Mark Scheme (Results)

November 2021

Pearson Edexcel GCE
In AS Further Mathematics (8FM0)
Paper 26 Further Mechanics 2

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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 GCE MATHEMATICS
General Instructions for Marking

1. The total number of marks for the paper is 40.

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. 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.

5. Where a candidate has made multiple responses and indicates which response they wish to submit, examiners should mark this response.
   If there are several attempts at a question which have not been crossed out, examiners should mark the final answer which is the answer that is the most complete.

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

7. Mark schemes will firstly show the solution judged to be the most common response expected from candidates. Where appropriate, alternatives answers are provided in the notes. If examiners are not sure if an answer is acceptable, they will check the mark scheme to see if an alternative answer is given for the method used.

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

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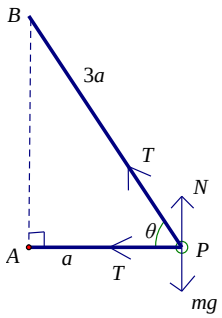
Question	Scheme	Marks	AOs
1a	By symmetry, centre of mass at centre of square.	B1	2.4
		(1)	
1b	Mass ratios 40 : 32 : 72	B1	1.2
	Distances $5a$: $9a$: ($\overline{x}$)	B1	1.2
	Moments about AB: $(40\times 5a+32\times 9a=72\overline{x} \quad (488a=72\overline{x}))$ (or $2\times 10\times 5a+10\times 10a+2\times 8\times 9a+8\times 5a+8\times 13a=72\overline{x}$) $\left(\overline{x}=\frac{61a}{9}\right)$	M1	2.1
	Complete method to find distance $=\sqrt{\overline{x}^2+\overline{x}^2}$	M1	3.1b
	Distance $=\frac{61\sqrt{2}a}{9}$	A1	1.1b
		(5)	
1b alt	Mass ratios 40 : 32 : 72	B1	1.2
	Distances $5\sqrt{2}a : 9\sqrt{2}a$: (d)	B1	1.2
	Moments about B: ($40\times 5\sqrt{2}a+32\times 9\sqrt{2}a=72d$)	M1	2.1
	Complete method to find distance	M1	3.1b
	Distance $=\frac{61\sqrt{2}a}{9}$	A1	1.1b
		(5)	
			(6 marks)

Notes:

(a)	
B1	Any clear explanation
(b)	
B1	Correct mass ratios seen or implied
B1	Correct distances seen or implied
M1	Moments equation for the whole framework about an axis parallel to *AB* or to *BC*.
M1	Use of symmetry of the framework and Pythagoras with their $\overline{x}$ to find the required distance
A1	Or equivalent. $9.6a$ $(9.585...a)$ or better

	Alternative approach:
	2^{nd} M1 moments equation using their distances and masses
	1^{st} M1 complete method to find distances from B

Question	Scheme	Marks	AOs
2(a)			
	Resolve vertically	M1	3.1b
	↕ $T\sin\theta + N = mg$	A1	1.1b
	Resolve horizontally	M1	3.1b
	↔ $T + T\cos\theta = ma \times \frac{2g}{3a}$ $\left(\frac{4}{3}T = \frac{2}{3}mg,\quad T = \frac{1}{2}mg\right)$	A1	1.1b
	Complete strategy to obtain and solve equations to find N	M1	2.1
	$\Rightarrow \frac{\sqrt{8}}{3} \times \frac{1}{2}mg + N = mg,\qquad N = mg\left(1 - \frac{\sqrt{2}}{3}\right)$	A1	1.1b
		(6)	
(b)	Max speed $\Rightarrow N = 0,\quad \frac{\sqrt{8}}{3}T = mg$	M1	2.1
	$\frac{4}{3}T = ma\omega^2 \Rightarrow \frac{3}{\sqrt{8}}mg \times \frac{4}{3} = ma\omega^2$	M1	1.1b
	$\omega = \sqrt{\frac{4g}{\sqrt{8}a}} = \sqrt{\frac{\sqrt{2}g}{a}}$	A1	1.1b
		(3)	
(c)	The tension in the string is the same on either side of P	B1	2.4
		(1)	
			(10 marks)

Notes:

2a	M1	Forces balance vertically. All terms required. Condone sign errors and sin/cos confusion
	A1	Correct unsimplified equation
	M1	Equation for motion in a horizontal circle. All terms required. Condone sign errors and sin/cos confusion
	A1	Correct unsimplified equation

	M1	Complete strategy to use the model to form simultaneous equations and solve for N
	A1	Any equivalent form. Accept $0.53mg$ or better
2b	M1	Resolve vertically and use max speed $\Rightarrow N = 0$ to form equation in T
	M1	Resolve horizontally and substitute for T to form equation in ω
	A1	Any equivalent simplified form. $1.2\sqrt{\frac{g}{a}}$ or better
2c	B1	Clear statement explaining how the modelling assumption has been used.

Question	Scheme	Marks	AOs
3(a)	<table><tr><td>Mass ratio</td><td>16</td><td>6</td><td>4</td><td>26</td></tr><tr><td>$\rightarrow$ from AJ</td><td>a</td><td>$3.5a$</td><td>$3a$</td><td>$\overline{x}$</td></tr><tr><td>$\downarrow$ from AB</td><td>$4a$</td><td>a</td><td>$5a$</td><td>$\overline{y}$</td></tr></table>	B1 B1	1.2 1.2
	M(AJ)	M1	2.1
	$16a + 21a + 12a\left(= 49a\right) = 26\overline{x}$	A1	1.1b
	$26\overline{x} = 49a \Rightarrow \overline{x} = \frac{49}{26}a$ *	A1*	1.1b
		(5)	
(b)	M(A)	M1	3.1b
	$5a \times T = \frac{49}{26}a \times W$	A1	1.1b
	$T = \frac{49}{130}W$	A1	1.1b
		(3)	
(c)	Distances from AB (as in table above)	B1	1.2
	M(AB): $64a + 6a + 20a = 26\overline{y}$	M1	2.1
	$\overline{y} = \frac{90}{26}a$	A1	1.1b
	$\tan\theta = \frac{49}{90}$	M1	1.1a
	$\theta = 28.6° \ \left(29°\right)$	A1	2.2a
		(5)	
			(13 marks)

Notes:

3a	B1	Correct mass ratios seen or implied
	B1	Correct distances from their vertical axis
	M1	Correct strategy to find distance including appropriate division of the lamina and moments about an axis parallel to AJ. Terms dimensionally correct. Condone sign errors.
	A1	Correct unsimplified moments equation for a correct division of the template.
	A1*	Obtain **given answer** from complete and correct working
3b	M1	Complete method to find the tension. Dimensionally correct equations.
	A1	Correct unsimplified equation for the tension

	A1	Correct simplified $(0.38W$ or better$)$
3c	B1	Distances from a horizontal axis for a complete correct division of the lamina (could be found in (a) but need to be used here to score the B1)
	M1	Moments about a horizontal axis. Terms dimensionally correct. Condone sign errors.
	A1	Correct vertical distance (any equivalent form) $\left(\frac{59}{13}a$ from $JI\right)$ seen or implied.
	M1	Use trig. with $\frac{49}{26}a$ and their $\overline{y}$, or equivalent, to find a relevant angle.
	A1	$29°$ or better. $28.5658...°$, 0.499 rads

Question	Scheme	Marks	AOs
4(a)	Instantaneous rest: $v = 5\sin 2t = 0$	M1	1.1b
	$\Rightarrow t = \frac{\pi}{2}$	A1	1.1b
	Differentiate to obtain a: $a = 10\cos 2t \ \ (= 10\cos \pi = -10)$	M1	3.1a
	$10\left(\text{ms}^{-2}\right)$ towards O	A1	1.1b
		(4)	
(b)	Integrate to obtain x: $x = -\frac{5}{2}\cos 2t\left(+C\right)$	M1	2.1
	Use boundary conditions: $t = 0,\ x = 1 \Rightarrow C = \frac{7}{2}$	M1	3.4
	$x = \frac{7}{2} - \frac{5}{2}\cos 2t$	A1	1.1b
	$-1 \leq \cos 2t \leq 1 \ \Rightarrow 1 \leq x \leq 6$ *	A1*	2.2a
		(4)	
(c)	$x = \frac{7}{2} - \frac{5}{2}\cos 2t = 3 \Rightarrow \cos 2t = \frac{1}{5}, \quad t = 0.6847.....$	M1	1.1b
	Total time $= 4\pi - 8t$	M1	3.1a
	$= 7.1$ (s) or better	A1	1.1b
		(3)	
			(11 marks)

Notes:

4a	M1	Solve $v = 0$ to find the first value of $t > 0$
	A1	Or equivalent (accept $2t = \pi$)
	M1	Use $a = \frac{\text{d}v}{\text{d}t}$ and substitute for t
	A1	Correct only
4b	M1	Use $x = \int v\text{d}t$. Condone missing $+C$
	M1	Use boundary conditions to find C
	A1	Any equivalent form
	A1*	Deduce given answer from correct working.
4c	M1	Use trig to find a relevant value of t

	M1	Correct method for the total time
	A1	7.1 (s) or better 7.08861…