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INTERNATIONAL A LEVEL MATHEMATICS • MECHANICS 2 (WME02)

Mechanics 2 Practice Paper 2

Mark Scheme

AIMING FOR 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* **61** • A **54** • B **46** • C **38**

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

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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	A projectile reaching a wall; energy and direction	9	Ch 1 Projectiles · Ch 4 Work and Energy	
2	Integrating a vector acceleration; an impulse	10	Ch 2 Variable Acceleration · Ch 5 Impulses and Collisions	
3	Centre of mass of a loaded frame; sliding or toppling	10	Ch 3 Centres of Mass · Ch 6 Statics of Rigid Bodies	
4	Work-energy on a rough slope, then restitution	11	Ch 4 Work and Energy · Ch 5 Impulses and Collisions	
5	A composite rod on a hinge: tension and hinge force	11	Ch 6 Statics of Rigid Bodies · Ch 3 Centres of Mass	
6	Successive collisions and a range of e	12	Ch 5 Impulses and Collisions · Ch 4 Work and Energy	
7	Force, power and work from a velocity function	12	Ch 2 Variable Acceleration · 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 a link between two chapters: a speed carried from an energy equation into a collision, a centre of mass used in a moments equation, or the sign of a velocity that decides what happens next. Paper 3 gives no route at all and hides a trap in every question.

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Question 1

9 marks

Part	Scheme	Marks
(a)	Horizontal: $25\cos\alpha = 15$, so $t = \dfrac{24}{15} = 1.6$	M1
	Vertical: $h = 20 \times 1.6 - 4.9 \times 1.6^2$	M1
	$\boxed{19.5\,\text{m}}$ (or 19)	A1
		(3)
(b)	Energy: $\frac{1}{2}mv^2 = \frac{1}{2}m \times 25^2 - mg \times 19.456$	M1
	$v^2 = 243.66$	A1
	$\boxed{15.6\,\text{m s}^{-1}}$ (or 16)	A1
	Finding the speed from components only scores 0: the question requires conservation of energy.	
		(3)
(c)	Vertical velocity at the wall: $20 - 9.8 \times 1.6 = 4.32$ (or from $v^2 - 15^2$)	M1
	$\tan\theta = \dfrac{4.32}{15}$	M1
	$\boxed{16.1^\circ \text{ above the horizontal}}$, still rising	A1
	The final A1 needs the direction: the vertical velocity is positive, so the ball is still going up.	
		(3)
		Total for Question 1: 9 marks

Question 2

10 marks

Part	Scheme	Marks
(a)	Integrates: $\mathbf{v} = 2t\mathbf{i} - 3t^2\mathbf{j} + \mathbf{c}$	M1
	Uses $\mathbf{v} = -4\mathbf{i} + 3\mathbf{j}$ at $t = 0$	M1
	$\boxed{\mathbf{v} = (2t-4)\mathbf{i} + (3-3t^2)\mathbf{j}}$	A1
		(3)
(b)	Parallel to $\mathbf{i}$: $3 - 3t^2 = 0$	M1
	$t = 1$ (rejecting $t = -1$), so $\mathbf{v} = -2\mathbf{i}$	A1
	$\boxed{2\,\text{m s}^{-1}}$	A1
		(3)
(c)	At $t = 2$: $\mathbf{v} = -9\mathbf{j}$	B1
	Impulse $= 0.5\big((3\mathbf{i} + 6\mathbf{j}) - (-9\mathbf{j})\big)$	M1
	$= 1.5\mathbf{i} + 7.5\mathbf{j}$	A1
	$\boxed{7.65\,\text{N s}}$ (or 7.6)	A1
		(4)
		Total for Question 2: 10 marks

Question 3

10 marks

Part	Scheme	Marks
(a)	Masses in proportion to length: AB 0.3 kg, BC 0.4 kg, CA 0.5 kg, with centres at the midpoints	B1
(i)	Moments about AB: $0.4 \times 20 + 0.5 \times 20 + 0.6 \times 0 = 1.8\bar{x}$	M1
	Correct equation	A1
	$\boxed{10\,\text{cm}}$	A1
(ii)	Moments about BC: $0.3 \times 15 + 0.5 \times 15 + 0.6 \times 30 = 1.8\bar{y}$	M1
	$\boxed{16.7\,\text{cm}}$ (or $\frac{50}{3}$)	A1
		(6)
(b)	Topples about B when G is vertically above B: $\tan\alpha = \dfrac{10}{16.7} = 0.6$	M1
	Slides when $\tan\alpha = \mu = 0.75$	M1
	$0.6 < 0.75$, so it $\boxed{\text{topples first}}$	A1
	$\boxed{\alpha = 31.0^\circ}$ (or 31)	A1
		(4)
	Total for Question 3: 10 marks	

Question 4

11 marks

Part	Scheme	Marks
(a)	$R = 2g\cos\alpha = 15.68$; work against friction $0.25 \times 15.68 \times 6.25$	B1
	Work-energy: gain in KE = loss of PE $-$ work against friction	M1
	$\frac{1}{2} \times 2v^2 = 2g \times 6.25 \times 0.6 - 0.25 \times 15.68 \times 6.25$	A1
	$v^2 = 73.5 - 24.5 = 49$: $\boxed{7\,\text{m s}^{-1}}$	A1
		(4)
(b)	Momentum: $2 \times 7 = 2v_P + 3v_Q$	M1
	Correct equation	A1
	Restitution: $v_Q - v_P = \frac{4}{7} \times 7 = 4$	M1
	Correct equation	A1
	$\boxed{P\text{: } 0.4\,\text{m s}^{-1},\ Q\text{: } 4.4\,\text{m s}^{-1}}$	A1
		(5)
(c)	$\frac{1}{2} \times 2 \times 7^2 - \left(\frac{1}{2} \times 2 \times 0.4^2 + \frac{1}{2} \times 3 \times 4.4^2\right)$	M1
	$\boxed{19.8\,\text{J}}$	A1
		(2)
	Total for Question 4: 11 marks	

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Question 5

11 marks

Part	Scheme	Marks
(a)	$3 \times 0.75 + 3 \times 1.75 = 6\bar{x}$	**M1**
	$\boxed{1.25\,\text{m}}$	**A1**
		(2)
(b)	Moments about A: $T \sin 30^\circ \times 2 = 6g \times 1.25$	**M1**
	Correct equation	**A1**
	$\boxed{73.5\,\text{N}}$ (or $7.5g$)	**A1**
		(3)
(c)	Horizontal: $H = T\cos 30^\circ$	**M1**
	$H = 63.65$, acting away from the wall	**A1**
	Vertical: $V + T\sin 30^\circ = 6g$	**M1**
	$V = 22.05$, upwards	**A1**
	$\sqrt{63.65^2 + 22.05^2} = \boxed{67.4\,\text{N}}$ (or 67)	**A1**
	$\boxed{19.1^\circ \text{ above the rod}}$, acting away from the wall	**A1**
	V can also come from moments about B: $2V = 6g \times 0.75$. Taking V downwards gives a negative value; the final A1 needs the direction stated.	
		(6)
		Total for Question 5: 11 marks

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Question 6

12 marks

Part	Scheme	Marks
(a)	Momentum: $mu = mv_A + 2mv_B$ and 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**
		(4)
(b)	$2m\,v_B = 2mw + 3mc$ and $c - w = e\,v_B$, with $v_B = \frac{u(1+e)}{3}$	**M1**
	Correct equations	**A1**
	$\boxed{w = \dfrac{u(1+e)(2-3e)}{15}}$	**A1**
		(3)
(c)	A catches B: $\dfrac{u(1+e)(2-3e)}{15} < \dfrac{u(1-2e)}{3}$	**M1**
	$e^2 - 3e + 1 > 0$	**A1**
	$\boxed{0 \leqslant e < \dfrac{3-\sqrt{5}}{2}}$ $(e < 0.382)$	**A1**
	The other root, $\frac{3+\sqrt{5}}{2}$, is rejected as $e \leqslant 1$. For $e > \frac{1}{2}$, A moves backwards and cannot catch B.	**(3)**
(d)	$v_A = \frac{u}{6}$, $v_B = \frac{5u}{12}$; loss $= \frac{1}{2}mu^2 - \frac{1}{2}m\left(\frac{u}{6}\right)^2 - \frac{1}{2}(2m)\left(\frac{5u}{12}\right)^2$	**M1**
	$\boxed{\dfrac{5}{16}mu^2}$	**A1**
		(2)
		Total for Question 6: 12 marks

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Question 7

12 marks

Part	Scheme	Marks
(a)	$a = \frac{dv}{dt} = 2t - 6$ and $F = 3a$	M1
	$\boxed{F = (6t - 18)\,\text{N}}$	A1
		(2)
(b)	$v = (t-3)^2 + 4$, or $\frac{dv}{dt} = 0$ at $t = 3$	M1
	$\boxed{4\,\text{m s}^{-1}}$	A1
		(2)
(c)	$P = Fv = 12 \times 8$	M1
	$\boxed{96\,\text{W}}$	A1
		(2)
(d)	Work done = change in kinetic energy, with $v(0) = 13$ and $v(5) = 8$	M1
	$\frac{1}{2} \times 3 \times 8^2 - \frac{1}{2} \times 3 \times 13^2$	A1
	$\boxed{-157.5\,\text{J}}$ (accept -158, or 158 J of work done against the motion)	A1
		(3)
(e)	$v > 0$ throughout (least value 4), so distance = $\int_0^5 (t^2 - 6t + 13)\,dt$	M1
	$\left[\frac{t^3}{3} - 3t^2 + 13t\right]_0^5$	A1
	$\boxed{31.7\,\text{m}}$ (or $\frac{95}{3}$)	A1
		(3)
		Total for Question 7: 12 marks

TOTAL FOR PAPER: 75 MARKS

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