L 3. APPLY GENERAL

PHYSICS

Physics is the natural science that studies matter, its fundamental constituents, its motion and behavior through space and time, and the related entities of energy and force**.**

Physics is one of the most fundamental scientific disciplines, and its main goal is to understand how the universe behaves.

LU1. DESCRIBE BASIC MEASUREMENTS IN PHYSICS

1.1 introduction to basic measurement in physics

A quantity may be defined as any observable property or process in nature with which a number may be associated. This number is obtained by the operation of measurements. The number may be obtained directly by a single measurement or indirectly, say for example, by multiplying together two numbers obtained in separate operations of measurement.

Fundamental quantities are those quantities that are not defined in terms of other quantities. In physics there are 7 fundamental quantities of measurements namely **length, mass, time, temperature, electric current**, amount of substance and luminous intensity.

SI units and symbols

In order to measure any quantity, a standard unit (base unit) of reference is chosen. This system is called the International System of Units (**SI).**

Fundamental quantity	SI Unit	Symbol
1. Length	Metre	m
2. Mass	Kilogram	kg
3. Time	Second	s
4. Temperature	Kelvin	K
5. Electric current	Ampere	A
6. Amount of substance	Moles	mol
7. Luminous Intensity	Candela	cd

At this level we will deal with the 3 fundamental quantity such as **Mass, Length and Time**.

1.2 Meaning of fundamental physical quantity

Mass is **a measure of how much matter there is in an object**, Its SI unit is the kilogram, kg while weight is a measure of the size of the pull of gravity on the object.

Length is the distance between two points. The SI unit of length is the meter, m. It is measured using a meter rule, tape measure etc.

Time is the duration between any two events. Its SI unit is the second, s. It is measured using a clock/watch.

1.3 Measure of delivered physical quantity

Quantities which are defined in terms of the fundamental quantities via a system of quantity equations are called derived quantities. Examples of derived quantities include **area**, **volume**, **velocity**, **acceleration, density, weight and force**.

The SI units of derived quantities are obtained from equations using mathematical expressions as follows:

(a) Area (e.g for square objects)=length (m) × length (m).
The SI unit of area in symbols is m^2.

(b) Volume(e.g for cubic objects)=length (m) × length (m) × length (m).
The SI unit of volume in symbols is m^3

(c) Density $= \frac{\text{mass (kg)}}{\text{volume } (m^3)}$. The SI unit of density in symbols is kg/m^3.

(d) Velocity $= \frac{\text{displacement } (m)}{\text{time taken } (s)}$. The SI unit of velocity in symbols is m/s.

(e) Acceleration $= \frac{\text{change in velocity } (m/s)}{\text{time taken } (s)}$ The SI unit of acceleration in symbols is m/s^2.

Weight is the measure of gravitational pull on an object. It always act from the centre of a body downwards in the direction of gravitational acceleration. The SI unit of weight is newton (N).

Weight is measured using a spring balance (See Fig. 3.30)

Weight = mass x gravitational field strength
$w = mg$

Differences between mass and weight

Mass	Weight
Quantity of matter in a body.	Pull of gravity on a body.
SI unit is kilogram (kg).	SI unit is newton (N).
Constant everywhere.	Changes from place to place.
Scalar quantity.	Vector quantity.
Measured using a beam balance.	Measured using a spring balance.

1.4 International system of units (SI) and Metric prefixes in everyday life

The International System of Units, known by the international abbreviation SI in all languages and sometimes pleonastically as the SI system, is the modern form of the metric system and the world's most widely used system of measurement. Established and maintained by the General Conference on Weights and Measures (CGPM), it is the only system of measurement with an official

status[g] in nearly every country in the world, employed in science, technology, industry, and everyday commerce.

1.5 Dimensional Analysis

1.5.1 Introduction to Dimensions of Physical Quantities

The dimension of a physical quantity are **the powers to which the fundamental (or base) quantities like mass, length and time etc,** have to be raised to represent the quantity.

There are following uses or advantages of dimensional analysis.

- To check the correctness of a given relation.
- To derive the relationship between various physical quantities.

- To determine the dimensions of unknown quantities.
- Conversion of one system of units into the other system of units

The seven fundamental quantities their dimensions.

Fundamental Quantity	Dimension
Length	L
Mass	M
Time	T
Temperature	K
Electric Current	A
Luminous Intensity	Cd
Amount of substance	mol

Let us consider a physical quantity **Q** which depends on base quantities like length, mass, time, electric current, the amount of substance and temperature, when they are raised to powers a, b, c, d, e, and f. Then dimensions of physical quantity Q can be given as:

$$[Q] = [L^a\, M^b\, T^c\, A^d\, mol^e\, K^f]$$

It is mandatory for us to use [ ] in order to write dimension of a physical quantity. In real life, everything is written in terms of dimensions of mass, length and time. Look out few examples given below:

1. The volume of a solid is given is the product of length, breadth and its height. Its dimension is given as:

Volume = Length × Breadth × Height
Volume = [L] × [L] × [L] (as length, breadth and height are lengths)
Volume = $[L]^3$
As volume is dependent on mass and time, the powers of time and mass will be zero while expressing its dimensions i.e. $[M]^0$ and $[T]^0$
The final dimension of volume will be $[M]^0[L]^3[T]^0 = [M^0L^3T]$

2. In a similar manner, dimensions of area will be $[M]^0[L]^2[T]^0$

3. Speed of an object is distance covered by it in specific time and is given as: Speed = Distance/Time

Dimension of Distance = [L]

Dimension of Time = [T]

Dimension of Speed = [L]/[T]

[Speed] = $[L][T]^{-1} = [LT^{-1}] = [M^0LT^-1]$

4. Acceleration of a body is defined as rate of change of velocity with respect to time, its dimensions are given as:

Acceleration = Velocity / Time

Dimension of velocity = $[LT^{-1}]$

Dimension of time = [T]

Dimension of acceleration will be = $[LT^{-1}]/[T]$

[Acceleration] = $[LT^{-2}] = [M^0LT^{-2}]$

M

5. Density of a body is defined as mass per unit volume, and its dimension are given as: Density = Mass / Volume

Dimension of mass = [M]

Dimension of volume = $[L^3]$

Dimension of density will be = $[M] / [L^3]$

[Density] = $[ML^{-3}]$ or $[ML^{-3}T^0]$

6. Force applied on a body is the product of acceleration and mass of the body Force = Mass × Acceleration

Dimension of Mass = [M]

Dimension of Acceleration = $[LT^{-2}]$

Dimension of Force will be = $[M] \times [LT^{-2}]$

[Force] = $[MLT^{-2}]$

1.5.2 Rules for writing dimensions of a physical quantity

We follow certain rules while expression a physical quantity in terms of dimensions, they are as follows:

- Dimensions are always enclosed in [ ] brackets
- If the body is independent of any fundamental quantity, we take its power to be 0

- When the dimensions are simplified we put all the fundamental quantities with their respective power in single [] brackets, for example as in velocity we write $[L][T]^{-1}$ as $[LT^{-1}]$
  - Force, [F] = $[MLT^{-2}]$
  - Velocity. [v] = $[LT^{-1}]$
  - Charge, (q) = [AT]
  - Specific heat, (s) = $[L^2T^2K^{-1}]$
  - Gas constant, [R] = $[ML^2T^{-2}K^{-1}\ mol^{-1}]$

1.5.3 Variation table for assigning Dimension to Physical Quantities

	Quantity	**Definition**	Formula	Units	Dimensions
Basic Mechanical	**Length**	Fundamental	d	m (meter)	L (Length)
	Time	Fundamental	t	s (second)	T (Time)
	Mass	Fundamental	m	kg (kilogram)	M (Mass)
	Area	length^2	$A = d^2$	m^2	L^2
	Volume	length^3	$V = d^3$	m^3	L^3
	Density	$\frac{\text{mass}}{\text{volume}}$	$\rho = \frac{m}{V}$	kg/m^3	$\frac{M}{L^3}$
	Velocity	$\frac{\text{length}}{\text{time}}$	$v = \frac{d}{t}$	m/s c (speed of light)	$\frac{L}{T}$
	Acceleration	$\frac{\text{velocity}}{\text{time}}$	$a = \frac{v}{t}$	m/s^2	$\frac{L}{T^2}$
	Momentum	mass × velocity	$p = m \cdot v$	kg·m/s	$\frac{ML}{T}$

Basic Mechanical	**Force** Weight	mass × acceleration mass × acceleration of gravity	$F = m \cdot a$ $W = m \cdot g$	N (newton) = $kg \cdot m/s^2$	$\frac{ML}{T^2}$
	Pressure	$\frac{\text{force}}{\text{area}}$	$p = \frac{F}{A}$	Pa (pascal) = N/m^2 = $kg/(m \cdot s^2)$	$\frac{M}{LT^2}$
	Energy or Work Kinetic Energy Potential Energy	force × distance $\frac{\text{mass x velocity}^2}{2}$ mass × acceleration of gravity × height	$E = F \cdot d$ $K = \frac{1}{2} mv^2$ $U = m \cdot g \cdot h$	J (joule) = $N \cdot m$ = $kg \cdot m^2/s^2$	$\frac{ML^2}{T^2}$
	Power	$\frac{\text{energy}}{\text{time}}$	$P = \frac{E}{t}$	W (watt) = J/s = $kg \cdot m^2/s^3$	$\frac{ML^2}{T^3}$
Thermal	**Temperature**	Fundamental	K	°C (celsius), K (kelvin)	K (Temp.)
	Heat	heat energy	$Q = mc\Delta t$	J (joule) = $kg \cdot m^2/s^2$	$\frac{ML^2}{T^2}$
Electromagnetic	**Electric Charge +/-**	Fundamental	Q	C (coulomb) e (elementary charge)	IT or Q(Charge)
	Current	$\frac{\text{velocity}}{\text{time}}$	$i = \frac{q}{t}$	A (amp) = C/s	$I = \frac{Q}{T}$
	Voltage or Potential	$\frac{\text{energy}}{\text{charge}}$	$V = \frac{E}{q}$	V (volt) = J/C	$\frac{ML^2}{IT^3}$
	Resistance	$\frac{\text{voltage}}{\text{current}}$	$R = \frac{V}{i}$	Ω (ohm) = V/A	$\frac{ML^2}{I^2T^2}$

Sources of errors in measurement of physical quantities

Error: It is a state of being wrong in conducting experiment.

SOURCES OF ERRORS

. Negligence

. Innappropriate use of instrument

A **measurement** is an observation that has a numerical value and unit. When you measure an object, you compare it with a standard unit. measurement must be expressed by a number and a un it.

Standard measurement is an exact quantity that people agree on to be used for comparison or as a reference to measure other quantities.

Experimental Errors

The experimental error can be defined as: "the difference between the observed value and the true value" (Merriam-Webster Dictionary).

Materials:

- Tape measure
- Table

Procedure:

- Using the tape-measure, measure the length of your table and record the result.
- Repeat the same measurement several times and record the results.
- Compare your findings.

Questions:

1. Are your results the same?
2. (If not) What may have caused the differences?
3. Where do you think errors come from?

1.5.4 Types of experimental Errors

random and ***systematic***.

Random errors

It is an error which occurs accidentally.
They may be due to: Misreading the results,poor instrument sensitivity, random noise, random external disturbances, and statistical fluctuations (due to data sampling or counting).
Example : .If you use a topwatch to measure a runner, sometimes you press abit late or early. It affects precison and this is a human error
.If you are measuring the temperature of someone, and the environment changes, you record the wrong records

1. ***Systematic errors***

This is an error that always comes from the problems of measuring instrument or method.
It is due to wrong use of instruments or broken instruments.
for example, a ruler or an ammeter. Repeating the measurement does not reduce or eliminate the error and the existence of the error may not be detected until the final result is calculated and checked.
This is an instruments's error.

Example: .A scale that is not set to zero will always add +2kg to every weight you measure
.A ruler with a broken edge will always give a shorter measurements.

There are two main causes of error

human and **instrument**.

Human error can be due to mistakes (misreading 22.5cm as 23.0cm) or random differences (the same person getting slightly different readings of the same measurement on different occasions**).**

Instrument errors can be systematic and predictable (a clock running fast or a metal ruler getting longer with a rise in temperature). The judgment of uncertainty in a measurement is called the absolute uncertainty.

1.5.5 Calculations of errors

Abreviations used:

Mv: measured value
Tv: true value
AB: absolute error

i) Absolute error

measured value – true value (Mv-Tv)

ii) Relative error

$$\frac{AB}{Tv}$$

iii) Percentage error

$$\frac{(mv-tv)x100}{Tv}$$

Examples

1. You measured mass of object as 50.3g while known accepted value is 50.0g

Calculate absolute error and relative error.

2. 24.13 is the actual value of a quantity and 25.09 is the measured value. Calculate the absolute erro

3. A student carried out an experiment and found measured value of 30 but the actual value 28.5. Calculate the absolute error

4. 50 is the true value of a quantity and the absolute error is 3.5. Calculate the measured value

iv) Significant figures of measurements

No quantity can be measured exactly. All measurements are approximations. A digit that was actually measured is called a **significant digit**.
Significant figures in a measurement are the digits in the measurement which are obtained from the instrument wihch are the numbers of meaningful digits.

v) The rules for identifying significant digits

The rules for identifying significant digits when writing or interpreting numbers are as follows:
⚫⚫ All non-zero digits are considered significant. For example, 91 has two significant figures (9 and 1), while 123.45 has five significant figures (1, 2, 3, 4 and 5).

⚫⚫ Zeros appearing anywhere between two non-zero digits (trapped zeroes) are significant. Example: 101.12 has five significant figures: 1, 0, 1, 1 and 2,
2009 it has 4 significant figures

⚫⚫ Trailing zeros (zeros that are at the right end of a decimal point are significant numbers) in a number containing a decimal point are significant. For example, 12.2300 has six significant figures: 1, 2, 2, 3, 0 and 0. And 13.000 has 5 significants

All zeros to left of decimal number but between non zero numbers are significant

Example: 800.08 they are 5 significant

All zeros to left of decimal numbers and zeros before the first non zero digit are always insignificant or not significants

Example: 0.00000053.   2 significants only

⚫⚫ All numbers without decimal point, and when zeros are behind the non zeros we consider the zeros insignificant

Example: 1300 we have two significant digits (1 and 3)

⚪⚪ But when there is a decimal point, it looks like this

1300. it has four significant digits

Exercises

Intructions: for each number below, state how many significant digits it has

1. 0.00456
2. 7.890
3. 0.000320
4. 1500
5. 600
6. 0.2
7. 0.000000053
8. 20.
9. 5005

vi) Rounding off numbers

Rounding off is to approximate the number to less or exact value.

The following rules will be found useful when rounding off figures:

⚫⚫ If the first of the digits to be dropped (reading from left to right) is 1, 2, 3 or 4, simply replace all dropped digits with the appropriate number of zeros. For example, 57,384 rounded off to the nearest thousands becomes 57,000.

⚫⚫ If the first of the digits to be dropped (reading from left to right) is 6, 7, 8 or 9, increase the preceding digit by 1. For e.g., 5,683 rounded off to the nearest hundred becomes 5,700.

⚫⚫ If only one digit is to be dropped and this digit is 5, increase the preceding digit by 1 if it is odd, and leave it unchanged if it is even. Thus, if 685 is to be rounded off to the nearest tens it becomes 680, while 635 rounded off to the nearest tens becomes 640.

⚫⚫ If a decimal fraction is rounded off, zeros should not replace the digits that are to the right of the decimal, because zeros to the right of a decimal are significant. For example, 70.2 rounded off to one significant figure becomes 70 and not 70.0 to the nearest tens.

EXAMPLES:

1.Round off the value of π

Π= 3.141592654

Answer: 3.1416

2. Round off 123.517

   Answer: 123.52

<u>TO WRITE SCIENTIFIC NOTATIONS OF FOLLOWING NUMBERS</u>

$1.0130 = 1.0\times10^{4}$

$12500.7545 = 1.25\times10^{4}$

1.6 Measuring instrument used to measure length

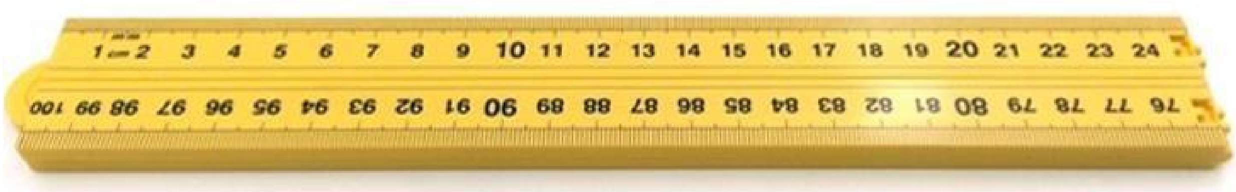
Definition of instrument

Instrument:

is a device or a tool used to measure size or quantity of an object according to its standard units

i) **Meter stick**

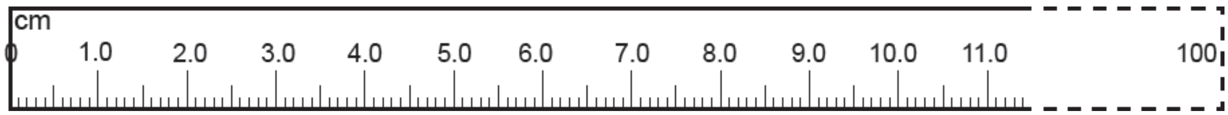
It is a **ruler used to measure length**, and is especially common in the construction industry. They are often made of wood or plastic, and often have metal or plastic joints so that they can be folded together.



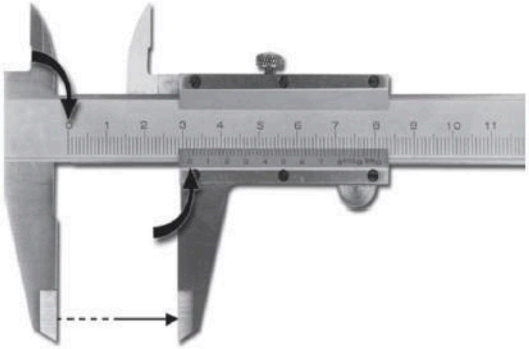
ii) **Meter rule**

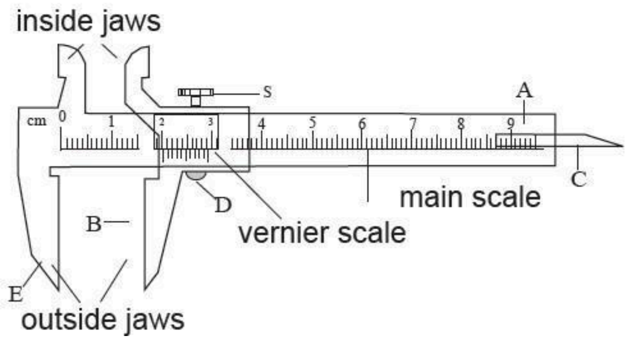
Straight distances which are less than one metre in length are generally measured using *metre rules*. Metre rules are graduated in *millimetres (mm)*.

Each division on the scale represents 1 mm unit.


cm
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
100

iii) Vernier calipers





They measure the thickness

iv) Micrometer screw gauge

A micrometer screw gauge is an instrument for measuring very short length such as the diameters of wires, thin rods, thickness of a paper etc. It was first made by an astronomer called *William Gascoigne* in the 17th century.

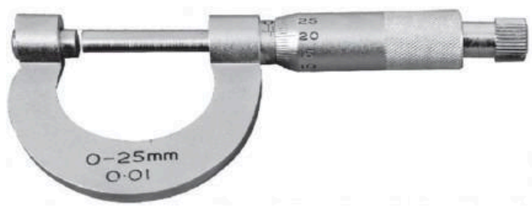


Fig. 1.18(a): Micrometer screw gauge

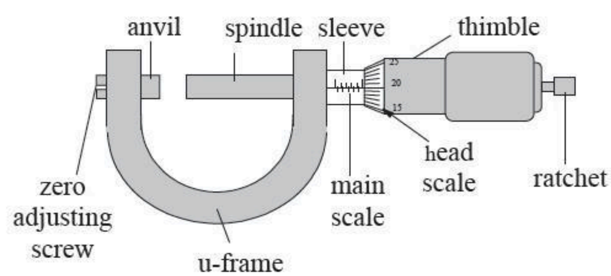
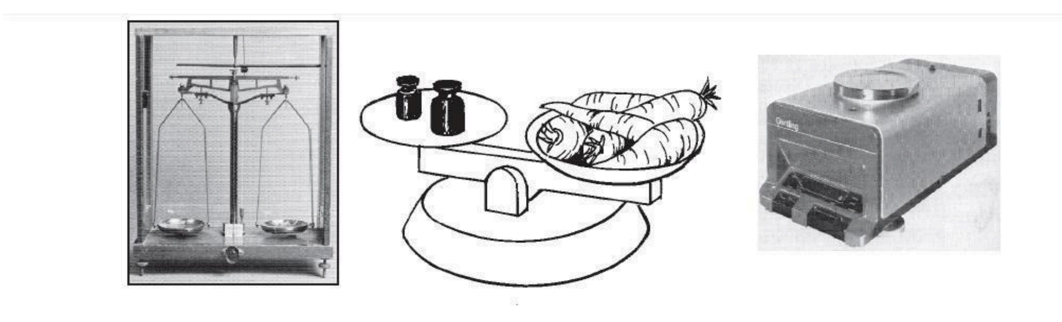


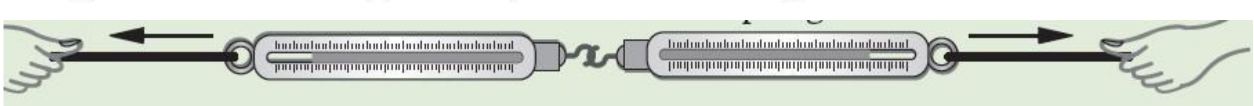
Fig. 1.18:(b) Parts of a micrometer screw gauge

1.7 Instrument used to measure mass

There are many kinds of balances used for measuring mass



(a) beam balance (b) traditional pan balance (c) electronic balance



Spring Balance

1.8 Measuring instrument used to measure time

- **Watches,cloks**

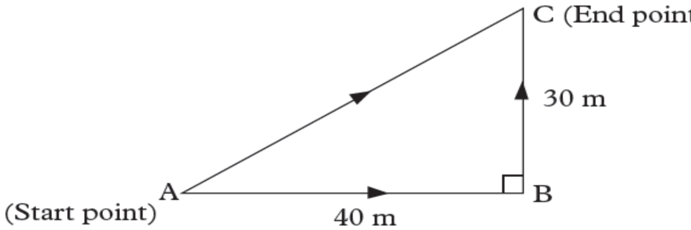
UNIT 2: DESCRIBE MOTION IN ONE DIMENSION

2.1 Displacement and Distance

Distance is *the total length of the path followed by an object, regardless of the direction of motion*. It is a scalar quantity and measured in units of length. The *SI unit* of distance is the *metre (m)*. Long distances may be measured in kilometres (km) while short distances may be measured in centimetres (cm) or millimetres (mm).

Displacement *is the object's overall change in position from the starting to the end point*.
It is the shortest distance along a straight line between two points in the direction of motion. The *SI unit* of displacement is the *metre* (m).

Examples: Suppose a boat starts at point A moves 40 km East to point B followed by 30 m North to point C as shown



We can determine its distance and displacement covered as follows:
Distance = AB + BC = 40 m + 30 m = 70 m
Displacement = AC = AB2 + BC2 = 402 + 302 = 50 m.

2.2 Speed and Velocity

Speed is the distance *moved by a body per unit time is called speed*. In this motion, direction is not considered. Thus,

$$\text{Speed} = \frac{\text{distance moved}}{\text{time taken}}$$

The SI unit of speed is **metres per second (m/s).**

Example 2.1

What is the speed of a racing car in metres per second if the car covers 360 km in 2 hours?

Solution

$$\text{Speed} = \frac{\text{distance moved}}{\text{time taken}} = \frac{360\text{ km}}{2\text{ h}} = 180\text{ km/h}$$

OR

$$\text{Speed} = \frac{\text{distance moved}}{\text{time taken}} = \frac{360 \times 1\,000\text{ m}}{2 \times 3600} = 50\text{ m/s}$$

Velocity is also defined *as the displacement covered per unit time* or *the rate of change of displacement.*

$$\text{Velocity} = \frac{\text{displacement}}{\text{time taken}}$$

The SI unit of velocity **is metres per second (m/s).**

2.3 Average and Instantaneous Acceleration

Average acceleration is the change of velocity over a period of time. Instantaneous acceleration is the change of velocity over an instance of time.

Instantaneous acceleration a(t) is a continuous function of time and gives the acceleration at any specific time during the motion.

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time taken}}$$

SI unit is m/s^2

Example

A car accelerates from rest to a velocity of 20 m/s in 5 s. Thereafter, it decelerates to a rest in 8 s. Calculate the acceleration of the car (a) in the first 5 s, (b) in the next 8 s.

Solution

(a) Acceleration $= \dfrac{\text{change in velocity}}{\text{time taken}}$

$= \dfrac{\text{final velocity} - \text{initial velocity}}{\text{time taken}}$

(rest means velocity is zero)

$= \dfrac{(20 - 0 \text{ m/s}}{5 \text{ s}}$

$= 4 \text{ m/s}^2$

(b) Acceleration

$\dfrac{\text{final velocity} - \text{initial velocity}}{\text{time taken}}$

$= \dfrac{(0 - 20) \text{ m/s}}{8 \text{ s}}$

$= \dfrac{-20 \text{ m/s}}{8 \text{ s}} = -2.5 \text{ m/s}^2$

or deceleration of 2.5 m/s^2

2.4 Slope and General Relationship

Rise means how many units you move up or down from point to point. On the graph that would be a change in the y values.

Run means how far left or right you move from point to point.

Slope Numerical measure of a line's inclination relative to the horizontal. In analytic geometry, the slope of any line, ray, or line segment is the ratio of the vertical to the horizontal distance between any two points on it ("slope equals **rise over run**").

Intercept: The point where the line or curve crosses the axis of the graph is called intercept. If a point crosses the x-axis, then it is called the x-intercept. If a point crosses the y-axis, then it is called the y-intercept.
Equation of a straight line is the common relation between the x-coordinate and y-coordinate of any point on the line. Note: The coordinates of any point on the straight line satisfy the equation of the line. Let the equation of a straight line y = 5x - 2.

Average speed

Average speed of a body is the total distance covered by the body over the total time taken

$$\text{Average speed} = \frac{\text{Total distance moved}}{\text{Total time taken}}$$

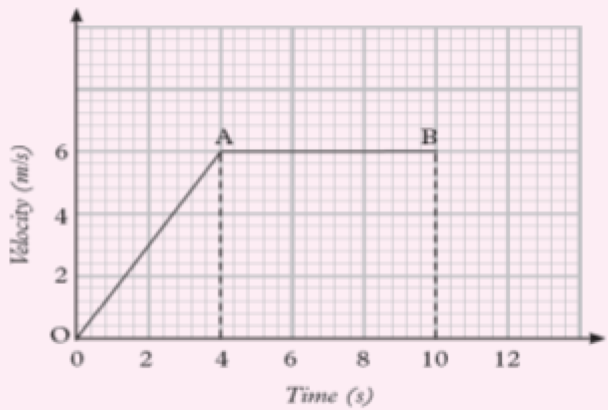
Example: Table shows the data collected to study the motion of cylist.

Velocity m/s	0	3	6	6	6	6
Time (s)	0	2	4	6	8	10

(a) Plot a graph of velocity (y-axis) against time (x-axis).
(b) Use your graph to determine the acceleration of the cyclist in the first four seconds

Solutions

(a)



b) Acceleration = slope of the graph

$$= \frac{\text{Change in velocity}}{\text{Change in time}}$$

$$= \frac{(6-0)\ \text{m/s}}{(4-0)\ \text{s}} = \frac{6\ \text{m/s}}{4\ \text{s}}$$

$$= 1.5\ \text{m/s}^2$$

UNIT 3 ANALYSE MOTION IN TWO DIMENSION

3.1 Scalar, Vector and their properties Scalar

A quantity that has magnitude but no particular direction is described **as scalar**.

Properties of Scalar

- Scalar product is commutative.
- Scalar product of two mutually perpendicular vectors is zero.
- Scalar product of two parallel vectors are equal to the product of their magnitudes.
- Self-product of a vector is equal to square of its magnitude.

Operation of Scalar

Perform several Scalar operations on the following vector:

$$\mathbf{A} = 2\mathbf{i} - 2\mathbf{j} + \mathbf{k}$$
$$\mathbf{B} = 3\mathbf{i} + 4\mathbf{j} + 12\mathbf{k}$$
$$A = \sqrt{A_x^2 + A_y^2 + A_z^2}$$
$$= \sqrt{(2)^2 + (-2)^2 + (1)^2} = 3$$
$$B = \sqrt{B_x^2 + B_y^2 + B_z^2}$$
$$= \sqrt{(3)^2 + (4)^2 + (12)^2} = 13$$

Multiply each entry in the matrix by the given scalar.

Example:

$$A = \begin{bmatrix} 3 & 7 \\ 9 & 10 \end{bmatrix}$$

$$2A = \begin{bmatrix} 2\cdot 3 & 2\cdot 7 \\ 2\cdot 9 & 2\cdot 10 \end{bmatrix}$$

$$= \begin{bmatrix} 6 & 14 \\ 18 & 20 \end{bmatrix}$$

Vector

A quantity that has magnitude and acts in a particular direction is described **as vector**.

Properties of Vector

- Two vector are equal if they have the same magnitude and same direction
- Any vector can be moved parallel to itself without being affected
- Relevant for vector algebra (like subtracting vector)

Operation on Vector

Given $u = \langle 2, 3 \rangle$ and $v = \langle -1, 4 \rangle$,
find a.) $2u$, b.) $2u+v$, c.) $v-3u$

a.) $2\cdot u = 2\langle 2, 3\rangle = \boxed{\langle 4, 6\rangle}$

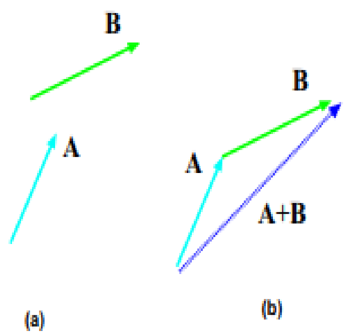
b.) $2\cdot u + v = \langle 4, 6\rangle + \langle -1, 4\rangle = \boxed{\langle 3, 10\rangle}$

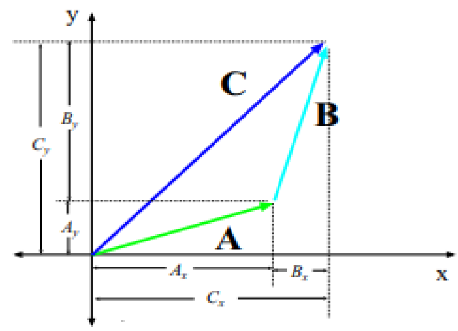
c.) $v - 3$

3.2 Vector Component in Cartesian Coordinate System

Position vector, straight line having one end fixed to a body and the other end attached to a moving point and used to describe the position of the point relative to the body.

Many of the quantities we encounter in physics have both magnitude ("how much") and direction. These are vector quantities. the sum of two (or more) vectors is often called the resultant. We can add vectors in any order we want: **A + B = B + A.** We say that vector addition is "commutative".
We express vectors in component form using the unit vectors i, j and k, which each have magnitude 1 and point along the x, y and z axes of the coordinate system, respectively.





Addition of vectors by components (in two dimensions).

Any vector can be expressed as a sum of multiples of these basic vectors; for example, for the vector A and B we would write:

$\mathbf{A} = \mathbf{A_x i} + \mathbf{A_y j} + \mathbf{A_z k}$ and $\mathbf{B} = \mathbf{B_x i} + \mathbf{B_y j} + \mathbf{B_z k}$

$$\mathbf{A} + \mathbf{B} = (A_x + B_x)\mathbf{i} + (A_y + B_y)\mathbf{j} + (A_z + B_z)\mathbf{k}$$

In terms of its components, the magnitude ("length") of a vector A (which we write as A) is given by:

$$A = \sqrt{A_x^2 + A_y^2 + A_z^2}$$

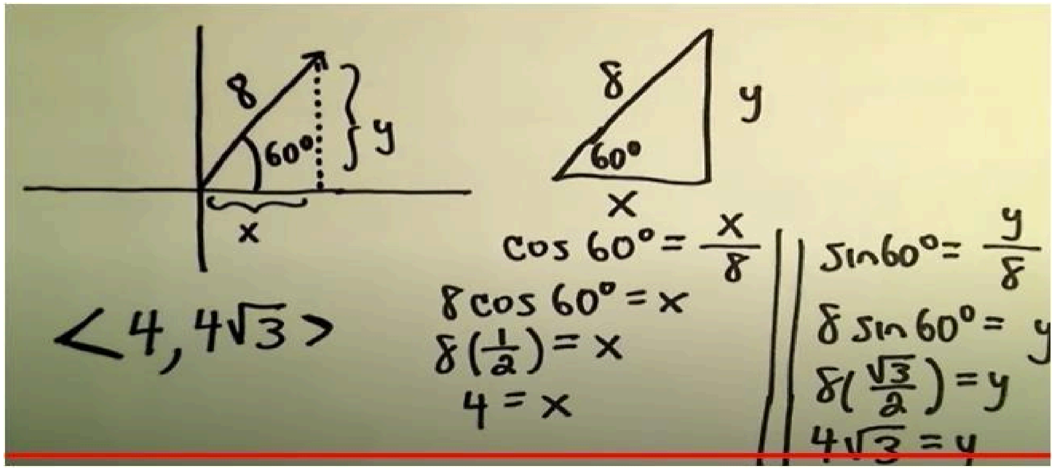
If A is a two–dimensional vector and θ as the angle that A makes with the +x axis measured counter-clockwise then we can express this vector in terms of components Ax and Ay or in terms of its magnitude A and the angle θ. These descriptions are related by:

$$A_x = A\cos\theta \qquad A_y = A\sin\theta$$

$$A = \sqrt{A_x^2 + A_y^2} \qquad \tan\theta = \frac{A_y}{A_x}$$

Example

What are the x and y components of a vector with magnitude of 8 and at the angle 60^0 from the origin?



3.3 Displacement in two dimension

3.3.1 Subtraction of Vector

Given that A(2, 1), B(4, 4) and C(6, 7), find $\overrightarrow{AC}$ in terms of $\overrightarrow{AB}$ and $\overrightarrow{BC}$.

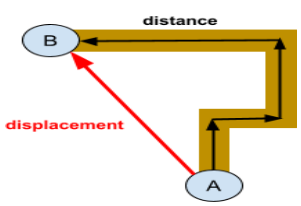
Solution

$\overrightarrow{AB} = (2, 3)$ and $\overrightarrow{BC} = (2, 3)$

$\overrightarrow{AC} = (4, 6) = 2(2, 3) = 2\overrightarrow{AB} = 2\overrightarrow{BC}.$

3.5 Velocity in two Dimension

Average speed and average velocity are expressed in the same units; they are different concepts. **Average** speed considers distance, while **average velocity** considers displacement.



$$\bar{v} = \frac{v_i + v_f}{2}$$

$\bar{v}$ is the average Velocity

V$_i$ =initial velocity

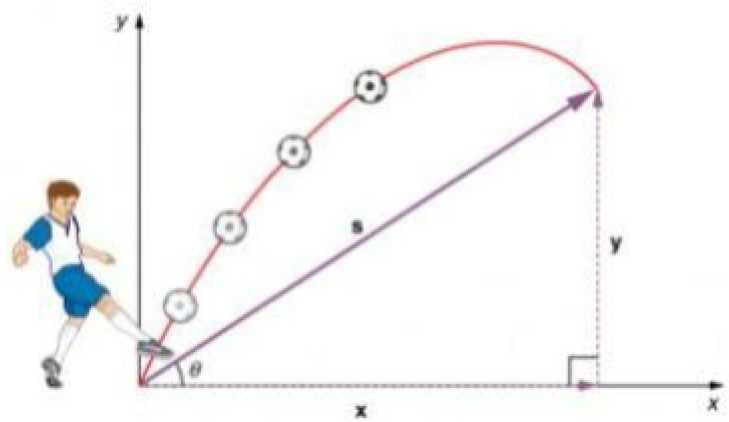
V$_f$ = final velocity

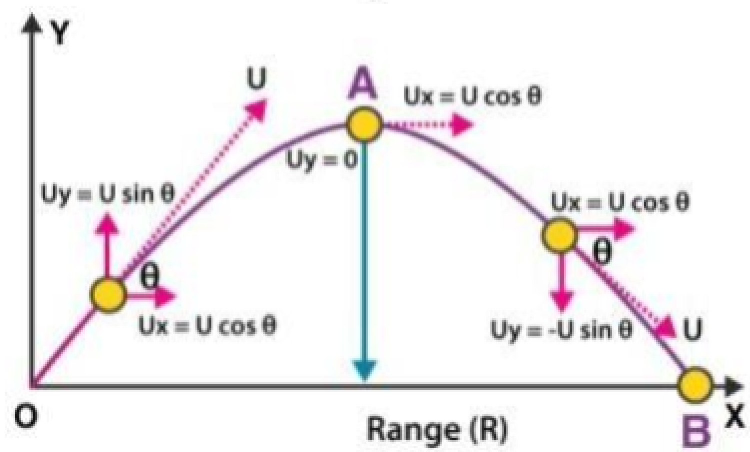
Average velocity is defined as the change in position or displacement (Δx) divided by the time intervals (Δt) in which the displacement occurs. The average velocity can be positive or negative depending upon the sign of the displacement.

Instantaneous velocity is the velocity of an object in motion at a specific point in time. This is determined similarly to average velocity, but we narrow the period of time so that it approaches zero.

3.7 Projectile Motion

We can **define a projectile** as anybody thrown into space/air. The path taken is called a trajectory. The motion of a projectile unless taken otherwise is a free motion under gravity. We assume that air resistance is negligible in this kind of motion.





REVIEW OF KINEMATIC EQUATIONS

$x = x_0 + \bar{v}t$

$\bar{v} = \frac{v_0 + v}{2}$

$v = v_0 + at$

$x = x_0 + v_0 t + \frac{1}{2}at^2$

$v^2 = v_0^2 + 2a(x - x_0)$

$x = x_0 + v_0 t + \frac{1}{2}at^2$

$v^2 = v_0^2 + 2a(x - x_0)$

Resolve or break the motion into horizontal and vertical components along the x- and y-axes. These axes are perpendicular, so $A_x = A \cos \theta$ and $Ay = A \sin \theta$ are used. The magnitude of the components of displacement **s** along these axes are *x* and *y.* The magnitudes of the components of the velocity **v** are $V_x = V \cos \theta$ and $V_y = v \sin \theta$ where *v* is the magnitude of the velocity and θ is its direction, as shown in 2. Initial values are denoted with a subscript 0, as usual.

UNIT 4: DEMONSTRATE ELECTROSTATIC PHENOMENA

4.0 Introduction to electrostatic

Electric charge: is the physical property of matter that causes it to experience a force when placed in an electromagnetic field. Electric charge can be positive or negative (commonly carried by protons and electrons respectively). Like charges repel each other and unlike charges attract each other.

SI unit: coulomb (*C*)

The study of static charges is called **electrostatics.** There are two types of static charges: **positive charges** and **negative charges**.

A body is said to be negatively charged if it has an excess or surplus of electrons. It is said to be positively charged if it has a deficiency or shortage of electrons.

Elementary charge: is the electrical charge carried by a single electron.

Point charge: an electric charge considered to exist at a single point, and thus having neither area nor volume.

Sign and magnitude of electric charge

Magnitude of electric charge on a single electron is **1.6×10^{-19} coulomb**.

the magnitude of the electric field (E) produced by a point charge with a charge of magnitude Q, at a point a distance r away from the point charge, is given by the equation $\mathbf{E = kQ/r^2}$, where k is a constant with a value of 8.99×10^9 N m^2/C^2.

The law of electrostatics.

States *that like charges repel and unlike charges attract.*

4.1 Electrification (Charging) Method

1. **Electrification by contact:** When a positively charged glass rod is brought in contact to the conductor, it neutralizes the negative charges on the conductor and repel the positive charge away from the side of the glass rod,
When the positively charged glass rod is removed (contact broken), the positive charges on the conductor repel each other and spread throughout its body, hence the conductor becomes positively charged.

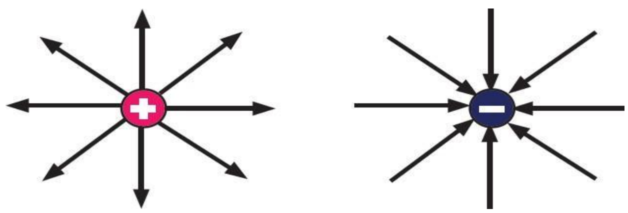
2. **Electrification by induction:** When the rod was brought near the insulated conductor, the negative charges on the conductor were attracted while the positive ones were repelled The process is called electrostatic induction.

3. **Charging by friction method:** includes rubbing one particle against another, causing electrons to move from one surface to the next.

Electrostatic field

In general field produced by electric charge is called electric field but when electric field is produced by stationary charge it is called electrostatic field.

Electric field lines: is the electric field around a charged object which represented by lines showing the direction in which the electrostatic forces act.



Electric field strength (E) is defined as the force per unit charge.

$$E = \frac{F}{Q}$$

Where Q is the charge, and F is the force acting on the charge. Its SI units are NC or NC^{-1}.

4.2 Coulomb's law

Two electrically charged bodies experience an attractive or repulsive force F, which is inversely proportional to the square of the distance(d) between them and directly proportional to the product of their electric charges Q_1 and Q_2, that is:

$$\boxed{F = k\,\frac{Q_1 . Q_2}{d^2}}$$

Where, the constant, $k = \frac{1}{4\pi\varepsilon}$

and is equal to 8.988 × 109 Nm2c–2. A covenient value of 9 × 109 Nm2c–2 is sometimes used for charges in free space.

Force is in newtons (N), the charges in coulombs(C) and distance (d) in metres (m).

Coulomb (C) can also be expressed as:

1 coulomb = 10^{-6} micro coulombs

1 coulomb = 10^{-9} nano coulombs

Example 1.

Suppose two point charges each with a charge of +1.0 C are separated by a distance of 1m. Determine the magnitude of the electrostatic force between them. Is the force attractive or repulsive? ($k = 9 \times 10^9$ Nm^2 c^{-2}).

Data given

$$Q_1 = +1.0\ C, Q_2 = +1.0\ C,\ d = 1\ m$$

$$\text{Since, } F = k\frac{Q_1 . Q_2}{d^2} = \frac{9 \times 10^9 \times 1.0 \times 1.0}{1^2} \text{ then,}$$

$F = 9 \times 10^9$ N. The force is repulsive since it is from two similar charges.

4.3 Capacitor

Capacitor: a device used to store an electric charge, consisting of one or more pairs of conductors separated by an insulator.

Capacitance: the ability of a system to store an electric charge.

parallel plate capacitor

are **formed by an arrangement of electrodes and insulating material or dielectric**. A parallel plate capacitor can only store a finite amount of energy before dielectric breakdown occurs.

The governing equation for capacitor design is: **$C = \varepsilon A/d$**, In this equation, C is capacitance; ε is permittivity, a term for how well dielectric material stores an electric field; A is the parallel plate area; and d is the distance between the two conductive plates

Effective capacitance for capacitor network

When capacitors are connected in parallel, the total capacitance is **the sum of the individual capacitors' capacitances**. If two or more capacitors are connected in parallel, the overall effect is that of a single equivalent capacitor having the sum total of the plate areas of the individual capacitors.

Parallel Capacitances

$$C_{total} = C_1 + C_2 + \ldots C_n$$

Series Capacitor

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

To find the charge stored in capacitor.

Q=CV

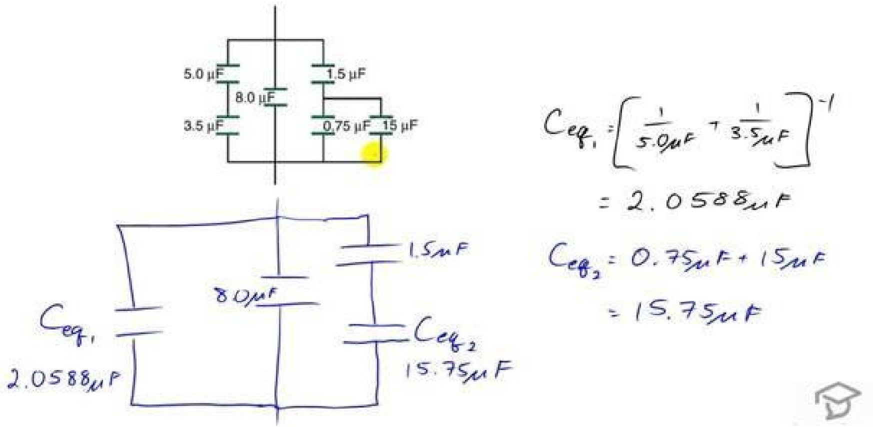
Exercises

1. What charge is stored in a **180.0-µF** capacitor when 120.0 V is applied to it?

   Q=CV = 180.0-µF * 120.0 V

   =

2. Find the equivalent Capacitance of the combination of series and parallel capacitors shown below.



Calculation of the energy sored in a capacitor

$$\mathbf{E}=\frac{1}{2}cv^2$$

Examples of electrostatic phenomena

- **Electrostatic discharge**: is the release of static electricity when two objects come into contact.
- **Lightning arrestor:** is a device used on electric power transmission and telecommunication systems to protect the insulation and conductors of the system from the damaging effects of lightning.
- **Paint spraying:** is a painting technique in which a device sprays coating material (paint, ink, varnish, etc.) through the air onto a surface.
- **Photocopies machine:**

Effect of electrostatic field on moving charge

- **Charge deflection:** is the **way for modifying the path of a beam of charged particles by the use of an electric field applied transverse to the path of the particles**.

- **Charge acceleration: Positive charges accelerate in the direction of the field** and negative charges accelerate in a direction opposite to the direction of the field. A moving charged particle produces a magnetic field.

Gauss'law

Gauss Law states that "**the total electric flux out of a closed surface is equal to the charge enclosed divided by the permittivity"**. The electric flux in an area is defined as the electric field multiplied by the area of the surface projected in a plane and perpendicular to the field.

UNIT 5: APPLY GEOMETRIC OPTIC

5.0 Introduction

Optics: is the study of the behavior and physical properties of light. This has led to development of various optical devices like the lenses that are used in cameras by people with eye defects, projectors, microscopes, telescope, fibre optics among others.

Geometrical optics: is **a model of optics that describes light propagation in terms of rays**. The ray in geometric optics is an abstraction useful for approximating the paths along which light propagates under certain circumstances.

Light: the natural agent that stimulates sight and makes things visible.

- **Natural light:** the light from the sun. Natural lighting, also known as **daylighting**, is a technique that efficiently brings natural light into your home using exterior glazing (windows, skylights, etc.)
- **Source light:** is anything that makes light, whether natural and artificial. Natural light sources include the Sun and stars.

5.1 Format principle

Fermat's principle, in optics, statement that light traveling between two points seeks a path such that the number of waves (the optical length between the points) is equal, in the first approximation, to that in neighboring paths.

5.1.1. Sources of light

(a) Luminous sources of light

These are sources (objects) that emit (give out) their own light.

Examples of non-living luminous objects are **sun, stars**, **fire**, candle flame and electric bulb.

Examples of living things that are luminous objects are **fireflies and glow worm**.

(b) Non-luminous sources of light

These are objects that do not emit (give out) their own light. We get to see these objects when they reflect the light falling on them from luminous source onto our eyes.

The moon is a good example of a non-living thing that is non-luminous source of light. Others are a wall and a car. Examples of a living things that are non-luminous sources are trees and animals.

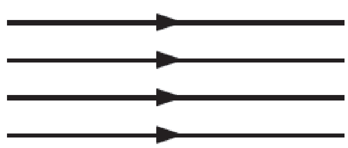
5.1.2 Propagation of light

Rays and beams

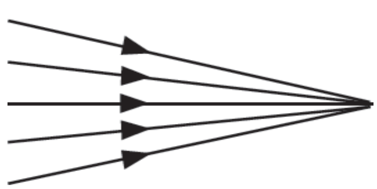
A ray of light is the path along which light travels in a medium.

A beam of light is a collection or group of light rays. There are three types of beam of light rays.

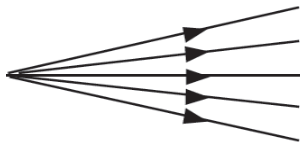
(a) Parallel beam: consists of rays that are parallel to one another



(b) **Convergent beam:** consists of rays of light that meet at a point



(c) **Divergent beam:** consists of rays of light originating from a point source and diverge(spread) to different directions.



Reflection: the throwing back by a body or surface of light, heat, or sound without absorbing it.

Laws of reflection

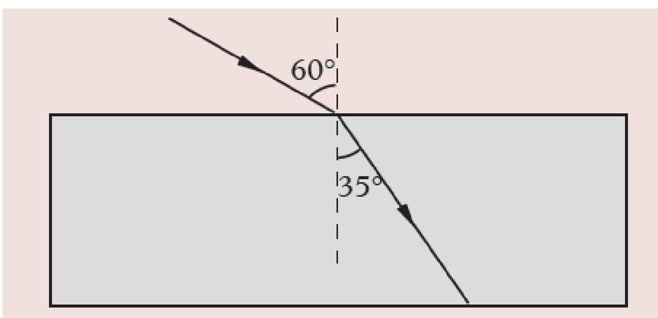
The laws of reflection of light state that:

1. The incident ray, the reflected ray and the normal, at the point of incidence all lie in the same plane.

2. The angle of incidence is equal to the angle of reflection.

Example

calculate the refractive index of glass.



Solution

$$\text{Refractive index of glass } ({}_a\eta_g) = \frac{\sin i}{\sin r} = \frac{\sin 60°}{\sin 35°}$$

$${}_a\eta_g = \frac{0.866}{0.574} = 1.51$$

The refractive index of glass is 1.51.

Refraction of light *is the bending of light rays when they travel from one medium to another of different optical density*. Also, refraction is the change of direction when light rays travel from one medium to another.

Laws of refraction

1. The incident ray, the refracted ray and the normal, at the point of incidence, all lie in the same plane.
2. The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant for a given pair of media (Snell's law)

$$\frac{\sin i}{\sin r} = \text{constant}$$

Example

A ray of light passing from air to glass is incident at an angle of 30°. Calculate the angle of refraction in the glass, if the refractive index of glass is 1.50.

Solution

$$\text{Refractive index of glass } {}_a\eta_g = \frac{\sin i}{\sin r}$$

$$\therefore \sin r = \frac{\sin i}{\eta_g} = \frac{\sin 30^\circ}{1.50} = \frac{0.50}{1.50} = 0.33$$

$$\therefore r = 19.5^\circ$$

The angle of refraction in glass is 19.5°

Medium of propagation

Transparent, translucent and opaque materials

Transparent materials – These are materials that allow all the light falling on them to pass through them freely. Therefore, we are able to see clearly through these materials.

Examples of transparent materials are air, water and clear glass.

Translucent materials – These are materials that allow some light falling on them to pass through. The light gets scattered as it passes through. Therefore, objects on the other side of such materials appear blurred and cannot be seen clearly.

Examples of translucent materials are frosted glass, oiled paper, wax paper, ice, tinted windows and some plastics.

Opaque materials – These are materials that do not allow light to pass through. When light strikes an opaque object, none of it passes through. Therefore, we cannot see through such materials.

When light falls on these materials, much of it is reflected away by the objects some while of it absorbed and converted to heat energy.

Examples of opaque materials are rocks, wood, soil, metals and exercise book.

To investigate how light travels

UNIT 6: CHARACTERIZE SOURCES OF INERGY IN WOLRD

WORK, ENERGY AND POWER

Definition of work

Work is defined as the product of force and distance moved in the direction of the force. i.e

Work = force × distance moved in the direction of the force

$W = F \times d$

The SI unit of work is joule.

Example

Find the work done in lifting a mass of 2 kg vertically upwards through 10 m. (g = 10 m/s2)

Solution

To lift the mass upwards against gravity, a force equal to its own weight is exerted. Applied force = **weight = mg = 2kg × 10N/kg = 20 N**

Work done = F × d = 20 N × 10 m

= 200 Nm

= 200 J

Definition of power

Power is the rate of doing work.

$$\text{Power} = \frac{\text{work done}}{\text{time taken}} = \frac{\text{force} \times \text{distance}}{\text{time}}$$

SI units of power are Watts.

$$1\text{watt} = 1 \ \frac{\text{joule}}{\text{second}}$$

Large units used are kilowatt and megawatt.

$$1\text{kilowatt} = 1\ 000\,\text{W}$$
$$1\text{megawatt} = 1\ 000\ 000\,\text{W}$$

Examples:

What power is expended by a boy who lifts a 300 N block through 10 m in 10 s?

Given data;

Force = 300 N, Distance = 10 m, Time = 10 s

$$\text{Work done by the boy} = F \times d = 300 \times 10 = 3000\ \text{J}$$

$$\text{Power} = \frac{\text{work}}{\text{time}} = \frac{3000\ \text{J}}{10\ \text{s}} = 300\ \text{W}$$

Definition of energy

Energy is the ability or capacity to do work.

Work done = energy transferred

SI unit of energy is joules (J).

Forms of energy

- Solar energy
- Sound energy
- Heat energy
- Electrical energy
- Nuclear energy
- Chemical energy
- Mechanical energy

Mechanical energy = kinetic energy + potential energy.

Kinetic energy $= \frac{1}{2}mv^2$, where m and v are the mass and velocity of the body respectively.

$$P.E = mgh$$

Example

A crane is used to lift a body of mass 30 kg through a vertical distance of 6.0 m.

(a) How much work is done on the body?

(b) What is the P.E stored in the body?

(c) Comment on the two answers.

Solution

(a) Work done = F × d = *mg* × d = 30 × 10 × 6 = 300 × 6 = 1 800 J

(b) P.E = *mgh* = 300 × 6 = 1 800 J

(c) The work done against gravity is stored as P.E in the body.

Sources of energy

There are two kinds of energy sources;

1. Primary sources.

Primary Sources are from sources which can be used directly as they occur in the natural environment. They include.

1. Flowing water
2. Nuclear
3. Sun
4. Wind
5. Geothermal (interior of the earth)
6. Fuels
7. Minerals
8. Biomass (living thing and their waste materials

3. Secondary sources.

are energy sources that are generated from primary sources. For instance, electricity is a secondary source because it is generated for example from solar energy using solar panels or from flowing water using the turbines to generate hydroelectricity. Other secondary sources of energy include; petroleum products, manufactured solid fuels, gases, heat and bio fuel.

Renewable and nonrenewable sources of energy

Renewable energy sources

A renewable energy source is an energy source which can't be depleted/exhausted. They exist infinitely i.e. never run out. They are renewed by natural processes. Examples include;

(i) Sun **(iii)** Geothermal

(ii) Wind **(iv)** Trees

Non-renewable energy sources

These are sources which can be depleted because they exist in fixed quantities. So they will run out one day. Examples are coal, crude oil, natural gas, and uranium.

Environmental effects of the use of energy sources

Air and water pollution
Climate change and global warming
Deforestation
Land degradation