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INTERNATIONAL A LEVEL MATHEMATICS • PURE 4

Pure Mathematics 4

Exam Questions by Topic: Mark Scheme

Pearson Edexcel International Advanced Level (WMA14/01) • 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 Proof Proof by contradiction: irrational numbers, primes, integers, inequalities	10	73	own PDF	
2 Partial Fractions Linear and repeated factors, improper fractions	10	78	own PDF	
3 Coordinate Geometry in the (x, y) Plane Parametric equations and conversion to Cartesian form	10	76	own PDF	
4 Binomial Expansion $(a + bx)^n$ for rational n , validity, using partial fractions	10	81	own PDF	
5 Differentiation Parametric and implicit differentiation, rates of change	10	81	own PDF	
6 Integration Volumes of revolution, substitution, parts, partial fractions, differential equations	10	86	own PDF	
7 Vectors 3D vectors, vector equations of lines, intersections, scalar product	10	82	3	

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Page 1 of 10

How to use this mark scheme

The same marking rules Pearson examiners use for WMA14.

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.

Marking a proof. A proof by contradiction earns its final mark only when it has all three parts: a clear assumption at the start (“Assume there is ...”), correct deductions in the right order, and a statement of the contradiction with a conclusion. A sketch or calculator values are not a proof.



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7

Chapter 7: Vectors

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

Question 1

6 marks

Part	Scheme	Marks
(a)	Subtracts: $\vec{QP} = \mathbf{p} - \mathbf{q}$ and $\vec{QR} = \mathbf{r} - \mathbf{q}$ $\vec{QP} = -2\mathbf{i} - 2\mathbf{j} - \mathbf{k}$, $\vec{QR} = 2\mathbf{i} + \mathbf{j} + 2\mathbf{k}$ Oct 2022 report: subtracting the wrong way round gives $\vec{PQ}$ and scores only the method mark.	M1 A1 (2)
(b)	$\vec{QP} \cdot \vec{QR} = -4 - 2 - 2 = -8$ $\cos PQR = \frac{-8}{3 \times 3} = -\frac{8}{9}$ 152.7° Using $\vec{PQ}$ with $\vec{QR}$ gives 27.3°: M1 dM1 A0. The vectors must both point out of Q.	M1 dM1 A1 (3)
(c)	Angle PQR: it is obtuse, and a triangle can have only one obtuse angle (the other two add up to 27.3°)	B1 (1)
Total for Question 1: 6 marks		

Question 2

5 marks

Part	Scheme	Marks
(a)	Direction $\vec{AB} = 2\mathbf{i} + 4\mathbf{j} - 4\mathbf{k}$ (or any multiple, e.g. $\mathbf{i} + 2\mathbf{j} - 2\mathbf{k}$) $\mathbf{r} = (2\mathbf{i} - \mathbf{j} + 3\mathbf{k}) + \lambda(\mathbf{i} + 2\mathbf{j} - 2\mathbf{k})$ The "r =" is required for the A mark (Oct 2024 report). Any point on the line and any multiple of the direction are accepted.	M1 A1 (2)
(b)	j components: $-1 + 2\lambda = 9$, so $\lambda = 5$ $p = 7, q = -7$	M1 A1 (2)
(c)	$\frac{1}{3}\mathbf{i} + \frac{2}{3}\mathbf{j} - \frac{2}{3}\mathbf{k}$ (or its negative)	B1 (1)
Total for Question 2: 5 marks		



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Question 3

6 marks

Part	Scheme	Marks
(a)	Equates components: $1 + 2\lambda = 3 - \mu$, $1 - \lambda = q + 2\mu$, $2 + \lambda = 8 + 2\mu$ Solves the i and k equations $\lambda = 2$, $\mu = -2$ j: $1 - 2 = q - 4$, so $q = 3$ <i>The j equation contains q, so it cannot be one of the pair used first.</i>	M1 M1 A1 A1 (4)
(b)	Substitutes $\lambda = 2$ into l_1 (or $\mu = -2$ into l_2) $(5, -1, 4)$	M1 A1 (2)
Total for Question 3: 6 marks		

Question 4

5 marks

Part	Scheme	Marks
	$\begin{pmatrix} 1 \\ -1 \\ 2 \end{pmatrix} \neq k \begin{pmatrix} 1 \\ 2 \\ 1 \end{pmatrix}$ for any k, so the lines are not parallel Equates two components and solves: $1 + \lambda = 3 + \mu$, $2 - \lambda = 3 + 2\mu$ $\lambda = 1$, $\mu = -1$ Checks the third: $3 + 2\lambda = 5$ but $1 + \mu = 0$ $5 \neq 0$, so the lines do not intersect; they are not parallel, so they are skew * <i>Oct 2022 scheme: the final mark needs both "do not intersect" and "not parallel" with a reason. Stating "skew" straight after finding conflicting values is not enough.</i>	B1 M1 A1 M1 A1* (5)
Total for Question 4: 5 marks		



Question 5

6 marks

Part	Scheme	Marks
(a)	$\vec{OP} = \begin{pmatrix} -4+2\lambda \\ 2+\lambda \\ 6-2\lambda \end{pmatrix} \text{ and } OP^2 = (-4+2\lambda)^2 + (2+\lambda)^2 + (6-2\lambda)^2$ $= 9\lambda^2 - 36\lambda + 56 \quad *$	M1 A1* (2)
(b)	$9(\lambda - 2)^2 + 20$ Least when $\lambda = 2$ $(0, 4, 2)$ Shortest distance $\sqrt{20} = 2\sqrt{5}$ <i>Check: $(0, 4, 2) \cdot (2, 1, -2) = 0$, so OP is perpendicular to l. Differentiating OP^2 and setting it to 0 is equally valid (Jan 2026 scheme).</i>	M1 A1 A1 A1 (4)
Total for Question 5: 6 marks		



Question 6

10 marks

Part	Scheme	Marks
(a)	$\vec{OD} = \vec{OA} + \vec{BC}$ (or $\mathbf{a} + \mathbf{c} - \mathbf{b}$) $D(2, 4, 3)$	M1 A1 (2)
(b)	$\vec{BA} = \begin{pmatrix} -2 \\ 1 \\ -2 \end{pmatrix}, \vec{BC} = \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}$ and $\vec{BA} \cdot \vec{BC} = -6$ $ \vec{BA} = 3, \vec{BC} = \sqrt{14}: \cos \angle ABC = \frac{-6}{3\sqrt{14}}$ $= -\frac{2}{\sqrt{14}} = -\frac{\sqrt{14}}{7} *$	M1 dM1 A1* (3)
(c)	$\sin \angle ABC = \sqrt{1 - \frac{14}{49}} = \sqrt{\frac{5}{7}}$ Area = $ \vec{BA} \vec{BC} \sin \angle ABC = 3\sqrt{14} \times \sqrt{\frac{5}{7}}$ $3\sqrt{10}$ <i>Using a decimal angle loses the A mark: the answer must be exact (Oct 2025 scheme).</i>	M1 M1 A1 (3)
(d)	Area = base $BC \times$ height: $\frac{3\sqrt{10}}{\sqrt{14}}$ $\frac{3\sqrt{35}}{7}$	M1 A1 (2)
Total for Question 6: 10 marks		



Question 7

10 marks

Part	Scheme	Marks
(a)	Direction $4\mathbf{i} + 2\mathbf{j} - 2\mathbf{k}$ (or $2\mathbf{i} + \mathbf{j} - \mathbf{k}$) $\mathbf{r} = (\mathbf{i} + 2\mathbf{k}) + \lambda(2\mathbf{i} + \mathbf{j} - \mathbf{k})$	M1 A1 (2)
(b)	$\vec{PX} = \begin{pmatrix} -2 + 2\lambda \\ -7 + \lambda \\ -5 - \lambda \end{pmatrix}$ $\vec{PX} \cdot \begin{pmatrix} 2 \\ 1 \\ -1 \end{pmatrix} = 0$ $6\lambda - 6 = 0, \text{ so } \lambda = 1$ $X(3, 1, 1)$ <i>June 2023 report: using $\vec{OX} \cdot \mathbf{d} = 0$ instead of $\vec{PX} \cdot \mathbf{d} = 0$ scores M1 only.</i>	M1 dM1 A1 A1 (4)
(c)	X is the midpoint of PP' : $\mathbf{p}' = 2\mathbf{x} - \mathbf{p}$ $P'(3, -5, -5)$	M1 A1 (2)
(d)	$PP' = 2PX = 12\sqrt{2}$ and $AX = \sqrt{6}$ is the perpendicular height; area = $\frac{1}{2} \times 12\sqrt{2} \times \sqrt{6}$ $12\sqrt{3}$	M1 A1 (2)
Total for Question 7: 10 marks		



Question 8

11 marks

Part	Scheme	Marks
(a)	Equates two components, e.g. $\lambda = -2 - 2\mu$ and $-3 + 2\lambda = 3 + \mu$ $\lambda = 2, \mu = -2$ $P(1, 2, 3)$	M1 A1 A1 (3)
(b)	$\begin{pmatrix} 2 \\ 1 \\ 2 \end{pmatrix} \cdot \begin{pmatrix} 1 \\ -2 \\ 2 \end{pmatrix} = 2 - 2 + 4 = 4$ Both direction vectors have magnitude 3: $\cos \theta = \frac{4}{3 \times 3}$ $\cos \theta = \frac{4}{9}^*$	M1 M1 A1* (3)
(c)	$Q(7, 5, 9)$ and $PQ = 3\mathbf{d}_1 = 9$ $PR = \mu + 2 \times 3 = 9$, so $\mu = 1$ or $\mu = -5$ $R(4, -4, 9)$ or $R(-2, 8, -3)$ <i>Finding only one position (one side of P) is the common error: a distance along a line gives two points.</i>	B1 M1 A1 (3)
(d)	$\sin \theta = \frac{\sqrt{65}}{9}$; area = $\frac{1}{2} \times 9 \times 9 \times \frac{\sqrt{65}}{9} = \frac{9\sqrt{65}}{2}$ The angle at P is θ for one position and $180^\circ - \theta$ for the other, and $\sin(180^\circ - \theta) = \sin \theta$	M1 A1 (2)
Total for Question 8: 11 marks		



Question 9

12 marks

Part	Scheme	Marks
(a)	$\vec{OF} = 6\mathbf{i} + 4\mathbf{j} + 3\mathbf{k}$ $\vec{AG} = -6\mathbf{i} + 4\mathbf{j} + 3\mathbf{k}$	B1 B1 (2)
(b)	$\vec{OF} \cdot \vec{AG} = -36 + 16 + 9 = -11$ $\cos \theta = \frac{-11}{\sqrt{61}\sqrt{61}} = -\frac{11}{61}$ Acute angle 79.6° <i>100.4° is the obtuse angle: A0 unless 79.6° is then given (Oct 2024 report).</i>	M1 dM1 A1 (3)
(c)	$\mathbf{r} = t(6\mathbf{i} + 4\mathbf{j} + 3\mathbf{k})$ and $\mathbf{r} = 6\mathbf{i} + s(-6\mathbf{i} + 4\mathbf{j} + 3\mathbf{k})$; equates two components $4t = 4s$ and $6t = 6 - 6s$: $t = s = \frac{1}{2}$, and the $\mathbf{k}$ components agree ($1.5 = 1.5$), so they intersect $(3, 2, 1.5)$	M1 A1 A1 (3)
(d)	$\vec{OA} \cdot \vec{OG} = (6\mathbf{i}) \cdot (4\mathbf{j} + 3\mathbf{k}) = 0$, so angle $AOG = 90^\circ$ Area = $\frac{1}{2} \times 6 \times 5 = 15$	B1 B1 (2)
(e)	$\frac{1}{2} \times AG \times h = 15$ with $AG = \sqrt{61}$ $h = \frac{30}{\sqrt{61}} = \frac{30}{61}\sqrt{61}$	M1 A1 (2)
Total for Question 9: 12 marks		



Question 10

11 marks

Part	Scheme	Marks
(a)	Every point of l has z coordinate 2, but A and B both have $z = 3$	B1 (1)
(b)	$C(\lambda, 1 + \lambda, 2): \vec{CA} = \begin{pmatrix} 5 - \lambda \\ -\lambda \\ 1 \end{pmatrix}, \vec{CB} = \begin{pmatrix} 1 - \lambda \\ 2 - \lambda \\ 1 \end{pmatrix}$ Sets $\vec{CA} \cdot \vec{CB} = 0$ $(5 - \lambda)(1 - \lambda) - \lambda(2 - \lambda) + 1 = 0$ $2\lambda^2 - 8\lambda + 6 = 0$, so $\lambda^2 - 4\lambda + 3 = 0$ *	M1 dM1 A1 A1* (4)
(c)	$(\lambda - 1)(\lambda - 3) = 0$ $C(1, 2, 2)$ or $C(3, 4, 2)$	M1 A1 (2)
(d)	The angle in a semicircle is 90° , so C lies on the sphere with diameter AB A line meets a sphere in at most two points (the condition is a quadratic in λ), so there are at most two such points	B1 B1 (2)
(e)	$\lambda = 1: CA = \sqrt{18} = 3\sqrt{2}$ and $CB = \sqrt{2}$; area = $\frac{1}{2} \times 3\sqrt{2} \times \sqrt{2}$ 3	M1 A1 (2)
Total for Question 10: 11 marks		

