Mark Scheme (Results)

Summer 2024

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.

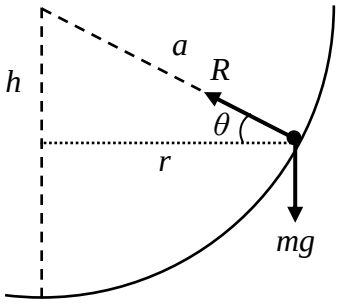
- Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft

- 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
1a	M(AF)	M1	2.1
	$24ad = 4a \times 4a + 4a \times 6a + 2 \times 3a \times 6a \left(= 76a^2\right)$	A1 A1	1.1b 1.1b
	$d = \dfrac{19a}{6}$ *	A1*	2.2a
		(4)	
1b	$\bar{y} = 2a$	B1	1.1b
	$D^2 = \text{their } \bar{x}^2 + \text{their } \bar{y}^2 \left(= \dfrac{361}{36}a^2 + 4a^2\right)$	M1	1.1b
	$D = \sqrt{\dfrac{505}{36}}a = \dfrac{\sqrt{505}}{6}a$	A1	1.1b
		(3)	
			(7 marks)

Notes:

1a	**M1**	Moments about AF or a parallel axis. All terms required. Dimensionally correct but allow consistent cancelling of a factor of a or $2a$.
	A1	Unsimplified equation with at most one error
	A1	Correct unsimplified equation E.g. $12d = 2 \times 4a + 2 \times 6a + 2 \times 3 \times 3a \left(= 38a\right)$
	A1*	Obtain given answer including "$d =$" from correct exact working
1b	**B1**	Seen or implied
	M1	Correct use of Pythagoras to find D or D^2
	A1	Any equivalent form. Accept $3.7a$ or better. (3.7453675…)

Question	Scheme	Marks	AOs
2a			
	Resolve horizontally	M1	3.1b
	$mr\omega^2 = R\cos\theta$	A1	1.1b
	Resolve vertically	M1	3.1b
	$mg = R\sin\theta$	A1	1.1b
	$\frac{g}{r\omega^2} = \tan\theta = \frac{h}{r}$	DM1	1.1b
	$\Rightarrow \omega^2 = \frac{g}{h}$ *	A1*	2.2a
		(6)	
2b	Resolve horizontally or vertically	M1	2.1
	$ma\cos\theta\omega^2 = 3mg\cos\theta \Rightarrow a\omega^2 = 3g$ or $mg = 3mg\sin\theta \Rightarrow g = 3g \times \frac{g}{a\omega^2}$	A1	1.1b
	$\omega = \sqrt{\frac{3g}{a}}$	A1	1.1b
		(3)	
2c	Have ignored the dimensions of B	B1	3.5b
		(1)	
			(10 marks)

Notes:		
2a	M1	Dimensionally correct. Condone sine/cosine confusion
	A1	Or equivalent correct unsimplified equation
	M1	Dimensionally correct. Condone consistent sine/cosine confusion
	A1	Or equivalent correct unsimplified equation
		NB: can score the first 4 marks by resolving tangentially: $mg\cos\theta = mr\omega^2\sin\theta$

	DM1	Eliminate R, θ to obtain equation in ω^2 Dependent on both previous M marks
	A1*	Obtain given answer from full and correct working
2b	M1	Resolve and substitute for R and r. Dimensionally correct. Condone sine/cosine confusion
	A1	Correct equation in a, g and ω
	A1	Correct only
2c	B1	Or equivalent or acceptable alternatives e.g. have ignored spin of B B0 for weight acts through a point B0 if any incorrect extras

Question	Scheme	Marks	AOs
3a	$a = 4 - 3v \quad \Rightarrow \quad \int \frac{1}{4-3v}\,\mathrm{d}v = \int 1\,\mathrm{d}t$	M1	2.1
	Integrate both sides of the equation	M1	1.1b
	$\Rightarrow -\frac{1}{3}\ln\lvert 4-3v\rvert = t\,(+C)$	A1	1.1b
	Use $t = 0,\ v = 0$	M1	3.4
	$t = \frac{1}{3}\ln\left(\frac{4}{4-3v}\right)$	A1	1.1b
	$\Rightarrow \mathrm{e}^{3t} = \frac{4}{4-3v}, \quad 4-3v = 4\mathrm{e}^{-3t}$	M1	1.1b
	$v = \frac{4}{3}\left(1-\mathrm{e}^{-3t}\right) \quad *$	A1*	2.2a
		(7)	
3b	$\frac{\mathrm{d}x}{\mathrm{d}t} = k\left(1-\mathrm{e}^{-3t}\right) \quad \Rightarrow \quad \int 1\,\mathrm{d}x = \int k\left(1-\mathrm{e}^{-3t}\right)\mathrm{d}t$	M1	3.3
	$x = k\left(t+\frac{1}{3}\mathrm{e}^{-3t}\right)(+C) = \frac{4}{3}\left(t+\frac{1}{3}\mathrm{e}^{-3t}\right)(+C)$	M1	1.1b
	Use $t = 0,\ x = 0$	M1	3.4
	$x = k\left(t+\frac{1}{3}\mathrm{e}^{-3t}-\frac{1}{3}\right) = \frac{4}{3}\left(t+\frac{1}{3}\mathrm{e}^{-3t}-\frac{1}{3}\right)$	A1ft	1.1b
		(4)	
			(11 marks)

Notes:

3a	M1	Use $a = \frac{\mathrm{d}v}{\mathrm{d}t}$ and separate the variables to form integrals in v and t
	M1	Integrate to obtain terms $p\ln(4-3v)$ and qt
	A1	Or equivalent. Accept with brackets in place of modulus signs. Condone missing constant of integration
	M1	Use boundary conditions in the model to evaluate constant of integration or as limits on a definite integral
	A1	Or equivalent
	M1	Rearrange to obtain expression for v in terms of t
	A1*	Obtain **given form** with $k = \frac{4}{3}$ from correct working
3b	M1	Use $v = \frac{\mathrm{d}x}{\mathrm{d}t}$ to form integrals in x and t

	M1	Integrate to obtain $\lambda t + \mu e^{-3t} (+C)$
	M1	Use boundary conditions in the model to evaluate constant of integration or as limits on a definite integral
	A1ft	Any equivalent form. Follow their k

Question	Scheme	Marks	AOs
4a	M(AC)	M1	2.1
	$(27-6)a^2d = 27a^2\times 3a - 6a^2\times 2a \left(=69a^3\right)$	A1	1.1b
	$\Rightarrow d = \frac{69}{21}a = \frac{23}{7}a$ *	A1*	2.2a
		(3)	
4b	M(AB)	M1	3.1a
	$(27-6)a^2\bar{y} = 27a^2\times 2a - 6a^2\times 1.5a \left(=45a^3\right)$	A1	1.1b
	$\bar{y} = \frac{45}{21}a = \frac{15}{7}a$	A1	1.1b
	$\tan\theta° = \frac{15}{23}$	M1	3.1a
	$\theta = 33 \quad (\theta = 33.111..)$	A1	1.1b
		(5)	
4c	M(A)	M1	3.1a
	$6aX + \frac{23}{7}a\times W = \frac{23}{7}a\times 4W$	A1 A1	1.1b 1.1b
	$X = \frac{23}{14}W$	A1	1.1b
		(4)	
			(12 marks)

Notes:

4a	M1	Take moments about AC or a parallel axis. Dimensionally correct terms. Correct number of terms.
	A1	Correct unsimplified equation
	A1*	Obtain the given answer including "$d =$" from correct working
4b	M1	Take moments about AB or a parallel axis. Dimensionally correct terms. Correct number of terms.
	A1	Correct unsimplified equation
	A1	Correct vertical distance. Any equivalent form
	M1	Correct use of trig to find a relevant angle
	A1	2 sf or better (33.111…)
4c	M1	Complete method to form an equation in X e.g by taking moments about A. $5W$ must be split correctly and equation must be dimensionally correct.

	A1	Unsimplified equation with at most one error
	A1	Correct unsimplified equation
	A1	3.1*W* or better (3.1428….*W*)

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