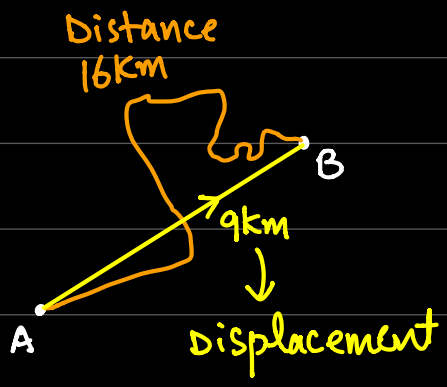
KINEMATICS (M1)
(20–25 Marks)

DISTANCE



DISPLACEMENT

Def SHORTEST DISTANCE BETWEEN START and END

SPEED

VELOCITY.

[DISPLACEMENT / VELOCITY] → BODY IS MOVING IN A STRAIGHT LINE.

ACCELERATION RATE OF CHANGE OF VELOCITY

$$a = \frac{\text{final velocity} - \text{initial velocity}}{\text{time}}.$$

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

Units: ms^{-2} or m/s^2

BODY SPEED UP = ACC is +ve = ACCELERATION
BODY SLOWS DOWN = ACC is -ve = DECELERATION / RETARDATION.

+/- SIGN OF ACCELERATION CANNOT COMMENT ON DIRECTION OF MOTION OF BODY.

CONSTANT SPEED ↓ $a = 0$	→ CONSTANT (UNIFORM) ACCELERATION → PULLEY (in any shape) → INCLINED PLANE → FREE FALL 1) BODY MUST BE IN AIR 2) ONLY FORCE ACTING IS WEIGHT $a = 10$ (speed up) OR $a = -10$ (slowdown)

Displacent = Velocity x time

$$s = v \times t$$

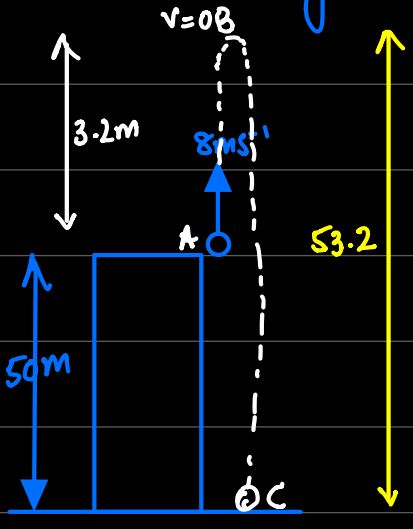
$$v = u + at$$

$$2as = v^2 - u^2$$

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

v = final velocity
u = initial velocity
t = time
a = acceleration.
s = displacement.

Q: A ball is projected vertically upwards with velocity 8 m/s from top of a 50 m tall building.



(a) Max height of ball above ground.

(A → B) (free fall)

$u = 8$, $a = -10$, $v = 0$, $s = ?$

$2as = v^2 - u^2$

$2(-10)s = 0^2 - 8^2$

$s = 3.2$

Max height $= 50 + 3.2 =$ **53.2 m**

(b) Speed of ball just before it

hits ground.

B ⟶ C Freefall.

$u = 0$, $v = ?$

$a = +10$, $s = 53.2$

$$2as = v^2 - u^2$$

$$2(10)(53.2) = v^2 - 0^2$$

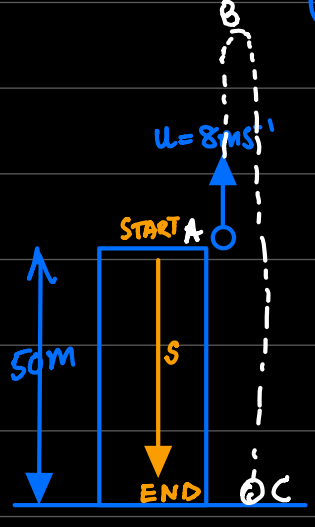
$$v^2 = 1064$$

$$v = 32.6 \text{ m/s}$$

(M1)

P

Q: A ball is projected vertically upwards with velocity 8m/s from top of a 50 m tall building.



(a) Speed of ball just before it hits ground.

A ⟶ (freefall) ⟶ C

$u = 8$, $v = ?$

$a = -10$, $s = -50$

$$2as = v^2 - u^2$$

$$2(-10)(-50) = v^2 - 8^2$$

$$1000 = v^2 - 64$$

$$v^2 = 1064$$

$$v = 32.6$$

+/− SIGNS DECISION

ACCELERATION

(S1) STAND AT INITIAL VELOCITY (u)

(S2) Observe what happens to object IMMEDIATELY After the experiment starts.

(S3) If it speeds up = a(+)
If it slows down = a(−)

DISPLACEMENT

STEPS

1 Mark an arrow from START to END and label displacement. (s)

2 Compare it with the arrow of initial velocity (u)

3 If both arrows are in same direction, take s(+)
If both arrows are in opp direction, take s(−).

IF QUESTION TALKS ABOUT FORCES AND ACCELERATION TOGETHER,

$$\boxed{\text{Fwd} - \text{Bwd} = ma}$$

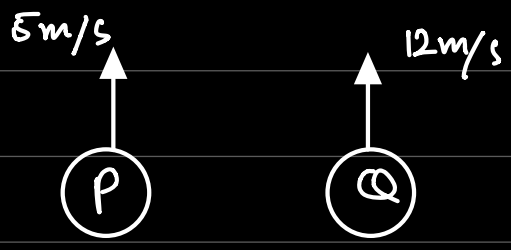
$$\text{Fwd} - \text{Bwd} = ma$$
$$20 - 3 = 4a$$
$$17 = 4a$$
$$a = \frac{17}{4} = \boxed{4.25\ ms^{-2}}$$

TIME DELAY :-

t = time of motion.

t	$t-0.2$
$t_p = 1$	$t_q = 0.8$

pause at $t=1$

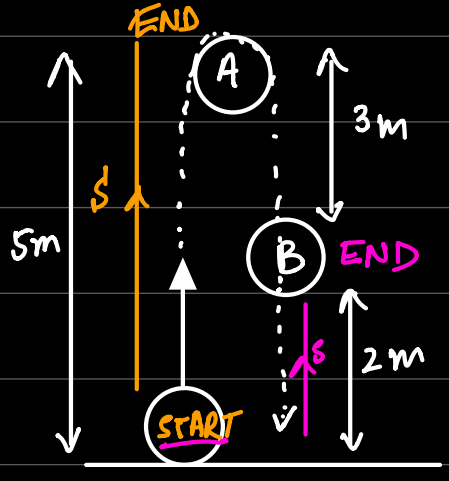


Q was projected 0.2 seconds later than P.

time = t ⟶ time = $t-0.2$

time = $T+0.2$ ⟵ time = T

IF A BODY STARTS FROM GROUND AND START TRAVELLING VERTICALLY, ITS DISPLACEMENT IS ALWAYS EQUAL TO ITS HEIGHT.



At A: $s = 5m$, $h = 5m$

At B: $s = 2m$, $h = 2m$

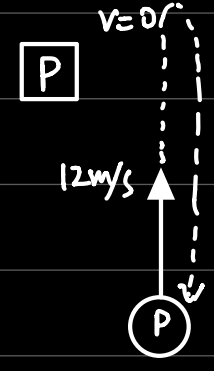
no DELAY.

36 Two particles P and Q are projected vertically upwards from horizontal ground at the same instant. The speeds of projection of P and Q are 12 m s^{-1} and 7 m s^{-1} respectively and the heights of P and Q above the ground, t seconds after projection, are h_P m and h_Q m respectively. Each particle comes to rest on returning to the ground.

(i) Find the set of values of t for which the particles are travelling in opposite directions. [3]

(ii) At a certain instant, P and Q are above the ground and $3h_P = 8h_Q$. Find the velocities of P and Q at this instant. [5]

HEIGHTS AND DISPLACEMENTS ARE SAME.



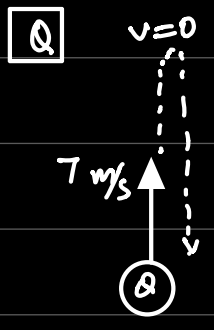
$u = 12,\ v = 0$

$a = -10,\ t = ?$

$v = u + at$

$0 = 12 + (-10)t$

$t = 1.2$ sec



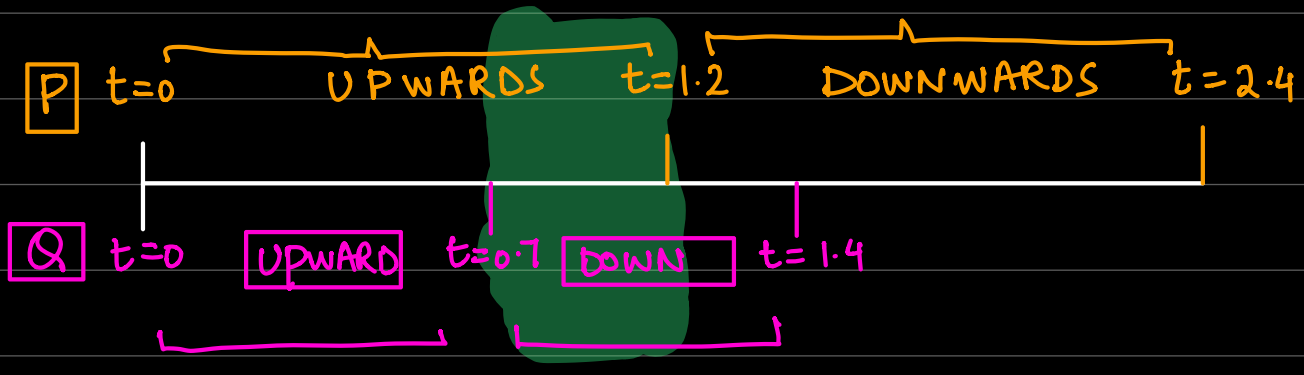
$u = 7,\ v = 0$

$a = -10,\ t = ?$

$v = u + at$

$0 = 7 + (-10)t$

$t = 0.7$



Set of values: $0.7 < t < 1.2$

(ii) $3h_P = 8h_Q$ height = displacement.

P: $u = 12,\ a = -10,\ s = ?$

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

Q: $u = 7,\ a = -10,\ s = ?$

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

$s = 12t + \frac{1}{2}(-10)t^2$ | $s = 7t + \frac{1}{2}(-10)t^2$

h_p $\boxed{s = 12t - 5t^2}$ | h_q $\boxed{s = 7t - 5t^2}$

$$3h_p = 8h_q$$

$$3(12t - 5t^2) = 8(7t - 5t^2)$$

$$36t - 15t^2 = 56t - 40t^2$$

$$40t^2 - 15t^2 = 56t - 36t$$

$$25t^2 = 20t$$

$$\boxed{t = 0.8}$$

P $v = u + at$

$v = 12 + (-10)(0.8)$

$v_p = 4 \text{ m/s}$

Q $v = u + at$

$v = 7 + (-10)(0.8)$

$v_Q = -1 \text{ m/s}$.

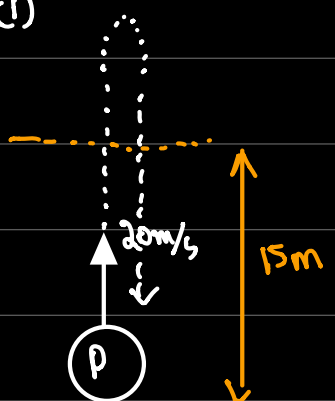
27 Particles P and Q are projected vertically upwards, from different points on horizontal ground, with velocities of 20 m s^{-1} and 25 m s^{-1} respectively. Q is projected 0.4 s later than P. Find

(i) the time for which P's height above the ground is greater than 15 m, [3]

(ii) the velocities of P and Q at the instant when the particles are at the same height. [5]

DISP.

(i)



$u = 20$, $s = 15$, $a = -10$, $t = ?$

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

$$15 = 20t + \frac{1}{2}(-10)t^2$$

$$15 = 20t - 5t^2$$

$$t^2 - 4t + 3 = 0$$

$$t^2 - t - 3t + 3 = 0$$

$$t(t-1) - 3(t-1) = 0$$

$$t = 1, \quad t = 3$$

Time duration $= 3 - 1 = 2$ seconds.

(iii) **P** $u = 20$, $a = -10$, $s_p = h_p$, time $= t$

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

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

$$\boxed{h_p = 20t - 5t^2}$$

Q $u = 25$, $a = -10$, $s_q = h_q$, time $= t - 0.4$

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

$$h_q = 25(t-0.4) + \frac{1}{2}(-10)(t-0.4)^2$$

$$\boxed{h_q = 25(t-0.4) - 5(t-0.4)^2}$$

$$\boxed{h_p = 20t - 5t^2} = \boxed{h_q = 25(t-0.4) - 5(t-0.4)^2}$$

$$20t - 5t^2 = 25(t-0.4) - 5(t^2 - 0.8t + 0.16)$$

$$20t - 5t^2 = 25t - 10 - 5t^2 + 4t - 0.8$$

$$10 + 0.8 = 25t + 4t - 20t$$

$$10.8 = 9t$$

$$t = \frac{10.8}{9}$$

$$\boxed{t = 1.2 \text{ sec}}$$

P $v = u + at$

$v = 20 + (-10)(1.2)$

$v = 8 m/s$

Q $v = u + a(t - 0.4)$

$v = 25 + (-10)(1.2 - 0.4)$

$v = 17 m/s$.

88 A particle P starts from rest at a point O on a horizontal straight line. P moves along the line with constant acceleration and reaches a point A on the line with a speed of $30\,\text{m s}^{-1}$. At the instant that P leaves O, a particle Q is projected vertically upwards from the point A with a speed of $20\,\text{m s}^{-1}$. Subsequently P and Q collide at A. Find

(i) the acceleration of P, [4]

(ii) the distance OA. [2]

71 A particle is projected vertically upwards with speed $9\ \text{m s}^{-1}$ from a point 3.15 m above horizontal ground. The particle moves freely under gravity until it hits the ground. For the particle's motion from the instant of projection until the particle hits the ground, find the total distance travelled and the total time taken. [6]

21 A particle is projected vertically upwards from a point O with initial speed $12.5\,\text{m s}^{-1}$. At the same instant another particle is released from rest at a point 10 m vertically above O. Find the height above O at which the particles meet. [5]