Mark Scheme (Results)

Summer 2022

Pearson Edexcel GCE
In 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

Question	Scheme	Marks	AOs
1(a)	ABF $BCEF$ CDE lamina		
	$\frac{3}{2}a^2$ $9a^2$ $\frac{3}{2}a^2$ $12a^2$	B1	1.2
	a $\frac{3}{2}a$ a $\overline{y}$	B1	1.2
	Moments about AD	M1	2.1
	$(\frac{3}{2}a^2 \times a) + (9a^2 \times \frac{3}{2}a) + (\frac{3}{2}a^2 \times a) = 12a^2\overline{y}$	A1	1.1b
	$\overline{y} = \frac{11a}{8}$ *	A1*	2.2a
		(5)	
1(b)	Moments about F, $Mg \times (3a - \frac{11a}{8}) = 3aT$	M1	3.1a
	$T = \frac{13Mg}{24}$ $(0.54166666\ldots\ Mg)$	A1	1.1b
		(2)	
			(7 marks)

Notes:

1a	B1	Any equivalent ratios e.g. 3 : 18 : 3 : 24
	B1	Or correct distances from a parallel axis
	M1	Or moments about a parallel axis
	A1	Correct unsimplified equation for their axis
	A1*	Correct given answer correctly obtained If they have centre of mass at (xa, ya) then the a might not be seen in the working. Otherwise, with no a in the working the maximum score is B1B0M1A0A0
1b	M1	A complete method to obtain an equation in T only
	A1	$0.54Mg$ or better

Question	Scheme	Marks	AOs
2.(a)	*ABCD* *BEC* framework		
	$6a$ πa $6a + \pi a$	B1	1.2
	$\frac{1}{2}a$ $(-)\frac{2a}{\pi}$ $\overline{x}$	B1	1.2
	Moments about *BC*	M1	2.1
	$6a \times \frac{1}{2}a - \pi a \times \frac{2a}{\pi} = (6a + \pi a)\overline{x}$	A1	1.1b
	$\overline{x} = \frac{a}{6+\pi}$ *	A1*	2.2a
		(5)	
2(b)	Angle $DAE = \tan^{-1}\left(\frac{2a}{a}\right)$	M1	1.1b
	Angle $DAG = \tan^{-1}\left(\frac{a - \frac{a}{6+\pi}}{a}\right) = \tan^{-1}\left(\frac{5+\pi}{6+\pi}\right)$	M1	1.1b
	Angle = *DAE* – *DAG*	M1	3.1a
	21.74637…	A1	1.1b
		(4)	
2(c)	Moments about *OA*	M1	2.1
	$kMa\sin 45^o = M\overline{x}\sin 45^o$	A1	1.1b
	$k = \frac{1}{6+\pi}$ (= 0.10939…)	A1	1.1b
		(3)	
2(c) alt	Moments about *O*	M1	2.1
	$kM\begin{pmatrix}0\\a\end{pmatrix} - M\begin{pmatrix}\frac{a}{6+\pi}\\0\end{pmatrix} = (k+1)M\begin{pmatrix}-\lambda\\\lambda\end{pmatrix}$	A1	1.1b
	$k = \frac{1}{6+\pi}$ (= 0.10939…)	A1	1.1b
		(3)	
			(12 marks)

Notes:		
2a	B1	Any equivalent ratios
	B1	Or correct distances from a parallel axis
	M1	Or moments about a parallel axis Must be using framework. If *BC* included twice mark as a misread.

	A1	Correct unsimplified equation for their axis. Allow within a vector equation
	A1*	Correct given answer correctly obtained
2b	M1	Correct relevant angle (or side if they use the cosine rule) Do not need to evaluate: accept $\tan\alpha = ...$ or $\alpha = \tan^{-1}...$ $\left(\text{e.g. } 63.4...^\circ \text{ or } 90^\circ - 63.4...^\circ\right)$
	M1	Another correct relevant angle (or side if they use the cosine rule) Do not need to evaluate: accept $\tan\beta = ...$ or $\beta = \tan^{-1}...$ $\left(\text{e.g. } 41.68...^\circ \text{ or } 90^\circ - 41.68...^\circ\right)$
	M1	Correct method for finding the required angle
	A1	22° or better
2c	M1	Complete method to give an equation in k only
	A1	Correct equation in k only
	A1	0.11 or better

Question	Scheme	Marks	AOs
3(a)	Resolving vertically	M1	3.4
	$R\cos\alpha - F\sin\alpha = mg$	A1	1.1b
	Equation of motion horizontally	M1	3.4
	$R\sin\alpha + F\cos\alpha = \dfrac{mV^2}{r}$	A1	1.1b
	Use of $F = \mu R$	M1	3.4
	Solve for V	M1	3.1b
	$V = \sqrt{\dfrac{(3+4\mu)rg}{4-3\mu}}$ *	A1*	1.1b
		(7)	
3(b)	Use of $\mu = 0$ oe	M1	2.1
	$U = \sqrt{\dfrac{3rg}{4}}$	A1	1.1b
		(2)	
3(c)	Since $3+4\mu > 3$ and $4-3\mu < 4$ oe	M1	2.1
	$\dfrac{3}{4} < \dfrac{3+4\mu}{4-3\mu}$ and hence $U < V$ *	A1*	2.2a
		(2)	
			(11 marks)

Notes:		
3a	M1	Correct no. of terms, dim correct, condone sin/cos confusion and sign errors
	A1	Correct equation
	M1	Correct no. of terms, dim correct, condone sin/cos confusion and sign errors
	A1	Correct equation
	M1	Independent but must be used in an equation
	M1	Substitute for trig and solve for V. Dependent on preceding M marks.
	A1*	Correct given answer correctly obtained
3b	M1	If they don't use $\mu = 0$, we need to see the first 6 marks from (a), without friction
	A1	cao
3c	M1	Any convincing argument
	A1*	Given answer correctly obtained

		SC: Allow M1A0 if they work in reverse to show that if $U < V$ then $\mu > 0$ and make an appropriate comment

Question	Scheme	Marks	AOs
4(a)	$a = \frac{dv}{dt} = \frac{1}{2} \times 6e^{2t}$	M1	1.1b
	$= 2v + 1$ *	A1*	1.1b
		(2)	
4(b)	3 ($m\,s^{-2}$)	B1	1.1b
		(1)	
4(c)	$\frac{dx}{dt} = \frac{1}{2}(3e^{2t} - 1)$ and integrate	M1	3.3
	$x = \frac{1}{2}(\frac{3}{2}e^{2t} - t)(+C)$	A1	1.1b
	Put either $\frac{1}{2}(3e^{2t} - 1) = 1$ or 4 and solve for t	M1	2.1
	$t = 0$	A1	1.1b
	$t = \frac{1}{2}\ln 3$ (0.549306…)	A1	1.1b
	Substitute their t values into their x expression and subtract	M1	3.1a
	$\frac{3}{2} - \frac{1}{4}\ln 3$ (m)	A1	1.1b
		(7)	
			(10 marks)

Notes:

4a	M1	Need to see evidence of attempt to differentiate v wrt t, not just a statement of intent.
	A1*	Given answer correctly obtained
4b	B1	cao
4c	M1	Set up differential equation and attempt to solve
	A1	Condone missing C
	M1	Use at least one of the given speeds to find a t value
	A1	cao
	A1	0.55 or better
	M1	Substitute their t values to find x values and showing subtracting. Need to see evidence. M0 if using 1 and 4.
	A1	cao

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