Pearson Edexcel

Mark Scheme

Mock Paper Set 2

Pearson Edexcel GCE Further Mathematics
Further Mechanics 1 Paper 9FM0_3C

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

Mock paper
Publications Code 9FM0_3C_Mock paper_MS

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 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. 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 Core Mathematics Marking

(*But note that specific mark schemes may sometimes override these general principles*)

Method mark for solving 3 term quadratic:

1. Factorisation

$(x^2 + bx + c) = (x + p)(x + q)$, where $|pq| = |c|$, leading to $x = ...$

$(ax^2 + bx + c) = (mx + p)(nx + q)$, where $|pq| = |c|$ and $|mn| = |a|$, leading to $x = ...$

2. Formula

Attempt to use the correct formula (with values for *a*, *b* and *c*)

3. Completing the square

Solving $x^2 + bx + c = 0$: $\left(x \pm \frac{b}{2}\right)^2 \pm q \pm c = 0, \quad q \neq 0$, leading to $x = ...$

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1. $(x^n \to x^{n-1})$

2. Integration

Power of at least one term increased by 1. $(x^n \to x^{n+1})$

Use of a formula

Where a method involves using a formula that has been learnt, the advice given in recent examiners' reports is that the formula should be quoted first.

Normal marking procedure is as follows:

Method mark for quoting a correct formula and attempting to use it, even if there are small errors in the substitution of values.

Where the formula is not quoted, the method mark can be gained by implication from correct working with values but may be lost if there is any mistake in the working.

Exact answers

Examiners' reports have emphasised that where, for example, an exact answer is asked for, or working with surds is clearly required, marks will normally be lost if the candidate resorts to using rounded decimals.

Question	Scheme	Marks	AOs
1	Driving force $F = \frac{12000}{w}$	M1	3.3
	Equation of motion	M1	3.4
	$\frac{12000}{w} - (200 + 10w) = 700 \times 0.6$	A1	1.1b
	$\Rightarrow 10w^2 + 620w - 12000 = 0$	M1	1.1b
	$w = 15$ or better	A1	1.1b
		(5)	
			(5 marks)

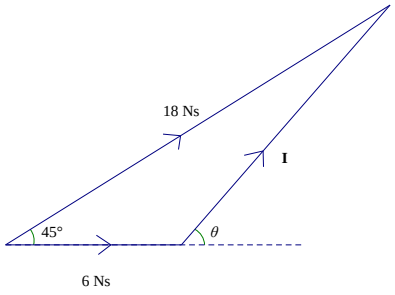
Notes:

M1	Use of $P = Fw$
M1	Use the model to form the equation of motion. All terms needed. Condone sign errors. Must be dimensionally correct. Allow F or their F
A1	Correct unsimplified equation in w
M1	Form and solve a three term quadratic in w
A1	15.486…….

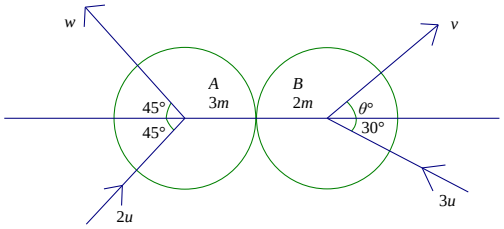
Question	Scheme	Marks	AOs
2	Complete method to find the magnitude of **I**	M1	3.3
	$\lvert\mathbf{I}\rvert = \sqrt{\left(9\sqrt{2}-6\right)^2+\left(9\sqrt{2}\right)^2}$	A1	1.1b
	$=14\,(\text{Ns})$ or better	A1	1.1b
	Complete method to find the direction of **I**	M1	3.4
	$\theta = \tan^{-1}\left(\dfrac{9\sqrt{2}}{9\sqrt{2}-6}\right)$	A1	1.1b
	$=62°$ or better	A1	1.1b
		(6)	
			(6 marks)

Notes:

M1	Find components and use Pythagoras
A1	Correct unsimplified expression
A1	14.366…
M1	Use components and trigonometry to find direction
A1	Correct unsimplified expression
A1	62.1…°

2 alt			
	Use of cosine rule on impulse momentum triangle	M1	3.3
	$\lvert\mathbf{I}\rvert^2 = 6^2+18^2-2\times6\times18\cos45°\left(=207.26\right)$	A1	1.1b
	$\lvert\mathbf{I}\rvert = 14\,(\text{Ns})$ or better	A1	1.1b
	Use of sine rule to find θ	M1	3.4
	$\dfrac{\sin\theta}{18} = \dfrac{\sin45°}{14.4}$	A1	1.1b
	$\theta = 62°$ or better	A1	1.1b
		(6)	

Notes:	
M1	Form impulse momentum triangle and use trigonometry to find $\left\|\mathbf{I}\right\|$. Sides of triangle must be dimensionally consistent
A1	Correct unsimplified equation
A1	14.366…..
M1	Use the impulse momentum triangle to find a relevant angle
A1	Correct unsimplified equation
A1	62.1…°

Question	Scheme	Marks	AOs
3(a)			
	$\updownarrow A: w\sin 45° = 2u\sin 45° \quad \Rightarrow \quad w = 2u$	B1	3.4
	$\updownarrow B: 3u\sin 30° = v\sin\theta° \left(= \frac{3u}{2}\right)$	B1	3.4
	CLM Parallel to line of centres	M1	3.1b
	$2mv\cos\theta° - 3mw\cos 45° = 6mu\cos 45° - 6mu\cos 30°$ $\left(v\cos\theta° = 6u\cos 45° - 3u\cos 30° = 1.6446....u\right)$	A1	1.1b
	Solve for v and θ	M1	3.1b
	$v = 2.2u, \quad \theta = 42$ or better	A1	2.2a
		(6)	
(b)	Use of impact law	M1	3.4
	$v\cos\theta° + w\cos 45° = e\left(2u\cos 45° + 3u\cos 30°\right)$	A1	1.1b
	$e = 0.76$ or better	A1	2.2a
		(3)	
			(9 marks)

Notes:

(a)	B1	Motion of *A* perpendicular to the line of centres – no impulse, so component of velocity unchanged.
	B1	Motion of *B* perpendicular to the line of centres – no impulse, so component of velocity unchanged.
	M1	Use of CLM parallel to the line of centres. Need all terms. Dimensionally correct.
	A1	Correct unsimplified equation
	M1	Complete method to find v and θ, e.g. form and solve simultaneous equations for v and θ
	A1	Both values correct to 2 sf or better 2.22589… 42.367…
(b)	M1	Correct use of impact law. With *e* on the correct side, but condone sign errors.
	A1	Correct unsimplified equation
	A1	0.76235…

Question	Scheme	Marks	AOs
4(a)	GPE lost $= 75 \times g \times 6 \left(= 4410(\text{J})\right)$	B1	1.1b
	KE gain $= \frac{1}{2} \times 75\left(49 - 25\right) \cdots \left(= 900(\text{J})\right)$	B1	1.1b
	WD against resistance $= 800 \times 12 \left(= 9600(\text{J})\right)$	B1	1.1b
	Work energy equation: $\text{WD} = 9600 + 900 - 4410$	M1	3.1b
	= 6100 (J) or 6090 (J)	A1	1.1b
		(5)	
(b)	$140 = F \times 7$	B1	3.3
	$F - 12 = 75k$	M1	3.1b
	$k = \frac{8}{75} \left(= 0.11 \text{ or better}\right)$	A1	1.1b
		(3)	
			(8 marks)

Notes:

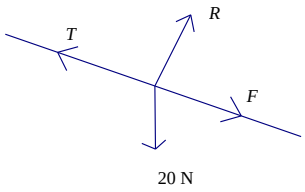
(a)	B1	Correct unsimplified expression
	B1	Correct unsimplified expression
	B1	Correct unsimplified expression
	M1	Complete method to find work done by cyclist. All terms needed. Terms must be dimensionally correct, but condone sign errors.
	A1	6100 (J) or 6090 (J) only
(b)	B1	Use of $P = Fv$
	M1	Equation of motion – all terms needed. Condone sign errors.
	A1	0.11 or better

Question	Scheme	Marks	AOs
5(a)	KE lost	M1	3.1b
	$= \frac{1}{2} \times \frac{3}{2}\left(64 - 5\lambda^2\right)\left(= 33\right)$	A1	1.1b
	$5\lambda^2 = 20 \Rightarrow \lambda = 2$	A1	1.1b
	Impulse = change in momentum	M1	3.4
	$= \frac{3}{2}\left(2\mathbf{i} + 4\mathbf{j} - 8\mathbf{i}\right) = -9\mathbf{i} + 6\mathbf{j}\left(\text{Ns}\right)$	A1	2.2a
		(5)	
(b)	(Unit) vector perpendicular to the wall $= \pm\left(\frac{1}{\sqrt{13}}\right)\left(-3\mathbf{i} + 2\mathbf{j}\right)$	B1ft	2.1
	Components of the velocities perpendicular to the wall.	M1	3.1b
	Before: $\frac{8 \times -3}{\left(\sqrt{13}\right)}$	A1ft	1.1b
	After: $\frac{2 \times -3 + 4 \times 2}{\left(\sqrt{13}\right)}$	A1ft	1.1b
	Impact law:	M1	3.4
	$2 = 24e, \quad e = \frac{1}{12}$	A1	2.2a
		(6)	
			(11 marks)

Notes:

5(a)	M1	Correct method for change in KE. Need both terms and dimensionally correct.
	A1	Correct expression for KE lost in terms of λ
	A1	Correct only
	M1	Complete method to find the impulse (Find **v** and use of $\mathbf{I} = m\mathbf{v} - m\mathbf{u}$)
	A1	Any equivalent simplified vector form
5(b)	B1ft	Follow their impulse. Vector perpendicular to the wall seen or implied.
	M1	Use of scalar product (or equivalent) to find components of velocities perpendicular to the wall. Condone without $\sqrt{13}$
	A1ft	Correct unsimplified. Follow their perpendicular. Accept $\pm$ Condone without $\sqrt{13}$
	A1ft	Correct unsimplified. Follow their perpendicular and their λ.

		Accept $\pm$ Condone without $\sqrt{13}$
	M1	Complete method to find the components of the velocities perpendicular to the wall and use the impact law. Law must be used correctly.
	A1	Correct only Condone without $\sqrt{13}$ in components.

Question	Scheme	Marks	AOs
6(a)			
	EPE at B: $\dfrac{\lambda x^2}{2a} = \dfrac{\lambda \times 4a^2}{2a} \left(= 2\lambda a\right)$	M1	1.2
	Work done against friction $B \to A$: $\dfrac{1}{4} \times 2g\cos\theta \times 3a \left(= 12a\right)$	M1	1.1b
	Gain in GPE $B \to A$: $2g\sin\theta \times 3a \left(= 36a\right)$	B1	1.1b
	Work-energy equation: $2\lambda a = 12a + 36a$	M1	2.1
	$\Rightarrow \lambda = 24$ *	A1*	2.2a
		(5)	
(b)	Tension in the string $= \dfrac{24 \times 2a}{a}$	M1	1.1b
	Motion of P:	M1	3.1a
	$48 - 20\sin\theta - \dfrac{1}{4} \times 20\cos\theta = 2 \times \text{accn} \quad \left(= 48 - 12 - 4\right)$	A1 A1	1.1b 1.1b
	$\text{acceleration} = 16\ \text{m s}^{-2}$	A1	1.1b
		(5)	
(c)	As the length of the string reduces, the tension reduces, so the net force reduces and acceleration reduces	B1	2.4
		(1)	
			(11 marks)

Notes:

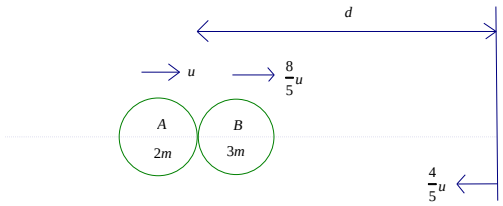
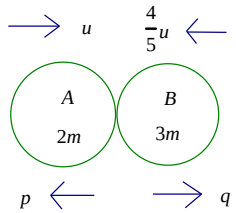
(a)	M1	Correct method to find EPE
	M1	Use of $F = \mu R$ to find work done against friction
	B1	Correct unsimplified expression for gain in GPE
	M1	All terms required. Must be dimensionally correct. Condone sin/cos confusion. Condone sign errors.
	A1*	Deduce given answer from correct working
		NB: If $g = 10$ not used then can score M1M1B1M1A0
(b)	M1	Use of $T = \dfrac{\lambda x}{a}$

	M1	Equation of motion of P. All terms required. Dimensionally consistent. Condone sin/cos confusion. Condone sign errors.
	A1 A1	Unsimplified equation with at most 1 error. Correct unsimplified equation
	A1	Correct answer.
(c)	B1	Or equivalent explanation

Question	Scheme	Marks	AOs
7(a)	Velocity after first impact $= 3\mathbf{i} + \mathbf{j}\left(\text{m s}^{-1}\right)$	B1 B1	3.1b 3.4
	CLM parallel to *BC*:	M1	3.1b
	$\left(\left(3\mathbf{i}+\mathbf{j}\right).\frac{1}{\sqrt{2}}\left(\mathbf{i}+\mathbf{j}\right)\right)\times\frac{1}{\sqrt{2}}\left(\mathbf{i}+\mathbf{j}\right) \quad \left(=2\left(\mathbf{i}+\mathbf{j}\right)\right)$	A1ft	1.1b
	Impact law perpendicular to *BC*:	M1	3.4
	$\frac{1}{4}\left(\left(3\mathbf{i}+\mathbf{j}\right).\frac{1}{\sqrt{2}}\left(\mathbf{i}-\mathbf{j}\right)\right)\times\frac{1}{\sqrt{2}}\left(-\mathbf{i}+\mathbf{j}\right) \quad \left(=\frac{1}{4}\left(-\mathbf{i}+\mathbf{j}\right)\right)$	A1ft A1ft	1.1b 1.1b
	$\Rightarrow \mathbf{v} = 2(\mathbf{i}+\mathbf{j})+\frac{1}{4}\left(-\mathbf{i}+\mathbf{j}\right)=\frac{7}{4}\mathbf{i}+\frac{9}{4}\mathbf{j}$	A1	2.2a
		(8)	
(b)	Find angle between $3\mathbf{i}-4\mathbf{j}$ and $\mathbf{v}$	M1	3.1a
	$=\cos^{-1}\left(\dfrac{3\times\frac{7}{4}-4\times\frac{9}{4}}{5\times\sqrt{\frac{130}{16}}}\right) \quad \left(=\cos^{-1}\dfrac{-3}{\sqrt{130}}\right)$ Or $\quad =\tan^{-1}\frac{4}{3}+\tan^{-1}\frac{9}{7}$	A1ft	1.1b
	$\theta = 105$ (nearest whole number)	A1	1.1b
		(3)	
			(11 marks)

Notes:

7(a)	B1 B1	One component correct Both components correct
	M1	Use CLM parallel to *BC* to find parallel component of velocity after impact
	A1ft	Correct unsimplified expression. Follow their $3\mathbf{i}+\mathbf{j}$
	M1	Use of impact law perpendicular to *BC* to find perpendicular component of velocity
	A1ft A1ft	Follow their $3\mathbf{i}+\mathbf{j}$. Unsimplified expression with at most one error. Follow their $3\mathbf{i}+\mathbf{j}$. Correct unsimplified expression.
	A1	Correct only. Any equivalent form.
7(b)	M1	Correct strategy to find the required angle
	A1ft	Correct unsimplified expression. Follow their $\mathbf{v}$
	A1	105 only.

Question	Scheme	Marks	AOs
8(a)			
	Speed of B after impact with wall $\frac{4}{5}u$	B1	3.4
	Use time of travel to form equation in x and d	M1	3.1a
	$\frac{d-x}{u}=\frac{d}{\frac{8}{5}u}+\frac{x}{\frac{4}{5}u}$ $\left(\frac{8}{5}(d-x)=d+2x\right)$	A1ft A1ft	1.1b 1.1b
	$\Rightarrow x=\frac{d}{6}$	A1	1.1b
		(5)	
(b)			
	Use of CLM:	M1	3.1a
	$2mu-\frac{12}{5}mu=-2mp+3mq$ $\left(=-\frac{2}{5}u\right)$	A1	1.1b
	Impact law:	M1	3.4
	$p+q=\frac{1}{3}\left(u+\frac{4}{5}u\right)$ $\left(=\frac{3}{5}u\right)$	A1	1.1b
	Complete method to find p and q	M1	3.1a
	$p=\frac{11}{25}u,\quad q=\frac{4}{25}u$	A1 A1	1.1b 1.1b
	Compare velocity of A after second collision of the balls with velocity of B after second collision with wall	M1	2.1
	e.g. A moving away from wall with speed $\frac{11}{25}u$, and B moving away from the wall with speed $\frac{2}{25}u$ $\frac{2}{25}u<\frac{11}{25}u$, so no third collision between A and B *	A1*	2.2a
		(9)	

		(14 marks)
Notes:		
8(a)	B1	Correct only
	M1	Correct method e.g. using $t = \frac{d}{v}$ to form equation in x and d
	A1ft	Follow their $\frac{4}{5}u$. Unsimplified equation with at most one error
	A1ft	Follow their $\frac{4}{5}u$. Correct unsimplified equation
	A1	Correct only
8(b)	M1	Use of CLM. All terms required and must be dimensionally consistent. Condone sign errors
	A1	Correct unsimplified equation
	M1	Use of impact law. Must have e on the correct side. Condone sign errors
	A1	Correct unsimplified equation. Signs consistent with equation for CLM.
	M1	Complete method to find the speeds of A and B after the second collision. E.g. form and solve simultaneous equations.
	A1	One value correct
	A1	Both values correct
	M1	Complete method to show the given result
	A1*	Complete argument to obtain given result from correct working. Need to comment on speeds and directions of motion.