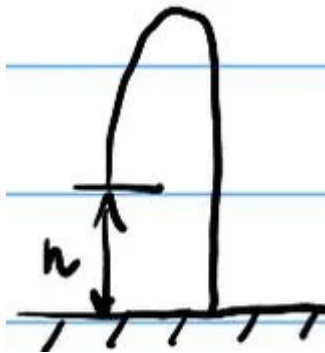


- 1
- (a)
- Use $v^2 = u^2 + 2as$: $(20)^2 = 0 + 2a(50) \Rightarrow 400 = 100a \Rightarrow a = 4 \text{ ms}^{-2}$ (M1)
 - Use $v = u + at$: $20 = 0 + 4t \Rightarrow t = 5 \text{ s}$ (A1)
- (b)
- Use $v^2 = u^2 + 2as$: $(30)^2 = u^2 + 2(2)(200) \Rightarrow 900 = u^2 + 800 \Rightarrow u = 10 \text{ ms}^{-1}$ (M1)
 - Use $v = u + at$: $30 = 10 + 2t \Rightarrow 20 = 2t \Rightarrow t = 10 \text{ s}$ (A1)
- (c)
- Use $s = \left(\frac{u+v}{2}\right)t$: $85 = \left(\frac{u+20}{2}\right)5 \Rightarrow 34 = u + 20 \Rightarrow u = 14 \text{ ms}^{-1}$ (M1)
 - Use $v = u + at$: $20 = 14 + a(5) \Rightarrow 6 = 5a \Rightarrow a = 1.2 \text{ ms}^{-2}$ (A1)
- (d)
- Use $s = ut + \frac{1}{2}at^2$: $100 = u(4) + \frac{1}{2}(2)(4)^2 \Rightarrow 100 = 4u + 16 \Rightarrow u = 21 \text{ ms}^{-1}$ (M1)
 - Use $v = u + at$: $v = 21 + 2(4) \Rightarrow v = 29 \text{ ms}^{-1}$ (A1)
- (e)
- Use $v = u + at$: $10 = u + 1.5(3) \Rightarrow u = 5.5 \text{ ms}^{-1}$ (M1)
 - Use $s = ut + \frac{1}{2}at^2$: $s = (5.5)(3) + \frac{1}{2}(1.5)(3)^2 = 23.25 \text{ m}$ (A1)

(Total for question 1 is 10 marks)

- 2
- (a)
- 
- Use $s = ut + \frac{1}{2}at^2$ with $u = 20, a = -9.8, t = 5$ (M1)
 - $s = 20(5) + \frac{1}{2}(-9.8)(5)^2 = -22.5$ (M1)
 - $h = 22.5 \text{ m}$ (A1)
- (b)
- Use $v = u + at$: $v = 20 + (-9.8)(5)$ (M1)
 - $v = -29 \text{ ms}^{-1}$ (A1)
 - Speed = 29 ms^{-1} (A1)

(Total for question 2 is 6 marks)

3

- (a)
- Convert speeds to m/s: $20 \text{ km/h} = \frac{50}{9} \text{ m/s}$, $70 \text{ km/h} = \frac{175}{9} \text{ m/s}$ (M1)
 - Use $v = u + at$: $\frac{175}{9} = \frac{50}{9} + 10a$ (M1)
 - $a = \frac{25}{18} \approx 1.39 \text{ ms}^{-2}$ (A1)
- (b)
- Use $s = \left(\frac{u+v}{2}\right)t$ (M1)
 - $s = \left(\frac{50/9 + 175/9}{2}\right)10$ (M1)
 - $s = 125 \text{ m}$ (A1)

(Total for question 3 is 6 marks)

4

- (a)
- Use $s = ut + \frac{1}{2}at^2$ with $s = -120$, $u = 0$, $a = -9.8$ (M1)
 - $-120 = -4.9t^2 \implies t^2 = 24.48\dots$ (M1)
 - $t = 4.9 \text{ s}$ (2sf) (A1)
- (b)
- Use $v^2 = u^2 + 2as$: $v^2 = 2(-9.8)(-120) = 2352$ (M1)
 - $v = \sqrt{2352} = 48.49\dots$ (M1)
 - Speed = 48 ms^{-1} (2sf) (A1)

(Total for question 4 is 6 marks)

5

- (a)
- Let speed at X be x , speed at Y be $2x$. Use $s = \left(\frac{u+v}{2}\right)t$ (M1)
 - $120 = \left(\frac{x+2x}{2}\right)8 \implies 120 = 12x$ (M1)
 - $x = 10 \text{ ms}^{-1}$ (A1)
- (b)
- Use $v = u + at$: $20 = 10 + 8a$ (M1)
 - $10 = 8a$ (M1)
 - $a = 1.25 \text{ ms}^{-2}$ (A1)

(Total for question 5 is 6 marks)

6

- (a)
- Use $v = u + at$: $20 = 5 + 8a$ (M1)
 - $15 = 8a$ (M1)
 - $a = 1.875 \text{ ms}^{-2}$ (A1)
- (b)
- Use $s = \left(\frac{u+v}{2}\right)t = \left(\frac{5+20}{2}\right)8$ (M1)
 - $s = 12.5 \times 8$ (M1)
 - $s = 100 \text{ m}$ (A1)
- (c)
- Midpoint $s = 50$. Use $s = ut + \frac{1}{2}at^2$: $50 = 5t + \frac{1}{2}(1.875)t^2$ (M1)
 - $\frac{15}{16}t^2 + 5t - 50 = 0$ (M1)
 - Solve quadratic: $t = 5.1 \text{ s}$ (or $t = -10$) (M1)
 - $t = 5.1 \text{ s}$ (A1)

(Total for question 6 is 10 marks)

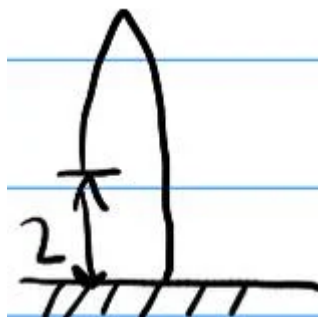
7

- (a)
- For A to C: $s = 100, u = 10, t = 6$. Use $s = ut + \frac{1}{2}at^2$ (M1)
 - $100 = 10(6) + \frac{1}{2}a(6)^2 \implies 40 = 18a$ (M1)
 - $a = \frac{20}{9} \text{ ms}^{-2}$ (A1)
- (b)
- For A to B: $s = 40, u = 10, a = \frac{20}{9}$. Use $v^2 = u^2 + 2as$ (M1)
 - $v^2 = 10^2 + 2\left(\frac{20}{9}\right)(40) = 100 + \frac{1600}{9} = \frac{2500}{9}$ (M1)
 - $v = \frac{50}{3} \text{ ms}^{-1}$ (A1)
- (c)
- For B to C: $s = 60, u = \frac{50}{3}, a = \frac{20}{9}$. Use $s = ut + \frac{1}{2}at^2$ (M1)
 - $60 = \frac{50}{3}t + \frac{10}{9}t^2 \implies 10t^2 + 150t - 540 = 0$ (M1)
 - $t^2 + 15t - 54 = 0 \implies (t - 3)(t + 18) = 0 \implies t = 3 \text{ s}$ (A1)

(Total for question 7 is 9 marks)

8

(a)



- At max height $v = 0$. Use $v^2 = u^2 + 2as$: $0 = 18^2 + 2(-9.8)s$ (M1)
- $s = \frac{324}{19.6} \approx 16.53$ (M1)
- Total height = $16.53 + 2 = 18.5$ m (3sf) (A1)

(b)

- Use $s = -2$, $u = 18$, $a = -9.8$. Use $v^2 = u^2 + 2as$ (M1)
- $v^2 = 18^2 + 2(-9.8)(-2) = 324 + 39.2 = 363.2$ (M1)
- $v = \sqrt{363.2} \approx 19 \text{ ms}^{-1}$ (2sf) (A1)

(c)

- Use $s = ut + \frac{1}{2}at^2$: $-2 = 18t - 4.9t^2$ (M1)
- $4.9t^2 - 18t - 2 = 0$ (M1)
- Solve quadratic: $t = 3.8$ s (A1)

(Total for question 8 is 9 marks)

9

(a)

- For P to Q: $50 = 2u + 2a$ (Eq 1) (M1)
- For P to R: $150 = 5u + 12.5a$ (Eq 2) (M1)
- Solve simultaneously: $a = \frac{10}{3} \text{ ms}^{-2}$ (A1)

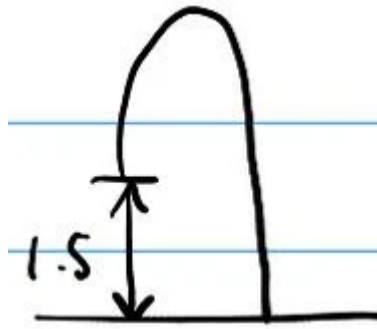
(b)

- Find u : $50 = 2u + 2(10/3) \implies 2u = 50 - 20/3 = 130/3 \implies u = 65/3$ (M1)
- Use $v = u + at$ for PQ: $v = 65/3 + (10/3)(2)$ (M1)
- $v = 85/3 \text{ ms}^{-1}$ (A1)

(Total for question 9 is 6 marks)

10

(a)



- At max height $v = 0$. Use $v^2 = u^2 + 2as$: $0 = 10^2 + 2(-9.8)s$ (M1)
- $s = 5.1$ m (2sf) (M1)
- Greatest height = $5.1 + 1.5 = 6.6$ m (A1)

(b)

- Height above ground = 3m means displacement $s = 1.5$ from start. (M1)
- $1.5 = 10t - 4.9t^2 \implies 4.9t^2 - 10t + 1.5 = 0$ (M1)
- $t = 1.88$ and $t = 0.16$. Time difference = $1.88 - 0.16 = 1.7$ s (A1)

(Total for question 10 is 6 marks)

11

(a)

- Total time for acc/dec = $112 - 72 = 40$ s (M1)
- Since magnitudes are equal, time for acc = time for dec = 20 s (A1)

(b)

- Trapezium shape starting at (0,0), peak at 32, ending at (112,0). (M1)
- Correct time labels: 20, 92 (72+20), 112. (A1)

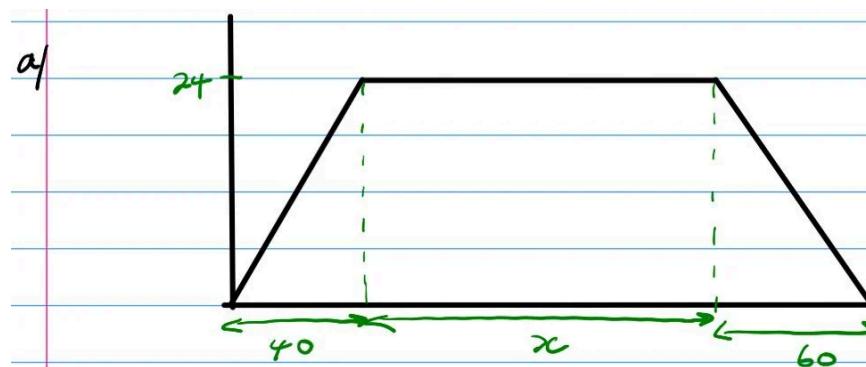
(c)

- Area of trapezium = $\frac{1}{2}(a + b)h$ (M1)
- Distance = $\frac{1}{2}(72 + 112) \times 32$ (M1)
- Distance = 2944 m (A1)

(Total for question 11 is 7 marks)

12

(a)



- Max velocity $v = 0.6 \times 40 = 24 \text{ ms}^{-1}$ (M1)
- Deceleration time $t = 24/0.4 = 60 \text{ s}$ (M1)
- Correct trapezium shape with labels. (A1)

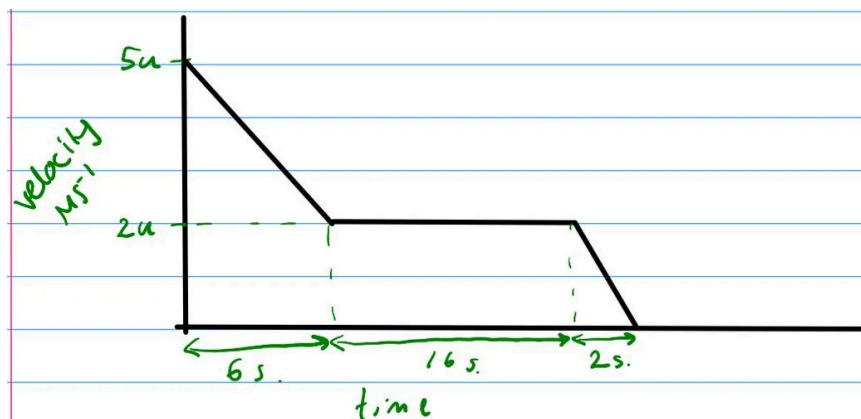
(b)

- Let constant velocity time be x . Total distance = 4000m. (M1)
- $\frac{1}{2}(x + (40 + x + 60)) \times 24 = 4000$ (M1)
- $12(2x + 100) = 4000 \Rightarrow 2x + 100 = 333.33 \Rightarrow x = 116.67 \text{ s}$ (M1)
- Total time = $40 + 116.67 + 60 = 216.7 \text{ s}$ (A1)

(Total for question 12 is 7 marks)

13

(a)



- Graph showing three stages: deceleration from $5U$ to $2U$, constant $2U$, deceleration to rest. (M1)
 - Correct time intervals (6, 16, 2) and velocity labels. (A1)
- (b)
- First deceleration = $\frac{5U-2U}{6} = \frac{3U}{6} = \frac{1}{2}U$ (M2)
 - Second deceleration = $\frac{2U-0}{2} = U$ (M2)
- (c)
- Area = $\frac{1}{2}(5U + 2U)6 + (16 \times 2U) + \frac{1}{2}(2 \times 2U) = 220$ (M2)
 - $21U + 32U + 2U = 220$ (M2)
 - $55U = 220 \implies U = 4$ (A2)

(Total for question 13 is 12 marks)

14

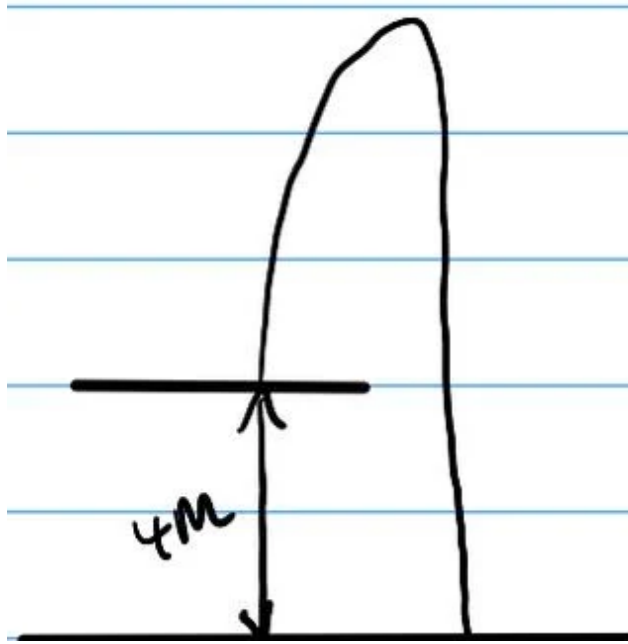
- (a)
- Acceleration = $V/6$ (M1)
 - Deceleration = $1.5(V/6) = V/4$ (M1)
 - Time for deceleration = $V/(V/4) = 4$ s. Total time = $6 + 50 + 4 = 60$ s (A1)

(b)



- Trapezium shape with labels V on y-axis and 6, 56, 60 on x-axis. (M2)
 - Correct annotations. (A1)
- (c)
- Area = $\frac{1}{2}(50 + 60)V = 1320$ (M1)
 - $55V = 1320$ (M1)
 - $V = 24$ (A1)

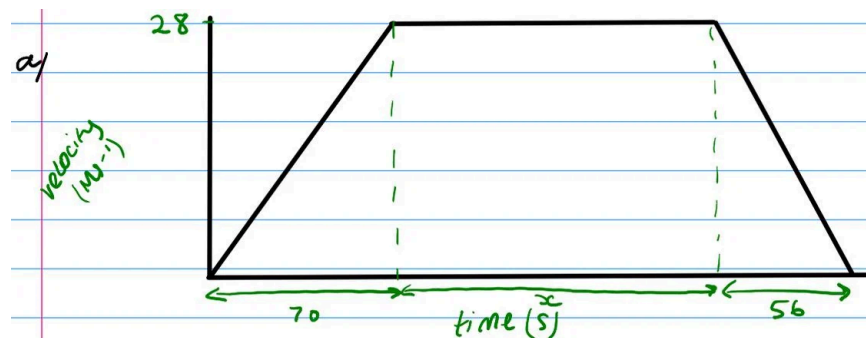
(Total for question 14 is 9 marks)



- Use $s = -4$, $u = 8$, $a = -10$. Use $s = ut + \frac{1}{2}at^2$ (M1)
- $-4 = 8T - 5T^2$ (M1)
- $5T^2 - 8T - 4 = 0$ (M1)
- $(5T + 2)(T - 2) = 0$ (M1)
- $T = 2$ s (A1)

(Total for question 15 is 5 marks)

(a)

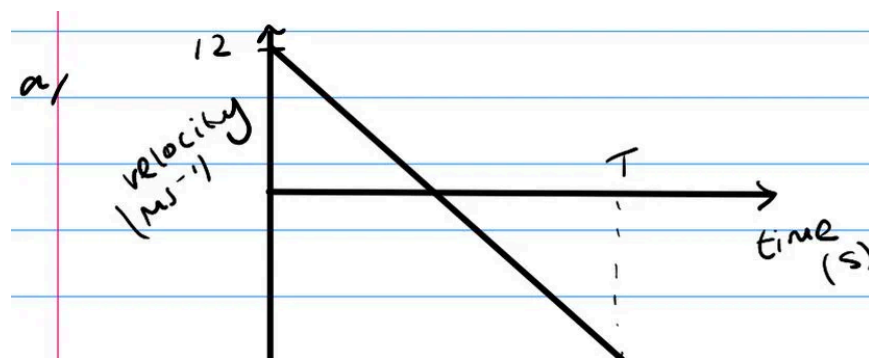


- Trapezium shape. (M1)
 - Max velocity $v = 0.4 \times 70 = 28$. Deceleration time $= 28/0.5 = 56$. (A1)
- (b)
- Area $= \frac{1}{2}(x + (70 + x + 56)) \times 28 = 3360$ (M1)
 - $14(2x + 126) = 3360 \Rightarrow 2x + 126 = 240 \Rightarrow x = 57$ (M2)
 - Total time $= 70 + 57 + 56 = 183$ s (A1)
- (c)
- The acceleration and deceleration could be modelled as non-uniform. (B1)

(Total for question 16 is 7 marks)

17

(a)



- Straight line with negative gradient starting at $(0, 12)$ and crossing the t -axis. (M1)
 - Ends at T with negative velocity. (A1)
- (b)
- At max height $v = 0$. Use $v = u + at$: $0 = 12 - 10t$ (M1)
 - $t = 1.2$ s (A1)
- (c)
- Use $s = -5$, $u = 12$, $a = -10$. Use $s = ut + \frac{1}{2}at^2$ (M1)
 - $-5 = 12T - 5T^2 \implies 5T^2 - 12T - 5 = 0$ (M1)
 - Solve quadratic: $T = 2.8$ s (A1)
- (d)
- It would increase the value of T . (B1)
- (e)
- A more accurate value for g could be used. (B1)

(Total for question 17 is 9 marks)