Section B: Mechanics

Question	Scheme	Marks	AOs
6.	Equation in t only	M1	2.1
	$-2 = 9t - \frac{1}{2} \times 10t^2$	A1	1.1b
	$5t^2 - 9t - 2 = 0 = (5t+1)(t-2)$	DM1	1.1b
	$T = 2$ (only)	A1	1.1b
		(4)	
			(4 marks)

Notes:

M1: Complete method to give equation in t only. This mark is for a complete method for the TOTAL time i.e. for finding sufficient equations, with usual rules, correct no. of terms in each equation but condone sign errors and g does not need to be substituted

A1: A correct equation **or** correct equations (e.g. if they find the speed, 11 ms^{-1}, when the ball strikes the ground and then use that to find the total time **or** if they split the time (e.g. 0.9s up and 1.1s down or 0.9s + 0.9s + 0.2s))

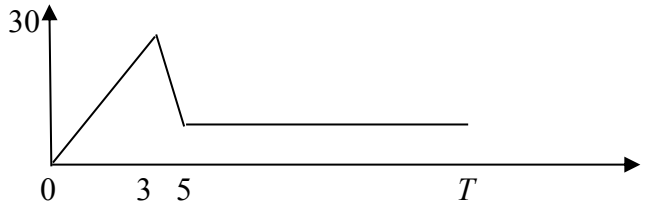
N.B. $g = 10$ must be substituted in all equations used.

DM1: Dependent on first M1, for solving a 3 term quadratic to find T **or** for solving their equations to find T **or** for solving their equations and adding their split times to find T

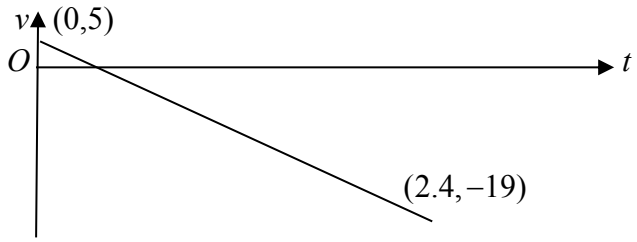
A1: $T = 2$ only (i.e. A0 if they give two times)

N.B. If solving a correct quadratic, the DM1 can be implied by a correct answer i.e. the method does not need to be shown, but if there is no method shown and the answer is wrong then award DM0 A0.

8MA0 22: Mechanics AS 1906 Mark Scheme

Question	Scheme	Marks	AOs	Notes
1 (a)	$V = 30\ (\text{m s}^{-1})$	B1	3.4	cao
		(1)		
(b)	 shape	B1	1.1b	Overall shape of the graph, starting at the origin. Dotted vertical line at end is OK but solid vertical line is B0
	figs	B1**ft**	1.1b	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 <u>correct structure for each section.</u> 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**	1.1b	**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	1.1b	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	1.1b	83 is the only answer
		(5)		
(d)	New value of T would be bigger (ignore their reasons whether correct or not)	B1	3.5a	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)		
(e)	e.g. effect of wind; allow for dimensions of parachutist; use a more accurate value for g; parachutist does not fall vertically after chute opens; smooth changes in v; time for parachute to open; deceleration not constant (but B0 if they say *acceleration* not constant); smooth changes in a; B0 for: moves horizontally; mass/weight of parachutist; upthrust; air pressure;air resistance; terminal velocity	B1	3.5c	Any appropriate refinement of the model. B0 if incorrect (or irrelevant) extras
		(1)		
		(10 marks)		

Question	Scheme	Marks	AOs
1.(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)	
(f)	Take into account: spin, wind effects, use a more accurate value of g, not model the ball as a particle	B1	3.5c
		(1)	

Question	Scheme	Marks	AOs
7(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}	A1ft	1.1b
			(7 marks)

Notes:

M1: For solving the problem by setting up two equations in a and u only and solving for either
M1: Use of (one or more) *suvat* formulae to produce an equation in u and a only
A1: For a correct equation
M1: Use of (one or more) *suvat* formulae to produce another equation in u and a only
A1: For a correct equation
A1: For correct accln 5 m s^{-2}
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 the next page

ALTERNATIVE

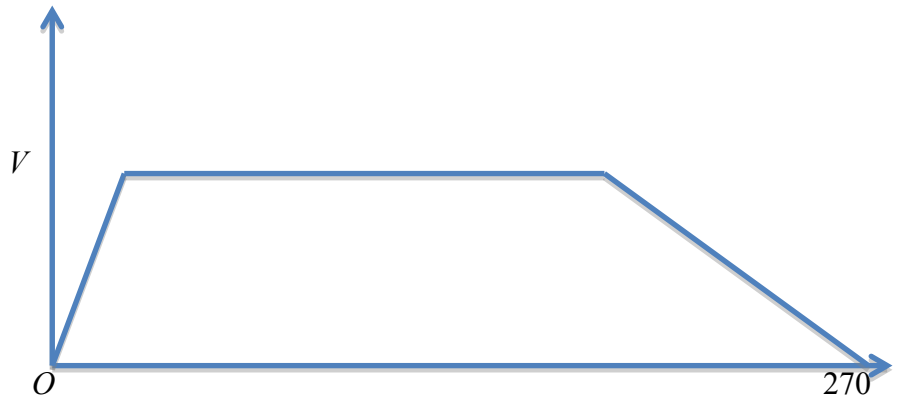
Question	Scheme	Marks	AOs
7(i)(ii)	Using a correct strategy for solving the problem by obtaining actual speeds at two times and using a = change in speed / time taken	M1	3.1b
	Actual speed at $t = 1$ = Average speed over interval	M1	3.1b
	22/2 = 11	A1	1.1b
	Actual speed at $t = 4$ = Average speed over interval	M1	3.1b
	104/4 = 26	A1	1.1b
	5 m s^{-2}	A1	1.1b
	6 m s^{-1}	A1ft	1.1b
			(7 marks)

Notes:

M1: For solving the problem by obtaining two actual speeds and use of $a = (v - u)/ t$
M1: Use of speed at half-time = av speed over interval to produce a speed at $t = 1$
A1: For a correct speed
M1: Use of speed at half-time = av speed over interval to produce a speed at $t = 4$
A1: For a correct speed
A1: For correct accln 5 m s^{-2}
A1: ft for correct speed 6 m s^{-1} (This is an ft mark, following an incorrect value of a)

N.B. Do not award the ft mark for absurd answers e.g. $a > 15$, $u > 50$

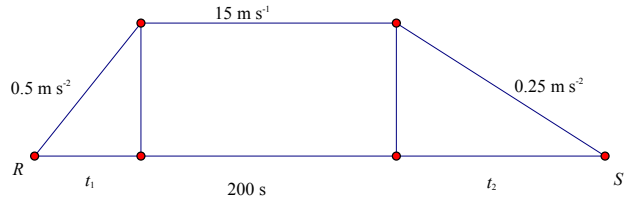
Question Number	Scheme	Marks
	First A1 for TWO correct equations (allow 4.12 or better) Second M1, independent, for solving a 'correct sine formula' for θ or ϕ **OR** independent for solving two equations, with correct structure, for α Second A1 for $\theta =$ AWRT 29^o or $\phi =$ AWRT 121^o **OR** $\alpha =$ AWRT 59^o	
	Third A1 for Bearing is 149^o (nearest degree)	
	N.B. First M1A1 Could use cos rule to find an angle	
	N.B. If the resolving method is used and there are no (i) or (ii) labels, only award M1A1 in both cases when an answer is reached.	
5a	$0 = 14.7^2 - 2 \times 9.8h$	M1A1
	$h = 11.025$	A1
	max ht $= 13.5$ or 14 (m)	A1 (4)
5b	$-1.5 = 14.7t - 4.9t^2$	M1A1
	$4.9t^2 - 14.7t - 1.5 = 0$	
	$t = \dfrac{14.7 \pm \sqrt{14.7^2 + 6 \times 4.9}}{9.8}$	**DM**1
	$t = 3.1$ or 3.10 (s)	A1 (4)
5c	$v^2 = 14.7^2 + 2 \times (-9.8) \times (-2.5)$	M1 A1
	$v = 16.3$ or 16 (m s^{-1})	A1 (3)
		11
	Notes	
5a	**N.B.** If they use $g = 9.81$, lose first A mark (once for whole question) but all other A marks can be scored. First M1 for a complete method to find the height (Could involve two *suvat* equations) condone sign errors. First A1 for a correct equation (or equations) Second A1 for $h = 11$ (may be unsimplified) or better (For other methods, give this A1 for any correct (may be unsimplified) intermediate answer) Third A1 for 13.5 or 14 (m)	
5b	First M1 for a complete method to find the required time (they may find the time up (1.5 s) and then add on the time down. Condone sign errors First A1 for a correct equation or equations Second DM1, dependent, for solving to find required time Second A1 for 3.1 or 3.10 (s)	

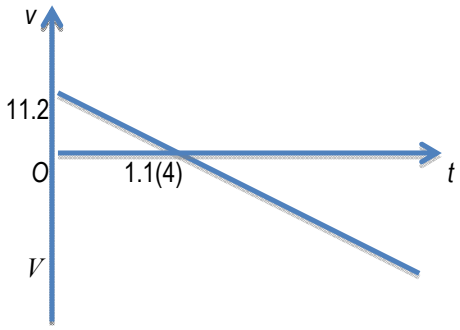
Question Number	Scheme	Marks
5c	First M1 for a complete method to find the speed / velocity(Could involve two *suvat* equations) Condone sign errors but must have correct numbers in their equation(s) First A1 for a correct equation (or equations) Second A1 for 16 or 16.3 (m s^{-1}) Must be *positive (speed)*	
6a		B1 shape B1 270, V (2)
6b	$\frac{V}{0.6}=\frac{5V}{3}$ **Given answer**	M1A1 (2)
6c	Time decelerating is $5V$	B1
	$\frac{1}{2}V\frac{5V}{3}+(270-5V-\frac{5V}{3})V+\frac{1}{2}V.5V=1500$ **OR:** $\frac{1}{2}(270+270-5V-\frac{5V}{3})V=1500$	M1 A2
	$V^2-81V+450=0$ **Given answer**	**DM1**A1 (6)
6d	$V^2-81V+450=0$ $(V-6)(V-75)=0$ or $V=\frac{81\pm\sqrt{81^2-4\times450}}{2}$	M1 solving
	$V=6$ or 75	A1 A1
	$V=6$ since $(5\times75)>270$ or $V=75$ unrealistic	**B**1 (4)
		14
	Notes	
6a	First B1 for a trapezium with line starting at the origin Second B1 for 270 and V correctly marked	
6b	M1 for $(t=)\frac{V}{0.6}$; **N.B.** M1A0 for V=0.6t then answer Must see division or intermediate step from V=0.6t e.g. Changing 0.6 into 3/5. A1 for $t=\frac{5V}{3}$ **Given answer**	

Question Number	Scheme	Marks
6.	$s_A = 35t + \frac{1}{2}0.4t^2; s_B = 44t + \frac{1}{2}0.5t^2$ $44t + \frac{1}{2}0.5t^2 = 200 + 35t + \frac{1}{2}0.4t^2$ $\frac{1}{20}t^2 + 9t - 200 = 0$ $(t-20)(t+200) = 0$ $t = 20$ $v = 44 + \frac{1}{2}.20 = 54 \text{ ms}^{-1}$	M1 A1 A1 M1 A1 M1 A1 **DM1** A1 **9**
	Notes	
	First M1 for use of $s = ut + \frac{1}{2}at^2$ for either *A* or *B* First A1 for a correct equation for *A* Second A1 for a correct equation for *B* Second M1 for producing a quadratic in *t* only from their s_A = their $s_B \pm 200$ Third A1 for a correct '3 term = 0' equation Third M1 (can be implied by one correct answer) for attempt to solve their quadratic (M0 if linear). Must include 200, must be 3 terms and must have come from using both distance expressions. Fourth A1 for $t = 20$ Fourth M1 dependent on third M1 for correctly using their *t* value to find *v* Fifth A1 for 54 **N.B. SC for trial and error to find *t* ; can score max M1A1A1M1A0M0A0M1A1 6/9**	

3(a)	$5.5 = \frac{1}{2}a.2^2$	M1	Complete method using *suvat* equations to form an equation in *a* only
	$\Rightarrow a = 2.75$	A1	
		(2)	
(b)	$R = 30\sin\alpha + 2g\cos\alpha$	M1	Resolve perpendicular to the plane to find an expression for *R*. Must have all terms. Condone sign errors and sin/cos confusion.
		A2	-1 each error. All correct A1A1, one error A1A0, two or more errors A0A0 ($R = 33.68$)
	$-F + 30\cos\alpha - 2g\sin\alpha = 2\ a$	M1	Equation of motion parallel to the plane with *a* or their *a*. Must have all terms. Condone sign errors and sin/cos confusion.
		A2	-1 each error ($F = 6.74$)
	$\mu = \dfrac{30\cos\alpha - 2g\sin\alpha - 5.5}{30\sin\alpha + 2g\cos\alpha}$	DM1	Use $F = \mu R$ Dependent on the 2 previous M marks
	$= 0.200$ or 0.20	A1	Do not accept 0.2
		(8)	
		10	
4.		M1	Use $s = ut + \dfrac{1}{2}at^2$ or a complete *suvat* route to find h in terms of *t*
	$h = \frac{1}{2}gt^2$	A1	Or $h = \frac{1}{2}g(t+1)^2$. The expression for time used in the first equation defines the expression expected in the second equation.
	$h = 19.6(t-1) + \frac{1}{2}g(t-1)^2$	A1	Or $h = 19.6(t) + \frac{1}{2}g(t)^2$ or $h = 4.9 + \left(9.8t + \dfrac{1}{2}gt^2\right)$
	$\frac{1}{2}gt^2 = 19.6(t-1) + \frac{1}{2}g(t-1)^2$	M1	Equate the two expressions for *h*.
		DM1	Solve for *t*. Dependent on the previous M1.
	$t = 1.5$	A1	Using the "Or" approach gives $t = 0.5$
	$h = 11$ m or 11.0 m	A1	Accept 2 or 3 s.f. only
		7	

Question Number	Scheme	Marks	Notes
2 (a)	$h = -20\times 5 + \frac{1}{2}\times 9.8\times 25$	M1	Use of $s = ut + \frac{1}{2}at^2$ to find h. Must quote the correct formula and be using 20 & 5, but condone slips in substitution. Accept complete alternative solutions working via the maximum height. (max ht 20.4..., time to top 2.04...) Accept complete alternative methods using other *suvat* equations.
		A1	Correctly substituted equation(s) Condone use of a premature approximation.
	$h = 22.5$	A1 (3)	Final answer. Accept 22.5 or 23. Maximum 3sf. -22.5 is A0.
	NB Do not ignore subsequent working if they reach 22.5 and then move on to do further work.		
(b)	$V^2 = 20^2 + 2\times 9.8\times 22.5$ OR $V = -20 + (5\times 9.8)$	M1	First ball - use of *suvat* to find V or V^2 Follow their h.
	$(V^2 = 841)$ $= 29$	A1	Correct only (condone -29)
	$\left(\frac{3}{4}V\right)^2 = w^2 + 2\times 9.8\times 22.5$	M1	Second ball - *suvat* equation in V (or their V) to find w. Must be using the $\frac{3}{4}$.
	$w^2 = \frac{9}{16}\times 841 - 2\times 9.8\times 22.5$	A1ft	Correctly substituted equation with their V and their h.
	$w = 5.66$	A1	or 5.7. Answer correct to 2 s.f. or to 3 s.f.
		(5)	
		[8]	

Question Number	Scheme	Marks
1a		
	Use of $v = u + at$ to find t_1 or t_2	M1
	$t_1 = 15 \div 0.5 = 30\,(\text{s})$ **OR** $t_2 = 15 \div 0.25 = 60$	A1
	Total time $= 30 + 200 + 60 = 290\,(\text{s})$	A1 **cso**
		(3)
1b	Use area/ *suvat* to find distance: $\text{distance} = \frac{1}{2} \times 30 \times 15 + 200 \times 15 + \frac{1}{2} \times 60 \times 15$ Follow their t_1 & t_2	M1A2 **ft**
	$= 3675\,(\text{m})$ (3.675 km)	A1
		(4)
1c	Ave. speed $= \frac{\text{their(b)}}{\text{their(a)}}$	M1
	$= \frac{3675}{290}$ oe (m s^{-1}) (12.6724..)	A1
		(2)
		[9]
	Notes	
1a	M1 for use of $v = u + at$ or gradient or any other complete method to find a value for t_1 or t_2 (condone sign errors)	
	First A1 for either 30 or 60 (A0 if negative)	
	Second A1 for 290 with no errors seen	
1b	M1 for a complete method to find distance (must have a ½) either by using trapezium rule or by using 2 triangles and a rectangle	
	A2 **ft** on their t_1 & t_2 (-1 each error)	
	A1 for 3675 (m) or 3.675 km	
1c	M1 for $= \frac{\text{their(b)}}{\text{their(a)}}$	
	A1 for 13 or better	

Question Number	Scheme	Marks
4(a)	$0^2 = 11.2^2 - 2gd$ $d = 6.4$ max ht. $= 3.6 + 6.4 = 10$ m	M1 A1 A1 A1 (4)
ALT	$11.2^2 = u^2 - 2g$ x 3.6 $u = 14$ $0^2 = 14^2 - 2gh$ $h = 10$ m	M1 A1 A1 A1 (4)
(b)	$10 = \frac{1}{2}gt^2$ $t = \frac{10}{7}$ Total $= 2\text{x}\frac{10}{7} = 2.9$ or 2.86	M1 A1 A1 **dM1** A1 (5)
(c)		B1 single line **dB1** $V <$ -11.2 B1 11.2 B1 1.1(4) (4) **13**
	Notes	
4(a)	M1 for a complete method to find d (d = distance from A to top) First A1 for a correct equation in d only. Second A1 for $d = 6.4$ Third A1 for 6.4 + 3.6 = 10 (m)	
ALT	M1 for a complete method (must have 2nd equation) to find h First A1 for $u = 14$ Second A1 for correct 2nd equation Third A1 for $h = 10$ (m)	
4(b)	First M1 for a complete method to find an intermediate time (A to top or A to O) First A1 for a correct equation or equations. Second A1 for any intermediate time (e.g. $_At_{TOP} = {}^8/_7$, $_At_O = {}^2/_7$, $_At_O = {}^{18}/_7$, $_At_A =$	

4.	$h = \frac{1}{2}gt^2$	B1
	$h = 7.35(t - \frac{1}{2}) + \frac{1}{2}g(t - \frac{1}{2})^2$	M1 A1
	$\frac{1}{2}gt^2 = 7.35(t - \frac{1}{2}) + \frac{1}{2}g(t - \frac{1}{2})^2$	**DM**1
	$t = 1$	M1 A1
	$h = 4.9$	A1 **7**

NOTES

Question 4

B1 for $h = \frac{1}{2}gt^2$ or $h = \frac{1}{2}g(t + \frac{1}{2})^2$

First M1 for $h = 7.35(t - \frac{1}{2}) + \frac{1}{2}g(t - \frac{1}{2})^2$ or $h = 7.35t + \frac{1}{2}gt^2$

M0 if different t used in the two terms and M0 if two terms have opposite signs.

First A1 for appropriate t value used

Second M1, dependent, for equating their two expressions for h, but must have different t's in the two expressions

Third M1, independent, for solving for their t (must have used two expressions etc.)

Second A1 for $t = 1$ (or $t = ½$)

Third A1 for $h = 4.9$

N.B. See alternative below where t is eliminated:

$h = \frac{1}{2}gt^2$	B1
$h = 7.35(t - \frac{1}{2}) + \frac{1}{2}g(t - \frac{1}{2})^2$	M1A1
$h = 7.35(\sqrt{\frac{2h}{g}} - \frac{1}{2}) + \frac{1}{2}g(\sqrt{\frac{2h}{g}} - \frac{1}{2})^2$	**DM**1
$h = 7.35\sqrt{\frac{2h}{g}} - 3.675 + 4.9(\frac{2h}{g} - \sqrt{\frac{2h}{g}} + 0.25)$	A1
$h = 4.9$	M1 A1