Pearson Edexcel

Mark Scheme (Results)

Summer 2022

Pearson Edexcel GCE
In Further Mathematics (8FM0)
Paper 25 Further Mechanics 1

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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 $\sqrt{}$ 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 <u>and indicates which response they wish to submit</u>, examiners should mark this response.
   If there are several attempts at a question <u>which have not been crossed out</u>, examiners should mark the final answer which is the answer that is the <u>most complete</u>.

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.	$F = \dfrac{32000}{20}$	M1	3.3
	Equation of motion	M1	3.1b
	$F - 1200g\sin\alpha - R = 1200 \times 0.5$	A1	1.1b
	Substitute for g, trig and F and solve for R	DM1	1.1b
	$R = 216$ or 220 (N)	A1	1.1b
		(5)	
			(5 marks)

Notes:

1	M1	Use of $P = Fv$. Allow $\dfrac{32}{20}$. Allow $32000 = 20F$ or $32 = 20F$, followed by an error when dividing M0 for $32000 = 20(F - R)$ or similar
	M1	Correct no. of terms, condone sign errors and sin/cos confusion M0 if they use power in equation of motion
	A1	Correct equation
	DM1	Dependent on second M1 (allow if g missing)
	A1	Cao ($R = 215.2$ if they use $g = 9.81$)

Question	Scheme	Marks	AOs
2(a)	$2u \rightarrow \qquad \leftarrow u$ $\frac{9mu}{2} \longleftarrow m \qquad 3m \longrightarrow \frac{9mu}{2}$ $v \leftarrow \qquad \rightarrow w$		
	Use of Impulse-momentum principle for A or B	M1	3.4
	A: $\frac{9mu}{2} = m(v - -2u)$ **or** B: $\frac{9mu}{2} = 3m(w - -u)$	A1	1.1b
	Use of Impulse-momentum principle for B or A or CLM	M1	3.4
	$\frac{9mu}{2} = 3m(w - -u)$ **or** $\frac{9mu}{2} = m(v - -2u)$ **or** $2mu - 3mu = -mv + 3mw$	A1	1.1b
	$v = \frac{5u}{2}$ and $w = \frac{u}{2}$	A1	1.1b
	$e = \dfrac{\frac{5u}{2} + \frac{u}{2}}{2u + u}$	M1	3.1a
	$e = 1$	A1cso	1.1b
	ALTERNATIVE:		
	NEL is written down before v and w are found: $v + w = 3ue$	3rd M1	
	Use of Impulse-momentum principle for A or B	1st M1	
	A: $\frac{9mu}{2} = m(v - -2u)$ **or** B: $\frac{9mu}{2} = 3m(w - -u)$	1st A1	
	Use of Impulse-momentum principle for B or A or CLM	2nd M1	
	$\frac{9mu}{2} = 3m(w - -u)$ **or** $\frac{9mu}{2} = m(v - -2u)$ **or** $2mu - 3mu = -mv + 3mw$	2nd A1	
	An equation (not an identity) in u and e only is produced	3rd A1	
	$e = 1$	A1cso	
		(7)	
2(b)	Perfectly elastic (or the coefficient of restitution is 1) so no loss in kinetic energy. Allow a direct evaluation of the KE loss i.e. $\frac{1}{2}m(2u)^2 + \frac{1}{2}\times 3mu^2 - \left(\frac{1}{2}m\left(\frac{5u}{2}\right)^2 + \frac{1}{2}\times 3m\left(\frac{u}{2}\right)^2\right) = 0$ B0 if incorrect extras	DB1	2.4
		(1)	
			(8 marks)

Notes:		
N.B. Ignore diagrams if it helps the candidate. **Equations need to be consistent, where appropriate, to earn A marks.**		
2a	M1	Use of Impulse-momentum principle for A or B, condone sign errors but M0 if dimensionally incorrect e.g. if m missing
	A1	Correct unsimplified equation
	M1	Use of Impulse-momentum principle for other particle or CLM, condone sign errors but M0 if dimensionally incorrect e.g. if m missing from impulse For CLM, allow consistent missing m's or extra g's.
	A1	Correct unsimplified equation
	A1	Cao for both. Allow one or both negative if correct for their symbols.
	M1	Use of NEL to obtain $e = \ldots$, condone sign errors in numerator but must be terms in u only AND must be $(2u + u)$ in denominator. M0 if inverted
	A1	cso
2b	DB1	Dependent on $e = 1$ **correctly** obtained in (a) A correct statement e.g. zero, 0 etc and a correct reason

Question	Scheme	Marks	AOs
3(a)	$mg \times \frac{25}{6}\sin\alpha$	B1	1.1b
	Use of the principle of conservation of mechanical energy	M1	3.4
	$\frac{1}{2}m \times 25^2 - \frac{1}{2}mv^2 = mg \times \frac{25}{6}\sin\alpha$	A1	1.1b
	$v = 24$ (m s^{-1}) (23.99895831… = 24 to 2SF if $g = 9.81$)	A1	1.1b
		(4)	
3(b)	Resolve perpendicular to the plane	M1	3.1a
	$R = mg\cos\alpha$	A1	1.1b
	$F = \frac{3}{5}R$	B1	3.4
	WD against friction = $F \times \frac{25}{6}$	B1	3.4
	Use of work-energy principle	M1	3.1a
	$\frac{1}{2}m \times 25^2 - \frac{1}{2}mv^2 = mg \times \frac{25}{6}\sin\alpha + \frac{3}{5} \times mg\cos\alpha \times \frac{25}{6}$	A1 A1	1.1b 1.1b
	$v = 23.2$ or 23 (m s^{-1}) (23.16700… = 23.2 or 23 to 3SF or 2SF if $g = 9.81$)	A1	1.1b
		(8)	
			(12 marks)

Notes:

		N.B. If consistent use of a specific value of *m*, allow all the marks but deduct the final A mark in each part but allow full marks if *m*'s have been cancelled or don't appear.
3a	B1	Seen anywhere
	M1	Correct no. of terms, dimensionally correct, condone sign errors and sin/cos confusion M0 for non-energy methods. Allow max M1A0A0 if 25/6 not resolved or not resolved correctly in PE term
	A1	Correct equation in *m*, *g*, *v* and α
	A1	cao
3b	M1	Correct no. of terms, dimensionally correct, condone sign errors and sin/cos confusion
	A1	Correct equation
	B1	Seen anywhere
	B1	Seen anywhere
	M1	Correct no. of terms, dimensionally correct, condone sign errors and sin/cos confusion M0 for non work-energy methods Allow max M1A1A0A0 if 25/6 not resolved or not resolved correctly in PE term

	A1	Equation in m, g, v and α with at most one error **N.B**. If KE terms reversed, only penalise ONCE.
	A1	Correct equation in m, g, v and α
	A1	cao

Question	Scheme	Marks	AOs
4(a)	$2u \rightarrow$ 0 $P\ (2m)$ $Q(3m)$ $w \leftarrow$ $\rightarrow v$		
	Use of CLM	M1	3.4
	$2m \times 2u = -2mw + 3mv$	A1	1.1b
	Use of NEL	M1	3.4
	$2ue = w + v$	A1	1.1b
	Solve for v	D M1	1.1b
	$v = \dfrac{4u(1+e)}{5}$ *	A1*	2.2a
		(6)	
4(b)	Since $0 \le e \le 1$, $\dfrac{4u(1+0)}{5} \le v \le \dfrac{4u(1+1)}{5}$	M1	3.1a
	i.e. $\dfrac{4u}{5} \le v \le \dfrac{8u}{5}$ *	A1*	2.2a
		(2)	
4(c)	Solve for w	M1	1.1b
	$w = \dfrac{2u(3e-2)}{5}$ oe $(\mathrm{m\,s^{-1}})$ or $\left\lvert \dfrac{2u(2-3e)}{5} \right\rvert$ oe	A1	1.1b
		(2)	
4(d)	Speed of Q after hitting the wall = $\dfrac{1}{6}v$ $(\mathrm{m\,s^{-1}})$	M1	3.4
	For a further collision between P and Q, $\dfrac{1}{6}v > w$	M1	3.1a
	Substitute for v and w and solve for e	M1	1.1b
	$e < \dfrac{7}{8}$	A1	1.1b
	$\dfrac{2}{3} < e < \dfrac{7}{8}$	A1	1.1b
		(5)	
			(15 marks)

Notes:

4a	M1	Correct no. of terms, condone sign errors, allow consistently cancelled m's or extra g's or common factors throughout
	A1	Correct equation; they may have w instead of $-w$
	M1	Correct no. of terms, condone sign errors. M0 if e on the wrong side of the equation

	A1	Correct equation; they may have w instead of $-w$
	DM 1	Solve for v, dependent on previous two marks
	A1*	Correct answer correctly obtained
4b	M1	Use of $0 \le e \le 1$ in the given answer; allow use of $e = 0$ and $e = 1$ to obtain the min and max expressions M1A0 for 'verification'.
	A1*	Correct answer correctly obtained (including use of max and min)
4c	M1	Solve for their w
	A1	cao
4d	M1	Speed so must see a positive quantity M0 if $\frac{1}{6}$ is on the wrong side of the equation
	M1	Correct inequality for their w (allow even if their w is dimensionally incorrect)
	M1	Independent M mark but must have an inequality in v and w: Substitute for v, using given answer, and w and solve for e
	A1	Correct upper bound for e
	A1	cao