the relative density bottle = 75.8 g – 25.8 g = 50.0 g

Mass of water having the same volume as the lead shots = 50.0 g – 46.1 g = 3.9 g

$$\text{Relative density of lead} = \frac{\text{Mass of lead}}{\text{Mass of the same volume of water}} = \frac{43.5g}{3.9g} = 11.2$$

Density of lead shots = Relative Density of lead shots × Density of water

= 11.2 x 1 g cm^{-3} =11.2 g cm^{-3}

Summary

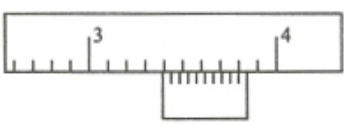
- Density is mass per unit volume. The standard unit of density is kilogram per cubic metre ($kg\ m^{-3}$).
- $$\text{Relative density} = \frac{\text{Density of substance}}{\text{Density of water}}$$
- Density of substance = Relative density of substance Ã— Density of water.

Practice questions 1e

1. (a) What do you understand by the density of gold is 19.3 $g\ cm^{-3}$?
   (b) What do you understand by the relative density of brass is 8.9?
2. If the density of mercury is 13.6 $g\ cm^{-3}$, what is the volume of 84 g of mercury?
3. (a) Outline the steps to determine the density of an iron sphere.
   (b) An iron sphere of diameter 28 cm has a density of 7.9 $g\ cm^{-3}$, calculate its mass.
4 A bee wax of mass 50 g and 120 g of paraffin wax were melted together. Calculate the density of the mixture when it solidifies. (Density of bee wax and paraffin wax are 0.94 $g\ cm^{-3}$ and 0.91 $g\ cm^{-3}$ respectively).

Past Questions

1. The diagram below represents the vernier caliper. M is the main scale and V the vernier scale. What reading is indicated?
   A. 3.30 cm
   B. 3.39 cm
   C. 3.90 cm
   D. 4.30 cm
   E. 4.38 cm



NECO

2. The motion of the prongs of a sounding turning fork is
   A. circular
   B. oscillatory
   C. random
   D. rotational
   E. translational

NECO

3. The period of an oscillatory motion is defined as the
   A. average of the times used in completing different numbers of oscillations.
   B. time to complete a number of oscillations.
   C. time to complete one oscillation.
   D. time to move from one extreme position to the other.

WASSCE

4. Which of the following quantities is not a *fundamental* quantity?
   A. Electric current
   B. Luminous intensity
   C. Reactance
   D. Time

WASSCE

5. In a simple pendulum experiment, 20 oscillations were completed in 38 s. Calculate the period of the pendulum.
   A. 0.03 s
   B. 0.05 s
   C. 0.50 s
   D. 1.90 s

WASSCE

6. Which is a fundamental unit?
   A. Ampere
   B. Joule
   C. Newton
   D. Ohm
   E. Watt

NECO

7. What is the mass of a rectangular block of density 2.5 Ã— 10^3 k gm^{-3} that measures 10 cm by 5 cm by 4 cm?
   A. 0.002 kg
   B. 0.080 kg
   C. 0.200 kg
   D. 0.500 kg
   E. 1.000 kg

8. An iron rod is moved from the earth to the moon. Which of the following properties of the rod would remain unchanged?
   I Mass II Weight III Relative density
   A. I only
   B. II only
   C. III only
   D. I and III only.

WASCE

9. The smallest unit on the sleeve of a micrometer screw gauge is 0.5 mm. There are 50 divisions on the thimble of the screw gauge. What is the smallest length that can be measured with the instrument?
   A. 0.05 cm
   B. 0.01 cm
   C. 0.005 cm
   D. 0.001cm
   E. 0.0001cm

NECO

10. A boy ran a distance of 200 m in 24 s. His average speed was 8.3 m s^{-1}. Which of the following is correct about the units in which the statements above are expressed?

A. All the units are fundamental.
B. All the units are derived.
C. All the units except one are SI units.
D. Two of the units are fundamental and one is derived.
E. None of the units is an SI unit.

NECO

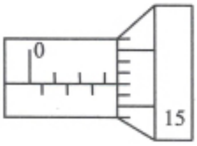
11. Which of the units of the following quantities are derived?
I Area II Thrust III Pressure IV Mass
A. I,II,III & IV
B. I, II & III only
C. I,II & IV only
D. I & III only
E. I & IV only

WAEC

12. Which of the following instruments is suitable for making the most accurate measurement of the internal diameter of a test tube?
A. A metre rule
B. A pair of callipers
C. Micrometer screw gauge
D. A tape rule
E. A pair of set squares

WAEC

13. The above represents a portion of a micrometer screw gauge. What is its reading?
A. 3.70 mm
B. 3.67 mm
C. 3.50 mm.
D. 3.33 mm
E. 3.17mm



WAEC

14. The density of water is 1 g cm^{-3} while that of ice is 0.9 g cm^{-3}. Calculate the change in volume when 90 g of ice is completely melted.
A. 0 cm^3
B. 9 cm^3
C. 10 cm^3
D. 90 cm^3
E. 100 cm^3

WAEC

15. Which of the following is a fundamental quantity?
A. Heat capacity
B. Electric current
C. Torque
D. Reactance

E. Density

WAEC

16. The density of solid is defined as

A. Mass of solid compared to the mass of equal volume of water.
B. Amount of water displaced when a unit mass of solid is immersed in it.
C. Weight per unit volume of the solid.
D. Volume per unit mass of the solid.
E. Mass per unit volume of the solid.

JAMB

17. The density of 400 cm^3 of palm oil was 0.9 g cm^{-3} before frying. If the density of the oil was 0.6 g cm^{-3} after frying, assuming no loss of oil due to spilling, its new volume was

A. 360 cm^3
B. 600 cm^3
C. 240 cm^3
D. 800 cm^3
E. 450 cm^3

JAMB

18. The relative density of zinc, brass, copper, gold and silver are respectively 7.1, 8.5, 8.9, 19.3 and 10.5. A metal ornament which weighs 0.425 kg and can displace 50 Ã— 10^{-6} m of water is made of

A. Zinc
B. Brass
C. Copper
D. Gold
E. Silver JAMB

19. In the equation $P^x V^y T^z$ = constant

A. Ã— = 0, y = 0, z = 1
B. Ã— = 1, y = 0, z = 0
C. Ã— = 1, y = 1, z = 0
D. Ã— = 1, y = 1, z = 1
E. Ã— = l, y = 1, z = -l

JAMB

20. The force with which an object is attracted to the earth is called

A. Acceleration
B. Mass
C. Gravity
D. Impulse
E. Weight JAMB

21. For which of the under listed quantities is the derived unit ML^2T^{-2} correct?

I Moment of a force II Work III Acceleration

A. I only
B. II only
C. III only
D. I and II only
E. II and III only

JAMB

22. What volume of alcohol with density of 8.4 Ã— 10^2 kg m^{-3} will have the same mass as 4.2 m^3 of alcohol whose density is 7.2 Ã— 10^2 kg m^{-3}?

A. 1.4 m^3

B. 3.6 m^3

C. 4.9 m^3

D. 5.0 m^3

E. 5.8 m^3

JAMB

23. Which of the following represents the correct precision if the length of a piece of wire is measured with a metre rule?

A. 35 mm

B. 35.0 mm

C. 35.00 mm

D. 35.01mm

JAMB

24. 40 m^3 of liquid Ï is mixed with 60 m^3 of another liquid Q. If the density of Ï and Q are 1.00 kg $m^3$and 1.6kgm^{-3} respectively, what is the density of the mixture?

A. 0.05 kg m^{-3}

B. 1.25 kg m^{-3}

C. 1.30 kg m^{-3}

D. 1.36 kg m^{-3}

JAMB

25. Which of the following is the dimension of pressure?

A. ML^{-1} T^{-2}

B. MLT^{-2}

C. ML^2 T^{-3}

D. ML^{-3}

JAMB

26. The equation $Ï^x$ V^y T^z = constant is Charles law when

A. Ã— = 1, y = -1, z = 1

B. Ã— = 0, y = 1, z = -1

C. Ã— = 1, y = 1, z = -1

D. Ã— = 0, y = 1, z = 1

JAMB

27. For which of the following sets are the units fundamental?

A. Area, length and volume.

B. Impulse, mass and time.

C. Length, time and mass.

D. Velocity, distance and time.

E. Volume, mass and density.

NECO

28. At what respective values of x, y and z would the unit of force, Newton be dimensionally equivalent to M^x L^y T^z?

A. -1, 1, 2

B. 1, 1, -2

C. 1, -1, 2
D. -1, 1, -2

JAMB