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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	own PDF	
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	3	
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 7: Statics of a Particle

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

Question 1

6 marks

Part	Scheme	Marks
	Horizontally: $T_A \cos 30^\circ = T_B \cos 45^\circ$	M1
	Correct	A1
	Vertically: $T_A \sin 30^\circ + T_B \sin 45^\circ = 4g$	M1
	Correct	A1
	Solves: $T_A = 28.7 \text{ N}$	A1
	$T_B = 35.1 \text{ N}$	A1
	<i>Jan 2022 report: the weight is 4g, not 4. The triangle of forces (sine rule with angles $45^\circ, 60^\circ, 75^\circ$) is equally valid.</i>	
		(6)
Total for Question 1: 6 marks		

Question 2

6 marks

Part	Scheme	Marks
(a)	$3 + p - 5 = 0$ and $-4 + 2 + q = 0$	M1
	$p = 2, q = 2$	A1
		(2)
(b)	Resultant of the other two forces = $-(-5\mathbf{i} + 2\mathbf{j}) = 5\mathbf{i} - 2\mathbf{j}$	M1
	$\mathbf{a} = \frac{1}{2}(5\mathbf{i} - 2\mathbf{j}) = 2.5\mathbf{i} - \mathbf{j}$	A1
	2.69 ms^{-2}	A1
	21.8° below $\mathbf{i}$ (towards $-\mathbf{j}$)	A1
		(4)
Total for Question 2: 6 marks		



Question 3

6 marks

Part	Scheme	Marks
(a)	$R + 20 \sin \theta = 40$ with $\sin \theta = \frac{3}{5}$ 28 N	M1 A1 (2)
(b)	Horizontally: $F = 20 \cos \theta = 16$ At rest: $F \leq \mu R$, so $16 \leq 28\mu$ $\mu \geq \frac{16}{28} = \frac{4}{7}$ * <i>Using $F = \mu R$ (an equation) instead of the inequality loses the A mark (Jan 2018 scheme).</i>	B1 M1 A1* (3)
(c)	Limiting equilibrium: P is on the point of slipping	B1 (1)
Total for Question 3: 6 marks		

Question 4

6 marks

Part	Scheme	Marks
(a)	East-west: $Q = 12 \sin 120^\circ$ $Q = 6\sqrt{3}$ (10.4)	M1 A1 (2)
(b)	North-south: $P + 12 \cos 120^\circ = 0$, i.e. $P = 12 \cos 60^\circ$ $P = 6$ <i>A diagram with north marked avoids the sign error in the component $12 \cos 120^\circ = -6$.</i>	M1 A1 (2)
(c)	East-west: $12 \sin \phi = 6$ with the bearing ϕ between 090° and 180° bearing 150° , and $P = -12 \cos 150^\circ = 6\sqrt{3}$ (10.4)	M1 A1 (2)
Total for Question 4: 6 marks		



Question 5

6 marks

Part	Scheme	Marks
(a)	Limiting: $2g \sin \alpha = \mu \times 2g \cos \alpha$ $\mu = \tan \alpha = \frac{7}{24}$ *	M1 A1* (2)
(b)	About to move up: $P = 2g \sin \alpha + \mu \times 2g \cos \alpha$ $= 2g \left(\frac{7}{25} + \frac{7}{24} \times \frac{24}{25} \right)$ 11.0N (11)	M1 A1 A1 (3)
(c)	Down the plane, opposing the direction in which the particle is about to move	B1 (1)
Total for Question 5: 6 marks		

Question 6

10 marks

Part	Scheme	Marks
(a)	Perpendicular to the plane: $R + \frac{1}{2}mg \sin 30^\circ = mg \cos \alpha$ $R = \frac{4}{5}mg - \frac{1}{4}mg$ $R = \frac{11}{20}mg$ Jan 2025 report: $R = mg \cos \alpha$, ignoring the effect of the string, is the most common error.	M1 A1 A1 (3)
(b)	Parallel: $F + \frac{1}{2}mg \cos 30^\circ = mg \sin \alpha$, so $F = \frac{3}{5}mg - \frac{\sqrt{3}}{4}mg$ Correct F Limiting: $F = \mu R$, $\mu = \frac{\frac{3}{5} - \frac{\sqrt{3}}{4}}{\frac{11}{20}}$ $= \frac{12 - 5\sqrt{3}}{11}$ *	M1 A1 M1 A1* (4)
(c)	$\mu = 0.304 < \tan \alpha = 0.75$ (or $0.6mg > 0.304 \times 0.8mg$), so it slides $mg \sin \alpha - \mu mg \cos \alpha = ma$ 3.50 ms^{-2}	B1 M1 A1 (3)
Total for Question 6: 10 marks		



Question 7

10 marks

Part	Scheme	Marks
(a)	Tension in the horizontal string = $3g$ (smooth pulley) Horizontally: $T \sin \theta = 3g$; vertically: $T \cos \theta = 4g$ Both correct $\tan \theta = \frac{3}{4}$: $\theta = 36.9^\circ$ $T = 5g = 49 \text{ N}$	B1 M1 A1 A1 A1 (5)
(b)	$\tan 45^\circ = \frac{Mg}{4g}$ $M = 4$	M1 A1 (2)
(c)	The tension is the same on both sides of the pulley, so it equals the weight $3g$ of the hanging particle	B1 (1)
(d)	Two perpendicular tensions of $3g$: $3g\sqrt{2}$ 41.6 N	M1 A1 (2)
Total for Question 7: 10 marks		



Question 8

11 marks

Part	Scheme	Marks
(a)	Least P: on the point of slipping down, friction up the plane Perpendicular: $R = 2g \cos \alpha + P \sin \alpha$ Parallel: $P \cos \alpha + 0.25R = 2g \sin \alpha$ $0.8P + 0.25(15.68 + 0.6P) = 11.76$ $P = 8.25$ (8.3)	B1 M1 M1 A1 A1 (5)
(b)	Greatest P: about to slip up, friction down: $P \cos \alpha = 2g \sin \alpha + 0.25R$ Correct equation with $R = 2g \cos \alpha + P \sin \alpha$ $0.65P = 15.68$ $P = 24.1$ (24)	M1 A1 M1 A1 (4)
(c)	$P \cos \alpha - 2g \sin \alpha = 12 - 11.76$ $0.24 \text{ N, acting down the plane}$ <i>The particle is not in limiting equilibrium here: friction is only as large as it needs to be</i> ($0.24 < 0.25 \times 24.68$).	M1 A1 (2)
Total for Question 8: 11 marks		



Question 9

10 marks

Part	Scheme	Marks
(a)	Vertically: $R + 1.5 \sin 30^\circ = 0.4g$, $R = 3.17$ Friction needed = $1.5 \cos 30^\circ = 1.30 \text{ N}$ Greatest friction $\mu R = 0.5 \times 3.17 = 1.585$ $1.30 < 1.585$ so the ring stays at rest; friction 1.30 N	M1 A1 M1 A1 (4)
(b)	Limiting with R upwards: $P \cos 30^\circ = 0.5(0.4g - P \sin 30^\circ)$ Correct equation $P(\cos 30^\circ + 0.25) = 1.96$ $P = 1.76$	M1 A1 M1 A1 (4)
(c)	When $P \sin 30^\circ > 0.4g$ the pull lifts the ring against the rod, so the rod pushes down: $R = P \sin 30^\circ - 0.4g$ Then limiting needs $P \cos 30^\circ \leq 0.5(0.5P - 3.92)$, i.e. $0.616P \leq -1.96$, which is impossible, so the ring moves	B1 B1 (2)
Total for Question 9: 10 marks		



Question 10

11 marks

Part	Scheme	Marks
(a)	$R = 5g \cos \alpha = \frac{60}{13}g$ and the greatest friction $0.2R = \frac{12}{13}g$ Least M : A about to slip down, friction up the plane: $Mg + \frac{12}{13}g = 5g \sin \alpha$ $Mg + \frac{12}{13}g = \frac{25}{13}g$ $M = 1$ *	B1 M1 A1 A1* (4)
(b)	Greatest M : about to slip up, friction down: $Mg = \frac{25}{13}g + \frac{12}{13}g$ Correct $M = \frac{37}{13}$ (2.85)	M1 A1 A1 (3)
(c)	$Mg = 5g \sin \alpha$: $M = \frac{25}{13}$ (1.92)	B1 (1)
(d)	A : $T - \frac{25}{13}g - \frac{12}{13}g = 5a$; hanging particle: $4g - T = 4a$ $\frac{15}{13}g = 9a$ 1.26 ms^{-2}	M1 A1 A1 (3)
Total for Question 10: 11 marks		

