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INTERNATIONAL A LEVEL MATHEMATICS • MECHANICS 2 (WME02)

Mechanics 2 Practice Paper 3

Mark Scheme

AIMING FOR A/A*

Written in the style of the Pearson Edexcel International Advanced Level paper (WME02/01) • 75 marks

Every question marked line by line the way an examiner marks it, with notes on the common errors

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 depends on the method mark before it.
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 / cso	Correct answer only / correct solution only, with no errors anywhere in the working.
ft / oe	Follow through from your own earlier answer / or any correct equivalent form.
awrt	Answers which round to the value given, so 21.52… earns “awrt 21.5”.

How mechanics marks work. A method mark for an equation (resolving, moments, $F = ma$, momentum) needs the right number of terms and the right dimensions; sign slips and sin/cos confusion are condoned there but lose the accuracy mark. When a question says to use the work-energy principle, a solution by $F = ma$ and constant acceleration scores nothing. Use $g = 9.8\,\text{m s}^{-2}$, and after using it give final answers to 2 or 3 significant figures.

Rough grade guide (out of 75): A* **56** • A **49** • B **41** • C **33**

Based on recent WME02 grade boundaries. Real boundaries change every series, so treat this as a guide, not a grade.

Question paper | Exam questions by topic | More practice papers

What to revise next

Write in your score for each question. Where you dropped marks, tap the chapter to practise ten more exam questions on it.

Q	What it tested	Marks	Practise it	Score
1	Projectile conditions: two inequalities and the second solution	12	Ch 1 Projectiles	
2	Velocity in two stages; distance when the particle turns back	12	Ch 2 Variable Acceleration	
3	Centre of mass of a lamina with a hole; sliding or toppling	13	Ch 3 Centres of Mass Ch 6 Statics of Rigid Bodies	
4	A ladder with friction at both ends	13	Ch 6 Statics of Rigid Bodies	
5	Restitution with a wall; a range of e	12	Ch 5 Impulses and Collisions	
6	Constant power with resistance kv on a hill	13	Ch 4 Work and Energy	
	Total	**75**		

Where did the marks go? If you lost the first marks of a question, the method needs work: go back to that chapter's key skills page. If you lost the final marks, the method is fine and the gap is the trap: the second solution of a trigonometric equation, a particle that turns back, a hole that moves the centre of mass, a friction that acts upwards, or a weight that helps a car downhill. At grade A* the method is rarely the problem; checking every answer against the situation is.

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Question 1

12 marks

Part	Scheme	Marks
(a)	Time to reach the wall: $t = \dfrac{10}{14\cos\alpha}$	M1
	Height there: $y = 14\sin\alpha\, t - 4.9t^2 = 10\tan\alpha - \dfrac{2.5}{\cos^2\alpha}$	M1
	Correct expression	A1
	Uses $\sec^2\alpha = 1+\tan^2\alpha$ and $y > 5$: $10\tan\alpha - 2.5(1+\tan^2\alpha) > 5$	M1
	$\tan^2\alpha - 4\tan\alpha + 3 < 0$	A1
	$\boxed{1 < \tan\alpha < 3}$	A1
		(6)
(b)	Range on level ground: $R = \dfrac{14^2\sin 2\alpha}{9.8} = 20\sin 2\alpha$	M1
	$R < 16$: $\sin 2\alpha < 0.8$	A1
	$2\alpha < 53.1°$ **or** $2\alpha > 126.9°$, so $\alpha < 26.6°$ or $\alpha > 63.4°$	M1
	Both solutions found	A1
	Combines with $45° < \alpha < 71.6°$ from (a): $\alpha < 26.6°$ is rejected	M1
	$\boxed{63.4° < \alpha < 71.6°}$	A1
	The trap: $\sin 2\alpha = 0.8$ *has a second solution. The first,* $\alpha < 26.6°$*, has* $\tan\alpha < 1$*, so the ball hits the wall. Inequality signs are condoned.*	
		(6)
		Total for Question 1: 12 marks

Question 2

12 marks

Part	Scheme	Marks
(a)	Integrates: $v = t^2 - 10t + c$	**M1**
	Continuity: $v(2) = 2^2 + 2 \times 2 = 8$, so $4 - 20 + c = 8$	**M1**
	$\boxed{v = t^2 - 10t + 24}$	**A1**
		(3)
(b)	$t^2 - 10t + 24 = 0$, so $(t - 4)(t - 6) = 0$	**M1**
	$\boxed{t = 4 \text{ and } t = 6}$	**A1**
		(2)
(c)	First stage: $\int_0^2 (t^2 + 2t)\,\mathrm{d}t = \frac{20}{3}$	**M1**
	Correct value	**A1**
	Second stage split at $t = 4$ and $t = 6$, where P turns back	**M1**
	$\int_2^4 v\,\mathrm{d}t = \frac{20}{3}$	**A1**
	$\int_4^6 v\,\mathrm{d}t = -\frac{4}{3}$	**A1**
	$\int_6^7 v\,\mathrm{d}t = \frac{4}{3}$	**A1**
	$\frac{20}{3} + \frac{20}{3} + \frac{4}{3} + \frac{4}{3} = \boxed{16\,\text{m}}$	**A1**
	One integral from 2 to 7 gives the displacement, $\frac{20}{3}$, and adding it to the first stage gives $\frac{40}{3}$: M1 A1 only.	
		(7)
		Total for Question 2: 12 marks

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Question 3

13 marks

Part	Scheme	Marks
(a)	Areas: rectangle 192, hole 9π, lamina $192 - 9\pi$	B1
(i)	Moments about AD: $192 \times 6 - 9\pi \times 8 = (192 - 9\pi)\bar{x}$	M1
	Correct equation	A1
	5.65 cm	A1
(ii)	Moments about AB: $192 \times 8 - 9\pi \times 12 = (192 - 9\pi)\bar{y}$	M1
	7.31 cm	A1
		(6)
(b)	Topples about A when G is vertically above A: $\tan\theta = \dfrac{5.65}{7.31}$	M1
	$\tan\theta = 0.774$, so toppling at 37.7°	A1
	Sliding when $\tan\theta = \mu = 0.75$, at 36.9°	M1
	Compares: $0.75 < 0.774$	M1
	Slides first, at $\theta = 36.9^\circ$	A1
	Without the hole both would happen at $\tan\theta = 0.75$*. The hole is in the upper part, so* G *is lower and toppling needs a larger angle.*	
		(5)
(c)	DG vertical: $\tan\phi = \dfrac{5.65}{16 - 7.31}$	M1
	33.0° (or 33)	A1
		(2)
		Total for Question 3: 13 marks

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Question 4

13 marks

Part	Scheme	Marks
(a)	About to slip: friction at the ground $F = 0.4R$, towards the wall	**B1**
	Friction at the wall $F_w = 0.5S$, acting *upwards* (B is about to slide down)	**B1**
	Resolving horizontally: $F = S$	**M1**
	Resolving vertically: $R + F_w = 100g$	**M1**
	$R + 0.2R = 100g$, so $R = \frac{250g}{3}$ and $S = \frac{100g}{3}$	**A1**
	Moments about A, with the man x m from A: $S \times 8\sin\alpha + F_w \times 8\cos\alpha = 30g \times 4\cos\alpha + 70g \times x\cos\alpha$	**M1**
	Correct equation, with F_w in the moments	**A1**
	$\frac{100}{3} \times 6.4 + \frac{50}{3} \times 4.8 = 72 + 42x$, i.e. $213.3 + 80 = 72 + 42x$	**A1**
	Solves for x	**dM1**
	5.27 m	**A1**
	Wall friction drawn downwards, or left out, loses B1 and every accuracy mark after it.	**(10)**
(b)	Total force = $\sqrt{R^2 + F^2}$, with $F = 0.4R$	**M1**
	$\frac{250g}{3}\sqrt{1.16}$	**A1**
	880 N (or 879)	**A1**
		(3)
		Total for Question 4: 13 marks

Question 5

12 marks

Part	Scheme	Marks
(a)	Momentum: $mu = mv_A + 2mv_B$	M1
	Restitution: $v_B - v_A = eu$	M1
	Both correct	A1
	$\boxed{v_A = \dfrac{u(1-2e)}{3}}$	A1
	$\boxed{v_B = \dfrac{u(1+e)}{3}}$	A1
		(5)
(b)	B rebounds from the wall with speed $\dfrac{1}{4} \times \dfrac{u(1+e)}{3} = \dfrac{u(1+e)}{12}$	B1
	For $e \leqslant \frac{1}{2}$, A is moving towards the wall, so they meet again	M1
	For $e > \frac{1}{2}$, A moves away from the wall at $\dfrac{u(2e-1)}{3}$: needs $\dfrac{u(1+e)}{12} > \dfrac{u(2e-1)}{3}$	M1
	$1 + e > 8e - 4$	A1
	$\boxed{0 \leqslant e < \frac{5}{7}}$	A1
		(5)
(c)	$e = \frac{1}{2}$: $v_B = \frac{u}{2}$, rebounds at $\frac{u}{8}$; loss $= \frac{1}{2}(2m)\left(\frac{u^2}{4} - \frac{u^2}{64}\right)$	M1
	$\boxed{\dfrac{15}{64}mu^2}$	A1
		(2)
		Total for Question 5: 12 marks

Question 6

13 marks

Part	Scheme	Marks
(a)	At top speed on the level: $\frac{20000}{40} = k \times 40$	M1
	$500 = 40k$	A1
	$\boxed{k = 12.5}$	A1
		(3)
(b)	Up the road: $\frac{20000}{v} = 12.5v + 800g \times \frac{1}{16}$	M1
	$12.5v^2 + 490v - 20000 = 0$	A1
	Solves, rejecting the negative root	dM1
	$\boxed{24.9\,\text{m s}^{-1}}$	A1
		(4)
(c)	Down the road, the weight component acts forwards: $\frac{20000}{v} + 490 = 12.5v$	M1
	$12.5v^2 - 490v - 20000 = 0$	A1
	Solves, rejecting the negative root	dM1
	$\boxed{64.1\,\text{m s}^{-1}}$	A1
	Using the same equation as (b) gives 24.9 again: M0. The weight component helps the car downhill.	
		(4)
(d)	Constant speed: driving force $= 12.5 \times 20 + 490 = 740$; power $= 740 \times 20$	M1
	$\boxed{14.8\,\text{kW}}$	A1
		(2)
		Total for Question 6: 13 marks

TOTAL FOR PAPER: 75 MARKS

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