MOTION

REST AND MOTION

Motion :- position of object changes with time

Example: Birds fly, fish swim


car is moving

Rest :- position of object does not change with time.

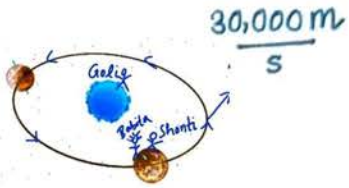
Example: Babita is sitting, shanti is standing


Motion is Relative

Babita is at Rest or in motion

shanti ⟶ motion

Holi ⟶ Rest



DISTANCE AND DISPLACEMENT

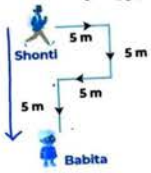
Distance :- Length of actual total path covered.

Displacement :- shortest path from starting (initial) point and ending (final) point, along with direction.

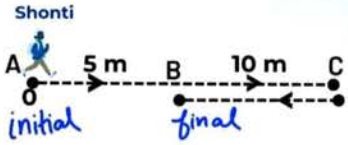
Example :-

✓ shanti Actual path travel = 20m

✓ shanti shortest path = 10m



Q- Distance = 5 + 10 + 10 = 25m
Displacement = 5m



Q- Distance = 3 + 4 = 7m
Displacement = 5m

$H^2 = P^2 + B^2$

$H^2 = 4^2 + 3^2$

$H^2 = 25$

$H = \sqrt{25} = 5m$

Q- After half revolution, find distance and displacement. (Radius = 14m)

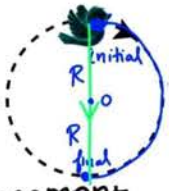
Dist = πR

$= \frac{22}{7} \times 14 = 44m$

Disp = 2R

$= 2 \times 14$

$= 28$



Q- Full Revolution. find distance and displacement. (Radius = 14m)

Dist = $2\pi R$

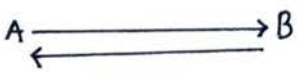
$= 88m$

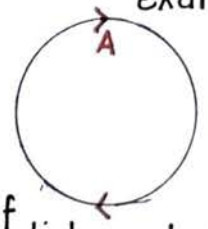
Disp = 0

Disp < Dist

Disp = Dist

Q- An object has moved through a distance. can it have zero displacement? if yes, support your answer with an example. (NCERT)





After 1 Revolution

Q- can the magnitude (value) of displacement be equal to distance travelled by object?

Yes, when object travels in straight line.

Dist = Disp (value)

Q - for the path

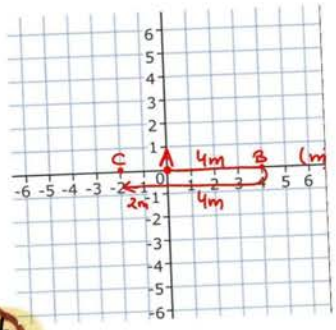
A ⟶ B ⟶ C

initial Final

Find distance and displacement.

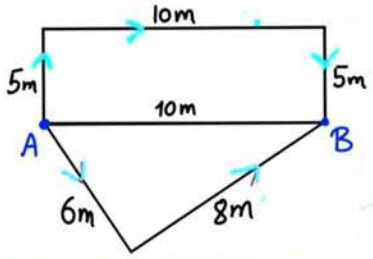
distance = 4+4+2 = 10m

displacement = 2m ✗ = -2m ✓



Distance Vs Displacement

Distance	Displacement
1. length of actual total path covered.	1. shortest path from initial position to final position.
2. Has only magnitude, no direction.	2. Has magnitude and direction.
3. Scalar Quantity	3. Vector Quantity.
4. Can never be negative.	4. Can be positive, negative, zero.
5. Depends on the path followed by object.	5. Depends only on initial and final position, not on path followed.



Distance = 6+8 = 14m

Distance = 5+10+5 = 20m

Displacement = shortest path A ⟶ B = 10m

SPEED AND VELOCITY

Speed :- Distance covered per unit time.

$$\text{Speed} = \frac{\text{Distance}}{\text{time}}$$

S.I unit = m/s

another unit = km/h

*convert to m/s

1 km/h = $\frac{5}{18}$ m/s

m/s → $\frac{18}{5}$ km/h

Velocity :- Displacement per unit time.

$$\text{Velocity} = \frac{\text{Displacement}}{\text{time}}$$

S.I unit = m/s

another unit = km/h

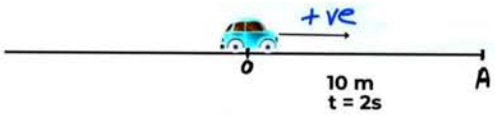
Examples :-

(1) 54 km/h = $54 \times \frac{5}{18}$ = 15 m/s

(2) 72 km/h = $72 \times \frac{5}{18}$ = 20 m/s

(3) 36 km/h = $36 \times \frac{5}{18}$ = 10 m/s

Q -



speed = $\frac{\text{Dist}}{\text{time}} = \frac{10\text{m}}{2\text{s}}$ = 5 m/s

Velocity = $\frac{\text{Disp}}{\text{time}} = \frac{10\text{m}}{2\text{s}}$ = 5 m/s

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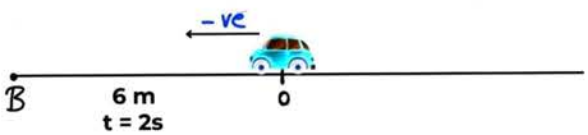
Q -

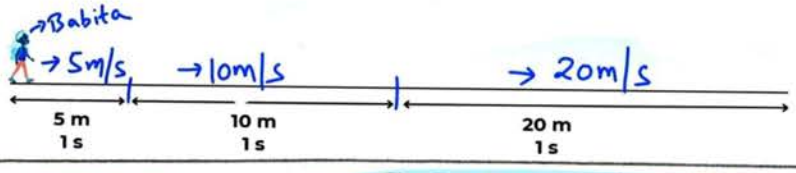


speed with direction is velocity.

speed = $\frac{\text{dist}}{\text{time}} = \frac{6\text{m}}{2\text{m}}$ = 3 m/s

velocity = $\frac{\text{disp}}{\text{time}} = \frac{-6\text{m}}{2\text{s}}$ = -3 m/s

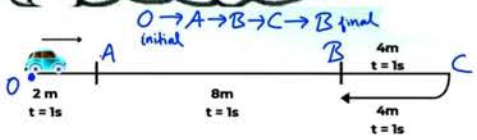
Q - Find speed



Average speed = Total Distance / Total time

Average Velocity = Total Displacement / Total time

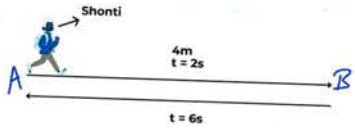
Q -



Average speed = $\frac{\text{Total dist}}{\text{total time}} = \frac{2+8+4+4}{4s} = \frac{18}{4} = 4.5\ m/s$

Average velocity = $\frac{\text{Total disp}}{\text{total time}} = \frac{2+8}{1+1+1+1} = \frac{10}{4} = 2.5\ m/s$

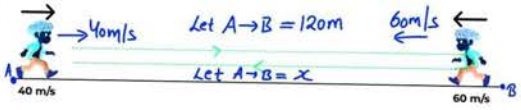
Q -



Avg. speed = $\frac{\text{total dist}}{\text{Total time}} = \frac{4+4}{2+6} = \frac{8}{8} = \frac{1m}{s}$ or $1\ m/s$

Avg. Velocity = $\frac{\text{Total Disp}}{\text{Total time}} = \frac{0}{8} = 0$

✡ Find average velocity and average speed



Avg velocity = $\frac{\text{total disp}}{\text{total time}} = \frac{0}{t} = 0$

Avg speed = $\frac{\text{Total dist}}{\text{total time}}$

$= 50\ m/s$ ✗

A → B

Dist = 120m

speed = 40 m/s

time = $\frac{\text{dist}}{\text{speed}} = \frac{120}{40} = 3s$

B → A

Dist = 120 m

speed = 60 m/s

time = $\frac{\text{dist}}{\text{speed}} = \frac{120}{60} = 2s$

Avg speed = $\frac{\text{total dist}}{\text{total time}} = \frac{240}{3+2} = \frac{240}{5} = 48\ m/s$

Speed	Vs	Velocity
1. Distance covered per unit time.		1. Displacement per unit time.
2. Has only magnitude, no direction.		2. Has both magnitude and direction.
3. Scalar Quantity.		3. Vector Quantity.
4. Can never be negative		4. Can be positive, negative, zero.

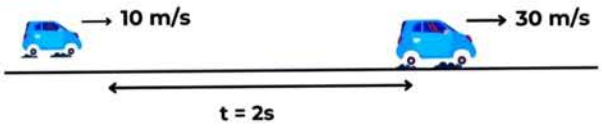
ACCELERATION :-

- Rate of change of velocity.
- change in velocity per unit time.

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

$$= \frac{30\,m/s - 10\,m/s}{2\,s}$$

$$= \frac{20\,m/s}{2s} = \frac{10\,m}{s^2}$$

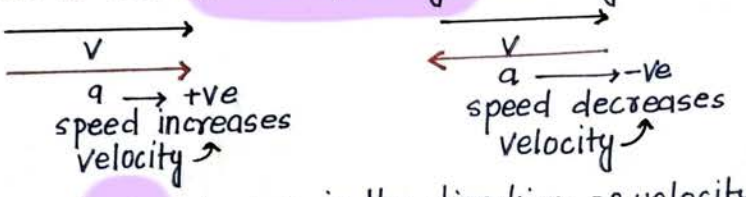


$$a = \frac{v - u}{t}$$

SI unit = m/s^2

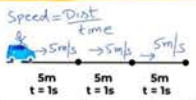
v → final velocity
u → initial velocity
t → time taken

- Acceleration is also a vector Quantity. it has magnitude and direction



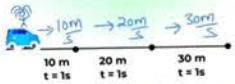
- Acceleration is +ve if it is in the direction of velocity.
- Acceleration is -ve if it is opposite to the direction of velocity.

Uniform Motion



1. Equal distance in equal intervals of time.
2. speed is same.
3. Acceleration $a = 0$
   Eg - A car moving with constant speed

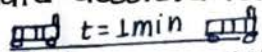
Non- Uniform Motion



1. Unequal distance in equal intervals of time
2. speed changes.
3. Acceleration is not zero.
   Eg - A car moving with variable speed.

Q- A train starting from a railway station attains a speed of 72 km/h in one minute. Calculate acceleration in S.I Unit.

(A) $1\,m/s^2$
(B) $0.66\,m/s^2$
(C) $0.33\,m/s^2$
(D) $0.5\,m/s^2$



Rest
$u = 0$

$72\,km/h$
$72 \times \frac{5}{18}$

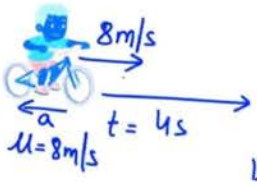
$t = 60s$

$V = 20\,m/s$

$$a = \frac{v - u}{t} = \frac{20 - 0}{60}$$

$$= \frac{1}{3}\,m/s^2$$

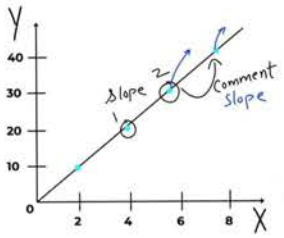
Q - Shanti is paddling his bicycle at 8 m/s. He applies brake such that his bicycle stops in 4s. Find the acceleration.



Note
Brake
$a = -ve$

$$a = \frac{v - u}{t} = \frac{0 - 8}{4} = -2\,m/s^2$$

Graphical Representation of Motion :-

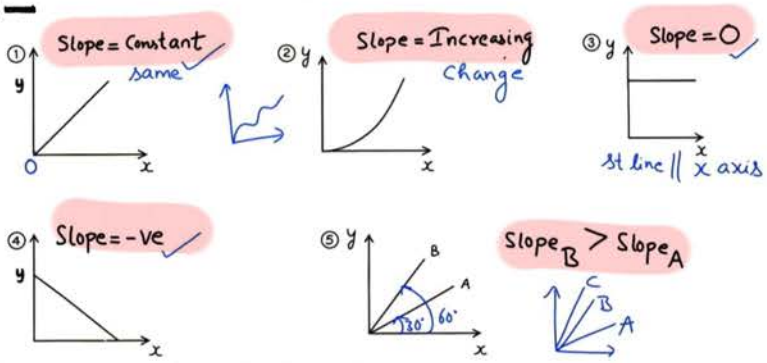


$$\text{slope} = \frac{Y}{X}$$

$$\text{slope} = \frac{y_2 - y_1}{x_2 - x_1}$$

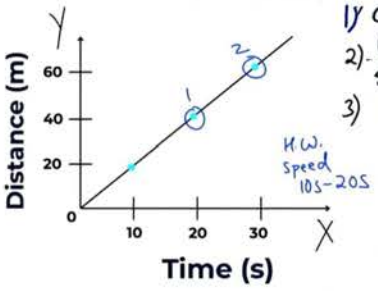
$$= \frac{30-20}{6-4} = \frac{10}{2} = 5$$

Some Graph Concept :-



Distance Time Graph

slope = speed



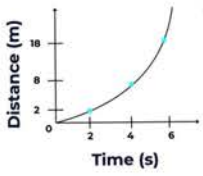
1) constant (same) speed.
2) Uniform motion
speed in interval 20s-30s?
3) speed = slope = $\frac{y_2 - y_1}{x_2 - x_1}$

$$= \frac{60-40}{30-20} = \frac{20}{10} = \frac{2m}{s} \text{ or } 2m/s$$

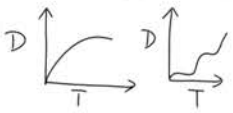
$$\text{slope} \Rightarrow \frac{Y}{X}$$

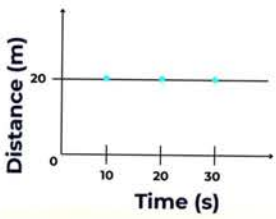
$$\downarrow$$

$$\text{speed} \approx \frac{\text{dist}}{\text{time}}$$



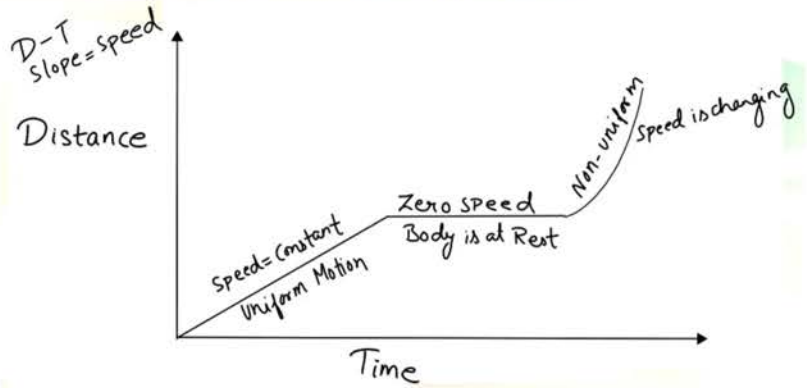
slope → increasing (increasing)
1) changing speed
2) Non-uniform motion





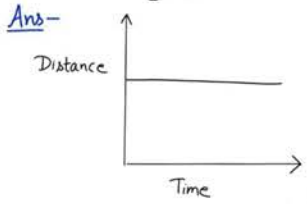
slope = 0
1) Zero speed
2) Body at rest

Explain different regions of the graph



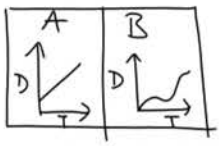
Q- What can you say about the motion of an object whose distance-time graph is a straight line parallel to the time axis?

Ans-



slope = 0
speed = 0
Body is at rest

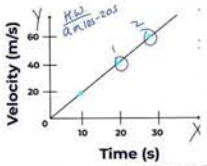
Dist - Time
slope = speed.



Velocity-Time Graph :-

$\frac{v-u}{t} = a$

slope = $\frac{y}{x} = \frac{\text{velocity}}{\text{time}}$ = acceleration

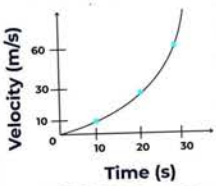


slope = constant

1) constant (Uniform) acceleration
2) uniform acceleration.
3) find a in interval 10s - 20s?

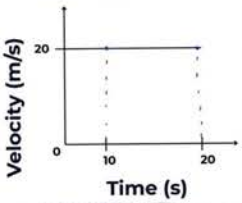
$a = \text{slope} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{40-20}{20-10}$

$= \frac{20}{10} = 2 m/s^2$



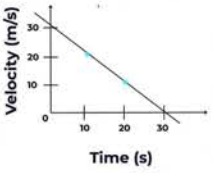
slope change

1) changing acceleration.
2) Non-uniform acceleration
check a in 10-20s
a in 20s-30s
a change



slope = zero

1) zero acceleration
2) speed same
3) uniform motion



$\frac{v}{a}$ a = -ve speed decrease

a = -ve → Retardation

slope = -ve

1) Negative acceleration
2) speed → decreases

Q- What can you say about the motion of an object if its speed-time graph is a straight line parallel to the time axis?

Slope = acceleration

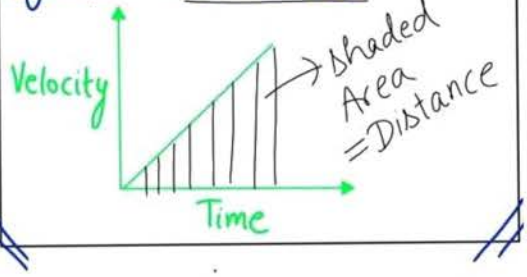
Speed / Velocity

slope = 0
acceleration = 0

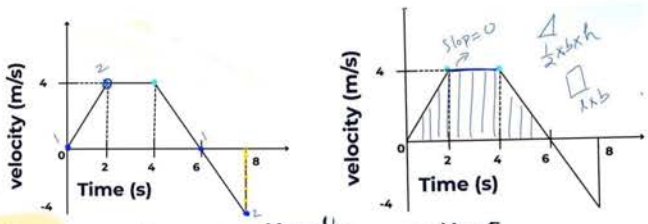
Speed is same
Uniform Motion

Time

Area under Velocity-Time graph = Distance



Q- Calculate
i) acceleration in first 2sec
ii) acceleration in last 2sec
iii) Distance covered in 6 seconds
iv) Time period of uniform motion



(i) $a = \text{slope} = \frac{y_2-y_1}{x_2-x_1} = \frac{4-0}{2-0}$
$= 2\ m/s^2$

(ii) $a = \text{slope} = \frac{y_2-y_1}{x_2-x_1} = \frac{-4-0}{8-6}$
$a = \frac{-4}{2} = -2 m/s^2$

(iii) dist = Area under V-T graph
$= \frac{1}{2} \times 2 \times 4 + 2 \times 4 + \frac{1}{2} \times 2 \times 4$
$= 4 + 8 + 4$
$= 16m$

(iv) Same speed
$a = 0$
slope = 0 (2s-4s)

Equations of Motion :-

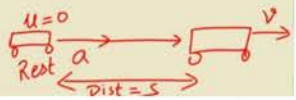
When objects travels in a STRAIGHT LINE with UNIFORM (SAME) ACCELERATION -

i) $v = u + at$
ii) $v^2 - u^2 = 2as$
iii) $s = ut + \frac{1}{2}at^2$

u = initial velocity
v = final velocity
s = Distance
t = time taken

Q -

A bus starting from rest moves with a uniform acceleration of 0.1 m s^{-2} for 2 minutes. Find
(a) the speed acquired,
(b) the distance travelled.



solution :-

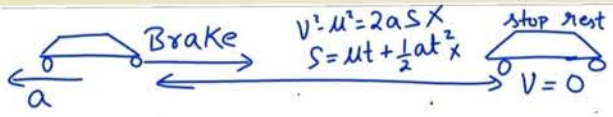
$u = 0$
$a = 0.1 m/s^2$
$t = 2min = 2 \times 60s$
$v = ?\ s = ?$

(i) $v = u + at$
$= 0 + \frac{0.1}{1} \times 2 \times 60$
$= 12 m/s$

(ii) $v^2 - u^2 = 2as$
$12^2 - 0^2 = 2 \times 0.1 \times s$
$12 \times 12 = \frac{2 \times 0.1}{10} \times s$
$s = 12 \times 6 \times 10 = 720m$

Q -

The brakes applied to a car produce an acceleration of 6 m s^{-2} in the opposite direction to the motion. If the car takes 2 s to stop after the application of brakes, calculate the distance it travels during this time.



$a = -6 m/s^2$
$t = 2s$
$V = 0$
$s = ?$

solution

(i) $v = u + at$
$0 = u - 6 \times 2$
$u = 12 m/s$

$s = 12 \times 2 + \frac{1}{2} \times -6 \times 4$
$= 24 - 12$
$= 12$

$V = 0$

(ii) $v^2 - u^2 = 2as$
$0^2 - 12^2 = 2 \times (-6) \times s$
$-12 \times 12 = 2 \times (-6) \times s$
$s = 12m$

Q -

A stone is thrown in a vertically upward direction with a velocity of 20 m s^{-1}. If the acceleration of the stone during its motion is 10 m s^{-2} in the downward direction, what will be the height attained by the stone and how much time will it take to reach there?

solution (i) $v = u + at$

$0 = 20 - 10 \times t$

$10t = 20$

$t = 2s$

height = s

$t = ?$

(ii) $v^2 - u^2 = 2as$

$0^2 - 20^2 = 2 \times (-10) \times s$

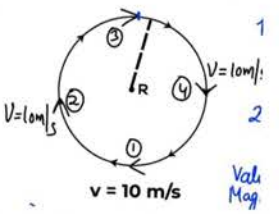
$-20 \times 20 = -20s$

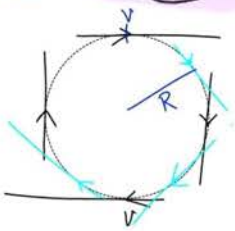
$s = 20m$

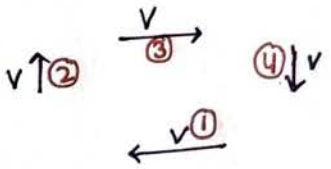
Uniform Circular Motion

1. circular motion with same speed
   speed = constant → uniform speed
2. Velocity ⇒ change
   - value magnitude same
   - Direction change
3. acceleration is not zero.

speed = $\frac{dist}{time}$, $v = \frac{2\pi R}{T}$







Examples of uniform circular motion

✓ A satellite revolving around earth in circular orbit with constant (same) speed.

✓ A cyclist on a circular track at constant speed.