KINEMATICS

(M1) (20 + marks)

DISTANCE

(cm, m, km)

DISPLACEMENT

(cm, m, km)

SHORTEST DISTANCE BETWEEN START AND END POINT.

SPEED

(m/s or km/h)

VELOCITY.

(m/s or km/h)

IF QUESTION USES TERM "DISPLACEMENT" OR "VELOCITY" BODY IS ALWAYS MOVING IN STRAIGHT LINE.

ACCELERATION Rate of change in speed.

$$a = \frac{\text{Final velocity} - \text{Initial velocity}}{\text{time}}.$$

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

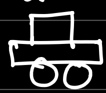
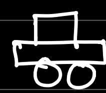
u = initial velocity

v = final velocity.

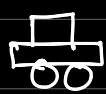
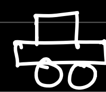
a = acceleration.

t = time.

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

(A) $u=0$  $t = 4\,sec$ $v = 100$ 

$$a = \frac{100-0}{4} = 25\,ms^{-2}$$

(B) $u=0$  $t = 10\,sec$ $v = 100$ 

$$a = \frac{100-0}{10} = 10\,ms^{-2}$$

Acc $\longrightarrow$ +ve $\longrightarrow$ BODY IS SPEEDING UP $\longrightarrow$ ACCELERATION

Acc $\longrightarrow$ −ve $\longrightarrow$ BODY IS SLOWING DOWN $\longrightarrow$ RETARDATION DECELERATION.

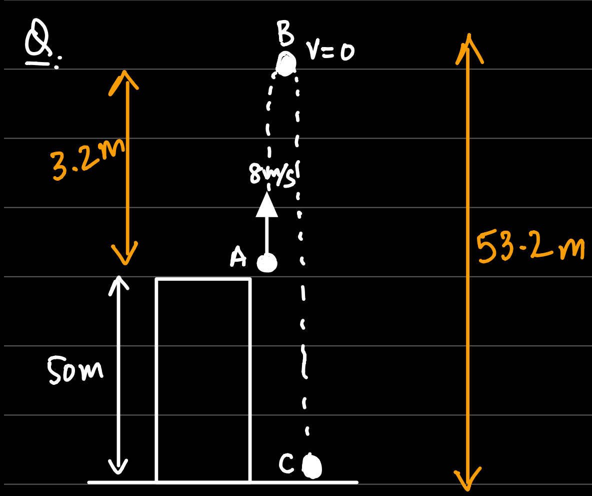
> +/− SIGN OF ACCELERATION CANNOT COMMENT ON DIRECTION OF MOTION OF BODY.

TYPE 1: CONSTANT ACCELERATION

CONSTANT SPEED	CONSTANT (UNIFORM) ACCELERATION.
$(a = 0)$	1) INCLINED PLANE 2) PULLEY (in any shape) 3) FREEFALL: (a) body is in air (b) only force acting on body is weight. $a = 10$ (speed up) or $a = -10$ (slowdown)
distance ↑ speed ↑ time ↑ $d = s \times t$ Displacement ↑ velocity ↑ 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
s = displacement.
a = acceleration.

Q.



A ball is thrown upwards from top of 50m tall building with 8m/s.

Find:

(i) max height reached by ball.

$$A \xrightarrow{\text{freefall.}} B$$

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

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

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

$$s = 3.2\text{ m}$$

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

(ii) Velocity with which ball hits ground.

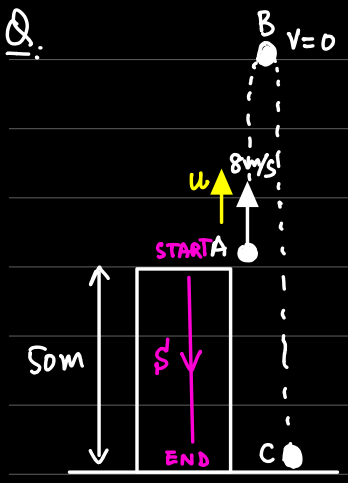
$$B \xrightarrow{\text{free fall}} C$$

$u = 0$, $a = +10$, $v = ?$, $S = 53.2$

$$2as = v^2 - u^2$$
$$2(10)(53.2) = v^2 - 0^2$$
$$v^2 = 1064$$
$$v = \sqrt{1064} = 32.6 \text{ m/s.}$$

IN M1, examiner requires to calculate from complete Journey from $A \longrightarrow C$.

Q.



A ball is thrown upwards from top of 50m tall building with 8m/s.

Find velocity of ball just before hitting ground.

$$A \xrightarrow{\text{FREEFALL}} C$$

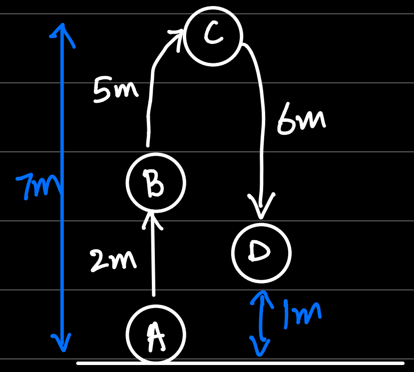
$u = 8$, $a = -10$, $S = -50$, $v = ?$

$$2as = v^2 - u^2$$
$$2(-10)(-50) = v^2 - 8^2$$
$$1000 = v^2 - 64$$
$$v^2 = 1064, \quad v = 32.6.$$

+/− SIGNS

ACCELERATION	DISPLACEMENT
STAND AT intial velocity (u) IF BODY IS ABOUT TO Speed up ⟶ $a = +ve$ Slow down ⟶ $a = -ve$	Mark an arrow from START ⟶ END and label it (s). Now compare this arrow with initial velocity (u) If both arrows are in: same direction ⟶ $s = +ve$ opp direction ⟶ $s = -ve$.

IF A BODY STARTS FROM GROUND AND MOVES VERTICALLY, ITS DISPLACEMENT AND HEIGHT IS ALWAYS SAME

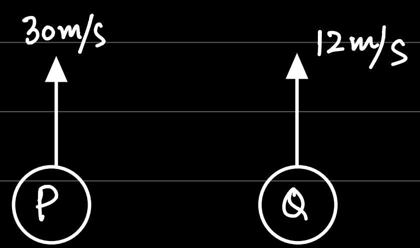


	Height	Displacement.
A	0	0
B	2	2
C	7	7
D	1	1

TIME DELAY BETWEEN TWO OBJECTS

In equations of motion, time of motion is needed.

$t_p = 5$ $\quad$ $t_q = 5-2 = 3$ $\quad$ $t = 5$ sec (Pause).



Q is released 2 seconds after P.

time $= t \rightarrow$ time $= t-2$

time $= T+2 \leftarrow$ time $= T$

HEIGHT = DISPLACEMENT.

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

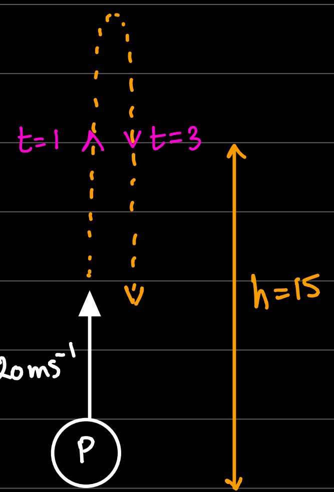
(i) the time for which P's height above the ground is greater than 15 m, [3]

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

Same displacement.

time = t   time = t − 0.4

(i)



$u = 20$, $a = -10$

$s = 15$, $t = ?$

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

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

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

$$5t^2 - 20t + 15 = 0$$

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

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

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

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

Time for which body stayed above 15m height = 3 − 1 = 2 sec

(ii) DISPLACEMENTS (HEIGHTS)

h_P = height of P
h_Q = height of Q.

P	Q
$u = 20$, $a = -10$	$u = 25$, $a = -10$
$s = h_P$, time $= t$	$s = h_Q$, time $= t - 0.4$
$s = ut + \frac{1}{2}at^2$	$s = ut + \frac{1}{2}at^2$
$h_P = 20t + \frac{1}{2}(-10)t^2$	$h_Q = 25(t-0.4) + \frac{1}{2}(-10)(t-0.4)^2$
$\boxed{h_P = 20t - 5t^2}$	$\boxed{h_Q = 25(t-0.4) - 5(t-0.4)^2}$

$$h_P = h_Q$$

$$20t - 5t^2 = 25(t-0.4) - 5(t-0.4)^2$$
$$20t - 5t^2 = 25t - 10 - 5(t^2 - 0.8t + 0.16)$$
$$20t - \cancel{5t^2} = 25t - 10 - \cancel{5t^2} + 4t - 0.8$$
$$0 = 9t - 10.8$$
$$t = 1.2$$

VELOCITIES

P

$v = u + at$

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

$v_P = 8$ m/s

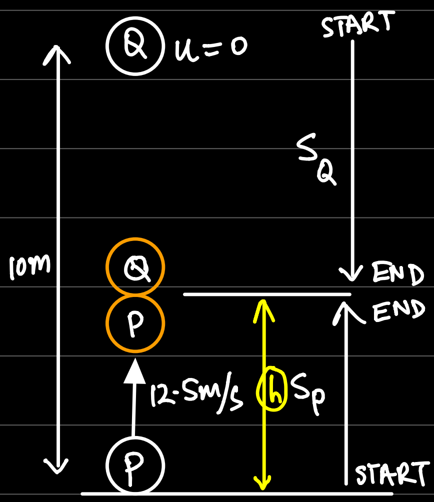
Q

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

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

$v_Q = 17$ m/s

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



P

$u = 12.5$, $a = -10$

$s = s_P$, time $= t$

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

$s_P = (12.5)t + \frac{1}{2}(-10)t^2$

$\boxed{s_P = 12.5t - 5t^2}$

Q

$u = 0$, $a = +10$

$s = s_Q$, time $= t$

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

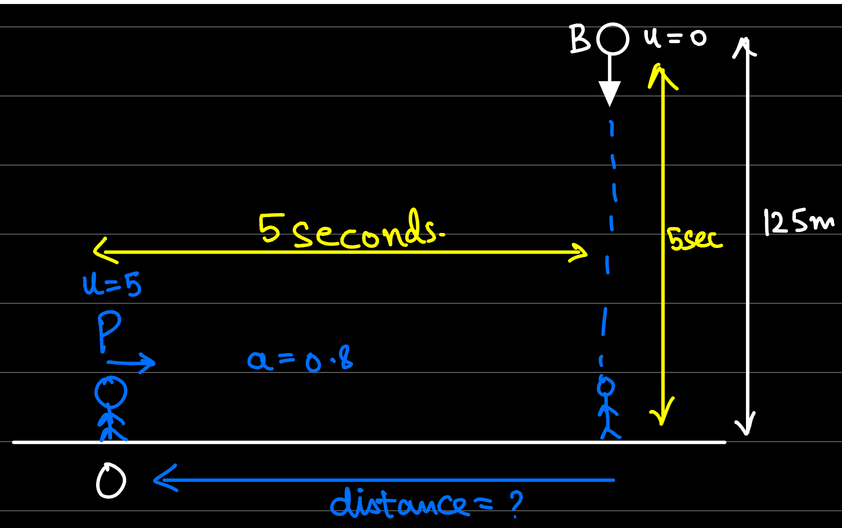
$s_Q = 0t + \frac{1}{2}(10)t^2$

$\boxed{s_Q = 5t^2}$

$$s_P + s_Q = 10$$
$$12.5t - 5t^2 + 5t^2 = 10$$
$$12.5t = 10$$
$$t = 0.8$$

$$h = s_P = 12.5t - 5t^2$$
$$= 12.5(0.8) - 5(0.8)^2$$
$$= 6.8\text{ m.}$$

51 An object is released from rest at a height of 125 m above horizontal ground and falls freely under gravity, hitting a moving target P. The target P is moving on the ground in a straight line, with constant acceleration $0.8\,\mathrm{m\,s^{-2}}$. At the instant the object is released P passes through a point O with speed $5\,\mathrm{m\,s^{-1}}$. Find the distance from O to the point where P is hit by the object. [4]



$\boxed{B}$ $u = 0$, $s = 125$, $t = ?$, $a = +10$

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

$$125 = 0t + \frac{1}{2}(10)t^2$$

$$125 = 5t^2$$

$$\boxed{t = 5}$$

$\boxed{P}$

$u = 5$

$a = 0.8$

$t = 5$

$s = ?$

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

$$= 5(5) + \frac{1}{2}(0.8)(5)^2$$

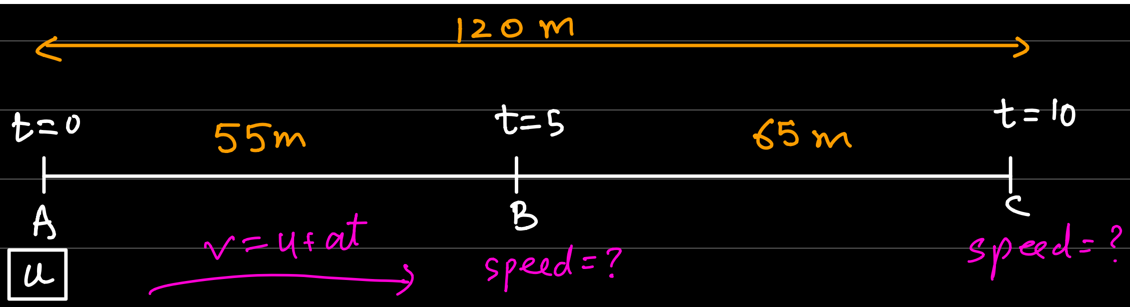
$$s = 35\text{ m.}$$

$v = u + at$

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

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

54 A car travels along a straight road with constant acceleration a m s^{-2}. It passes through points A, B and C; the time taken from A to B and from B to C is 5 s in each case. The speed of the car at A is u m s^{-1} and the distances AB and BC are 55 m and 65 m respectively. Find the values of a and u. [6]



$A \longrightarrow B$

$u = u$, $a = a$

$t = 5$, $s = 55$

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

$55 = u(5) + \frac{1}{2}a(5)^2$

$\boxed{55 = 5u + 12.5a}$

$A \longrightarrow C$

$u = u$, $a = a$

$t = 10$, $s = 120$

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

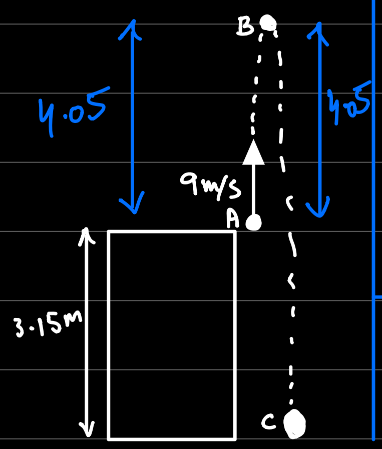
$120 = u(10) + \frac{1}{2}(a)(10)^2$

$\boxed{120 = 10u + 50a}$

$u =$

$a =$

71 A particle is projected vertically upwards with speed 9 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]



$A \longrightarrow B$

$u=9,\ a=-10$

$s=?\ ,\ v=0$

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

$2(-10)s = 0^2 - 9^2$

$s = 4.05$

$v = u + at$

$0 = 9 + (-10)t$

$t = 0.9$

Total Distance

$4.05 + 4.05 + 3.15$

$= 11.25\text{ m}.$

$B \longrightarrow C$

$u=0,\ t=?,\ a=10$

$s = 4.05 + 3.15 = 7.2$

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

$7.2 = 0t + \frac{1}{2}(10)t^2$

$\boxed{t = 1.2}$

Total time $= 1.2 + 0.9 = 2.1$

Direct: $A \rightarrow C$

$u = 9,\ a = -10$

$s = -3.15,\ t = ?$

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

$-3.15 = 9t + \frac{1}{2}(-10)t^2$

Solve Quadratic.

TYPE 2: NON CONSTANT ACCELERATION

$$\begin{tikzcd}
\boxed{\text{DISPLACEMENT}} \arrow[r, bend left, "\text{DIFF}"] & \boxed{\text{VELOCITY}} \arrow[l, bend left, "\text{integrate}"] \arrow[r, bend left, "\text{DIFF}"] & \boxed{\text{ACCELERATION}} \arrow[l, bend left, "\text{integrate}"]
\end{tikzcd}$$

<u>CASE 1</u>:

VALUE OF DISPLACEMENT IS **GIVEN** OR **TO BE FOUND**

INTEGRATE WITH LIMITS.

<u>CASE 2</u>:

Expression for Displacement

INTEGRATE WITHOUT LIMITS

USE $\boxed{+C}$

For integrating from acceleration to velocity, ALWAYS integrate "WITHOUT LIMITS" and use $\boxed{+C}$

$$s = 6t^3 - 7t^2 + 12$$

Diff ↓   ↑ integrate.

$$v = 18t^2 - 14t$$

Diff ↓   ↑ integrate

$$a = 36t - 14$$

TURNING POINT (INSTANTENOUS REST)		$V=0$
MAX DISPLACEMENT	disp $\xrightarrow{\text{diff}}$ velocity	$V=0$
MAX VELOCITY	velocity $\xrightarrow{\text{Diff}}$ acc	$a=0$
MAX ACCELERATION	acc $\xrightarrow{\text{diff}}$ $\frac{da}{dt}$	$\frac{da}{dt}=0$

$t=0$ $v=0$

2 A particle starts from rest at the point A and travels in a $\boxed{\text{straight line}}$ until it reaches the point B. T h e velocity of the particle t seconds after leaving A is $v\,\text{m}\,\text{s}^{-1}$, where $v = 0.009t^2 - 0.0001t^3$. Given that the velocity of the particle when it reaches B is zero, f nd

(i) the time taken for the particle to travel from A to B, [2]

(ii) the distance AB, (value) (with limits Integration). [4]

(iii) the maximum velocity of the particle. (acc = 0) [4]

$t=0$ $\qquad\qquad\qquad\qquad$ $t=90$

A ———————————————— B

$v=0$ $\qquad$ $v=0.009t^2-0.0001t^3$ $\qquad$ $v=0$

(i) Put $v=0$

$$0 = 0.009t^2 - 0.0001t^3$$

$$0 = t^2(0.009 - 0.0001t)$$

$t^2 = 0$, $\quad 0.009 - 0.0001t = 0$

$t = 0$ $\qquad\qquad t = 90$

A B

(ii) Integration. (with limits)

$$S = \int_0^{90} (0.009t^2 - 0.0001t^3)\,dt$$

$$S = \left| \frac{0.009t^3}{3} - \frac{0.0001t^4}{4} \right|_0^{90}$$

$$S = \left| \left(\frac{0.009(90)^3}{3} - \frac{0.0001(90)^4}{4} \right) - \left(\frac{0.009(0)^3}{3} - \frac{0.0001(0)^4}{4} \right) \right|$$

$$S = 546.75.$$

(iii) Max velocity $a = 0$

$v = 0.009t^2 - 0.0001t^3$

diff

$a = 0.018t - 0.0003t^2$

$0 = 0.018t - 0.0003t^2$

$0.0003t^2 = 0.018t$

$0.0003t = 0.018$

$t = 60$

$v = 0.009(60)^2 - 0.0001(60)^3$

$v = 10.8$ m/s

40 A particle travels in a straight line from A to B in 20 s. Its acceleration t seconds after leaving A is a m s^{-2}, where $a = \frac{3}{160}t^2 - \frac{1}{800}t^3$. It is given that the particle comes to rest at B.

(i) Show that the initial speed of the particle is zero. **[4]**

t = 0

(ii) Find the maximum speed of the particle. (put acc = 0) **[2]**

(iii) Find the distance AB. (integrate velocity) (with limits) **[4]**

$t=0$ $\qquad\qquad\qquad\qquad\qquad\qquad$ $t=20$

A $\qquad\qquad\qquad\qquad\qquad\qquad$ B

$v = ?$ $\qquad\qquad$ $a = \frac{3}{160}t^2 - \frac{1}{800}t^3$ $\qquad\qquad$ $v = 0$

(i) integrate without limits (+c)

$$v = \int \left(\frac{3}{160}t^2 - \frac{1}{800}t^3\right) dt.$$

$$v = \frac{3}{160}\frac{t^3}{3} - \frac{1}{800}\frac{t^4}{4} + C$$

$$\boxed{v = \frac{1}{160}t^3 - \frac{1}{3200}t^4 + c}$$

$v = 0$ at B

$t = 20$

$$0 = \frac{1}{160}(20)^3 - \frac{1}{3200}(20)^4 + c$$

$$c = 0$$

$$\boxed{v = \frac{1}{160}t^3 - \frac{1}{3200}t^4}$$

For initial velocity, put $t=0$

$$v = \frac{1}{160}(0)^3 - \frac{1}{3200}(0)^4 = 0.$$

(ii) Max Speed (acc = 0)

$$a = \frac{3}{160}t^2 - \frac{1}{800}t^3$$

$$0 = \frac{3}{160}t^2 - \frac{1}{800}t^3$$

$$0 = t^2\left(\frac{3}{160} - \frac{1}{800}t\right)$$

$$\frac{3}{160} - \frac{1}{800}t = 0$$

$$t = 15$$

max velocity, put $t = 15$

$$v = \frac{1}{160}t^3 - \frac{1}{3200}t^4$$

$$v = \frac{1}{160}(15)^3 - \frac{1}{3200}(15)^4$$

$$v = 5.27.$$

$$s = \int_0^{20}\left(\frac{1}{160}t^3 - \frac{1}{3200}t^4\right)dt$$

$$\left|\frac{1}{160}\frac{t^4}{4} - \frac{1}{3200}\frac{t^5}{5}\right|_0^{20}$$

$$\left|\frac{t^4}{640} - \frac{t^5}{16000}\right|_0^{20}$$

$$\left|\left(\frac{20^4}{640} - \frac{20^5}{16000}\right) - \left(\frac{0^4}{640} - \frac{t^5}{16000}\right)\right|$$

$$= 50.$$

TYPE 2 ADVANCED SPLIT JOURNEY.

$t=0$ $\qquad\qquad$ $t=15$ $\qquad\qquad$ $t \geq 15$

$v = 3t^2 - 9t$ $\qquad\qquad$ $v = \dfrac{B}{t^3}$

	AT BOUNDARY TIME
INSTANTENEOUS DISP. STAYS SAME	1- Displacement is same in both equation
INSTANTENEOUS VELOCITY STAYS SAME	2- Velocity is same from both expressions
INSTANTENEOUS ACCELERATION MAY OR MAY NOT BE SAME.	3- Acc may or may not be same.

Find value of B:

put $t=15$ in both velocity expressions and equate them.

$v = 3t^2 - 9t$ $\qquad$ $\boxed{t=15}$ $\qquad$ $v = \dfrac{B}{t^3}$

$$3(15)^2 - 9(15) = \frac{B}{15^3}$$

$$B = 1822500$$

21 A vehicle is moving in a straight line. The velocity v m s^{-1} at time t s after the vehicle starts is given by

$$v = A(t - 0.05t^2) \quad \text{for } 0 \leqslant t \leqslant 15,$$

$$v = \frac{B}{t^2} \quad \text{for } t \geqslant 15,$$

where A and B are constants. The distance travelled by the vehicle between $t = 0$ and $t = 15$ is 225 m.

(i) Find the value of A and show that $B = 3375$. [5]

$v = \dfrac{3375}{t^2}$

without limits. integration

(ii) Find an expression in terms of t for the total distance travelled by the vehicle when $t \geqslant 15$. [3]

(iii) Find the speed of the vehicle when it has travelled a total distance of 315 m. [3]

$v = A(t - 0.05t^2)$ $A = 4$ $v = \dfrac{B}{t^2}$ $B = 3375$

(i) $S = \int A(t - 0.05t^2)\,dt$

$225 = \int_0^{15} A(t - 0.05t^2)\,dt$

$225 = A\int_0^{15} (t - 0.05t^2)\,dt$

$225 = A\left|\dfrac{t^2}{2} - \dfrac{0.05t^3}{3}\right|_0^{15}$

$225 = A\left|\left(\dfrac{15^2}{2} - \dfrac{0.05(15)^3}{3}\right) - \left(\dfrac{0^2}{2} - \dfrac{0.05(0)^3}{3}\right)\right|$

$225 = A\left|\dfrac{225}{4}\right|$

$225 = A\left(\dfrac{225}{4}\right)$

$A = 4$

FOR B we use BOUNDARY TIME

$t = 15$

$v = 4(t - 0.05t^2)$ $\swarrow$ $\searrow$ $v = \frac{B}{t^2}$

$$4(15 - 0.05(15)^2) = \frac{B}{15^2}$$

$$15 = \frac{B}{225}$$

$$B = 3375$$

(ii) $$S = \int \frac{3375}{t^2}\,dt$$

$$S = \int 3375t^{-2}\,dt$$

$$S = \frac{3375t^{-1}}{-1} + c$$

$$\boxed{S = -\frac{3375}{t} + c}$$

This c will always be calculated from the displacement and time of BOUNDARY TIME.

$S = 225$, $t = 15$

$$225 = -\frac{3375}{15} + c$$

$$c = 450$$

$$\boxed{S = -\frac{3375}{t} + 450}$$

Expression for total distance travelled.

(iii) Total distance = 315

$$S = -\frac{3375}{t} + 450$$

$$315 = \frac{-3375}{t} + 450$$

$$\frac{3375}{t} = 450 - 315$$

$$t = 25$$

For speed put $t = 25$ in:

$$v = \frac{3375}{t^2}$$

$$v = \frac{3375}{25^2}$$

$$v = 5.4.$$

$t=0$ $v=0$

5 A particle P starts from rest at O and travels in a straight line. Its velocity v m s^{-1} at time t s is given by $v = 8t - 2t^2$ for $0 \leqslant t \leqslant 3$, and $v = \dfrac{54}{t^2}$ for $t > 3$. Find

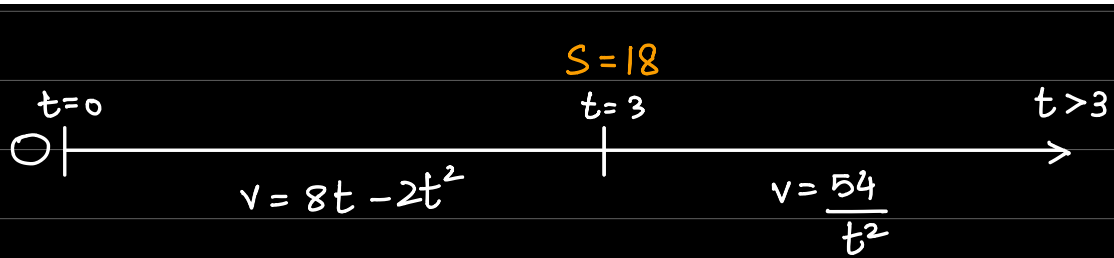
integrate with limits.

(i) the distance travelled by P in the first 3 seconds, [4]

without limits. integrate

(ii) an expression in terms of t for the displacement of P from O, valid for $t > 3$, [3]

(iii) the value of v when the displacement of P from O is 27 m. [3]



(i)
$$S = \int_0^3 (8t - 2t^2)\,dt$$

$$S = \left| \frac{8t^2}{2} - \frac{2t^3}{3} \right|_0^3$$

$$S = \left| 4t^2 - \frac{2t^3}{3} \right|_0^3$$

$$s = \left| \left(4(3)^2 - \frac{2(3)^3}{3}\right) - \left(4(0)^2 - \frac{2(0)^3}{3}\right) \right|$$

$$s = 18m.$$

(ii) $$s = \int \frac{54}{t^2}\,dt$$

$$s = \int 54t^{-2}\,dt$$

$$s = \frac{54t^{-1}}{-1} + c$$

$$\boxed{s = -\frac{54}{t} + c}$$

$\left.\begin{matrix} t = 3 \\ s = 18 \end{matrix}\right\}$ BOUNDARY TIME.

$$18 = -\frac{54}{3} + c$$

$$c = 36$$

$$\boxed{s = \frac{-54}{t} + 36}$$

(iii) $$s = 27$$

$$s = \frac{-54}{t} + 36$$

$$27 = -\frac{54}{t} + 36$$

$$\frac{54}{t} = 36 - 27$$

$$\boxed{t = 6}$$

$$v = \frac{54}{t^2}$$

$$v = \frac{54}{6^2}$$

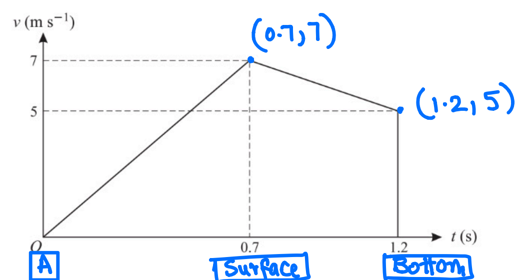
$$v = 1.5$$

TYPE 3 GRAPHS

$$\begin{tikzcd} \boxed{\text{DISPLACEMENT}} \arrow[r, bend left, "\text{GRADIENT}"] & \boxed{\text{VELOCITY}} \arrow[l, bend left, "\text{Area}"] \arrow[r, bend left, "\text{GRADIENT}"] & \boxed{\text{ACCELERATION}} \arrow[l, bend left, "\text{Area}"] \end{tikzcd}$$

IMP: ALWAYS DRAW REAL LIFE DIAGRAM OF SCENARIO AND RELATE KEY TIMES TO GRAPH.

7



The diagram shows the velocity-time graph for the motion of a small stone which falls vertically from rest at a point A above the surface of liquid in a container. The downward velocity of the stone t s after leaving A is $v\,\mathrm{m\,s^{-1}}$. The stone hits the surface of the liquid with velocity $7\,\mathrm{m\,s^{-1}}$ when $t = 0.7$. It reaches the bottom of the container with velocity $5\,\mathrm{m\,s^{-1}}$ when $t = 1.2$.

(i) Find

displacement (area under graph)

(a) the height of A above the surface of the liquid, (From A to surface)

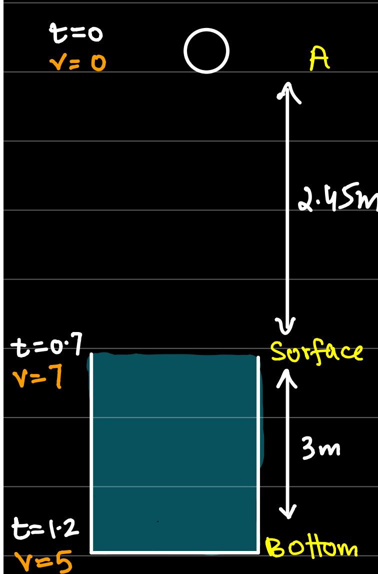
(b) the depth of liquid in the container. [3]

displacement (area under graph)

(ii) Find the deceleration of the stone while it is moving in the liquid. [2]

acc (grad) when slowing down

(iii) Given that the resistance to motion of the stone while it is moving in the liquid has magnitude 0.7 N, find the mass of the stone. [3]



(i) height of A to surface

$$\text{Area} = \frac{1}{2}(0.7)(7) = 2.45\text{m}$$

(ii) Depth = Area from surface to Bottom

$$\text{Area of trapezium} = \frac{1}{2} \times h \times (a+b)$$

$= \frac{1}{2} \times 0.5 \times (7+5)$

$= 3\text{ m}$

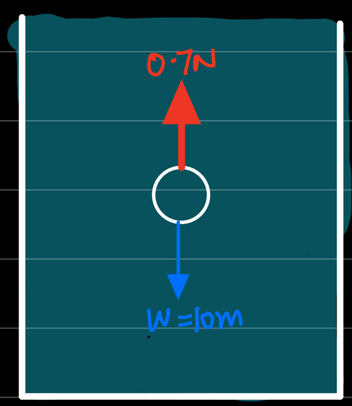
(iii) Deceleration: $(0.7, 7)\ (1.2, 5)$

$\text{grad} = \text{acc} = \frac{5-7}{1.2-0.7} = \frac{-2}{0.5} = -4\text{ m/s}^2$

$\text{acc} = -4$

$\text{Deceleration} = 4\text{ m/s}^2$

(iii) **(iii)** Given that the resistance to motion of the stone while it is moving in the liquid has magnitude 0.7 N, find the mass of the stone. [3]



$\text{Fwd} - \text{Bwd} = ma$ → acc

$10m - 0.7 = m(-4)$

$10m + 4m = 0.7$

$14m = 0.7$

$m = 0.05$

$W = mg = m(10) = 10m$

ACC

KINEMATICS

$v = u + at$

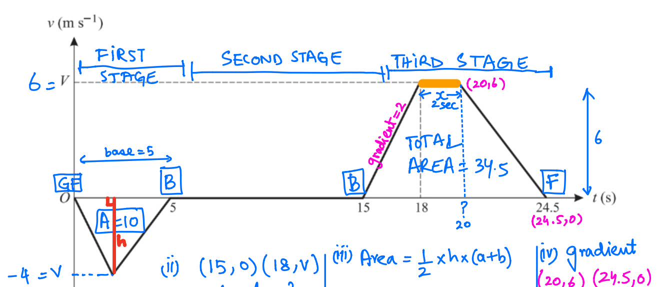
$2as = v^2 - u^2$

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

FORCES

Fwd − Bwd = ma

3



(i) $A = \frac{1}{2} \times b \times h$

$10 = \frac{1}{2} \times (5) \times h$

$h = 4$

speed $= 4$

(ii) $(15, 0)\ (18, V)$

gradient $= 2$

$\frac{V - 0}{18 - 15} = 2$

$V = 6$

(iii) Area $= \frac{1}{2} \times h \times (a + b)$

$34.5 = \frac{1}{2} \times 6 \times (9.5 + x)$

$69 = 6(9.5 + x)$

$x = 2$

(iv) gradient

$(20, 6)\ (24.5, 0)$

$a = \frac{0 - 6}{24.5 - 20}$

$a = -\frac{4}{3}$

$dec = \frac{4}{3}$.

The diagram shows the velocity-time graph for a lift moving between floors in a building. The graph consists of straight line segments. In the first stage the lift travels downwards from the ground floor for 5 s, coming to rest at the basement after travelling 10 m. (area = 10)

(i) Find the greatest speed reached during this stage. [2]

The second stage consists of a 10 s wait at the basement. In the third stage, the lift travels upwards until it comes to rest at a floor 34.5 m above the basement, arriving 24.5 s after the start of the first stage. The lift accelerates at 2 m s^{-2} for the first 3 s of the third stage, reaching a speed of V m s^{-1}. Find

gradient = 2

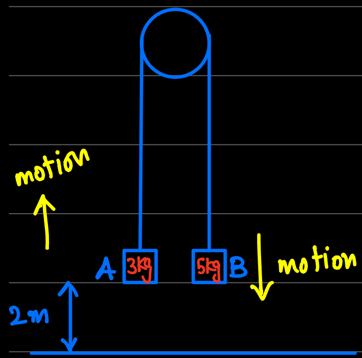
(ii) the value of V, [2]

(iii) the time during the third stage for which the lift is moving at constant speed, [3]

(iv) the deceleration of the lift in the final part of the third stage. [2]

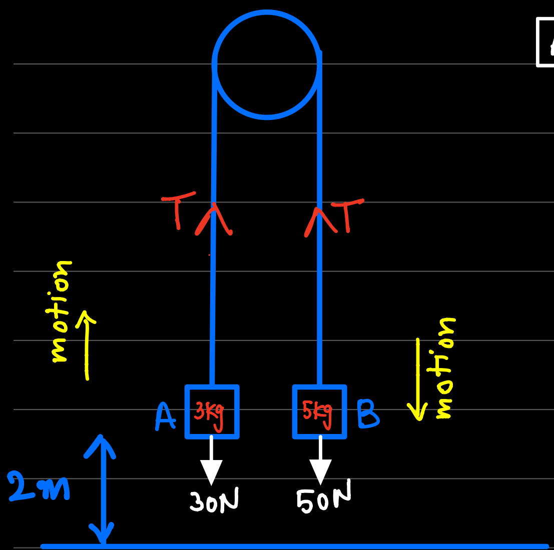
gradient .

PULLEYS



Mass of 3kg and 5kg are held at rest. The system is released and objects start to move.

(i) Find the acceleration of both particles and tension in string.



$\boxed{A}$ Fwd − Bwd = ma

$T - 30 = 3a$

$T = 30 + 3a$

$\boxed{B}$ Fwd − Bwd = ma

$50 - T = 5a$

$T = 50 - 5a$

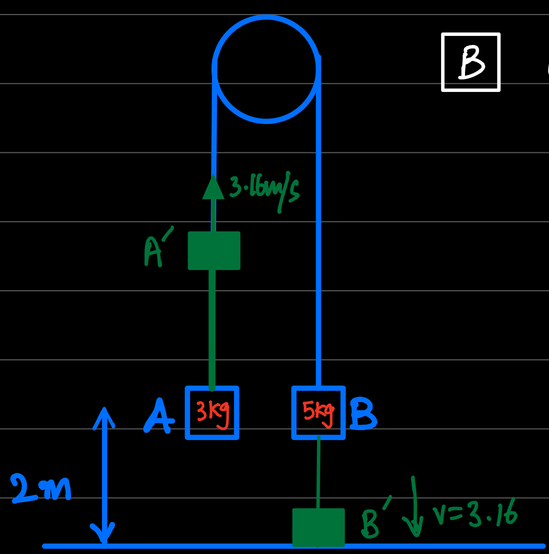
$30 + 3a = 50 - 5a$

$8a = 20$

$a = 2.5\ m/s^2$

$T = 30 + 3(2.5) = 37.5$ N.

(ii) Find speed with which B hits ground.



$\boxed{B}$ $u = 0$, $v = ?$, $s = 2$, $a = 2.5$

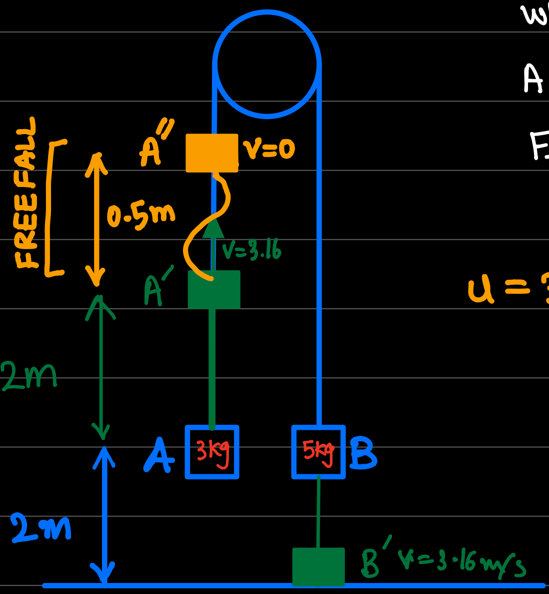
$2as = v^2 - u^2$

$2(2.5)(2) = v^2 - 0^2$

$10 = v^2$

$v = \sqrt{10} = 3.16$

(iii) Find greatest height above ground reached by A (5)



When B hits ground it comes to rest
A keeps moving up, under gravity
Freefall because string is not taut

A' —— A''

$u = 3.16,\ s = ?,\ a = -10,\ v = 0$

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

$$2(-10)s = 0^2 - 3.16^2$$

$$s = 0.5$$

VARIATIONS

Find:

(a) Max height above ground reached by A.

$2 + 2 + 0.5 = 4.5\text{ m}$

(b) Distance travelled by A to reach max height.

$2 + 0.5 = 2.5\text{ m}$

(c) Distance travelled by A from start of journey till it comes to rest again.

$2 + 0.5 + 0.5 = 3\text{ m}$