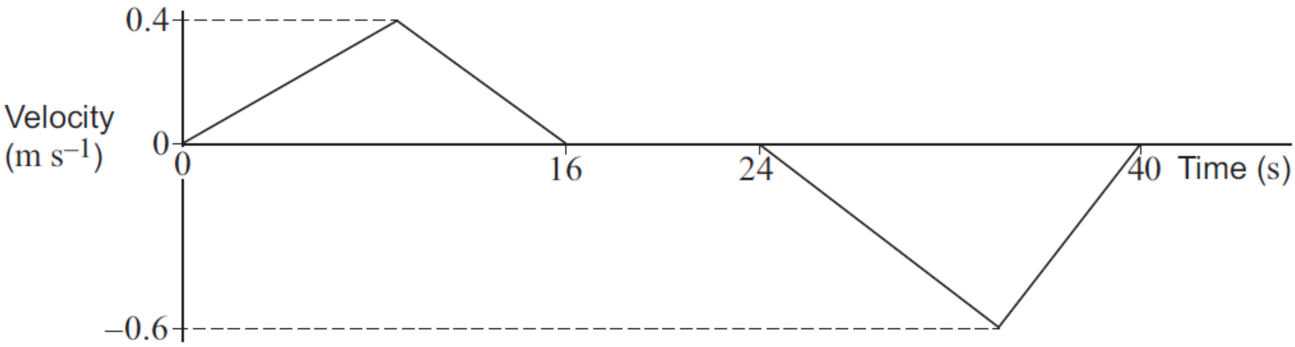
2 The graph below shows how the velocity of a lift varies during a 40 second period.



(a) Find the distance travelled by the lift in the first 16 seconds of the motion.

[2 marks]

(b) Find the total distance travelled by the lift in the 40 second period.

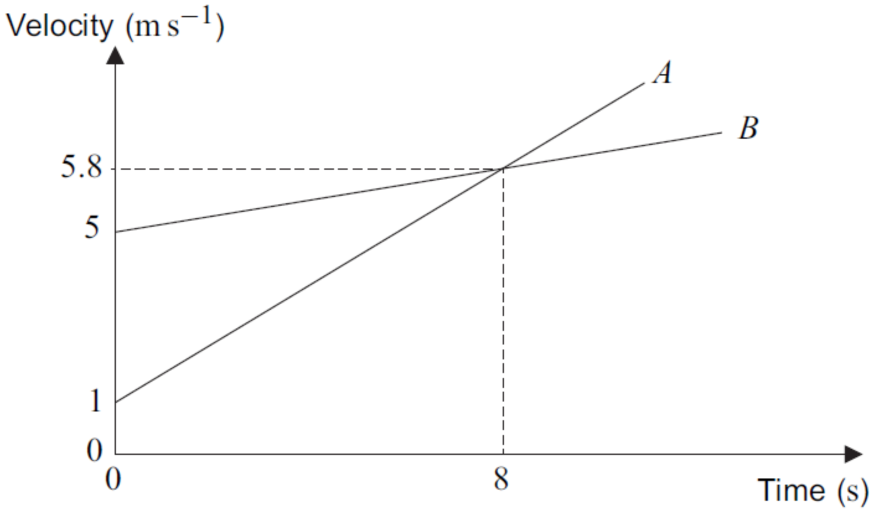
[3 marks]

(c) Find the average velocity of the lift during the 40 second period.

[3 marks]

2 (a)	$s_1 = \frac{1}{2} \times 0.4 \times 16$ $= 3.2 \text{ metres}$	**M1** **A1**	**2**	M1: Finding distance for first stage. A1: Correct distance.
(b)	$s_2 = \frac{1}{2} \times 0.6 \times 16$ $= 4.8 \text{ metres}$ $s_1 + s_2 = 3.2 + 4.8$ $= 8 \text{ metres}$	**B1** **M1** **A1**	**3**	B1: Correct distance for second stage. Allow -4.8. M1: Adding both their distances. A1: Correct sum of their distances. CAO
(c)	$s_1 - s_2 = 3.2 - 4.8$ $= -1.6$ $\text{Average Velocity} = \frac{-1.6}{40}$ $= -0.04 \text{ m s}^{-1}$	**M1** **M1** **A1**	**3**	M1: Difference of their two distances. dM1: Their difference divided by 40. A1: Correct average velocity. CAO

8 Two trains, A and B, are moving on straight horizontal tracks which run alongside each other and are parallel. The trains both move with constant acceleration. At time $t = 0$, the fronts of the trains pass a signal. The velocities of the trains are shown in the graph below.



(a) Find the distance between the fronts of the two trains when they have the same velocity and state which train has travelled further from the signal.

[3 marks]

(b) Find the time when A has travelled 9 metres further than B.

[8 marks]

Q	Solution	Mark	Total	Comment
8. (a)	$s = \frac{1}{2} \times 4 \times 8 = 16\text{ m}$	M1A1		M1: Finding the area of the triangle formed by the two lines and the v-axis. A1: Correct distance.
	OR $s_A = \frac{1}{2}(1+5.8) \times 8 = 27.2\text{ m}$ $s_B = \frac{1}{2}(5+5.8) \times 8 = 43.2\text{ m}$ $43.2 - 27.2 = 16\text{ m}$	(M1A1)		M1: Areas of two trapezia to find distance travelled by each train. A1: Subtracting to find the correct distance.
	B has travelled further.	B1	**3**	B1: Stating that *B* has travelled further, not necessarily supported by correct numeric arguments.
8. (b)	$a_A = \frac{5.8-1}{8} = 0.6\text{ m s}^{-2}$	B1		B1: Correct acceleration of *A*.
	$a_B = \frac{5.8-5}{8} = 0.1\text{ m s}^{-2}$	B1		B1: Correct acceleration of *B*.
	$s_A = t + 0.3t^2$	B1		B1: Correct expression for the displacement of *A*.
	$s_B = 5t + 0.05t^2$	B1		B1: Correct expression for the displacement of *B*.
	$t + 0.3t^2 - (5t + 0.05t^2) = 9$ $0.25t^2 - 4t - 9 = 0$ $t^2 - 16t - 36 = 0$	M1 A1		M1: Difference for their two quadratic displacements equated to 9. A1: Correct equation may be unsimpilified.
	$(t-18)(t+2) = 0$ $t = 18$ or $t = -2$ $t = 18$	dM1 A1	**8**	**Solving their Quadratic** **If working shown in full (eg factorising):** dM1: Award for correct factorisation or $(t+18)(t-2) = 0$ A1: Correct solution stated.

3. At time $t = 0$, a toy rocket is fired vertically upwards from rest from a point A on the ground. The rocket moves with constant acceleration $2.8\,\mathrm{m\,s^{-2}}$. At time $t = 5.25\,\mathrm{s}$, the rocket runs out of fuel and then moves vertically upwards under gravity. At time $t = T$ seconds, the rocket reaches its greatest height above A. The rocket is modelled as a particle.

(a) Find the value of T.

(5)

(b) Without doing any further calculations, sketch a velocity-time graph for the motion of the rocket from when it was fired to when it returns to A, showing the value of T on the t-axis.

(2)

6. A cyclist is moving along a straight horizontal road and passes a point A. Five seconds later, at the instant when she is moving with speed $10\,\mathrm{m\,s^{-1}}$, she passes the point B. She moves with constant acceleration from A to B.

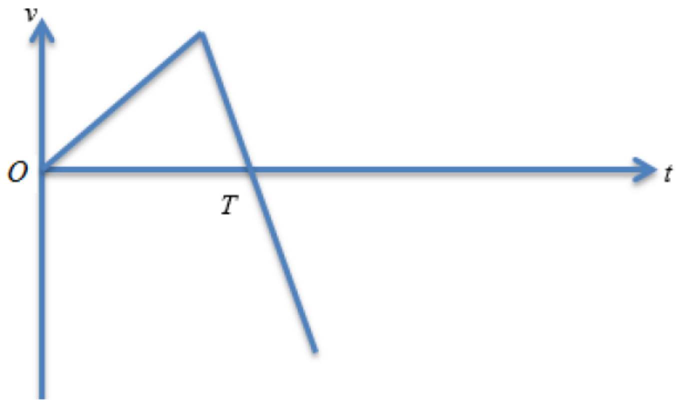
Given that $AB = 40\,\mathrm{m}$, find

(a) the acceleration of the cyclist as she moves from A to B,

(4)

(b) the time it takes her to travel from A to the midpoint of AB.

(5)

3(a)	$v = 5.25 \times 2.8 = 14.7$ $0 = 14.7 - 9.8t$ $T(= 5.25 + 1.5) = 6.75$ or 6.8	M1 A1 M1 A1 A1 (5)
(b)	 **N.B.** Graph could be reflected in the *t*-axis	B1 1st line B1 **ft** 2nd line with their **value** of *T* CLEARLY marked (2)
		(7)

6(a)	$s = vt - \frac{1}{2}at^2$ $40 = 10 \times 5 - \frac{1}{2}a5^2$ $a = 0.8$	M1 A2 A1 (4)
(b)	Finding u (= 6) $s = ut + \frac{1}{2}at^2$ (A to M) $20 = 6t + \frac{1}{2}0.8t^2$ $t = \dfrac{-15 \pm \sqrt{225 + 200}}{2}$ $= 2.8$ or 2.81 or better	M1 M1 A1 **DM**1 A1 (5)

7. A car is moving with constant speed along a straight horizontal road. Whenever the brakes are applied they produce a deceleration of $5\,\text{m}\,\text{s}^{-2}$. The driver sees a STOP sign which is at the point S on the road ahead. Unfortunately due to the time he takes to react, he does not apply the brakes immediately and the car overshoots the sign. Had he applied the brakes 0.5 s sooner the car would have come to rest at S. The car is modelled as a particle.

(a) Show that, at the instant the car passes S, the speed of the car is $2.5\,\text{m}\,\text{s}^{-1}$.

(2)

(b) Find how far the car travels past S before coming to rest.

(2)

At the instant when the driver sees the sign, the speed of the car is $64.8\,\text{km}\,\text{h}^{-1}$. The total time from the instant when the driver first sees the sign to the instant when the car comes to rest is 4.2 seconds.

(c) Find the total distance travelled by the car, from the instant when the driver first sees the sign to the instant when the car reaches the sign.

(7)

Question	Scheme	Marks
7(a)	$0 = u - 0.5 \times 5$ $u = 2.5\ (\text{m s}^{-1})$ Given answer	M1 A1 (2)
(b)	$0 = 2.5^2 - 2 \times 5s$ $s = 0.625\ (\text{m})$ or oe **OR** e.g. $s = \frac{(0+2.5)}{2} \times 0.5 = 0.625\ (\text{m})$	M1 A1 (2)
(c)	$64.8\ \text{km h}^{-1} = 18\ \text{m s}^{-1}$	B1
	$0 = 18 - 5t$, $t = 3.6$ **OR** $2.5 = 18 - 5t$, $t = 3.1$	M1 A1**ft** on their 18
	Any of:- e.g. $18 \times (4.2 - t)$ **OR** $18 \times (4.2 - 0.5 - t)$ $s = \frac{1}{2}(18 + 2.5) \times 3.1$ $s = (18 \times 3.1 + \frac{1}{2} \times -5 \times 3.1^2)$ $s = (2.5 \times 3.1 - \frac{1}{2} \times -5 \times 3.1^2)$ $2.5^2 = 18^2 + 2 \times (-5)s$	M1
	10.8	A1**ft** on t &18
	31.775 m	A1 cao
	Total distance = (10.8 + 31.775) = 42.575 (m)	A1 cao (7)

4. A ball of mass 0.2 kg is projected vertically downwards with speed U m s^{-1} from a point A which is 2.5 m above horizontal ground. The ball hits the ground. Immediately after hitting the ground, the ball rebounds vertically with a speed of 10 m s^{-1}. The ball receives an impulse of magnitude 7 N s in its impact with the ground. By modelling the ball as a particle and ignoring air resistance, find

(a) the value of U.

(6)

After hitting the ground, the ball moves vertically upwards and passes through a point B which is 1 m above the ground.

(b) Find the time between the instant when the ball hits the ground and the instant when the ball first passes through B.

(4)

(c) Sketch a velocity-time graph for the motion of the ball from when it was projected from A to when it first passes through B. (You need not make any further calculations to draw this sketch.)

(3)

4. Two trains M and N are moving in the same direction along parallel straight horizontal tracks. At time $t = 0$, M overtakes N whilst they are travelling with speeds 40 m s^{-1} and 30 m s^{-1} respectively. Train M overtakes train N as they pass a point X at the side of the tracks.

After overtaking N, train M maintains its speed of 40 m s^{-1} for T seconds and then decelerates uniformly, coming to rest next to a point Y at the side of the tracks.

After being overtaken, train N maintains its speed of 30 m s^{-1} for 25 s and then decelerates uniformly, also coming to rest next to the point Y.

The times taken by the trains to travel between X and Y are the same.

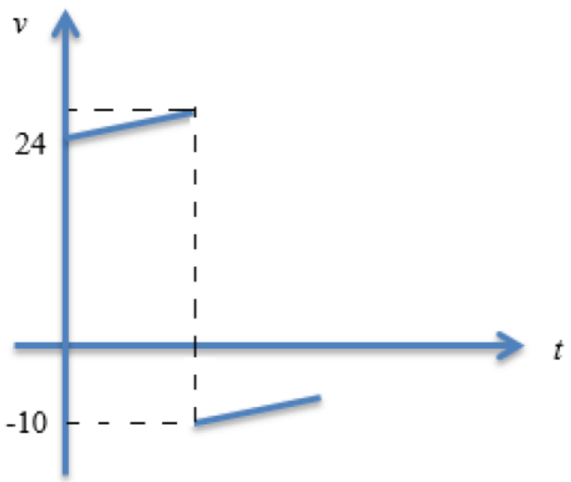
(a) Sketch, on the same diagram, the speed-time graphs for the motions of the two trains between X and Y.

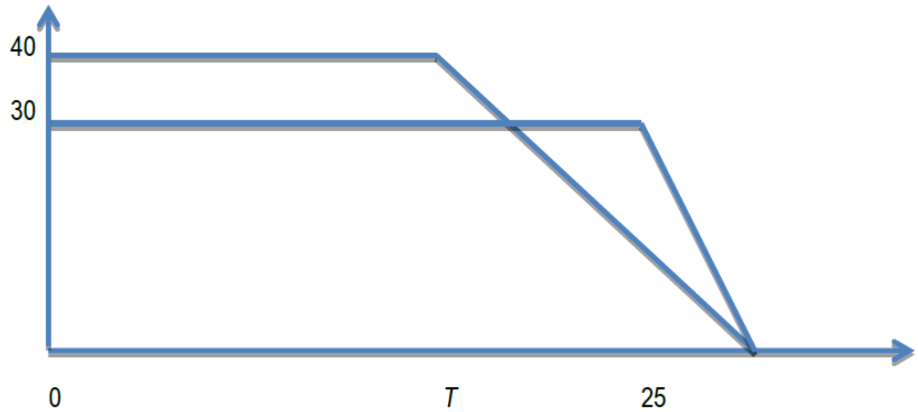
(4)

Given that $XY = 975$ m,

(b) find the value of T.

(8)

4.(a)	$V^2 = U^2 + 2g \times 2.5$	M1A1
	Eliminate V *and* solve for U	A1 **(DM1)**
	$7 = 0.2(10 - -V)$	M1A1
	$U = 24$	A1 (6)
4.(b)	$1 = 10t - 4.9t^2$ **OR** e.g. $v^2 = 10^2 - 2 \times 9.8 \times 1$ and $v = 10 - 9.8t$	
	$1 = 10t - 4.9t^2$ to give $\sqrt{80.4} = 10 - 9.8t$	M1 A1
	$t = \dfrac{10 \pm \sqrt{100 - 19.6}}{9.8}$ so $t = \dfrac{10 - \sqrt{10^2 - 2 \times 9.8 \times 1}}{9.8}$	**DM**1
	$t = 0.11$ s or 0.105 s	A1 (4)
4(c)		B1**ft**1st line B1 2nd line B1 ,-10 (3)

4(a)		B1 shape (M) B1 figs (40,T) B1 shape (N) B1 figs (30,25) (4)
(b)	**For N**: $\frac{1}{2}(25+25+t).30 = 975$ OR $\frac{1}{2}(25+t_1).30 = 975$ $t = 15$ $t_1 = 40$ **For M**: $\frac{1}{2}(25+t+T).40 = 975$ OR $\frac{1}{2}(t_1+T).40 = 975$ $T = 8.75$ ($8\frac{3}{4}$ or $\dfrac{35}{4}$ oe)	M1 A1 **DM**1 A1 M1 A1 **DM**1 A1 (8) **12**

2. A small stone is projected vertically upwards from a point O with a speed of $19.6 \mathrm{m s^{-1}}$.

Modelling the stone as a particle moving freely under gravity,

(a) find the greatest height above O reached by the stone,

(2)

(b) find the length of time for which the stone is more than 14.7 m above O.

(5)

7. A train travels along a straight horizontal track between two stations, A and B. The train starts from rest at A and moves with constant acceleration $0.5 \mathrm{~m~s^{-2}}$ until it reaches a speed of $V \mathrm{m s^{-1}}$, ($V < 50$). The train then travels at this constant speed before it moves with constant deceleration $0.25 \mathrm{~m~s^{-2}}$ until it comes to rest at B.

(a) Sketch in the space below a speed-time graph for the motion of the train between the two stations A and B.

(2)

The total time for the journey from A to B is 5 minutes.

(b) Find, in terms of V, the length of time, in seconds, for which the train is

(i) accelerating,

(ii) decelerating,

(iii) moving with constant speed.

(5)

Given that the distance between the two stations A and B is 6.3 km,

(c) find the value of V.

(6)

2(a)	$0^2 = 19.6^2 - 2 \times gH$ $H = 19.6\text{m}\ (20)$	M1 A1 (2)
(b)	$14.7 = 19.6t - \frac{1}{2}gt^2$ $t^2 - 4t + 3 = 0$ $(t-1)(t-3) = 0$ $t = 1$ or 3; Answer 2 s	M1 A1 **DM**1 A1; A1 (5)
		7

7(a)		B1 (shape) B1 (V) (2)
(b) **(i) (ii)** **(iii)**	$\frac{V}{t_1} = \frac{1}{2} \Rightarrow t_1 = 2V$ s; $t_2 = 4V$ s $t_3 = 300 - 2V - 4V = 300 - 6V$ s	M1 A1; A1 M1 A1 (5)
(c)	$6300 = \frac{V(300 + 300 - 6V)}{2}$ or $\frac{1}{2}2V.V + (300 - 6V).V + \frac{1}{2}4V.V$ $V^2 - 100V + 2100 = 0$ $(V-30)(V-70) = 0$ $V = 30$ or 70 $V = 30\ (< 50)$	M1 **A1 ft** A1 M1 A1 A1 (6)