Mark Scheme (Results)

October 2024

Pearson Edexcel International Advanced Level In Mechanics M1 (WME01) Paper 01

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October 2024
Question Paper Log Number P76181A
Publications Code WME01_01_2410_MS

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.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

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: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
     - 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
         - should have the correct number of terms
         - 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: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
   - **B** marks are unconditional accuracy marks (independent of M marks)

   Marks should not be subdivided.

3. General Abbreviations

   These are some of the traditional marking abbreviations that will appear in the mark schemes and can be used if you are using the annotation facility on ePEN:
   - bod – benefit of doubt
   - ft – follow through
     - the symbol √ 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)
   - d… or dep – dependent

- indep – independent
- dp – decimal places
- sf – significant figures
- ∗ – The answer is printed on the paper or ag- answer given
- ⌐ or d… – 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:
   a) If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
   b) 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.

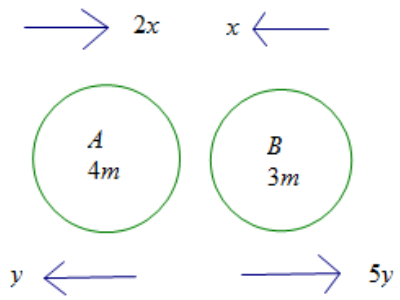
In all cases, if the candidate clearly labels their working under a particular part of a question, e.g., (a) or (b) or (c), then that working can only score marks for that part of the question.

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

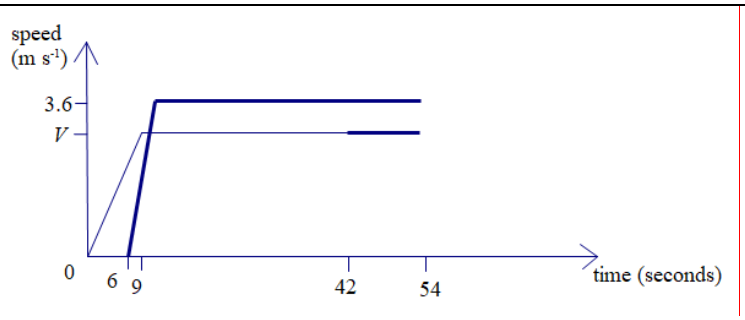
Q	Scheme	Marks	Notes
1			
(a)	Use of CLM Or equating impulses	M1	Dimensionally correct. Condone sign errors and allow missing m's and extra g's.
	$(4m\times 2x)-3mx=(3m\times 5y)-4my$ Or: $3m(5y--x)=4m(y--2x)$	A1	Correct unsimplified equation and must see all 4 terms but allow missing m's.
	$y=\frac{5}{11}x$ *	A1*	Obtain given answer from correct working with m's seen. Allow $y=\frac{5x}{11}$ but A0 if x is *clearly* in the denominator of the fraction.
		[3]	
(b)	Use of $I=mv-mu$	M1	Dimensionally correct. Condone sign errors and y not substituted but mass and velocities must match. M0 if m is used for mass or g is included or m is missing.
	$\pm 3m\left(\frac{25}{11}x+x\right)$ or $\left(\pm 4m\left(\frac{5}{11}x+2x\right)\right)$	A1	Correct unsimplified expression
	$\frac{108}{11}mx$ oe	A1	$9.8mx$ or better (9.8181..mx), must be positive.
		[3]	
		(6)	

Q	Scheme	Marks	Notes
2a	Resolve vertically or take moments	M1	**First** equation in R_C and/or R_D. Dimensionally correct, correct no. of terms. Condone sign errors. **N.B.** $3Rc + 2R_D = 75g$ or $5Rc = 75g$ are both M0A0 unless they recover.
			N.B. They may use: $R_C = 2R$ and $R_D = 3R$ so $5R = 75g$ is M1A1
	$\updownarrow R_C + R_D = 50g + 25g\,(= 75g)$	A1	Correct unsimplified equation but A0 if they assume $R_C = R_D$. **N.B.** This mark can be awarded even if they clearly have $R_C = 3X$ and $R_D = 2X$ oe
	Form a moments equation or resolve vertically	M1	**Second** equation in R_C and/or R_D. Dimensionally correct, correct no. of terms. Condone sign errors
	M(D): $50gx + 25g \times 1.2 = 3.3R_C$ M(A): $0.9R_C + 4.2R_D = 3 \times 25g + (4.2 - x)50g$ M(B): $5.1R_C + 1.8R_D = 3 \times 25g + (1.8 + x)50g$ M(C): $3.3R_D = 2.1 \times 25g + (3.3 - x)50g$ M(E): $2.1R_C = (x - 1.2)50g + 1.2R_D$ M(G): $R_D x = 25g(x - 1.2) + R_C(3.3 - x)$	A1	Correct unsimplified equation in R_D or R_C seen but give A0 if the equation is incorrect e.g if they put $3R$ (in place of R_C) straight into the equation. A0 if they assume $R_C = R_D$.
	$(2R_D = 3R_C \Rightarrow R_C = 30g)$ $50x + 30 = 99$	M1	Complete method, using either $2R_D = 3R_C$ or $2R_C = 3R_D$ to find an equation in x only
	$x = \frac{69}{50} = 1.38$ * **N.B**. Two **correct** equations and use of $2R_C = 3R_D$ leads to x = 2.37 and could score max : M1A1M1A1M1A0*	A1*	Obtain given answer from correct working, with no incorrect equations seen.
		[6]	
2b	Complete method to form an equation in M only.	M1	e.g. moments about D or vertical resolution and

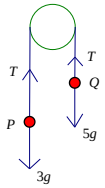
			moments about another point or two moments equations. Dimensionally correct equation. Condone sign errors
	M(D) $25g\times1.2+50g\times1.38=1.8Mg$ **OR any two of :** $(50+25+M)g=R_D$ M(A) $4.2R_D=3\times25g+(4.2-1.38)50g+6Mg$ M(B) $1.8R_D=3\times25g+(1.8+1.38)50g$ M(C) $3.3R_D=2.1\times25g+(3.3-1.38)50g+5.1Mg$ M(E) $3Mg=(1.38-1.2)50g+1.2R_D$ M(G) $R_D\times1.38=25g(1.38-1.2)+Mg(1.38+1.8)$ **AND** R_D eliminated	A1	Correct unsimplified equation in M
	(M) = 55	A1	Correct only
		[3]	
		(9)	

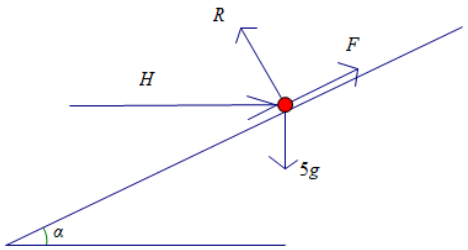
			Allow use of column vectors apart from in given answer.
Q	Scheme	Marks	Notes
3a	Use of $\mathbf{v}=\frac{\mathbf{r}-\mathbf{r}_0}{2}$ to find $\mathbf{v}$	M1	Or equivalent, allow difference reversed. Allow 120 min
	$\mathbf{v}=\frac{1}{2}\left(\left(55\mathbf{i}+34\mathbf{j}\right)-\left(25\mathbf{i}+10\mathbf{j}\right)\right)$ $\left(=15\mathbf{i}+12\mathbf{j}\right)$	A1	Correct unsimplified expression for $\mathbf{v}$
	$\mathbf{r}_A=25\mathbf{i}+10\mathbf{j}+t\left(15\mathbf{i}+12\mathbf{j}\right)$	M1	With the correct structure Possible use of $\mathbf{r}_A=\left(55\mathbf{i}+34\mathbf{j}\right)+(t-2)\left(15\mathbf{i}+12\mathbf{j}\right)$.
	$(\mathbf{r}_A=)\ \ \left(25+15t\right)\mathbf{i}+\left(10+12t\right)\mathbf{j}$ *	A1*	We are looking for the RHS **only** to be correct. Allow order of terms to be reversed in the brackets. **N.B** Use of i's and j's in columns i.e. poor notation, can score Max M1A1M1A0*
		[4]	
3b	$\sqrt{12^2+15^2}$	M1	Correct use of Pythagoras for their $\mathbf{v}$
	$\sqrt{12^2+15^2}\times\frac{1000}{3600}=\frac{5\sqrt{369}}{18}=\frac{5\sqrt{41}}{6}$	A1	5.3 or better (5.3359……)
		[2]	
3c	Position of B at $t=1.5$ (allow t = 1.30)	M1	Correct use of position and direction vectors with correct structure.
	$\mathbf{r}_B=\left(35\mathbf{i}+51\mathbf{j}\right)+1.5\left(20\mathbf{i}-6\mathbf{j}\right)$	A1	Correct unsimplified
	$\Rightarrow\begin{pmatrix}65\\42\end{pmatrix}=\begin{pmatrix}25+15t\\10+12t\end{pmatrix}$ oe	M1	Use $\mathbf{r}_P=\mathbf{r}_A$ and use one component to solve for t **N.B.** If they use $\frac{65}{42}=\frac{25+15t}{10+12t}$ oe and solve for t, it's M0 unless they go on and substitute $t=\frac{8}{3}$ into $\mathbf{r}_A$ and obtain $65\mathbf{i}+42\mathbf{j}$, in which case it is M1A1, and could earn the final A1* with a correct conclusion.
	Obtain $t=\frac{8}{3}$ for one component	A1	**N.B.** Allow t = 2.7 or better for A1 but not for the second A1* but allow 2.6 recurring for both A marks.

	Obtain $t = \frac{8}{3}$ for both components and hence confirm *A* passes through *P* **OR** sub $t = \frac{8}{3}$ into $\mathbf{r}_A$ and obtain $65\mathbf{i} + 42\mathbf{j}$ and hence confirm *A* passes through *P*	A1*	Obtain given result from correct work. **N.B** Use of i's and j's in columns i.e. poor notation, can score Max M1A1M1A1A0* but only penalise ONCE for the whole question.
		[5]	
		(11)	

Q	Scheme	Marks	Notes
4a	Correct method to form an equation in V only using either area = distance travelled or *suvat*.	M1	Condone confusion over units for time.
	$120=\frac{1}{2}(42+33)\times V$ **OR** $\frac{1}{2}\times 9V+33V=120$ **OR** $42V-\frac{1}{2}\times 9V=120$	A1	Correct unsimplified equation in V only.
	$V = 3.2$ *	A1*	Obtain given answer from correct working Allow *v*. **N.B.** A correct equation is required but NO intermediate line(s) of working.
		[3]	
4b	$a=\frac{3.2}{9}$	M1	Correct method
	$=\frac{16}{45}=0.3555...=0.36$ or better (ms^{-2})	A1	cao
		[2]	
4c		B1	Correct shape for *Q*. Allow crossing before $t = 9$ and ignore gradients but horizontal line must be above the *P* graph. B0 if it starts at the origin.
		DB1	3.6 and 6 marked
		B1	Correct shape for *P* (line extended) and both ending at $t = 54$ (or equiv) marked
	N.B. Allow dotted vertical lines but withhold the first B1 if any continuous vertical lines.		
		[3]	

4d	Dist. travelled by $P = 120 + (12 \times 3.2)$ **OR** $\frac{1}{2}(54+45)\times 3.2$ **OR** $\frac{3.2\times 9}{2} + (45\times 3.2)$	B1	Seen, or implied by 158.4 used
	Distance travelled by Q: Clear attempt to use area or *suvat* to form an expression in T only. Must be attempting to use 54 i.e **extended** graph, with correct structure (i.e. triangle + rectangle or trapezium)	M1	Any complete method.
	$\frac{\left(48+\left(48-T\right)\right)}{2}\times 3.6$ **OR** $\frac{1}{2}\times T\times 3.6 + \left(48-T\right)\times 3.6$	A1	Correct unsimplified expression in T only.
	$\frac{\left(48+\left(48-T\right)\right)}{2}\times 3.6 = 158.4$ ($= \frac{1}{2}(54+45)\times 3.2$)	**D**M1	Dependent on previous M mark,form and solve an equation in T only using **total** distances.
	$T = 8$	A1	Correct only
		[5]	
		(13)	

Q	Scheme	Marks	Notes
5a			**N.B**. If they use 3*m* AND 5*m* consistently, can score for (a), (b) and (c), Max M1A0 in (a) Max M1A0 DM1 A0 in (b) Max M1A0 in (c). Max B1M1A1**ft**M1A0 in (d).
	Equation of motion for *P*	M1	Require all terms. Condone sign errors
	$T-3g=3a$ oe	A1	Correct unsimplified equation
		[2]	
5b	Equation of motion for *Q*	M1	Require all terms. Condone sign errors
	$Q:5g-T=5a$ oe	A1	Second correct equation.
			Condone combined equation $5g-3g=(5+3)a$ in place of one of the above
	Solve for *T*	**D**M1	Dependent on both previous M marks, for solving for *T*. **N.B.** They could solve using a calculator, in which case this DM could be implied by a correct answer.
	$T = 36.8$	A1	Accept $\frac{15g}{4}$ oe or 37 **N.B.** Must be a numerical value.
		[4]	
5c	Force on pulley $=2T$	M1	Correct for their *T*, provided $T\neq 0$
	$F = 73.5$	A1**ft**	Accept $\frac{15g}{2}$ or 74 (not 73.6), ft on their *T* value. **N.B.** Must be a numerical value.
		[2]	
5d	Use of $a=\frac{g}{4}$ oe	B1	Must be used in (d).
	Complete method to find *v* or v^2 with $a\neq g$	M1	M0 if *s* = 8 is used
	$v^2=2\times a\times 2$ $\left(v^2=2\times\frac{g}{4}\times 2\right)$	A1**ft**	Correct unsimplified equation in *v* or v^2. ft on their $a\neq\pm g$
	Speed at ground	M1	Complete method with $a=\pm g$, *s* = 8, and a calculated v^2 at *s* = 2, condone sign errors.
	$w^2=v^2+2\times g\times 8$ $w=12.9(13)\left(\text{m s}^{-1}\right)$	A1	3 sf or 2 sf **N.B.** Only penalise overaccuracy after *g* = 9.8, ONCE for the whole question.
		[5]	
		(13)	

Q	Scheme	Marks	Notes
6a			$\tan\alpha = 0.75$ **N.B**. If they use 5*m* consistently, can score Max M1A0M1A0 B1A0 in (a) Max B0B1M1A0M1A0 in (b)
	First equation e.g. resolve perpendicular to the slope	M1	Need all terms. Condone sign errors and sin/cos confusion.
	$R = 5g\cos\alpha + H\sin\alpha$	A1	Correct unsimplified equation
	Second equation e.g. resolve parallel to the slope	M1	Need all terms. Condone sign errors and sin/cos confusion.
	$H\cos\alpha + F = 5g\sin\alpha$	A1	Correct unsimplified equation
	N.B. Consistent omission of *g* from both equations, penalise ONCE so can score max: M1A0M1A1B1A0		
	Alternative equations: Resolve horizontally: $H + F\cos\alpha \left(= H + \mu R\cos\alpha\right) = R\sin\alpha$ Resolve vertically: $5g = R\cos\alpha + F\sin\alpha \left(= R\cos\alpha + \mu R\sin\alpha\right)$		
	N.B. If they use the wrong values for $\sin\alpha$ and $\cos\alpha$, still allow the A marks for the equations, provided it's clear that the correct ratios have been used.		
	$F = \frac{1}{4}R$	B1	Seen or implied. Allow $F \le \frac{1}{4}R$
	$H =$ 20.6 or 20.7 or 21 or $\frac{40g}{19}$	A1	Must be 3 sf or 2 sf or exact multiple of *g*. A0 for $\frac{392}{19}$
		[6]	
			N.B. No marks available in (b) if they use *R* and *F* from (a).
6b	**N.B**. If they use the wrong values for $\sin\alpha$ and $\cos\alpha$, still allow the A marks for the equations, provided it's clear that the correct ratios have been used. **N.B**. If *g* is omitted consistently, can score max : B0B1M1A1M1A0		
	$S = 5g\cos\alpha \left(= 4g\right)$	B1	Seen or implied
	$F = \frac{1}{4}S$	B1	Used with a **new** value for the reaction.
	Equation of motion for *P*: $5g\sin\alpha - g \left(= 3g - g\right) = 5a$ oe	M1	Need all terms. Condone sign errors and sin/cos confusion.

	$a = \frac{2g}{5}$ or 3.92	A1	Correct value for a **N.B.** Allow -ve value provided it's clear that their a was up the plane.
	$1.5 = \frac{1}{2} \times \frac{2g}{5} \times T^2$	M1	Complete method to form an equation in T only. Follow their $a \neq g$.
	(T) = 0.875 or 0.87	A1	3 sf or 2 sf **N.B.** Only penalise overaccuracy after g = 9.8, ONCE for the whole question.
		[6]	
		(12)	

Q	Scheme	Marks	Notes
7a	$-8 = 8 - gT_1$ **OR** $0 = 8T_1 - \frac{1}{2} \times 9.8T_1^2$ **OR** $0 = 8 - gt$ and $T_1 = 2 \times \frac{8}{g}$	M1	Complete method using *suvat*. Condone sign error
	$T_1 = 1.63$ *	A1*	Given single answer correctly obtained (Allow T or t = 1.63 or just 1.63)
		[2]	
7b	$0 = u^2 - 2g \times 2$	M1	Complete method to find speed immediately after 1st impact **N.B.** Could use energy.
	$u = 2\sqrt{g} = 6.26099..$	A1	Seen or implied. Do not penalise for > 3 sf
	Use of $I = mv - mu$	DM1	Dependent on M1, condone sign errors and a recalculated '8'.
	$I = 0.1(8 - (-6.3))$	A1	Must have 8 and 6.3 or better.
	= 1.4 or 1.43 (Ns)	A1	2sf or 3sf
		[5]	
7c	Equal heights	M1	Complete method using *suvat* to form an **equation** in T_2 Allow with $T_2 + 1, T_2$ with $T_2 + 1$ used for A and T_2 used for B Allow t instead of T_2 **N.B.** M0 if they use the same times for both or a mixture of t and $t + 1$. **ALT 1** At $t = 1$, A is (8 – 4.9) = 3.1m above the ground and moving downwards with speed $(9.8 - 8) = 1.8$ m s^{-1} then use $h - s_A = s_B$ oe to find $T_2 - 1$. Must find **both** height and speed.
	$8T_2 - \frac{1}{2}gT_2^2 = 5(T_2 - 1) - \frac{1}{2}g(T_2 - 1)^2$ **OR** $8(T_2 + 1) - \frac{1}{2}g(T_2 + 1)^2 = 5T_2 - \frac{1}{2}gT_2^2$	A1 A1 A1 A1	One distance correct Both distances correct One distance 'correct' Both distances 'correct'

	ALT 1: $3.1-(1.8t+4.9t^2)=(5t-4.9t^2)$	A1 A1	Allow t instead of T_2 in either. One side correct Both sides correct
	($t=\frac{3.1}{6.8}$) $(T_2=)$ 1.5 or 1.46 **ALT 2:** $8(T_1-T_2)-\frac{1}{2}g(T_1-T_2)^2=5(T_2-1)-\frac{1}{2}g(T_2-1)^2$	A1 A1 A1	Must be rounded to 2 sf or 3 sf A0 for $\frac{99}{68}$ = 1.45588.. **N.B.** Only penalise overaccuracy after g = 9.8, ONCE for parts (b) and (c) only.
		[4]	
		(11)	

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