Chapter 1
Measurement

☛Is the process of comparing the amount of unknown quantity with another same kind

To see how many times the first contain the second.

Measurements requirements.

(1) Physical quantities
(2) Tools of measurements
(3) Units of measurements

The Physical quantity

☛It is any quantity that can be determined and has a unit of measurements in our life.

So: Every thing that can be measured is called Physical quantity.

Classification of Physical quantities:

(1) The fundamental Physical quantities	(2) Derivable Physical quantities
Quantities which can't be derived from other Physical quantities ***Ex:*** Length – time mass – temperature	Quantities which can be derived from other Physical quantities ***Ex:*** Speed – work energy – force

Systems that define the fundamental "Basic" Physical quantities and its own measuring units:-

Basic quantity	French System	British System	Metric System
	C.G.S	F.P.S	M.K.S
Length	CM	Foot	Meter
Mass	Gm	Pound	Kg
Time	Sec	Sec	Sec

Mathematical equations

☛They are just a shorthand formulas to give a physical illustration of a particular indications.

OR

☛The simplest form to express the relation between the Physical quantities and shows the Physical meaning.

(1) Modern metric system (International)

International system of units	
BASE Physical quantity	**Unit**
Length (L)	Meter (m)
Mass (m)	Kilogram (Kg)
Time (T)	Second (s)
Electric current intensity (I)	Ampere (A)
Absolute temperature (T)	Kelvin (K)
Amount of matter (n)	Mole (mol)
Luminosity (l_v)	Candela (cd)

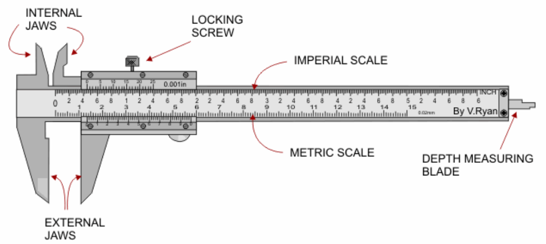
Two additional units has been added

1. Radian for the angle measure. 2- Astrdian for solid angle measure.

(2) Measuring tools

Some old and recent measurement tools	
Length scale	Metric tape, ruler, micrometer and Vernier caliper
Mass scale	Roman balance, two pan balance, one pan balance and digital balance
Time scale	Hourglass, pendulum clock, stopwatch and digital clock

Note ***:- Vernier caliper used to measure small lengths***



(3) Standard Units

☛It is a measuring Units internationally agreed and used in the International system units.

A) Standard meter

- Is calibrated by the distance between the two marks engraved at both end of rod of the alloy platinum – Iridium kept at zero °C.

B) Standard kilogram

☛Is calibrated by equal to the mass of the alloy Cylinder platinum-Iridium with finite dimensional reserved at zero °C.

C) Standard second

- Is equal to $\frac{1}{86400}$ the average solar day

The Importance of using atomic clocks

1. Characterized accuracy infinite.
2. Study of a large number of important matters such as

- to determine the time of day.
- Reviews to improve the ground and air navigation.
- Checking spaceship trips to discover the universe.

Dimensional equation (formula)

☛ It is the formula that expresses the derived physical quantities in terms of the fundamental physical quantities;Mass,Length and Time each has a certain exponent.

General formula : $[A] = M^{\pm a}\ L^{\pm b}\ T^{\pm c}$

And used in

1. The expression of most of the derivable Physical quantities.
2. Determine a unit of measurement.
3. We can add or subtract two Physical quantities.
4. Test the validity of laws.

Physical quantity	Relationship with other quantities	Dimensional equation	Measuring unit
Area (A)	Length × width	$L \times L = L^2$	m^2
Volume (V_{ol})	Length × width × height	$L \times L \times L = L^3$	m^3
Density (p)	Mass ÷ volume $(p = \frac{M}{V_{01}})$	$M/L^3 = ML^{-3}$	kg/m^3
Force (F)	Mass × acceleration (F = m× a)	$M \times LT^{-2} = MLT^{-2}$	$Kg.m/s^2$= Newton
Work.energy (W)	Force × displacement W = F × d	$MLT^{-2} \times L = ML^2T^{-2}$	$Kg.m^2/s^2$ = N.M=joule
Power (P)	Work ÷ time $P = \frac{w}{t}$	$\frac{ML^2T^{-2}}{T} = ML^2T^{-3}$	$Kg.m^2/s^3$ = N.m/s = j/s= watt

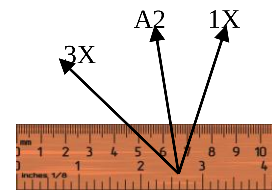
Power of the number (10)

☛It used to express large or small quantities in the simplest from

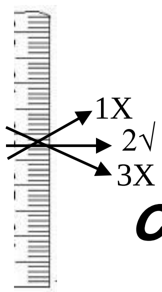
Factor	10^{-9}	10^{-6}	10^{-3}	10^{-2}	10^{3}	10^{6}	10^{9}
Name	Nano	Micro	Millie	Centi	Kilo	Mega	Giga
Symbol	nm	μm	mm	cm	K	M	G

☛From bigger to smaller (times), from smaller to bigger (divide)

Measurement error



Measurement process cannot be accurately 100%
But there should be even a simple percentage of error



Causes an error in the measurement?

1. Choosing measuring instrument not suitable
2. The existence of a defect in the measurement tool
3. A measurement error manner
4. Environmental factors

(temperature, humidity and air currents)

Comparison between the measurement of direct and indirect

Types of measurement

Direct measurement	*Indirect measurement*
using a single tool by using the hydrometer to measure density of liquid.	(using more than one tool to measure density of the liquid by measuring the mass using balance, as well as volume by using measuring cylinder

(1) Calculation error in the case of direct measurement

Absolute error (ΔX)

It is the difference between the real (χ_0) value and the measured value (χ) $\Delta x = |\chi_0 - \chi|$

N.B

Mark scale | | indicates that the product is always positive even if it were real quantity less than the measured quantity

because what is important is to know how error whether it increase or decreases or decreases for instance, $|d - 8d| = 8$

Relative error (r)

It is the ratio between the absolute error (Δx) to the real value (χ_0) $r = \frac{\Delta\chi}{\chi_0}$

Problem (1)

One of the students measured the length of a pencil and found it equals (9.9cm) and the real value of a pencil length is equal to (10cm), while classmate measured the length of the class room he found it equals (9.13m), while the real value of the length of classroom (9.11m)

Calculate the absolute error and relative error in each case

Solution

In case of first student

- Calculation the absolute error

$\Delta x = |x_0 - x| = |10 - 9.9| = 0.1\text{cm}$

- Calculation the relative error

$r = \frac{\Delta x}{X_0} = \frac{0.1}{10} = 0.01 = 1\%$

In case of second student:

Calculation the absolute error:

$\Delta x = |x0 - x| = |9.11 - 9.13| = |-0.02| = 0.02\text{ m}$

Calculation the relative error

$r = \frac{\Delta x}{\chi_0} \quad \frac{0.02}{9.11} = 0.0022 = 0.22\%$

☛ And can be expressed as a result of the measurement process as follows

Length of a pencil = (10± 0.1) cm **&** Length of classroom = (9.11 ± 0.02) m

N.B

The relative error of more significance in the accuracy of the measurement than the absolute error, and be more accurate measurement whenever the relative error is small

(2) Calculation error in the indirect measurement

☛The method of calculating the error in the case of indirect measurement depending on the mathematical relationship during the calculation process

Mathematical relationship	Example	How to calculate the error
Add	Measure the volume of two quantities of liquid	Absolute error = absolute error in the first measurement + absolute error in the second measurement $\Delta\chi = \Delta\chi_1 + \Delta\chi_2$
Subtract	Measuring the volume of a coin subtracting the volume of water before you put them in a graduated cylinder the volume of the water after placed in the cylinder	
Times	Measure the area of a rectangle measuring the length and width and finding (L×W)	Relative error = relative error in first measurement + relative error in second measurement $r = r_1 + r_2$
Divide	Measure the density of the liquid, measure mass and volume then find mass ÷ volume	

Problem (2) Calculate the relative error and the absolute error in measuring the area of the rectangle (A) its length (6±0.1), and width (5±0.2)

Solution

Relative error in the measurement of length $r_1 = \frac{\Delta x}{x_0} = \frac{0.1}{6} = 0.017$

Relative error in the measurement of width $r_2 = \frac{\Delta x}{x_0} = \frac{0.2}{5} = 0.04$

Relative error in the measurement area $r = r_1 + r_2 = 0.017 + 0.04 = 0.057$

Ant that's where $r = \frac{\Delta A}{A_0}$ $\therefore \Delta A = r \times A_0 = 0.057 \times (5 \times 6) = 1.7\ m^2$

Based on the above the area of the rectangle (A) = (30± 1.7) m^2

Chapter 2 Scalar quantities and vector quantities

Physical quantities can be classified into

Scalar	Vector
It is a physical quantity known by its magnitude only Such as; distance, mass, time temperature and energy	It is a physical quantity known by its magnitude and direction. Such as; displacement, velocity, acceleration and force.

N.B

Scalar × scalr = scalar vector × vector = scalar

the product or dividing of any two quantities of them scalar and the other is vector always equal vector quantity

The difference between the distance and displacement

Distance

- It is the actual length of the path moved by an object from a position to another
- The distance is scalar quantity measured by meter needs to know value (magnitude) only

Displacement

It is the straight distance in a certain direction from the start point to the end point

- ❖ Distance equal displacement when the motion in straight line
- ❖ displacement is vector quantity measured by meter

Vector representation

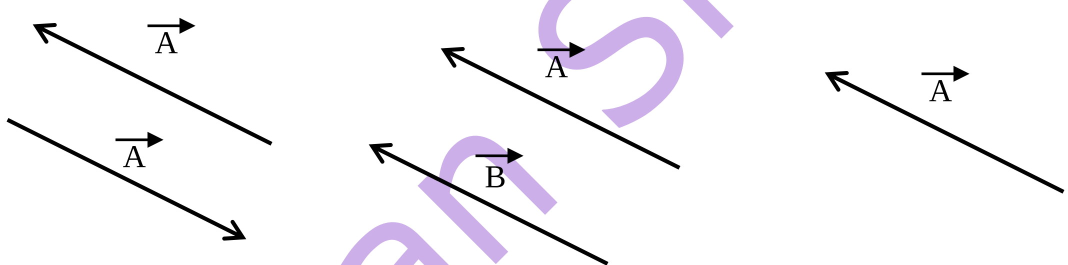
☛Vector is represented with directed line segment its length proportion with the value of the vector start from the starting point and point towards the end point is symbolized with dark A or normal character and above it a small arrow

Graphic representation of vectors

☛Vector is represented by a drawing a line segment directed appropriate scale so that

a- The length of the line segment represents the amount of vector.

b- The direction of the line segment represents the direction of vector.



vectros can be moved parallel to themselves in adiagram

Properties of vector**Vector algebra basic

(1) When two vectors be equal if the two are same in the amount and had the same direction (even if different starting point each)

(2) When two vectors be in reverse (opposite direction)

Vector $\vec{A}$ its numerical value equal to the numerical value of the vector- $\vec{A}$

N.B

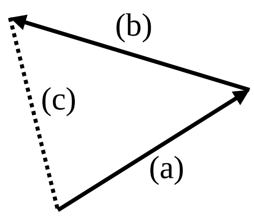
If we multiply the vector – $\vec{A}$ by (-1)
became equal to the vector $\vec{A}$ magnitude and direction

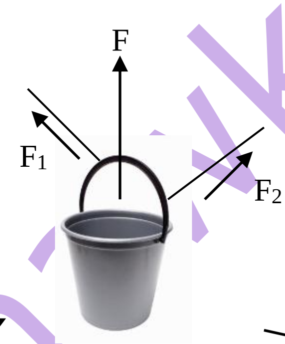
(3) A Resultant vector represents the SUM of two or more vectoers

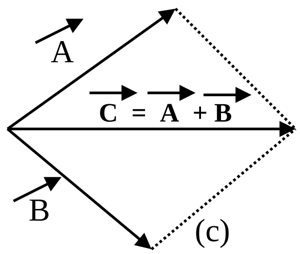
☛The force that affect the body as a result of the impact of several force is called (RESULTANT) force.

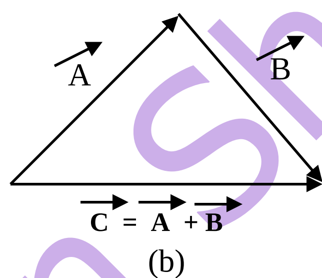
Vectors are added in two ways

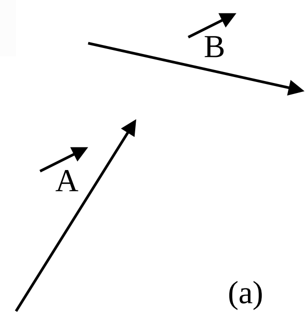
1. Draw a triangle as shown in Figure
2. Draw a parallelogram where A and B are two adjacent sides shall be representative of the diameter (resultant) vectors as shown in Figure





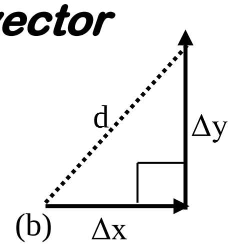






There are two opposite (reverse) operation on vector

First/ find the resultant of two vectors (adding)



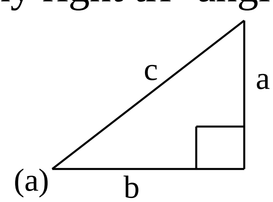
$d^2 = \Delta x^2 + \Delta y^2$

If the angle between vectors is = 90

Pythagoras Theorem for right triangles

(a) The **Pythagoras** theorem can be applied to any right tri- angle

(b) It can also be applied to find the magnitude of a resul-tant displacement



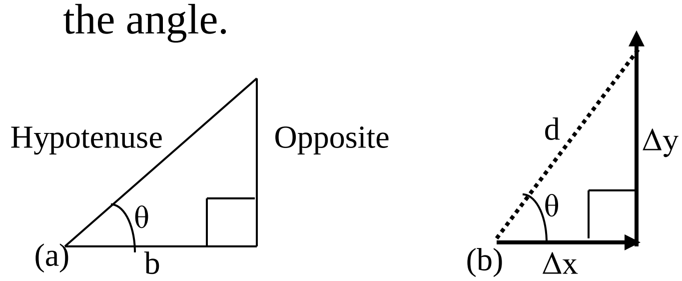
$C^2 = a^2 + b^2$

The way to find the direction of the resultant vector

Definition of the tangent function for right triangles

$$\tan\theta = \frac{opp}{adj} \qquad \text{tangent of angle} = \frac{\text{opposite leg}}{\text{adjacent leg}}$$

The inverse of the tangent function, which is shown below, gives the angle.



$$\tan\theta = \frac{opp}{adj}$$

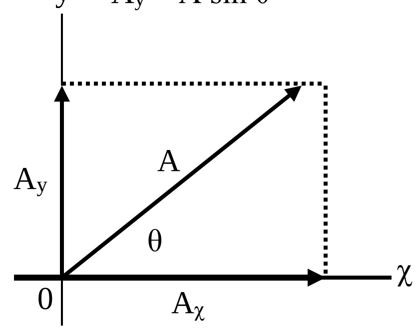
(a) The tangent function can be applied to any right triangle, and

$$\theta = \tan^{-1}\left(\frac{opp}{adj}\right) \qquad \tan\theta = \frac{\Delta y}{\Delta \chi} \qquad \theta = \tan^{-1}\left(\frac{\Delta y}{\Delta \chi}\right)$$

(b) It can also be used to find the direction of a resultant displacement.

Second Vector analysis

$A_y = A \sin\theta$



$A_\chi = A \cos\theta$

can be analyzed into two forces perpendicular on (X, Y) axis

$F_y = F \sin\theta$

$F_x = F \cos\theta$

Vectors product (multiply)

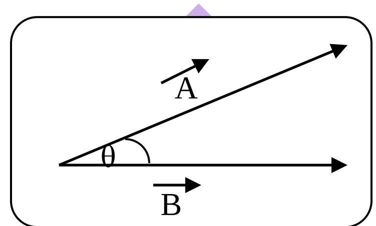
☛ There are different forms vectors products

(1) Scalar product

The result of scalar product between two vectors $\vec{A}$, $\vec{B}$ $\quad \mathbf{\vec{A} \cdot \vec{B} = AB\cos\theta}$

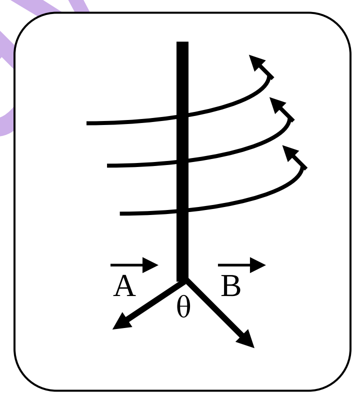
(2) Vector product

☛ The result of vector product between two vectors $\vec{A}$, $\vec{B}$ $\mathbf{\vec{C} = \vec{A} \wedge \vec{B} \sin\theta\ \vec{n}}$
Where (n) is the unit vectors in the perpendicular direction level which include two vectors $\vec{A}$, $\vec{B}$ and determines the direction of ($\vec{C}$) rule called right hand rule



Right hand rule

By moving the fingers of the right hand of the first vector towards the second vector across the small angle between them, shall be thumb points for the result of vector product



N.B In the case of vector product (θ) located between $\vec{A}$, $\vec{B}$

$\vec{A} \wedge \vec{B} \neq \vec{B} \wedge \vec{A}$ $\qquad$ $\vec{A} \wedge \vec{B} = -\,\vec{B} \wedge \vec{A}$

Unit 2 Chapter 1

Motion in a Straight line

Motion

The change in the position of an object relative to a fixed point as time passes.

Objects around us can be classified into

Static object	Moving object
The object that doesnot change its position relative to a given point with time.	The object that changes its position relative to a given point with time.

Types pf motion

(1) Translational motion

A motion which has a starting and end points

* Motion in a straight line
* Projectiles

(2) Periodic motion

The motion that repeats itself over equal intervals

* Motion in a circle.
* Vibrational motion.
* Motion of the moon around the earth.

Velocity (V)

$$= \frac{\Delta d}{\Delta t}$$ m/sec (L-T^{-1})

The rate of change of displacement

Or

The displacement of an object in one second.

N.B To convert the unit of measuring " V "

1 km / 1 h → $\times \frac{5}{18}$ m/sec

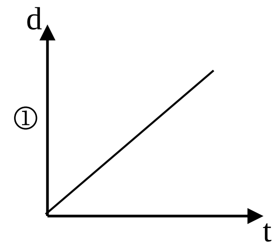
What is meant by "A car moves at velocity of 30 m/s?

Its mean that A car is displaced through 30 m in One second.

What is the difference between:

Speed	***Velocity***
*The distance moved by the object per unit time *Scalar quantity	*The displacement of the object unit time *Vector quantity

Types of velocity

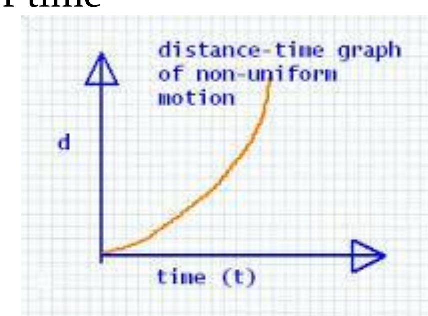


(1)Uniform velocity

equal displacement in equal intervals of time.

(2)Non-Uniform velocity

Unequal displacement in equal intervals of time



N.B The slope = $\frac{\Delta d}{\Delta t}$ = velocity

Instantaneous velocty $V = \dfrac{\Delta d}{\Delta t}$

The velocity of the object at a given instant.

Average velocity ($\bar{V}$)

It is given by dividing the total displacement of the object from the starting point to the end point by the total time of motion.

> **N.B** Instantaneous velocity and average velocity are equal If the object moves at a uniform velocity.

Acceleration (a)

The change of the object velocity per unit time.

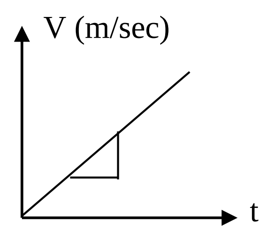
Or

The rate of change velocity

$$* \quad a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t} \quad m/sec^2 \quad (L.T^{-2})$$

Types of acceleration

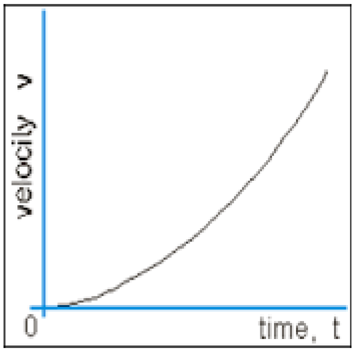
(1) Uniform Acceleration

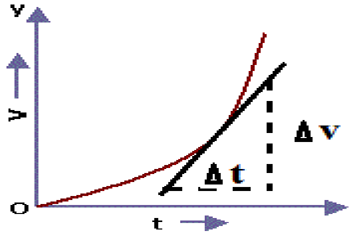


The object moves when it changes velocity with equal amount in equal intervals time.

(2) Non- Uniform acceleration

The object moves when it changes velocity with unequal a mounts in equal intervals of time.

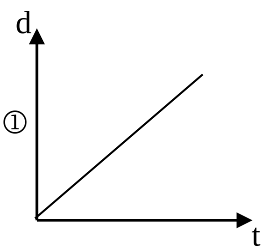


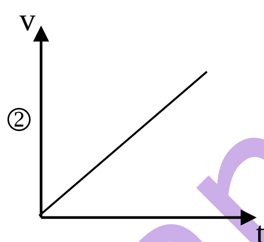


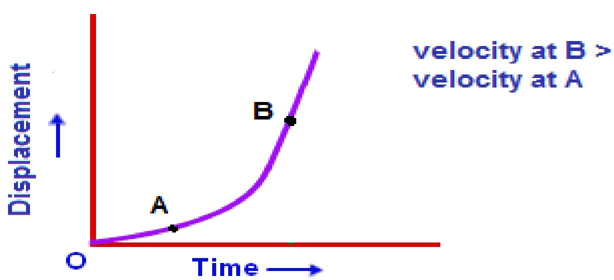
Acceleration may be:

1) + ve acceleration (increasing velocity)
2) – ve acceleration or deceleration (decreasing velocity)
3) Zero acceleration (uniform velocity)

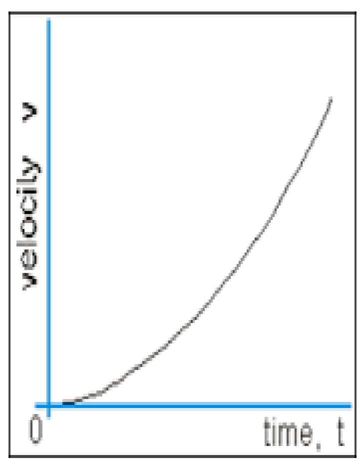
Graphical Representation

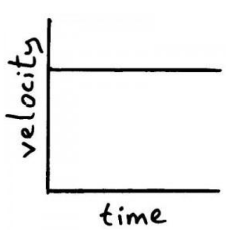






Displacement-time graph when an object moving with non-uniform velocity





1. Uniform velocity
2. Uniform acceleration
3. Non-uniform (V)
4. Non-uniform (a)
5. Static object (at rest)
6. Uniform velocity[zero (a)]
7. deceleration

🕮 *What is meant by:-*

(1) An object moves at a uniform (a) = 5 m/sec^2?
It means that the object velocity increases by 5m/sec in one second

(2) An object moves at a uniform (a) = - 5 m/sec^2?
It means that the object velocity decreases by 5 m/sec in one second.

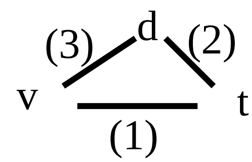
N.B Guidelines to solve problems,

1-when the object starts motion from rest Vi= zero.
2-when the object will stop (comes to rest) Vf = zero.
3-If the object moves at uniform velocity it's (a)= zero
4- If (V) and (a) have the same signs [+ ve or – ve] then the acceleration is positive .{ Acceleration motion}
5- If (V) and (a) have different signs then the acceleration is negative .{ Deceleration motion}

Chapter 2

Motion at uniform Acceleration

Equation of motion



1st equation **(v-t)**

Uniform acceleration (a) is given by

$$a = \frac{V_f - V_i}{t}$$

$$V_f - V_i = at$$

$$\boxed{V_f = V_i + at}$$

2nd equation **(d-t)**

The average velocity of a moving object can be given by the relation

$$\bar{V} = \frac{d}{t} \quad - ①$$

$$\because \bar{V} = \frac{V_f + V_i}{2} \quad -②$$

From 1 s 2

$$d = \bar{V} \quad t$$

$$d = \left(\frac{V_f + V_i}{2}\right) t$$

from $V_f = Vi + at$

$$\therefore d = \left(\frac{vi + at + vi}{2}\right) t$$

$$= \left(\frac{2\ vi + at}{2}\right) t = \frac{2\ vit + at^2}{2}$$

$$\boxed{\therefore d = vit + \tfrac{1}{2} at^2}$$

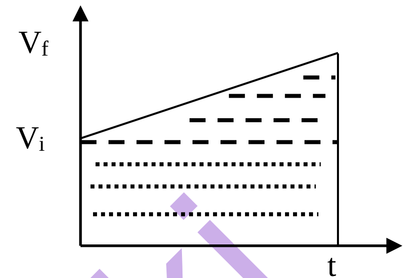
Deriving the second equation of motion graphically:

In case of motion at uniform velocity

Displacement = velocity × time.

In case of motion at uniform acceleration

We can divide the area below the curve into:



* A rectangle of area $= V_i \cdot t$

* A triangle of area

$= \frac{1}{2} (V_f - V_i)\, t$

$= \frac{1}{2} at^2$

By adding the two areas:

$$\boxed{\therefore d = v_i t + \frac{1}{2} at^2}$$

3rd equation (d – v)

$$\because d = \bar{v}\, t$$

$$\because \bar{V} = \frac{V_f + V_i}{2} \qquad t = \frac{v_f - v_i}{a}$$

Substituting in equation

$$\therefore d = \frac{V_f + V_i}{2} \cdot \frac{v_f - v_i}{a}$$

$$d = \frac{V_f^{\,2} - v_i^2}{2a}$$

$$\boxed{\therefore V_f^{\,2} - V_i^2 = 2\, a\, d}$$

<u>*Application of motion at uniform acceleration.*</u>

1- Free fall 2- Projectiles.

First :- Free fall

It is the uniform acceleration by which object moves during free fall towards the ground.

📖This acceleration varies from one position to another depending on its distance from the Earth's centre.

Its average value equal $\underline{9.8\ m/s^2}$ and it can be considered $\underline{10\ m/s^2}$

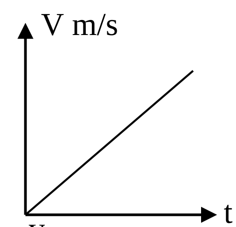
📖What is meant by:

<u>free fall acceleration of an object = $9.8\ m/s^2$</u>

This means that the velocity of the object that falls freely increase by 9.8 m/s every second.

1- When an object falls freely downwards

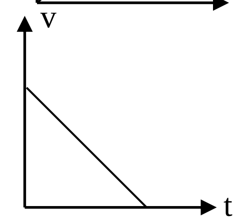
V_i = zero V_f increases



2- When an object is projected vertically

$\therefore V_f$ = zero

(g) has (-ve) value due to the motion against gravity.

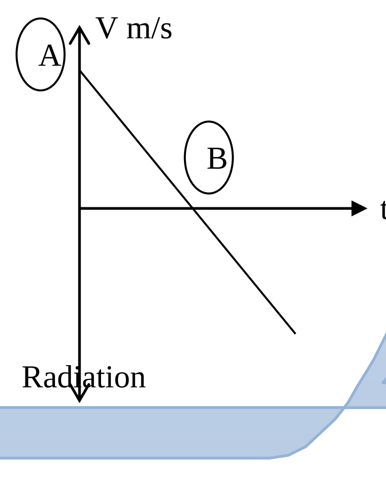


Projectiles

(1)Vertical Projectile

* a = g = -10 m/sec2 Due to the motion against the gravity
* At maximum height V_f = zero
* Velocity of the object when it projected up = (-) its velocity at the same point on falling
* Time of rise = Time of fall.

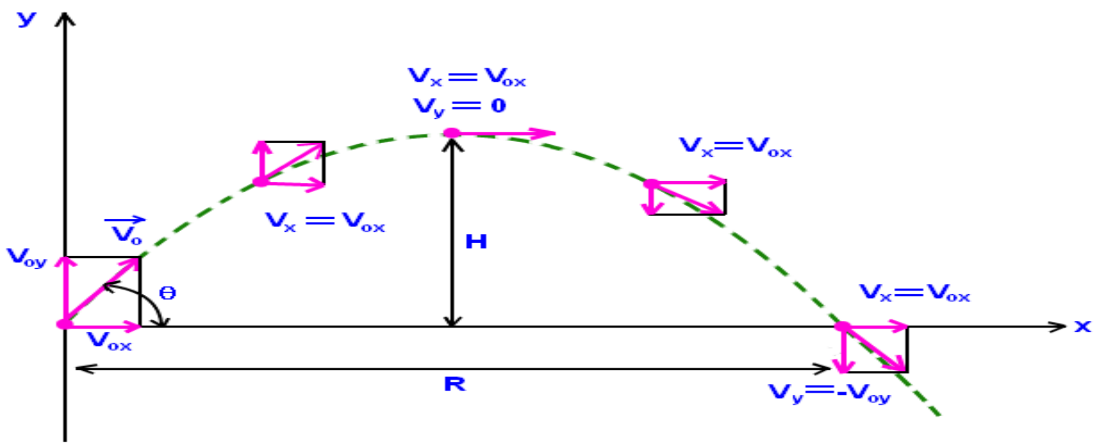
☺The vertical projectiles. Its motion can be represented by the following diagram.



☺Point (A) represents The " Viy

Point (B) represents" t " to reach max. height

(2) Projectiles in two dimensions



We can resolve velocity in two dimension:

1-<u>Horizontal (x) as shown</u>. $\boxed{* \ V_{ix} = V_i \cos\theta}$

(neglecting any friction) and $a_x = 0$

Bec. The ball velocity is uniform.

2-Vertical (Y) as shown $\boxed{* \ V_{iy} = V_i \sin\theta}$

(velocity varies) due to the ball moves at the acceleration due to gravity. $a_y = -10 \ m/sec^2$

* The velocity of the projectile at any instant is given by Pythagoras' relation

$V_f = \sqrt{V_{fx}^2 + V_{fy}^2}$

(1) Finding the time of reaching the maximum height "L"

From 1st eq. $t = \frac{-V_{iy}}{g}$ when V_{fy} = zero

Time taken till returning back to the plane of projection (flight time)

$T = 2t = \frac{-2 V_{iy}}{g}$

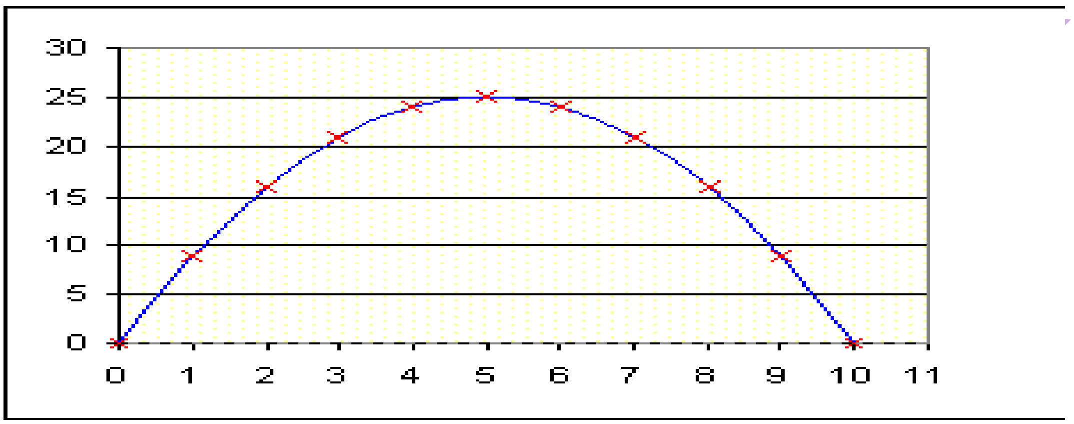
(2) Finding the maximum height reached

by the projectile (h) From 3rd eq. $h = \frac{-V_{iy}^2}{2g}$

(3) Finding the horizontal rang (The horizontal distance reached by the projectile) "R "

$R = V_{ix} .T = 2\ V_{ix} .t$ From 2nd eq.

1. The projectile reaches maximum horizontal range when it is projected at an angle 45°
2. The horizontal range is the same when the projectile is projected at complementary Angles (Angles of sum 90°)



Chapter 3 Force and Motion

Force

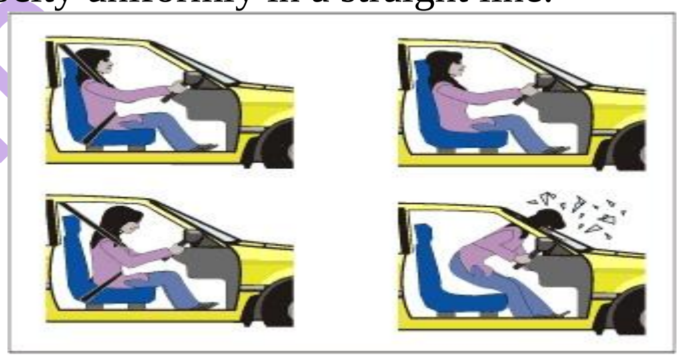
✵An external influence that affects
The object to change its state of motion or direction.

(1) Newton's first law

❐ A static object keeps its state of rest, and a moving object keeps its state of motion at a uniform velocity in a straight line unless acted upon by a resultant force
The mathematical formula $\boxed{\Sigma F = \text{zero}}$

🕮🕮 ***Inertia***

❐The tendency of an object to keep either its state of rest or state of motion at its original velocity uniformly in a straight line.



Or: The property of objects to resist the change of its static or dynamic state

🕮🕮 ***LinearMomentum*** (P_L):-

it is the dot product of (velocity) and (mass).
Linear momentum is a vector physical quantity**.**

✵ Law = M.V ✵ Measuring unit (kg.m/sec).
✵ Dimensional formula M.L.T^{-1}

(2) Newton's second law

When a resultant force affects an object.

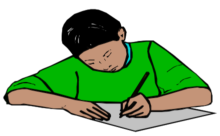
❅The object acquires an acceleration which is directly proportional to the resultant force and inversely proportional to the object mass.

The mathematical formula: $\Sigma F \neq$ zero

$\Sigma F = m\,a$ $\qquad\qquad a = \dfrac{\Sigma F}{m}$

What is meant by: Newton?

❅It is the force that when acts on an object of mass 1 kg accelerates it at 1 m/sec^2



Note

In case of more than one forces acts on the body , then

$\sum F = F\ (\text{moving}) = \mathbf{f_1 + f_2 + f_3} + \ldots\ldots..$ where the forces acting in opposite direction such as friction force take negative sign

Mass and weight

Points of comparison	Mass	Weight
Definition:	It is the resistance of the body to change its velocity.	It is the force of Earth gravity acting on the body.
Type of physical quantity:	Scalar	Vector.
Measuring unit:	Kilogram (kg)	Newton (N)
Constancy:	Constant any where.	Varies from place to another.
I[illegible]	$m = \dfrac{F}{a}$	$F_g = mg$

1) Weight of body depends on the free fall acceleration.
2) Weight of a body changes from a place to another on Earth's surface.
3) The weight of a body is larger than its mass.

(3) Newton's Third Law

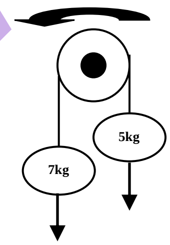
For every action there is a reaction equal in magnitude and opposite in direction. The mathematical formula **$F_1 = -F_2$**

❅Applications of Newton's Third Law

1) when a man jumps from a boat to the reef (action)
the boat shifts backwards (reaction)
2) When a bullet is fired (action) the rifle recoils back wards (reaction)

Problems

☯1. From the opposite figure, calculate the acceleration by which the two loads move.

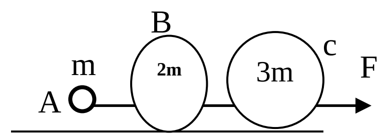


Solution

$$m_1 g - m_2 g = (m_1 + m_2)\ a$$
$$70 - 50 = 12\ a$$
$$20 = 12a$$
$$a = 1.67\ m/s^2$$

☯2- A group of three masses as shown in figure moves at a changeable velocity by the effect of a resultant force F = 30N find

a- The tension force in the Thread between A and B



Solution

$$\because F = (M_A + M_B + M_C)\ .\ a$$
$$= (m + 2m + 3m)\ a = 6\ m\ a$$
$$\therefore 30 = 6\ m\ a \Rightarrow m\ a = 5$$
$$a = \frac{5}{m}$$

$$F_{AB} = m_A\ .\ a = m \times \frac{5}{m} = 5\ N$$

b- The tension force in the thread between B and C

$$F_{BC} = (M_A + M_B)\ a$$

$$= 3\ m \times \frac{5}{m} = 15\ N$$

3-A force of 24 N acts on a body of mass 5 kg that moves on a horizontal surface at acceleration of $3\ m / s^2$. frictional force equal ?

Solution

F (moving) = $\mathbf{f_1 - f_2}$

As $\mathbf{f_1}$= acting force $\mathbf{f_2}$ = frictional force

$5 \times 3 = 24 - \mathbf{f_2}$ $\mathbf{f_2} = 9$ N

4-If the mass of a body is decreased to half and the acting force is reduced to quarter. The acceleration of its motion ?

Solution

$F = m \times a$

So $a_2 = 0.25\ f \div 0.5\ m = 0.5\ a_1$

Unit 3

Chapter 1

Laws of Circular Motion

When a force acts on a body moving at a uniform velocity, it acquires acceleration
If the direction of the acting force.

(1) In the same direction of the motion .The velocity increases and no change in the direction.

(2) In the opposite direction of the motion.The velocity decreases and no change in the direction.

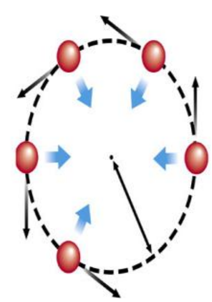
(3) In perpendicular (Normal) to the direction of motion.The velocity remains unchanged and the direction of motion changes.

Uniform circular motion

The motion of body in a circular path at a constant speed and changeable direction.

From the Opposite Figure

Centripetal force (Fc)



The force acting continuously in a direction normal to the motion of a body, changing its straight path into a circular path.

Tangential velocity (V)

📖The velocity of the object in the tangential direction to the circular path at the release moment.

Types of centripetal force

1. Tension force (F_T):-

☛When pulling a body by a string and the tension force acts in normal to the direction of motion.

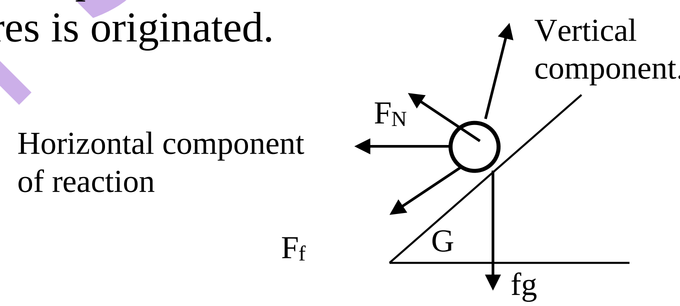
2. Gravitational force (F_G):-

☛An attractive force exists between the sun and the planets in a direction perpendicular to the path.

3. Friction force (F_F):-

☛When a car turns in a circular path or curve a friction force between the road and the car tyres is originated.

4. Reaction force (F_N):-

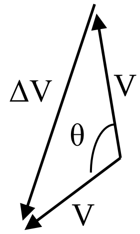


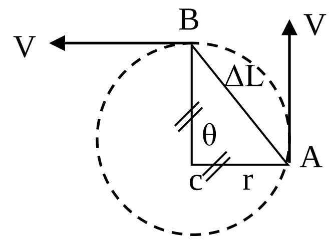
☛The centripetal force is the sum of the two components of the reaction force and the friction force in the horizontal direction.

5. Lifting force. (F_L):

The lifting force acts normally to the aeroplane body. The horizontal component of the lifting force on an aero plane acts as a centripetal force.

🕮Deduction " *Centripetal acceleration* "





From the similarity of triangle (CBA) with the triangle of velocities:

$$\frac{\Delta L}{r} = \frac{\Delta V}{V} \qquad \therefore \Delta v = \frac{\Delta L}{r} .v \quad ①$$

$$\because a_c = \frac{\Delta V}{\Delta t} \quad ②$$

from① and ②

$$a_c = \left(\frac{\Delta L}{r} . V\right) \div \Delta t$$

$$a_c = \frac{\Delta L}{\Delta t} . \frac{v}{r} \qquad \because \frac{\Delta L}{\Delta t} = V$$

$$a_c = V . \frac{v}{r} = \frac{v^2}{r}$$

❅ *Centripetal acceleration* $a_c = \frac{v^2}{r}$

The acceleration acquired by an object moving in a circular path due to a continuous change in the direction of its velocity.

❅ *Tangential Speed*

$$V = \frac{\text{Distance}}{\text{Periodic time}} \quad \text{" circle circumference " } = \frac{2\pi r}{T}$$

$$\text{To find the } T = \frac{\text{total time}}{\text{no. of the revolutions}}$$

Centripetal force

$$F = m a_c = m \frac{v^2}{r}$$

Important Applications

1) Designing curved roads

- If a car moves in a curved slippery road the velocity must be slowly.
- Engineers define certain velocity for vehicle when moving in curves.
- It is forbidden for trucks and trailers to move on some of dangerous curves ($F \propto m$)
- Slowing down in dangerous curves is a must to avoid accidents.

$$(F \propto \frac{1}{r})$$

2) When moving bucket half filled with water in a vertical circular path at sufficient speed, the water does not spill out from the opening of the bucket.

3) We can make benefit of skidding objects

a) Making candy floss
b) Rotating barrels in amusement park
c) Drying cloths.

4) On using electric sharpener, the glowing metal splints blow in straight lines at tangent velocities.

Chapter 2

The general gravitational Law

A body in the universe attracts another body by a force which is

- Directly proportional to the product of their masses.
- Inversely proportional to square the distance between them.

$$F = G\,\frac{Mm}{r^2}$$

$G = 6.67 \times 10^{-11}$ $N\,m^2/kg^2$

general gravitational constant.

D.F = M^{-1} L^{3} T^{-2}

<u>Gravitational field.</u>

The space in which the gravitational forces appear.

<u>The gravitational field intensity.</u>

The gravitational force acting on amass of 1 kgm

$$g = \frac{GM}{r^2}$$

(1) If the body is at a height (h) above Earth's surface

$$g = \frac{GM}{(R+h)^2}$$

Where R radius of the earth.

(2) If the body is at a depth (h) below Earth's surface.

$$g = \frac{GM}{(R-h)^2}$$

To compare the acceleration due gravity for two planets:

Planet 1 $$g_1 = \frac{GM_1}{R_1^2}$$

Planet 2 $$g_2 = \frac{GM_2}{R_2^2}$$

$1 \div 2$ $$\frac{g_1}{g_2} = \frac{M_1}{M_2} \; \frac{R_2^2}{R_1^2}$$

.

Satellites

📖An object projected at a certain velocity to rotate in a roughly circular path at a constant distance from the Earth's surface.

❋**<u>The orbital velocity of a satellite</u>**

The velocity that makes the satellite orbit Earth in a roughly circular path at a constant distance from the Earth surface.

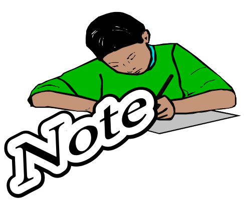
$$F = G\frac{mM}{r^2} = \frac{mV^2}{r}$$

$$V^2 = \frac{GM}{r}$$

$$V = \sqrt{\frac{GM}{r}}$$

Where r = is the orbit radius

= h + R



$$V = \frac{2\pi r}{T}$$

Importance of Satellites

1. Communication Satellites, used in
   TV, Radio, Phone calls, Locating sites through GPS
   Monitor regions using Google earth.
2. Astronomical Satellites:- They are huge telescopes.
3. Remote sensing satellites
4. Explanatory and spying satellites
5. Meteorological satellites.

Give reason for

The orbital velocity keeps the satellite at the same height.

✵ ***Bec:*** the centripetal force acting on it, and it moves in a circular path without changing the magnitude of its velocity.

Problem

A satellite rotates in a circular path at height 300 km from Earth's surface find:

a- Its orbital velocity.

b- Its periodic time.

c- Centripetal acceleration during its motion.

(R= 6400 km – g = 9.8 m/sec^2)

Answer

a- $v = \sqrt{\frac{GM}{r}} = \sqrt{gr}$

$= \sqrt{(9\text{-}8) \times (6400+300) \times 10^3} = 8.1 \times 10^3$ m/s

b- $T = \frac{2\pi r}{V} = \frac{2\pi \times (6400 + 300) \times 10^3}{8.1 \times 10^3} = 5.2 \times 10^3 s$

c- Answer your self.

Unit 4

Chapter 1

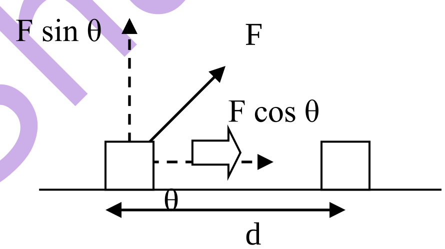
Work and Energy

When a force acts on an object to move it through a certain distance in the direction of the force, it is said that

The force does work

Work

(scalar quantity)



The dot product of the acting force and the displacement in the direction of the force

$W = F \cdot d$

Or

$W = F \cdot d \cos\theta$

The measuring unit $kg.m^2/sec^2$

= joule

D . f $\quad M \cdot L^2 \cdot T^{-2}$

The joule

✵The work done by a force of one Newton to move an object through a displacement of one meter in the direction of the force.

🕮 *What is meant by…*

A person does work on an object of 300 j?

🕮 ***It means that:-*** The person acts on the object by a force 300N, the object is displaced through 1m

🕮🕮 *Factors that affect work done.*

1) The acting force on the body " Directly prop. "
2) Displacement of the body " Directly prop . "
3) The angle between the force and displacement
   " Directly prop. To cosine the angle "

🕮 *What will happen If…*

(1) The angle = 90° ∴ W = zero

✵ ***Bec:*** The cos 90 = 0

(2) The angle is greater than 90° " $\theta > 90°$ "

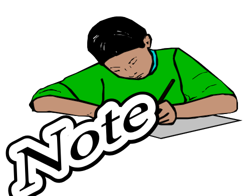
∴ Work done is negative the object does work on the person.

$W = F\, d \cos\theta = -\, W$

(3) The angle = 180°

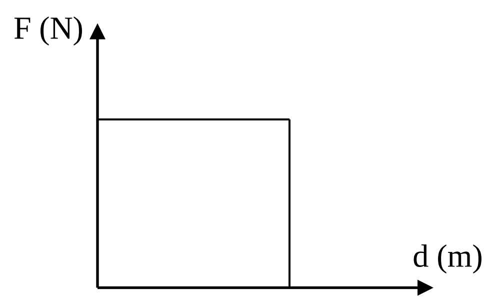
$W = F\, d \cos\theta = -\, F\, d$

The work done by the friction force



Work done when pushing an object forwards is greater than dragging it behind.

Finding work done graphically



Work = length × width
= the area below The (f – d) curve
if $\theta = 0°$

Finding the kinetic energy of an object

❅ If a force (F) acts on an object of mass (m) at rest to move it at " a " to reach velocity " V_f "

From 3rd equation $\qquad V_f^{\,2} - V_i^{\,2} = 2ad$

$\therefore V_f^{\,2} = 2ad \qquad \div 2a$

$\therefore d = \dfrac{V_f^{\,2}}{2a} \qquad \times F$

$\therefore F.d = \dfrac{FV_f^{\,2}}{2a} \qquad F.d = \dfrac{1}{2}\;\dfrac{F}{a}\;V_f^{\,2}$

$\because M = \dfrac{F}{a} \qquad \therefore f.d = \dfrac{1}{2}\; m\,V_f^{\,2}$

$\Downarrow$

the work done

$$\boxed{\therefore K.E = \tfrac{1}{2} mv^2}$$

Kinetic energy

❅ The energy possessed by the object due to its motion.

Finding the potential energy of an object

❅ When an object is lifted up work is done

$W = F.h \qquad :h \longrightarrow$ height

$\because F = m.g \qquad W = m.g.h$

$P.E = m.g.h$

Potential energy

❅ The energy stored in objects because of their new positions.

On converting energy from one form into another, the amount of energy remains constant.
This is known as the law of conservation of energy.

Law of conservation of energy

❁Energy is neither created nor destroyed but it can be converted from one form into another.

* Law of conservation of mechanical energy.

Assume that an object of mass (m) is projected up wards from

- **Point (C)** at initial velocity (V_i) at y_i (distance)
- **to point (A)** at final velocity (V_f) at y_f (distance)

☯**The work done on the object while rising leads to:-**

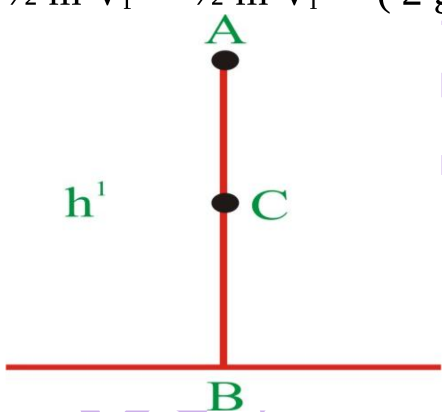
1. An increase in the P.E of the object with height.
2. A decrease in K.E of the object due to a decrease in its velocity.

According to 3rd Law of motion

$V_f^2 - V_i^2 = 2\,a\,d$

$\because a = -g$ and multiply (½m)

$\frac{1}{2} m V_f^2 - \frac{1}{2} m V_i^2 = (2\,g\,d) \times \frac{1}{2} m$



$\frac{1}{2} m V_f^2 - \frac{1}{2} m V_i^2 = -\,m\,g\,(y_f - y_i)$

$\frac{1}{2} m V_f^2 - \frac{1}{2} m V_i^2 = -m\,g\,y_f + m\,g\,y_i$

$m\,g\,y_f + \frac{1}{2} m V_f^2 = m\,g\,y_i + \frac{1}{2} m V_i^2$

$P.E_f \quad + K.E_f \qquad = P.E_i \quad + \; K.E_i$

Note

So :-Throwing an object up wards The K.E. is max. (Because **vi is max**.) While **P.E**.. is zero(because **d = 0**).
•At the maximum height the **KE.** is zero (because **v = 0**) While P.E. is maximum (**because d = max**.). (The K.E. converts into P.E.)
• At the mid height while the body is moving up wards or down wards the **P.E.= the K.E.** because the mechanical energy of the body [**P.E. = K.E.**] is constant
The sum of P.E. and K.E. is constant. The mechanical energy of

Mechanical energy.

🕮 *The mechanical energy*

The sum of potential energy and kinetic energy of an object.
Mechanical energy = PE + KE

🕮 *Law of conservation of mechanical energy*

The sum of P.E and K.E of an object at any point on its path under the effect of gravity only is constant.

☯ *In every day life*

1. Projecting an object up wards
By increasing height, the potential energy increases.
*** P.E at max. height = K.E at the ground = mechanical energy.**

2-In pole vault, P.E is stored in the pole and then is converted into K.E

3. When flinging arrows, P.E is stored in the string and bow and then converted into kinetic energy when the string is released.

4. The roller coaster acquires the max. P.E at the top which is then converted into K.E on falling.