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INTERNATIONAL A LEVEL MATHEMATICS • PURE 2

Pure Mathematics 2

Exam Questions by Topic: Mark Scheme

Pearson Edexcel International Advanced Level (WMA12/01) • Calculator allowed

Every question in the booklet, marked line by line the way an examiner marks it

Chapters (tap a chapter to jump to it)	Qs	Marks	Page	My score
1 Algebraic Methods Algebraic fractions, the factor and remainder theorems, proof	10	66	3	
2 Coordinate Geometry in the (x, y) Plane Equations of circles, tangents, chords and intersections	10	68	own PDF	
3 Exponentials and Logarithms Laws of logarithms, exponential equations, modelling	10	68	own PDF	
4 The Binomial Expansion Expanding $(a + bx)^n$, coefficients and approximations	10	65	own PDF	
5 Sequences and Series Arithmetic and geometric series, sigma notation, recurrence	10	69	own PDF	
6 Trigonometric Identities and Equations $\tan \theta = \frac{\sin \theta}{\cos \theta}$, $\sin^2 \theta + \cos^2 \theta = 1$, solving equations	10	66	own PDF	
7 Differentiation Increasing and decreasing functions, stationary points, optimisation	10	67	own PDF	
8 Integration Definite integrals, areas under curves, the trapezium rule	10	67	own PDF	

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How to use this mark scheme

The same marking rules Pearson examiners use for WMA12.

Mark every line, not just the answer. Method marks are given for a correct method even when the final answer is wrong. If you lost marks, find the *first* line where your working differs from the scheme. That is the thing to fix.

Code	Meaning
M1	Method mark: for knowing a correct method and attempting to apply it. Small slips in the working do not lose this mark.
dM1	Dependent method mark: can only be given if the method mark before it has been given.
A1	Accuracy mark: for a correct answer or line of working. It can only be given if the method mark it depends on has been given.
B1	Independent mark: for a correct result or statement, whatever method was used.
*	The answer is given in the question. Every step must be shown, and the answer must follow from correct working (cso).
cao	Correct answer only.
cso	Correct solution only: no errors anywhere in the working.
ft	Follow through: the mark can be given for correct work using your own earlier (wrong) answer.
oe	Or equivalent: any correct equivalent form is accepted.

“Solutions relying on calculator technology are not acceptable.” When a question says this, a correct final answer with no algebraic working scores **no marks**. The notes under each scheme line say when this applies.



1

Chapter 1: Algebraic Methods

Mark scheme. Marks are shown on the right of each line.

Question 1

5 marks

Part	Scheme	Marks
(a)	$f(3) = 27 + 9a + 3b + 6 = 0 \Rightarrow 3a + b = -11$	M1
	$f(-2) = -8 + 4a - 2b + 6 = 0 \Rightarrow 2a - b = 1$	M1
	Solves simultaneously: $5a = -10$	M1
	$a = -2, b = -5$	A1
		(4)
(b)	$(x-3)(x+2)(x-1)$	B1
	The third factor comes from the constant term: $-3 \times 2 \times c = 6$, so $c = -1$; or by division.	(1)
Total for Question 1: 5 marks		

Question 2

4 marks

Part	Scheme	Marks
	Attempts to divide: $2x^3 - 3x^2 - 11x + 7 = (x-3)(2x^2 + \dots) + \dots$	M1
	$2x^2 + 3x \dots$	A1
	Quotient $2x^2 + 3x - 2$	A1
	Remainder 1	B1
	The remainder may come from $f(3) = 54 - 27 - 33 + 7 = 1$ (remainder theorem).	(4)
Total for Question 2: 4 marks		



Question 3

5 marks

Part	Scheme	Marks
(a)	$f\left(-\frac{1}{2}\right) = 2\left(-\frac{1}{8}\right) + 3\left(\frac{1}{4}\right) - \frac{a}{2} - 6 = 0$ $\frac{1}{2} - \frac{a}{2} - 6 = 0$, so $a = -11$ * <i>Must set $f\left(-\frac{1}{2}\right)$ equal to 0. Using $f\left(\frac{1}{2}\right)$ scores M0.</i>	M1 A1* (2)
(b)	Divides by $(2x+1)$: $x^2 + x - 6$ $(2x+1)(x^2 + x - 6)$ $(2x+1)(x-2)(x+3)$ <i>The final answer must be the full product on one line.</i>	M1 A1 A1 (3)
Total for Question 3: 5 marks		

Question 4

4 marks

Part	Scheme	Marks
(a)	$f(2) = 16 - 4 + 2k + 4 = 10$ $k = -3$	M1 A1 (2)
(b)	$f\left(-\frac{1}{2}\right) = -\frac{1}{4} - \frac{1}{4} + \frac{3}{2} + 4$ 5	M1 A1 (2)
Total for Question 4: 4 marks		



Question 5

5 marks

Part	Scheme	Marks
(i)	Chooses a value that gives a composite number, e.g. $n = 10$: $100 + 10 + 11 = 121$ $121 = 11 \times 11$, which is not prime, so the statement is not true $n = 11$ ($143 = 11 \times 13$) also works. The conclusion must be stated.	M1 A1 (2)
(ii)	Tries all five values: $n = 1, 2, 3, 4, 5$ give 0, 6, 24, 60, 120 All correct and each shown to be a multiple of 6: $0 = 6 \times 0$, $6 = 6 \times 1$, $24 = 6 \times 4$, $60 = 6 \times 10$, $120 = 6 \times 20$ Conclusion: for all integers $1 \leq n \leq 5$, $n^3 - n$ is a multiple of 6 Checking only some of the cases scores M0.	M1 A1 A1 (3)
Total for Question 5: 5 marks		

Question 6

8 marks

Part	Scheme	Marks
(a)	-9	B1 (1)
(b)	$f\left(\frac{1}{2}\right) = \frac{3}{2}\left(\frac{1}{2} - \frac{1}{2} + k\right) - 9 = 0$ $\frac{3}{2}k = 9$, so $k = 6$ * "= 0" must be seen.	M1 A1* (2)
(c)	(i) Expands: $f(x) = 2x^3 + x^2 + 5x - 3$ Divides by $(2x - 1)$ or compares coefficients $f(x) = (2x - 1)(x^2 + x + 3)$	M1 M1 A1 (3)
	(ii) For $x^2 + x + 3$: $b^2 - 4ac = 1 - 12 = -11$ $-11 < 0$, so $x^2 + x + 3 = 0$ has no real roots and the only real root of $f(x) = 0$ is $x = \frac{1}{2}$ The discriminant must be of the quotient. A calculator giving complex roots with no statement scores M0 A0.	M1 A1 (2)
Total for Question 6: 8 marks		



Question 7

8 marks

Part	Scheme	Marks
(a)	$f(2) = 8 + 8 - 10 - 6$ $= 0$, so $(x - 2)$ is a factor *	M1 A1* (2)
(b)	$(x - 2)(x^2 + 4x + 3)$ $(x - 2)(x + 1)(x + 3)$	M1 A1 (2)
(c)	$(x - 2)(x + 1)(x + 3) = x + 3 \Rightarrow (x + 3)[(x - 2)(x + 1) - 1] = 0$ $(x + 3)(x^2 - x - 3) = 0$ Solves the quadratic: $x = \frac{1 \pm \sqrt{1 + 12}}{2}$ $x = -3, x = \frac{1 \pm \sqrt{13}}{2}$ <i>Dividing both sides by $(x + 3)$ loses the solution $x = -3$ and scores at most M1 A1 M1 A0.</i>	M1 A1 M1 A1 (4)
Total for Question 7: 8 marks		

Question 8

8 marks

Part	Scheme	Marks
(a)	Considers $x^3 + y^3 - xy(x + y) = x^3 - x^2y - xy^2 + y^3$ Factorises: $x^2(x - y) - y^2(x - y) = (x - y)(x^2 - y^2)$ $= (x + y)(x - y)^2$ $(x - y)^2 \geq 0$ and $x + y > 0$ as $x, y > 0$, so $(x + y)(x - y)^2 \geq 0$, hence $x^3 + y^3 \geq xy(x + y)$ <i>The final mark needs both reasons, $(x - y)^2 \geq 0$ and $x + y > 0$ because x and y are positive, and a conclusion.</i>	M1 M1 A1 A1* (4)
(b)	Chooses values with $x + y < 0$ and $x \neq y$, e.g. $x = -2, y = 1$ $x^3 + y^3 = -7$ and $xy(x + y) = 2$; $-7 < 2$, so the inequality is not true for all real x and y	M1 A1 (2)
(c)	Divides both sides of the result in (a) by x^2y^2 , which is positive, so the inequality is unchanged $\frac{x^3}{x^2y^2} + \frac{y^3}{x^2y^2} \geq \frac{xy(x + y)}{x^2y^2}$, giving $\frac{x}{y^2} + \frac{y}{x^2} \geq \frac{1}{x} + \frac{1}{y}$ *	M1 A1* (2)
Total for Question 8: 8 marks		



Question 9

9 marks

Part	Scheme	Marks
(a)	$f(3) = 27 - 27 - 12 + 12$ $= 0$, so $(x - 3)$ is a factor *	M1 A1* (2)
(b)	$(x - 3)(x^2 - 4)$ $(x - 3)(x - 2)(x + 2)$	M1 A1 (2)
(c)	Positive cubic shape Crosses the x -axis at $(-2, 0)$, $(2, 0)$ and $(3, 0)$ Crosses the y -axis at $(0, 12)$	B1 B1ft B1 (3)
(d)	Uses the sketch: $f(x) \geq 0$ between the first two roots and after the third $-2 \leq x \leq 2$ or $x \geq 3$	M1 A1 (2)
Total for Question 9: 9 marks		



Question 10

10 marks

Part	Scheme	Marks
(a)	$f(2) = 8 + 4p + 2q + 12 = 0$ $4p + 2q = -20$, so $2p + q = -10$ *	M1 A1* (2)
(b)	Writes $f(x) = (x-2)^2(x+c)$ and compares constant terms: $4c = 12$, so $c = 3$ $f(x) = (x^2 - 4x + 4)(x+3) = x^3 - x^2 - 8x + 12$ $p = -1$ $q = -8$ Alternative: the curve touches the axis at $x = 2$, so $f'(2) = 12 + 4p + q = 0$; solve with $2p + q = -10$.	M1 M1 A1 A1 (4)
(c)	$(x-2)^2(x+3)$	B1 (1)
(d)	$f(k) = 12$: $k^3 - k^2 - 8k + 12 = 12 \Rightarrow k(k^2 - k - 8) = 0$ $k \neq 0$, so $k^2 - k - 8 = 0$ and $k = \frac{1 \pm \sqrt{1+32}}{2}$ $k = \frac{1 \pm \sqrt{33}}{2}$	M1 M1 A1 (3)
Total for Question 10: 10 marks		

