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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	3	
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	own PDF	
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.



3

Chapter 3: Vectors in Mechanics

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

Question 1

6 marks

Part	Scheme	Marks
(a)	$\tan \theta = \frac{3}{4}$ (angle below east) or $\frac{4}{3}$; uses a diagram to place the direction $90^\circ + 36.9^\circ = 127^\circ$ <i>Summer 2019 and Jan 2015 reports: stopping at the acute angle 36.9° or 53.1° scores M1 A0.</i>	M1 A1 (2)
(b)	$\mathbf{r} = (-10 + 4t)\mathbf{i} + (18 - 3t)\mathbf{j}$	B1 (1)
(c)	Due east: $\mathbf{j}$ component = 0, $18 - 3t = 0$ $t = 6$ $\mathbf{r} = 14\mathbf{i}$: 14 m from O	M1 A1 A1 (3)
Total for Question 1: 6 marks		

Question 2

6 marks

Part	Scheme	Marks
(a)	Angle $STF = 180^\circ - (150^\circ - 60^\circ) = 90^\circ$ (turning from 060° to 150°) $SF^2 = 6^2 + 8^2$ 10 km Or components: $\vec{SF} = (6 \sin 60^\circ + 8 \sin 150^\circ)\mathbf{i} + (6 \cos 60^\circ + 8 \cos 150^\circ)\mathbf{j} = 9.196\mathbf{i} - 3.928\mathbf{j}$	M1 M1 A1 (3)
(b)	Angle TSF : $\tan^{-1} \frac{8}{6} = 53.1^\circ$ Bearing = $60^\circ + 53.1^\circ$ 113°	M1 M1 A1 (3)
Total for Question 2: 6 marks		



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Question 3

6 marks

Part	Scheme	Marks
(a)	$\tan \theta = \frac{4}{3}$ 53.1°	M1 A1 (2)
(b)	$\mathbf{a} + \mathbf{b} = (3 + p)\mathbf{i} - 2\mathbf{j}$ Parallel: $\frac{3+p}{2} = \frac{-2}{-1}$ (or $= \lambda(2\mathbf{i} - \mathbf{j})$) $p = 1$ <i>Equating the resultant to $2\mathbf{i} - \mathbf{j}$ itself (so $-2 = -1$) is the Summer 2019 error: M0.</i>	B1 M1 A1 (3)
(c)	$ 4\mathbf{i} - 2\mathbf{j} = \sqrt{20} = 4.47 \text{ m}$ ($2\sqrt{5}$)	B1 (1)
Total for Question 3: 6 marks		

Question 4

6 marks

Part	Scheme	Marks
(a)	$ 5\mathbf{i} - 12\mathbf{j} = 13$, so $\mathbf{v} = \frac{26}{13}(5\mathbf{i} - 12\mathbf{j})$ $(10\mathbf{i} - 24\mathbf{j}) \text{ km h}^{-1}$	M1 A1 (2)
(b)	$\mathbf{r} = (-20 + 10t)\mathbf{i} + (60 - 24t)\mathbf{j}$	B1ft (1)
(c)	$60 - 24t = 0$, so $t = 2.5$ $11:30$ $\mathbf{r} = 5\mathbf{i}$: 5 km from O <i>Oct 2019 report: a value of t must be turned into the time of day when the question asks for it.</i>	M1 A1 A1 (3)
Total for Question 4: 6 marks		



Question 5

6 marks

Part	Scheme	Marks
(a)	$\mathbf{r}_A = (1 + 2t)\mathbf{i} + (2 + t)\mathbf{j}$ $\mathbf{r}_B = (7 - t)\mathbf{i} + (-4 + 4t)\mathbf{j}$	B1 B1 (2)
(b)	i: $1 + 2t = 7 - t$, so $t = 2$ j: $2 + t = -4 + 4t$, so $t = 2$ Both components are equal at the same time $t = 2$, so they collide $(5\mathbf{i} + 4\mathbf{j}) \text{ m}$ <i>Jan 2021 report: both the i and the j components must be checked.</i>	M1 M1 A1 A1 (4)
Total for Question 5: 6 marks		

Question 6

10 marks

Part	Scheme	Marks
(a)	$\sqrt{4^2 + 3^2} = 5 \text{ km h}^{-1}$	B1 (1)
(b)	$\mathbf{r}_A = (2 + 4t)\mathbf{i} + (-3 + 3t)\mathbf{j}$, $\mathbf{r}_B = (12 + pt)\mathbf{i} + (7 + qt)\mathbf{j}$ $\vec{AB} = \mathbf{r}_B - \mathbf{r}_A = (10 + (p - 4)t)\mathbf{i} + (10 + (q - 3)t)\mathbf{j}$ Compares with the given $\vec{AB}$: $p - 4 = -6$, $q - 3 = -8$ $p = -2$, $q = -5$	M1 M1 M1 A1 (4)
(c)	$(10 - 6t)^2 + (10 - 8t)^2 = 40$ $100t^2 - 280t + 160 = 0$, $(5t - 4)(t - 2) = 0$: $t = 0.8$ or $t = 2$ $14:48$ and $16:00$	M1 A1 A1 (3)
(d)	$t = 2$: $\vec{AB} = -2\mathbf{i} - 6\mathbf{j}$; angle $\tan^{-1} \frac{2}{6} = 18.4^\circ$ west of south 198°	M1 A1 (2)
Total for Question 6: 10 marks		



Question 7

10 marks

Part	Scheme	Marks
(a)	10 km h^{-1}	B1 (1)
(b)	$1.5(6\mathbf{i} + 8\mathbf{j})$ $(9\mathbf{i} + 12\mathbf{j}) \text{ km}$	M1 A1 (2)
(c)	$\mathbf{r} = (9\mathbf{i} + 12\mathbf{j}) + s(-4\mathbf{i} + 3\mathbf{j})$ $(9 - 4s)\mathbf{i} + (12 + 3s)\mathbf{j}$ <i>Using t hours after 12:00 with $s = t - 1.5$ is equally valid.</i>	M1 A1 (2)
(d)	Due west of L : $\mathbf{j}$ components equal, $12 + 3s = 18$, $s = 2$ $15:30$ Boat at $(\mathbf{i} + 18\mathbf{j})$: 4 km west of L	M1 A1 A1 (3)
(e)	$\overrightarrow{BL} = (5\mathbf{i} + 18\mathbf{j}) - (9\mathbf{i} + 12\mathbf{j}) = -4\mathbf{i} + 6\mathbf{j}$; $\tan^{-1} \frac{4}{6} = 33.7^\circ$ west of north 326°	M1 A1 (2)
Total for Question 7: 10 marks		



Question 8

10 marks

Part	Scheme	Marks
(a)	$\mathbf{v} = \frac{(12\mathbf{i} + 11\mathbf{j}) - (-3\mathbf{i} + 5\mathbf{j})}{5 - 2}$ $(5\mathbf{i} + 2\mathbf{j}) \text{ ms}^{-1}$ <i>Dividing by 5 (the time, not the time interval) is the Jan 2025 error: M0.</i>	M1 A1 (2)
(b)	Speed $\sqrt{29} = 5.39 \text{ ms}^{-1}$ $\tan^{-1} \frac{5}{2}$ from north 068°	B1 M1 A1 (3)
(c)	$\mathbf{r}_0 = (-3\mathbf{i} + 5\mathbf{j}) - 2(5\mathbf{i} + 2\mathbf{j}) = -13\mathbf{i} + \mathbf{j}$ $\mathbf{r} = (-13 + 5t)\mathbf{i} + (1 + 2t)\mathbf{j}$	M1 A1 (2)
(d)	North-east of O: $-13 + 5t = 1 + 2t$ (both positive) $t = \frac{14}{3}$ (4.67 s)	M1 A1 (2)
(e)	$\mathbf{r} = \frac{31}{3}\mathbf{i} + \frac{31}{3}\mathbf{j}$: $\frac{31}{3}\sqrt{2} = 14.6 \text{ m}$	B1 (1)
Total for Question 8: 10 marks		



Question 9

10 marks

Part	Scheme	Marks
(a)	Angle between the two velocities in the triangle: $180^\circ - (150^\circ - 30^\circ) = 60^\circ$ $v^2 = 200^2 + 60^2 - 2 \times 200 \times 60 \cos 60^\circ$ 178 km h^{-1} (177.8) <i>Oct 2019 report: using 120° (vectors not top to tail) is M0. Components give $130\mathbf{i} + 121.2\mathbf{j}$.</i>	B1 M1 A1 (3)
(b)	$\frac{\sin \alpha}{60} = \frac{\sin 60^\circ}{177.8}$ (or $\tan^{-1} \frac{130}{121.2}$ from north) $\alpha = 17.0^\circ$, bearing $30^\circ + 17.0^\circ$ 047°	M1 M1 A1 (3)
(c)	Heading θ: north components cancel, $200 \cos \theta + 60 \cos 150^\circ = 0$ $\cos \theta = \frac{60 \cos 30^\circ}{200}$, $\theta = 74.9^\circ$: heading 075° Speed = $200 \sin \theta + 60 \sin 150^\circ$ 223 km h^{-1}	M1 A1 M1 A1 (4)
Total for Question 9: 10 marks		



Question 10

11 marks

Part	Scheme	Marks
(a)	$A: (5\mathbf{i} + 2\mathbf{j}) + 2(\mathbf{i} + 3\mathbf{j}) = 7\mathbf{i} + 8\mathbf{j}$ at $t = 2$ $B: (-13\mathbf{i} + 23\mathbf{j}) + 5(4\mathbf{i} - 3\mathbf{j}) = 7\mathbf{i} + 8\mathbf{j}$ at $t = 5$ They are at X at different times (14:00 and 17:00), so they do not collide	M1 A1 A1 (3)
(b)	$\vec{AB} = (-18 + 3t)\mathbf{i} + (21 - 6t)\mathbf{j}$ $AB^2 = (3t - 18)^2 + (21 - 6t)^2 = 45t^2 - 360t + 765$ $= 45(t^2 - 8t + 17)$ *	M1 A1 A1* (3)
(c)	$45((t - 4)^2 + 1)$: least when $t = 4$ (or $\frac{d}{dt}(AB^2) = 0$) $\sqrt{45} = 6.71 \text{ km}$ ($3\sqrt{5}$) at 16:00 <i>Jan 2022 report: substitute t into $\vec{AB}$, not into $\mathbf{r}_A$ and $\mathbf{r}_B$ separately.</i>	M1 A1 A1 (3)
(d)	$t = 4: \vec{AB} = -6\mathbf{i} - 3\mathbf{j}; \tan^{-1} \frac{6}{3} = 63.4^\circ$ west of south 243°	M1 A1 (2)
Total for Question 10: 11 marks		

