Pearson Edexcel

Mark Scheme (Results)

Summer 2025

Pearson Edexcel GCE

Advanced Subsidiary Level

Further Mathematics (8FM0)

Paper 22 Further Pure Mathematics 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 $\sqrt{}$ 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
- $\ast$ 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.

Question	Scheme	Marks	AOs
1(i)(a)	$105 = 4\times 24+9$	M1	1.1b
	$24 = 2\times 9+6, \quad 9 = 1\times 6+3, \quad 6 = 2\times 3+0$	M1	1.1b
	$h = 3$	A1	2.2a
		(3)	
(i)(b)	$3 = 9-1\times 6$	M1	1.1b
	$= 9-1\times(24-2\times 9) = 3\times 9-1\times 24$ $= 3(105-4\times 24)-1\times 24$	M1	1.1b
	$= 3\times 105-13\times 24$ ($a = 3$, $b = -13$)	A1	1.1b
		(3)	
(ii)	$179 = 16\times 11+3$ $\Rightarrow 179 \equiv 3(\text{mod}\,11)$ $179^5 \equiv 3^5(\text{mod}\,11) \equiv 243(\text{mod}\,11)$ $243 = 22\times 11+1$	M1	1.1b
	$179^5 \equiv 1(\text{mod}\,11)$ so the remainder is 1	A1	2.2a
		(2)	
			(8 marks)

Notes

(i)(a)
M1: Starts the Euclidean algorithm to obtain $105 = p\times 24+q$
M1: Completes the algorithm correctly to obtain a zero remainder.
A1: All correct and concludes $h = 3$
(i)(b)
M1: Begins the progress of back substitution.
M1: Completes the process.
A1: Correct expression or correct values.
(ii)
M1: Attempts the remainder when 179 is divided by 11 and makes progress in establishing the remainder when 179^5 is divided by 11
A1: Obtains the remainder 1

Question	Scheme	Marks	AOs
2(i)	$1+3+3+6+6+1+7=27$	M1	1.1b
	The sum of the digits is 27 which is a multiple of 9 so 13 306 617 is divisible by 9	A1	1.1b
		(2)	
(ii)(a)	(table below)	M1 A1 A1	1.1b 1.1b 1.1b
		(3)	
(ii)(b)	3	B1	1.1b
		(1)	
(ii)(c)	4	B1	1.1b
		(1)	
(ii)(d)	{1, 3, 7, 9} or {1, 9, 13, 17} or {1, 9, 11, 19}	B1	1.1b
		(1)	
			(8 marks)

$\times_{20}$	1	3	7	9	11	13	17	19
1	1	3	7	9	11	13	17	19
3	3	9	1	7	13	19	11	17
7	7	1	9	3	17	11	19	13
9	9	7	3	1	19	17	13	11
11	11	13	17	19	1	3	7	9
13	13	19	11	17	3	9	1	7
17	17	11	19	13	7	1	9	3
19	19	17	13	11	9	7	3	1

Notes

(i)
M1: Applies the divisibility test by summing the digits.
A1: Correct solution and explanation.
(ii)(a)
M1: Makes a start with the table, achieving at least 7 correct entries.
A1: At least 18 correct entries.
A1: Completely correct table.
(ii)(b)
B1: Cao
(ii)(c)
B1: Cao
(ii)(d)
B1: any of the three correct subgroups.

Question	Scheme	Marks	AOs
3(a)	• The loan amount is £180 000 before any interest is added or payments made so $B_0 = 180$ as the units are 1000's • Interest is added at 0.15% so the monthly balance is multiplied by 100.15% = 1.0015 to give $1.0015\,B_{n-1}$ as the new balance • After the interest has been added, £900 is paid off which is 0.9 in thousands of pounds so $B_n = 1.0015B_{n-1} - 0.9$	B1 B1	2.4 3.3
		(2)	
(b)	E.g. The interest rate stays the same The monthly repayments stay the same	B1	3.5b
		(1)	
(c)	A complete method to solve the recurrence relation using $B_n = \text{CF} + \text{PS} = a(1.0015)^n + b$	M1	3.1a
	$\text{PS} = b \Rightarrow b = 1.0015b - 0.9$ leading to $b = ...$	M1	1.1b
	$b = 600$	A1	1.1b
	Uses $B_0 = 180$ and their value for b to find the value of a $180 = a(1.0015)^0 + 600$ $a = ...(-420)$	M1	1.1b
	$B_n = 600 - 420(1.0015)^n \quad (n \geqslant 0)$	A1	1.1b
		(5)	
(d)	Require $600 - 420(1.0015)^n = 0 \Rightarrow n = ...(237.96...)$	M1	3.1b
	So 19 years and 10 months	A1	1.1b
		(2)	
			(10 marks)

Notes

(a)
B1: For explaining 2 of the 3 aspects as above. Allow attempts that convey the right idea even if not precisely described.
B1: All 3 aspects explained with sufficient detail shown. Must see the 1.0015 explained, not just "the 1.0015 is the 0.15%" or such.
(b)
B1: See scheme for answers. Must refer to the model, do not accept answer about "rounding" values.
(c)
M1: A complete method to solve the recurrence relation using $B_n = \text{CF} + \text{PS} = a(1.0015)^n + b$
M1: Uses $\text{PS} = b \Rightarrow b = 1.0015b - 900$ to find a value for b
A1: $b = 600$
M1: Uses B_0 and their value for b to find a value for a
A1: Fully correctly defined sequence $B_n = 600 - 420(1.0015)^n \quad (n \geqslant 0)$
(d)
M1: Uses a correct strategy to identify the value for n. NB "impossible equations" score M0.
A1: Correct number of years and months.

Question	Scheme	Marks	AOs
4	$\lvert\mathbf{A}-\lambda\mathbf{I}\rvert=0\Rightarrow\begin{vmatrix}6-\lambda & -1\\ 2 & 3-\lambda\end{vmatrix}=0\Rightarrow(6-\lambda)(3-\lambda)+2=0$ $\Rightarrow\lambda^2-9\lambda+20=0\Rightarrow\lambda=...$	M1	3.1a
	$\lambda=5,\ 4$	A1	1.1b
	$\lambda=5\Rightarrow\begin{matrix}6x-y=5x\\ 2x+3y=5y\end{matrix}\Rightarrow x=...,y=...$ or $\lambda=4\Rightarrow\begin{matrix}6x-y=4x\\ 2x+3y=4y\end{matrix}\Rightarrow x=...,y=...$	M1	2.1
	$\lambda=5\to\begin{pmatrix}1\\1\end{pmatrix}$ or $\lambda=4\to\begin{pmatrix}1\\2\end{pmatrix}$	A1	1.1b
	$\lambda=5\to\begin{pmatrix}1\\1\end{pmatrix}$ and $\lambda=4\to\begin{pmatrix}1\\2\end{pmatrix}$	A1	1.1b
	$\mathbf{P}=\begin{pmatrix}1 & 1\\ 1 & 2\end{pmatrix}$ or $\mathbf{P}=\begin{pmatrix}1 & 1\\ 2 & 1\end{pmatrix}$	B1ft	1.1b
	$\mathbf{D}=\begin{pmatrix}5 & 0\\ 0 & 4\end{pmatrix}$ or $\mathbf{D}=\begin{pmatrix}4 & 0\\ 0 & 5\end{pmatrix}$	B1ft	2.2a
		(7)	
			(7 marks)

Notes

M1: Makes a start to the problem by finding the eigenvalues of **A**
A1: Correct eigenvalues
M1: Uses a correct method to find an eigenvector for any eigenvalue
A1: One correct eigenvector (allow any integer multiple)
A1: Both correct eigenvectors (allow any integer multiples)
B1ft: For a matrix **P** with their eigenvectors as columns
B1ft: For **D** as a matrix with their eigenvalues on the leading diagonal. Must be consistent with their **P** if **P** is attempted.

Note method must be shown for full marks. Answer that obtain eigenvectors from a calculator can score M1A1 (if method shown for eigenvalues) M0A0A0 B1ftB1ft max.

Question	Scheme	Marks	AOs
5(a)	$\dfrac{z+4}{z-2\mathrm{i}}=\dfrac{x+\mathrm{i}y+4}{x+\mathrm{i}y-2\mathrm{i}}=\dfrac{(x+\mathrm{i}y+4)(x-\mathrm{i}(y-2))}{(x+\mathrm{i}y-2\mathrm{i})(x-\mathrm{i}(y-2))}$	M1	3.1a
	$=\dfrac{x^2+y^2+4x-2y}{x^2+(y-2)^2}+\dfrac{2x-4y+8}{x^2+(y-2)^2}\mathrm{i}$	M1	1.1b
	$\arg\left(\dfrac{z+4}{z-2\mathrm{i}}\right)=\dfrac{\pi}{4}\Rightarrow x^2+y^2+4x-2y=2x-4y+8$	M1	2.2a
	$\Rightarrow x^2+y^2+2x+2y-8=0$	A1	2.1
		(4)	
(b)	$\Rightarrow x^2+y^2+2x+2y-8=0\Rightarrow r=...,$ centre $=...$	M1	1.1b
	$\lvert z\rvert_{\min}=\sqrt{10}-\sqrt{1^2+1^2}$	M1	3.1a
	$\sqrt{10}-\sqrt{2}$	A1	1.1b
		(3)	
		(7 marks)	

Notes

(a)

M1: Starts the problem by introducing $z = x + \mathrm{i}y$ into $\dfrac{z+4}{z-2\mathrm{i}}$ and multiplies numerator and denominator by the complex conjugate of the denominator

M1: Collects terms and establishes the real and imaginary parts

M1: Deduces from $\arg\left(\dfrac{z+4}{z-2\mathrm{i}}\right)=\dfrac{\pi}{4}$ that the real and imaginary parts are equal

A1: Correct equation

(b)

M1: Uses their equation from part (a) to establish the centre and radius of the circle

M1: Adopts the correct strategy for the minimum value using their centre and radius

A1: Correct exact value.

Question	Scheme	Marks	AOs
5(a) Alt	Angle subtended at centre $=\dfrac{\pi}{2}\Rightarrow r^2+r^2=(-4)^2+2^2\Rightarrow r=...\left(\sqrt{10}\right)$	M1	3.1a
	Midpoint $(-2,1)$, gradient $m=\dfrac{2}{4}\Rightarrow\perp$ bisector is $y-1=-2(x+2)$	M1	1.1b
	e.g. $10=(x-(-4))^2+(-2x-3)^2\Rightarrow x=...(-3,-1)\Rightarrow y=...(3,-1)$	M1	2.2a
	$\Rightarrow x^2+y^2+2x+2y-8=0$	A1	2.1
		(4)	

Notes

M1: Realises the angle subtended at the centre gives a right triangle and proceeded to find the radius (or its square).

M1: Attempts the perpendicular bisector of the two known points on the arc.

M1: Complete method to find the centre using their radius and bisector.

A1: Correct equation with justification as to which points were chosen for the centre.

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