

MARK SCHEME for the October/November 2012 series

9709 MATHEMATICS

9709/11

Paper 1, maximum raw mark 75

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Mark Scheme Notes

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M Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated method mark is earned (or implied).

B Mark for a correct result or statement independent of method marks.

- When a part of a question has two or more “method” steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly when there are several B marks allocated. The notation DM or DB (or dep*) is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.
- The symbol $\checkmark$ implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only. A and B marks are not given for fortuitously “correct” answers or results obtained from incorrect working.
- Note: B2 or A2 means that the candidate can earn 2 or 0.
B2/1/0 means that the candidate can earn anything from 0 to 2.

The marks indicated in the scheme may not be subdivided. If there is genuine doubt whether a candidate has earned a mark, allow the candidate the benefit of the doubt. Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored.

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AEF	Any Equivalent Form (of answer is equally acceptable)
AG	Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
BOD	Benefit of Doubt (allowed when the validity of a solution may not be absolutely clear)
CAO	Correct Answer Only (emphasising that no “follow through” from a previous error is allowed)
CWO	Correct Working Only – often written by a ‘fortuitous’ answer
ISW	Ignore Subsequent Working
MR	Misread
PA	Premature Approximation (resulting in basically correct work that is insufficiently accurate)
SOS	See Other Solution (the candidate makes a better attempt at the same question)
SR	Special Ruling (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)

Penalties

MR –1	A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become “follow through $\sqrt{}$ ” marks. MR is not applied when the candidate misreads his own figures – this is regarded as an error in accuracy. An MR –2 penalty may be applied in particular cases if agreed at the coordination meeting.
PA –1	This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

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1	$\frac{n}{2}[122 + (n-1)(-4)]$ $n = \frac{n}{2}[122 + (n-1)(-4)]$ $2n(n-31) = 0$ $n = 31$	M1 A1 DM1 A1 [4]	Attempt sum formula with $a = 61, d = -4$ Equated to n cao Attempt to solve. Accept div. by n cao
2	$y = \frac{4}{x^2} - x \quad (+c)$ Sub (2, 4) $\rightarrow c = 5$	M1A1 DM1A1 [4]	Attempt integration. cao Dependent on c present
3	$A = \pi r^2 \rightarrow \left(\frac{dA}{dr}\right) = 2\pi r$ $\frac{dA}{dt} = \frac{dA}{dr} \times \frac{dr}{dt}$ used $\frac{dr}{dt} = 3$ soi 300π (or 942)	B1 M1 B1 A1 [4]	
4	(i) $(2x - x^2)^6 = 64x^6 - 192x^7 + 240x^8$ (ii) $\times (2 + x)$ coeff of $x^8 = 2 \times 240 - 192$ 288	B1B1B1 [3] M1 A1 [^] [2]	cao Looks at exactly 2 terms
5	$\frac{dy}{dx} = 2 - 2(x-1)^{-3}$ Sub $x = 2 \rightarrow \frac{dy}{dx} = 2 - 2 = 0 \Rightarrow$ stat value at $x = 2$ $\frac{d^2y}{dx^2} = 6(x-1)^{-4}$ (and sub $x = 2$) (At $x = 2, \frac{d^2y}{dx^2} = 6$) $> 0 \Rightarrow$ Minimum	B2,1,0 B1 M1 A1 [5]	-1 each error in 2, -2, $(x-1)^{-3}$ AG Reasonable attempt to diff form $(x-1)^{-n}$ Correct $\frac{d^2y}{dx^2}$ and 'minimum' is required Or other valid method for last 2 marks
6	(i) $AC = r - r \cos \theta$ (ii) $\text{arc } AB = \frac{4\pi}{3}$ $\text{arc } AD = \frac{\pi}{2} \times \text{their } AC = \frac{\pi}{2} \times (4 - 4 \cos \frac{\pi}{3}) = \pi$ $BD = 4 \sin \frac{\pi}{3} - \text{their } AC = 2\sqrt{3} - 2$ Perimeter $= \frac{7\pi}{3} + 2\sqrt{3} - 2$	B1 [1] B1 M1A1 M1A1 A1 [6]	Allow $\pi \times \text{their } AC$ for M1. Allow 3.14 Allow 1.46 cao Accept $\sqrt{12}$
7	(i) $2(1 - \sin^2 \theta) = 3 \sin \theta$ $(2 \sin \theta - 1)(\sin \theta + 2) = 0$ $\theta = 30^\circ$ or 150° (ii) $n = \frac{\text{their } 30}{10} = 3$ $(\text{their } 3)\theta = 720 + \text{their } 150 = 870$ $\theta = 290^\circ$	M1 M1 A1A1 [4] B1 [^] M1 A1 [3]	Use $c^2 + s^2 = 1$ Attempt to solve cao ft provided n is an integer Allow full list up to at least 870 cao

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8 (i) $y^2 = 3y \Rightarrow y(y - 3) = 0 \Rightarrow y = 3$ (or 0) $x = \frac{1}{2}$ or 5 ($\Rightarrow a = 5$) AG (ii) $\left[\frac{(2x-1)^2}{\frac{3}{2}} \right] [\div 2], \quad \left[\frac{2}{3} \times \frac{x^2}{2} - \frac{x}{3} \right]$ $\left[\frac{27}{3} - 0 \right], \quad \left[\frac{25}{3} - \frac{5}{3} - \left(\frac{1}{12} - \frac{1}{6} \right) \right]$ Subtract areas at some stage $\frac{9}{4}$ oe	M1 A1 [2] B1B1B1 M1 M1 A1 [6]	OR form equation in x and attempt solution OR sub $x=5$ each eq (M1) $\rightarrow y = 3$(twice) (A1) (5,3) subst only once scores 0/2 Or $\Delta = \frac{1}{2}(5 - \frac{1}{2}) \times 3$ Apply limits $\frac{1}{2}$ and 5 for, at least, curve Dependent on some integration cao $\frac{9}{4}$ with no working scores 0/6, but $9 - 27/4 = 9/4$ scores 1/6 (M1 subtraction)
9 (i) $\overrightarrow{CD} = -3 \begin{pmatrix} 2 \\ 1 \\ 2 \end{pmatrix} + 2 \begin{pmatrix} 4 \\ 0 \\ 6 \end{pmatrix} = \begin{pmatrix} 2 \\ -3 \\ 6 \end{pmatrix}$ Unit vector $= \frac{1}{7} \begin{pmatrix} 2 \\ -3 \\ 6 \end{pmatrix}$ (ii) $\overrightarrow{OE} = \begin{pmatrix} 6 \\ 3 \\ 6 \end{pmatrix} + \begin{pmatrix} 1 \\ -1\frac{1}{2} \\ 3 \end{pmatrix} = \begin{pmatrix} 7 \\ 1\frac{1}{2} \\ 9 \end{pmatrix}$ $\overrightarrow{OE} \cdot \overrightarrow{OD} = 56 + 0 + 108 = 164$ $\overrightarrow{OE} = \sqrt{132.25} (= 11.5); \quad \overrightarrow{OD} = \sqrt{208}$ $164 = \sqrt{132.25} \times \sqrt{208} \times \cos \theta$ $\theta = 8.6^\circ$ cao	B1 M1A1 [3] M1A1 M1 M1 M1 A1 [6]	Allow M1A1 for $\frac{1}{7} \begin{pmatrix} -2 \\ 3 \\ -6 \end{pmatrix}$ or $(\frac{2}{7} \frac{-3}{7} \frac{6}{7})$ etc or equivalent method Use of $x_1x_2 + y_1y_2 + z_1z_2$ Correct method for moduli All connected correctly. Dependent on $\overrightarrow{OE}, \overrightarrow{EO}, \overrightarrow{OD}, \overrightarrow{DO}$ used
10 (i) $4(x - 3)^2 - 25$ Vertex is (3, -25) (ii) range is $(g(x)) \geq -9$ Allow $>$ (iii) $(x - 3)^2 = \frac{1}{4}(y + 25)$ $x - 3 = (\pm) \frac{1}{2} \sqrt{y + 25}$ $g^{-1}(x) = 3 - \frac{1}{2} \sqrt{x + 25}$ Domain is $x \geq -9$	B1B1B1 B1$\wedge$ [4] B1B1 [2] M1 DM1 A1 B1$\wedge$ [4]	Or $a = 4, b = 3, c = -25$ fit to <i>their</i> (b, c). Accept if not ‘hence’ B1 for $\geq$, B1 for -9 Accept e.g. $[-9, \infty]$ Attempt to square root both sides cao fit from <i>their</i> (ii)

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11 (i) $\frac{dy}{dx} = [6] \times [\frac{1}{3}(6x + 2)^{-\frac{2}{3}}]$ Equation of tangent is $y - 2 = m(x - 1)$ Equation of normal is $y - 2 = -\frac{1}{m}(x - 1)$ Both eqns correct with $m = \frac{1}{2}$ cao (ii) $B = (0, 1\frac{1}{2}); C = (2, 0)$ $BC = \sqrt{2^2 + (1\frac{1}{2})^2} = 2\frac{1}{2}$ (iii) $BC: y - 1\frac{1}{2} = -\frac{3}{4}(x - 0)$ or $y = -\frac{3}{4}(x - 2)$ Intersection (E): $-\frac{3}{4}x + 1\frac{1}{2} = 2x$ $x = \frac{6}{11}; y = \frac{12}{11}$ Mid-point of $OA = (\frac{1}{2}, 1) \rightarrow E$ not mid-point	B1B1 M1 M1 A1 [5] B1 M1A1^ [3] M1 M1 A1 B1 [4]	Independent Where $m = \text{numerical } \frac{dy}{dx}$ Including use of $m_1 m_2 = -1$ SC 1/3 Blatant tangent/normal reversal Both cao fit from <i>their</i> B and C or $y = -\frac{3}{4}x + 1\frac{1}{2}$ cao Dependent on correct x values or y values for both E and the mid-point of OA
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1	$\left(x^2 - \frac{a}{x}\right)^7$ Term in x^5 is ${}^7C_3 \times (x^2)^4 \times (-a/x)^3$ This term isolated Equated to $-280 \rightarrow a = 2$.	B1 M1 A1 [3]	Allow on own or in an expansion. Correct term in x^5 selected. Equated to -280
2	(i) $f(x) = \sqrt{\frac{x+3}{2}} + 1$, for $x \geq -3$ Make x the subject or interchanges x, y $\rightarrow 2(x-1)^2 - 3$ $\rightarrow 2x^2 - 4x - 1$ (ii) domain of f^{-1} is ≥ 1.	M1 M1 A1 [3] B1 [1]	Attempt at x as subject and removes $+1$ Squares both sides and deals with $" +3 "$ and $" \div 2 "$. co co. condone >1
3	(i) $A = 2400 - 20(60 - 2x) - x(40 - x) - 30x$ $\rightarrow A = x^2 - 30x + 1200$. (could be trapezium – triangle) (ii) $\frac{dA}{dx} = 2x - 30$ or $(x - 15)^2 + 975$ $= 0$ when $x = 15$ or Min at $x = 15$ $\rightarrow A = 975$.	M1 A1 [2] B1 M1 A1 [3]	Needs attempts at all areas co answer given co - either method okay Sets differential to 0 + solution. co co.
4	$y = \frac{x}{k} + k \quad 4y = x^2$ (i) $\frac{x^2}{4} = \frac{x}{k} + k \rightarrow kx^2 - 4x - 4k^2 = 0$ Uses $b^2 - 4ac \rightarrow k = -1$ (calculus $\frac{1}{k} = \frac{2x}{4}$ B1 $\rightarrow x = \frac{2}{k}, y = \frac{1}{k^2}$ M1 $\rightarrow k = -1$ A1) (ii) $y = -x - 1, 4y = x^2$ $\rightarrow x^2 + 4x + 4 = 0$ $\rightarrow P(-2, 1)$	M1 M1 A1 [3] M1 M1 A1 [3]	Eliminates x or y completely. Uses $b^2 - 4ac$ for a quadratic $= 0$ co nb a, b, c must not be $f(x)$ Elimination of x or y Soln of eqn. co.

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5	$A(1, 3), B(5, 11), X(4, 4)$ (i) Gradient of $AB = 2$ Gradient of $BC = -\frac{1}{2}$ $\rightarrow$ Eqn of BC is $y - 11 = -\frac{1}{2}(x - 5)$ (ii) gradient of AC (or AX) is $\frac{1}{3}$ $\rightarrow$ eqn of AC is $y - 3 = \frac{1}{3}(x - 1)$ or $y - 4 = \frac{1}{3}(x - 4)$ Sim equations $\rightarrow C(13, 7)$	B1 M1 A1 [3] B1 M1 A1 [3]	co For use of $m_1 m_2 = -1$ co – unsimplified is fine co Correct form of line equation + sim eqns co answer only -0/3- assumed $AB = BC$. Uses graph or table and gets exactly (13, 7) allow the 3 marks for (ii).
6	$2 \cos x = 3 \tan x$ (i) Replaces $\tan x$ by $\sin x \div \cos x$ $\rightarrow 2c^2 = 3s \rightarrow 2s^2 + 3s - 2 = 0$ (ii) Soln of quadratic $\rightarrow y = 15^\circ$ $2y$ can also be $180 - 30$ $\rightarrow y = 75^\circ$.	M1 M1 A1 [3] M1 A1 DM1 A1 $\sqrt{}$ [4]	Uses $t = s \div c$ Uses $s^2 + c^2 = 1$. Correct eqn . Method for quadratic = 0 and $\div 2$ co Works with $2y$ first before $\div 2$ for $90^\circ - 1^{\text{st}}$ answer. (loses $\sqrt{}$ mark if extra soln in range)
7	$\vec{OA} = \begin{pmatrix} 1 \\ 0 \\ 2 \end{pmatrix} \quad \vec{OB} = \begin{pmatrix} k \\ -k \\ 2k \end{pmatrix}$ (i) $\begin{pmatrix} 1 \\ 0 \\ 2 \end{pmatrix} \cdot \begin{pmatrix} 2 \\ -2 \\ 4 \end{pmatrix} = 10$ $= \sqrt{5} \times \sqrt{24} \cos \theta$ $\rightarrow \theta = 24.1^\circ$ (ii) $\vec{AB} = \begin{pmatrix} k-1 \\ -k \\ 2k-2 \end{pmatrix}$ allow each cpt $\pm$ $(k-1)^2 + k^2 + (2k-2)^2$ $\rightarrow 6k^2 - 10k + 4 = 0$ $\rightarrow k = 1 \text{ or } \frac{2}{3}$	M1 M1 M1 A1 [4] M1 M1 A1 A1 [4]	Use of $x_1 x_2 + y_1 y_2 + z_1 z_2$ Product of 2 moduli All connected correctly. co Correct for either AB or BA. Sum of 3 squares (doesn't need =1) Correct quadratic co

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8	(a) (i) $ar = 24$, $ar^3 = 13\frac{1}{2}$ Eliminates a (or r) $\rightarrow r = \frac{3}{4}$ $\rightarrow a = 32$ (ii) sum to infinity $= 32 \div \frac{1}{4} = 128$ (b) $a = 3$, $d = 2$ $\frac{n}{2}(6 + (n-1)2) (= 360)$ $\rightarrow 2n^2 + 4n - 720 = 0$ $\rightarrow n = 18$	B1 M1 A1 [3] M1A1$\sqrt{\frac{1}{2}}$ [2] B1 M1 A1 A1 [4]	Both needed Method of Solution. co Correct formula used. $\sqrt{\frac{1}{2}}$ on value of r Correct value for d Correct S_n used. no need for 360 here. Correct quadratic co
9	$y = \frac{9}{2x+3}$ A (3, 1) B (0, 3) (i) $\frac{dy}{dx} = \frac{-9}{(2x+3)^2} \times 2$ $\rightarrow m = -\frac{2}{9}$ $\rightarrow y - 1 = -\frac{2}{9}(x - 3)$ (ii) Meets the y-axis when $x = 0$, $y = 1\frac{2}{3}$ This is nearer to B than to O. (iii) Integral of $\frac{81}{(2x+3)^2} = \frac{-81}{2x+3} \div 2$ Uses limits 0 to 3 $\rightarrow \frac{-9}{2} - \frac{-81}{6} = 9\pi$	B1 B1 M1 A1$\sqrt{\frac{1}{2}}$ [4] B1 [1] B1 B1 M1 A1 [4]	Correct without the $\times 2$. For $\times 2$, independent of first part. Correct form of tan - numerical dy/dx For his m following use of dy/dx. (normal $\rightarrow$ max 2/4, no calculus 0/4) Sets x to 0 in his tangent. The $1\frac{2}{3}$ and part (i) must be correct. Correct without the $\div 2$. For $\div 2$, Use of limits with integral of y^2 only no π - max $\frac{3}{4}$. Use of area - 0/4,

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10	$\frac{dy}{dx} = x + \frac{4}{x^2}$ and $P(4, 8)$ (i) $y = \frac{x^2}{2} - \frac{4}{x} + (c)$ Uses $(4, 8) \rightarrow c = 1$ (ii) $\frac{d^2y}{dx^2} = 1 - \frac{8}{x^3}$ $= 0$ when $x = 2$ $\rightarrow$ gradient of 3 $d/dx(1 - \frac{8}{x^3}) = \frac{24}{x^4} \rightarrow +ve \rightarrow \text{Min.}$	B1 B1 M1 A1 [4] B1 B1 B1 B1 [4]	co.co (ignore +c at this stage) Uses the point after integration for c Co Sets to 0 + solution or verifies and states a conclusion (stationary or min) Allow for $x = 2$ into dy/dx . Any valid method - 3rd differential +ve 2nd diff goes $-0+$, or 1st goes $>3, 3, >3$
11	(i) $OQ = x + OC = 20$ $\sin 0.6 = \frac{x}{OC} \rightarrow OC = \frac{x}{\sin 0.6}$ $x + \frac{x}{\sin 0.6} = 20 \rightarrow x = 7.218$ (ii) Area $= \frac{1}{2} \cdot 20^2 \times 1.2 - \pi \times 7.218^2$ $= 76.3$ (iii) Angle $PCR = \pi - 1.2$ Arc $PR = 7.218 \times (\pi - 1.2) = (14.01)$ $OP = OR = \frac{x}{\tan 0.6}$ $\rightarrow$ Perimeter of 35.1 cm	B1 M1 M1 A1 [4] M1 A1 [2] B1 M1 M1 A1 [4]	Used somewhere – needs “20”. Use of trig in 90° triangle Soln of linear equation. (answer given, ensure there is a correct method) Use of $\frac{1}{2}r^2\theta$ - needs $r=20$ and $\theta = 1.2$ co co Use of $s=r\theta$ with $r = 7.218$ -any θ -even $2\pi/3$ Correct use of trig or Pythagoras co

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The following abbreviations may be used in a mark scheme or used on the scripts:

AEF	Any Equivalent Form (of answer is equally acceptable)
AG	Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
BOD	Benefit of Doubt (allowed when the validity of a solution may not be absolutely clear)
CAO	Correct Answer Only (emphasising that no “follow through” from a previous error is allowed)
CWO	Correct Working Only – often written by a ‘fortuitous’ answer
ISW	Ignore Subsequent Working
MR	Misread
PA	Premature Approximation (resulting in basically correct work that is insufficiently accurate)
SOS	See Other Solution (the candidate makes a better attempt at the same question)
SR	Special Ruling (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)

Penalties

MR –1	A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become “follow through ✓” marks. MR is not applied when the candidate misreads his own figures – this is regarded as an error in accuracy. An MR –2 penalty may be applied in particular cases if agreed at the coordination meeting.
PA –1	This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

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1	$7C3 \times 2^4 \times \left(-\frac{x}{2}\right)^3$ powers 4 and 3 35 seen or implied -70	M1 B1 A1 [3]	
2	$f'(x) = -3x^{-4} - 3x^2$ $< 0 \Rightarrow$ decreasing function	B1 B1 B1 [3]	Dependent upon minus signs & even powers
3	$7 \cos x + 5 = 2(1 - \cos^2 x)$ $(2 \cos x + 1)(\cos x + 3) = 0$ $\cos x = -0.5$ $x = 120^\circ, 240^\circ$	M1 A1 A1 A1 [✓] [4]	Use of $c^2 + s^2 = 1$ ft for $360 - 1^{\text{st}}$ solution
4	area $\Delta = 2\sqrt{3}$ $\tan A = \frac{2\sqrt{3}}{2} \Rightarrow A = \frac{\pi}{3}$ Area sector $= \frac{1}{2} \times 2^2 \times \frac{\pi}{3} = \frac{2\pi}{3}$ Shaded area $= 2\sqrt{3} - \frac{2\pi}{3}$	B1 B1 M1 A1 [4]	Accept 60° Use of $\frac{1}{2}r^2\theta$ with θ in radians cao
5	(i) $2\frac{1}{4} = 5\frac{1}{3}r^3$ $r^3 = \frac{9}{4} \times \frac{3}{16} = \frac{27}{64}$ $r = \frac{3}{4}$ or 0.75 (ii) $S_\infty = \frac{5\frac{1}{3}}{1 - \frac{3}{4}} = \frac{64}{3}$ (or $21\frac{1}{3}$ or 21.3)	M1 A1 A1 [3] M1 A1 [2]	cao cao
6	(i) $\cos\left(\frac{1}{2}x + \frac{\pi}{6}\right) (= 1)$ $x = -\frac{\pi}{3}$ (ii) $\frac{1}{2}\cos x + \frac{\pi}{6} = 1$ $\cos x = 0.9528$ $x = \pm 0.31$	B1 B1 [2] B1 B1 B1 B1 [✓] [4]	cao [✓] for negative of first answer
7	(i) $11 - x^2 = 5 - x \Rightarrow x^2 - x - 6 (= 0)$ $(x + 2)(x - 3)$ $p = 3; q = 2$ (ii) $f^{-1}(x) = \begin{cases} \sqrt{11 - x} & \text{for } 2 \leq x \leq 11 \\ 5 - x & \text{for } x < 2 \end{cases}$	B1 B1 B1 [3] B1 B1 B1 B1 B1 [5]	oe cao

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8 (i) $f''(x) = [9] \times [(3x+4)^{\frac{1}{2}}] - [6]$ (ii) $f'(-1) = 2 + 6 - 8 = 0$ hence stat value at $x = -1$ $f''(-1) = 9 - 6 = 3 > 0$ hence minimum (iii) $y = [\frac{4}{15} \text{ oe}] \times [(3x+4)^{\frac{5}{2}}] - [3x^2 + 8x] + (c)$ Sub $(-1, 5) \rightarrow \frac{4}{15} - 3 + 8 + c = 5 \rightarrow c = -\frac{4}{15}$	B2,1,0 [2] B1 B1 [2] B1 B1 B1 M1 A1 [5]	1 each error AG allow unsimplified $\frac{4}{15}$ Dependent on c present cao
9 (i) $p = 2$ Unit vector $\frac{1}{\sqrt{6}} \begin{pmatrix} 2 \\ 1 \\ 1 \end{pmatrix}$ or $\frac{1}{\sqrt{24}} \begin{pmatrix} 4 \\ 2 \\ 2 \end{pmatrix}$ oe (ii) $\overrightarrow{AB} = \begin{pmatrix} 4 \\ 2 \\ p \end{pmatrix} - \begin{pmatrix} p \\ 1 \\ 1 \end{pmatrix} = \begin{pmatrix} 4-p \\ 1 \\ p-1 \end{pmatrix}$ $\overrightarrow{OA} \cdot \overrightarrow{AB} = 0 \Rightarrow 4p - p^2 + 1 + p - 1 = 0$ $5p - p^2 = 0 \Rightarrow p = 0$ or 5 (iii) $\overrightarrow{OC} = \overrightarrow{OB} - \overrightarrow{OA} = \begin{pmatrix} 4 \\ 2 \\ 3 \end{pmatrix} - \begin{pmatrix} 3 \\ 1 \\ 1 \end{pmatrix}$ oe $= \begin{pmatrix} 1 \\ 1 \\ 2 \end{pmatrix}$	B1 M1 A1 ✓ [3] M1 A1 M1 A1 ✓ A1 [5] M1 A1 [2]	ft for <i>their p</i> ft from <i>their AB</i> cao
10 (i) $-2x + k = \frac{2}{x-3} \Rightarrow 2x^2 - (6+k)x + 2 + 3k = 0$ (ii) $(6+k)^2 - (4)(2)(2+3k) = 0$ $k^2 - 12k + 20 (=0)$ $(k-10)(k-2) = 0$ $k = 2$ or 10 (iii) $k = 2 \Rightarrow 2(x-2)^2 = 0$ $x = 2, y = -2$ or $(2, -2)$ $k = 10 \Rightarrow 2(x-4)^2 = 0$ $x = 4, y = 2$ or $(4, 2)$ AB: $y - 2 = 2(x - 4)$ or $y + 2 = 2(x - 2)$	B1 [1] M1 A1 A1 [3] M1 A1 M1 A1 M1 A1 [6]	AG Apply $b^2 - 4ac$ cao $(y = 2x - 6)$

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11 (i) $a = 2$ (ii) $y = x^3 - 4x^2 + 4x$ $\frac{dy}{dx} = 3x^2 - 8x + 4$ $(x - 2)(3x - 2) = 0$ $b = \frac{2}{3}$ (iii) area = $\int y \, dx = \left[\frac{x^4}{4} - \frac{4x^3}{3} + 2x^2 \right]$ $4 - \frac{32}{3} + 8$ $\frac{4}{3}$ (iv) $\frac{d^2y}{dx^2} = 6x - 8 = 0 \Rightarrow x = \frac{4}{3}$ When $x = \frac{4}{3}$, $\frac{dy}{dx}$ (or m) = $-\frac{4}{3}$	B1 [1] B1 B2, 1, 0 ✓ B1 [4] B2, 1, 0 M1 A1 [4] M1 A1 DM1 A1 [4]	–1 for eeo cao –1 for eeo Apply limits $0 \rightarrow 2$ – ft <i>their a</i> from (i) cao Attempt $\frac{d^2y}{dx^2}$ and set = 0 cao
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