

MARK SCHEME for the May/June 2010 question paper
for the guidance of teachers

9709 MATHEMATICS

9709/11

Paper 11, maximum raw mark 75

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1 $\tan x = k$ (i) $\tan(\pi - x) = -k$ (ii) $\tan\left(\frac{\pi}{2} - x\right) = \frac{1}{k}$ (iii) $\sin x = \frac{k}{\sqrt{1+k^2}}$ from 90° triangle.	B1 [1] B1 [1] M1 A1 [2]	co. www Mark final answers co. www Any valid method – 90° triangle or formulae.
2 $\left(2x - \frac{3}{x}\right)^5$ (i) $32x^5 - 240x^3 + 720x$ (ii) $\left(1 + \frac{2}{x^2}\right)(32x^5 - 240x^3 + 720x)$ Coeff of x (1×720) + (2×-240) $\rightarrow 240$	$3 \times$ B1 [3] M1 A1✓ [2]	co. SC B2 for other 3 terms (i.e. ascending) Looks at exactly 2 terms. co from his answer to (i).
3 9^{th} term = 22, $S_4 = 49$ (i) $a + 8d = 22$ $2(2a + 3d) = 49$ Soln of sim eqns $\rightarrow d = 1.5, a = 10$ (ii) $a + (n-1)d = 46$ Substitutes for a and d $\rightarrow n = 25$	B1 B1 M1 A1 [4] M1 A1 [2]	co co Solution of two linear sim eqns. co Correct formula needed and attempt to solve. co.
4 $y = 6x - x^2$ Meets $y = 5$ when $x = 1$ or $x = 5$. Integral = $3x^2 - \frac{1}{3}x^3$ Their limits (1 to 5) used $\rightarrow 30\frac{2}{3}$ Area of rectangle = 20 Shaded area = $10\frac{2}{3}$ (integral of $6x - x^2 - 5$ B1, M1, A1 DM1 as above, then “$-5x$” B1✓ A1)	B1 M1 A1 DM1 B1✓ A1 [6]	co attempt to integrate. co. value at top limit – value at lower co to his x values co

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5 $x \mapsto 2\sin^2 x - 3\cos^2 x$ (i) $2(1 - \cos^2 x) - 3\cos^2 x$ $\rightarrow 2 - 5\cos^2 x$ ($a = 2, b = -5$) (ii) Values are -3 and 2 (iii) $2 - 5\cos^2 x = -1$ $\rightarrow \cos^2 x = 0.6$ $x = 0.685, 2.46$ (accept 0.684)	M1 A1 [2] B1√ B1√ [2] B1√ B1 B1√ [3]	Uses $s^2 + c^2 = 1$ co co √ for $\pi -$ (first answer) SC B1 for both 39.2 and 140.8
6 $\frac{dy}{dx} = 3\sqrt{x} - 6$ (9, 2) (i) $y = \frac{3x^{\frac{3}{2}}}{\frac{3}{2}} - 6x (+c)$ (9, 2) $2 = 54 - 54 + c$ $\rightarrow c = 2.$ (ii) $\frac{dy}{dx} = 0 \rightarrow x = 4$ $\frac{d^2y}{dx^2} = \frac{3x^{-\frac{1}{2}}}{2}$ $\rightarrow +ve$ (or $\frac{3}{4}$) Minimum	B2,1 M1 A1 [4] B1 M1 A1 [3]	Loses 1 for each error – ignore $+c$ Uses (9, 2) with integration to find c. co. Ignore any y-value Any valid method. co.
7 $y = 2 - \frac{18}{2x+3}$ (i) A is (3, 0) $\frac{dy}{dx} = 18(2x+3)^{-2} \times 2$ If $x = 3, m = \frac{4}{9}.$ m of normal $= -\frac{9}{4}$ Equation of normal $y = -\frac{9}{4}(x - 3)$ $\rightarrow 4y + 9x = 27$ (ii) Normal meets y-axis at (0, $6\frac{3}{4}$) Curve meets y-axis at (0, -4) $\rightarrow BC = 10\frac{3}{4}$	B1 B1 B1 M1 M1 A1 [6] M1 A1 [2]	Anywhere – but not from given answer B1 for $18(2x+3)^{-2}$, B1 for $\times 2$ Use of $m_1 m_2 = -1$ with m from dy/dx Correct method for normal co (answer was given) Needs to put $x = 0$ in both normal and curve. co

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8 (i) $y\text{-step} \div x\text{-step} = 2$ $\rightarrow m = 1$ (ii) Eqn of AC $y + 2 = -2(x - 3)$ Eqn of BC $y - 22 = (x - 15)$ Sim eqns $y + 2x = 4$, $y = x + 7$ $\rightarrow C(-1, 6)$ (iii) M is $(9, 10)$ Perp gradient is $-\frac{1}{2}$ $\rightarrow 2y + x = 29$, $y = x + 7$ Sim eqns $\rightarrow D(5, 12)$	M1 A1 [2] M1 A1√ A1√ A1 [4] B1 M1 M1 A1 [4]	Gradient = $y\text{-step} \div x\text{ step}$ used co Correct form of one of lines. √ to his m √ to his m co co Use of $m_1 m_2 = -1$ Solve sim eqns for their BC & perp. bis co
9 (i) $2x^2 - 12x + 7 = 2(x - 3)^2 - 11$ (ii) Range of $f \geq -11$ (iii) $2x^2 - 12x + 7 < 21$ $\rightarrow 2x^2 - 12x - 14$ or $2(x - 3)^2 < 32$ $\rightarrow$ end-values of 7 or -1 $\rightarrow -1 < x < 7$ (iv) $gf(x) = 2(2x^2 - 12x + 7) + k = 0$ Use of $b^2 - 4ac$ $\rightarrow 24^2 - 16(14 + k)$ $\rightarrow k = 22$	$3 \times$ B1 [3] B1√ [1] M1 A1 A1 [3] M1 A1 M1 A1 [4]	B1 for each value – accept if a, b, c not specifically quoted. √ to his “c”. allow $>$ or $\geq$. 3-term quadratic to 0 or $2(x - 3)^2 < 32$ Correct end-values co Puts f into g. co. Used correctly with quadratic co.
10 $\vec{OA} = \mathbf{i} + 3\mathbf{j} + 3\mathbf{k}$, $\vec{OC} = 3\mathbf{i} - \mathbf{j} + \mathbf{k}$. (i) $\vec{OB} = \vec{OA} + \vec{OC} = 4\mathbf{i} + 2\mathbf{j} + 4\mathbf{k}$ Unit vector = $\frac{1}{6}(4\mathbf{i} + 2\mathbf{j} + 4\mathbf{k})$ (ii) $\vec{AC} = \vec{OC} - \vec{OA} = 2\mathbf{i} - 4\mathbf{j} - 2\mathbf{k}$ $\vec{AC} \cdot \vec{OB} = 8 - 8 - 8 = -8$ $\vec{OB} = 6$; $\vec{AC} = \sqrt{24}$ $-8 = 6 \times \sqrt{24} \times \cos \theta$ $\theta = 105.8^\circ \rightarrow 74.2^\circ$ (iii) $OA = \sqrt{19}$ or $OC = \sqrt{11}$ Perimeter = $2(\sqrt{} + \sqrt{})$ $\rightarrow 15.4$	B1 M1 A1√ [3] B1 M1 M1 M1 A1 [5] B1 M1 A1 [3]	co Divides by the modulus. √ on $\vec{OB}$. co Use of $x_1 x_2 + y_1 y_2 + z_1 z_2$ Correct method for a modulus. Connected correctly provided $\vec{OB}$, $\vec{AC}$ used co (accept acute or obtuse) Used as a length. co (accept 15.3)

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1 (i) $3(2 \sin x - \cos x) = 2(\sin x - 3 \cos x)$ $\rightarrow 6s - 3c = 2s - 6c \rightarrow 4s = -3c$ $\rightarrow \tan x = -\frac{3}{4}$ (ii) $x = 180 - 36.9 = 143.1^\circ$ or $x = 360 - 36.9 = 323.1^\circ$	M1 A1 [2] B1 B1✓ [2]	Expanding, collecting, use of $t = s \div c$ Answer given. All correct. co For 180 + first answer.
2 $y = \frac{a}{x}$ Volume = $\pi \int \left(\frac{a^2}{x^2} \right) dx = (\pi) \left[\frac{-a^2}{x} \right]$ Use of limits 1 to 3 $\rightarrow \frac{2\pi a^2}{3}$ Equates to $24\pi \rightarrow a = 6$	M1 B1 M1 A1 [4]	For using correct formula with π. For correct integration of x^{-2} only Must be using y^2 or πy^2. Co, allow ± 6.
3 $f: x \mapsto 4x - 2x^2$, $g: x \mapsto 5x + 3$. (i) Turning point at $x = 1$. Range is ≤ 2. (ii) $gf(x) = 5(4x - 2x^2) + 3$ $= k$ and use of $b^2 - 4ac$ $\rightarrow k = 13$	M1 A1 [2] B1 M1 A1 [3]	Calculus or completing the square etc. Condone $<$ instead of $\leq$. For putting f into g. Setting to k, using $b^2 - 4ac$ co
4 Gradient of L_1 is $\frac{1}{3}$. Equation of L_1 is $y - 3 = \frac{1}{3}(x + 1)$ Gradient of AB is $-\frac{1}{2}$. Perp = 2. Equation of L_2 is $y - 1 = 2(x - 3)$. Sim eqns $3y = x + 10$, $y = 2x - 5$. $\rightarrow (5, 5)$	M1 A1 M1 A1 M1 A1 [6]	M1 for equation for his m. A1 co. Use of $m_1 m_2 = -1$ co Method of solution co

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5 (i) $-8 + 3 + p = 0$ $\rightarrow p = 5.$ (ii) Vector $\overrightarrow{AB} = \mathbf{b} - \mathbf{a}$ $= 6\mathbf{i} - 2\mathbf{j} + (p - 1)\mathbf{k}$ $36 + 4 + (p - 1)^2 = 49$ $\rightarrow p = 4$ or $p = -2$	M1 A1 [2] M1 M1 A1 A1 [4]	Must be scalar. co. Must be $\mathbf{b} - \mathbf{a}$ or $\mathbf{a} - \mathbf{b}$ Must be sum of 3 squares. A1 $\sqrt{\quad}$ lost. co.
6 (i) $1 + 5ax + 10a^2x^2$ (ii) $\times (1 - 2x) \rightarrow 5ax - 2x$ $\rightarrow a = \frac{2}{5}$ (iii) Coeff of x^2 is $-10a + 10a^2$ $\rightarrow -4 + 1.6 = -2.4$	B2,1 [2] M1 A1 [2] M1 A1 $\sqrt{\quad}$ A1 [3]	Loses 1 mark for each incorrect term. Needs to consider exactly 2 terms. co Needs to consider exactly 2 terms. co
7 (a) $a = 100, d = 5,$ $n = 41$ $\rightarrow S = 8200$ (b) (i) $a + ar + ar^2$ or $a \frac{(1 - r^3)}{1 - r}$ $= 35 \rightarrow a = 45$ (ii) $S_{\infty} = \frac{a}{1 - r} = 27$	B1 M1 A1 [3] B1 M1 A1 [3] M1 A1 $\sqrt{\quad}$ [2]	co Use of correct sum formula. co co Solution of equation. co Correct use of formula. $\sqrt{\quad}$ for his a.
8 (i) $4xh + 2x^2 = 96$ $\rightarrow h = \frac{24}{x} - \frac{x}{2}$ $V = x^2h \rightarrow V = 24x - \frac{x^3}{2}.$ (ii) $\frac{dV}{dx} = 24 - \frac{3x^2}{2}$ $= 0$ when $x = 4$ $\rightarrow V = 64.$ (iii) $\frac{d^2V}{dx^2} = -3x \rightarrow \text{Max.}$	M1 A1 M1 [3] B1 M1 A1 [3] M1 A1 $\sqrt{\quad}$ [2]	Needs to consider at least 5 areas. co for $V = x^2h$ with h as $f(x)$ co Sets differential to 0 and solves. co Any valid method. co.

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9 $y = (x-2)^2$ and $y + 2x = 7$ Elimination of $y \rightarrow x^2 - 2x - 3 = 0$ $\rightarrow A(-1, 9)$ and $B(3, 1)$ Area under line = $\frac{1}{2} \times 4 \times 10$ or $[7x - x^2]$ from -1 to 3. Area under curve = $\left[\frac{(x-2)^3}{3} \right]$ or $\left[\frac{x^3}{3} - 2x^2 + 4x \right]$ from -1 to 3 $\rightarrow 10\frac{2}{3}$. [ok to use $\int (y_1 - y_2) dx$ – marks the same]	M1 DM1A1 M1 M1 A1 M1 A1 [8]	y (or x) removed completely. Soln of quadratic. Both points correct. Uses any valid method – integration or area of trapezium etc. Any attempt at integration. Correct integration in either form. Correct use of limits in an integral. co
10 $y = \frac{1}{6}(2x-3)^3 - 4x$ (i) $\frac{dy}{dx} = \frac{1}{6} \times 3 \times (2x-3)^2 \times 2 - 4$ (ii) $x = 0, y = -\frac{27}{6},$ $y + \frac{27}{6} = 5x \rightarrow 2y + 9 = 10x$ (iii) $(2x-3)^2 - 4 (> 0)$ $\rightarrow x = 2\frac{1}{2}$ or $\frac{1}{2}$ $\rightarrow x > 2\frac{1}{2}, x < \frac{1}{2}.$	B2,1 B1 [3] B1 M1 A1 [3] M1 DM1 A1 [3]	Everything but the “$\times 2$” For the “$\times 2$”, even if B0 given above. For correct y value Must be using calculus for m. co. (ok unsimplified) Links $\frac{dy}{dx}$ with 0 Method for quadratic – lead to 2 answers Correct set of values.
11 $f: x \mapsto 4 - 3\sin x$ (i) $4 - 3\sin x = 2 \rightarrow \sin x = \frac{2}{3}$ $\rightarrow x = 0.730$ or 2.41 (ii) (iii) $k < 1, k > 7.$ (iv) $A = \frac{3\pi}{2}.$ (v) $\sin x = \frac{1}{3}$ – or using inverse $g^{-1}(3) = 2.80$	M1 A1 A1√ [3] B1 B1 [2] B1 B1 [2] B1 [1] M1A1 [2]	Makes $\sin x$ the subject + solution. co. $\sqrt{\quad}$ for π – first answer. Must be 1 complete oscillation. Shape and position correct, in 1st quadrant, curve not lines. B1 for $k = 1, 7$, B1 for answer Or B1 for $k < 1$, B1 for $k > 7$ co M1 for soln of $3 = 4 - 3\sin x$ or inverse.

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1 (i) $a = 12, ar = -6 \rightarrow r = -\frac{1}{2}$ $ar^9 = \frac{-3}{128}$ (ii) $S_{\infty} = \frac{a}{1-r}$ used $\rightarrow 8$	M1 M1 A1 [3] M1 A1 [2]	Attempt at r from “ar” ar^9 must be correct. co Correct formula used. M1 needs $r < 1$
2 (i) $\left(x - \frac{2}{x}\right)^6 = x^6 - 12x^4 + 60x^2$ (ii) $\times (1 + x^2) \rightarrow 60 - 12 = 48$	B1 $\times 3$ [3] M1 A1 $\checkmark$ [2]	co Must be exactly 2 terms. $\checkmark$ from his (i).
3 $f: x \mapsto a + b \cos x$ (i) $f(0) = 10, a + b = 10$ $f(\frac{2}{3}\pi) = 1, a - \frac{b}{2} = 1$ $\rightarrow a = 4, b = 6$ (ii) Range is -2 to 10. (iii) $\cos\left(\frac{5}{6}\pi\right) = -\cos\left(\frac{1}{6}\pi\right) = -\frac{\sqrt{3}}{2}$ $\rightarrow 4 - 3\sqrt{3}$	B1 B1 [2] B1 $\checkmark$ [1] B1 B1 [2]	EITHER OF THESE both co $\checkmark$ for his “$a - b$” to “$a + b$” For $\cos 30^\circ = \frac{1}{2}\sqrt{3}$ used somewhere. co
4 (i) $2 \sin x \tan x + 3 = 0$ $2 \sin x \frac{\sin x}{\cos x} + 3 = 0$ $2 \frac{(1 - \cos^2 x)}{\cos x} + 3 = 0$ $\rightarrow 2 \cos^2 x - 3 \cos x - 2 = 0$ (ii) $2 \cos^2 x - 3 \cos x - 2 = 0$ $\rightarrow \cos x = -\frac{1}{2}$ or 2 $x = 120^\circ$ or 240°	M1 M1 [2] M1 A1 B1 $\checkmark$ [3]	For using $\tan = \sin \div \cos$ For using $\sin^2 + \cos^2 = 1$ <u>and</u> everything correct Answer given – check. Solution of quadratic. co. $\checkmark$ for 360 – his answer.

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5 $\frac{dy}{dx} = \frac{6}{\sqrt{3x-2}}$ (i) $x = 2$, tangent has gradient 3 $\rightarrow$ normal has gradient $-\frac{1}{3}$ $\rightarrow y - 11 = -\frac{1}{3}(x - 2)$ (ii) Integrate $\rightarrow 6 \frac{\sqrt{3x-2}}{\frac{1}{2}} \div 3$ $\rightarrow y = 4\sqrt{3x-2} + c$ through (2,11) $\rightarrow y = 4\sqrt{3x-2} + 3$	M1 M1 A1 [3] B1 B1 M1 A1 [4]	Use of $m_1 m_2 = -1$ with dy/dx Correct form of line eqn. for normal Without the $\div 3$ For $\div 3$, even if B0 above Using (2, 11) for c co
6 $\vec{OA} = \mathbf{i} - 2\mathbf{j} + 4\mathbf{k}$, $\vec{OB} = 3\mathbf{i} + 2\mathbf{j} + 8\mathbf{k}$, $\vec{OC} = -\mathbf{i} - 2\mathbf{j} + 10\mathbf{k}$ (i) $(\pm) 2\mathbf{i} + 4\mathbf{j} + 4\mathbf{k}$ $(\pm) 4\mathbf{i} + 4\mathbf{j} - 2\mathbf{k}$ $\vec{AB} \cdot \vec{CB} = 16$ $\vec{AB} \cdot \vec{CB} = \sqrt{36}\sqrt{36} \cos \theta$ $\theta = 63.6^\circ$ (ii) Perimeter $= 6 + 6 + \sqrt{40}$ or $6 + 6 + 6 \sin 31.8^\circ \times 2$ $\rightarrow 18.32$	B1 B1 M1 M1 M1 A1 [6] M1 A1 [2]	co co Needs to be scalar. For product of 2 moduli and cosine All correct. Correct overall method for perimeter. co
7 (i) $\sin \frac{1}{2}\theta = \frac{6}{10}$ Angle $DOE = 1.287$ radians. (ii) $P = 12 + 12 + 2 \times 10 \times \text{angle } BOD$ Angle $BOD = (\pi - 1.287)$ $\rightarrow 61.1$ (iii) Sector $DOE = \frac{1}{2} \times 10^2 \times 1.287$ Triangle $DOE = \frac{1}{2} \times 10^2 \times \sin 1.287$ Area $= \pi \times 10^2 - (2 \text{ sectors} - 2 \text{ triangles})$ (or $48 + 48 + 2 \times \frac{1}{2} \times 10^2 \times (\pi - 1.287)$) M1 M1 $\rightarrow 281$ or 282	M1 A1 [2] M1 M1 A1 [3] M1 M1 A1 [3]	Use of trig with/without radians co – answer given. Use of $s = r\theta$ for arc length. Correct angle co Correct formula used with radians. Correct formula used with radians. co

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8 (i) Mid-point of $AC = (2, 3)$ Gradient of $AC = \frac{1}{3}$ Gradient of $BD = -3$ Equation $y - 3 = -3(x - 2)$ (ii) If $x = 0, y = 9, B(0, 9)$ Vector move $D(4, -3)$ (iii) $AC = \sqrt{40}$ $BD = \sqrt{160}$ Area = 40 (or by matrix method M2 A1)	B1 M1 A1 [3] B1√ M1 A1 [3] M1 M1 A1 [3]	Co Use of $m_1 m_2 = -1$ Co √ on his equation. Valid method. co. Correct use on either AC or BD, Full and correct method. co
9 $y = x + \frac{4}{x}$ (i) $x + \frac{4}{x} = 5 \rightarrow A(1, 5), B(4, 5)$ $\frac{dy}{dx} = 1 - \frac{4}{x^2}$ = 0 when $x = 2, M(2, 4)$. (ii) Vol of cylinder = $\pi 5^2 \cdot 3$ Vol under curve = $\pi \int y^2 dx$ Integral = $\frac{x^3}{3} - \frac{16}{x} + 8x$ Uses his limits "1 to 4" $\rightarrow 75\pi - 57\pi = 18\pi$	B1 B1 M1 DM1 A1 [5] B1 M1 A2, 1, 0 DM1 A1 [6]	co. co. Differentiates. Setting to 0. co. Any valid method. Attempt at integrating y^2 Allow if no π present. Using his limits. co.
10 $f: x \mapsto 2x^2 - 8x + 14$ (i) $y + kx = 12$, Sim Eqns. $\rightarrow 2x^2 - 8x + kx + 2 = 0$ Use of $b^2 - 4ac$ $\rightarrow (k - 8)^2 = 16 \rightarrow k = 12$ or 4. (ii) $2x^2 - 8x + 14 = 2(x - 2)^2 + 6$ (iii) Range of $f \geq 6$. (iv) Smallest $A = 2$ (v) Makes x the subject Order of operations correct. $g^{-1}(x) = \sqrt{\frac{x - 6}{2}} + 2$	M1 A1 M1 A1 [4] B1×3 [3] B1√ [1] B1√ [1] M1 M1 A1 [3]	Complete elimination of y (or x) Uses $b^2 - 4ac$ on eqn = 0, no "x" in a, b, c. co.co √ for c or from calculus. √ to answer to (ii). Could interchange x, y first. Order must be correct. co