Kinematics -2

Velocity:

- Inst Velocity
- Average Velocity = $\frac{\text{Displacement}}{\text{"time interval"}}$

Instantaneous Velocity:

- # Velocity at an instant
- # Avg velocity in very small time of interval

a) if a particle is moving along x-axis as a function of time $x = t^2$. then find

a) Average velocity from 2 sec to 4 sec.

$$\text{Avg velocity} = \frac{x_f - x_i}{\Delta t}$$

$x(4) = 16\ m$

$x(2) = 4\ m$

$\Delta t = 2\ sec$

$$(V_{avg})_{2 \to 4\ sec} = \frac{16 - 4}{2} = 6\ m/s$$

b) find Avg velocity from 2 sec to 3 sec

$x(3) = 9\ m$

$x(2) = 4\ m$

$\Delta t = 1\ sec$

$$(V_{avg})_{2-3\ sec} = \frac{5}{1}$$

$= 5\ m/s$

c) (V_{avg}) from $= \{2 \rightarrow (2.5)\ sec\}$

$x(2.5) = (2.5)^2 = 6.25$

$x(2) = 4m$

$\Delta t = 0.5sec$

$$(V_{avg})_{2 \rightarrow 2.5s} = \frac{6.25 - 4}{0.5}$$

$$= \frac{2.25}{0.5}$$

$$= 4.5\ m/s$$

find Vavg from $2 \rightarrow (2 + \Delta t)$

$$x(2 + \Delta t) = (2 + \Delta t)^2$$

$x(2) = (2)^2$

$\Delta t = \Delta t$

$$V_{avg} = \frac{(2+\Delta t)^2 - (2)^2}{\Delta t}$$

$$V_{avg} = \frac{(2)^2 + (\Delta t)^2 + 4\Delta t - (2)^2}{\Delta t}$$

$$V_{avg} = \frac{\Delta t(\Delta t + 4)}{\Delta t}$$

$$\{V_{avg}\} = (\Delta t + 4)\ m/s$$

$\Delta t \to 0$

$V_{avg} = V_{inst} = 4\ m/s$ $\quad 2 \to (2+0t)$

$\Delta t \to 0$

$V_{inst} = 4\ m/s^2$ at $t = 2\ sec$

b) $x = (2t^2 + 5)\ m$ $\quad t = sec$

then find inst velocity at $t = 3\ sec$

H.w =

$x(3+0t) = 2(3+0t)^2 + 5$

$x(3) = 2(3)^2 + 5$

$\Delta t = 0$

$V_{avg} = \dfrac{2(3+0t)^2 + 5 - 2(3)^2 + 5}{0t}$

$V_{avg} = V_{inst} = 12$ m/s

$\Delta t \to 0$

Inst Velo

$|\vec{V}_{inst}| = |V_{inst}|$ ← Inst Speed

$|\vec{ds}| = ds$

$|\vec{V}_{avg}| \leq$ Avg Speed

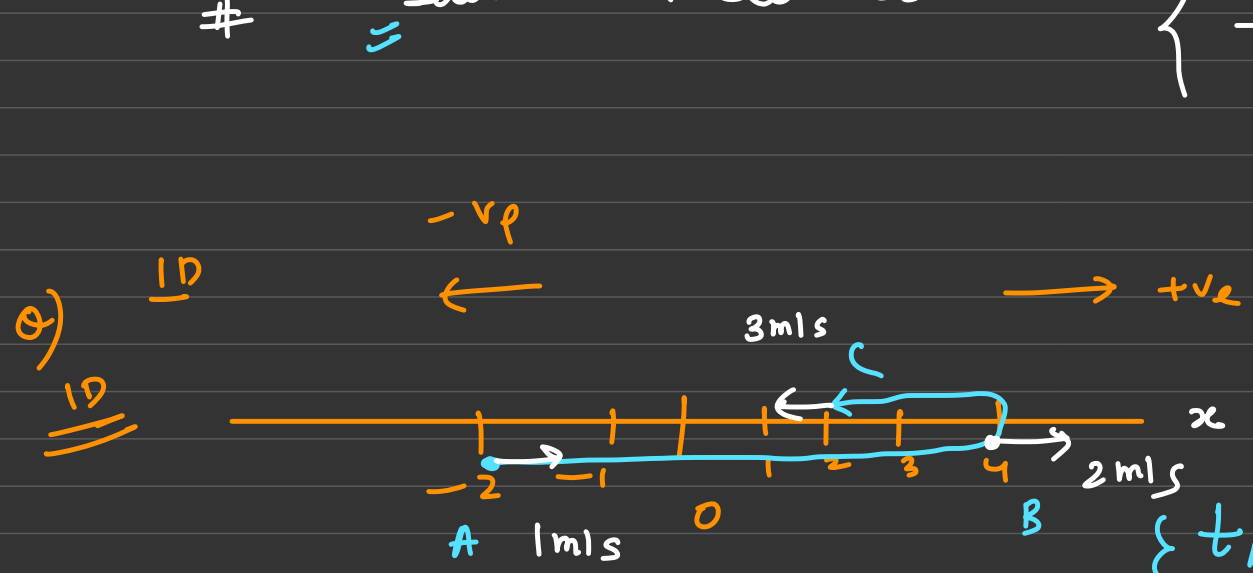
$|\vec{V}_{avg}|$ ↓ Avg velocity

Acceleration: → Average
→ Inst Acceleration

Remember

Average Acceleration $= \left(\frac{\vec{v}_f - \vec{v}_i}{\Delta t} \right)$

Inst Acceleration = { change in velocity / very small time interval



Q) 1D

1D

given

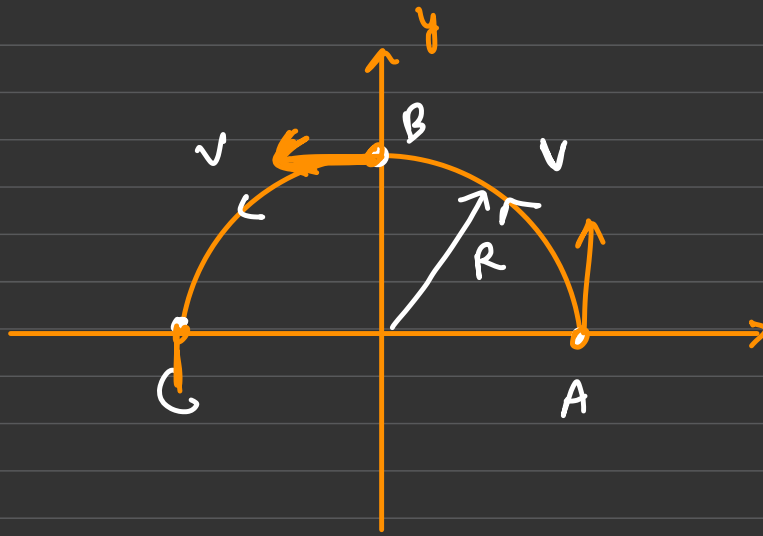
$t_{AB} = 1$ sec

$t_{BC} = 0.5$ sec

then find $(a_{avg})_{AB} = \frac{+2-1}{1} = 1\ m/s^2$

$(a_{avg})_{BC} = \frac{-3-(+2)}{0.5} = -10\ m/s^2$

$(a_{avg})_{AC} = \frac{-3-(1)}{1.5} = -\frac{4}{3} \times 2 = -\frac{8}{3}\ m/s^2$



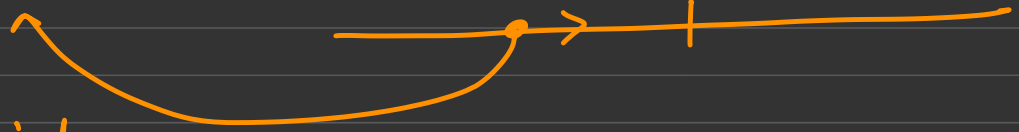
$(a_{avg})_{AB} = \frac{\{-V_i^\circ - V_j^\circ\}}{(\pi R/2v)}\ m/s^2$

$(a_{avg})_{BC} = \frac{-V_j^\circ - (-V_i^\circ)}{(\pi R/2v)}\ m/s^2$

$(a_{avg})_{AC} = \frac{-2V_j^\circ}{(\pi R/v)}\ m/s^2$

Q)

$v = t^3$



then find

$$(a_{avg})_{1 \to 2\,sec} = \frac{V(2) - V(1)}{1\,sec}$$

$$= \frac{8 - 1}{1} = 7\ m/s^2$$

$$(a_{avg})_{1 \to 1.5} = \frac{V(1.5) - V(1)}{0.5} = (\quad)$$

Classical method (Basic method)

1 sec $a_{inst} = ?$

$$a_{\text{avg } 1 \to 1+\Delta t} = = \frac{(1+\Delta t)^3 - (1)^3}{\Delta t}$$

check

$$(4\Delta t + 3)$$

$\Delta t \to 0$

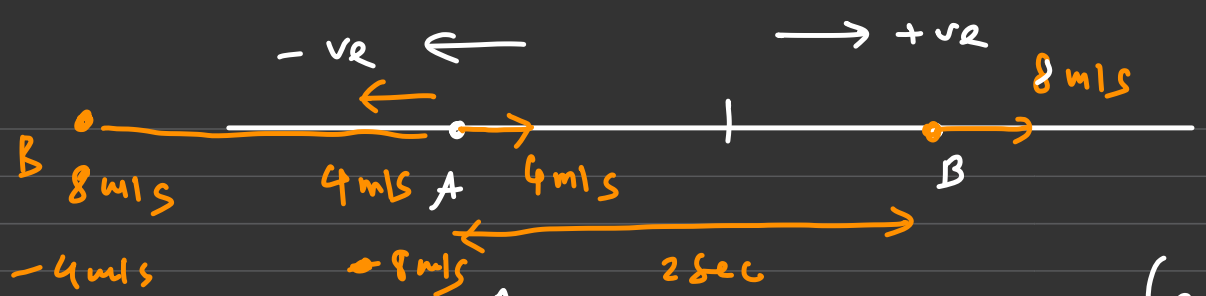
$$= 3 \text{ m/s}^2$$

Retardation:

1. Speed down "Retardation"
2. $\vec{a}$ and $\vec{v}$ must be opposite ($180^\circ \rightarrow$ in 1D)
3. Retardation could (+ve, or −ve)

Q)

1D



1D

Δt	A	B
	+4 m/s	+8 m/s
2 sec	8 m/s	+4 m/s
"	-4 m/s	-8 m/s
"	-8 m/s	-4 m/s

$(a_{avg})_{\text{for B}}$

$$\frac{8\ m/s - 4\ m/s}{2} = +2\ m/s^2$$

Acceleration

$$\frac{+4 - 8}{2} = -2\ m/s$$

Retardation

$$\frac{-8\ m/s - (-4\ m/s)}{2} = -2\ m/s^2$$

Accelerating

$$\frac{-4\ m/s - (-8\ m/s)}{2} = +2\ m/s^2$$

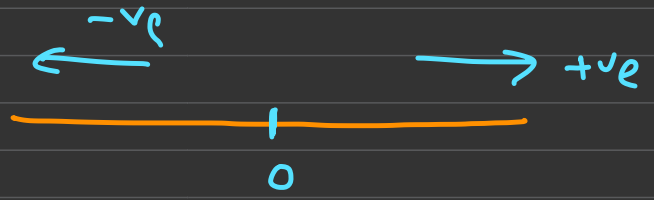
motion 1D (Kinematics):

- Uniformly Accelerated ($\vec{a}$ = const)
  - $\vec{a}$ = const
- Non-Uniformly Accelerated motion
  - $\vec{a}$ = Variable

if acceleration is constant { 1D }

: Equation of motion:

1. $\vec{v} = \vec{u} + \vec{a}t$
2. $\vec{s} = \vec{u}t + \frac{1}{2}\vec{a}t^2$
3. $v^2 = u^2 + 2as$

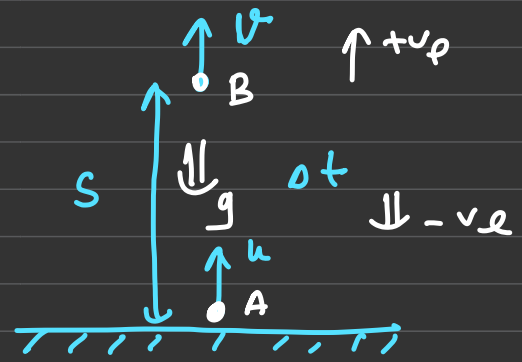


④ $S_{nth} = u + \frac{1}{2}a(2n-1)$

nth Second

Examples: ① motion Under gravity (a = Const)

g m/s^2 (near the surface of earth)



① $+v = +u + (-g)t$

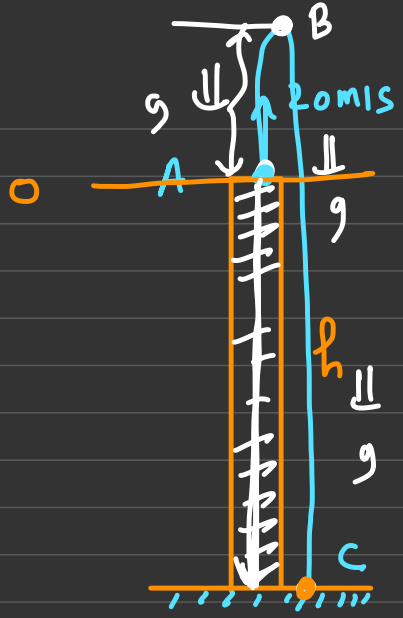
② $+s = +ut + \frac{1}{2}(-g) \times t^2$

③ $v^2 = u^2 + 2(-g)+s$

$v^2 = u^2 - 2gs$

$A \rightarrow B$

Q)



$g = 10 m/s^2$ time of flight = 10sec

a) find Height of tower?

$$\vec{S} = \vec{U} \times t + \frac{1}{2} \vec{a} \times t^2$$

$\vec{S}$ ↙ Displacement

$\vec{U}$ ↘ U velocity at $t = 0$

$$\vec{S} = +20 m/s \times 10 + \frac{1}{2}(-10)(10)^2$$

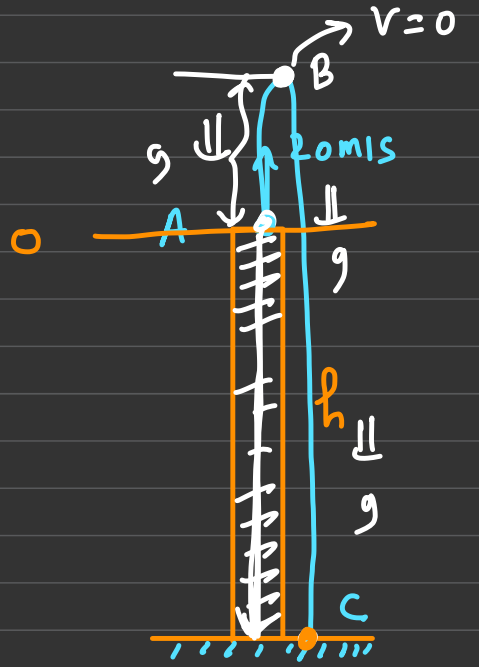
$$\vec{S} = +200 - 500$$

$$\vec{S} = -300 m$$

$|\vec{S}| = 300$ Height of tower

b) find maximum Height attained by particle?
w.r.t

Max. Height = (300 + AB)



A → B

$v^2 = u^2 + 2as$

$0 = (20 \times 20) + 2 \times (-10) \times AB$

$AB = \frac{400}{20} = 20\ m$

Max = 300 + 20

= 320 m

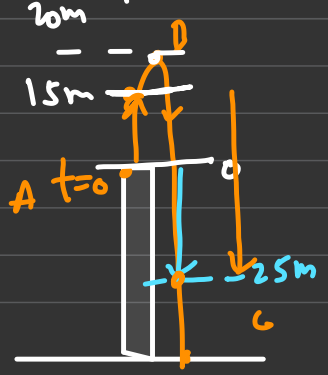
(c) total Distance covered by particle?

Distan $= (20 + 20 + 300)$ → {Distance is always +ve}

$= 340\text{m}$

(d) find displacement from 1 sec to 5 sec during motion?

$x(5) - x(1) =$ displacement



0 → 1 sec

$s = ut + \frac{1}{2}at^2$

$s(1) = +20 \times 1 + \frac{1}{2}(-10) \times (1)^2$

$= 20 - 5 = 15\text{m/s}$

0 → 5 sec

$$S = +20 \times (5) + \frac{1}{2}(-10)(5)^2$$

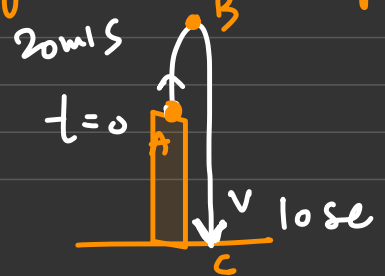
$$S = 100 - 125$$

$$S = -25 \text{ m}$$

$$x(5) = -25 - (+15)$$

$$= -40 \text{ m}$$

(e) find velocity with which particle hits ground?



find v?

$v = u + at$

$A \rightarrow B$

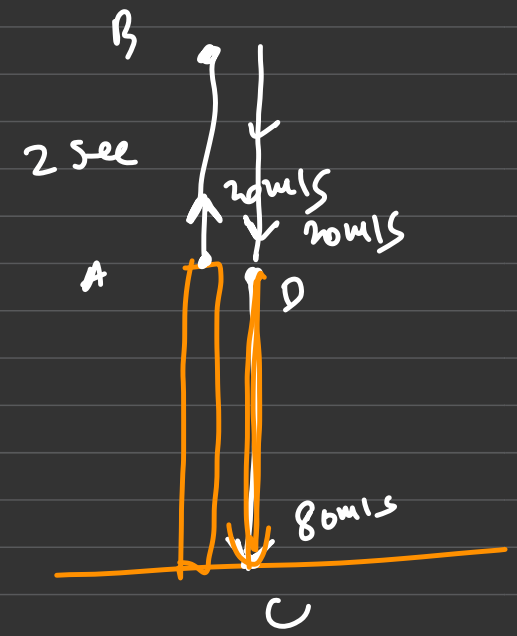
$v = u + at$

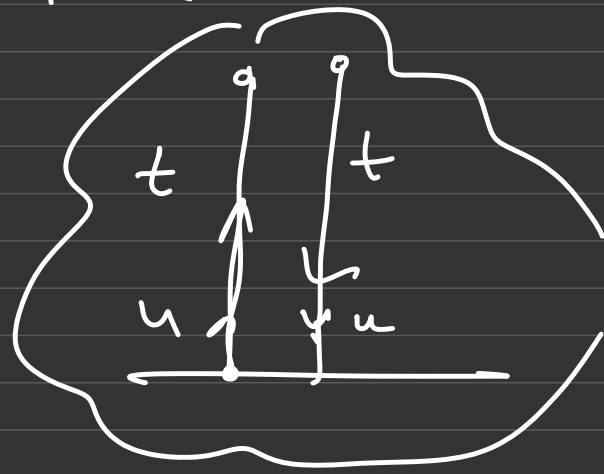
$0 = 20\text{m/s} - 10 \times t$

$t = 2\text{sec}$

$V = +20 + (-10) \times 10$

$V = 20 - 100 = -80\text{m/s}$





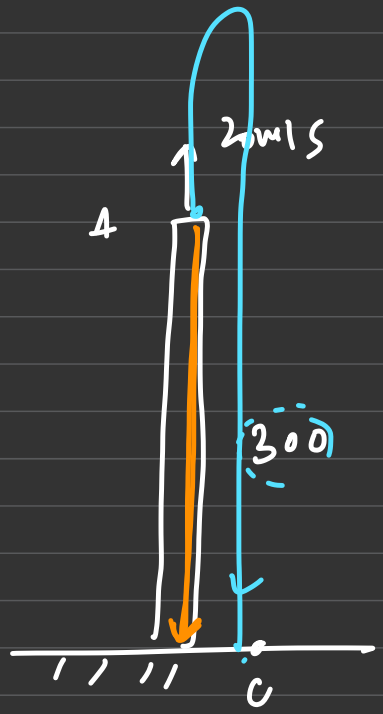
$D = C$

$v = u + at$

$V = -20 \text{ m/s} - 10 \times 6$

$V = -20 - 60 = -80 \text{ m/s}$

c)

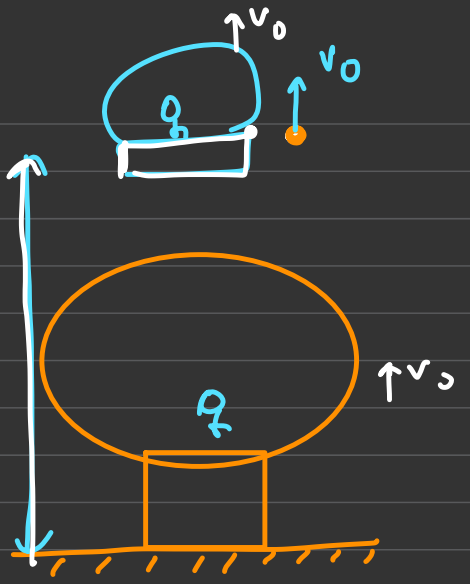


find time from A → C

A – C

$-300 = +20 \times t + \frac{1}{2}(-10)(t)^2$

Q)

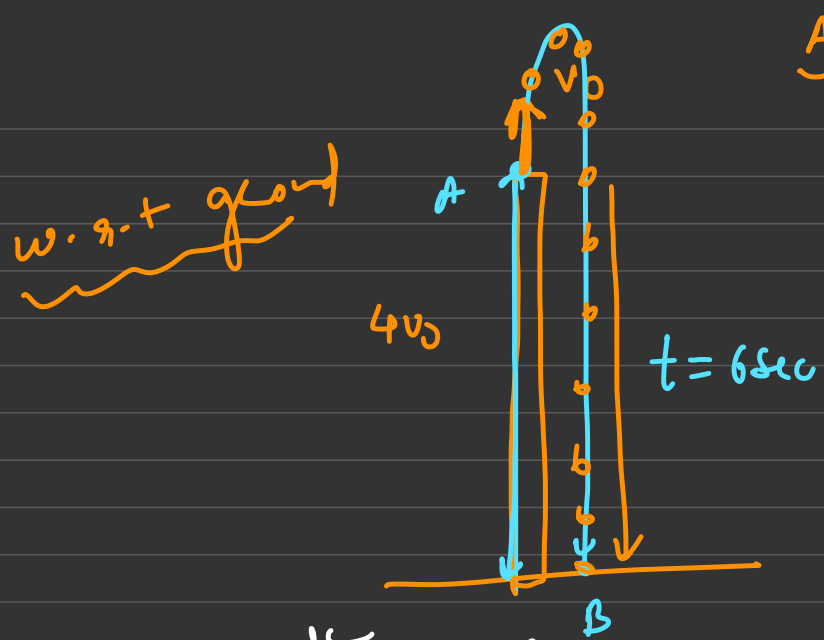


balloon is rising up at const velocity v_0 from ground

After 4 sec, A man inside balloon let go a stone. and it took another 6 sec to hit ground then find

a) v_0

2) total distance covered in air time by stone



w.r.t ground

A - B $\quad s = ut + \frac{1}{2}at^2$

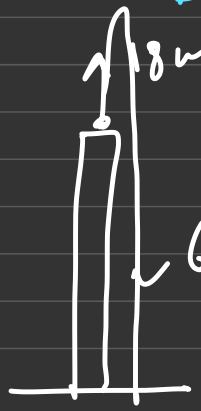
$-4v_0 = +v_0 \times 6 + \left(\frac{1}{2}(-10)(6)^2\right)$

$-4v_0 = 6v_0 - 5 \times 36$

$-10v_0 = -5 \times 36$

$v_0 = 18\ m/s$

Homework



find total distance covered in air ?

: Diff. + graph + integration

Pre-class

module

module

Kinematic

module

INE A

module → DTS 1/2

Level

Lecture