eClassroom

INTERNATIONAL A LEVEL MATHEMATICS • MECHANICS 2 (WME02)

Mechanics 2 Practice Paper 1

Mark Scheme

AIMING FOR B

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* **66** • A **59** • B **51** • C **43**

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

★★★★★

Join students already acing their exams.

Book your FREE lesson at www.eclassroom.org.uk

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	Variable acceleration: integrating, and distance when the particle turns back	7	Ch 2 Variable Acceleration	
2	Impulse in vector form; speed and kinetic energy	8	Ch 5 Impulses and Collisions Ch 4 Work and Energy	
3	Power, driving force and acceleration on a slope	9	Ch 4 Work and Energy	
4	Centre of mass of a composite lamina; hanging freely	9	Ch 3 Centres of Mass	
5	A projectile from a cliff: time, range and speed	9	Ch 1 Projectiles	
6	Restitution in a direct collision and at a wall	10	Ch 5 Impulses and Collisions	
7	A ladder in limiting equilibrium	10	Ch 6 Statics of Rigid Bodies	
8	The work-energy principle on a rough slope, up and back	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 a sign, a missing g, a term left out of an energy equation, or a speed given as a vector. A clear diagram, with every force and every height marked, stops most of these.

★★★★★

Join students already acing their exams.
Book your FREE lesson at www.eclassroom.org.uk

Question 1

7 marks

Part	Scheme	Marks
(a)	Integrates: $v = 3t^2 - 14t + c$, with $c = 8$ from $v = 8$ at $t = 0$	M1
	$\boxed{v = 3t^2 - 14t + 8}$	A1
		(2)
(b)	$3t^2 - 14t + 8 = 0$, so $(3t - 2)(t - 4) = 0$	M1
	$\boxed{t = \frac{2}{3} \text{ and } t = 4}$	A1
		(2)
(c)	Integrates v: $s = t^3 - 7t^2 + 8t$ (no constant, as $s = 0$ at $t = 0$)	M1
	Uses $s\left(\frac{2}{3}\right) = \frac{68}{27}$ and $s(4) = -16$, and splits the motion at $t = \frac{2}{3}$: $2 \times \frac{68}{27} + 16$	dM1
	$\boxed{21.0\,\text{m}}$ (or $\frac{568}{27}$)	A1
	The particle turns back at $t = \frac{2}{3}$. Giving the displacement, 16 m, scores M1 only.	
		(3)
	Total for Question 1: 7 marks	

Question 2

8 marks

Part	Scheme	Marks
(a)	Impulse = change in momentum: $-3\mathbf{i} + 2\mathbf{j} = 0.4\left(\mathbf{v} - (5\mathbf{i} + 2\mathbf{j})\right)$	M1
	Correct equation	A1
	$\mathbf{v} = -2.5\mathbf{i} + 7\mathbf{j}$	A1
	Speed = $\sqrt{2.5^2 + 7^2}$	M1
	$\boxed{7.43\,\text{m s}^{-1}}$ (or 7.4)	A1
	The question asks for the speed. Leaving the answer as a vector loses the last two marks.	
		(5)
(b)	Kinetic energy before and after: $\frac{1}{2} \times 0.4 \times 29 = 5.8$ and $\frac{1}{2} \times 0.4 \times 55.25 = 11.05$	M1
	Both correct	A1
	$\boxed{5.25\,\text{J}}$	A1
		(3)
	Total for Question 2: 8 marks	

★★★★★
Join students already acing their exams.
Book your FREE lesson at www.eclassroom.org.uk

Question 3

9 marks

Part	Scheme	Marks
(a)	Driving force $= \frac{24000}{v}$	M1
	At top speed the acceleration is zero: $\frac{24000}{v} = 500 + 1000g \times \frac{1}{14}$	M1
	$\frac{24000}{v} = 1200$	A1
	$v = 20\,\text{m s}^{-1}$	A1*
		(4)
(b)	$\frac{24000}{12} - 500 - 700 = 1000a$	M1
	Correct equation	A1
	$0.8\,\text{m s}^{-2}$	A1
		(3)
(c)	Constant speed, so driving force = 500 N; power $= 500 \times 30$	M1
	$15\,\text{kW}$	A1
		(2)
		Total for Question 3: 9 marks

Question 4

9 marks

Part	Scheme	Marks
(a)	Areas: rectangle 48, semicircle $\frac{9}{2}\pi$ (or masses in that ratio)	B1
	Distances from AD: rectangle 4, semicircle $\frac{4\times3}{3\pi} = \frac{4}{\pi}$ on the other side of AD	B1
	Moments about AD: $48 \times 4 - \frac{9}{2}\pi \times \frac{4}{\pi} = \left(48 + \frac{9}{2}\pi\right)\bar{x}$	M1
	Correct equation, with the semicircle's term subtracted	A1
	$2.80\,\text{cm}$ (or 2.8)	A1
		(5)
(b)	By symmetry, G is 3 cm from AB; horizontal distance from B along BA is $8 - 2.80 = 5.20$	B1
	$\tan\theta = \frac{3}{5.20}$, with θ the angle between BA and the vertical through B and G	M1
	Correct ratio	A1
	30.0° (or 30°)	A1
		(4)
		Total for Question 4: 9 marks

Question 5

9 marks

Part	Scheme	Marks
(a)	Components: 11.2 horizontally and 8.4 vertically	B1
	Vertical motion: $-30 = 8.4t - 4.9t^2$	M1
	Correct equation	A1
	$\boxed{3.48\,\text{s}}$ (or 3.5)	A1
		(4)
(b)	$11.2 \times 3.475\ldots$	M1
	$\boxed{38.9\,\text{m}}$ (or 39)	A1
		(2)
(c)	Vertical speed $8.4 - 9.8 \times 3.475\ldots = -25.66$, or energy: $v^2 = 14^2 + 2 \times 9.8 \times 30$	M1
	$v^2 = 11.2^2 + 25.66^2 = 784$	A1
	$\boxed{28\,\text{m s}^{-1}}$	A1
		(3)
		Total for Question 5: 9 marks

Question 6

10 marks

Part	Scheme	Marks
(a)	Conservation of momentum, with B's velocity negative: $3m(2u) - mu = 3mv_A + mv_B$	M1
	$5u = 3v_A + v_B$	A1
	Newton's law of restitution: $v_B - v_A = e(2u + u)$	M1
	$v_B - v_A = 3eu$	A1
	Solves: $4v_B = 5u + 9eu$, so $v_B = \dfrac{u(5+9e)}{4}$	A1*
		(5)
(b)	$v_A = \dfrac{u(5-3e)}{4} = u$ and $v_B = 2u$; kinetic energy before $\frac{1}{2}(3m)(2u)^2 + \frac{1}{2}mu^2 = \frac{13}{2}mu^2$	M1
	After: $\frac{1}{2}(3m)u^2 + \frac{1}{2}m(2u)^2 = \frac{7}{2}mu^2$	A1
	$\boxed{3mu^2}$	A1
		(3)
(c)	B rebounds at $\frac{1}{4} \times 2u = \frac{u}{2}$; impulse $= m\left(\frac{u}{2} - (-2u)\right)$	M1
	$\boxed{\frac{5}{2}mu}$	A1
	The velocity changes direction, so the change is $2u + \frac{u}{2}$, not $2u - \frac{u}{2}$.	
		(2)
		Total for Question 6: 10 marks

★★★★★ Join students already acing their exams.
Book your FREE lesson at www.eclassroom.org.uk

Question 7

10 marks

Part	Scheme	Marks
(a)	Resolving: $R = 20g$ and $F = S$, where S is the reaction at the wall	**M1**
	Moments about A: $S \times 6\sin\alpha = 20g \times 3\cos\alpha$	**M1**
	$S = 7.5g$, so $F = 7.5g$	**A1**
	$F \leqslant \mu R$: $7.5g \leqslant \mu \times 20g$	**M1**
	$\mu \geqslant \frac{3}{8}$	**A1***
		(5)
(b)	About to slip: $R = 100g$ and $F = 0.5 \times 100g = 50g$, so $S = 50g$	**B1**
	Moments about A, with the man x m from A: $S \times 6\sin\alpha = 20g \times 3\cos\alpha + 80g \times x\cos\alpha$	**M1**
	$50g \times 4.8 = 20g \times 1.8 + 80g \times 0.6x$	**A1**
	Solves: $240 = 36 + 48x$	**dM1**
	$\boxed{4.25\text{ m}}$	**A1**
		(5)
		Total for Question 7: 10 marks

★★★★★
Join students already acing their exams.
Book your FREE lesson at www.eclassroom.org.uk

Question 8

13 marks

Part	Scheme	Marks
(a)	$R = 2g\cos\alpha = 15.68$, so friction $= 15.68\mu$	B1
	Work-energy: loss of kinetic energy = gain in potential energy + work done against friction	M1
	$\frac{1}{2}\times 2\times 11.2^2 = 2g\times 8\sin\alpha + 15.68\mu\times 8$	A1
	$125.44 = 94.08 + 125.44\mu$	A1
	$\mu = \frac{1}{4}$	A1*
	A solution by $F = ma$ and $v^2 = u^2 + 2as$ scores 0 in (a): the question requires the work-energy principle.	(5)
(b)	Compares $2g\sin\alpha = 11.76$ N with the greatest friction $\frac{1}{4}\times 15.68 = 3.92$ N (or $\tan\alpha = 0.75 > 0.25$)	M1
	$11.76 > 3.92$, so the particle slides back down	A1
		(2)
(c)	Work-energy from B to A: loss of potential energy = gain in kinetic energy + work against friction	M1
	$2g\times 8\times 0.6 = \frac{1}{2}\times 2v^2 + 3.92\times 8$	A1
	$v^2 = 62.72$	A1
	$\boxed{7.92\,\text{m s}^{-1}}$ (or 7.9)	A1
		(4)
(d)	3.92×16, or the total loss of kinetic energy $\frac{1}{2}\times 2(11.2^2 - v^2)$	M1
	$\boxed{62.7\,\text{J}}$ (or 63)	A1
		(2)
	Total for Question 8: 13 marks	

TOTAL FOR PAPER: 75 MARKS

★★★★★
Join students already acing their exams.
Book your FREE lesson at www.eclassroom.org.uk