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INTERNATIONAL A LEVEL MATHEMATICS • MECHANICS 1 (WME01)

Mechanics 1 Practice Paper 3

Mark Scheme

AIMING FOR A/A*

Written in the style of the Pearson Edexcel International Advanced Level paper (WME01/01) • 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. 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 **50** • B **42** • C **34**

Based on recent WME01 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	Two collisions and a range of masses	12	Ch 6 Momentum and Impulse	
2	Overtaking on a speed-time graph	12	Ch 2 Constant Acceleration	
3	A string at an angle to a rough slope	13	Ch 7 Statics of a Particle Ch 5 Forces and Friction	
4	A hanging rod with a string at its limits	13	Ch 8 Moments	
5	A pulley and a string jerked taut	12	Ch 4 Dynamics of a Particle Ch 6 Momentum and Impulse	
6	Velocity vectors under two forces	13	Ch 3 Vectors in Mechanics Ch 2 Constant Acceleration	
	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: a particle moving the other way, a root from before the motion started, a reaction that depends on the tension, a string gone slack, or a turning point outside the time allowed. At grade A* the method is rarely the problem; checking every answer against the situation is.

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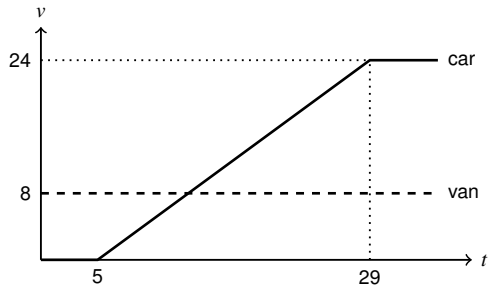
Question 1

12 marks

Part	Scheme	Marks
(a)	Conservation of momentum, with A's new velocity negative: $2 \times 6 = 2 \times (-1) + 4v$	**M1**
	Correct equation	**A1**
	$\boxed{3.5\,\text{m s}^{-1}}$	**A1**
		(3)
(b)	$4 \times 3.5 - 0$, or $2 \times \big(6 - (-1)\big)$	**M1**
	$\boxed{14\,\text{N s}}$	**A1**
		(2)
(c)	Conservation of momentum for B and C, with C's velocity negative: $4 \times 3.5 - 4m = (4+m)v$	**M1**
	$v = \dfrac{14-4m}{4+m}$	**A1**
	D moves towards A when $v < 0$	**M1**
	$\boxed{m > 3.5}$	**A1**
	C moves towards B, so its momentum is $-4m$. Using $+4m$ makes D always move away from A and loses all four marks.	
		(4)
(d)	A is moving away from B at $1\,\text{m s}^{-1}$, so D must move towards A faster: $\dfrac{4m-14}{4+m} > 1$	**M1**
	$4m - 14 > 4 + m$	**A1**
	$\boxed{m > 6}$	**A1**
	The trap: $m > 3.5$ only makes D move towards A. If D is slower than A, it never catches it.	
		(3)
		Total for Question 1: 12 marks

Question 2

12 marks

Part	Scheme	Marks
(a)	 Van: a horizontal line at speed 8 for the whole interval Car: zero until $t = 5$, then a straight line rising to 24 at $t = 29$ Car then horizontal at 24 until $t = 35$, with 5, 29, 8 and 24 marked	B1 B1 B1 (3)
(b)	Greatest distance when the speeds are equal: $t - 5 = 8$, so $t = 13$ Van $8 \times 13 = 104$, car $\frac{1}{2} \times 8 \times 8 = 32$; difference of distances (or area between the graphs) $\boxed{72\text{ m}}$	M1 M1 A1 (3)
(c)	Equal distances from O: $\frac{1}{2}(t-5)^2 = 8t$ Correct equation $t^2 - 26t + 25 = 0$ $t = 1$ or $t = 25$ $\boxed{t = 25}$, rejecting $t = 1$ (the car has not set off) and checking $25 < 29$ (still accelerating) *The car's distance $\frac{1}{2}(t-5)^2$ only holds for $5 \leqslant t \leqslant 29$. The final A1 needs both checks.*	M1 A1 dM1 A1 A1 (5)
(d)	$8 \times 25 = \boxed{200\text{ m}}$	B1 (1)
		Total for Question 2: 12 marks

Question 3

13 marks

Part	Scheme	Marks
(a)	Perpendicular to the plane: $R + T\sin\beta = 4g\cos\alpha$ $\boxed{R = 31.36 - \frac{5}{13}T}$ *The string pulls the particle away from the plane, so R is less than $4g\cos\alpha$.*	**M1** **A1** **(2)**
(b)	Least T: about to slide down, friction up the plane: $T\cos\beta + 0.5R = 4g\sin\alpha$ $\frac{12}{13}T + 0.5\left(31.36 - \frac{5}{13}T\right) = 23.52$ Solves: $\frac{9.5}{13}T = 7.84$ $\boxed{10.7}$	**M1** **A1** **dM1** **A1** **(4)**
(c)	Greatest T: about to slide up, friction down the plane: $T\cos\beta = 4g\sin\alpha + 0.5R$ $\frac{12}{13}T = 23.52 + 0.5\left(31.36 - \frac{5}{13}T\right)$ $\boxed{35.1}$	**M1** **A1** **A1** **(3)**
(d)	$4g\sin\alpha - 20\cos\beta = 23.52 - 18.46$ $\boxed{5.06\,\text{N}}$ acting up the plane	**M1** **A1** **(2)**
(e)	$R = 4g\cos\alpha$ now: $4g\sin\alpha - 0.5 \times 4g\cos\alpha = 4a$ $\boxed{1.96\,\text{m s}^{-2}}$ down the plane	**M1** **A1** **(2)**
		Total for Question 3: 13 marks

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Question 4

13 marks

Part	Scheme	Marks
(a)	$T_C + T_B = 4g$ and $T_C = 5T_B$, so $T_B = \frac{2g}{3}$	**M1**
	Moments about C (or A), with the centre of mass d m from A	**M1**
	$\frac{2g}{3} \times 3 = 4g(d-1)$	**A1**
	$\boxed{1.5\,\text{m}}$	**A1**
		(4)
(b)	Moments about C: $3T_B = 4g \times 0.5 + 4g \times 2$	**M1**
	$T_B = \frac{10g}{3} = \boxed{32.7\,\text{N}}$	**A1**
	$T_C = 8g - T_B = \boxed{45.7\,\text{N}}$	**A1**
		(3)
(c)	Moments about C: $3T_B = 4g \times 0.5 + 4g(x-1)$	**M1**
	$T_B = \dfrac{g(4x-2)}{3}$	**A1**
	Lower limit: the string at B is about to go slack, $T_B \geqslant 0$	**M1**
	$x \geqslant 0.5$	**A1**
	Upper limit: $\dfrac{g(4x-2)}{3} \leqslant 39.2$	**M1**
	$\boxed{0.5 \leqslant x \leqslant 3.5}$	**A1**
	With P between A and C the rod turns about C and the string at B goes slack: that is the lower limit, not $x = 0$. $T_C = 8g - T_B$ stays positive throughout.	
		(6)
		Total for Question 4: 13 marks

Question 5

12 marks

Part	Scheme	Marks
(a)	B: $3g - T = 3a$	**M1**
	A: $T - 2g = 2a$	**M1**
	$\boxed{a = 1.96\,\text{m s}^{-2}}$	**A1**
	$\boxed{T = 23.5\,\text{N}}$ (accept 23.52)	**A1**
		(4)
(b)	$v^2 = 2 \times 1.96 \times 1.6$	**M1**
	$\boxed{2.50\,\text{m s}^{-1}}$ (or 2.5)	**A1**
		(2)
(c)	A moves freely under gravity and returns to the same point: $0 = 2.50t - 4.9t^2$, or $t = \frac{2v}{g}$	**M1**
	$\boxed{0.511\,\text{s}}$ (or 0.51)	**A1**
		(2)
(d)	A returns with speed 2.50 downwards. Momentum: $2 \times 2.50 = (2+3)w$	**M1**
	Correct equation, with both particles moving at w afterwards	**A1**
	$\boxed{1.00\,\text{m s}^{-1}}$ (or 1.0)	**A1**
	Common errors: $2 \times 2.50 = 3w$ (forgetting that A keeps moving), or including gravity in the jerk.	
		(3)
(e)	$3 \times 1.00 = \boxed{3.01\,\text{N s}}$ (accept 3.0 or 3.00)	**B1**
		(1)
		Total for Question 5: 12 marks

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Question 6

13 marks

Part	Scheme	Marks
(a)	$\mathbf{a} = \frac{1}{2}(6\mathbf{i} - 8\mathbf{j}) = 3\mathbf{i} - 4\mathbf{j}$ and $\mathbf{v} = \mathbf{u} + \mathbf{a}t$	M1
	$\boxed{\mathbf{v} = (3t - 4)\mathbf{i} + (10 - 4t)\mathbf{j}}$	A1
		(2)
(b)	Speed$^2 = (3t - 4)^2 + (10 - 4t)^2$	M1
	$= 25t^2 - 104t + 116$	A1
	Turning point at $t = 2.08$, outside $0 \leqslant t \leqslant 2$, so the speed is decreasing throughout and is least at $t = 2$	M1
	$\sqrt{8} = \boxed{2.83\,\text{m s}^{-1}}$	A1
	The trap: $\sqrt{7.84} = 2.8$ is the least value of the formula, but at $t = 2.08$ the force has already changed. Giving 2.8 scores M1 A1 M0 A0.	
		(4)
(c)	At $t = 2$: $\mathbf{v} = 2\mathbf{i} + 2\mathbf{j}$	M1
	Straight line to rest in 2 s: $\mathbf{a} = \dfrac{\mathbf{0} - (2\mathbf{i} + 2\mathbf{j})}{2} = -\mathbf{i} - \mathbf{j}$	M1
	$\boxed{\mathbf{G} = (-2\mathbf{i} - 2\mathbf{j})\,\text{N}}$	A1
		(3)
(d)	At $t = 2$: $\mathbf{r} = 2\mathbf{u} + \frac{1}{2}\mathbf{a} \times 2^2$	M1
	$= -2\mathbf{i} + 12\mathbf{j}$	A1
	Then adds $(2\mathbf{i} + 2\mathbf{j}) \times 2 + \frac{1}{2}(-\mathbf{i} - \mathbf{j}) \times 2^2 = 2\mathbf{i} + 2\mathbf{j}$	M1
	$\boxed{14\mathbf{j}\,\text{m}}$	A1
		(4)
	Total for Question 6: 13 marks	

TOTAL FOR PAPER: 75 MARKS

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