Mark Scheme (Provisional)

Summer 2021

Pearson Edexcel IAL In Mechanics 1

Paper WME01/01

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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.
- 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.

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: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **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. 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.

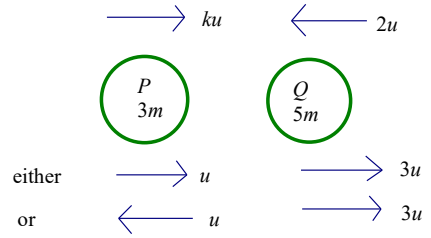
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.

- 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.

Q	Solution	Mark	Notes
1.			
(a)	$\pm 5m\left(3u-\left(-2u\right)\right)$	M1	Use of $I=m\left(v-u\right)$ seen or implied, with correct terms. Condone sign errors. M0 if g included
	$25mu$	A1	Must be positive
		(2)	
(b)	Use of CLM	M1	Or equal and opposite impulses. Requires all terms dimensionally correct. Condone sign errors.
	$3mku-10mu=3mu+15mu$ or $3mku-10mu=-3mu+15mu$	A1	Correct unsimplified equation for either case.
	$\Rightarrow k=\frac{28}{3}$ or $k=\frac{22}{3}$	A1	One correct value. Any equivalent form. Accept decimal to 1dp or better.
	Equation for second value	M1	Their equation from M1 above with the final direction of P reversed.
	Second value correct.	A1	Any equivalent form. Accept decimal to 1dp or better.
		(5)	
		[7]	

2.	Use of $s = ut + \frac{1}{2}at^2$	M1	Form equation in u and a. **N.B.** Marks are available if they use two other unknowns, rather than u and a
	$20 = 3u + \frac{9a}{2}$	A1	Correct unsimplified equation
	Use of *suvat*	M1	Form second equation in u and a. **N.B.** Marks are available if they use the same two other unknowns, rather than u and a
	$10 = (u + 3a) + \frac{a}{2}$ or $30 = 4u + 8a$	A1	Correct unsimplified equation
	$30 = 3u + \frac{21a}{2} \Rightarrow 10 = 6a,\ a = \frac{5}{3}$	M1	Solve for u or a **Or** for one of their unknowns.
	$u = \frac{25}{6}$	A1	u and a both correct **or** both their unknowns correct. Accept equivalent forms. 1.7, 4.2 or better
	Use of $v = u + at$, $20 = \frac{25}{6} + \frac{5}{3}t$	M1	Complete method using *suvat* to find t. Correct unsimplified for their u, a.
	$t = 9.5$ (s)	A1	cao
		[8]	

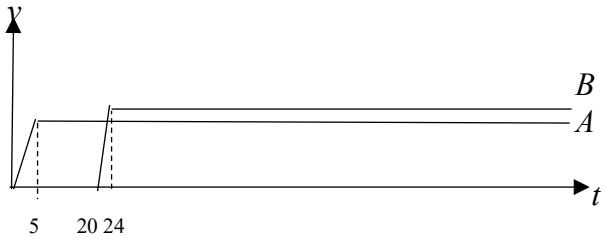
	Allow use of column vectors		
3a	$(5\mathbf{i}+2\mathbf{j})+(-3\mathbf{i}+\mathbf{j})+\mathbf{F}_3=\mathbf{0}$ oe	M1	Use equilibrium to find $\mathbf{F}_3$
	$\mathbf{F}_3=-2\mathbf{i}-3\mathbf{j}\ (\Rightarrow a=-2,\quad b=-3)$	A1	Correct $\mathbf{F}_3$
	$\tan\theta=\frac{2}{3}$	M1	For an equation in a relevant angle using their a and b
	$\theta=33.7°$	A1	$34°$ or better. 0.588 (0.59) rads
		(4)	
3b	Resultant force $=(2+\lambda)\mathbf{i}+(3+3\lambda)\mathbf{j}$	B1	Seen or implied. They must collect the **i**'s and **j**'s.
	$\mathbf{F}=4\mathbf{a}$ oe, where **F** is their resultant, seen or implied (could be implied by $\lvert\mathbf{F}\rvert=13$)	M1	Must have attempted to add all 3 forces. **N.B.** $3.25=\frac{1}{4}\left[(2+\lambda)\mathbf{i}+(3+3\lambda)\mathbf{j}\right]$ oe Scores B1M1M0M0A0 but allow recovery.
	Finding magnitude of their **a** or **F** $\sqrt{\left(\frac{2+\lambda}{4}\right)^2+\left(\frac{3+3\lambda}{4}\right)^2}$ or $\sqrt{(2+\lambda)^2+(3+3\lambda)^2}$	M1	
	Use of $\lvert\mathbf{a}\rvert=3.25$ or $\lvert\mathbf{F}\rvert=13$ to form (3 term quadratic in λ) $=0$ $(10\lambda^2+22\lambda-156=0)$	M1	
	$\lambda=3$	A1	A0 if they give 2 values.
		(5)	
		[9]	

4a	$\updownarrow T-(15g+25g)=(15+25)\times 0.2$	M1	All terms required. Must be in T only. Condone sign errors
		A1	Correct unsimplified equation in T
	$T=400$ (N)	A1	Must be positive
		(3)	
4b	$\updownarrow 12g-R=-0.1\times 12$	M1	All terms required. Condone sign errors
		A1	Correct unsimplified equation in R only. Allow + R at this stage
	$R=119$ (N) (120)	A1	Must be positive
		(3)	
		[6]	

	Allow use of column vectors		
5a	$\mathbf{a} = \dfrac{(\mathbf{i}+7\mathbf{j})-(3\mathbf{i}+5\mathbf{j})}{0.5}$ oe	M1	Use of $\mathbf{a} = \dfrac{\mathbf{v}-\mathbf{u}}{t}$ Allow **u** and **v** reversed
	$\mathbf{a} = -4\mathbf{i}+4\mathbf{j}$	A1	Or equivalent
	$\Rightarrow \mathbf{v}_P = (3\mathbf{i}+5\mathbf{j})+(-4\mathbf{i}+4\mathbf{j})t$	M1	For their **a**
	$= (3-4t)\mathbf{i}+(5+4t)\mathbf{j}$	A1ft	Follow their **a.** Must collect **i**'s and **j**'s This could be implied in subsequent working
	$\Rightarrow 5+4T = -2(3-4T)$	M1	Use of correct ratio to form equation in T (allow t)
	$T = \dfrac{11}{4}$ oe	A1	cao
		(6)	
5b	$\mathbf{v}_P = \mathbf{v}_Q \Rightarrow \begin{pmatrix} 3-4t \\ 5+4t \end{pmatrix} = \begin{pmatrix} -4-2t \\ \mu+3t \end{pmatrix}$ $\Rightarrow 3-4t = -4-2t$ and $5+4t = \mu+3t$	M1	Equate velocities and form two equations in t and μ i.e. must equate coefficients of **i** and **j** oe Follow their $\mathbf{v}_P$
		M1	Solve for μ. Follow their $\mathbf{v}_P$
	$\mu = 8.5$ oe	A1	cao
		(3)	
		[9]	

6a	Resolve perpendicular to the plane	M1	Condone sin/cos confusion
	$R = 6g\cos\theta$	A1	Correct resolution
	$F = \frac{1}{4}R = \frac{18g}{13} = 13.6(\text{N})$ or $14(\text{N})$	A1	2 sf or 3 sf for decimal answer
		(3)	
6b	Equation of motion parallel to the plane	M1	Need all terms and dimensionally correct. Condone sign errors and sin/cos confusion.
	$-F - 6g\sin\theta = 6a$	A1	Correct unsimplified equation in F Allow $-6a$ on RHS
	$0 = 5^2 + 2\times as$	M1	Complete method using *suvat* and calculated a ($a \neq g$) to find s This is independent of previous M mark but they must have found a value for a.
	$0 = 5^2 - 2\times\frac{8g}{13}s$	A1	Correct unsimplified equation. Allow ($-s$)
	$s = 2.07(\text{m})$ or $2.1(\text{m})$	A1	Must be positive.
		(5)	
6c	Equation of motion parallel to the plane	M1	Need all terms and dimensionally correct. Condone sign errors and sin/cos confusion.
	$6g\sin\theta - F = 6a'$	A1	Correct unsimplified equation in F
	$5^2 = 0 + 2a's$	M1	Complete method using *suvat*, with $a' \neq a$ and $a' \neq g$ to find s
	$5^2 = 0 + 2\times\frac{2g}{13}\times s$	A1	Correct unsimplified equation
	$8.29(\text{m})$ or $8.3(\text{m})$	A1	
		(5)	
		[13]	

7a	Possible equations: $\updownarrow R+3R\left(=4R\right)=60g$ M(A), $60gx=R\times a+3R\times 6a$ M(B), $60g(8a-x)=R\times 7a+3R\times 2a$ M(C), $60g(x-a)=3R\times 5a$ M(D), $60g(6a-x)=R\times 5a$	M1A1 M1A1	Two equations required. For each equation, M1 for correct no. of terms, dim correct but condone sign errors. A1 for a correct unsimplified equation. Consistent omission of g could score full marks. Inconsistent omission of g is an A error. All four of these marks could be scored for consistent use of another unknown length which is clearly defined e.g. on a diagram **N.B.** M marks only available if using R and $3R$ oe but allow if wrong way round. For vertical resolution, can score M1A1, even if wrong way round.
	S.C. M(G), $R(x-a)=3R(6a-x)$	M2A2	-1 each error
	$x=\frac{19a}{4}$ oe	A1	Or equivalent
		(5)	
7b			
	Possible equations: ($\uparrow$), $60g+Mg=S+S$ M(A), $60gx+Mg\times 2a=S\times a+S\times 6a$ M(B), $60g(8a-x)+Mg\times 6a=S\times 7a+S\times 2a$ M(C), $60g(x-a)+Mga=S\times 5a$ M(D), $60g(6a-x)+Mg\times 4a=S\times 5a$ M(G), $S(x-a)=S(6a-x)+Mg(x-2a)$	M1A1ft M1A1ft	Two equations in two unknowns (M and S) required. For each equation, M1 for correct no. of terms, dim correct but condone sign errors. A1ft for a correct unsimplified equation, follow their x. x must be substituted to earn the A marks. Consistent omission of g could score full marks. Inconsistent omission of g is an A error.
	$M=50$	A1	Exact answer only.
		(5)	
		[10]	

8a			
	Correct shape for sketch for A, starting at the origin.	B1	B0 if solid vertical line at the end of either.
	Correct shape for sketch for B, must be correct relative to A, crossing it and ending at same time. Must be done on the same axes.	B1	Tram B starts later and acceleration greater.
	5, 20, 24 shown	DB1	Dependent on previous two marks
		(3)	
8b	$t = 20 + \frac{10}{3}\left(= \frac{70}{3}\right)$	B1	
	Distance travelled for either vehicle	M1	
	$\frac{1}{2} \times \frac{10}{3} \times 10$ **OR** $\frac{1}{2} \times 5 \times 10 + \frac{55}{3} \times 10$; $\frac{1}{2}\left(\frac{70}{3} + \frac{70}{3} - 5\right) \times 10$	A1	
	Find second distance and subtract	M1	
	$d = \frac{625}{3} - \frac{50}{3} = \frac{575}{3} = 191\frac{2}{3}$	A1	Accept 192 or better.
		(5)	
8c	Equate distances from O	M1	Find both distances at time t seconds and equate, using correct structure – see examples.
	$\left(\frac{t + t - 5}{2}\right) \times 10 = \left(\frac{t - 20 + t - 24}{2}\right) \times 12$ **OR** $\left(\frac{1}{2} \times 5 \times 10\right) + 10(t - 5) = \left(\frac{1}{2} \times 4 \times 12\right) + 12(t - 24)$	A2	Correct unsimplified equation, -1 each error (up to a maximum of 2)
	$t = 119.5$	M1	Solve for t
	Distance $= 5 \times \left(6 \times 44 - 30\right) = 1170\,(\text{m})$	A1	Accept 1200 or better
		(5)	
		[13]	

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