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INTERNATIONAL A LEVEL MATHEMATICS • MECHANICS 1

Mechanics 1

Exam Questions by Topic: Mark Scheme

Pearson Edexcel International Advanced Level (WME01/01) • Calculator allowed • Take $g = 9.8 \text{ ms}^{-2}$

Every question in the booklet, marked line by line the way an examiner marks it

Chapters (tap a chapter to jump to it)	Qs	Marks	Page	My score
1 Mathematical Models in Mechanics Not examined on its own: modelling ideas are tested within Chapters 2 to 8	—	—	Not applicable	
2 Constant Acceleration Motion graphs, the suvat formulae, vertical motion under gravity	10	82	3	
3 Vectors in Mechanics Resultants, velocity and position vectors, $\mathbf{r} = \mathbf{r}_0 + \mathbf{v}t$	10	81	own PDF	
4 Dynamics of a Particle Moving in a Straight Line $F = ma$, connected particles, pulleys, lifts	10	82	own PDF	
5 Forces and Friction Resolving forces, friction, inclined planes	10	86	own PDF	
6 Momentum and Impulse Conservation of momentum, impulse	10	81	own PDF	
7 Statics of a Particle Equilibrium, limiting friction	10	82	own PDF	
8 Moments Beams and rods, tilting, non-uniform rods	10	82	own PDF	

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How to use this mark scheme

The same marking rules Pearson examiners use for WME01.

Mark every line, not just the answer. Method marks are given for a correct method even when the final answer is wrong. If you lost marks, find the *first* line where your working differs from the scheme. That is the thing to fix.

Code	Meaning
M1	Method mark: for knowing a correct method and attempting to apply it. Small slips in the working do not lose this mark.
dM1	Dependent method mark: can only be given if the method mark before it has been given.
A1	Accuracy mark: for a correct answer or line of working. It can only be given if the method mark it depends on has been given.
B1	Independent mark: for a correct result or statement, whatever method was used.
*	The answer is given in the question. Every step must be shown, and the answer must follow from correct working (cso).
cao	Correct answer only.
cso	Correct solution only: no errors anywhere in the working.
ft	Follow through: the mark can be given for correct work using your own earlier (wrong) answer.
oe	Or equivalent: any correct equivalent form is accepted.

Accuracy after using $g = 9.8$. When $g = 9.8 \text{ ms}^{-2}$ has been substituted, the final answer must be given to 2 or 3 significant figures: more accurate answers (and fractions) lose the final A mark. Exact multiples of g are usually accepted. Using $g = 9.81$ loses accuracy marks.

Marking a sketch. Graph marks are given for the correct shape (straight lines for constant acceleration, no solid vertical lines) and for the key values marked on the axes. An equation of motion or a suvat equation must have the correct number of terms and be dimensionally correct to earn its method mark.



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Chapter 2: Constant Acceleration

Mark scheme. Marks are shown on the right of each line.

Question 1

6 marks

Part	Scheme	Marks
(a)	Uses $s = \frac{1}{2}(u + v)t$: $84 = \frac{1}{2}(u + 2.5u) \times 6$ $10.5u = 84$ $u = 8$	M1 A1 A1 (3)
(b)	$a = \frac{20 - 8}{6} = 2 \text{ ms}^{-2}$	B1 (1)
(c)	$v^2 = u^2 + 2as$: $14^2 = 8^2 + 2 \times 2 \times s$ 33 m	M1 A1 (2)
Total for Question 1: 6 marks		

Question 2

6 marks

Part	Scheme	Marks
(a)	$v^2 = u^2 + 2as$ with $u = 14.7$, $a = -9.8$ and $s = -19.6$ (signs consistent) $v^2 = 14.7^2 + 2 \times 9.8 \times 19.6 = 600.25$ 24.5 ms^{-1} <i>Using $s = 0$ or the height of the top only is M0. Jan 2021 report: the value of s was misread; $g = 9.81$ loses the A marks.</i>	M1 A1 A1 (3)
(b)	A complete method: $-19.6 = 14.7t - 4.9t^2$ (or $v = u + at$ with $v = -24.5$) $4.9t^2 - 14.7t - 19.6 = 0$, i.e. $t^2 - 3t - 4 = 0$ $t = 4 \text{ s}$ <i>Splitting into up (1.5 s) and down (2.5 s) is equally valid; finding one part only scores M0.</i>	M1 A1 A1 (3)
Total for Question 2: 6 marks		



Question 3

7 marks

Part	Scheme	Marks
(a)	Trapezium shape starting at the origin and ending on the t -axis, with no solid vertical lines	B1
	20 marked on the speed axis; 40, $T + 40$ (or T shown as a length) and $T + 65$ on the time axis	B1
		(2)
(b)	Time to reach 20 ms^{-1} : $\frac{20}{0.5} = 40 \text{ s}$; area = $\frac{1}{2} \times 40 \times 20 + 20T + \frac{1}{2} \times 25 \times 20$	M1
	$400 + 20T + 250 = 3650$ (the distance in metres)	A1
	$T = 150$	A1
		(3)
(c)	$\frac{3650}{40 + 150 + 25}$	M1
	17.0 ms^{-1} (17)	A1
		(2)
Total for Question 3: 7 marks		

Question 4

6 marks

Part	Scheme	Marks
(a)	$\frac{240}{60} = 4 \text{ ms}^{-1}$	B1
	$\frac{0 - 240}{80} = -3 \text{ ms}^{-1}$ (3 ms^{-1} back towards O)	B1
		(2)
(b)	Average speed = $\frac{480}{180} = 2.67 \text{ ms}^{-1}$ ($\frac{8}{3}$)	B1
	Average velocity 0 ms^{-1} , as the displacement after 180 s is 0	B1
		(2)
(c)	Three horizontal segments: $v = 4$ for $0 < t < 60$, $v = 0$ for $60 < t < 100$, $v = -3$ for $100 < t < 180$	B1
	Values 4 and -3 and times 60, 100, 180 marked; no solid vertical lines	B1
		(2)
Total for Question 4: 6 marks		



Question 5

6 marks

Part	Scheme	Marks
(a)	$0 = 24.5^2 - 2 \times 9.8 \times s$ 30.6 m (or 31 m)	M1 A1 (2)
(b)	$19.6 = 24.5t - 4.9t^2$ $t^2 - 5t + 4 = 0$ $(t - 1)(t - 4) = 0: t = 1 \text{ and } t = 4$ 3 s <i>The ball passes 19.6 m twice (going up and coming down): the time between the two roots is required.</i>	M1 A1 M1 A1 (4)
Total for Question 5: 6 marks		

Question 6

10 marks

Part	Scheme	Marks
(a)	Two straight lines: up from 3 to V , then down to 2 (not to 0); no solid vertical lines 3, V and 2 marked on the speed axis and the total time 20 marked <i>Jan 2025 report: the total time for both stages must not be labelled T_2.</i>	B1 B1 (2)
(b)	$A \text{ to } B: 108 = \frac{1}{2}(3 + V)T_1, \text{ so } T_1 = \frac{216}{V + 3}$ $B \text{ to } C: 68 = \frac{1}{2}(V + 2)T_2, \text{ so } T_2 = \frac{136}{V + 2}$ $T_1 + T_2 = 20: 216(V + 2) + 136(V + 3) = 20(V + 3)(V + 2)$ $352V + 840 = 20V^2 + 100V + 120 \Rightarrow 5V^2 - 63V - 180 = 0 \quad *$	M1 M1 M1 A1* (4)
(c)	$(V - 15)(5V + 12) = 0$ $V = 15$; $V = -2.4$ is rejected since a speed cannot be negative (and $V > 3$) <i>Failing to reject the other root loses the A mark (Jan 2025 report).</i>	M1 A1 (2)
(d)	$T_2 = \frac{136}{17} = 8 \text{ s}; a = \frac{2 - 15}{8}$ Deceleration 1.625 ms^{-2} <i>A deceleration is a positive quantity: an answer of -1.625 loses the A mark.</i>	M1 A1 (2)
Total for Question 6: 10 marks		



Question 7

10 marks

Part	Scheme	Marks
(a)	$v^2 = 0 + 2 \times 9.8 \times 10$ 14 ms^{-1}	M1 A1 (2)
(b)	Rebound speed 7 ms^{-1} : $0 = 7^2 - 2 \times 9.8 \times h$ 2.5 m	M1 A1 (2)
(c)	Height = $\frac{v^2}{2g}$ and the rebound speed halves each time, so each greatest height is $\frac{1}{4}$ of the one before: 2.5, 0.625, ... Total = $10 + 2 \times \frac{2.5}{1 - \frac{1}{4}}$ (each rebound height is travelled up and down) 16.7 m ($\frac{50}{3}$) <i>Counting each rebound height once (giving 13.3 m) is the Oct 2019 "miscounting" error.</i>	M1 M1 A1 (3)
(d)	Straight line from (0, 0) to $v = 14$ at $t = \frac{10}{7} \approx 1.43$, then a parallel line from $v = -7$ up to $v = 0$ at $t \approx 2.14$ Values 14 and -7 shown; no solid vertical line at the bounce; lines parallel	B1 B1 (2)
(e)	e.g. the model predicts infinitely many bounces; air resistance is ignored; the ball will not rebound with exactly half its speed each time	B1 (1)
Total for Question 7: 10 marks		



Question 8

10 marks

Part	Scheme	Marks
(a)	$v = 0 + 9.8 \times 3 = 29.4 \text{ ms}^{-1}$	B1 (1)
(b)	Straight line from the origin to (3, 29.4), a less steep line down to V, then horizontal to $t = 20$; no vertical lines 29.4, 3 and $3 + T$ marked	B1 B1 (2)
(c)	$100.8 = 29.4T - \frac{1}{2} \times 4.2T^2$ $2.1T^2 - 29.4T + 100.8 = 0$, i.e. $T^2 - 14T + 48 = 0$ $(T - 6)(T - 8) = 0$ $T = 6$: $T = 8$ is rejected because her speed would be $29.4 - 4.2 \times 8 < 0$ (she would stop after 7 s) <i>Jan 2021 report: using +4.2 instead of -4.2 for the acceleration was the main error.</i>	M1 A1 M1 A1 (4)
(d)	$V = 29.4 - 4.2 \times 6 = 4.2 \text{ ms}^{-1}$ Distance = $\frac{1}{2} \times 3 \times 29.4 + 100.8 + 4.2 \times (20 - 3 - 6)$ $44.1 + 100.8 + 46.2 = 191.1$: 191 m <i>Using $20 - T$ (not $20 - 3 - T$) for the last stage is the common error.</i>	M1 M1 A1 (3)
Total for Question 8: 10 marks		



Question 9

10 marks

Part	Scheme	Marks
(a)	Height of A: $19.6t - 4.9t^2$ Height of B: $29.4 - 4.9t^2$, and equates $19.6t = 29.4$, so $t = 1.5$ *	M1 M1 A1* (3)
(b)	$19.6 \times 1.5 - 4.9 \times 1.5^2$ 18.4 m (or 18 m)	M1 A1 (2)
(c)	A: $19.6 - 9.8 \times 1.5 = \text{4.9 ms}^{-1}$, still moving upwards B: 14.7 ms⁻¹ downwards (-14.7)	B1 B1 (2)
(d)	Two straight lines: A from 19.6 down to 4.9; B from 0 down to -14.7 Lines parallel, ending at $t = 1.5$, with the values marked	B1 B1 (2)
(e)	The gradient is the acceleration, and both balls have the same acceleration -9.8 ms^{-2}	B1 (1)
Total for Question 9: 10 marks		



Question 10

11 marks

Part	Scheme	Marks
(a)	$Q: 16 \times 12 = 192; P: \frac{1}{2} \times 12 \times 24 = 144$ $192 - 144 = 48 \text{ m}^*$	M1 A1* (2)
(b)	The gap increases while Q is faster: greatest when both speeds are 16, at $t = 8$ (P accelerates at 2 ms^{-2}) Gap = $16 \times 8 - \frac{1}{2} \times 8 \times 16$ (or $16t - t^2$ maximised) 64 m	M1 M1 A1 (3)
(c)	For $t > 12$: P has travelled $144 + 24(t - 12)$ $24t - 144 = 16t$ $t = 18 \text{ s}$ <i>$t^2 = 16t$ gives $t = 16$, but that formula for P only holds for $t \leq 12$: M1 M0 A0.</i>	M1 M1 A1 (3)
(d)	$a = 2$ (horizontal line) for $0 < t < 12$ $a = 0$ for $12 < t < 24$, with no solid vertical line	B1 B1 (2)
(e)	e.g. the acceleration of P changes suddenly from 2 to 0 at $t = 12$, which is unrealistic; the acceleration of a car is unlikely to be constant	B1 (1)
Total for Question 10: 11 marks		

