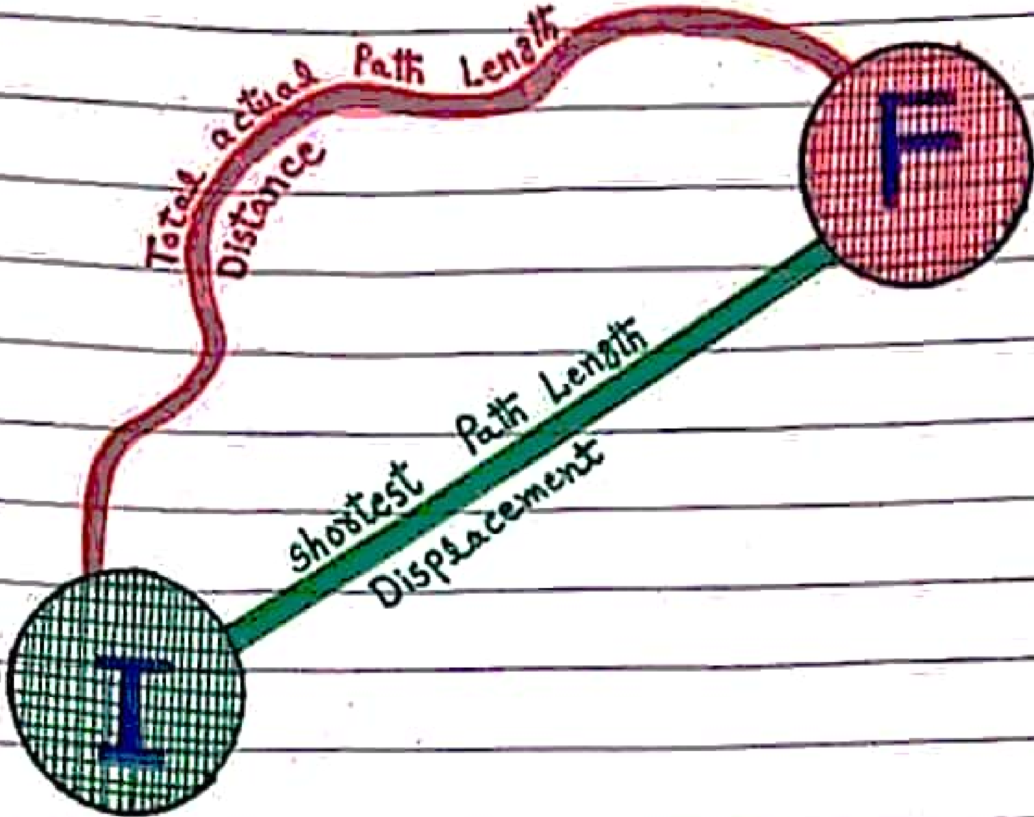
Distance & Displacement:-



Distance:-(S)	Displacement:-($\vec{d}$)
1- Total actual Path length From initial to Final Point during motion.	1- Shortest Path or shortest distance b/w initial and Final Point during motion.
2- independent of direction.	2- Direction always matters.
3- Scalar	3- Vector
4- S.I. unit (m)	4- S.I unit (m)
5- Dimensions. [L]	5- Dimensions. [L]

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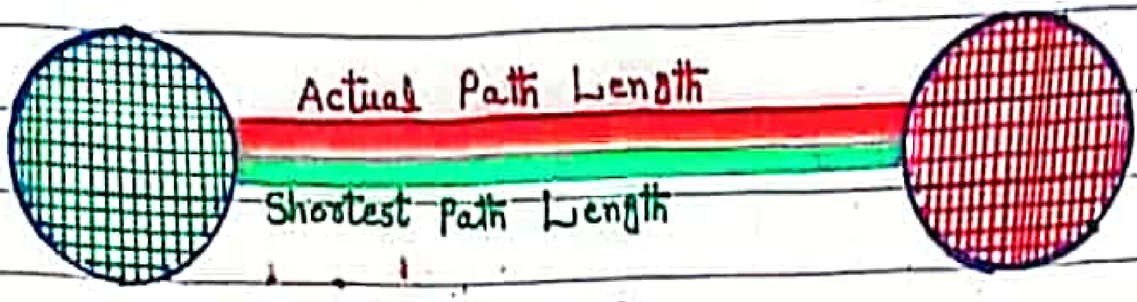
When Body moves in Straight Line:-



Linear motion:-

$\frac{S}{d} = 1 \leftarrow \boxed{S = |\vec{d}|} \rightarrow \frac{d}{S} = 1$

S and $\vec{d}$ concides eacth other

In All Other Motions Exept Straight Line Motion/Linear Motion:-

$S > d$ or $d < S$ always

$S/d > 1$ $\quad$ $d/S < 1$

When Body Moves:-

1. $\boxed{S/d \geq 1}$ $\quad$ 2. $\boxed{d/S \leq 1}$

3. Distance can never be zero $[S \neq 0]$

4. Displacement can be zero

i. $d = 0 \longrightarrow$ closed path

ii. $d \neq 0 \longrightarrow$ open Path

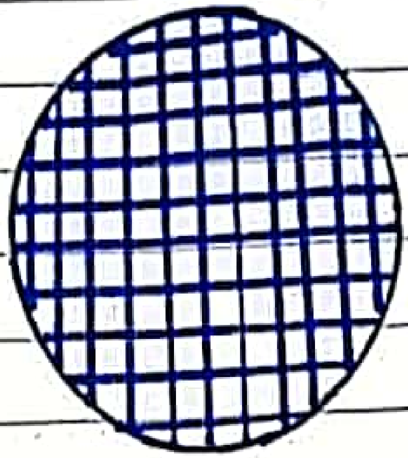
Open Path:- initial & Final Points are Separate.

Closed Path:- initial & Final Points is same

i-e. body stops From where it starts.

Complete Circle:- (100%)

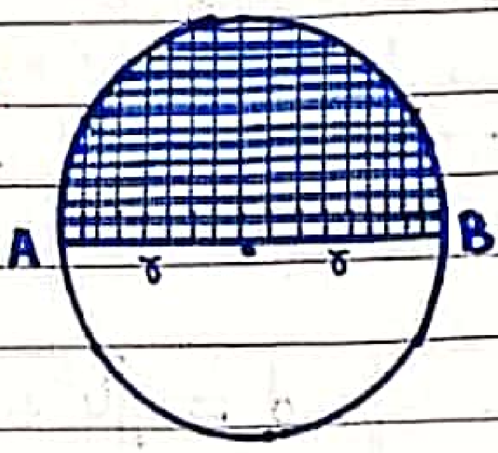
$S = 2\pi r$



$d = 0$

Semi / or Half Circle:- (50%)

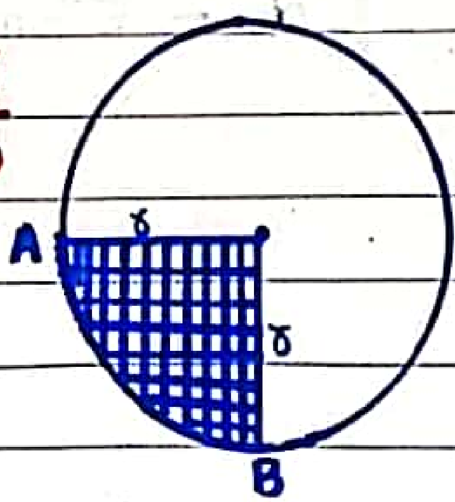
$S = \pi r$



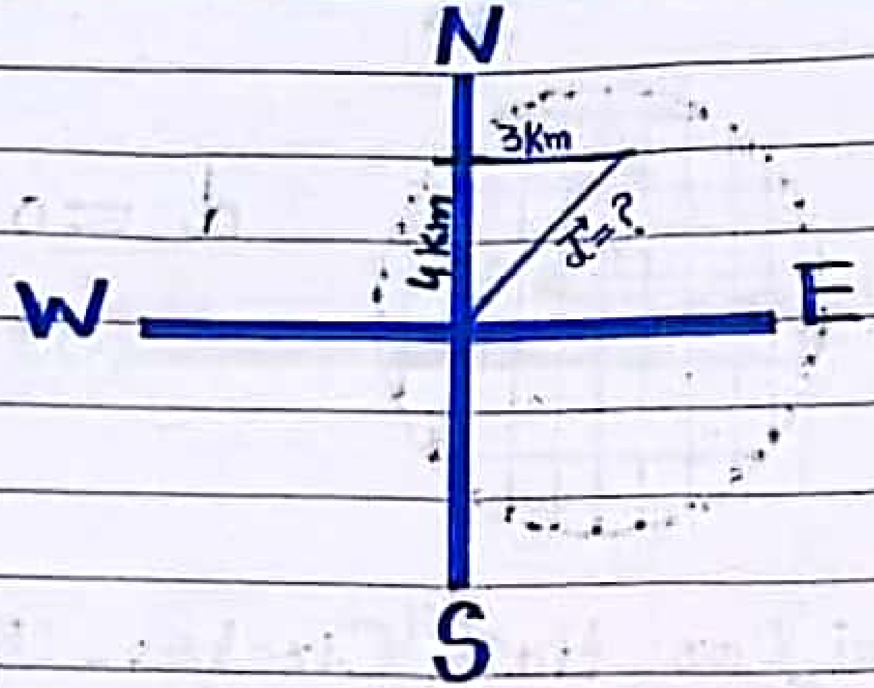
$d = 2r$

Quarter / 1/4 of Circle:- (25%)

$S = \frac{\pi r}{2}$



$d = \sqrt{2} . r$



A mas walks 4 km towards north then 3 km towards east. What is the total distance and displacement covered by man?

$S = 4 + 3$

$S = 7\ km$

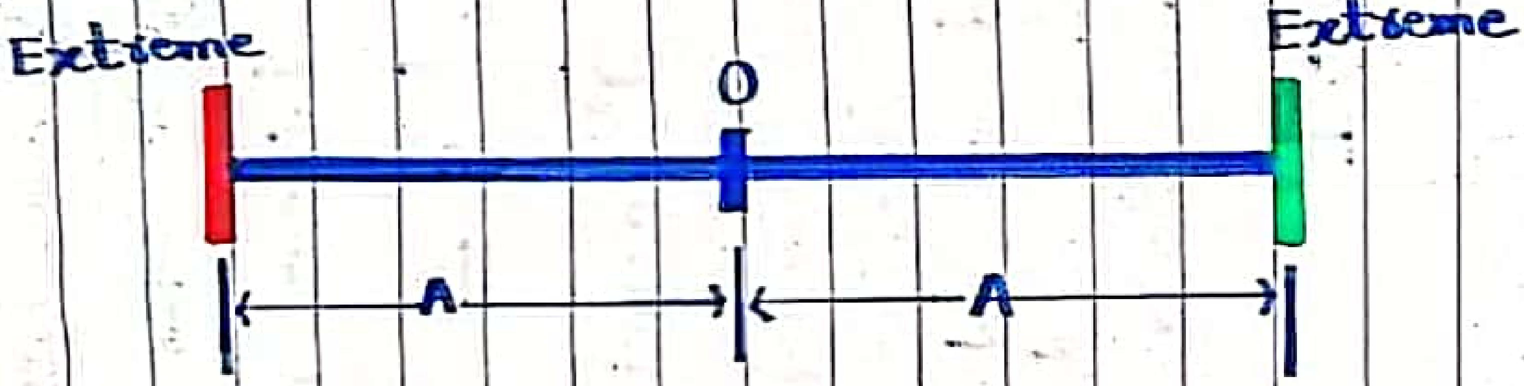
$d = \sqrt{4^2 + 3^2}$

$= \sqrt{16 + 9}$

$= \sqrt{25}$

$d = 5\ km$

To & Fro Oscillator:-



1- Complete Vibration:- ⟶ $S = 4A$, $d = 0$

2- Half Vibration:- ⟶ $S = 2A$, $d = 0$

3- $\frac{1}{4}$ of Vibration:- ⟶ $S = A$, $d = A$

$S = d$

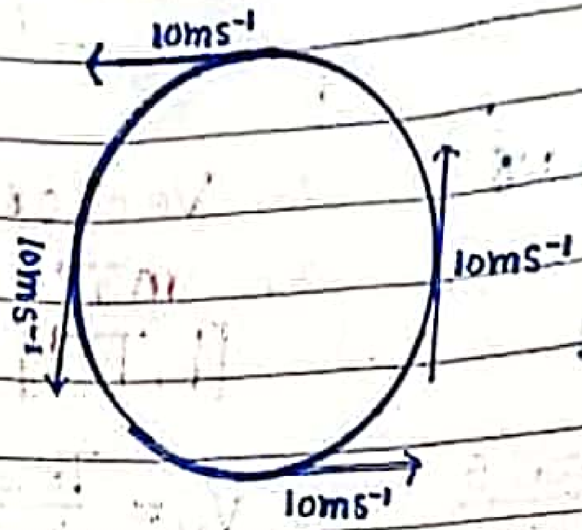
Speed:	Velocity:
1- Time rate of change of distance	2- Time rate of change of displacement.
$\boxed{Speed = \Delta S / t}$	$\boxed{Velocity = \Delta \vec{d} / t}$
2- Scalar	2- Vector
3- ms^{-1} $[LT^{-1}]$	3- ms^{-1} $[LT^{-1}]$
4- $V_{av} = \dfrac{\text{Total } S}{\text{Time}}$	4- $\vec{V}_{av} = \dfrac{\text{Total } \vec{d}}{\text{total time}}$
5- When Body moves.	5- When Body moves.
S can never be zero $S \neq 0$ So, average speed can not be zero $V_{av} \neq 0$	i- if closed Path. $d = 0 \rightarrow \Delta d = 0$ So, average velocity is zero $\vec{V}_{av} = 0$ ii- if open Path $\vec{V}_{av} \neq 0$

Special Case:-

i. Speed is uniform.

ii. Velocity is variable.

A body is moving with constant velocity of $10ms^{-1}$ in a circle:-



Reason:-

At every Point magnitude of velocity remains same which is called speed i.e. $10ms^{-1}$ but at every Point direction changes so velocity changes.

Speed:-

1. $S_1 \neq S_2$, $t_1 = t_2$ $\longrightarrow$ $V_{av} = \frac{V_1 + V_2}{2}$

2. $S_1 = S_2$, $t_1 \neq t_2$ $\longrightarrow$ $V_{av} = \frac{2V_1V_2}{V_1+V_2}$

3. $S_1 = S_2$, $t_1 = t_2$ $\longrightarrow$ $V_{av} = V_{ins}$

4. $S_1 \neq S_2$, $t_1 \neq t_2$ $\longrightarrow$ $V_{av} = \frac{S_1+S_2+---}{t_1+t_2+---}$

Uniform Velocity:- $d_1 = d_2 \rightarrow t_1 = t_2 \rightarrow \vec{V}_{av} = \vec{V}_{ins}$

Variable Velocity:- $d_1 \neq d_2 \rightarrow t_1 = t_2$

Acceleration:-

Time rate of change of velocity.

$$\boxed{a_{av} = \frac{\Delta \vec{V}}{\Delta t}}$$

Type:- Vector , Unit:- ms^{-2} $[LT^{-2}]$

$\vec{a}$ is Uniform:- if $\vec{V}$ changes by equal amount in equal intervals of time.

$\vec{a}$ is Variable:- if $\vec{V}$ changes are unequal in equal intervals of time.

$$\boxed{\vec{a}_{uniform} \Rightarrow \vec{a}_{av} = \vec{a}_{ins}}$$

1- $\vec{V}$ is increasing in a Straight Line:-
$\vec{a}$ is +ive , $\vec{a}$ in The direction of $\vec{V}$
θ b/w $\vec{a}$ & $\vec{V}$ is $0°$ [Parallel]

2- $\vec{V}$ is decreasing in a Straight Line:-
$\vec{a}$ is -ive , opposite direction of $\vec{V}$
θ b/w $\vec{a}$ & $\vec{V}$ is $180°$ [Antiparallel]

Negative $\vec{a}$ $\longrightarrow$ Retardation
$\vec{V}$ is Uniform $\longrightarrow$ $\vec{a}$ is constant
$\vec{V}$ is Constant $\longrightarrow$ $\Delta V = 0$ $\longrightarrow$ $\vec{a} = 0$

Calculation:

$\vec{a}_{av}$ From variable $\vec{a}$
$\vec{a}_{ins}$ From Uniform $\vec{a}$

$\vec{V}$ - t Graph:-

Slope of $\vec{v}$-t graph	→ Acceleration
Area of $\vec{v}$ - t graph	→ Distance

When $\vec{V}$ is Constant:-

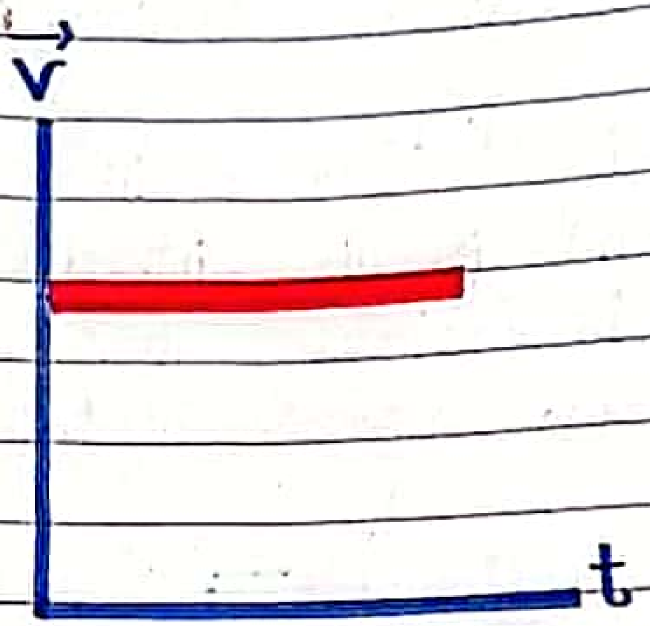
$\vec{v}$ = constant

$\Delta v = 0$

$\vec{a} = 0$

Slope = 0

Graph is straight Line Parallel to x-axis or time axis

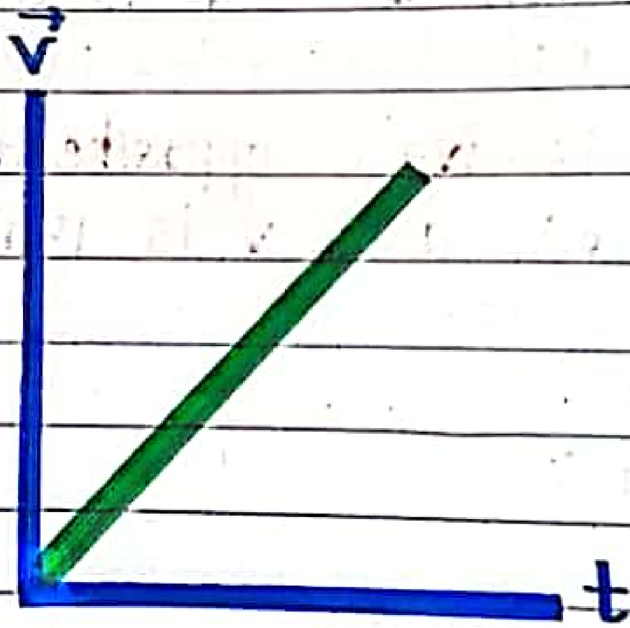


When $\vec{V}$ is increasing UniFormly:-

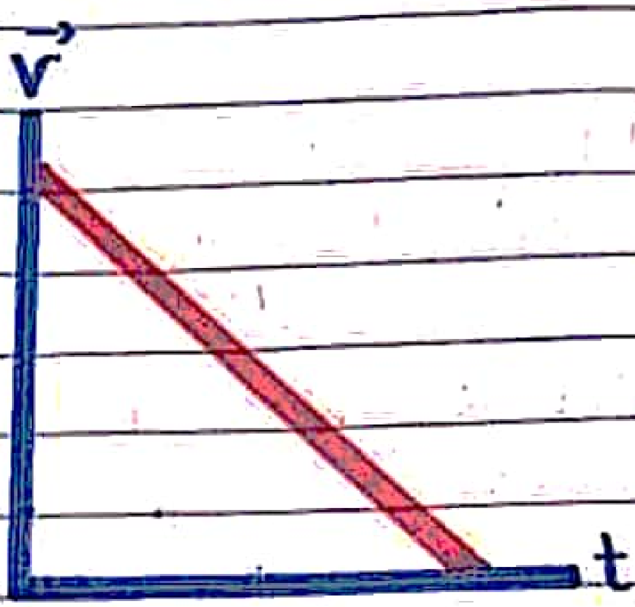
$\vec{V}$ is increasing uniFormly.

$\vec{a}$ is +ive constant or uniForm

Slope = $\vec{a}$ = $\tan\theta$



When $\vec{V}$ is decreasing UniFormly:-

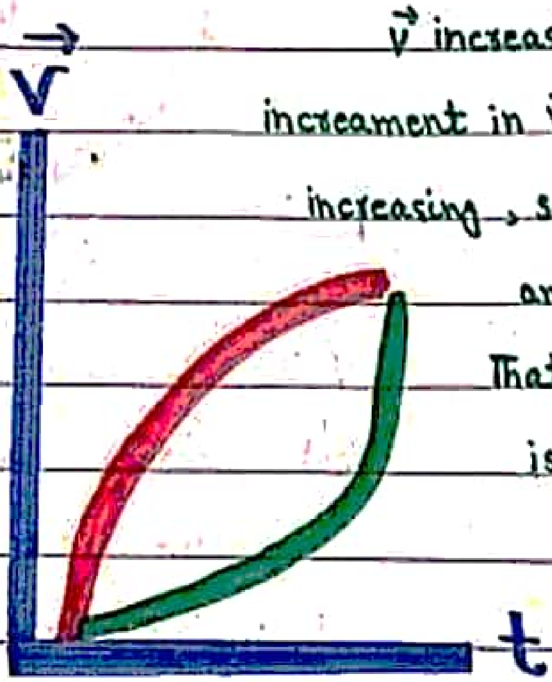


$\vec{V}$ is decreasing uniFormly.

$\vec{a}$ is -ive constant or uniForm

-ive $\vec{a}$ = Retardation

When $\vec{V}$ is increasing non-uniFormly:-



$\vec{V}$ increasing non-uniFormly. But ncreament in $\vec{V}$ w.r.t ime decreasing, so $\vec{a}$ is +ive but decrease hat's why slope is decreasing

$\vec{V}$ increasing non-uniFormly increament in $\vec{V}$ with time increasing, so $\vec{a}$ is +ive and increasing That's why slope is increasing.

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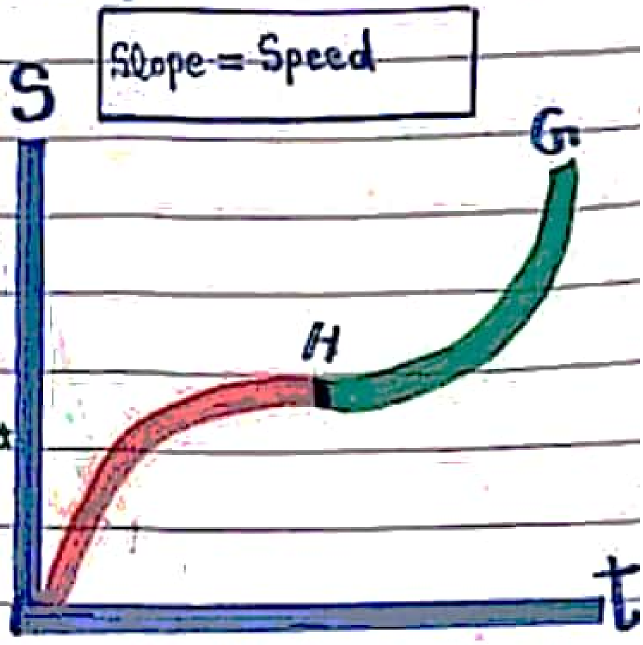
A Body is Thrown upward Then it Falls Back to Ground:

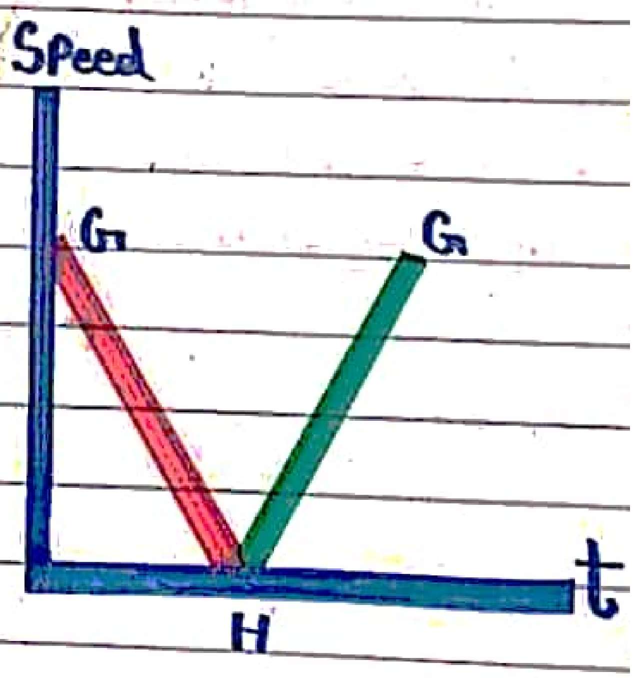
1- Distance-time Graph:-

When body Thrown upward Then S is increasing with time but slope is decreasing because speed is decreasing upto heighest Point H. Then From Heighest Point H body Falls to ground so distance again increasing and slope also increasing because speed is increasing as body Falls back to ground.

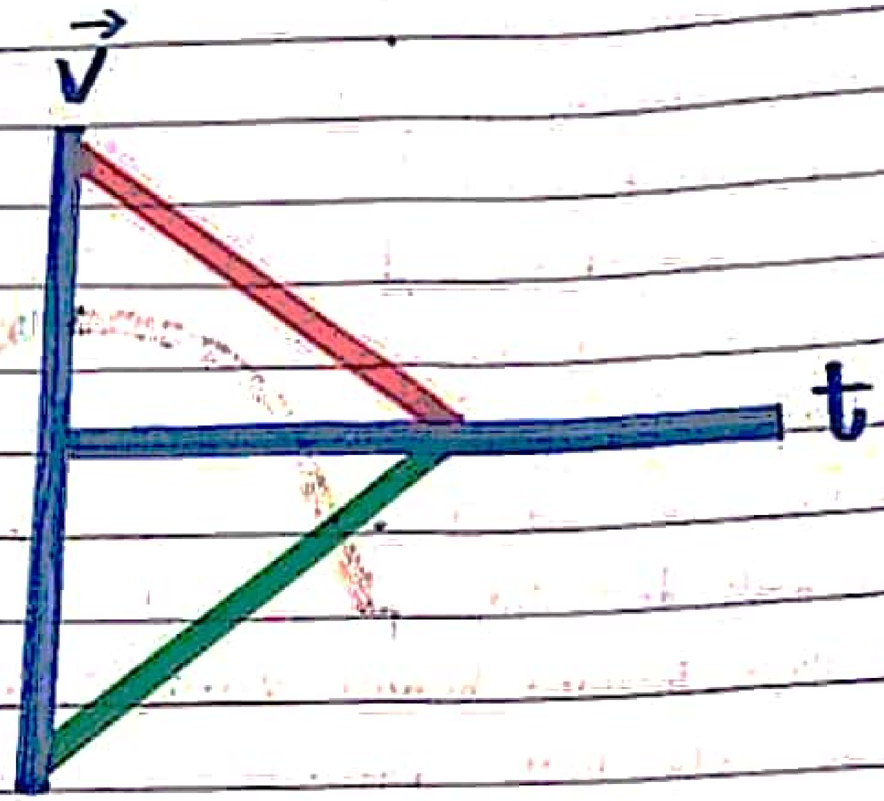


2- Speed-time Graph:-

When body Thrown upward From ground G Then it's speed decreases uniformly upto heighest point 'H' at which speed becomes zero. Then From heighest point 'H' body Falls back and it speed increases uniformly till body strikes the Ground.



When Breaks are applied:-



When Breaks applied along a straight road Then $\vec{v}$ is decreasing and $\vec{a}$ is (-ive) so slope is (-ive) because angle b/w $\vec{v}$ and $\vec{a}$ is 180° i-e $\vec{v}$ and $\vec{a}$ are in opposite direction

Gravitational Acceleration:-

All bodies Falls Freely in The absence of air resistance regardless of Their masses with same acceleration which is called gravitational acceleration "g".

$\boxed{\text{Average value near Earth Surface is } 9.8\,ms^{-2}}$

Direction of 'g' always directed downward.

As, $g \propto \frac{1}{R^2}$, so,

At Equator: g is minimum
At Poles: g is maximum

$\boxed{\text{At centre of Earth } 'g' = 0}$

From surface to depth towards centre	From Earth Surface to upward with altitude.
$g' = g\left[1 - \frac{d}{R}\right]$	$g' = g\left[\frac{1}{(R+h)^2}\right]$
when $d = R/2$	when $h = R/2$,
$g' = g/2$	$g' = 4/9\,g$
when $d = R$	when $h = R$
$g' = 0$ (centre)	$g' = 1/4\,g$
	when $h = 2R \rightarrow g' = \frac{1}{9}g$

$$\boxed{\text{At moon, } g_m = \frac{g_E}{6} = 1.63\,ms^{-2}}$$

For 1 Km range, value of 'g' remains same from Earth Surface.

Value of 'g' changes on Earth surface due to eliptical shape of Earth. As value of 'R' changes from Equator to Pole.

$\boxed{\text{Value of 'g' in a body orbiting the Earth is zero.}}$

Mass & Weight :-

Mass: Quantity of matter [remains same everywhere]

Type: Scalar   Unit:- kg   [M]

Weight: Force of gravity or Pull of Earth on a body towards centre of Earth.

Type: Vector   S.I. Unit $N = Kgms^{-2}$

Move upward:
↓
W decreases as g decrease

$$\boxed{W = mg}$$

$1N = 10^5 dyne$
$1 dyne = 10^{-5} N$

At Equator: g is less so W is small

At Poles: g is Larg so W is Large.

At Earth Centre: $g = 0$ so $W = 0$

Freely Falling Body:- Gravity or Earth Pull towards centre is zero. So weight is zero

Equations of Motion:-

$v_f = v_i + at$, $v_f = v_i + gt$

$S = v_i t + \frac{1}{2}at^2$, $h = v_i t + \frac{1}{2}gt^2$

$2aS = v_f^2 - v_i^2$, $2gh = v_f^2 - v_i^2$

These equations are applicable if

i- $\vec{a}$ is uniform
ii- V_i is always +ive
iii- Linear motion i-e Straight Line

1- Body Falls From Height:-

$h = v_i t + \frac{1}{2}gt^2$, $2gh = v_f^2 - v_i^2$, $v_i = 0$

i- Distance Covered:-

$$h = \frac{1}{2}gt^2 = 5t^2$$

ii- Time to reach the Ground:-

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{h}{5}}$$

iii Velocity with which it reach The Ground:-

$$v = \sqrt{2gh}$$

2- Body Thrown Upward:-

i- Maximum Height:-

$$h = \frac{V^2}{2g}$$

ii- Time to reach maximum Height:-

$$t = \frac{V_i}{g}$$

iii- Time to hit the ground:- Total time in air:-

$$t = 2 \cdot \frac{V_i}{g}$$

iii- Speed with which it hit the ground:-

$$V = V_i$$

When Body Thrown upward Then after every second, velocity decreases $10ms^{-2} \approx 9.8ms^{-2}$

3- Body starts From rest and moves with constant acceleration:-

Distance $\propto$ (time)^2

$S \propto t^2$ iF $\vec{a}$ is constant

$S = \frac{1}{2}at^2 \longrightarrow$ Distance Covered

$t = \sqrt{\frac{2S}{a}} \longrightarrow$ time iF distance given

4- A body moves Then comes to rest i-e- brakes applied [slows down]

i- If V_i, V_f, t is given

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

ii- If V_i, V_f and a = retardation is given

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

5- A body is moving at ___ ms^{-2} rate withe some velocity 'V_i' ms^{-1} for 't' seconds- Then Distance covered is

$$S = V_i t + \frac{1}{2}at^2$$

Distance Covered By Freely Falling body

$$S = \frac{1}{2}gt^2 = 4.9t^2 = 5t^2$$

S in 1 second:-

$$S_1 = 5t^2 = 5 \times 1^2 = 5m$$

S in 2 seconds:-

$$S_2 = 5t^2 = 5 \times 2^2 = 5 \times 4 = 20m$$

S in 3 seconds:-

$$S_3 = 5t^2 = 5 \times 3^2 = 5 \times 9 = 45m$$

$$S_1 : S_2 : S_3 = 5:20:45 = 1:4:9$$

$$\boxed{S_1 : S_2 : S_3 = 1:4:9}$$

Distance Covered in n^{th} second During motion:-

$$S = \frac{g}{2}(2n-1) = 5(2n-1)$$

S in 1^{st} second:-

$$S_1 = 5(2.1-1) = 5(2-1) = 5(1) = 5m$$

S in 2^{nd} second:-

$$S_2 = 5(2 \times 2-1) = 5(4-1) = 5(3) = 15m$$

S in 3^{rd} second:-

$$S_3 = 5(2 \times 3-1) = 5(6-1) = 5(5) = 25m$$

$$S_{1^{st}} : S_{2^{nd}} : S_{3^{rd}} = 5:15:25 = 1:3:5$$

$$\boxed{S_{1^{st}} : S_{2^{nd}} : S_{3^{rd}} = 1:3:5}$$

Newton's Laws of Motion:-

These Laws are applicable if speed of body is Less than speed of Light.

$$v < c$$

$$v < 3\times10^{8}\,ms^{-1}$$

1st Law: → A body maintains it rest state or uniform motion state unless a Force is applied.

1st Law: defines Force.

1st Law: defines Qualitative nature of Force.

1st Law Holds: inertial Fram ($a=0$)

1st Law does'nt Hold: non-inertial Fram ($a\neq0$)

1st Law: Law of inertia.

Inertia: Property which maintains state of rest or state of uniform motion

Mass is a Quantitative measure of inertia

Resistance to movement (a) is called inertia

$$\boxed{\text{mass} \propto \text{Inertia}}$$

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2nd Law: → When $\vec{F}$ applied Then $\vec{a}$ is produced in direction of $\vec{F}$.

$a \propto F$, $a \propto \frac{1}{m}$, $a \propto F/m$

$F = ma \longrightarrow m_1 a_1 = m_2 a_2$

Unit of $F = N = Kgms^{-2}$

2nd Law: measures Force

2nd Law: measures Quantitative nature of Force.

2nd Law: measures acceleration

2nd Law: Law of acceleration

3rd Law: → action & reaction are equal but opposite in direction

3rd Law: explains Force in Pairs.

3rd Law: Swimming

3rd Law: Rocket in space

We cannot Find resultant of action and reaction Forces because They cannot balance each other as They act on the different bodies not on same body

Linear Momentum:- (P)

Product of mass and velocity is called momentum.

Momentum: Quantity of motion of moving body.
Type: vector quantity
Direction: in the direction of Velocity.
S.I. unit: $Kgms^{-1} = Ns$ $[MLT^{-1}]$

Momentum & Newton's 2nd Law:-

Time rate of change of the momentum of a body is equal to the applied Force.

$$F = \frac{\Delta P}{t}$$

Impulse:-

When Large variable Force acts For very short time Then it changes momentum. This change in momentum is called impulse.

$$F \times t = I = \Delta P$$

Unit: Ns Direction: in direction of P $[MLT^{-1}]$
- If body moves with constant velocity, so $\Delta V = 0$
- In This case: $\Delta P = 0$ so $I = 0$

Law of Momentum Conservation:

> Total linear momentum of an isolated system always remains constant.

$$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$$

$$mv = \text{Constant.}$$

Isolated System: on which no external $\vec{F}$ applied.

Collisions:-

Elastic: K.E. is not lost i-e. K.E. is conserved.

In-elastic: K.E. is lost i-e. K.E. is not conserved.

All Collisions: momentum & total energy is conserved.

K.E. : conserved only in elastic collision.

Elastic: Bodies separate after collision.

Bodies should be solid and hard.

Bounce Back of ball: From wall or Floor.

In-elastic: Bodies stick together after collision.

Bodies should be solid & soft

or

soft & elastic

Collision of Ball From Sand or Bed Foam.

Elastic Collision in One Dimension:-

Relative velocities before and after collision

i- same magnitude . ii- opposite direction

Conditions: a- Collision must be one dimensional

b- Collision must be elastic

$$\boxed{\text{Relative speed of Approach} = \text{Relative speed of Separation}}$$

Special Cases:

Two Bodies: m_1 and m_2.

Before Collision:-

velocity of $m_1 = V_1$, velocity of $m_2 = V_2$

After Collision:-

velocity of $m_1 = V_1'$, velocity of $m_2 = V_2'$

They collides head on & Collision is elastic:

1- $m_1 = m_2$

$V_1' = V_2$

$V_2' = V_1$

2- $m_1 = m_2$

$V_2 = 0$ [m_2 at rest]

$V_1' = 0$

$V_2' = V_1$

3- $m_1 >> m_2$

$V_2 = 0$ [m_2 at rest]

$V_1' = V_1$

$V_2' = 2V_1$

4- $m_1 << m_2$

$V_2 = 0$ [m_2 at rest]

$V_1' = -V_1$

$V_2' = 0$

Rocket Propulsion:-

Motion of Rocket obeys:

i- 3rd Law of motion.

ii- Law of conservation of Linear 'P'.

Acceleration of Rocket:-

$$\boxed{a = \frac{mv}{M}}$$

m: gases mass.
M: Rocket mass.
v: gas velocity ejected relative to rocket.

Units of 'm': $Kg\,S^{-1}$

Fuel: Liquid or solid [H_2 and O_2]

Before Launching: 80% of it's total mass consists of Fuels mass or more

Mass of Fuel consumed by rocket to overcome gravity: $10{,}000 kgS^{-1}$

Velocity of ejected Gases: $4000 ms^{-1}$

As time Passes in Space:

Fuel in rocket burns, so mass of rocket M decreases, so it's speed/acceleration increases.

Ballistic Missile:

i- Un- Powered.
ii- Un- Guided.

Path Followed: Ballistic trajectory

Ballistic Missile is Used For:

i- Short Ranges
ii- Parabolic Path
iii- Flat Earth approximation

Powered & Remote Control Missile Used For:

i- Long Ranges
ii- Elipitical Path
iii- Spherical Earth approximation
iv- Greater Precision

At High Speed & Long Trajectory:

Air Friction > Gravity

So, angle 'θ' needs more Precision and accuracy:-

Projectile Motion:-

Two dimensional motion of a body under constant acceleration due to gravity is called projectile motion.

Components of Motion:

Two components of motion:

i- Along x-axis i-e- Horizontal

ii- Along y-axis i-e Vertical

Path Followed by Projectile is called trajectory of projectile.

Trajectory: Parabolic Path

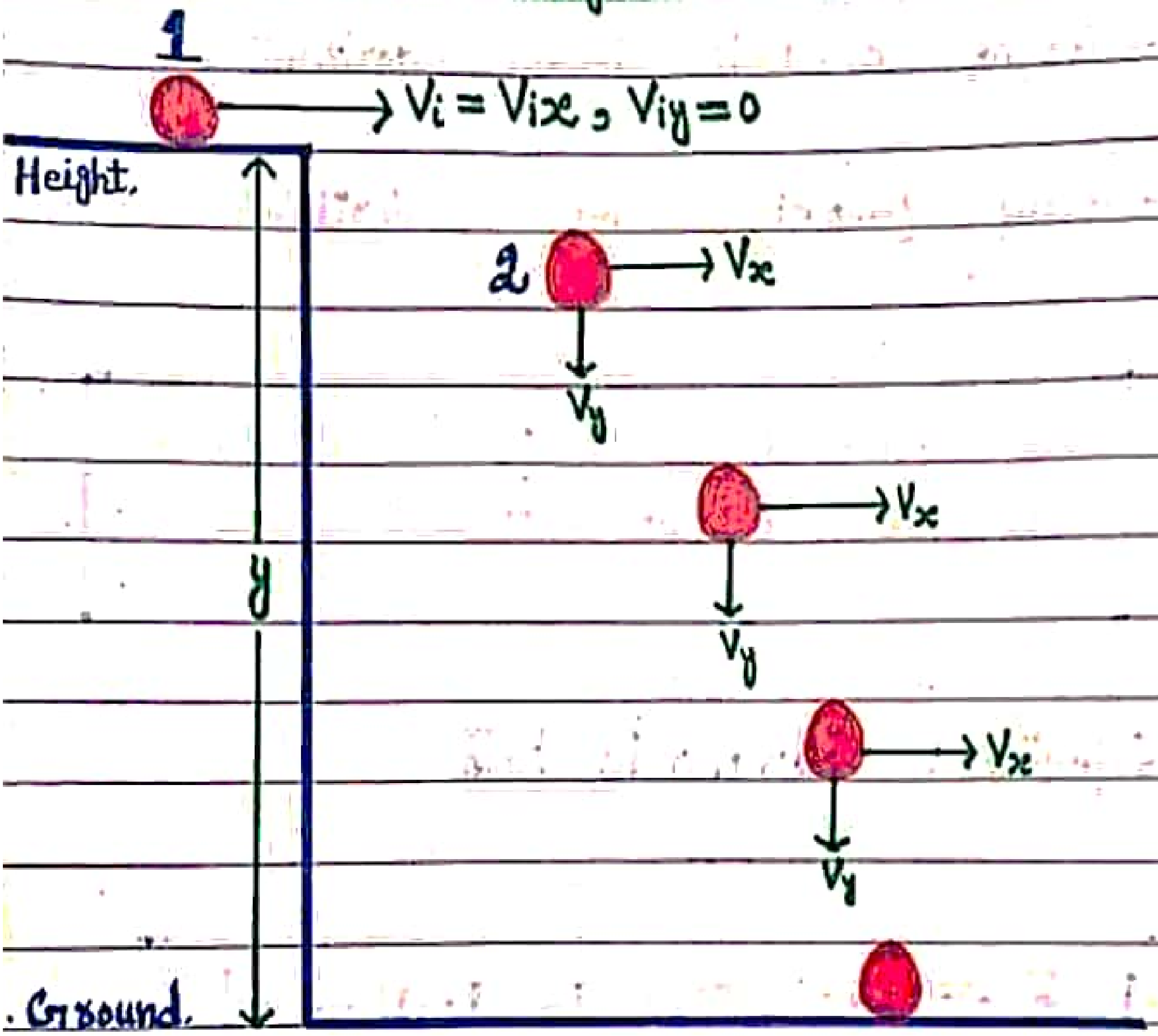
Path of Projectile is Followed by & Find by Gravitational Field.

Linear Projectile:-

Projected From some height horizontally with angle $[\theta = 0°]$ with horizontall.

a- At point '1' [Projection Point], $V_{iy} = 0$, $V_{ix} = V_i = V_x = V$

b. As no air Friction, So, $V_{ix} = V_{fx} = V_x$ i-e. V_x remains constant so $a_x = 0$ Throughout motion



c- At Point '2' only Force is gravity (downward), so V_y generated which keeps on increasing, becomes maximum just beFore strike The ground. Net $V = \sqrt{V_x^2 + V_y^2}$. As V_x = constant but V_y is increasing so net Velocity increases. [a_y = Constant]

Vertical Distance:-

$$\boxed{y = \frac{1}{2} g t^2}$$

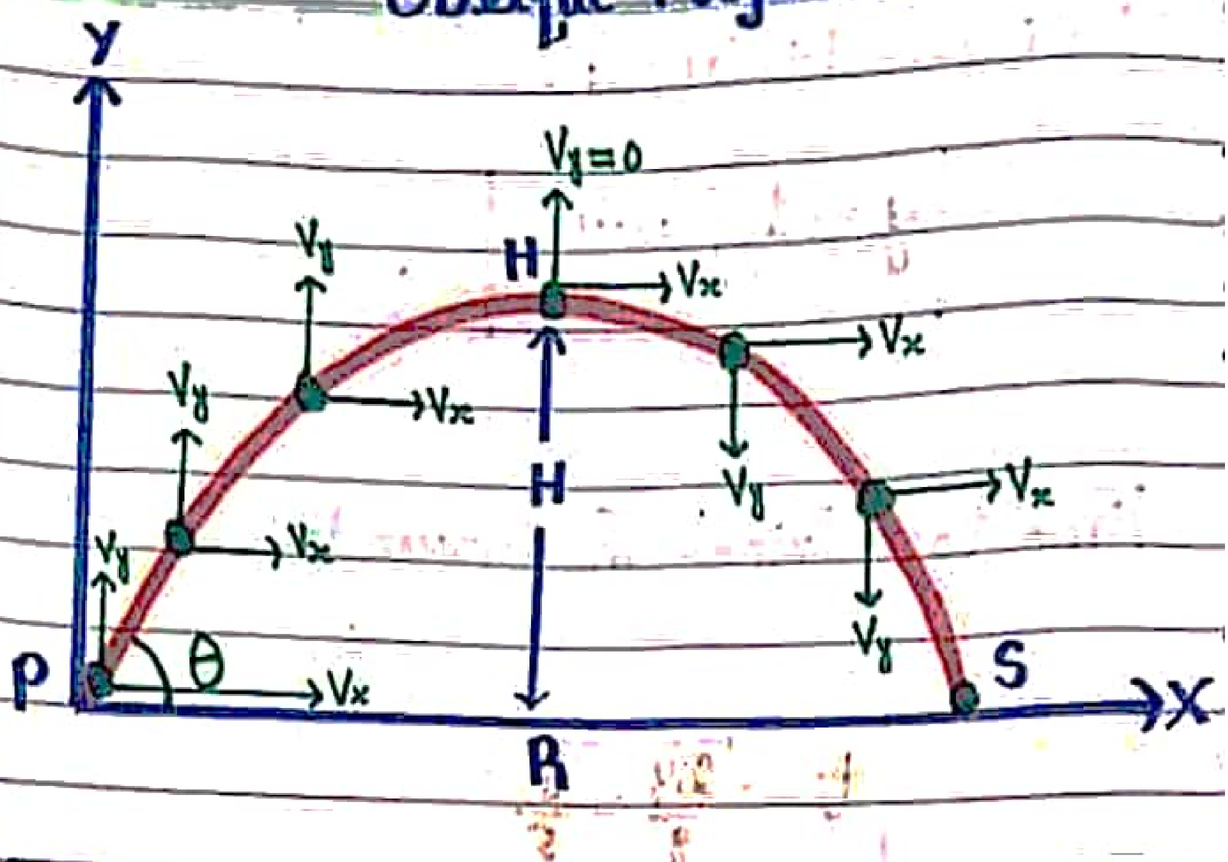
Time to strikes The Ground:-

$$\boxed{t = \sqrt{\frac{2y}{g} = \frac{y}{s}}}$$

Horizontal Distance on Ground From Point of Projection:-

$$\boxed{x = V_x \times t}$$

Oblique Projectile:-



Projected at angle $[\theta > 0°]$ with horizontal.

i- At Projection Point 'P' it has both components of velocity ['V_x' and V_y].

ii- As There is no air Friction so $F_x = 0$ so $V_{ix} = V_{fx} = V_x$ [V_x constant Throughout motion] and $a_x = 0$. $V_{ix} = V_{fx} = V_x = V_i \cos\theta$

iii- V_y changes continously. From projection Point to highest Point V_y decreases and becomes zero at Heighest Point.

iv- From Heighest Point to onward V_y goes on increasing and becomes maximum just beFore hit the ground.

v- At hieghest Point $V_y = 0$ but $V_{net} \neq 0$ because $V_{net} = \sqrt{V_x^2 + V_y} = \sqrt{V_x^2 + 0} = \sqrt{V_x^2} = V_x$ at heighest Point.

Height :- [H]

Maximum Vertical Distance covered by Projectile

$$\boxed{H = \frac{V_i^2 \sin^2\theta}{2g}}$$

$H \propto V_i^2$ $H \propto 1/g$

At moon, $g_m = g_E/6$ so, H reduced not but increased six times For same angle

θ and Height :-

θ	Height (H)
0°	Zero . H = 0
90°	Maximum H
45°	Half of maximum Value.
76°	Height = Range

θ From (0° to 75°)

Height is Less Than range. (H < R)

$\theta = 76°$ [$\tan^{-1} 4$]

Height = Range. (H = R)

θ From [77° to 90°]

Height is greater than range. (H > R)

$\theta = 45° \rightarrow [R = 4H]$ or $[H = \frac{1}{4}R]$