Mark Scheme (Results)

Summer 2025

Pearson Edexcel International Advanced Level In Mechanics M2 (WME02) Paper 01

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

PEARSON EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

'M' marks
These are marks given for a correct method or an attempt at a correct method. In Mechanics they are usually awarded for the application of some mechanical principle to produce an equation.
e.g. resolving in a particular direction, taking moments about a point, applying a suvat equation, applying the conservation of momentum principle etc.
The following criteria are usually applied to the equation.

To earn the M mark, the equation
(i) should have the correct number of terms
(ii) be dimensionally correct i.e. all the terms need to be dimensionally correct
e.g. in a moments equation, every term must be a 'force x distance' term or 'mass x distance', if we allow them to cancel 'g' s.
For a resolution, all terms that need to be resolved (multiplied by sin or cos) must be resolved to earn the M mark.

M marks are sometimes dependent (DM) on previous M marks having been earned.
e.g. when two simultaneous equations have been set up by, for example, resolving in two directions and there is then an M mark for solving the equations to find a particular quantity – this M mark is often dependent on the two previous M marks having been earned.

'A' marks
These are dependent accuracy (or sometimes answer) marks and can only be awarded if the previous M mark has been earned. E.g. M0 A1 is impossible.

'B' marks
These are independent accuracy marks where there is no method (e.g. often given for a comment or for a graph)

A few of the A and B marks may be f.t. – follow through – marks.

3. General Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- * The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
   - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

General Principles for Mechanics Marking

(But note that specific mark schemes may sometimes override these general principles)

- Rules for M marks: correct no. of terms; dimensionally correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
- Omission or extra g in a resolution is an accuracy error not method error.
- Omission of mass from a resolution is a method error.
- Omission of a length from a moments equation is a method error.
- Omission of units or incorrect units is not (usually) counted as an accuracy error.
- DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.
- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.
- Use of g = 9.81 should be penalised once per (complete) question.

  N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *once* per complete question. However, premature approximation should be penalised every time it occurs.
- Marks must be entered in the same order as they appear on the mark scheme.
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.
- Accept column vectors in all cases.
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft
- Mechanics Abbreviations

  M(A) Taking moments about A.

  N2L Newton's Second Law (Equation of Motion)

  NEL Newton's Experimental Law (Newton's Law of Impact)

  HL Hooke's Law

  SHM Simple harmonic motion

  PCLM Principle of conservation of linear momentum

  RHS, LHS Right hand side, left hand side

Question Number	Scheme	Marks
1(a)	$\int k(3-t^2)\mathrm{d}t$	M1
	$= k(3t-\frac{1}{3}t^3) + (C)$	A1
	$t = 0, v = 0 \Rightarrow C = 0$ **and** $t = 1.5, v = 13.5$ **OR** $\left[k(3t-\frac{1}{3}t^3)\right]_0^{1.5} = 13.5$ $\Rightarrow k(3\times1.5-\frac{1}{3}\times1.5^3) = 13.5 \Rightarrow k = 4$*	A1*
		(3)
1(b)	$s = \int 4(3t-\frac{1}{3}t^3)\mathrm{d}t$	M1
	$s = 4(3\times\frac{1}{2}t^2-\frac{1}{3}\times\frac{1}{4}t^4) = \frac{1}{3}t^2(18-t^2)$ + D **and** $t = 0, s = 0 \Rightarrow D = 0$ **OR** $s = \left[4(3\times\frac{1}{2}t^2-\frac{1}{3}\times\frac{1}{4}t^4)\right]_0^t$ so $s = \frac{1}{3}t^2(18-t^2)$ * Accept any equivalent factorised form e.g. $s = \frac{(18-t^2)t^2}{3}$	A1*
		(2)
1(c)	$v = 0 \Rightarrow (k)(3t-\frac{1}{3}t^3) = 0$	M1
	$t = 3$	A1
	When $t = 3$, $s = 27$	M1
	Total distance = 54 (m)	A1
		(4)
	Notes for question 1	**(9)**
1(a)	M1 Integrate a wrt t, with both powers increasing by 1	
	A1 Correct integral	
	A1* $k = 4$ correctly obtained. $t = 0$ and $v = 0$ must be referred to but do not need to be actually substituted in. We must see the substitution of 1.5 and 13.5	
1(b)	M1 Integrate *their* v wrt t, with both powers increasing by 1, where v has come from a valid attempt at an integral of a. **N.B.** Allow without k being substituted.	
	A1* Given answer correctly obtained including "$s =$ " Must see reference to $t = 0$, $s = 0$ but do not need to be actually substituted in.	
1(c)	M1 Equate their v to 0 and solve for t	
	A1 cao	
	M1 Put their non-zero t, which must have come from $v = 0$, into s	

Question Number	Scheme	Marks
	A1 cao	
	N.B. $t = 3$ could come from a correct sketch of the graph of their v	

2.	$\frac{\mathrm{d}}{\mathrm{d}t}(4t^{\frac{1}{2}}\mathbf{i} - 3t\mathbf{j})$	M1
	$2t^{-\frac{1}{2}}\mathbf{i} - 3\mathbf{j}$	A1
	$t = 4$: $\mathbf{i} - 3\mathbf{j}$	M1
	$(6\mathbf{i} - 3\mathbf{j}) = 3(\mathbf{v} - (\mathbf{i} - 3\mathbf{j}))$	M1
	$\mathbf{v} = 3\mathbf{i} - 4\mathbf{j}$	A1
	Speed $= \sqrt{3^2 + (-4)^2} = 5\ (\mathrm{m\,s^{-1}})$	M1A1
		(7)
	Notes for question 2	
	N.B. Column vectors are acceptable throughout.	
2.	M1 for differentiating **r** wrt to t with both powers decreasing by 1, must be a vector. M0 if **i** or **j** is missing and never reappear(s).	
	A1 Correct vector	
	M1 for putting $t = 4$ in their **v,** allow a slip, must have **attempted** to differentiate e.g. $\mathbf{v} = \frac{\mathrm{d}\mathbf{r}}{\mathrm{d}t}$ seen.	
	M1 for use of impulse-momentum (M0 if g included or 3 missing) to form an equation in **v** only using their **u**, which must have come from an attempt at finding a **velocity** at $t = 4$. M0 if they use **r** at $t = 4$. Condone $(6\mathbf{i} - 3\mathbf{j}) = 3((\mathbf{i} - 3\mathbf{j}) - \mathbf{v})$ and a slip.	
	A1 correct **v,** seen or implied**.**	
	M1 Use of Pythagoras on their **v**	
	A1 cao from a **correct v**	

3(a)	arc AB arc CD $AC + DB$ L Length : $\pi(2a)$ πa $2a$ $3\pi a + 2a$ (mass) or ratios: 2π π 2 $3\pi + 2$	B1
	Distance : $\frac{4a}{\pi}$ $\frac{2a}{\pi}$ 0 d from AB	B1
	$\pi(2a) \times \frac{4a}{\pi} - \pi a \times \frac{2a}{\pi} = (3\pi a + 2a)d$	M1A1
	$*(d =) \frac{6a}{(3\pi + 2)}$ **N.B.** Accept any equivalent form with whole numbers.	A1*
		(5)
3(b)	tan OAG (α) = $\frac{\frac{6a}{(3\pi+2)}}{2a} = \frac{3}{(3\pi+2)}$	B1
	$\tan\theta = \tan(45^o - \alpha)$ **or** $\tan(\theta + \alpha) = \tan 45^o$ **or** $\tan\alpha = \tan(45^o - \theta)$	M1
	$\tan\theta = \frac{1-\tan\alpha}{1+\tan\alpha}$ $\frac{\tan\theta + \tan\alpha}{1-\tan\theta\tan\alpha} = 1$ $\tan\alpha = \frac{1-\tan\theta}{1+\tan\theta}$	**D**M1
	Substitute for $\tan\alpha$ e.g. $\tan\theta = \frac{1-\frac{3}{(3\pi+2)}}{1+\frac{3}{(3\pi+2)}}$	DM1
	$\tan\theta = \frac{3\pi - 1}{3\pi + 5}$ (must have π 's and integers)	A1
	OR	
	Let F be on AE where GF is perpendicular to AE.	
	$GF = GE\sin 45^o$	B1
	$\tan\theta = \frac{GF}{AF} = \frac{GE\sin 45^o}{AE - GE\cos 45^o}$	M1
	$= \frac{(2a - \bar{x})\sin 45^o}{2a\sqrt{2} - (2a - \bar{x})\sin 45^o}$	**D**M1
	$= \frac{(2a - \bar{x})}{(2a + \bar{x})}$ where $\bar{x} = \frac{6a}{(3\pi+2)}$ is substituted in.	DM1
	$= \frac{3\pi - 1}{3\pi + 5}$	A1
		(5)
		(10)
	Notes for question 3	

3(a)	**N.B.** If they treat it as a lamina, can score max B0B0M1A0A0*	
	B1 Mass (length) ratios	
	B1 Distances from *AB* or a parallel axis	
	M1 Moments about *AB* or parallel axis, dimensionally correct, condone sign errors, using their 'masses' and distances, including all terms.	
	A1 Correct unsimplified equation **N.B**. Condone missing brackets on RHS here but penalise the A1*	
	A1* Given answer correctly obtained with no errors seen **N.B.** Need to see reference to *AC* and *DB*, either in the table or in the equation**.**	
3(b)	B1 Correct unsimplified expression for tan *OAG*, seen or implied **N.B.** B0 if they have $OAG = \theta$	
	M1 Correct method seen or implied. May see arctan1 instead of 45^o **N.B.** If their first line of working is: $\tan\theta = \tan 45^o - \tan\alpha$ oe, treat as a correct method but wrong formula.	
	DM1 Dependent on previous M for use of a correct formula used to give an equation in $\tan\theta$ and $\tan\alpha$ only	
	DM1 Dependent on previous M for substitution for **their** $\tan\alpha$ to give an equation in $\tan\theta$ only	
	A1 cao. Must be simplified.	

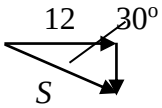
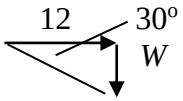
4(a)	$F = \frac{20000}{V}$	M1
	$F - 750g\sin\alpha - 200 = 0$	M1
	$\frac{20000}{V} - 750g\sin\alpha - 200 = 0$	A1
	Speed = 16 (m s^{-1})	A1
		(4)
4(b)	$D - 750g\sin\alpha - 200 = 750a$	M1
	$\frac{20000}{10} - 750g\sin\alpha - 200 = 750a$	A1A1
	a = 1 (m s^{-2})	A1
		(4)
4(c)	$\frac{1}{2}\times 750\times 10^2 - 750gh = 200d$	M1
	$\frac{1}{2}\times 750\times 10^2 - 750gd\sin\alpha = 200d$ **OR** $\frac{1}{2}\times 750\times 10^2 - 750gh = 200\times\frac{h}{\sin\alpha}$	A1A1
	d = 30 (m)	A1
		(4)
		(12)
	Notes for question 4	
4(a)	M1 for use of $P = Fv$, condone wrong number of 0's	
	M1 for equation of motion with correct terms, condone sign errors and sin/cos confusion, F does not need to be substituted	
	A1 Correct equation in V and α	
	A1 cao **N.B.** Allow use of $-F$ and/or $-V$ throughout.	
4(b)	M1 for equation of motion with correct terms, condone sign errors and sin/cos confusion, D does not need to be substituted.	
	A1 correct equation in a only with at most one error	
	A1 correct equation in a	
	A1 cao	
4(c)	M1 for work-energy equation, dimensionally correct, with correct terms, condone sign errors and allow with h and d **N.B**. Treat use of 16 instead of 10 an A error. **N.B.** M0 for $\frac{1}{2}\times 750\times 10^2 - 750gh = 200h$	
	A1 correct equation in d only or h only with at most one error	
	A1 correct equation in d only or h only	
	A1 cao	

5(a)		
	CLM: $2mu = 2mv_P + mv_Q$	M1A1
	NEL: $eu = -v_P + v_Q$	M1A1
	(v_Q =) $\frac{2(1+e)u}{3}$ *	A1*
		(5)
5(b)	e.g. $v_P = \frac{2(1+e)u}{3} - eu \quad \left(= \frac{u}{3}(2-e)\right)$	B1
	KE After = $\frac{1}{2} \times 2m\left(\frac{u}{3}(2-e)\right)^2 + \frac{1}{2}m\left(\frac{2(1+e)u}{3}\right)^2$	M1A1
	KE Loss = $\frac{1}{2} \times 2mu^2 -$ their KE after	DM1
	$= \frac{1}{3}(1-e^2)mu^2$ so $k = \frac{1}{3}$	A1
		(5)
5(c)	$\frac{8mu}{9} = m \times \frac{2(1+e)u}{3}$ **OR** $-\frac{8mu}{9} = 2m\left(\frac{u}{3}(2-e) - u\right)$	M1
	$e = \frac{1}{3}$	A1
		(2)
5(d)	$\frac{2(1+e)uf}{3}$ seen or implied, e does not need to be substituted.	B1
	$\frac{2\left(1+"\frac{1}{3}"\right)uf}{3}$ = their speed of P, with their value of e used to give an equation in f **only**.	M1
	$f = \frac{5}{8}$ or 0.625	A1
		(3)
		(15)
	Notes for question 5	
5(a)	**N.B.** Mark CLM equation first.	
	M1 for a CLM equation, dimensionally correct with correct no. of terms, condone sign errors, consistent extra g's or cancelled m's	
	A1 for a correct equation	
	M1 for a NEL equation, with e on the correct side, condone sign errors	
	A1 for a correct equation, consistent with the CLM equation.	
	A1* for given answer correctly obtained, with at least one line of intermediate working. **N.B.** Allow any fully factorised equivalent form.	
5(b)	B1 for a correct unsimplified expression in e and u for v_P seen or	

	implied.	
	M1 for correct unsimplified expression, using **their** v_P and the **given** v_Q for KE after (must be adding the KE's)	
	A1 for a correct unsimplified expression for the KE After	
	DM1 for $\left(\frac{1}{2}\times 2mu^2 - \text{ their KE after}\right)$ using their v_P and the **given** v_Q, condone Final KE – Initial KE.	
	A1 Accept 0.33 or better. **N.B.** Must be from correct working.	
5(c)	M1 for a **correct** impulse-momentum equation for either Q or P i.e. do NOT condone sign errors.	
	A1 Accept 0.33 or better.	
5(d)	B1 cao	
	M1 for equating their speeds of P and Q, with their e substituted, to give an equation **in *f* only**, allow slip when substituting in their e value, provided the method is clear. **N.B**. Must be using a value of e where $0 < e \leq 1$	
	A1 Accept 0.63	

6(a)	M(A), $S \times 1.5a = mga\cos\theta$	M1A1
	$S = \dfrac{2mg\cos\theta}{3}$ * **N.B.** Allow RHS in any equivalent form with the same terms in any order.	A1*
		(3)
6(b)	$V = mg - S\cos\theta$	M1A1
	$*V = \dfrac{mg}{3}(3 - 2\cos^2\theta)$	A1*
		(3)
6(c)	$\dfrac{4}{7}V$ seen or implied	B1
	Horizontal: $F = S\sin\theta$ Other possible equations: Perp to rod: $F\cos\theta + V\sin\theta = mg\sin\theta$ Parallel to rod: $F\sin\theta + mg\cos\theta = V\cos\theta + S$ M(B): $F \times 2a\sin\theta + mga\cos\theta = V \times 2a\cos\theta + S \times 0.5a$ M(C): $F \times 1.5a\sin\theta + mg \times 0.5a\cos\theta = V \times 1.5a\cos\theta$ M(G): $Fa\sin\theta + S \times 0.5a = Va\cos\theta$	M1A1
	e.g. $\dfrac{4}{7} \times \dfrac{mg}{3}(3 - 2\cos^2\theta) = \dfrac{2mg\cos\theta}{3} \times \sin\theta$	DM1
	Divide by $\cos^2\theta$ to produce an equation in $\tan\theta$	**DM**1
	$6\tan^2\theta - 7\tan\theta + 2 = 0$	A1
		(6)
		(12)
	Notes for question 6	
6(a)	M1 for moments about A equation, dimensionally correct, correct no. of terms, condone sin/cos confusion and sign errors **N.B.** M0 if a's missing	
	A1 for a correct equation (allow a different letter for S e.g. R_C provided it's clear that $R_C = S$)	
	A1* for given answer correctly obtained including "S = "but not necessarily in the final line of working..	
6(b)	M1 for resolving vertically, correct no. of terms, condone sin/cos confusion and sign errors	
	A1 for a correct equation (allow a different letter for V e.g. R_A provided it's clear that $R_A = V$)	
	A1* for obtaining the given answer from fully correct working including "V = .." but not necessarily in the final line of working. **N.B.** If S is never seen, can score max M1A1A0*	
6(c)	**N.B.** The first 3 marks below can be earned if the 'equations' appear in (a) or (b).	

	B1 $\frac{4}{7}V$ seen or implied	
	M1 for another equation: either resolving or taking moments, correct no. of terms, dimensionally correct, condone sin/cos confusion and sign errors	
	A1 for a correct equation	
	DM1, dependent on previous M, for substituting for V and S and using $F = \frac{4}{7}V$ to give an equation in θ and m or g or both only	
	DM1, dependent on previous M, for dividing by $\cos^2\theta$ and using $\sec^2\theta = 1 + \tan^2\theta$ to produce an equation in $\tan\theta$	
	A1 for answer, or an integer multiple of answer, correctly obtained **N.B.** Allow the terms in a different order.	

7(a)	Use of conservation of energy	M1
	$\frac{1}{2}m\times 20^2-\frac{1}{2}mv^2=mg\times 11$	A1
	$\frac{1}{2}m\times 20^2-\frac{1}{2}m\left(V^2+(2V)^2\right)=mg\times 11$	A1
	$V=6$ *	A1*
		(4)
7(b)	At A,  $S=\frac{12}{\cos 30^o}$ $(8\sqrt{3})$	M1A1
	$\frac{1}{2}m\times 20^2-\frac{1}{2}mS^2=mgH$ (from O to A) OR $\frac{1}{2}mS^2-\frac{1}{2}m\times(6^2+12^2)=mgh$ (from ht. 11m to A)	M1A1
	Solve for H or h (0.6)	DM1
	H = 10 m (2sf)	A1
		(6)
	OR	
	At A,  $W=12\tan 30^o$ $(4\sqrt{3})$ (**OR**: $12=S\cos 30^o$ **AND** $W=S\sin 30^o$)	M1A1
	$W^2=\left(20\times\frac{4}{5}\right)^2-2gH$ (from O to A) **OR** $W^2=\left(20^2-12^2\right)-2gH$ (from O to A) **OR** $W^2=6^2-2gs$ (from ht. 11m to A) **N.B.** All 3 equations are using positive UP	M1A1
	Solve for H (10.4) OR $s=-0.6$ so height is $11-0.6=10.4$	DM1
	Height is 10 m (2sf)	A1
		(6)
		(10)
	Notes for question 7	
7(a)	M1 for an energy equation, dimensionally correct with correct terms, condone sign errors **N.B.** M0 if not using energy. **N.B.** If clearly using V, must include both horizontal and vertical cpts.	
	A1 correct equation in v May find v first: $(v^2=180)$	
	A1 correct equation in V then $V^2+(2V)^2=180$	
	A1* for correct given answer correctly obtained, by putting g = 10,	

	cancelling *m*'s and solving for *V*.	
7(b)	M1 for using perpendicularity at *A* to find *S*, the speed at *A* Condone sin/cos confusion.	
	A1 for correct unsimplified speed	
	M1 for complete method using energy to find an equation in *S* and *H*, or *S* and *h*, correct no. of terms, condone sign errors	
	A1 correct equation **without *S* replaced**	
	DM1, dependent on both M marks, solve for *H*	
	A1 cao	
	OR	
	M1 for using perpendicularity at *A* to find *W*, the vertical velocity component at *A*. Condone 30^o / 60^o confusion.	
	A1 for correct unsimplified vertical component. Allow + or −.	
	M1 for complete method using *suvat* to find an equation in *W* and *H*, condone sign errors, **N.B.** They may find *t* first and then use that to form this equation.	
	A1 correct equation **without *W* replaced**	
	DM1, dependent on both M marks, solve for *H*	
	A1 cao	

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