MOTION IN A STRAIGHT LINE UNDER CONSTANT ACCELERATION

1. Using $v = u + at$ M1

$v = 8 + 1.5\ (3) = 12.5\ ms^{-1}$ A1

Using $s = ut + \frac{1}{2}at^2$ M1

$= 8 \times 3 + \frac{1}{2} \times 1.5 \times 9 = 30.75$ m A1

[4]

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2. a) Using $v^2 = u^2 + 2ah$ M1

$$h = \frac{100^2}{2g} \approx 510.2 \text{ m}$$ A1

[2]

b) Time to fall through 460.2 m = $\frac{1}{2}$ time that particle is over 50 m above ground. M1

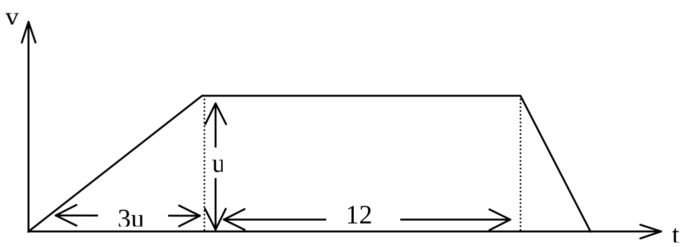
$s = ut + \frac{1}{2}at^2 \Rightarrow 460.2 = \frac{1}{2}gt^2$

Time required $= 2\sqrt{\frac{920.4}{g}}$ sec. M1 A1

≈ 19.4 seconds A1

[4]

3.



Let top speed be u. Then time spent accelerating is 3u B1

Area = distance covered: $\frac{u}{2}[60 + 12] = 432$ M1 A1

$36u = 432$ M1

$\Rightarrow u = 12$ top speed A1

Thus decelerating is $60 – 12 – 3u = 12$ seconds M1 A1

[7]

MOTION IN A STRAIGHT LINE UNDER CONSTANT ACCELERATION

4. a) Using $s = ut + \frac{1}{2}at^2$ $a = g = 9.8\ ms^{-2}$ $u = 0$ M1

$s = \frac{1}{2} \times 9.8 \times \frac{100}{9} = 54.4$ m

A1
[2]

b) Using $s = ut + \frac{1}{2}at^2$ $a = g = 9.8\ ms^{-2}$; $u = 12$; $s = 4.9 \times \frac{100}{9}$ M1

$4.9 \times \frac{100}{9} = 12t + 4.9t^2$ A1

$4.9t^2 + 12t - 54.4 = 0$ M1 (solving)

$t = 2.33$ seconds (negative second root is impossible answer) A1
[4]

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5. a) Using $s = ut + \frac{1}{2}at^2$ $a = g = 9.8\ ms^{-2}$; M1

$u = 0$ for the first stone $\Rightarrow s_1 = \frac{1}{2}gt^2$ A1

u=12, time is t–1 for the second stone B1

$s_2 = 12(t-1) + 4.9(t-1)^2$ A1

$\Rightarrow 4.9t^2 = 12(t-1) + 4.9(t-1)^2$ M1 (equating)

$\Rightarrow 4.9t^2 = 12t - 12 + 4.9t^2 - 9.8t + 4.9$ M1 (solving)

$\Rightarrow 2.2t = 7.1 \Rightarrow t = 3.23$ seconds.

so time is 3.23 seconds for the first stone. A1
[7]

b) Using $s = ut + \frac{1}{2}at^2$ $a = g = 9.8\ ms^{-2}$; $u = 0$ for first stone M1

$s = 4.9t^2$ using t for the first stone,

$s = 4.9(3.23)^2 = 51$m A1
[2]

c) No air resistance B1 (either)

Stone has not reached terminal velocity.

(But, NOT accept anything about stones having same mass or weight.)

[1]

---

6. a) Using $s = ut + \frac{1}{2}at^2$ $a = -g = -9.8\ ms^{-2}$; $s = -30$ m; $u = 25\ ms^{-1}$ M1 B1

$-30 = 25t - 4.9t^2$ M1 (solving)

$t = 6.1$ seconds A1
[4]

b) Using $v = u + at$ downwards: $a = g = 9.8\ ms^{-2}$; $u = -25$; $t = 6.1$ M1

$v = -25 + 9.8(6.1) = 34.8\ ms^{-1}$ vertically downwards A1
[2]

c) No air resistance B1

arrow can be treated as particle B1
[2]

MOTION IN A STRAIGHT LINE UNDER CONSTANT ACCELERATION

7. a) Using $v = u + at$ — $a = g = 9.8\ ms^{-2}$; $v = 33\ ms^{-1}$; $u = 0$ — M1

$33 = 0 + 9.8t$

so, $t = \frac{33}{9.8} = 3.37$ seconds. — A1

[2]

b) Using $s = ut + \frac{1}{2}at^2$ — $a = g = 9.8\ ms^{-2}$; $u = 0$ — $t = \frac{33}{9.8}$ — M1

$s = 0 + 4.9(3.37)^2 = 55.6$m. — A1

[2]

---

8. a) Using $v^2 = u^2 + 2as$ — $a = -g = -9.8\ ms^{-2}$; $v = 0$; $u = 25\ ms^{-1}$ — M1

$0 = 25^2 - 2gs$

$0 = 625 - 19.6(s)$

$s = 31.9$ — A1

[2]

b) Using $v = u + at$ for time to maximum height: $a = -g = -9.8\ ms^{-2}$; $v = 0$; $u = 25$ — M1

$0 = 25 - 9.8t \Rightarrow t = 2.55$ seconds — A1

Total time is double this by symmetry $\Rightarrow$ total time is 5.1 seconds — A1

[3]

---

9. a) Using $v^2 = u^2 + 2as$ — $a = -g = -9.8\ ms^{-2}$; $v=0$; $s = 4$m — M1

$0 = u^2 - 8(9.8)$

so, $u^2 = 78.4$ and $u = 8.85\ ms^{-1}$, vertically upwards. — A1 A1

[3]

b) Time = 2 × time to fall 3m from rest — M1

$s = 3$ $u = 0$ $a = g$ — B1

$3 = \frac{1}{2}gt^2$ — M1

$\sqrt{\frac{6}{g}} = t$

$\Rightarrow$ time $= 2\sqrt{\frac{6}{g}} = 1.56$ seconds — A1

[4]

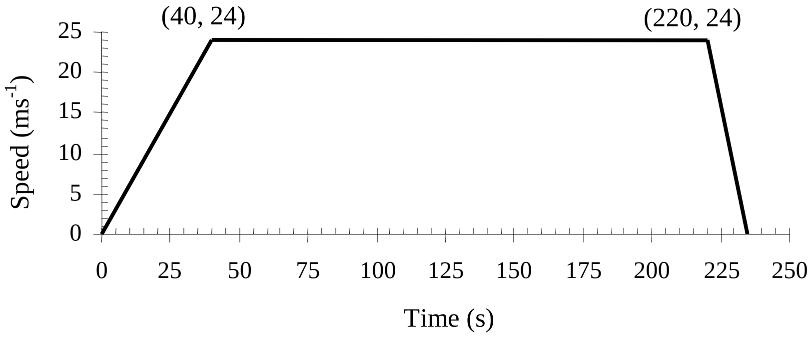
c) Droplets behave as particles — B1 (either)

Ignore air resistance

[1]

MOTION IN A STRAIGHT LINE UNDER CONSTANT ACCELERATION

10. a)



G2 (all points shown clearly)
G1 (shape)

[3]

b) i) Time for A to decelerate: use $v = u + at$ $v=0$; $u=24$, $a= -1.6$ — M1

$0 = 24 - 1.6\,t \Rightarrow t=15$

So reaches Wylde Heath after 235 seconds — A1

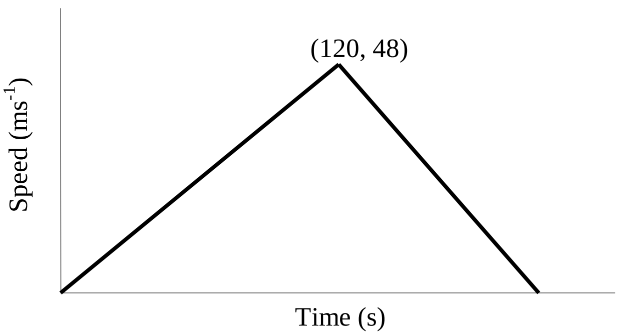
[2]

ii) Distance = area under graph — M1

$= \frac{1}{2} \times (235+180) \times 24 = 4980$ — A1

[2]

c) i)



Area under graph = $\frac{1}{2} \times T \times 48 = 4890$ — M1 A1

$T = 207.5$ seconds — A1

[3]

ii) Deceleration = gradient of part with negative slope — M1

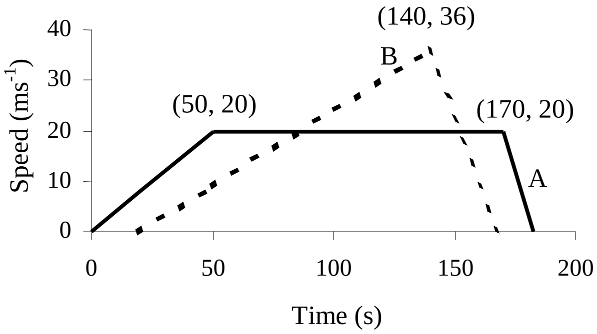
$$= \frac{-48}{207.5 - 120} = -0.55 \text{ ms}^{-2}$$

$\Rightarrow$ deceleration is 0.55 ms^{-2} — A1

[2]

MOTION IN A STRAIGHT LINE UNDER CONSTANT ACCELERATION

11.a)



G2 shapes
G3 points shown
G1 same axes

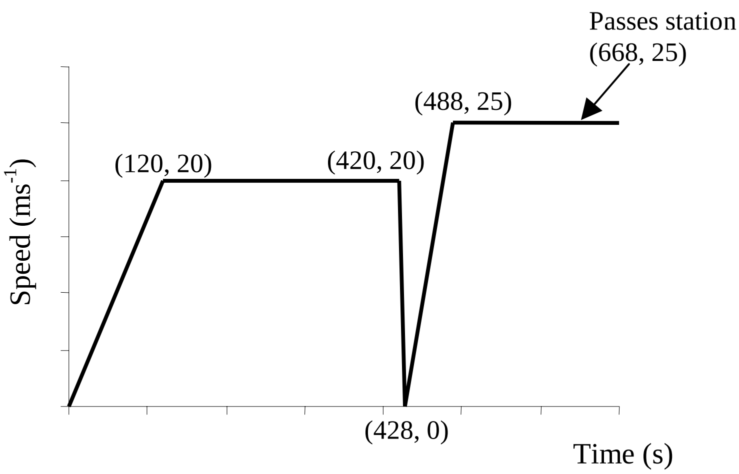
[6]

b) For A: Use v = u + at to find time spent decelerating: v = 0; u = 20; a = -1.6 — M1
$0 = 20 - 1.6t \Rightarrow t = 12.5$ seconds
Total time for A = 50 + 120 + 12.5 = 182.5 — A1

To find time for B: use area under graph = distance. — M1
So, using A: distance = $\frac{1}{2} \times (182.5 + 120) \times 20 = 3025$ — A1
So, for B: $\frac{1}{2} \times T \times 36 = 3025 \Rightarrow T = 168.06$ — A1

So B arrives at Notown 188.06 after A departs Anyplace
So A gets in first by 5.56 seconds — B1
[6]

12.a)



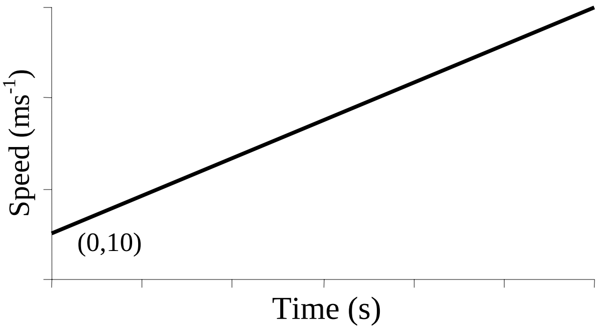
G2 (shape)
G1 (passing pt shown)
G3 (all points correct)

[6]

b) Distance = area under graph — M1
$= \frac{1}{2} \times (300 + 428) \times 20 + \frac{1}{2} \times (240 + 180) \times 25$ — A1 A1
$= 12530$ m — A1
[4]

MOTION IN A STRAIGHT LINE UNDER CONSTANT ACCELERATION

13. a)



G1 point
G1 shape

[2]

b) Use v = u + at — M1

$\Rightarrow$ v = 10 + $\frac{1}{12}$t — A1

So when t = 140, v = 21$\frac{2}{3}$ ms^{-1} — A1

[3]

c) v = u + at $\Rightarrow$ 60 =10+$\frac{1}{12}$t $\Rightarrow$ t = 600 seconds — M1 A1

Distance = area under graph = $\frac{1}{2}\times(10 + 60)\times 600$ = 21000m — M1 A1

[4]

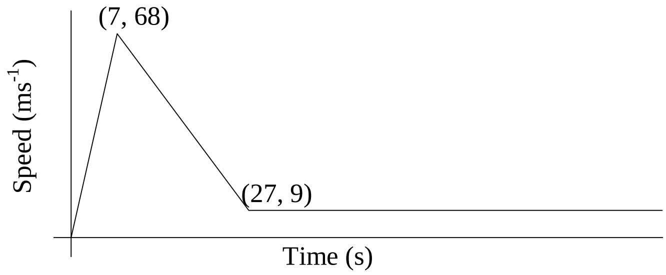
14.a) i) resultant force downwards — B1

ii) resultant force upwards — B1

iii) no resultant force — B1

[3]

b)



G2 shape
G1 points

[3]

c) Distance = area under curve — M1

While accelerating, area = $\frac{1}{2}\times 68\times 7$ = 238m — A1

While decelerating, area = $\frac{1}{2}\times(68 + 9)\times 20$ = 770m — A1

While at constant speed, area = 63×9 = 567m — B1

Total distance = height of helicopter = 1575m — B1

[5]

MOTION IN A STRAIGHT LINE UNDER CONSTANT ACCELERATION

15.a) Using $v^2 = u^2 + 2as$ $v = 0\ ms^{-1}$; $u = 27\ ms^{-1}$ $s = 40$ m M1
$0 = 27^2 - 2a(40)$
$a = 9.1125\ ms^{-2}$ deceleration A1
[2]

b) Using $v = u + at$ $v = 0\ ms^{-1}$; $u = 27\ ms^{-1}$; $a = -9.1125\ ms^{-2}$ M1
$0 = 27 - 9.1125t$
$t = 2.96$ seconds A1
[2]

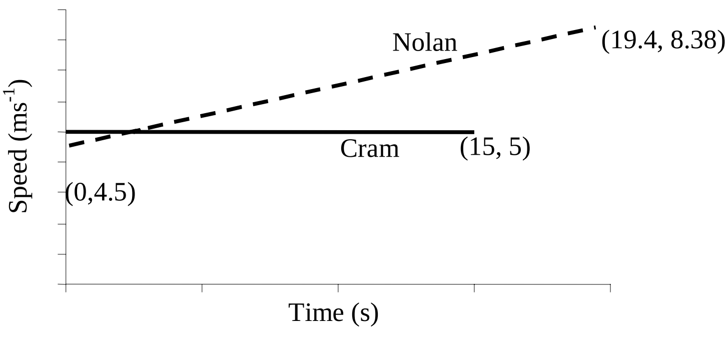
c) Using $v^2 = u^2 + 2as$ $v = 0\ ms^{-1}$; $u = U\ ms^{-1}$ $a = -9.12\ ms^{-2}$ M1
$0 = U^2 - 9.1125x$
$x = \frac{U^2}{9.1125}$ A1
[2]

iv) Takes UT metres while waiting for driver to brake B1
So $UT + \frac{U^2}{9.1125}$ in total B1
[2]

v) Braking distance $= 22 \times \frac{1}{2} + \frac{22^2}{9.1125} \approx 64$ m M1 A1
[2]

16.a) Cram takes $75 \div 5 = 15$ seconds B1
For Nolan: use $s = ut + \frac{1}{2}at^2$ $s = 125$; $u = 4.5$; $a = 0.2$ M1
$125 = 4.5t + 0.1t^2$ M1 (solving)
$t = 19.4$ seconds so Nolan cannot win A1
[4]

b)



B2 correct finish times
G2 correct shapes

[4]

MOTION IN A STRAIGHT LINE UNDER CONSTANT ACCELERATION

17. a) Using average speed = $\frac{s}{t}$

Average speed (11^{th} level) = $\frac{H}{1.2}$ ms^{-1} B1

Average speed (10^{th} level) = $\frac{H}{0.5}$ ms^{-1} B1

[2]

b) Consider object falling between middle of 11^{th} level and middle of 10^{th} level
Speed at middle of level will be average speeds above M1
Using $2as = v^2 - u^2$, with $a = g$: M1

$2gH = \left(\frac{H}{0.5}\right)^2 - \left(\frac{H}{1.2}\right)^2$ A1

$H = \frac{2g}{3.3056} = 5.9m$ M1 (solving) A1

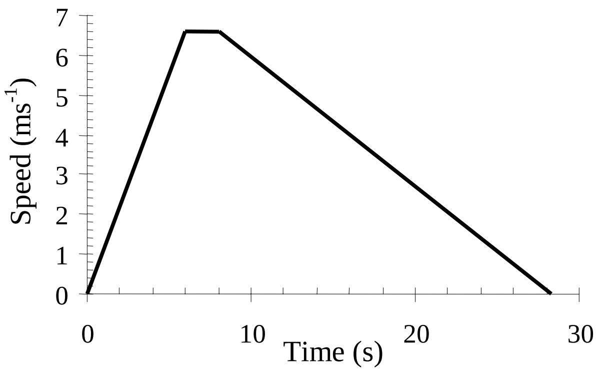
[5]

c) Object behaves as particle. B1
Air resistance neglected B1
[2]

MOTION IN A STRAIGHT LINE UNDER CONSTANT ACCELERATION

18. a)	Use $v = u + at$ $u = 0; a=1.1;$ $t=6$	M1
	$v = 6.6 \text{ ms}^{-1}$	A1
		[2]

b)



First find total time he takes:	
Distance = area under graph	M1
$100 = \frac{1}{2} \times 6.6 \times (2 + T) \Rightarrow T= 28.3$	A1
Deceleration $= \dfrac{6.6}{28.3-8} = 0.33 \text{ ms}^{-2}$	A1
	[3]

c) Need Dominic's distance + Andrea's distance = 100	B1
In the first 8 seconds, Andrea has travelled 48m	B1
Dominic has travelled $\frac{1}{2} \times 6.6 \times (8 + 2) = 33\text{m}$	M1 A1
So they do not meet during the first 8 seconds	
Andrea's distance after time $t = 6t$	B1
Dominic's distance after time t (where $t > 8$) can be found by subtracting the distance he has yet to run from 100.	
Distance he has yet to run is $(28.3 - t) \times 0.33(28.3 - t)$	M1 A1
So $s_D = 100 - (28.3 - t) \times 0.33(28.3 - t)$	A1
So require $6t + 100 - (28.3 - t) \times 0.33(28.3 - t) = 100$	
i.e. $-0.33t^2 + 24.68t - 264.3 = 0$	M1
$t = 62$ seconds or 13 seconds	M1 (solving)
62 seconds is after finish of race $\Rightarrow$ 13 seconds	A1
	[11]

MOTION IN A STRAIGHT LINE UNDER CONSTANT ACCELERATION

19. a)	Using $s = ut + \frac{1}{2}at^2$	M1
	For Kerry's ball, $u=30$, $a = -g = -9.8\ ms^{-2}$	
	$s_K = 30t - 4.9t^2$	A1
	For Liam's ball, $u=0$, $a = g = 9.8\ ms^{-2}$	
	$s_L = 4.9t^2$	A1
	Same height $\Rightarrow s_K + s_L = 20$	M1
	$30t - 4.9t^2 + 4.9t^2 = 20 \Rightarrow t = \frac{2}{3}$	A1
		[5]
b)	$s_K = 4.9t^2 = 4.9 \times \frac{4}{9} = 2.18\text{m}$	M1 A1
	above ground level	A1
		[3]
c)	Balls treated as particles	B1
	Air resistance ignored	B1
		[2]

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20. a)	Using $v^2 = u^2 + 2as$	M1
	Between A and B: $80 = 32 + 2aD$	A1
	$\Rightarrow 24 = aD$	A1
		[3]
b)	Using $v^2 = u^2 + 2as$ between B and C:	
	$82 = 80 + 2a \times 2 \Rightarrow a = \frac{1}{2}\ ms^{-2}$	M1 A1
		[2]
c)	Using $v = u + at$: $u=0$, $v=\sqrt{32}\ ms^{-1}$; $a= \frac{1}{2}\ ms^{-2}$	M1
	$\sqrt{32} = \frac{1}{2}t \Rightarrow t = 11.3$ seconds	A1
		[2]

MOTION IN A STRAIGHT LINE UNDER CONSTANT ACCELERATION

21.a) Using $s = \frac{1}{2}(u + v)t$ u=0; v=7; t=70 M1

$s = \frac{1}{2} \times 7 \times 70 = 245$m A1

[2]

b) Has to cover another 555m

Using $s = \frac{1}{2}(u+v)t$ u=7; v=0; s=555 M1

$555 = \frac{1}{2} \times 7 \times t \Rightarrow t = 158\frac{4}{7}$ A1

[2]

c) While running at 5 ms^{-1}, he covers 350m B1

While accelerating: use $s = ut + \frac{1}{2}at^2$ M1

$s = 5\times3 + \frac{1}{2} \times 0.5 \times 9 = 17.25$m A1

So he has 232.75 left of the 600m to cover

He runs this at 6.5 ms^{-1} B1

So time taken for this is 35.808 seconds B1

So total time for first 600m is 108.808 seconds B1

[6]

iv) Distance travelled while decelerating:

Use $s = \frac{1}{2}(u+v)t$ M1

$= \frac{1}{2} \times (6.5 + 4) \times 10 = 52.5$ m A1

So distance travelled while at 4 ms^{-1} = 200 – 52.5 = 147.5m A1

[3]

v) Kevin takes 147.5 ÷ 4 = 36.875 seconds to travel last 147.5m. B1

So his total time is 108.808 + 10 + 36.875 = 155.68m B1

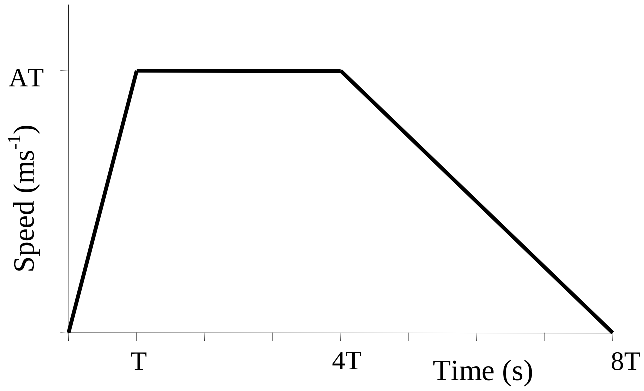
Glenn takes $70 + 158\frac{4}{7} = 228\frac{4}{7}$ seconds B1

So Kevin wins by 72.9 seconds B1

[4]

MOTION IN A STRAIGHT LINE UNDER CONSTANT ACCELERATION

22. a)



B1 (AT)
G1 (correct labels)
G1 (shape)

[3]

b) Average speed = $\dfrac{\text{total distance}}{\text{total time}}$ M1

Total distance = area under graph = $\frac{1}{2} \times (8T + 3T) \times AT$ M1 A1

So average speed = $\dfrac{11AT^2}{2} \div 8T = \dfrac{11AT}{16}$ A1

So $\dfrac{11AT}{16} = 2.5 \Rightarrow 11AT = 40$ M1 A1

[6]

c) $\dfrac{11AT^2}{2} = 200 \Rightarrow 11AT^2 = 400$ B1

Dividing this equation by previous one: T=10 M1 A1

[3]

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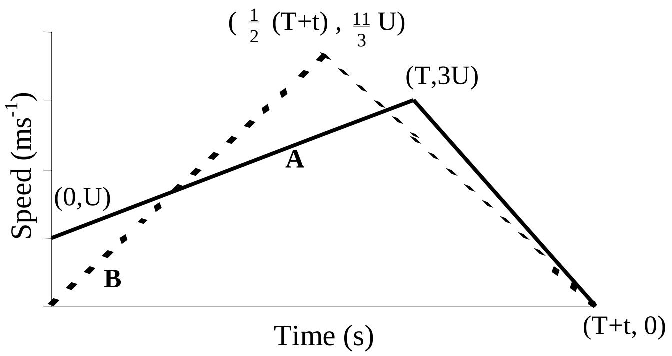
23. a)



G2 shapes
G1 symmetry for B
G2 any 3 points labelled

[5]

b) Total distance the same $\Rightarrow$ same area under graphs M1

$\frac{1}{2} \times (T + t) \times \frac{11}{3} U = \frac{1}{2} \times (U + 3U) \times T + \frac{1}{2} \times 3U \times t$ M1 A1 A1 A1

$\Rightarrow \frac{11}{3}(T + t) = 4T + 3t$ M1 A1 (simplifying)

$\Rightarrow 11T + 11t = 12T + 9t$

$\Rightarrow 2t = T$ A1

[8]
