Pearson

Topic 9

Constant Acceleration

Bronze, Silver, Gold
Worksheets for
AS Level Mathematics

ALWAYS LEARNING

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Teacher Notes

These Bronze, Silver and Gold worksheets are designed to be used either straight after the content has been taught or as part of a skills gap analysis, especially as students move into year 13.

They are drawn from the latest specification questions and legacy questions. The papers are between 25 and 35 marks.

The topic number on this worksheet relates to the corresponding chapter number in the 'Pearson Edexcel AS and A Level Mathematics: Statistics and Mechanics Year 1/AS' textbook.

Quick Links

(Press Ctrl, as you click with your mouse to follow these links)

- Bronze Questions
- Bronze Mark Scheme
- Silver Questions
- Silver Mark Scheme
- Gold Questions
- Gold Mark Scheme

Extension and Enrichment

If you have students that have enjoyed the challenge of the Gold questions, then they should have a go at the more challenging question from our Advanced Extension Award (AEA) papers. The Mathematics AEA is a single, 3 hour non-calculator paper, taken at the end of year 13. It helps students to develop high level problem solving and proof skills. It is entirely based on the content of the A Level Mathematics Course. No extra material needs to be covered to take the AEA in Mathematics. A second important difference is that marks are awarded for the clarity and quality of their solution. Developing this key skill, alongside the extra problem-solving experience, can pay dividends in the way they approach A Level Mathematics and Further Mathematics problems.

More information about the Advanced Extension Award can be found here on the Pearson Edexcel Website, or here on the Maths Emporium

Bronze Questions

Calculator

The total mark for this section is 35

Q1

A girl runs a 400 m race in a time of 84 s. In a model of this race, it is assumed that, starting from rest, she moves with constant acceleration for 4 s, reaching a speed of 5 m s^{-1}. She maintains this speed for 60 s and then moves with constant deceleration for 20 s, crossing the finishing line with a speed of V m s^{-1}.

(a) Sketch, in the space below, a speed-time graph for the motion of the girl during the whole race.

(2)

(b) Find the distance run by the girl in the first 64 s of the race.

(3)

(c) Find the value of V.

(5)

(d) Find the deceleration of the girl in the final 20 s of her race.

(2)

(Total for Question 1 is 12 marks)

Q2

A car is moving along a straight horizontal road with constant acceleration.

There are three points A, B and C, in that order, on the road, where $AB = 22\ m$ and $BC = 104\ m$.

The car takes 2 s to travel from A to B and 4 s to travel from B to C.

Find

(i) the acceleration of the car,

(ii) the speed of the car at the instant it passes A.

(Total for Question 2 is 7 marks)

Q3

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 ms^{-1}, she passes the point B. She moves with constant acceleration from A to B.

Given that $AB = 40$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)

(Total for Question 3 is 9 marks)

Q4

A small stone is projected vertically upwards from a point O with a speed of 19.6ms^{-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)

(Total for Question 4 is 7 marks)

End of Questions

Bronze Mark Scheme

Q1

Question Number	Scheme	Marks
(a)		B1 shape B1 figs (2)
(b)	$(\frac{1}{2}x4x5) + 60 \times 5$ $= 310$	M1 A1 A1 (3)
(c)	$\frac{(5+V)}{2} \times 20 = (400\text{-}310)$ $V = 4$	M1 A2 **ft** **DM**1 A1 (5)
(d)	$\frac{5-4}{20} = 0.05 \ \text{ms}^{-2}$	M1 A1 (2) **12**

Q2

Question	Scheme	Marks	AOs
(i)(ii)	Using a correct strategy for solving the problem by setting up two equations in a and u only and solving for either	M1	3.1b
	Equation in a and u only	M1	3.1b
	$22 = 2u + \frac{1}{2} a 2^2$	A1	1.1b
	Another equation in a and u only	M1	3.1b
	$126 = 6u + \frac{1}{2} a 6^2$	A1	1.1b
	5 m s^{-2}	A1	1.1b
	6 m s^{-1}	A1 ft	1.1b
			(7 marks)

Notes

1st M1 for solving the problem by setting up two equations in a and u only and solving for either
2nd M1 use of (one or more) *suvat* formulae to produce equation in u and a only
1st A1 for a correct equation
3rd M1 use of (one or more) *suvat* formulae to produce another equation in u and a only
2nd A1 for a correct equation
3rd A1 for correct accln 5 m s^{-2}
4th A1 for correct speed 6 m s^{-1} (The second of these A marks is an **ft** mark, following an incorrect value for u or a, depending on which has been found first)
N.B. Do not award the **ft** mark for absurd answers e.g. $a > 15$, $u > 50$

See alternative on next page

Q3

Question Number	Scheme	Marks
(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) $20 = 6t + \frac{1}{2}0.8t^2$ $t = \frac{-15 \pm \sqrt{225+200}}{2}$ $= 2.8$ or 2.81 or better	M1 M1 A1 **DM1** A1 (5)
	Alternative : Finding v $(=\sqrt{68})$ $s = vt - \frac{1}{2}at^2$ (A to M) $20 = \sqrt{68}t - \frac{1}{2}0.8t^2$ $t = \frac{\sqrt{68} \pm \sqrt{68-32}}{0.8}$ $= 2.8$ or 2.81 or better	M1 M1 A1 **DM1** A1 (5)
	Alternative : $s = vt_1 - \frac{1}{2}at_1^2$ (M to B) $20 = 10t_1 - \frac{1}{2}0.8t_1^2$ $t_1 = \frac{10 \pm \sqrt{100-32}}{0.8}$ $= 2.192$ $t = 5 - t_1 = 2.8$ or 2.81 or better	M2 A1 **DM1** A1 (5) **9**

Q4

Question Number	Scheme	Marks
(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 **DM1** A1; A1 (5) 7
(b) **ALT 1**	(their h - 14.7) = ½ g t^2 **OR** $v^2 = 19.6^2 - 2g$ x 14.7 => v = (±) 9.8 t =1 and 0 9.8 – 9.8 t => t = 1 Total = 2 x their 1 = 2 s	M1 A1 A1 **DM** 1 A1
(b) **ALT 2/3**	$v^2 = 19.6^2 - 2g$ x 14.7 $v = \pm 9.8$ **EITHER:** - 9.8 = 9.8 – gT $T = 2$ **OR:** 0 = 9.8t - ½ g t^2 t = (0) or 2	M1 A1 **DM1** A1 A1 **DM1** A1 A1
	Notes	
(a)	M1 is for a complete method (which could involve use of two *suvat* equations) for finding H i.e. for an equation in H *only*, condone sign errors A1 for 19.6 or 20 correctly obtained ($2g$ is A0)	
(b)	First M1 is for a quadratic equation in t only (where t is time at 14.7 above O) First A1 for a correct equation Second DM1, dependent on first M1, for solving for t Second A1 for both values of t, 1 and 3. **N.B.** If answer(s) are wrong or have come from an incorrect quadratic, and the quadratic formula has been used, M1 can only be awarded if there is clear evidence that the correct formula has been used. If their expression is not correct for their quadratic, allow a slip but only if we see an attempt to substitute into a stated correct formula. Third A1 for 2 s **N.B.** Obtaining $t = 1$ at $s = 14.7$ (above O) only, can score max M1 A1	

Silver Questions

Calculator

The total mark for this section is 36

Q1

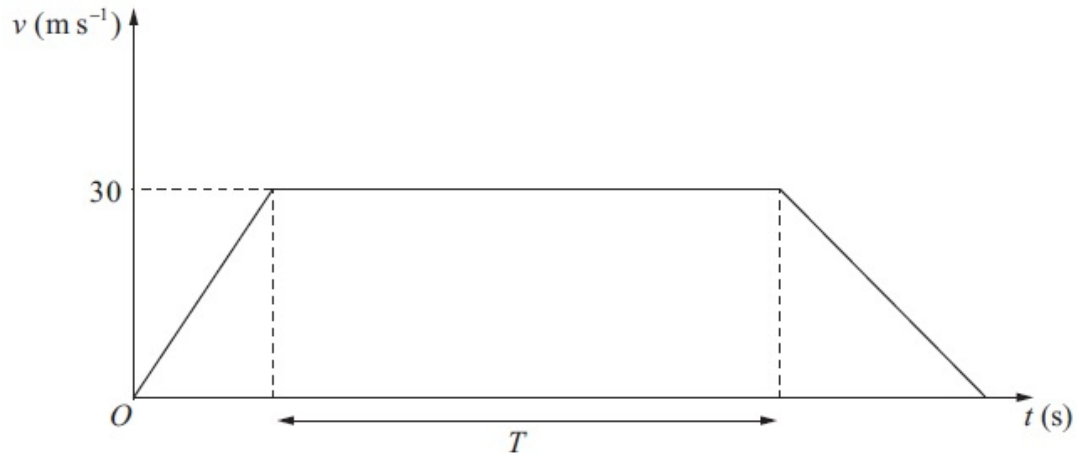


Figure 1

The velocity-time graph in Figure 1 represents the journey of a train P travelling along a straight horizontal track between two stations which are 1.5 km apart. The train P leaves the first station, accelerating uniformly from rest for 300 m until it reaches a speed of 30 m s^{-1}. The train then maintains this speed for T seconds before decelerating uniformly at 1.25 m s^{-2}, coming to rest at the next station.

(a) Find the acceleration of P during the first 300 m of its journey.

(2)

(b) Find the value of T.

(5)

A second train Q completes the same journey in the same total time. The train leaves the first station, accelerating uniformly from rest until it reaches a speed of V m s^{-1} and then immediately decelerates uniformly until it comes to rest at the next station.

(c) Sketch on the diagram above, a velocity-time graph which represents the journey of train Q.

(2)

(d) Find the value of V.

(6)

(Total for Question 1 is 15 marks)

Q2

A ball is projected vertically upwards with a speed of 14.7 m s^{-1} from a point which is 49 m above horizontal ground. Modelling the ball as a particle moving freely under gravity, find

(a) the greatest height, above the ground, reached by the ball,

(4)

(b) the speed with which the ball first strikes the ground,

(3)

(c) the total time from when the ball is projected to when it first strikes the ground.

(3)

(Total for Question 2 is 10 marks)

Q3

At time $t = 0$, a small ball is projected vertically upwards with speed U m s^{-1} from a point A that is 16.8 m
above horizontal ground.

The speed of the ball at the instant immediately before it hits the ground for the first time is 19 m s^{-1}

The ball hits the ground for the first time at time $t = T$ seconds.

The motion of the ball, from the instant it is projected until the instant just before it hits the ground for the first time, is modelled as that of a particle moving freely under gravity.

The acceleration due to gravity is modelled as having magnitude 10 m s^{-2}

Using the model,

(a) show that $U = 5$

(2)

(b) find the value of T,

(2)

(c) find the time from the instant the ball is projected until the instant when the ball is 1.2 m below A.

(4)

(d) Sketch a velocity-time graph for the motion of the ball for $0 \leq t \leq T$, stating the coordinates of the start point and the end point of your graph.

(2)

In a refinement of the model of the motion of the ball, the effect of air resistance on the ball is included and this refined model is now used to find the value of U.

(e) State, with a reason, how this new value of U would compare with the value found in part (a), using the initial unrefined model.

(1)

(Total for Question 3 is 11 marks)

End of Questions

Silver Mark Scheme

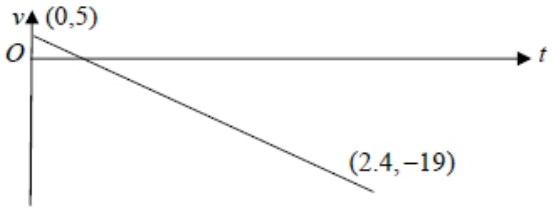
Q1

Question Number	Scheme	Marks
(a)	$30^2 = 2a.300$ $a = 1.5$	M1 A1 (2)
(b)	$0^2 = 30^2 - 2 \text{ x } 1.25s$ OR $0 = 30 - 1.25t_2$ $s = 360$ $t_2 = 24$ $300 + 30T + 360 = 1500$ $\frac{(20+T+24+T)}{2} \text{ x } 30 = 1500$ $T = 28$ $T = 28$	M1 A1 M1 A1 A1 (5)
(c)	triangle, *drawn on the diagram*, with base coinciding with base of trapezium, top vertex above line $v = 30$ and meeting trapezium at least once V marked correctly	B1 DB1 (2)
(d)	$30 = 1.5t_1 \Rightarrow t_1 = 20$ $30 = 1.25t_2 \Rightarrow t_2 = 24$ $\frac{1}{2}(20 + 28 + 24)V = 1500$ $V = \frac{750}{18} = 41.67$ $= \frac{125}{3}$ (oe) 0r 42 (or better)	M1 A1 A1 M1 A1 A1 (6)

Q2

Question Number	Scheme	Marks
(a)	$(\uparrow) v^2 = u^2 + 2as$ $0 = 14.7^2 - 2\text{x } 9.8 \text{ x } s$ $s = 11.025$ (or 11 or 11.0 or 11.03) m Height is 60 m or 60.0 m **ft**	M1A1 A1 A1ft (4)
(b)	$(\downarrow) v^2 = u^2 + 2as$ $v^2 = (-14.7)^2 + 2\text{x } 9.8 \text{ x } 49$ $v = 34.3$ or 34 m s^{-1}	M1 A1 A1 (3)
(c)	$(\downarrow) v = u + at$ **OR** $(\downarrow) s = ut + \frac{1}{2}at^2$ $34.3 = -14.7 + 9.8t$ $49 = -14.7t + 4.9t^2$ $t = 5$ $t = 5$	M1 A1 A1 (3) **[10]**

Q3

Question	Scheme	Marks	AOs
(a)	$19^2 = (-U)^2 + 2\times10\times16.8$ (Allow use of $g = 9.8$ for this M mark)	M1	2.1
	$U = 5$ *	A1*	1.1b
		(2)	
	For consistent use of $g = 9.8$ in parts (b), (c) and (d), treat as a MR. i.e. max (b) M1A0 (c)M1A0M(A)0A1ft (d)B1B1ft		
(b)	$19 = -5 + 10T$ **OR** $16.8 = \frac{(-5+19)}{2}T$ **OR** $16.8 = -5T + \frac{1}{2}\times10T^2$ **OR** $16.8 = 19T - \frac{1}{2}\times10T^2$	M1	2.1
	$T = 2.4$	A1	1.1b
		(2)	
(c)	$1.2 = -5t + \frac{1}{2}\times10\times t^2$	M1	2.1
	$5t^2 - 5t - 1.2 = 0$	A1	1.1b
		M(A)1	1.1b
	$t = 1.2$ (s)	A1	1.1b
		(4)	
(d)		B1 shape	1.1b
	(0,5) and (2.4, −19) Allow these to be marked on the axes.	B1ft	1.1b
		(2)	
(e)	Greater since air resistance would slow the ball down.	B1	3.5a
		(1)	

Notes:		
(a)	M1	Complete method to find U, condone sign errors and use of $g = 9.8$
	A1*	$U = 5$ cao correctly obtained – allow U^2 instead of $(-U)^2$. Allow verification.
(b)	M1	Complete method to find T, condone sign errors
	A1	$T = 2.4$
(c)	M1	Complete method to find t, condone sign errors
	A1	Correct equation with at most one error
	(A)1	Correct equation
	A1	$t = 1.2$ (s)
(d)	B1	Graph could be reflected in the t-axis.
	B1ft	Follow through on their T value. If graph is reflected, $(0, -5)$ and $(2.4, 19)$
(e)	B1	Any similar appropriate comment
(f)	B1	B0 if any incorrect extras e.g. weight/mass included

Gold Questions

Calculator

The total mark for this section is 35

Q1

A car is travelling along a straight horizontal road. The car takes 120 s to travel between two sets of traffic lights which are 2145 m apart. The car starts from rest at the first set of traffic lights and moves with constant acceleration for 30 s until its speed is 22 m s^{-1}. The car maintains this speed for T seconds. The car then moves with constant deceleration, coming to rest at the second set of traffic lights.

(a) Sketch, in the space below, a speed-time graph for the motion of the car between the two sets of traffic lights.

(2)

(b) Find the value of T.

(3)

A motorcycle leaves the first set of traffic lights 10 s after the car has left the first set of traffic lights. The motorcycle moves from rest with constant acceleration, a m s^{-2}, and passes the car at the point A which is 990 m from the first set of traffic lights. When the motorcycle passes the car, the car is moving with speed 22 m s^{-1}.

(c) Find the time it takes for the motorcycle to move from the first set of traffic lights to the point A.

(4)

(d) Find the value of a.

(2)

(Total for Question 1 is 11 marks)

Q2

At time $t = 0$, two balls A and B are projected vertically upwards. The ball A is projected vertically upwards with speed 2 m s^{-1} from a point 50 m above the horizontal ground. The ball B is projected vertically upwards from the ground with speed 20 m s^{-1}. At time $t = T$ seconds, the two balls are at the same vertical height, h metres, above the ground. The balls are modelled as particles moving freely under gravity. Find

(a) the value of T,

(5)

(a) the value of h,

(2)

(Total for Question 2 is 7 marks)

Q3

At time $t = 0$, a parachutist falls vertically from rest from a helicopter which is hovering at a height of 550 m above horizontal ground.

The parachutist, who is modelled as a particle, falls for 3 seconds before her parachute opens.

While she is falling, and before her parachute opens, she is modelled as falling freely under gravity.

The acceleration due to gravity is modelled as being 10 m s^{-2}.

(a) Using this model, find the speed of the parachutist at the instant her parachute opens.

(1)

When her parachute is open, the parachutist continues to fall vertically.

Immediately after her parachute opens, she decelerates at 12 m s^{-2} for 2 seconds before reaching a constant speed and she reaches the ground with this speed.

The total time taken by the parachutist to fall the 550 m from the helicopter to the ground is T seconds.

(b) Sketch a speed–time graph for the motion of the parachutist for $0 \leq t \leq T$.

(2)

(c) Find, to the nearest whole number, the value of T.

(5)

In a refinement of the model of the motion of the parachutist, the effect of air resistance is included before her parachute opens and this refined model is now used to find a new value of T.

(d) How would this new value of T compare with the value found, using the initial model, in part (c)?

(1)

(Total for Question 3 is 9 marks)

Q4

At time $t = 0$, a particle is projected vertically upwards with speed u from a point A. The particle moves freely under gravity. At time T the particle is at its maximum height H above A.

(a) Find T in terms of u and g.

(2)

(b) Show that $H = \frac{u^2}{2g}$

(2)

The point A is at a height $3H$ above the ground.

(c) Find, in terms of T, the total time from the instant of projection to the instant when the particle hits the ground.

(4)

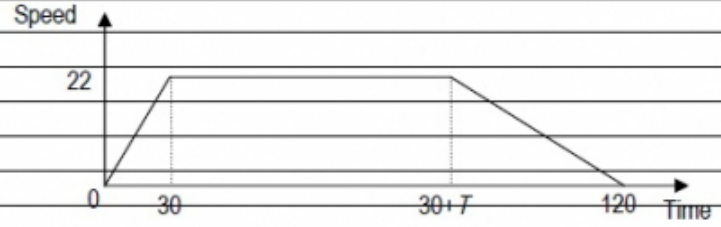
(4)

(Total for Question 4 is 8 marks)

End of Questions

Gold Mark Scheme

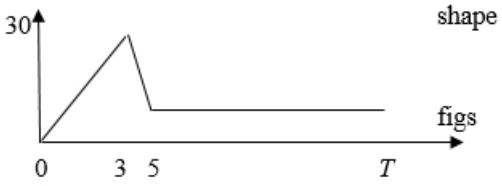
Q1

Question Number	Scheme	Marks
(a)	 Shape	B1
	Figures	B1
		(2)
(b)	$\frac{(120+T)22}{2} = 2145$	M1 A1
	$T = 75$	A1
		(3)
(c)	$\frac{(t+t-30)22}{2} = 990$	M1 A1
	$t = 60$	A1
	Answer $= 60 - 10 = 50$	A1
		(4)
(d)	$990 = 0.5a50^2$	M1
	$a = 0.79, 0.792, 99/125$ oe	A1
		(2)
		[11]

Q2

Question Number	Scheme	Marks
(a)	Use of $s = ut + \frac{1}{2}at^2$	M1
	$-2t + \frac{1}{2}gt^2$ (+ or – 50)	A1
	$20t - \frac{1}{2}gt^2$ (+ or – 50)	A1
	$50 = -2T + \frac{1}{2}gT^2 + 20T - \frac{1}{2}gT^2 = 18T$	M1
	$T = \frac{50}{18} = 2.777.... = 2.8$ or better	A1
		(5)
(b)	$h = 20 \times T - 4.9 \times T^2 = 17.74.... \approx 17.7$ (18 to 2 s.f.) (use of 2.8 gives 17.584)	M1A1
		(2) **[7]**
	Notes on Question	
Q (a)	First M1 for use of $s = ut + 1/2at^2$ (or use of 2 *suvat* formulae AND eliminating v, to give an equation in s and t). N.B. M0 if they use $s = 50$ or $u = 0$ or $v = 0$) First A1 with $u = 2$ and $a = -g$ or -9.8 to obtain a distance, possibly with 50 added or subtracted. (2 and 4.9 must have *opposite* signs) Second A1 with $u = 20$ and $a = -g$ or -9.8 to obtain a distance, possibly with 50 added or subtracted. (2 and 4.9 must have *opposite* signs) Second M1 dependent on first M1 for a *correct* equation obtained correctly in T only. Third A1 for 25/9 oe, 2.8 or better	
Q (b)	First M1 for substituting their T value (allow –ve changed to +ve but A mark is then unavailable) into an appropriate equation First A1 for 17.7 or 18 (m). (A0 if they then add 50)	

Q3

Question	Scheme	Marks	AOs	Notes
(a)	$V = 30\ (\text{m s}^{-1})$	B1	3.4	cao
		(1)		
(b)		B1	1.1 b	Overall shape of the graph, starting at the origin. Dotted vertical line at end is OK but solid vertical line is B0
		B1**ft**	1.1 b	3, 5 and T marked on the t-axis, and **ft** on their 30 marked on the speed axis. 3 must be where graph reaches a peak. Allow delineators: 3, 2 and $T-5$ or a mixture
		(2)		
(c)	Using total area = 550 to set up an equation in **one unknown,** Or they may use *suvat* on one or more of the sections (but must still be considering all sections) M0 if they use one *suvat* equation for the whole motion	M1	2.1	Need all sections to be included, with correct structure for each section. e.g. triangle + trapezium + rectangle oe = 550 to give an equation in **one unknown (may not be *T*)**
	$\frac{1}{2}\times 3\times 30+\frac{(30+6)}{2}\times 2+6(T-5)=550$ **OR**: $\frac{1}{2}\times 3\times 30+\frac{1}{2}\times 2\times 24+6(T-3)=550$ **OR:** $\frac{1}{2}\times 3\times 30+\frac{1}{2}\times 2\times 24+(2\times 6)+6(T-5)=550$	A2 **ft**	1.1 b	**ft** on their answer to (a). -1 each error. **N.B.** If '6' is incorrect, treat as one error, unless it is correct ft from their 30.
	Solve for T	M1	1.1 b	Attempt to solve for T provided they have tried to find the area using at least 3 sections. (M0 if they only solve for their unknown and never try to find T)
	$T = 83$ (nearest whole number)	A1	1.1 b	83 is the only answer
		(5)		
(d)	New value of T would be bigger (ignore their reasons whether correct or not)	B1	3.5 a	Clear statement about the value of T Allow '*it* would increase, get larger etc' B0 for 'Takes longer' or 'the value of T would be longer'
		(1)		

Q4

Question Number	Scheme	Marks
(a)	Max ht $v=0$. $v=u-gt \Rightarrow T=\dfrac{u}{g}$	M1A1 (2)
(b)	Max ht $H=ut+\dfrac{1}{2}at^2=\dfrac{u^2}{g}-\dfrac{u^2}{2g}=\dfrac{u^2}{2g}$ * Given answer* Or use of $v^2=u^2+2as$	M1A1 (2)
(c)	$-3\times\dfrac{u^2}{2g}=ut-\dfrac{1}{2}gt^2$ $-3u^2=2ugt-g^2t^2$ $g^2t^2-2ugt-3u^2=0, \quad gt=\dfrac{2u\pm\sqrt{4u^2+12u^2}}{2}$ $t=\dfrac{3u}{g}=3T$	M1 **DM1** A1 A1 (4)
(c) alt	$-4H=-\dfrac{1}{2}gt^2$ Total time $=T+\sqrt{\dfrac{8H}{g}}=T+\sqrt{\dfrac{8u^2}{2g^2}}$ $=T+2T=3T$	M1 **DM1A1** A1 (4)
		[8]

Notes for Question

Question

In this question, condone sign errors in a *suvat* equation for the M mark, but a missing term is M0 or an incorrect term is M0. An incorrect *suvat* formula is M0

Allow use of symmetry of motion.

e.g. in (a), using $v = u + at$, *either* $0 = u - gT$ *or* $u = 0 + gT$

Question (a)

M1 for use of *suvat* to obtain an equation in T, u and g only.

A1 for $T = u/g$ correctly obtained.

Question (b)

M1 for use of *suvat* to obtain an equation in H, u and g only.

A1 for $H = u^2/2g$ correctly obtained **(given answer)**

Question (c) *Watch out for t / T confusion* (N.B. if only T's used, M0DM0)

First M1 for a complete method to find the *total* time in terms of u, g, H or T:-

either: $3H = -ut + \frac{1}{2} gt^2$

or: $4H = \frac{1}{2} gt^2$ and $t + T$

or: $v^2 = u^2 + 6gH$ and $v = -u + gt$,with v eliminated

Second M1, **dependent on first M1**, for producing an expression, in terms of u, g, H or T, for the total time, by solving a quadratic

First A1 for any correct expression for the total time in terms of u, g, H or T.

Second A1 for $3T$ cso

Pearson

Topic 10

Forces and Motion

Bronze, Silver, Gold
Worksheets for
AS Level Mathematics

Teacher Notes

These Bronze, Silver and Gold worksheets are designed to be used either straight after the content has been taught or as part of a skills gap analysis, especially as students move into year 13.

They are drawn from the latest specification questions and legacy questions. The papers are between 25 and 35 marks.

The topic number on this worksheet relates to the corresponding chapter number in the 'Pearson Edexcel AS and A Level Mathematics: Statistics and Mechanics Year 1/AS' textbook.

Quick Links

(Press Ctrl, as you click with your mouse to follow these links)

- Bronze Questions
- Bronze Mark Scheme
- Silver Questions
- Silver Mark Scheme
- Gold Questions
- Gold Mark Scheme

Extension and Enrichment

If you have students that have enjoyed the challenge of the Gold questions, then they should have a go at the more challenging question from our Advanced Extension Award (AEA) papers. The Mathematics AEA is a single, 3 hour non-calculator paper, taken at the end of year 13. It helps students to develop high level problem solving and proof skills. It is entirely based on the content of the A Level Mathematics Course. No extra material needs to be covered to take the AEA in Mathematics. A second important difference is that marks are awarded for the clarity and quality of their solution. Developing this key skill, alongside the extra problem-solving experience, can pay dividends in the way they approach A Level Mathematics and Further Mathematics problems.

More information about the Advanced Extension Award can be found here on the Pearson Edexcel Website, or here on the Maths Emporium

Bronze Questions

Calculator

The total mark for this section is 24

Q1

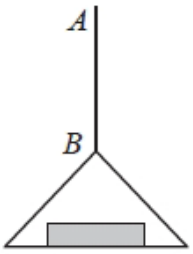


Figure 1

A vertical rope AB has its end B attached to the top of a scale pan. The scale pan has mass 0.5 kg and carries a brick of mass 1.5 kg, as shown in Figure 1. The scale pan is raised vertically upwards with constant acceleration 0.5 m s^{-2} using the rope AB. The rope is modelled as a light inextensible string.

(a) Find the tension in the rope AB.

(3)

(b) Find the magnitude of the force exerted on the scale pan by the brick.

(3)

(Total for Question 1 is 6 marks)

Q2

A car of mass 1000 kg is towing a caravan of mass 750 kg along a straight horizontal road. The caravan is connected to the car by a tow-bar which is parallel to the direction of motion of the car and the caravan. The tow-bar is modelled as a light rod. The engine of the car provides a constant driving force of 3200 N. The resistances to the motion of the car and the caravan are modelled as constant forces of magnitude 800 newtons and R newtons respectively.

Given that the acceleration of the car and the caravan is 0.88 m s^{-2},

(a) show that $R = 860$,

(3)

(b) find the tension in the tow-bar.

(3)

(Total for Question 2 is 6 marks)

Q3

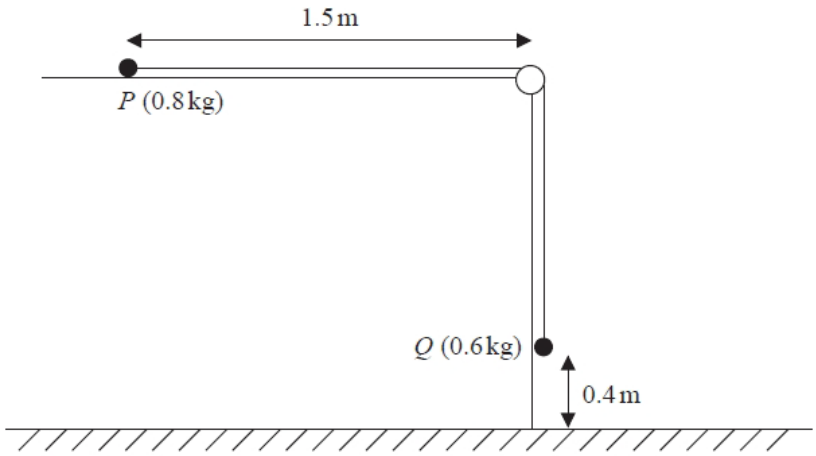


Figure 2

A small ball, P, of mass 0.8 kg, is held at rest on a smooth horizontal table and is attached to one end of a thin rope.

The rope passes over a pulley that is fixed at the edge of the table.

The other end of the rope is attached to another small ball, Q, of mass 0.6 kg, that hangs freely below the pulley.

Ball P is released from rest, with the rope taut, with P at a distance of 1.5 m from the pulley and with Q at a height of 0.4 m above the horizontal floor, as shown in Figure 1.

Ball Q descends, hits the floor and does not rebound.

The balls are modelled as particles, the rope as a light and inextensible string and the pulley as small and smooth.

Using this model,

(a) show that the acceleration of Q, as it falls, is 4.2 m s^{-2}

(5)

(b) find the time taken by P to hit the pulley from the instant when P is released.

(6)

(c) State one limitation of the model that will affect the accuracy of your answer to part (a).

(1)

(Total for Question 3 is 12 marks)

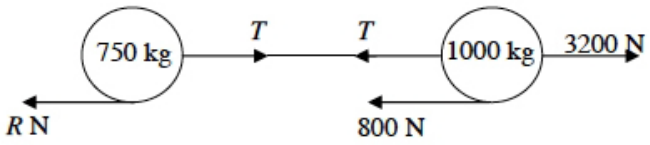
End of Questions

Bronze Mark Scheme

Q1

Question Number	Scheme	Marks
(a)	$T - 0.5g - 1.5g = 2 \times 0.5$ $T = 20.6$ (N) or 21 (N)	M1 A1 A1 (3)
(b)	$R - 1.5g = 1.5 \leftrightarrow 0.5$ Force = 15.5 (N) or 15 (N) OR: $T - R - 0.5g = 0.5 \leftrightarrow 0.5$ Force = 15.5 (N) or 15 (N)	M1 A1 A1 (3) **OR** M1 A1 A1 (3) **6**
	Notes	
(a)	**N.B.** In both parts of this question use the mass which is being used to guide you as to which part of the system is being considered M1 is for an equation for whole system in T only, with usual rules First A1 for a correct equation Second A1 for 20.6 or 21	
(b)	First M1 is for an equation for the brick only (1st alternative) or for the scale pan only (2nd alternative) with usual rules. First A1 for a correct equation (in the second alternative T does not need to be substituted) Second A1 for 15.5 or 15	
	N.B. If R is replaced by $-R$ in either equation, can score M1A1. This would lead to $R = -15.5$ or -15. The second A1 can then only be scored if the candidate explains why the –ve sign is being ignored.	

Q2

Question Number	Scheme	Marks
(a)	 For the whole system R(→) $3200-800-R=1750\times0.88$ Leading to $R=860$ *	M1 A1 A1 (3)
(b)	For the caravan R(→) $T-860=750\times0.88$ Leading to $T=1520$ (N)	M1 A1 A1 (3) **6**
	Alternative for (b) For the car R(→) $3200-800-T=1000\times0.88$ Leading to $T=1520$ (N)	M1 A1 A1 (3)

Q3

Question	Scheme	Marks	AOs	Notes
(a)	Equation of motion for Q	M1	3.3	Equation of motion for Q with correct no. of terms, condone sign errors.
	$0.6g - T = 0.6a$	A1	1.1 b	A correct equation
	Equation of motion for P	M1	3.3	Equation of motion for Q with correct no. of terms, condone sign errors.
	$T = 0.8a$	A1	1.1 b	A correct equation
	$a = 4.2$ (m s^{-2}) *	A1*	2.2 a	Given acceleration obtained correctly. **You must see an equation in a only before reaching $a = 4.2$**
		(5)		**N.B.** if they just use the whole system equation: $0.6g = 1.4a$, can only score max M1A1M0A0A0 **N.B.** Use of $g = 9.81$ or 10 loses final A mark only. **N.B.** Complete verification, using both equations, can score full marks.

(b)	$0.4=\frac{1}{2}\times 4.2\times t_1^2$ or e.g. they may find v first and then use $v=4.2t_1$	M1	2.1	Complete method (they may use more than one *suvat* equation) to find time for Q to hit the floor (M0 if 0.4 **not** used as distance moved and/or if 4.2 is **not** used as acceleration and this applies to finding v as well if they use v to find t_1)
	$t_1 = 0.436(4357\ldots..)$ Allow 0.43, 0.44, 0.436, or better, or any surd form e.g. $\frac{2}{\sqrt{21}}$	A1	1.1 b	See alternatives
	$v=4.2\times t_1$ or $v=\sqrt{2\times 4.2\times 0.4}$ or $0.4=\frac{(0+v)}{2}\times t_1$ $(v=1.8330\ldots)$	M1	3.4	Complete method to find speed of Q as it hits the floor (M0 if 0.4 **not** used as distance moved and/or if 4.2 is **not** used as acceleration and this applies to finding t_1 as well if they use t_1 to find v)
	$t_2=\frac{1.5-0.4}{v}$	M1	1.1 b	Uses distance/speed to find time for P to hit the pulley after Q has hit the floor. N.B. This is independent of previous M mark.
	Complete strategy to solve the problem by finding the sum of the two times t_1+t_2	**DM** 1	3.1 b	Complete method to solve the problem by finding and adding the two required times, dependent on previous three M marks
	1.0 (s) or 1.04 (s)	A1	1.1 b	
		(6)		
(c)	e.g. rope being light; rope being inextensible; pulley being smooth; pulley being small; balls being particles	B1	3.5 b	Clear statement. Allow negatives of these i.e. the rope may not be light, the rope may not be inextensible etc Must be a limitation of the model stated in the question Penalise incorrect or irrelevant extras
		(1)		B0 for: Air resistance, table being smooth
		(12 marks)		

Silver Questions

Calculator

The total mark for this section is 35

Q1

A woman travels in a lift. The mass of the woman is 50 kg and the mass of the lift is 950 kg. The lift is being raised vertically by a vertical cable which is attached to the top of the lift. The lift is moving upwards and has constant deceleration of 2 m s^{-2}. By modelling the cable as being light and inextensible, find

(a) the tension in the cable,

(3)

(b) the magnitude of the force exerted on the woman by the floor of the lift.

(3)

(Total for Question 1 is 6 marks)

Q2

A car of mass 800 kg pulls a trailer of mass 200 kg along a straight horizontal road using a light towbar which is parallel to the road. The horizontal resistances to motion of the car and the trailer have magnitudes 400 N and 200 N respectively. The engine of the car produces a constant horizontal driving force on the car of magnitude 1200 N. Find

(a) the acceleration of the car and trailer,

(3)

(b) the magnitude of the tension in the towbar.

(3)

The car is moving along the road when the driver sees a hazard ahead. He reduces the force produced by the engine to zero and applies the brakes. The brakes produce a force on the car of magnitude F newtons and the car and trailer decelerate. Given that the resistances to motion are unchanged and the magnitude of the thrust in the towbar is 100 N,

(c) find the value of F.

(7)

(Total for Question 2 is 13 marks)

Q3

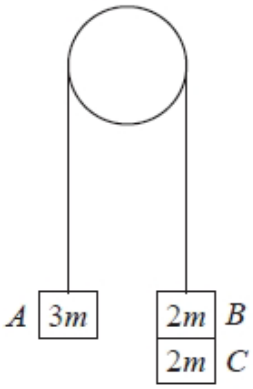


Figure 1

Three particles A, B and C have masses $3m$, $2m$ and $2m$ respectively. Particle C is attached to particle B. Particles A and B are connected by a light inextensible string which passes over a smooth light fixed pulley. The system is held at rest with the string taut and the hanging parts of the string vertical, as shown in Figure 1. The system is released from rest and A moves upwards.

(a) (i) Show that the acceleration of A is $\frac{g}{7}$

(ii) Find the tension in the string as A ascends.

(7)

At the instant when A is 0.7 m above its original position, C separates from B and falls away. In the subsequent motion, A does not reach the pulley.

(b) Find the speed of A at the instant when it is 0.7 m above its original position.

(2)

(c) Find the acceleration of A at the instant after C separates from B.

(4)

(d) Find the greatest height reached by A above its original position.

(3)

(Total for Question 3 is 16 marks)

End of Questions

Silver Mark Scheme

Q1

Question Number	Scheme	Marks
(a)	For system, $(\uparrow)$, $T - 950g - 50g = 1000 \times -2$	M1 A1
	$T = 7800$ N	A1
		(3)
(b)	For woman, $(\uparrow)$, $R - 50g = 50 \times -2$	M1 A1
	$R = 390$ N	A1
		(3)
		[6]
	Notes for Question	
Q (a)	(In both parts, use the *mass* to decide which part of the system is being considered and M marks can only be scored if an equation contains only forces acting on that part of the system) M1 is for a complete method for finding T i.e. for an equation in T *only*, dimensionally correct, with the correct number of terms. First A1 for a correct equation. Second A1 for 7800 (N).	
Q (b)	M1 is for a complete method for finding R i.e. for an equation in R *only*, dimensionally correct, with the correct number of terms. First A1 for a correct equation. Second A1 for 390 (N). N.B. Equation for lift *only* is: $T - 950g - R = 950 \times (-2)$	

Q2

Question Number	Scheme	Marks
(a)	For whole system: $1200 - 400 - 200 = 1000a$	M1 A1
	$a = 0.6$ m s^{-2}	A1 (3)
(b)	For trailer: $T - 200 = 200 \times 0.6$	M1 A1 ft
	$T = 320$ N	A1
		OR:
	OR: For car: $1200 - 400 - T = 800 \times 0.6$	M1 A1 ft
	$T = 320$ N	A1 (3)
(c)	For trailer: $200 + 100 = 200f$ or $-200f$	M1 A1
	$f = 1.5$ m s^{-2} (-1.5)	A1
	For car: $400 + F - 100 = 800f$ or $-800f$	M1 A2
	$F = 900$	A1 (7)
	(N.B. For both: $400 + 200 + F = 1000f$)	[13]

Q3

Question Number	Scheme	Marks
(a)	$4mg - T = 4ma$	M1A1
	$T - 3mg = 3ma$	M1A1
	Condone the use of $4mg - 3mg = 4ma + 3ma$ in place of one of these equations.	M1A1
	Reach **given answer** $a = \frac{g}{7}$ correctly ***	A1
	Form an equation in T: $T = 3mg + 3\left(mg - \frac{T}{4}\right)$, $T = 3mg + 3m\frac{g}{7}$, or $T = 4mg - 4m\frac{g}{7}$	M1
	$T = \frac{24}{7}mg$ or equivalent, $33.6m$, $34m$	A1 (7)
(b)	$v^2 = u^2 + 2as = 2 \times \frac{g}{7} \times 0.7 = 1.96$, $v = 1.4$ ms^{-1}	M1A1 (2)
(c)	$3mg - T = 3ma$ $T - 2mg = 2ma$ $a = \frac{g}{5}$	M1A1 A1 A1 (4)
(d)	$0 = 1.96 - 2 \times \frac{g}{5} \times s$	M1
	$s = \frac{5 \times 1.96}{2g} = 0.5$ (m)	A1
	Total height = $0.7 + 0.5 = 1.2$ (m)	A1 **ft** (3)

Gold Questions

Calculator

The total mark for this section is 30

Q1

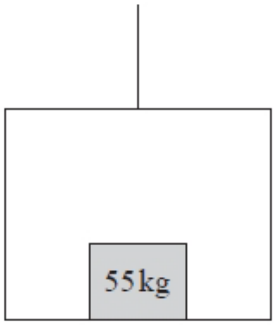


Figure 1

A lift of mass 200 kg is being lowered into a mineshaft by a vertical cable attached to the top of the lift. A crate of mass 55 kg is on the floor inside the lift, as shown in Figure 1. The lift descends vertically with constant acceleration. There is a constant upwards resistance of magnitude 150 N on the lift. The crate experiences a constant normal reaction of magnitude 473 N from the floor of the lift.

(a) Find the acceleration of the lift.

(3)

(b) Find the magnitude of the force exerted on the lift by the cable.

(4)

(Total for Question 1 is 7 marks)

Q2

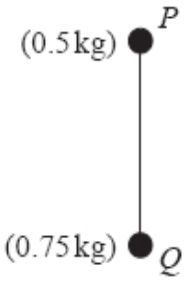


Figure 2

A vertical light rod PQ has a particle of mass 0.5kg attached to it at P and a particle of mass 0.75kg attached to it at Q, to form a system, as shown in Figure 2. The system is accelerated vertically upwards by a vertical force of magnitude 15N applied to the particle at Q. Find the thrust in the rod.

(Total for Question 2 is 6 marks)

Q3

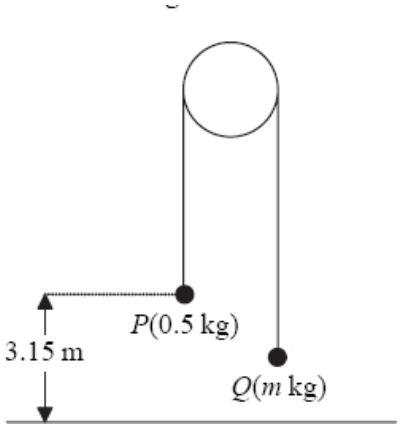


Figure 3

Two particles P and Q have mass 0.5 kg and m kg respectively, where $m < 0.5$. The particles are connected by a light inextensible string which passes over a smooth, fixed pulley, as shown in Figure 3. Initially P is 3.15 m above horizontal ground. The particles are released from rest with the string taut and the hanging parts of the string vertical, as shown in Figure 4. After P has been descending for 1.5 s, it strikes the ground. Particle P reaches the ground before Q has reached the pulley.

(a) Show that the acceleration of P as it descends is 2.8 m s^{-2}.

(3)

(b) Find the tension in the string as P descends.

(3)

(c) Show that $m = \frac{5}{18}$.

(4)

(d) State how you have used the information that the string is inextensible.

(1)

When P strikes the ground, P does not rebound and the string becomes slack. Particle Q then moves freely under gravity, without reaching the pulley, until the string becomes taut again.

(e) Find the time between the instant when P strikes the ground and the instant when the string becomes taut again.

(6)

(Total for Question 3 is 17 marks)

End of Questions

Gold Mark Scheme

Q1

Question Number	Scheme	Marks
(a)	For crate, $55g - 473 = 55a$ $a = 1.2 \text{ m s}^{-2}$	M1 A1 A1 (3)
(b)	For system, $55g + 200g \pm T - 150 = 255a$ Magnitude $= 2040$ N or 2000 N OR For lift, $200g + 473 - 150 \pm T = 200a$ Magnitude $= 2040$ N or 2000 N	M1 A2 A1 M1 A2 A1 (4) 7
	Notes	
(a)	M1 for an equation in a only, with usual rules. First A1 for a correct equation Second A1 for 1.2 (m s^{-2}). Allow – 1.2 (m s^{-2}) if appropriate	
(b)	M1 for an equation, in T and a , for the system or the lift only, with usual rules. (a does not need to be a numerical value) A2 (-1 each error) for a correct equation (**Allow** $\pm T$). We do **not** need to see a numerical value for a. Third A1 for 2040 (N) or 2000 (N) **N.B.** In both parts of this question use the mass which is being used to guide you as to which part of the system is being considered.	

Q2

Question Number	Scheme	Marks
	$T - 0.5g = 0.5a$ $15 - T - 0.75g = 0.75a$ (OR: $15 - 0.5g - 0.75g = 1.25a$) $(a = 2.2 \text{ m s}^{-2})$ $T = 6$ N	M1 A1 M1 A1 M1 A1 **6**
	Notes	
	First M1 for an equation of motion for either P or Q with usual rules i.e. correct no. of terms, dimensionally correct but condone sign errors First A1 for a correct equation (allow T replaced by $-T$ and/or a replaced by $-a$) Second M1 for another equation of motion (for either P or Q or whole system) with usual rules as above Second A1 for a correct equation (allow T consistently replaced by $-T$ and/or a consistently replaced by $-a$) Third M1 for solving two THREE term equations of **motion** for T Third A1 for 6 (N). Must be positive but allow a change from – 6 to 6, if they have consistently used $-T$ instead of T.	

Q3

Question Number	Scheme	Marks
	(a) $s = ut + \frac{1}{2}at^2 \Rightarrow 3.15 = \frac{1}{2}a \times \frac{9}{4}$ $a = 2.8 \quad (\text{m s}^{-2})$ * cso	M1 A1 A1 **(3)**
	(b) N2L for P: $0.5g - T = 0.5 \times 2.8$ $T = 3.5 \quad (\text{N})$	M1 A1 A1 **(3)**
	(c) N2L for Q: $T - mg = 2.8m$ $m = \frac{3.5}{12.6} = \frac{5}{18}$ * cso	M1 A1 DM1 A1 **(4)**
	(d) The acceleration of P is equal to the acceleration of Q.	B1 **(1)**
	(e) $v = u + at \Rightarrow v = 2.8 \times 1.5$ (or $v^2 = u^2 + 2as \Rightarrow v^2 = 2 \times 2.8 \times 3.15$) $(v^2 = 17.64, v = 4.2)$	M1 A1
	$v = u + at \Rightarrow 4.2 = -4.2 + 9.8t$ $t = \frac{6}{7}$, 0.86, 0.857 (s)	DM1 A1 DM1 A1 **(6)**
		[17]

Pearson

Topic 11

Variable Acceleration

Bronze, Silver, Gold
Worksheets for
AS Level Mathematics

ALWAYS LEARNING

PEARSON

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Bronze Questions

Calculator

The total mark for this section is 30

Q1

A particle P moves along a straight line such that at time t seconds, $t \geq 0$, after leaving the point O on the line,
the velocity, v m s^{-1}, of P is modelled as

$$v = (7 - 2t)(t + 2)$$

(a) Find the value of t at the instant when P stops accelerating.

(4)

(b) Find the distance of P from O at the instant when P changes its direction of motion.

(5)

In this question, solutions relying on calculator technology are not acceptable.

(Total for Question 1 is 9 marks)

Q2

At time $t = 0$ a particle P leaves the origin O and moves along the x-axis. At time t seconds the velocity of P is v m s^{-1}, where

$$v = 8t - t^2.$$

(a) Find the maximum value of v.

(4)

(b) Find the time taken for P to return to O.

(5)

(Total for Question 2 is 9 marks)

Q3

At time $t = 0$ a particle P leaves the origin O and moves along the x-axis. At time t seconds, the velocity of P is v m s^{-1} in the positive x direction, where

$$v = 3t^2 - 16t + 21$$

The particle is instantaneously at rest when $t = t_1$ and when $t = t_2$ ($t_1 < t_2$).

(a) Find the value of t_1 and the value of t_2.

(2)

(b) Find the magnitude of the acceleration of P at the instant when $t = t_1$.

(3)

(c) Find the distance travelled by P in the interval $t_1 \leq t \leq t_2$.

(4)

(d) Show that P does not return to O.

(3)

(Total for Question 1 is 12 marks)

End of Questions

Bronze Mark Scheme

Q1

Question	Scheme	Marks	AOs
(a)	$v = 3t - 2t^2 + 14$ and differentiate	M1	3.1a
	$a = \frac{dv}{dt} = 3 - 4t$ or $(7 - 2t) - 2(t + 2)$ using product rule	A1	1.1b
	$3 - 4t = 0$ and solve for t	M1	1.1b
	$t = \frac{3}{4}$ oe	A1	1.1b
		(4)	
(b)	Solve problem using $v = 0$ to find a value of t $\left(t = \frac{7}{2}\right)$	M1	3.1a
	$v = 3t - 2t^2 + 14$ and integrate	M1	1.1b
	$s = \frac{3t^2}{2} - \frac{2t^3}{3} + 14t$	A1	1.1b
	Substitute $t = \frac{7}{2}$ into their s expression (M0 if using *suvat*)	M1	1.1b
	$s = \frac{931}{24} = 38\frac{19}{24} = 38.79166..(\text{m})$ Accept 39 or better	A1	1.1b
		(5)	
			(9 marks)

Q2

Question Number	Scheme	Marks
(a)	$\frac{dv}{dt} = 8 - 2t$	M1
	$8 - 2t = 0$	M1
	Max $v = 8 \times 4 - 4^2 = 16\,(\text{ms}^{-1})$	M1A1 (4)
(b)	$\int 8t - t^2 dt = 4t^2 - \frac{1}{3}t^3 (+c)$	M1A1
	(t=0, displacement = 0 $\Rightarrow$ c=0)	
	$4T^2 - \frac{1}{3}T^3 = 0$	DM1
	$T^2(4 - \frac{T}{3}) = 0 \Rightarrow T = 0, 12$	DM1
	$T = 12$ (seconds)	A1 (5) [9]

Q3

Q.	Scheme	Marks	Notes
a	$v=0 \Rightarrow 3t^2-16t+21=0$	M1	Set $v=0$ and attempt to solve
	$((3t-7)(t-3)=0) \quad t_1=\frac{7}{3}, \quad t_2=3$	A1	
		(2)	
b	$a=\frac{\mathrm{d}}{\mathrm{d}t}\left(3t^2-16t+21\right)$	M1	Differentiate v to obtain a
	$=6t-16$	A1	
	$t=t_1, \quad a=6\times\frac{7}{3}-16=-2\ (\mathrm{m\,s^{-2}})$ Magnitude 2 $(\mathrm{m\,s^{-2}})$	A1	No errors seen. Must be positive - the Q asks for magnitude.
		(3)	
c	$s=\int\left(3t^2-16t+21\right)\mathrm{d}t$	M1	Integrate v to find s
	$=t^3-8t^2+21t(+C)$	A1	
	$\pm\left(\left(3^3-8\times9+21\times3\right)-\left(\left(\frac{7}{3}\right)^3-8\times\frac{49}{9}+21\times\frac{7}{3}\right)\right)$	M1	Correct use of their limits
	$s=0.148$ (m) $\quad\left(\frac{4}{27}\right)$	A1	Final answer must be positive. 0.15 or better
		(4)	
d	Return to $O \Rightarrow s=0=t\left(t^2-8t+21\right)$	B1	seen or implied
	Discriminant of quadratic $=64-4\times21(=-20)<0$	M1	Or equivalent. ***given answer so must show some evidence of method***
	No real roots $\Rightarrow$ does not return to O	A1	Sufficient correct working to justify ***given answer***
		(3)	
dalt	Travels away until $t_1=\frac{7}{3}$, turns back at $t_2=3$ then turns away again	M1	Complete story
	$s_3=18$	B1	Seen or implied
	Complete argument	A1	
		(3)	
dalt	Distance time graph	B1	
	Locate min turning point	M1	
	Complete argument	A1	
		(3)	
		[12]	

Silver Questions

Calculator

The total mark for this section is 26

Q1

A bird leaves its nest at time $t = 0$ for a short flight along a straight line.

The bird then returns to its nest.

The bird is modelled as a particle moving in a straight horizontal line.

The distance, s metres, of the bird from its nest at time t seconds is given by

$$s = \frac{1}{10}(t^4 - 20t^3 + 100t^2), \quad \text{where } 0 \leq t \leq 10$$

(a) Explain the restriction, $0 \leq t \leq 10$

(3)

(b) Find the distance of the bird from the nest when the bird first comes to instantaneous rest.

(6)

(Total for Question 1 is 9 marks)

Q2

A particle P moves on the x-axis. The acceleration of P at time t seconds, $t \geq 0$, is $(3t + 5)$ m s^{-2} in the positive x-direction. When $t = 0$, the velocity of P is 2 m s^{-1} in the positive x-direction. When $t = T$, the velocity of P is 6 m s^{-1} in the positive x-direction. Find the value of T.

(Total for Question 2 is 6 marks)

Q3

A particle P moves on the x-axis. The acceleration of P at time t seconds is $(t - 4)$ m s^{-2} in the positive x-direction. The velocity of P at time t seconds is v m s^{-1}. When $t = 0$, $v = 6$.

Find

(a) v in terms of t,

(4)

(b) the values of t when P is instantaneously at rest,

(3)

(c) the distance between the two points at which P is instantaneously at rest.

(4)

(Total for Question 3 is 11 marks)

End of Questions

Silver Mark Scheme

Q1

Question	Scheme	Marks	AOs
(a)	Substitution of both $t = 0$ and $t = 10$	M1	2.1
	$s = 0$ for both $t = 0$ and $t = 10$	A1	1.1b
	Explanation ($s > 0$ for $0 < t < 10$) since $s = \frac{1}{10}t^2(t-10)^2$	A1	2.4
		(3)	
(b)	Differentiate displacement s w.r.t. t to give velocity, v	M1	1.1a
	$v = \frac{1}{10}(4t^3 - 60t^2 + 200t)$	A1	1.1b
	Interpretation of 'rest' to give $v = \frac{1}{10}(4t^3 - 60t^2 + 200t) = \frac{2}{5}t(t-5)(t-10) = 0$	M1	1.1b
	$t = 0, 5, 10$	A1	1.1b
	Select $t = 5$ and substitute their $t = 5$ into s	M1	1.1a
	Distance = 62.5 m	A1 ft	1.1b
		(6)	
			(9 marks)

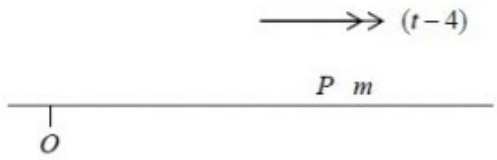
Notes

(a) M1 for substituting $t = 0$ and $t = 10$ into s expression
A1 for noting that $s = 0$ at both times
A1 Since s is a perfect square, $s > 0$ for all other t- values.
(b) 1st M1 for differentiating s w.r.t. t to give v (powers of t reducing by 1)
1st A1 for a correct v expression in any form
2nd M1 for equating v to 0 and factorising
2nd A1 for correct t values
3rd M1 for substituting their intermediate t value into s
3rd A1 ft following an incorrect t-value.

Q2

Question Number	Scheme	Marks
		
	$\frac{dv}{dt} = 3t + 5$	
	$v = \int (3t+5)\,dt$	M1*
	$v = \frac{3}{2}t^2 + 5t \quad (+c)$	A1
	$t = 0 \quad v = 2 \Rightarrow c = 2$	B1
	$v = \frac{3}{2}t^2 + 5t + 2$	
	$t = T \quad 6 = \frac{3}{2}T^2 + 5T + 2$	DM1*
	$12 = 3T^2 + 10T + 4$	
	$3T^2 + 10T - 8 = 0$	
	$(3T-2)(T+4) = 0$	M1
	$T = \frac{2}{3} \quad (T = -4)$	
	$\therefore T = \frac{2}{3} \quad (\text{or } 0.67)$	A1
		[6]

Q3

Question Number	Scheme	Marks
(a)		
	$\frac{dv}{dt} = t - 4$	
	$v = \frac{1}{2}t^2 - 4t(+c)$	M1 A1
	$t = 0 \quad v = 6 \quad \Rightarrow c = 6$	M1
	$\therefore v = \frac{1}{2}t^2 - 4t + 6$	A1
		(4)
(b)	$v = 0 \quad 0 = t^2 - 8t + 12$	M1
	$(t-6)(t-2) = 0$	DM1
	$t = 6 \quad t = 2$	A1
		(3)
(c)	$x = \frac{t^3}{6} - 2t^2 + 6t + k$	M1 A1 ft
	$x_6 - x_2 = \frac{6^3}{6} - 2\times 6^2 + 6^2 + k$	DM1
	$-\left(\frac{2^3}{6} - 2\times 2^2 + 6\times 2 + k\right)$	
	$= -5\frac{1}{3}$	
	$\therefore$ Distance is $5\frac{1}{3}$m	A1
		(4)
		11

Gold Questions

Calculator

The total mark for this section is 30

Q1

A particle P moves along a straight line in such a way that at time t seconds its velocity v m s^{-1} is given by

$$v = \frac{1}{2}t^2 - 3t + 4$$

Find

(a) the times when P is at rest,

(4)

(b) the total distance travelled by P between $t = 0$ and $t = 4$.

(5)

(Total for Question 1 is 9 marks)

Q2

A particle P moves along a straight line. The speed of P at time t seconds ($t \geq 0$) is v m s^{-1}, where $v = (pt^2 + qt + r)$ and p, q and r are constants. When $t = 2$ the speed of P has its minimum value. When $t = 0$, $v = 11$ and when $t = 2$, $v = 3$

Find

(a) the acceleration of P when $t = 3$

(8)

(b) the distance travelled by P in the third second of the motion.

(5)

(Total for Question 2 is 13 marks)

Q3

A particle P moves along the x-axis in a straight line so that, at time t seconds, the velocity of P is v m s^{-1}, where

$$v = \begin{cases} 10t - 2t, & 0 \leq t \leq 6 \\ \dfrac{-432}{t^2}, & t > 6 \end{cases}$$

At $t = 0$, P is at the origin O. Find the displacement of P from O when

(a) $t = 6$,

(3)

(b) $t = 10$.

(5)

(Total for Question 3 is 8 marks)

End of Questions

Gold Mark Scheme

Q1.

Question Number	Scheme	Marks	Notes
(a)	$\frac{1}{2}t^2-3t+4=0$	M1	Set $v=0$
	$t^2-6t+8=0$		
	$(t-2)(t-4)=0$	DM1	Solve for v
	$t=2$ s *or* 4 s	A1 A1	
		(4)	
(b)	$\int \frac{1}{2}t^2-3t+4\mathrm{d}t$	M1	Integration – majority of powers increasing
	$=\frac{1}{6}t^3-\frac{3}{2}t^2+4t(+C)$	A1	Correct ($+C$ not required)
	$s=\int_0^2 \frac{1}{2}t^2-3t+4\ \mathrm{d}t-\int_2^4 \frac{1}{2}t^2-3t+4\ \mathrm{d}t$	DM1	Correct strategy for finging the required distance. Follow their "2". Subtraction/swap limits/modulus signs
	$=\left[\frac{1}{6}t^3-\frac{3}{2}t^2+4t\right]_0^2-\left[\frac{1}{6}t^3-\frac{3}{2}t^2+4t\right]_2^4$		
	$=\frac{8}{6}-6+8-(\frac{64}{6}-24+16-(\frac{8}{6}-6+8))$	A1	Correct unsimplified
	$=\frac{10}{3}-\frac{8}{3}+\frac{10}{3}$		
	$=4$	A1	
		(5)	
		[9]	

Q2

Q	Scheme	Marks	Notes
a	$t=0,\ v=11\ \Rightarrow r=11$	B1	
	$t=2,\ v=3\ \Rightarrow 4p+2q+11=3,$	M1	Accept $4p+2q+r=3$
	$4p+2q=-8$	A1	Any equivalent unsimplified form with 11 used
	Differentiate to find acceleration	M1	OR use symmetry, $t=4, v=11$
	$a=2pt+q$	A1	$\Rightarrow 11=16p+4q+11\ ,\ 4p+q=0$
	$t=2,\ a=0\ \Rightarrow 4p+q=0$	DM1	2nd eqn in p & q and solve for p & q Dependent on both previous m marks
	$\Rightarrow -q+2q=-8,\ q=-8,\ p=2$	A1	
	$\left(v=2t^2-8t+11\right)$		
	$t=3,\ a=4t-8=4\,(\text{ms}^{-2})$	A1	
		(8)	
a alt	Min speed at $t=2\ \Rightarrow$ $v=\left(pt^2+qt+r\right)=k\left(t-2\right)^2+c$	B1	
		M1	Completed square form.
	$v=k\left(t-2\right)^2+3$	A1	Correct completed square form
	$t=0,\ v=11\ \Rightarrow 4k+3=11,$	M1	Solve for k
	$k=2$	A1	$v=2\left(t-2\right)^2+3\left(=2t^2-8t+11\right)$
	Differentiate to find acceleration	DM1	Dependent on both previous m marks
	$a=4\left(t-2\right)$	A1	
	$t=3,\ a=4\,(\text{m s}^{-2})$	A1	
		(8)	
b	Integrate: $\int 2\left(t-2\right)^2+3\text{d}t=\frac{2}{3}\left(t-2\right)^3+3t\left(+C\right)$ or $\int 2t^2-8t+11\text{d}t=\frac{2}{3}t^3-4t^2+11t\left(+C\right)$	M1	follow their coefficients found in (a) Accept in p, q, r
	At most one error seen	A1ft	For their coefficients
	All correct	A1ft	For their coefficients provided $\neq 0$
	$\left[\frac{2}{3}\left(t-2\right)^3+3t\right]_2^3=\left(\frac{2}{3}+9\right)-\left(0+6\right)$ or $\left[\frac{2}{3}t^3-4t^2+11t\right]_2^3$ $=\left(18-36+33\right)-\left(\frac{16}{3}-16+22\right)$	DM1	Use of $t=2, t=3$ as limits on a definite integral (or subtract distances to cancel C). Dependent on having integrated. Allow with p, q, r
Q	Scheme	Marks	Notes
	$3\frac{2}{3}$ (m)	A1	Accept exact equivalent or 3.7 or better
		(5)	
		[13]	

Q3

(a)	$v = 10t - 2t^2$, $s = \int v\,dt$	M1
	$= 5t^2 - \frac{2t^3}{3}(+C)$	A1
	$t = 6 \Rightarrow s = 180 - 144 = \underline{36}$ (m)	A1 (3)
(b)	$\underline{s} = \int v\,dt = \frac{-432t^{-1}}{-1}(+K) = \underline{\frac{432}{t}}(+K)$	B1
	$t = 6$, s = "36" $\Rightarrow 36 = \frac{432}{6} + K$	M1*
	$\Rightarrow K = -36$	A1
	At $t = 10$, $s = \frac{432}{10} - 36 = \underline{7.2}$ (m)	d*M1
		A1 (5) **[8]**