

Chapter 2 Exercise 2A

Q. 1. (i) $u = 0$, $v = 10$, $t = 5$, $a = ?$

$$\begin{aligned} v &= u + at \\ 10 &= 0 + 5a \\ a &= 2 \text{ m/s}^2 \end{aligned}$$

(ii) $u = 0$, $a = 2$, $t = 5$, $s = ?$

$$\begin{aligned} s &= ut + \frac{1}{2}at^2 \\ s &= (0)(5) + \frac{1}{2}(2)(25) \\ &= 25 \text{ m} \end{aligned}$$

Q. 2. (i) $u = 0$, $v = 24$, $a = 3$, $t = ?$

$$\begin{aligned} v &= u + at \\ 24 &= 0 + 3t \\ t &= 8 \text{ s} \end{aligned}$$

(ii) $u = 0$, $a = 3$, $t = 8$, $s = ?$

$$\begin{aligned} s &= ut + \frac{1}{2}at^2 \\ s &= (0)(8) + \frac{1}{2}(3)(64) = 96 \text{ m} \end{aligned}$$

Q. 3. $u = 0$, $a = 3$, $s = 6$, $v = ?$

$$\begin{aligned} v^2 &= u^2 + 2as \\ v^2 &= 0 + 2(3)(6) \\ v &= 6 \text{ m/s} \end{aligned}$$

Q. 4. $u = 50$, $v = 70$, $s = 300$, $a = ?$

$$\begin{aligned} v^2 &= u^2 + 2as \\ 4,900 &= 2,500 + 2(a)(300) \\ a &= 4 \text{ m/s}^2 \end{aligned}$$

$u = 50$, $v = 70$, $a = 4$, $t = ?$

$$\begin{aligned} v &= u + at \\ 70 &= 50 + 4t \\ t &= 5 \text{ s} \end{aligned}$$

Q. 5. $a = 0.5$, $s = 600$, $t = 40$, $u = ?$

$$\begin{aligned} s &= ut + \frac{1}{2}at^2 \\ 600 &= u(40) + \frac{1}{2}(0.5)(1,600) \\ 600 &= 40u + 400 \\ 200 &= 40u \\ u &= 5 \text{ m/s} \end{aligned}$$

Q. 6. $u = 3$, $v = 11$, $t = 6$, $s = ?$

$$\begin{aligned} s &= \left(\frac{u+v}{2}\right)t \\ s &= \left(\frac{3+11}{2}\right)(6) \\ &= 42 \text{ m} \end{aligned}$$

Q. 7. $u = 3$, $v = 0$, $s = 6$, $a = ?$

$$\begin{aligned} v^2 &= u^2 + 2as \\ 0 &= 9 + 2a(6) \\ a &= -\frac{3}{4} \text{ m/s}^2 \end{aligned}$$

$u = 3$, $v = 0$, $a = -\frac{3}{4}$, $t = ?$

$$\begin{aligned} v &= u + at \\ 0 &= 3 + \left(-\frac{3}{4}\right)t \\ t &= 4 \text{ s} \end{aligned}$$

Q. 8. (i) $u = 70$, $v = 50$, $t = 8$, $a = ?$

$$\begin{aligned} v &= u + at \\ 70 &= 50 + a(8) \\ a &= -2\frac{1}{2} \text{ m/s}^2 \end{aligned}$$

$u = 70$, $t = 8$, $a = -2\frac{1}{2}$, $s = ?$

$$\begin{aligned} s &= ut + \frac{1}{2}at^2 \\ s &= 70(8) + \frac{1}{2}\left(-2\frac{1}{2}\right)(64) \\ &= 560 - 80 = 480 \text{ s} \end{aligned}$$

(ii) $u = 50$, $v = 0$, $a = -2\frac{1}{2}$, $s = ?$

$$\begin{aligned} v^2 &= u^2 + 2as \\ 0 &= 2,500 - 2s \\ s &= 500 \text{ m} \end{aligned}$$

Q. 9. (i) $u = 24$, $v = 0$, $a = -8$, $s = ?$

$$\begin{aligned} v^2 &= u^2 + 2as \\ 0 &= 576 + 2(-8)s \\ s &= 36 \text{ m} \end{aligned}$$

(ii) $v^2 = u^2 + 2as$
 $0 = 2,304 + 2(-8)s$
 $s = 144 \text{ m}$

Q. 10. (i) $72 \text{ km/hr} = \frac{72,000 \text{ m}}{3,600 \text{ s}}$
 $= 20 \text{ m/s}$

(ii) $48 \text{ km/hr} = \frac{48,000 \text{ m}}{3,600 \text{ s}} = \frac{40}{3} \text{ m/s}$

$$\begin{aligned} v^2 &= u^2 + 2as \\ \frac{1,600}{9} &= 400 + 2a(500) \\ a &= -\frac{2}{9} \text{ m/s}^2 \end{aligned}$$

$$\begin{aligned} v &= u + at \\ \frac{40}{3} &= 20 + \left(-\frac{2}{9}\right)t \\ t &= 30 \text{ s} \end{aligned}$$

$$(iii) v^2 = u^2 + 2as$$

$$0 = \frac{1,600}{9} + 2\left(-\frac{2}{9}\right)s$$

$$s = 400 \text{ m}$$

Q. 11. (i) $1 \text{ km/hr} = \frac{1,000 \text{ m}}{3,600 \text{ s}} = \frac{5}{18} \text{ m/s}$

$$\therefore 72 \text{ km/hr} = 20 \text{ m/s and}$$

$$54 \text{ km/hr} = 15 \text{ m/s}$$

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

$$225 = 400 + 2(a)(35)$$

$$a = -2\frac{1}{2} \text{ m/s}^2$$

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

$$0 = 225 + 2\left(-2\frac{1}{2}\right)s$$

$$s = 45 \text{ m}$$

Q. 12. Let t be the time of meeting.

$$s_1 = 5t + \frac{1}{2}(3)t^2 = 5t + \frac{3}{2}t^2$$

$$s_2 = 7t + \frac{1}{2}(2)t^2 = 7t + t^2$$

$$s_1 + s_2 = 162$$

$$12t + \frac{5}{2}t^2 = 162$$

$$t = 6 \left(t = -\frac{54}{5} \text{ rejected} \right)$$

At $t = 6$,

$$v_1 = u + at = 5 + (3)(6)$$

$$= 23 \text{ m/s}$$

$$v_2 = 7 + (2)(6)$$

$$= 19 \text{ m/s}$$

Q. 13. (i) They will meet when $s_1 + s_2 = 400$.

$$\therefore 3t + \frac{1}{2}(4)t^2 + 7t + \frac{1}{2}(2)t^2 = 400$$

$$\therefore 10t + 3t^2 = 400$$

$$\therefore 3t^2 + 10t - 400 = 0$$

$$\therefore (3t + 40)(t - 10) = 0$$

$$\therefore t = -\frac{40}{3} \text{ OR } t = 10$$

$$\therefore t = 10 \text{ s}$$

$$(t = -\frac{40}{3} \text{ is rejected as impossible})$$

(ii) $s_1 = 3(10) + \frac{1}{2}(4)(10)^2 = 230 \text{ m}$

$$s_2 = 7(10) + \frac{1}{2}(2)(10)^2 = 170 \text{ m}$$

Q. 14. (i) $30 \text{ km/hr} = \frac{30,000 \text{ m}}{3,600 \text{ s}} = \frac{25}{3} \text{ m/s}$

$$v = u + at$$

$$\frac{25}{3} = 0 + 2t$$

$$t = 4\frac{1}{6} \text{ s}$$

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

$$\left(\frac{50}{3}\right)^2 = 0^2 + 2(2)s$$

$$s = \frac{625}{9} \text{ m}$$

(iii) $v^2 = u^2 + 2as$

$$0^2 = \left(\frac{50}{3}\right)^2 + 2(a)(2)$$

$$a = -\frac{625}{9} \text{ m/s}^2$$

Exercise 2B

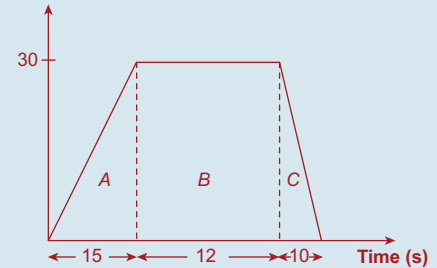
Q. 1. (i) $u = 0, a = 2, v = 30$

$$v = u + at$$

$$30 = 0 + 2t$$

$$t = 15 \text{ s}$$

(ii) **Speed (m/s)**



Total distance covered = Area under graph

$$= A + B + C$$

$$= \frac{1}{2}(15)(30) + (12)(30) + \frac{1}{2}(10)(30)$$

$$= 225 + 360 + 150$$

$$= 735 \text{ m}$$

(iii) $u = 30, v = 0, t = 10$

$$v = u + at$$

$$0 = 30 + 10a$$

$$10a = -30$$

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

Magnitude of deceleration is 3 m/s^2

Q. 2. (i) $v = u + at$

$$20 = 0 + a(5)$$

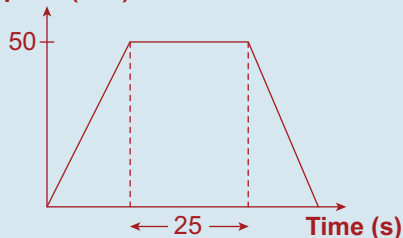
$$a = 4 \text{ m/s}^2$$

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

$$s = 0(5) + \frac{1}{2}(4)(25) = 50 \text{ m}$$

- (iii) Remaining distance = 200 m.
200 m at 20 m/s takes 10 seconds.
The total time taken = 5 + 10 = 15 s

Q. 3. (i) **Speed (m/s)**



During acceleration

$$u = 0, v = 50, a = 5$$

$$v = u + at$$

$$50 = 0 + 5t$$

$$t = 10 \text{ s}$$

During deceleration

$$u = 50, v = 0, a = -10$$

$$v = u + at$$

$$0 = 50 - 10t$$

$$10t = 50$$

$$t = 5 \text{ s}$$

Total distance travelled = Area under graph

$$= \frac{1}{2}(10)(50) + (25)(50) + \frac{1}{2}(5)(50)$$

$$= 250 + 1,250 + 125$$

$$= 1,625 \text{ m}$$

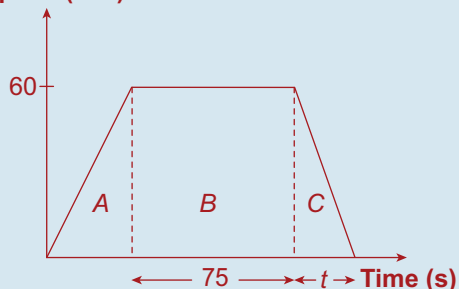
(ii) Average speed = $\frac{\text{Total distance}}{\text{Total time}}$

$$= \frac{1,625}{10 + 25 + 5}$$

$$= \frac{1,625}{40}$$

$$= 40.625 \text{ m/s}$$

Q. 4. **Speed (m/s)**



(i) **During deceleration**

$$\text{Area under graph} = 150$$

$$\text{Area C} = 150$$

$$\frac{1}{2}(t)(60) = 150$$

$$30t = 150$$

$$t = 5 \text{ s}$$

(ii) **During acceleration**

$$u = 0, v = 60, a = 3$$

$$v = u + at$$

$$60 = 0 + 3t$$

$$t = 20 \text{ s}$$

Total distance covered = Area under graph

$$= \frac{1}{2}(20)(60) + (75)(60) + 150$$

$$= 600 + 4,500 + 150$$

$$= 5,250 \text{ m}$$

(iii) Average speed = $\frac{5,250}{100}$

$$= 52.5 \text{ m/s}$$

Q. 5. (i) $v^2 = u^2 + 2as$

$$(40)^2 = 0^2 + 2(2)s$$

$$s = 400 \text{ m}$$

$$v = u + at$$

$$40 = 0 + 2t$$

$$t = 20 \text{ s}$$

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

$$0 = (40)^2 + 2(-5)s$$

$$s = 160 \text{ m}$$

$$v = u + at$$

$$0 = 40 + (-5)t$$

$$t = 8 \text{ s}$$

(iii) Remainder = 1,000 - 400 - 160

$$= 440 \text{ m}$$

440 m at 40 m/s takes 11 seconds.

$$\therefore \text{Total time} = 20 + 11 + 8 = 39 \text{ s}$$

Q. 6. (i) $v = u + at$

$$27 = 0 + a(9)$$

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

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

$0 = (27)^2 + 2(a)(54)$

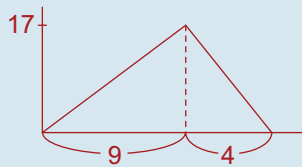
$a = -6\frac{3}{4} \text{ m/s}^2$

(iii) 2nd part:

$v = u + at$

$0 = 27 + \left(-6\frac{3}{4}\right)t$

$t = 4 \text{ s}$



Distance = Area under the curve

$= \frac{1}{2}(17)(27)$

$= 175\frac{1}{2} \text{ m}$

Average speed = $\frac{\text{Total distance}}{\text{Total time}}$

$= \frac{175\frac{1}{2}}{13}$

$= 13\frac{1}{2} \text{ m/s}$

(iv) First part:

$v = u + at$

$15 = 0 + 3t$

$t = 5 \text{ s}$

2nd part:

$v = u + at$

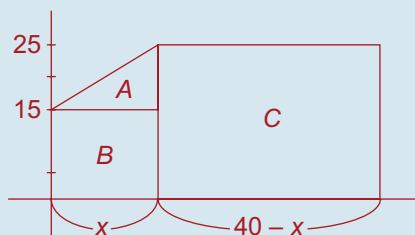
$15 = 27 + \left(-6\frac{3}{4}\right)t$

$t = 1\frac{7}{9} \text{ s}$

Answer: After 5 seconds and

after $\left(9 + 1\frac{7}{9}\right) = 10\frac{7}{9} \text{ s}$

Q. 7.



Area under the curve = 980

$\frac{1}{2}(x)(10) + (15)(x) + (40 - x)(25) = 980$

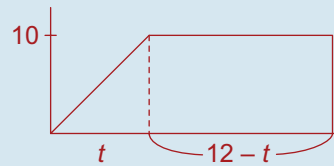
$x = 4 \text{ s}$

$v = u + at$

$25 = 15 + (a)(4)$

$a = 2\frac{1}{2} \text{ m/s}^2$

Q. 8.



Let $t =$ time spent accelerating

$\frac{1}{2}(t)(10) + (12 - t)(10) = 100$

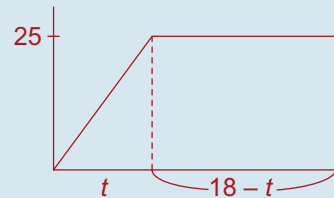
$5t + 120 - 10t = 100$

$20 = 5t$

$t = 4$

$\therefore a = \frac{10}{4} = 2.5 \text{ m/s}^2$

Q. 9.



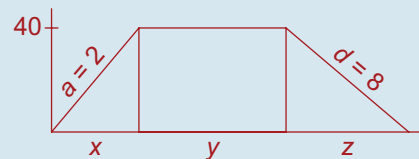
$\frac{1}{2}(t)(25) + (18 - t)(25) = 350$

$12.5t + 450 - 25t = 350$

$\therefore 100 = 12.5t$

$\therefore t = 8 \text{ s}$

Q. 10.



$x = \frac{40}{2} = 20$

$z = \frac{40}{8} = 5$

Area = 700

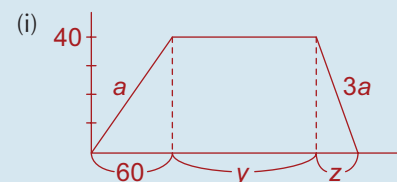
$\therefore \frac{1}{2}(20)(40) + 40y + \frac{1}{2}(5)(40) = 700$

$\therefore 400 + 40y + 100 = 700$

$\therefore y = 5$

$\therefore \text{Time} = 20 + 5 + 5 = 30 \text{ s}$

Q. 11.



$$a = \frac{40}{60} = \frac{2}{3} \text{ m/s}^2$$

$$\text{Since } 60a = 40 = 3az$$

$$\therefore z = \frac{60a}{3a} = \frac{60}{3} = 20 \text{ s}$$

$$\text{Area} = 8,800$$

$$\therefore \frac{1}{2}(60)(40) + 40y + \frac{1}{2}(20)(40) = 8,800$$

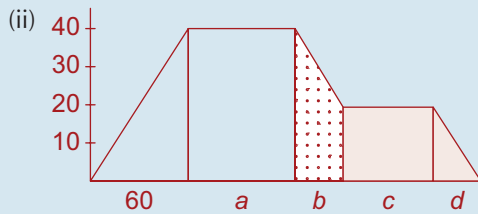
$$\therefore 1,200 + 40y + 400 = 8,800$$

$$\therefore 40y = 7,200$$

$$\therefore y = 180$$

\therefore Distances are 1,200, 7,200, 400 metres

$$\text{Total time} = 60 + 180 + 20 = 260 \text{ s}$$



$$\text{Shaded region} = 1 \text{ km} = 1,000 \text{ m}$$

$$\begin{aligned} \text{The deceleration} &= 3a = 3\left(\frac{2}{3}\right) \\ &= 2 \text{ m/s}^2 \quad (\text{from (i)}) \end{aligned}$$

$$\therefore d = \frac{20}{2} = 10 \text{ s}$$

$$\text{Shaded region} = 1,000$$

$$\therefore 20c + \frac{1}{2}(d)(20) = 1,000$$

$$\therefore 20c + \frac{1}{2}(10)(20) = 1,000$$

$$\therefore 20c + 100 = 1,000$$

$$\therefore 20c = 900$$

$$\therefore c = 45$$

$$\begin{aligned} \text{Dotted region: } u &= 40, v = 20, \\ a &= -2, t = b \end{aligned}$$

$$v = u + at$$

$$\therefore 20 = 40 - 2b$$

$$\therefore b = 10$$

$$\text{Area} = 10(20) + \frac{1}{2}(10)(20) = 300 \text{ m}$$

$$\text{Total area} = 8,800$$

$$\begin{aligned} \therefore \frac{1}{2}(60)(40) + 40a + 300 + 900 + 100 \\ = 8,800 \end{aligned}$$

$$\therefore 40a = 6,300$$

$$\therefore a = 157.5$$

$$\begin{aligned} \text{Total time} &= 60 + 157.5 + 10 + 45 + 10 \\ &= 282.5 \end{aligned}$$

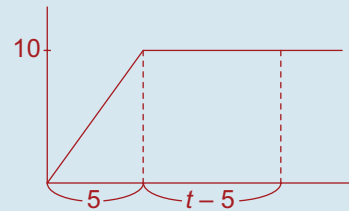
$$\text{Extra time} = 282.5 - 260$$

$$= 22.5 \text{ seconds more than the first time}$$

QED

Exercise 2C

Q. 1.



$$v = u + at$$

$$10 = 0 + 2t$$

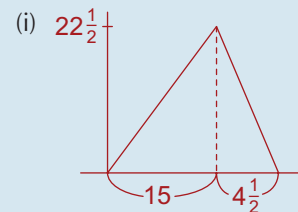
$$t = 5 \text{ s}$$

$$\text{Area under the curve} = 100$$

$$\frac{1}{2}(5)(10) + (t - 5)(10) = 100$$

$$t = 12.5 \text{ s}$$

Q. 2.



$$v = u + at$$

$$v = 0 + \left(1\frac{1}{2}\right)(15) = 22\frac{1}{2} \text{ m/s}$$

$$v = u + at$$

$$0 = 22\frac{1}{2} + (-5)t$$

$$t = 4\frac{1}{2} \text{ s}$$

(ii) Distance = Area under the curve

$$= \frac{1}{2}\left(19\frac{1}{2}\right)\left(22\frac{1}{2}\right) = 219\frac{3}{8} \text{ m}$$

Q. 3.

(i) $v = u + at$

$$24 = 0 + 2t$$

$$t = 12 \text{ s}$$

$$s = \left(\frac{u+v}{2}\right)t$$

$$48 = \left(\frac{24+0}{2}\right)t$$

$$t = 4 \text{ s}$$

$$\begin{aligned} \text{(ii) First part: } a &= ut + \frac{1}{2}at^2 \\ &= 0(12) + \frac{1}{2}(2)(12)^2 \\ &= 144 \text{ m} \\ \therefore \text{ Total distance} &= 144 + 48 = 192 \text{ m} \\ \text{Total time} &= 12 + 4 = 16 \text{ s} \\ \therefore \text{ Average speed} &= \frac{192}{16} = 12 \text{ m/s} \end{aligned}$$

Q. 4. $s_1 = ut + \frac{1}{2}at^2 = 0(t) + \frac{1}{2}(4)t^2 = 2t^2$

$$s_2 = 20t$$

$$s_1 = s_2$$

$$2t^2 = 20t$$

$$t = 10 \text{ s}$$

$$s = 200 \text{ m}$$

Q. 5. (i) $v_1 = 10 + 3t$; $v_2 = 20 + 2t$

(ii) $s_1 = 10t + \frac{3}{2}t^2$; $s_2 = 20t + t^2$

(iii) $v_1 = v_2$

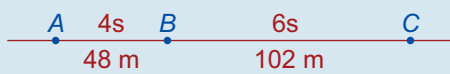
$$10 + 3t = 20 + 2t$$

$$t = 10 \text{ s}$$

(iv) $s_1 = s_2$

$$10t + \frac{3}{2}t^2 = 20t + t^2$$

$$t = 0 \quad \text{OR} \quad t = 20 \text{ s}$$

Q. 6. 

A to B: $u = u$, $t = 4$, $s = 48$, $a = a$

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

$$48 = 4u + 8a$$

$$u + 2a = 12$$

A to C: $u = u$, $t = 10$, $s = 150$, $a = a$

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

$$150 = 10u + 50a$$

$$u + 5a = 15$$

Solving gives $a = 1$, $u = 10$

Answer: 1 m/s^2

Q. 7. (i) $s = ut + \frac{1}{2}at^2$

$$18 = u(2) + \frac{1}{2}(a)(4)$$

$$u + a = 9 \quad \text{(1st part)}$$

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

$$48 = u(4) + \frac{1}{2}(a)(16)$$

$$u + 2a = 12 \quad \text{(1st and 2nd parts)}$$

Solving these gives (i) $a = 3 \text{ m/s}^2$

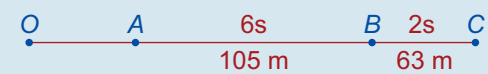
(ii) $u = 6 \text{ m/s}$

(iii) First 6 seconds:

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

$$s = (6)(6) + \frac{1}{2}(3)(36) = 90 \text{ m}$$

The distance travelled = $90 - 48 = 42 \text{ m}$

Q. 8. 

(i) A to B: $u = u$, $s = 105$, $t = 6$, $a = a$

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

$$105 = 6u + 18a$$

A to C: $u = u$, $s = 168$, $t = 8$, $a = a$

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

$$168 = 8a + 32a$$

Solving gives $a = 3.5$, $u = 7$

Answer: $a = 3.5 \text{ m/s}$

(ii) O to A: $u = 0$, $v = 7$, $a = 3.5$, $s = s$

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

$$49 = 0 + 7s$$

$$s = 7 \text{ m}$$

Q. 9. 1st part: $s = ut + \frac{1}{2}at^2$

$$39 = u(1) + \frac{1}{2}a(1)^2$$

$$2u + a = 78$$

1st and 2nd parts: $76 = u(2) + \frac{1}{2}a(2)^2$

$$2u + 2a = 76$$

First three parts: $111 = u(3) + \frac{1}{2}a(3)^2$

$$6u + 9a = 222$$

$$u + 3a = 74$$

Solving the first two equations gives $a = -2$, $u = 40$

Solving the last two equations gives $a = -2$, $u = 40$

\therefore They are consistent.

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

$$0 = (40)^2 + 2(-2)s$$

$$s = 400 \text{ m}$$

∴ It will travel a further $400 - 111 = 289 \text{ m}$

Q. 10. a to b: $s = ut + \frac{1}{2}at^2$

$$20 = u(5) + \frac{1}{2}a(5)^2$$

$$2u + 5a = 8$$

a to c: $40 = u(8) + \frac{1}{2}a(8)^2$

$$2u + 8a = 10$$

Solving these gives $u = \frac{7}{3} \text{ m/s}$, $a = \frac{2}{3} \text{ m/s}^2$

a to d: $a = ut + \frac{1}{2}at^2$

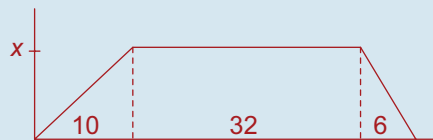
$$60 = \frac{7}{3}t + \frac{1}{2}\left(\frac{2}{3}\right)t^2$$

$$t^2 + 7t - 180 = 0 \quad (\text{use formula})$$

$$t = 10.4 \text{ s} \quad (-17.4 \text{ is rejected}).$$

$$\text{The time taken} = 10.4 - 8 = 2.4 \text{ s}$$

Q. 11.



$$\text{Area} = \frac{1}{2}(10)x + 32x + \frac{1}{2}(6)x = 1,000$$

$$x = 25 \text{ m/s}$$

$$\text{Distances are: } \frac{1}{2}(10)(25) = 125;$$

$$32(25) = 800;$$

$$\frac{1}{2}(6)(25) = 75 \text{ m}$$

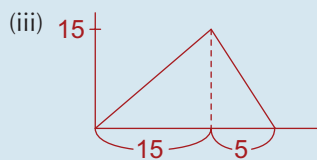
Q. 12. (i) $t_1 : t_2 = 3 : 1 = \frac{3}{4} : \frac{1}{4}$

$$\therefore t_1 = \frac{3}{4}(20) = 15 \text{ s}$$

$$\therefore t_2 = \frac{1}{4}(20) = 5 \text{ s}$$

(ii) $v = u + at$

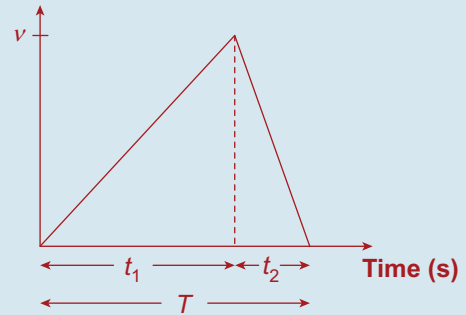
$$v = 0 + (1)(15) = 15 \text{ m/s}$$



$$s = \text{Area under curve}$$

$$= \frac{1}{2}(20)(15) = 150 \text{ m}$$

Q. 13. Speed (m/s)



Let the top speed = v

$$t_1 = \frac{v}{2}$$

$$t_2 = \frac{v}{7}$$

The time taken = 90 seconds = T

$$T = \frac{v}{2} + \frac{v}{7} = \frac{7v + 2v}{14}$$

$$= \frac{9v}{14}$$

$$\frac{9v}{14} = 90$$

$$9v = 1,260$$

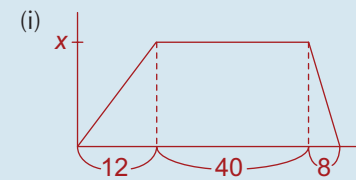
$$v = 140 \text{ m/s}$$

$$\text{Distance} = \frac{1}{2}(90)(140)$$

$$= 6,300 \text{ m}$$

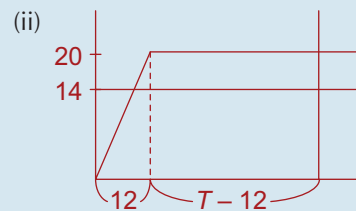
$$= 6.3 \text{ km}$$

Q. 14.



$$\text{Area} = \frac{1}{2}(12)x + 40x + \frac{1}{2}(8)x = 1,000$$

$$x = 20 \text{ m/s}$$



$$\text{Area}_1 = \text{Area}_2$$

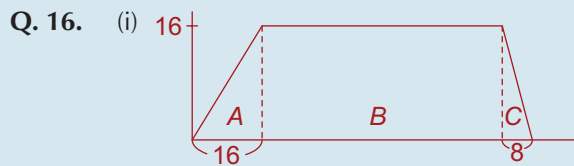
$$14T = \frac{1}{2}(12)(20) + 20(T - 12)$$

$$T = 20 \text{ s}$$

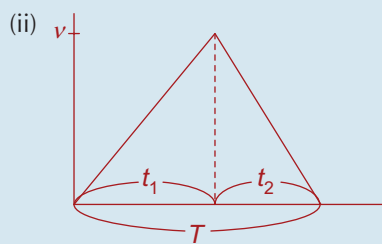
$$s = 14T$$

$$= 280 \text{ m}$$

Q. 15. 1st part: $s = ut + \frac{1}{2}at^2$
 $24 = u(2) + \frac{1}{2}a(2)^2$
 $u + a = 12$
 1st and 2nd parts: $48 = u(3) + \frac{1}{2}a(3)^2$
 $2u + 3a = 32$
 Solving these gives $a = 8, u = 4$
 First three parts: $72 = 4t + \frac{1}{2}(8)t^2$
 $t^2 + t - 18 = 0$
 $t = 3.772$ ($t = -4.772$ is rejected)
 Time taken = $3.772 - 3$
 $= 0.772$ s



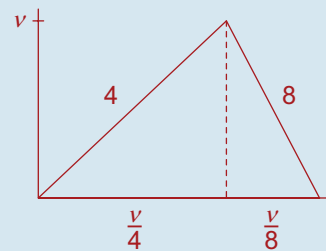
Distance in A = $\frac{1}{2}(16)(16) = 128$ m
 Distance in C = $\frac{1}{2}(8)(16) = 64$ m
 Total distance travelled = 192 m
 Remainder for B = $300 - 192$
 $= 108$ m
 Time taken = $\frac{108}{16} = 6.75$ s
 Total time = $16 + 6.75 + 8$
 $= 30.75$ s



Let $T =$ the time taken
 $t_1 : t_2 = d : a = 2 : 1 = \frac{2}{3} : \frac{1}{3}$
 $\therefore t_1 = \frac{2}{3}T$ and $t_2 = \frac{1}{3}T$
 $v = u + at$
 $v = 0 + (1)\left(\frac{2}{3}T\right) = \frac{2}{3}T$
 Area = 300
 $\frac{1}{2}(T)\left(\frac{2}{3}T\right) = 300$
 $T = 30$ s

Q. 17. (i) $s_1 = 0 + \frac{1}{2}\left(\frac{1}{2}\right)t^2 = \frac{1}{4}t^2$
 $s_2 = 0 + \frac{1}{2}(1)t^2 = \frac{1}{2}t^2$
 Distance apart, $s = s_1 + s_2$
 $= \frac{3}{4}t^2$
 When $t = 10, s = \frac{3}{4}(100) = 75$ m
 (ii) When $s = 108$
 $\frac{3}{4}t^2 = 108$
 $t^2 = 144$
 $t = 12$ s
 This is $12 - 10 = 2$ seconds later

Q. 18. Let $v =$ top speed



$\frac{1}{2}\left(\frac{v}{4} + \frac{v}{8}\right)v = 1,200$
 $\frac{1}{2}\left(\frac{3v}{8}\right)v = 1,200$
 $\frac{3v^2}{16} = 1,200$
 $v^2 = 6,400$
 $v = 80$ m/s
 \therefore Time = $\frac{v}{4} + \frac{v}{8} = \frac{80}{4} + \frac{80}{8} = 30$ s

Q. 19. Let $t =$ time after cyclist passes P

Greatest gap $v_1 = v_2$
 $12 = 0 + 1(t - 5)$
 $t = 17$
 at $t = 17, s_1 = 12(17) = 204$ m
 $s_2 = \frac{1}{2}(1)(17 - 5)^2 = 72$ m
 Gap = $204 - 72 = 132$ m

Q. 20. Greatest gap $\Rightarrow v_1 = v_2$
 $8 + 4t = 30 + 3(t - 2)$
 $8 + 4t = 30 + 3t - 6$
 $t = 16$

at $t = 16, s_1 = 8(16) + \frac{1}{2}(4)(16)^2 = 640$
 at $t = 16 - 2 = 14,$
 $s_2 = 30(14) + \frac{1}{2}(3)(14)^2 = 714$
 Gap = $714 - 640 = 74$ m **QED**



After t seconds, Alberto has travelled

$$s_1 = 12t + \frac{1}{2}t^2$$

After t seconds, Gustav has travelled $s_2 = t^2$

At both P_1 and P_2 ,

$$s_1 = s_2 + 22$$

$$12t + \frac{1}{2}t^2 = t^2 + 22$$

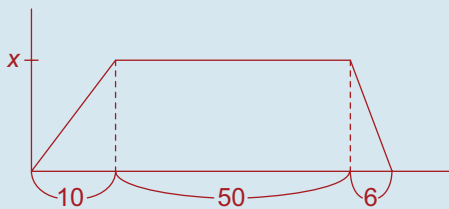
$$t^2 - 24t + 44 = 0$$

$$t = 2, 22$$

Answer: (i) After 2 seconds

(ii) After 20 seconds more

Q. 22.



Area under the curve = 696

$$\frac{1}{2}(10)x + 50x + \frac{1}{2}(6)x = 696$$

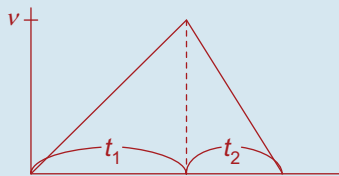
$$x = 12$$

$$v = u + at$$

$$12 = 0 + a_1(10)$$

$$a_1 = 1.2 \text{ m/s}^2$$

Similarly, $a_2 = 2 \text{ m/s}^2$



$$t_1 : t_2 = 2 : 1.2 = 5 : 3 = \frac{5}{8} : \frac{3}{8}$$

$$\therefore t_1 = \frac{5}{8}T, \quad t_2 = \frac{3}{8}T$$

$$v = u + at$$

$$v = 0 + (1.2)\left(\frac{5}{8}T\right) = \frac{3}{4}T$$

Area = 696

$$\frac{1}{2}(T)\left(\frac{3}{4}T\right) = 696$$

$$T^2 = 1,856$$

$$T = 8\sqrt{29}$$

Q. 23. Take speeds, accelerations, distances relative to the goods train.

Let p = the passenger train and g = the goods train.

The initial relative speed,

$$\begin{aligned} u_{pg} &= u_p - u_g \\ &= 80 - 30 \\ &= 50 \text{ m/s} \end{aligned}$$

The relative distance = 1,500 m

The final relative speed is zero, since the two trains must eventually be travelling at the same speed to avoid a crash.

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

$$0 = (50)^2 + 2a(1,500)$$

$$a = -\frac{5}{6} \text{ m/s}^2$$

The relative deceleration is, therefore,

$$\frac{5}{6} \text{ m/s}^2$$

The actual deceleration of the passenger train is $\frac{5}{6} \text{ m/s}^2$, since the goods train does not decelerate at all.

Q. 24. (i) Initial relative speed,
 $u = 20 - 8 = 12 \text{ m/s}$

Relative distance = 120 m

Final relative speed = 0 m/s

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

$$0 = (12)^2 + 2a(120)$$

$$a = -\frac{3}{5} \text{ m/s}^2$$

(ii) (i) $u = 12$

$$a = -1$$

$$s = 120 - 66 = 54$$

$$t = ?$$

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

$$54 = 12t + \frac{1}{2}(-1)t^2$$

$$t^2 - 24t + 108 = 0$$

$$(t - 6)(t - 18) = 0$$

$$t = 6, 18$$

Answer: After 6 seconds

(ii) $u = 12$
 $a = -1$
 $s = s$
 $t = t$
 $s = ut + \frac{1}{2}at^2$
 $s = 12t - \frac{1}{2}t^2$
 $\frac{ds}{dt} = 12 - t$
 $= 0$ (Since s is a minimum)
 $t = 12$
 At $t = 12, s = 12(12) - \frac{1}{2}(12)^2 = 72$ m
 This means that they have travelled a distance of 72 m towards each other, and so the distance between them will be $120 - 72 = 48$ m.

Exercise 2D

Q. 1. (i) $s = 35t - 4.9t^2 = 0$
 $\therefore t(35 - 4.9t) = 0$
 $\therefore t = 0$ OR $t = \frac{350}{49} = \frac{50}{7}$ s

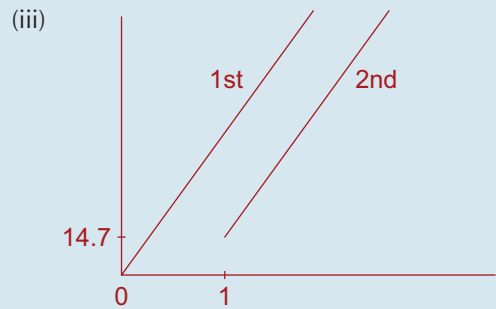
(ii) $v = 0$
 $35 - 9.8t = 0$
 $\therefore t = \frac{350}{98} = \frac{50}{14} = \frac{25}{7}$
 $s = 35\left(\frac{25}{7}\right) - 4.9\left(\frac{25}{7}\right)^2$
 $= 125 - 62.5 = 62.5$ m

Q. 2. (i) $u(1) - 4.9(1)^2 = 16.1$
 $\therefore u - 4.9 = 16.1$
 $\therefore u = 21$ m/s

(ii) $v = 0$
 $21 - 9.8t = 0$
 $t = \frac{21}{9.8} = \frac{210}{98} = \frac{15}{7}$
 at $t = \frac{15}{7}$,
 $s_y = 21\left(\frac{15}{7}\right) - 4.9\left(\frac{15}{7}\right)^2$
 $= 45 - 22.5 = 22.5$ m

(iii) $s_y = 0$
 $21t - 4.9t^2 = 0$
 $\therefore t = 0$ OR $t = \frac{21}{4.9}$
 $= \frac{210}{49} = \frac{30}{7}$ s

Q. 3. (i) $s_1 = s_2$
 $\therefore 0(t) + 4.9t^2$
 $= 14.7(t - 1) + 4.9(t - 1)^2$
 $\therefore t^2 = 3(t - 1) + (t - 1)^2$
 $\therefore t^2 = 3t - 3 + t^2 - 2t + 1$
 $\therefore t = 2$
 (ii) $4.9(2)^2 = 19.6$ m



Q. 4. (i) Let $t =$ time Q is in motion.
 $\therefore t + 2 =$ time P is in motion.
 $s_P = s_Q$
 $47(t + 2) - 4.9(t + 2)^2 = 64.6t - 4.9t^2$
 $47t + 94 - 4.9t^2 - 19.6t - 19.6$
 $= 64.6t - 4.9t^2$
 $74.4 = 37.2t$
 $\therefore t = 2$ s
 (ii) $64.6(2) - 4.9(2)^2 = 109.6$ m

Q. 5. First t seconds
 $u = u, s = 70, a = -9.8, t = t$
 $\therefore 70 = ut - 4.9t^2$... **Equation 1**
 First $2t$ seconds
 $u = u, s = 70 + 50 = 120,$
 $a = -9.8, t = 2t$
 $120 = 2ut - 4.9(2t)^2$
 $\therefore 120 = 2ut - 19.6t^2$... **Equation 2**
Eq 2: $120 = 2ut - 19.6t^2$
 $-2 \times$ **Eq. 1:** $-140 = -2ut + 9.8t^2$
 $-20 = -9.8t^2$
 $200 = 98t^2$
 $\therefore t^2 = \frac{100}{49}$
 $\therefore t = \frac{10}{7}$ s

$$70 = u\left(\frac{10}{7}\right) - 4.9\frac{100}{49}$$

$$\therefore 70 = \frac{10u}{7} - 10$$

$$\therefore u = 56 \text{ m/s}$$

Q. 6. (i) $u = u$, $a = -9.8$, $s = -30$, $t = 5$

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

$$\therefore -30 = 5u + \frac{1}{2}(-9.8)(25)$$

$$\therefore 92.5 = 5u$$

$$\therefore u = 18.5 \text{ m/s}$$

(ii) $v = u + at$

$$= 18.5 + (-9.8)(5)$$

$$= -30.5$$

$$\therefore \text{Speed} = 30.5 \text{ m/s}$$

Q. 7. $49t - 4.9t^2 = 78.4$

$$\therefore 10t - t^2 = 16$$

$$\therefore t^2 - 10t + 16 = 0$$

$$\therefore (t - 2)(t - 8) = 0$$

$$\therefore t = 2, 8$$

$$\therefore t_1 = 2, t_2 = 8$$

$$\therefore t_1 + t_2 = 10 \quad \text{QED}$$

OR

$$t_1 + t_2 = -\frac{b}{a}$$

$$\therefore t_1 + t_2 = -\frac{(-10)}{1}$$

$$\therefore t_1 + t_2 = 10$$

Q. 8. $70t - 4.9t^2 = 210$

$$\therefore 700t - 49t^2 = 2,100$$

$$\therefore 7t^2 - 100t + 300 = 0$$

Product of roots = $\frac{c}{a}$

$$\therefore t_1 t_2 = \frac{300}{7}$$

$$\therefore 7 t_1 t_2 = 300 \quad \text{QED}$$

Exercise 2E

Q. 1. $s = d$, $t = n$, $u = 0$, $a = a$

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

$$d = \frac{1}{2}an^2 \dots \text{Equation A}$$

$$a = d + k, \quad t = 2n, \quad u = 0, \quad a = a$$

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

$$d + k = \frac{1}{2}a(2n)^2$$

$$d + k = 2an^2 \dots \text{Equation B}$$

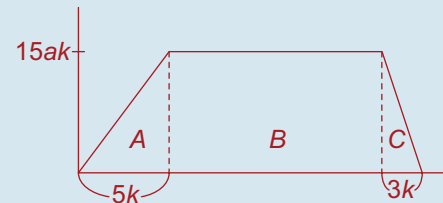
$$4 \times \text{Equation A} \Rightarrow 2an^2 = 4d$$

$$\text{But } 2an^2 = d + k$$

$$\therefore d + k = 4d$$

$$k = 3d \quad \text{QED}$$

Q. 2. (i)



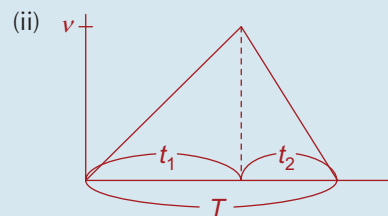
$$\text{Distance in A} = \frac{1}{2}(5k)(15ak) = 37\frac{1}{2}ak^2$$

$$\text{Distance in C} = \frac{1}{2}(3k)(15ak) = 22\frac{1}{2}ak^2$$

$$\begin{aligned} \text{Remainder} &= 90ak^2 - 37\frac{1}{2}ak^2 - 22\frac{1}{2}ak^2 \\ &= 30ak^2 \end{aligned}$$

$$\text{Time for B} = \frac{30ak^2}{15ak} = 2k \text{ s}$$

$$\begin{aligned} \text{Total time} &= 5k + 2k + 3k \\ &= 10k \text{ s} \end{aligned}$$



Let T = the total time

$$t_1 : t_2 = d : a = 5a : 3a = \frac{5}{8} : \frac{3}{8}$$

$$\therefore t_1 = \frac{5}{8}T \text{ and } t_2 = \frac{3}{8}T$$

$$v = u + at$$

$$v = 0 + (3a)\left(\frac{5}{8}T\right) = \frac{15}{8}aT$$

$$\text{Area} = 90ak^2$$

$$\frac{1}{2}(T)\left(\frac{15}{8}aT\right) = 90ak^2$$

$$T^2 = 96k^2$$

$$T = 4\sqrt{6}k$$

Q. 3. $h = ut + \frac{1}{2}(-g)t^2$
 $2h = 2ut - gt^2$
 $gt^2 - 2ut + 2h = 0$
 Product of roots = $\frac{c}{a}$
 $\therefore t_1 t_2 = \frac{2h}{g}$ **QED**

Q. 4. Let $|PQ| = |QR| = x$

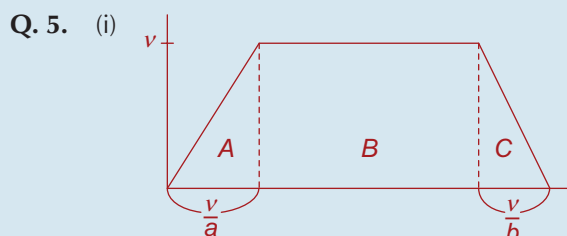


(i) The journey $P \rightarrow R$: $u = u, v = 7u,$
 $s = 2x, a = a$
 $\therefore v^2 = u^2 + 2as$
 $\therefore 49u^2 = u^2 + 2(a)(2x)$
 $\therefore 48u^2 = 4ax$
 $\therefore 12u^2 = ax$
 $\therefore a = \frac{12u^2}{x}$

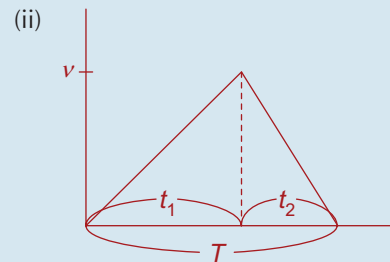
The journey $P \rightarrow Q$: $u = u, v = v,$
 $s = x, a = \frac{12u^2}{x}$
 $v^2 = u^2 + 2as$
 $\therefore v^2 = u^2 + 2\left(\frac{12u^2}{x}\right)(x)$
 $\therefore v^2 = u^2 + 24u^2$
 $\therefore v^2 = 25u^2$
 $\therefore v = 5u$

(ii) P to Q : $u = u, v = 5u, s = x,$
 $t = t_1, a = a$
 $v = u + at$
 $\therefore 5u = u + at_1$
 $\therefore t_1 = \frac{4u}{a}$

Q to R : $u = 5u, v = 7u, t = t_2,$
 $a = a$
 $v = u + at$
 $\therefore 7u = 5u + at_2$
 $\therefore t_2 = \frac{2u}{a}$
 $\therefore t_1 = 2t_2$ **QED**



Distance $A = \frac{1}{2}\left(\frac{v}{a}\right)v = \frac{v^2}{2a}$
 Distance $C = \frac{1}{2}\left(\frac{v}{b}\right)v = \frac{v^2}{2b}$
 Remainder = $s - \frac{v^2}{2a} - \frac{v^2}{2b}$
 Time taken in $B = \left(s - \frac{v^2}{2a} - \frac{v^2}{2b}\right) \div v$
 $= \frac{s}{v} - \frac{v}{2a} - \frac{v}{2b}$
 Total time taken = $\frac{v}{a} + \left(\frac{s}{v} - \frac{v}{2a} - \frac{v}{2b}\right) + \frac{v}{b}$
 $= \frac{v}{2a} + \frac{v}{2b} + \frac{s}{v}$ **QED**



Let $T =$ the total time
 $t_1 : t_2 = b : a = \frac{b}{a+b} : \frac{a}{a+b}$
 $\therefore t_1 = \frac{bT}{a+b}, t_2 = \frac{aT}{a+b}$
 $v = u + at$
 $v = 0 + (a)\left(\frac{bT}{a+b}\right) = \frac{abT}{a+b}$
 Area = s
 $\frac{1}{2}(T)\left(\frac{abT}{a+b}\right) = s$
 $T = \sqrt{2s\left(\frac{a+b}{ab}\right)}$ **QED**

Q. 6. (a) $t = n - 1, u = u, a = a, s = s_1$
 $s = ut + \frac{1}{2}at^2$
 $s_1 = u(n - 1) + \frac{1}{2}a(n - 1)^2$
 $= un - u + \frac{1}{2}an^2 - an + \frac{1}{2}a$
 $t = n, u = u, a = a, s = s_2$
 $s = ut + \frac{1}{2}at^2$
 $s_2 = un + \frac{1}{2}an^2$

Distance travelled, $s = s_2 - s_1$
 $= u + an - \frac{1}{2}a$ **QED**

(b) When $n = 2$, $s = 17$

$$17 = u + 2a - \frac{1}{2}a$$

$$u + 1\frac{1}{2}a = 17$$

When $n = 7$, $s = 47$

$$47 = u + 7a - \frac{1}{2}a$$

$$u + 6\frac{1}{2}a = 47$$

Solving these gives $a = 6$, $u = 8$

(i) $n = 10$

$$s = u + an - \frac{1}{2}a$$

$$= 8 + (6)(10) - \frac{1}{2}(6)$$

$$= 65 \text{ m}$$

(ii) $n = n$

$$s = 8 + 6n - \frac{1}{2}(6)$$

$$= (6n + 5) \text{ m}$$

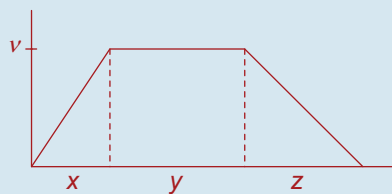
(c) $s_n + s_{n+1} = 256$

$$6n + 5 + 6(n + 1) + 5 = 256$$

$$n = 20$$

Answer: In the 20th and 21st seconds

Q. 7.



$$\text{Average speed} = \frac{\text{total distance}}{\text{total time}}$$

$$= \frac{\frac{1}{2}xv + yv + \frac{1}{2}zv}{x + y + z}$$

$$= \frac{5v}{6}$$

$$\therefore 5xv + 5yv + 5zv = 3xv + 6yv + 3zv$$

$$\therefore 5x + 5y + 5z = 3x + 6y + 3z$$

$$\therefore 2x + 2z = y$$

$$\therefore x + z = \frac{1}{2}y$$

Fraction of distance travelled at constant

$$\text{speed} = \frac{yv}{\frac{1}{2}xv + yv + \frac{1}{2}zv}$$

$$= \frac{y}{\frac{1}{2}x + y + \frac{1}{2}z}$$

$$= \frac{2y}{x + 2y + z}$$

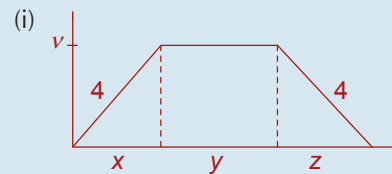
$$= \frac{2y}{(x + z) + 2y}$$

$$= \frac{2y}{\frac{1}{2}y + 2y}$$

$$= \frac{2y}{2\frac{1}{2}y}$$

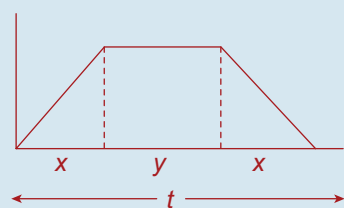
$$= \frac{4}{5} \quad \text{QED}$$

Q. 8.



(ii) $v = 4x = 4z$

$$\therefore x = z \text{ and } v = 4x$$



$$2x + y = t$$

$$\therefore x = \frac{t - y}{2}$$

$$\therefore v = 4x = 2(t - y)$$

Area under curve = d

$$\frac{1}{2}\left(\frac{t - y}{2}\right)(2(t - y)) + y(2)(t - y) + \frac{1}{2}\left(\frac{t - y}{2}\right)(2(t - y)) = d$$

$$\therefore \frac{1}{2}(t - y)^2 + 2yt - 2y^2 + \frac{1}{2}(t - y)^2 = d$$

$$\therefore (t - y)^2 + 2yt - 2y^2 = d$$

$$\therefore t^2 - 2yt + y^2 + 2yt - 2y^2 = d$$

$$\therefore t^2 - y^2 = d$$

$$\therefore y^2 = t^2 - d$$

$$\therefore y = \sqrt{t^2 - d} \quad \text{QED}$$