

MARK SCHEME for the October/November 2013 series

9709 MATHEMATICS

9709/11

Paper 1, maximum raw mark 75

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Penalties

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1 (i) $64 + 576x + 2160x^2$ (ii) $576a(x^2) + 2160(x^2) = 0$ $a = -\frac{2160}{576}$ oe (eg $-\frac{15}{4}$) or -3.75	B1B1B1 [3] M1 A1 [2]	Can score in (ii)
2 Attempt integration $f(x) = 2(x+6)^{\frac{1}{2}} - \frac{6}{x} (+c)$ $2(3) - \frac{6}{3} + c = 1$ $c = -3$	M1 A1A1 M1 A1 [5]	Accept unsimplified terms Sub. $x = 3, y = 1$. c must be present
3 (i) DB = $6\mathbf{i} + 4\mathbf{j} - 3\mathbf{k}$ cao DE = $3\mathbf{i} + 2\mathbf{j} - 3\mathbf{k}$ cao (ii) DB.DE = $18 + 8 + 9 = 35$ $ \mathbf{DB} = \sqrt{61}$ or $ \mathbf{DE} = \sqrt{22}$ $35 = \sqrt{61} \times \sqrt{22} \times \cos \theta$ oe $\theta = 17.2^\circ$ (0.300 rad) cao	B1 B1 [2] M1 M1 M1 A1 [4]	Use of $x_1x_2 + y_1y_2 + z_1z_2$ Correct method for moduli All connected correctly Use of e.g. BD, DE can score M marks (leads to obtuse angle)
4 (i) $4(1 - \cos^2 x) + 8\cos x - 7 = 0$ $4c^2 - 8c + 3 = 0 \rightarrow (2\cos x - 1)(2\cos x - 3) = 0$ $x = 60^\circ$ or 300° (ii) $\frac{1}{2}\theta = 60^\circ$ (or 300°) $\theta = 120^\circ$ only	M1 M1 A1A1 [4] M1 A1 [2]	Use $c^2 + s^2 = 1$ Attempt to solve Allow 300° in addition
5 (i) $x = (\pm)\sqrt{y-1}$ $f^{-1} : x \mapsto \sqrt{x-1}$ for $x > 1$ (ii) $ff(x) = (x^2 + 1)^2 + 1$ $x^2 + 1 = (\pm)13/4$ $x = 3/2$ Alt. (ii) $f(x) = f^{-1}(185/16) = 13/4$ M1 $x = f^{-1}(13/4)$ M1 $x = 3/2$ A1	B1 B1B1 [3] B1 M1 A1 [3]	OR $y^2 = x - 1$ (x/y interchange 1 st) Or $x^4 + 2x^2 - (153/16) = 0$ Or $x^2 = 9/4, (-17/4)$ www. Condone $\pm 3/2$ Alt. (ii) $f(3/2) = 13/4$ B1 $f(13/4) = 185/16$ B1 $x = 3/2$ B1 SC.B2 answer 1.5 with no working

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6 (i) $r(2\pi - \alpha) + 2r\alpha + 2r$ $2\pi r + r\alpha + 2r$ (ii) $\frac{1}{2}(2r)^2\alpha + \pi r^2 - \frac{1}{2}r^2\alpha$ $\frac{3r^2\alpha}{2} + \pi r^2$ (iii) $\pi r^2 - \frac{1}{2}r^2\alpha = 2r^2\alpha$ $\alpha = \frac{2}{5}\pi$	B1B1 B1 [3] B1B1 B1 [3] M1 A1 [2]	ft for $r\alpha$ instead of $2r\alpha$ or omission $2r$ SC1 for $2r\alpha + 4r$. (Plate = shaded part) Either B1 can be scored in (iii) For equating <i>their</i> 2 parts from (ii)
7 (i) mid-point = (3, 4) Grad. $AB = -\frac{1}{2} \rightarrow$ grad. of perp., = 2 $y - 4 = 2(x - 3)$ $y = 2x - 2$ (ii) $q = 2p - 2$ oe $p^2 + q^2 = 4$ oe $p^2 + (2p - 2)^2 = 4 \rightarrow 5p^2 - 8p = 0$ {OR $\frac{1}{4}(q + 2)^2 + q^2 = 4 \rightarrow 5q^2 + 4q - 12 = 0$ } (0, -2) and $\left(\frac{8}{5}, \frac{6}{5}\right)$	B1 M1 M1 A1 [4] B1 B1 M1 A1A1 [5]	soi For use of $-1/m$ soi ft on <i>their</i> (3, 4) and 2 ft for 1st eqn. Attempt substn (linear into quadratic) & simplify
8 (i) $A = 2xr + \pi r^2$ $2x + 2\pi r = 400 \Rightarrow x = 200 - \pi r$ $A = 400r - \pi r^2$ (ii) $\frac{dA}{dr} = 400 - 2\pi r$ $= 0$ $r = \frac{200}{\pi}$ oe $x = 0 \Rightarrow$ no straight sections AG $\frac{d^2A}{dr^2} = -2\pi$ (< 0) Max	B1 B1 M1A1 [4] B1 M1 A1 A1 B1 [5]	Subst & simplify to AG (www) Differentiate Set to zero and attempt to find r Dep on -2π, or use of other valid reason

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9 (a) $\frac{10}{2}(2a+9d)=400$ oe $\frac{20}{2}(2a+19d)=1400$ OR $\frac{10}{2}[2(a+10d)+9d]=1000$ $d=6 \quad a=13$ (b) $\frac{a}{1-r}=6$ $\frac{2a}{1-r^2}=7$ $\frac{12(1-r)}{1-r^2}=7$ or $\frac{1-r^2}{1-r}=\frac{12}{7}$ $r=\frac{5}{7}$ or 0.714 $a=\frac{12}{7}$ or 1.71(4)	B1 B1 M1A1A1 [5] B1B1 M1 A1 A1^{ft} [5]	$\rightarrow 2a+9d=80$ $\rightarrow 2a+19d=140$ or $2a+29d=200$ Solve sim. eqns both from S_n formulae Substitute or divide Ignore any other solns for r and a
10 (i) $\frac{dy}{dx} = [3(3-2x)^2] \times [-2]$ At $x=\frac{1}{2}$, $\frac{dy}{dx} = -24$ $y-8 = -24\left(x-\frac{1}{2}\right)$ $y = -24x+20$ (ii) Area under curve $= \left[\frac{(3-2x)^4}{4} \right] \times \left[-\frac{1}{2} \right]$ $-2 - \left(-\frac{81}{8} \right)$ Area under tangent $= \int (-24x+20)$ $= \left -12x^2 + 20x \right$ or 7 (from trap) $\frac{9}{8}$ or 1.125	B1B1 M1 DM1 A1 [5] B1B1 M1 M1 A1 A1 [6]	OR $-54+72x-24x^2$ B2,1,0 OR $27x-27x^2+12x^3-2x^4$ B2,1,0 Limits $0 \rightarrow \frac{1}{2}$ applied to integral with intention of subtraction shown or area trap $= \frac{1}{2}(20+8) \times \frac{1}{2}$ Could be implied Dep on both M marks

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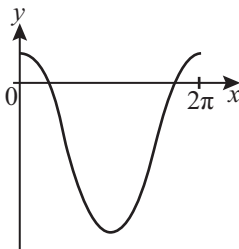
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1 (i) $\sin x = \sqrt{1-p^2}$ (ii) $\tan x = \frac{\sin x}{\cos x} = \frac{\sqrt{1-p^2}}{p}$ (iii) $\tan(90-x) = \frac{p}{\sqrt{1-p^2}}$	B1 [1] B1✓ [1] B1✓ [1]	Allow $1-p$ if following $\sqrt{1-p^2}$ ± is B0. ✓ for answer to (i) used. ✓ for reciprocal of (ii)
2 (i) slant length = 10 cm. circumference of base = 12π arc length = 10θ (= 12π) → $\theta = 1.2\pi$ or 3.77 radians. (ii) $\frac{1}{2}r^2\theta = 188.5 \text{ cm}^2$ or 60π.	B1 B1 B1✓ [4] B1 M1 A1✓ [2]	Use of $r\theta$, θ calculated, not 6 or 8. Use of $\frac{1}{2}r^2\theta$ with radians and r = calculated '10', not 6 or 8.
3 $y = \frac{2}{\sqrt{5x-6}}$ (i) $\frac{dy}{dx} = 2 \times -\frac{1}{2} \times (5x-6)^{-\frac{3}{2}} \times 5$ → $-\frac{5}{8}$ (ii) integral = $\frac{2\sqrt{5x-6}}{\frac{1}{2}} \div 5$ Uses 2 to 3 → $2.4 - 1.6 = 0.8$	B1 B1 B1 [3] B1 B1 M1 A1 [4]	B1 without '×5'. B1 For '×5' Use of 'uv' or 'u/v' ok. B1 without '÷5'. B1 for '÷5' Use of limits in an integral.
4 $\vec{OA} = \mathbf{i} + 2\mathbf{j}$ and $\vec{OB} = 4\mathbf{i} + p\mathbf{k}$, (i) $\vec{AB} = \mathbf{b} - \mathbf{a} = 3\mathbf{i} - 2\mathbf{j} + 6\mathbf{k}$ Unit vector = $(3\mathbf{i} - 2\mathbf{j} + 6\mathbf{k}) \div 7$ (ii) Scalar product = 4 = $\sqrt{5} \times \sqrt{(16+p^2)} \times \cos \theta$ → $p = \pm 8$	B1 M1 A1✓ [3] M1 M1 M1 A1 [4]	Must be $\vec{AB} = \mathbf{b} - \mathbf{a}$ Divides by modulus. ✓ on vector AB. Use of $x_1x_2 + y_1y_2 + z_1z_2$ For modulus. All linked correctly including correct use of $\cos\theta=1/5$.
5 A (0, 8) B (4, 0) $8y + x = 33$ m of AB = -2 m of BC = $\frac{1}{2}$ Eqn BC → $y - 0 = \frac{1}{2}(x - 4)$ Sim eqns → C (16, 6) Vector step method → D (12, 14) (or AD $y = \frac{1}{2}x + 8$, CD $y = -2x + 38$) (or M = (8, 7) → D = (12, 14))	B1 M1 M1 M1 A1 M1 A1 [7]	Use of $m_1m_2 = -1$ for BC or AD Correct method for equation of BC Sim Eqns for BC, AC. M1 valid method.

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6 (i) Sim triangles $\frac{y}{16-x} = \frac{12}{16}$ (or trig) $\rightarrow y = 12 - \frac{3}{4}x$ $A = xy = 12x - \frac{3}{4}x^2$. (ii) $\frac{dA}{dx} = 12 - \frac{6x}{4}$ $= 0$ when $x = 8$. $\rightarrow A = 48$. This is a Maximum. From -ve quadratic or 2nd differential.	M1 A1 A1 [3] B1 M1 A1 B1 [4]	Trig, similarity or eqn of line (could also come from eqn of line) ag – check working. Sets to 0 + solution. Can be deduced without any working. Allow even if '48' incorrect.
7 (a) (i) $a = 300, d = 12$ $\rightarrow 540 = 300 + (n-1)12 \rightarrow n = 21$ (ii) $S_{26} = 13(600 + 25 \times 12) = 11700$ $\rightarrow 3$ hours 15 minutes. (b) $ar = 48$ and $ar^2 = 32 \rightarrow r = \frac{2}{3}$ $\rightarrow a = 72$. $S_{\infty} = 72 \div \frac{1}{3} = 216$.	M1 A1 [2] M1 A1 [2] M1 A1 M1 A1✓ [4]	Use of nth term. Ans 20 gets 0. Ignore incorrect units Correct use of s_n formula. Needs ar and ar^2 + attempt at a and r. Correct S_{∞} formula with $r < 1$
8 $f: x \mapsto 3 \cos x - 2$ for $0 \leq x \leq 2\pi$. (i) $3 \cos x - 2 = 0 \rightarrow \cos x = \frac{2}{3}$ $\rightarrow x = 0.841$ or 5.44 (ii) range is $-5 \leq f(x) \leq 1$ (iii)  (iv) max value of $k = \pi$ or 180°. (iv) $g^{-1}(x) = \cos^{-1}\left(\frac{x+2}{3}\right)$	M1 A1 A1✓ [3] B2,1 [2] B1, B1 [2] B1 [1] M1 A1 [2]	Makes $\cos$ subject, then $\cos^{-1}$ ✓ for $2\pi - 1$st answer. B1 for ≥ -5. B1 for ≤ 1. B1 starts and ends at same point. Starts decreasing. One cycle only. B1 for shape, not 'V' or 'U'. Make x the subject, copes with 'cos'. Needs to be in terms of x.

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9 $y = \frac{8}{x} + 2x$ (i) $\frac{dy}{dx} = \frac{-8}{x^2} + 2$ (– 6 at A) $\frac{dy}{dt} = \frac{dy}{dx} \times \frac{dx}{dt}$ $\rightarrow -0.24$ (ii) $\int y^2 = \int \frac{64}{x^2} + 4x^2 + 32$ $= \left(\frac{-64}{x} + \frac{4x^3}{3} + 32x \right)$ Limits 2 to 5 used correctly $\rightarrow 271.2\pi$ or 852 (allow 271π or 851 to 852)	M1 A1 M1 A1 [4] M1 A3,2,1 DM1 A1 [6]	Attempt at differentiation. algebraic – unsimplified. Ignore notation – needs product of 0.04 and ‘his’ $\frac{dy}{dx}$. Use of integral of y^2 (ignore π) 3 terms $\rightarrow -1$ each error. Uses correct limits correctly. (omission of π loses last mark)
10 $f : x \mapsto 2x^2 - 3x, g : x \mapsto 3x + k,$ (i) $2x^2 - 3x - 9 > 0$ $\rightarrow x = 3$ or $-1\frac{1}{2}$ Set of x $x > 3$, or $x < -1\frac{1}{2}$ (ii) $2x^2 - 3x = 2\left(x - \frac{3}{4}\right)^2 - \frac{9}{8}$ Vertex $\left(\frac{3}{4}, -\frac{9}{8}\right)$ (iii) $6x^2 - 9x + k = 0$ Use of $b^2 - 4ac \rightarrow k = \frac{27}{8}$ oe.	M1 A1 A1 [3] B3,2,1 B1 $\sqrt{}$ [4] B1 M1 A1 [3]	For solving quadratic. Ignore $>$ or $\geq$ condone $\geq$ or $\leq$ – x^2 in bracket is an error. $\sqrt{}$ on ‘c’ and ‘b’. Used on a quadratic (even fg).

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1	$(x+1)(x-2)$ or other valid method $-1, 2$ $x < -1, x > 2$	M1 A1 A1 [3]	Attempt soln of eqn or other method Penalise $\leq, \geq$
2	$f(x) = 2x^{\frac{1}{2}} + x (+c)$ $5 = -2 \times \frac{1}{2} + 4 + c$ $c = 2$	M1A1 M1 A1 [4]	Attempt integ $x^{\frac{1}{2}}$ or $+x$ needed for M Sub (4, 5). c must be present
3	(i) gradient of perpendicular = $-\frac{1}{2}$ soi $y - 1 = -\frac{1}{2}(x - 3)$ (ii) $C = (-9, 6)$ $AC^2 = [3 - (-9)]^2 + [1 - 6]^2$ (ft on <i>their C</i>) $AC = 13$	B1 B1 [2] B1 M1 A1 [3]	soi in (i) or (ii) OR $AB^2 = [3 - (-21)]^2 + [1 - 11]^2$ M1 $AB = 26$ A1 $AC = 13$ A1
4	(i) $\mathbf{OD} = 4\mathbf{i} + 3\mathbf{j}$ $\mathbf{CD} = 4\mathbf{i} + 3\mathbf{j} - 10\mathbf{k}$ (ii) $\mathbf{OD} \cdot \mathbf{CD} = 9 + 16 = 25$ $ \mathbf{OD} = \sqrt{25}$ or $ \mathbf{CD} = \sqrt{125}$ $25 = \sqrt{25} \times \sqrt{125} \times \cos \theta$ oe $\text{ODC} = 63.4^\circ$ (or 1.11 rads)	B1 B1 $\sqrt{h}$ [2] M1 M1 M1 A1 [4]	$\sqrt{h}$ for $\mathbf{OD} - 10\mathbf{k}$ Use of $x_1x_2 + y_1y_2 + z_1z_2$ Correct method for moduli All connected correctly cao
5	(a) $\frac{a}{1-r} = 8a \Rightarrow 1(a) = 8(a)(1-r)$ $r = \frac{7}{8}$ oe (b) $a + 4d = 197$ $\frac{10}{2}[2a + 9d] = 2040$ $d = 14$	B1 B1 [2] B1 B1 M1A1 [4]	Or $2a + 9d = 408$ Attempt to solve simultaneously
6	(i) sector areas are $\frac{1}{2}11^2\alpha, \frac{1}{2}5^2\alpha$ $k = \frac{\frac{1}{2} \times 11^2\alpha - \frac{1}{2} \times 5^2\alpha}{\frac{1}{2} \times 5^2\alpha}$ $k = \frac{96}{25}$ or 3.84	B1 M1 A1 [3]	Sight of $11^2, 5^2$ Or $\frac{11^2 - 5^2}{5^2}$

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(ii) perimeter shaded region = $11\alpha + 5\alpha + 6 + 6 = 16\alpha + 12$ perimeter unshaded region = $5\alpha + 5 + 5 = 5\alpha + 10$ $16\alpha + 12 = 2(5\alpha + 10)$ $\alpha = 4/3$ or 1.33	B1 B1 M1 A1 [4]	
7 (a) $x^2 - 1 = \sin \frac{\pi}{3}$ $x = \pm 1.366$ (b) $2\theta + \frac{\pi}{3} = \frac{5\pi}{6} \left(\text{or } \frac{13\pi}{6} \text{ or } \frac{\pi}{6} \right)$ $2\theta = \frac{\pi}{2} \left(\text{or } \frac{11\pi}{6} \right)$ $\theta = \frac{\pi}{4}, \frac{11\pi}{12}$	M1 A1A1[✓] [3] B1 M1 A1A1 [4]	[✓] for negative of 1st answer 1 correct angle on RHS is sufficient Isolating 2θ SC decimals 0.785 & 2.88 scores M1B1
8 (i) $81(x^8)$ (ii) $10 \times 3^3(x^8)$ soi leading to their answer $270(x^8)$ (iii) $k \times$ (i) 405 soi + (ii) 675 (x^8)	B1 [1] B1B1 B1 [3] M1 A1 DM1 A1 [4]	B1 for 10, 5C2 or 5C3. B1 for 3^3. But must be multiplied. $k \neq 1, 0$
9 $\frac{dy}{dx} = -k^2(x+2)^{-2} + 1 = 0$ $x+2 = \pm k$ $x = -2 \pm k$ $\frac{d^2y}{dx^2} = 2k^2(x+2)^{-3}$ When $x = -2 = k$, $\frac{d^2y}{dx^2} = \left(\frac{2}{k}\right)$ which is (> 0) min When $x = -2 - k$, $\frac{d^2y}{dx^2} = \left(\frac{2}{-k}\right)$ which is (< 0) max	M1A1 DM1 A1 M1 M1 A1 A1 [8]	Attempt differentiation & set to zero Attempt to solve cao Attempt to differentiate again Sub their x value with k in it into $\frac{d^2y}{dx^2}$ Only 1 of bracketed items needed for each but $\frac{d^2y}{dx^2}$ and x need to be correct.

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10 (i) Range is $(y) \geq c^2 + 4c$ $x^2 + 4x = (x + 2)^2 - 4$ (Smallest value of c is) -2 (ii) $5a + b = 11$ $(a + b)^2 + 4(a + b) = 21$ $(11 - 5a + a)^2 + 4(11 - 5a + a) = 21$ $(8)(2a^2 - 13a + 18) = (8)(2a - 9)(a - 2)$ $= 0$ $a = \frac{9}{2}, 2$ OR $b = \left(-\frac{23}{2}\right), 1$ Alt. (ii) Last 5 marks $f^{-1}(x) = \sqrt{x+4} - 2$ B1 $g(1) = f^{-1} = (21)$ used M1 $a + b = \sqrt{25} - 2 = 3$ A1 Solve $a + b = 3, 5a + b = 11$ M1 $a = 2, b = 1$ A1	B1 M1 A1 [3] B1 B1 M1 M1 A1 A1 [6]	Allow $>$ OR $\frac{dy}{dx} = 2x + 4 = 0$ -2 with no (wrong) working gets B2 OR corresponding equation in b OR $(8)(2b + 23)(b - 1) = 0$ A1 for either a or b correct. Condone 2nd value. Spotted solution scores only B marks. Alt. (ii) Last 4 marks $(a + b + 7)(a + b - 3) = 0$ M1A1 (Ignore solution involving $a + b = -7$) Solve $a + b = 3, 5a + b = 11$ M1 $a = 2, b = 1$ A1
11 (i) $\frac{dy}{dx} = \left[\frac{1}{2}(x^4 + 4x + 4)^{\frac{1}{2}}\right] \times [4x^3 + 4]$ At $x = 0$, $\frac{dy}{dx} = \frac{1}{2} \times \frac{1}{2} \times 4 = (1)$ Equation is $y - 2 = x$ (ii) $x + 2 = \sqrt{x^4 + 4x + 4} \Rightarrow (x + 2)^2$ $= x^4 + 4x + 4$ $x^2 - x^4 = 0$ oe $x = 0, \pm 1$ (iii) $(\pi) \left[\frac{x^5}{5} + 2x^2 + 4x \right]$ $(\pi) \left[0 - \left(\frac{-1}{5} + 2 - 4 \right) \right]$ $\frac{11\pi}{5}$ (6.91) oe	B1B1 M1 A1 [4] B1 B1 B2,1,0 [4] M1A1 DM1 A1 [4]	Sub $x = 0$ and attempt eqn of line following differentiation. AG www Attempt to integrate y^2 Apply limits $-1 \rightarrow 0$