Mark Scheme (Results)

October 2023

Pearson Edexcel International Advanced Level in Mechanics (WME01) 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.

General Instructions for Marking

The total number of marks for the paper is 75.

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) each term needs to be dimensionally correct

For example, 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 and B marks may be f.t. – follow through – marks.

General Abbreviations

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

- bod means benefit of doubt
- ft means follow through
- the symbol $\sqrt{}$ will be used for correct ft
- cao means correct answer only
- cso means correct solution only, i.e. there must be no errors in this part of the question to obtain this mark
- isw means ignore subsequent working

- awrt means answers which round to
- SC means special case
- oe means or equivalent (and appropriate)
- dep means dependent
- indep means independent
- dp means decimal places
- sf means significant figures
- * means the answer is printed on the question paper
- means the second mark is dependent on gaining the first mark

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.

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.

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.

Ignore wrong working or incorrect statements following a correct answer.

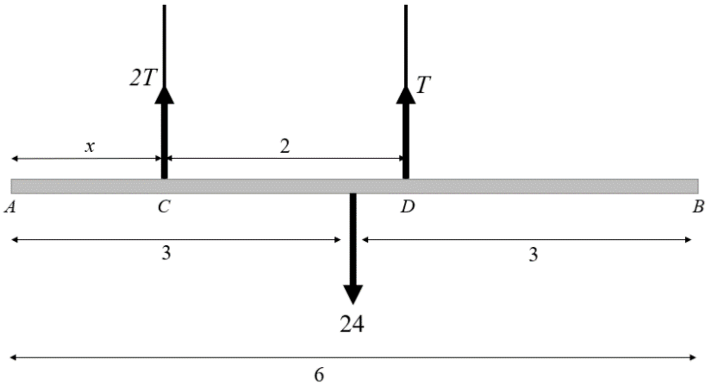
General Principles for Mechanics Marking

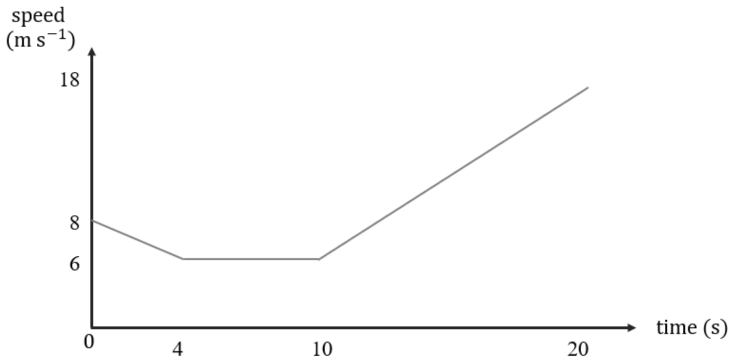
(NB specific mark schemes may sometimes override these general principles)

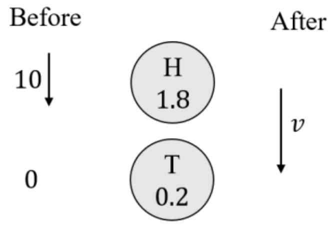
- Rules for M marks:
    - correct no. of terms;
    - dimensionally correct;
    - all terms that need resolving (i.e. multiplied by cos or sin) are resolved.
- Omission or extra g in a resolution is an accuracy error not method error.
- Omission of mass from a resolution is a method error.
- Omission 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

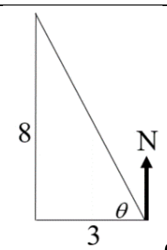
M(A)	Taking moments about A.
N2L	Newton's Second Law (Equation of Motion)
NEL	Newton's Experimental Law (Newton's Law of Impact)
HL	Hooke's Law
SHM	Simple harmonic motion
PCLM	Principle of conservation of linear momentum
RHS	Right hand side
LHS	Left hand side

QUESTION NUMBER	SCHEME	MARKS
1		
	Form a moments equation M(A): $(2T\times x)+T(x+2)=(24\times 3)$	M1 A1
	Form a second equation vert $3T=24$	M1
	Alternative moments equations in x and T M(C): $24(3-x)=T\times 2$ M(G): $2T(3-x)=T(x-1)$ M(D): $(2T\times 2)=24\times(x-1)$ M(B): $2T(6-x)+T(4-x)=(24\times 3)$ M(C): $\frac{24x}{6}\times\frac{x}{2}+2T=\frac{24(6-x)}{6}\times\frac{(6-x)}{2}$	
	$T=8\text{(N)}$	A1
	$x=\frac{7}{3}$ accept 2.3 or better	A1
		(5)
	Notes for question 1	
M1	Forms a moments equation in x and T only with the correct no. of terms. Allow consistent extra g' s. M0 if no x.	
A1	Correct unsimplified moments equation. Where two moments equations are used, award this mark for the first correct equation.	
M1	Resolves vertically to give equation in T only or a second moments equation in x and T (M0 if no x.). Must be dimensionally correct with the correct no. of terms.	
A1	Correct value for tension at D	
A1	Correct value for x. Accept 2.3 or better **N.B.** If T and $2T$ the wrong way round or they use $24g$, can score max M1A0M1A0A0.	

QUESTION NUMBER	SCHEME	MARKS
2(a)	$v = u + at: \quad w = 8 + (-0.5)(4)$ (the value of w may not be seen)	M1
	$v = u + at: \quad v = w + (1.2)(10)$	M1
	$v = 18\,*$	A1*
		(3)
2(b)		B1 shape B1 time labels 4,10,20 B1 speed labels 6, 8, 18
		(3)
2(c)	Clear **attempt** to find distance using the area under their graph from t = 0 to t = 20 or another suitable method, <u>even if they are using the wrong shapes.</u> Distance = $\frac{(8+"6")\times 4}{2} + (6\times "6") + \frac{("6"+18)\times 10}{2}$ **OR** $= (6\times 4) + \frac{1}{2}\times 4\times(8-6) + (6\times 6) + (6\times 10) + \frac{1}{2}\times 10\times(18-6)$	M1 A1ft A1ft
	= 184 (m)	A1
		(4)
		(10)
	Notes for question 2	
(a) **M1** **M1** **A1*** **(b)** **B1** **B1** **B1** **(c)** **M1** **A1ft** **A1ft** **A1**	 Complete method for finding the velocity (w) when t = 4 M0 if u = 0. **N.B.** 6 on its own can imply this mark. Method completed to show the speed when t = 20 M0 if initial speed is not w. Fully correct solution leading to given answer Correct shape of graph Correct time labels Correct speed labels **N.B**. Solid vertical line(s) B0 for the shape. Complete method to find distance travelled in 20 seconds. May use speed-time graph or *suvat* equations for **three** sections (28m, 36m, 120m) of the journey. Award this mark for a clear **attempt** to find the area and penalise errors in the A marks. M0 if graph does not have three sections. Equation with at most one error, ft their “6” Correct equation, ft their “6” Correct final answer	

QUESTION NUMBER	SCHEME	MARKS
3		
3(a)	$10\times1.8=(0.2+1.8)v$	M1
	v = 9 (positive)	A1
		(2)
3(b)	For tent peg, $I=\pm0.2(v-0)$ or For hammer, $-I=\pm1.8(v-10)$	M1 A1
	1.8 Ns **OR** 1.8 kgms^{-1} units needed.	A1
		(3)
3(c)	$0=9^2+2a(0.12)$ **OR** $0=9^2-2a(0.12)$	M1A1
	$2g-R=2a$ $R-2g=2a$	M1 A1
	$R=690$ or 695	A1
		(5)
	N.B. Using u =10 for 9 can score M0A0M1A1A0 max	
	Using s = 12, can score M1A0M1A1A0 max	**(10)**
ALT 1	$0.12=\dfrac{(9+0)}{2}t$	M1A1
	$(R-2g)t=2\times9$	M1A1
	$R=690$ or 695	A1
ALT 2	$0.12R=\dfrac{1}{2}\times2\times9^2+2g\times0.12$	M2A2
	$R=690$ or 695	A1
	Notes for question 3	
(a)		
M1 **A1** **(b)** **M1** **A1** **A1** **(c)** **M1** **A1**	Forms CLM equation, condone sign errors and extra g's and any correct cancellation cao Impulse-momentum equation, dimensionally correct, correct no. of terms. Condone sign errors. **N.B**. M0 if g is included. A1 correct unsimplified equation A1 cao must include units. Equation formed to find the acceleration. Must be dimensionally correct and have the correct no. of terms. Correct unsimplified equation. Note $a=-337.5$	

M1	Use of $F=ma$. Must be dimensionally correct and have the correct no. of terms.	
A1	Correct equation, a does **not** need to be substituted but should be consistent with their a from first equation. **N.B.** Use the equation for a to **define** the positive direction.	
A1	cao	
	ALT 1	
M1	Equation(s) formed to find the time	
A1	Correct unsimplified equation. Note $t=\frac{2}{75}=0.02666..$	
M1	Use of imp-mom equation. Must be dimensionally correct and have the correct no. of terms.	
A1	Correct equation, t does **not** need to be substituted but should be consistent with their t from first equation.	
A1	cao	
	ALT 2	
M2	Use of work-energy equation. Must be dimensionally correct and have the correct no. of terms.	
A2	Correct unsimplified equation, -1 each error.	
A1	cao	

QUESTION NUMBER	SCHEME	MARKS
4(a)	$(5\mathbf{i}-8\mathbf{j})+5(-\lambda\mathbf{i}+2\lambda\mathbf{j})$ (m s^{-1}) isw	M1 A1
		(2)
4(b)	$13=\sqrt{(5-5\lambda)^2+(-8+10\lambda)^2}$	M1 A1
	$169=25-50\lambda+25\lambda^2+64-160\lambda+100\lambda^2$	
	$25\lambda^2-42\lambda-16=0$ *	A1* cso
		(3)
4(c)	$(-2\mathbf{i}+4\mathbf{j})$ seen or implied	B1
	$(5\mathbf{i}-8\mathbf{j})+(-2\mathbf{i}+4\mathbf{j})4$	M1A1
	 e.g. $\tan^{-1}\left(\pm\frac{8}{3}\right)$, $\tan^{-1}\left(\pm\frac{3}{8}\right)$, $\sin^{-1}\left(\pm\frac{8}{\sqrt{73}}\right)$,...	M1
	339°	A1
		(5)
		(10)
	Notes for question 4	
(a) **M1** **A1** **(b)** **M1** **A1** **A1*** **(c)** **B1** **M1** **A1** **M1** **A1**	 Use of **v**=**u**+**a***t* to form a vector expression in λ and t Correct unsimplified expression with $t = 5$ **N.B.** Allow use of column vectors for the M mark but not for the A mark**.** Collect **i**'s and **j**'s and correct use of Pythagoras to form an equation in λ Correct equation cso. Expand brackets and correctly reach the GIVEN answer. **N.B.** Allow $0=25\lambda^2-42\lambda-16$ Or column vector Complete method to find the velocity when $t = 4$. Correct unsimplified expression. Note the correct velocity is $\mathbf{v}=-3\mathbf{i}+8\mathbf{j}$ Use **their** velocity vector **at *t* = 4** with trig to find a relevant angle. Cao. Degrees sign not required. **N.B.** if they work with both values of λ, can score max all the marks except the last one.	

QUESTION NUMBER	SCHEME	MARKS
5		
5(a)	$F = 10\cos\theta - 0.2g$ **or** $F = 0.2g - 10\cos\theta$	M1 A1
	$\lvert F \rvert = 1.9 \text{ or } 1.89$ (N)	A1
		(3)
5(b)	Friction acts downwards or down.	A1
	A0 for anything else.	
		(1)
5(c)	$R = T\sin\theta$ $\left(R = \dfrac{12T}{13}\right)$	M1 A1
	$F = \dfrac{1}{4}R$	B1
	Resolve vertically For min value $T\cos\theta = 0.2g - F$ For max value $T\cos\theta = 0.2g + F$	M1 A1 A1
(i)	Min T $3.2 \text{ or } 3.19$ (N)	A1
(ii)	Max T $13 \text{ or } 12.7$ (N)	A1
	N.B. Penalise over accuracy once for the whole question and penalise the FIRST time it is seen.	
	N.B. If 2 instead of 0.2 is used throughout the WHOLE question, treat as a MR.	
		(8)
		(12)
	Notes for question 5	
(a) M1	Resolve vertically, dimensionally correct, condone sin/cos confusion and sign errors.	
A1	Correct unsimplified equation.	
A1	Correct value for Friction, must be positive **N.B**. If they use μR as their notation for F and never separate μ and R, allow M1A1A1. If, however, they do separate them, give M1A1A0.	
(b) A1	Correct direction from **a correct, but possibly unrounded, answer to part (a).**	
(c) M1	Resolve perpendicular to the rod. Must be dimensionally correct and have correct no of terms. Condone sin/cos confusion. **N.B.** M0 if they use $T = 10$	
A1	Correct unsimplified equation	
B1	$F = \dfrac{1}{4}R$ seen or implied	
M1	Resolve parallel to the rod for either case. Must be dimensionally correct and have correct no of terms. Condone sin/cos confusion. **N.B.** M0 if they use $T = 10$ or if they use F from part (a).	
A1	Correct minimum case equation	
A1	Correct maximum case equation	
(i)A1	cao for min T. Allow 0.325g	
(ii)A1	cao for max T Allow 1.3g **N.B.** If only one found and no labels, allow the A mark for the equation but must state which one it is to score the A mark for the answer. **N.B.** If both correctly found and no labels, allow all the marks. **N.B.** If both correctly found but the answers are labelled wrongly, lose the final two A marks.	

QUESTION NUMBER	SCHEME	MARKS
6(a)	$\dfrac{(20\mathbf{i}+34\mathbf{j})-(15\mathbf{i}+36\mathbf{j})}{0.5}$ oe	M1
	$(10\mathbf{i}-4\mathbf{j})$ *	A1*
		(2)
6(b)	$(15\mathbf{i}+36\mathbf{j})+t(10\mathbf{i}-4\mathbf{j})$	M1 A1
		(2)
6(c)(i)	Verify using $t=1.5$ in **p or q** $\mathbf{p}=(15\mathbf{i}+36\mathbf{j})+1.5(10\mathbf{i}-4\mathbf{j})=30\mathbf{i}+30\mathbf{j}$ $\mathbf{q}=(42-8\times1.5)\mathbf{i}+(9+14\times1.5)\mathbf{j}=30\mathbf{i}+30\mathbf{j}$	M1 A1 A1
(ii)	$30\mathbf{i}+30\mathbf{j}$	A1 (B1)
	N.B. The A mark for (ii) is now to be treated as a B mark.	
		(4)
ALT1 (i)	Find t by equating **i or j** components of **p** and **q** Equate **i**'s $15+10t=42-8t \rightarrow t=1.5$ **j**'s $36-4t=9+14t \rightarrow t=1.5$	M1 A1 A1
(ii)	$30\mathbf{i}+30\mathbf{j}$	A1 (B1)
ALT2 (i)	Uses ratio: $\dfrac{15+10t}{36-4t}=\dfrac{42-8t}{9+14t}$ $\rightarrow t=1.5$ or -8.5 verifies that components are both 30 at $t=1.5$	M1 A1 A1
(ii)	$30\mathbf{i}+30\mathbf{j}$	A1 (B1)
		(4)
6(d)	Position of P at 14:30 is $40\mathbf{i}+26\mathbf{j}$	B1
	Position of Q when $t=0.5$ $\mathbf{q}=(42-8\times0.5)\mathbf{i}+(9+14\times0.5)\mathbf{j}$ $(=(38\mathbf{i}+16\mathbf{j}))$	M1
	$15\mathbf{j}$ seen or implied	B1
	New position of Q at time 14:30 $\mathbf{q}=(38\mathbf{i}+16\mathbf{j})+2(15\mathbf{j})$ **N.B.** M0 if 2.5 is used.	M1
	$\mathbf{q}=38\mathbf{i}+46\mathbf{j}$	A1
	$\lvert PQ\rvert=\sqrt{(40-38)^2+(26-46)^2}$	**d**M1
	$=\sqrt{404}$ or $2\sqrt{101}$ (km)	A1
		(7)
		(15)

	Notes for question 6	
	N.B. Allow use of column vectors throughout apart from the A marks in (a) and (b).	
(a)		
M1	Complete method to find an expression for the velocity. Allow if they use 30 minutes. Give M1A0, if there are missing brackets.	
A1*	Reaches the given answer from **fully correct** working.	
(b)		
M1	Finds an expression for **p** in terms of *t* with the correct structure	
A1	Correct answer in terms of **i**, **j** and *t*.	
(c)		
(i) M1	Substitutes $t = 1.5$ into the given **q** **or** their **p**	
A1	*P* equation correct	
A1	*Q* equation correct **N.B. p** or **q** = $30\mathbf{i}+30\mathbf{j}$ alone can imply a correct equation in each case.	
(ii) A1(B1)	$30\mathbf{i}+30\mathbf{j}$ seen	
	ALT 1	
(i) M1	Equates coefficients of **i or j** using the given **q** and their **p**	
A1	Correct equation for **i** leading to $t = 1.5$	
A1	Correct equation for **j** leading to $t = 1.5$ **N.B.** Allow both A marks if they only write $t = 1.5$ once.	
(ii) A1(B1)	$30\mathbf{i}+30\mathbf{j}$ seen	
	ALT 2	
(i) M1	Uses ratio of components to form equation.	
A1	Two *t* values	
A1	Verifies that components are both 30 at $t = 1.5$	
(ii) A1(B1)	$30\mathbf{i}+30\mathbf{j}$ seen	
(d)		
B1	Position of *P* at 14:30	
M1	Use $t = 0.5$ to find the new position of *Q* at 12:30	
B1	Correct expression seen for new velocity of *Q*	
M1	Complete method to find the new position of *Q* at 14:30, using their new **v** for *Q*.	
A1	Correct position,	
dM1	Use of Pythagoras to find the distance. Dependent on both previous M marks.	
A1	Correct **surd** answer	

QUESTION NUMBER	SCHEME	MARKS
7(a)(i)	For A: $\frac{4mg}{3} - mg\sin\alpha - F = ma$	M1A1
	$R = mg\cos\alpha$	M1 A1
	Use of $F = \frac{1}{3}R$ in an equation.	M1
	$a = \frac{11g}{15}$ or $0.73g$ or better	A1
(ii)	For B: $kmg - \frac{4mg}{3} = kma$	M1 A1
	$k = 5$	A1
	N.B. Either equation of motion could be replaced by a whole system equation: $kmg - mg\sin\alpha - F = (k+1)ma$	
		(9)
7(b)	Complete method to find resultant force $2T\cos\left(\frac{90° - \alpha}{2}\right)$	M1 A1
	Substitute $T = \frac{4mg}{3}$ and trig $\frac{32mg}{15}$ or $2.1mg$ or better.	**d**M1 A1
ALT 1	Use of cosine rule: $\sqrt{T^2 + T^2 - 2(T)(T)\cos(90+\alpha)}$	M1 A1
ALT 2	Use of vert and horiz components to find the resultant: $\sqrt{(T\cos\alpha)^2 + (T + T\sin\alpha)^2}$	M1 A1
		(4)
		(13)
	Notes for question 7	
(a) M1	For A use $F=ma$ parallel to the plane. Must be dimensionally correct and have correct no of terms. Condone sin/cos confusion. **N.B.** If they use T in this equation and never replace it, allow M1.	
A1	Correct unsimplified equation. **N.B**. a could be replaced by $-a$	
M1	Resolve perpendicular to the plane Must be dimensionally correct and have correct no of terms. Condone sin/cos confusion.	
A1	Correct equation	
M1	Use of $F = \frac{1}{3}R$	
A1	Correct answer	
M1	For B use $F=ma$ vertically. Must be dimensionally correct and have correct no of terms. Condone sin/cos confusion. **N.B**. Must have *km* on *both* sides for this mark. **N.B.** If they use T in this equation and never replace it, allow M1.	
A1	Correct unsimplified equation **N.B**. a could be replaced by $-a$, but must be consistent with the equation for A.	
A1	correct answer	

(b) M1	Complete method to find resultant force on pulley , allow sin/cos confusion
A1	Correct expression
dM1	Substitute $T = \dfrac{4mg}{3}$ and trig, dependent on previous M mark
A1	Correct answer.
(b) ALT1	
M1	Complete method – must involve α or its numerical value
A1	Correct expression
dM1	Substitute $T = \dfrac{4mg}{3}$ and trig, dependent on previous M mark
A1	Correct answer. Allow $\sqrt{\dfrac{1024m^2g^2}{225}}$ or similar.
(b) ALT2	
M1	Complete method, allow sin/cos confusion
A1	Correct expression
dM1	Substitute $T = \dfrac{4mg}{3}$ and trig, dependent on previous M mark
A1	Correct answer. Allow $\sqrt{\dfrac{1024m^2g^2}{225}}$ or similar.

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