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7268412163

MATHEMATICS **9709/12**

Paper 1 Pure Mathematics 1 **February/March 2025**

1 hour 50 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- If additional space is needed, you should use the lined page at the end of this booklet; the question number or numbers must be clearly shown.
- You should use a calculator where appropriate.
- You must show all necessary working clearly; no marks will be given for unsupported answers from a calculator.
- Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place for angles in degrees, unless a different level of accuracy is specified in the question.

INFORMATION

- The total mark for this paper is 75.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **16** pages.

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1 A curve has equation $y = 5 + 3x - 2x^2$ and a straight line has equation $y = kx + 13$, where k is a constant.

Find the set of values of k for which the curve and the line do **not** meet. [4]

$5+3x-2x^2 = kx+13$

$2x^2 + (k-3)x + 8 = 0$

$b^2 - 4ac < 0$

$(k-3)^2 - 4(2)(8) < 0$

$k^2 - 6k + 9 - 64 < 0$

$k^2 - 6k - 55 < 0$

$k^2 - 6k - 55 = 0$

$k^2 - 11k + 5k - 55 = 0$

$k(k-11) + 5(k-11) = 0$

$(k-11)(k+5) = 0$

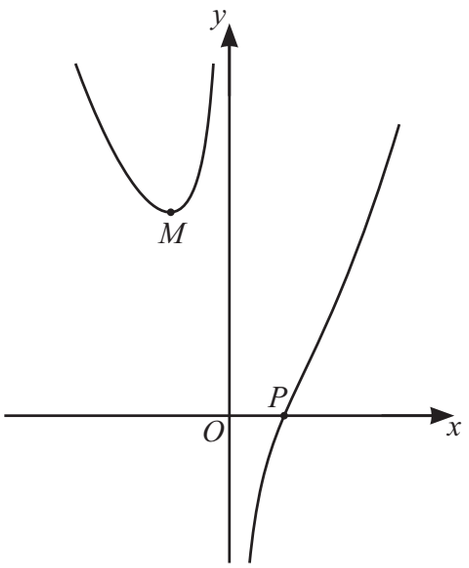
$k = 11$ or $k = -5$

$-5 < k < 11$

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2



The diagram shows the curve with equation $y = 2x^2 - \frac{5}{x} + 3$. The curve crosses the x-axis at the point $P(1, 0)$ and M is a minimum point.

(a) Find the gradient of the curve at P. [2]

$\frac{dy}{dx} = 4x + \frac{5}{x^2}$

Gradient at P = $4(1) + \frac{5}{(1)^2}$

Gradient at P = 9

(b) Find the coordinates of M. Give each coordinate correct to 3 significant figures. [3]

M → $4x + \frac{5}{x^2} = 0$

M → $4x^3 + 5 = 0$

M → $x = \sqrt[3]{-5/4}$

x = -1·08

$y = 2\left(\sqrt[3]{-5/4}\right)^2 - \frac{5}{\sqrt[3]{-5/4}} + 3$

y = 9·96

Co-ordinates of M = (-1·08, 9·96)

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3 **(a)** Find the complete expansion of $\left(2x-\frac{3}{x}\right)^4$. [4]

$^4C_0(2x)^4\left(\frac{-3}{x}\right)^0 + {}^4C_1(2x)^3\left(\frac{-3}{x}\right)^1 + {}^4C_2(2x)^2\left(\frac{-3}{x}\right)^2 + {}^4C_3(2x)^1\left(\frac{-3}{x}\right)^3 + {}^4C_4(2x)^0\left(\frac{-3}{x}\right)^4$

$\left(1\times 16x^4\times 1\right) + \left(4\times 8x^3\times\frac{-3}{x}\right) + \left(6\times 4x^2\times\frac{9}{x^2}\right) + \left(4\times 2x\times\frac{-27}{x^3}\right) + \left(1\times 1\times\frac{81}{x^4}\right)$

$= 16x^4 - 96x^2 + 216 - \frac{216}{x^2} + \frac{81}{x^4}$

(b) Hence determine the coefficient of x^2 in the expansion of $\left(x^2+5\right)\left(2x-\frac{3}{x}\right)^4$. [2]

$(x^2+5)\left(16x^4 - 96x^2 + 216 - \frac{216}{x^2} + \frac{81}{x^4}\right)$

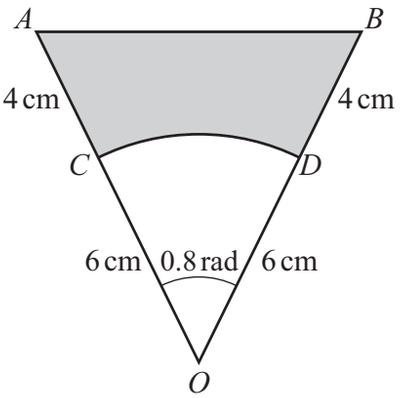
Coefficient of x^2 $= 216 - 480$

$= -264$

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4



The diagram shows a triangle OAB where $OA = OB = 10$ cm and angle $AOB = 0.8$ radians. Points C and D on OA and OB respectively are such that the arc CD is part of a circle with centre O and radius 6 cm. The shaded region is bounded by the arc CD and the line segments CA, AB and BD.

(a) Find the perimeter of the shaded region. [3]

$AB = \sqrt{10^2+10^2-2\times10\times10\times\cos(0.8)}$

$AB = 7.7884$

Sof $CD \rightarrow r\theta = 6(0.8) = 4.8$

Perimeter $= AC + $ Sof $CD + BD + AB$

Perimeter $= 4 + 4.8 + 4 + 7.7884$

Perimeter $= 20.6$

(b) Find the area of the shaded region. [3]

Shaded Area = Area of Triangle - Area of Sector

Shaded Area $= \left[\frac{1}{2}\times10\times10\times\sin0.8\right] - \left[\frac{1}{2}\times6\times6\times0.8\right]$

Shaded Area $= 35.8678 - 14.4$

Shaded Area $= 21.5$

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5 An arithmetic progression has first term 5 and common difference 6.

For this progression, find the sum of all the terms that lie between 150 and 400. [6]

$a = 5$

$d = 6$

$5 + (n-1)6 = 150$	$5 + (n-1)6 = 400$
$6n - 1 = 150$	$6n - 1 = 400$
$6n = 151$	$6n = 401$
$n = 25.16$	$n = 66.8$
$n = 26$	$n = 67$

S of terms $= 66 - 26 + 1 = 41$

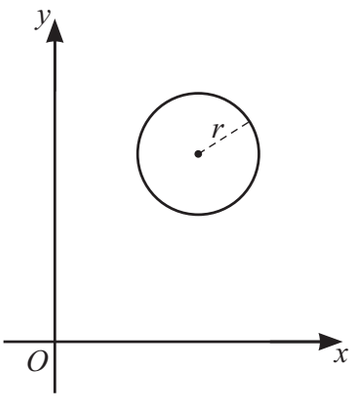
$S_{41} = \frac{41}{2}(310 + 40 \times 6)$

$= 11275$

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6



The diagram shows a circle C of radius r, where $x > 0$ and $y > 0$ for all points on C. The least distance between any point on C and the x-axis is 8 units, and the least distance between any point on C and the y-axis is 5 units.

(a) State the coordinates of the centre of the circle in terms of r. [1]

$(5+r, 8+r)$

(b) Given that the distance between the origin and the centre of the circle is 15 units, find the value of r. [3]

$(5+r)^2 + (8+r)^2 = 15^2$

$r^2 + 10r + 25 + r^2 + 16r + 64 - 225 = 0$

$2r^2 + 26r - 136 = 0$

$r^2 + 13r - 68 = 0$

$r^2 + 17r - 4r - 68 = 0$

$r(r+17) - 4(r+17) = 0$

$(r-4)(r+17) = 0$

$r = 4$ or $r = -17$

(c) The point on the circle furthest from the origin is denoted by P.

Find the gradient of the tangent to the circle at P. [2]

Centre = $(9, 12)$

m of O to C: $\frac{12}{9} = \frac{4}{3}$

m of Tangent at P: $-3/4$.

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7 **(a)** Show that $3\tan^2\theta + 5\sin^2\theta \equiv \dfrac{8\sin^2\theta - 5\sin^4\theta}{1-\sin^2\theta}$. [3]

$\dfrac{3\sin^2\theta}{\cos^2\theta} + 5\sin^2\theta$

$= \dfrac{3\sin^2\theta + 5\sin^2\theta(1-\sin^2\theta)}{1-\sin^2\theta}$

$= \dfrac{3\sin^2\theta + 5\sin^2\theta - 5\sin^4\theta}{1-\sin^2\theta}$

$= \dfrac{8\sin^2\theta - 5\sin^4\theta}{1-\sin^2\theta}$.

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(b) Hence solve the equation $3\tan^2\theta + 5\sin^2\theta = 9$ for $0° < \theta < 270°$. [4]

$$\frac{8\sin^2\theta - 5\sin^2\theta}{1-\sin^2\theta} = 9$$

$$8\sin^2\theta - 5\sin^4\theta = 9 - 9\sin^2\theta$$

$$5\sin^4\theta - 17\sin^2\theta + 9 = 0$$

$$5a^2 - 17a + 9 = 0$$

$$= \frac{-b \pm \sqrt{b^2-4ac}}{2a} = \frac{17 \pm \sqrt{(17)^2-4(5)(9)}}{2(5)}$$

$\sin^2\theta = 2.744030651$ OR $\sin^2\theta = 0.6559693$

$\sin\theta = 1.6565$ OR $\sin\theta = 0.8099$

$\alpha =$ No solution. $\alpha = \sin^{-1}(0.8099) = 54.0861$

$\theta = 54.1, 125.9, 234.1, 365.9$

Hence $\theta = 54.1, 125.9, 234.1$

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8 A geometric progression is such that its second term is -120 and its sum to infinity is 160.

(a) Find the common ratio. [4]

$ar = -120$

$\frac{a}{1-r} = 160$

$a = 160 - 160r$

$\frac{-120}{r} = 160 - 160r$

$-120 = 160r - 160r^2$

$160r^2 - 160r - 120 = 0$

$4r^2 - 4r - 3 = 0$

$4r^2 - 6r + 2r - 3 = 0$

$2r(2r-3) + 1(2r-3) = 0$

$(2r+1)(2r-3) = 0$

$r = -\frac{1}{2}$ or $r = \frac{3}{2}$

$a = 240$.

(b) The first nine terms of the progression are now removed.

Find the sum to infinity of the remaining terms of the progression. [3]

$a = T_{10} = 240\left(-\frac{1}{2}\right)^9$

$T_{10} = -\frac{15}{32}$

$S_\infty = \frac{-\frac{15}{32}}{1 + \frac{1}{2}}$

$S_\infty = \frac{-5}{16}$

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9 A curve is such that $\frac{d^2y}{dx^2} = \frac{6}{x^4} - \frac{5}{x^3}$. It is given that the curve has a stationary point at $\left(\frac{1}{2}, 9\right)$.

(a) Use the expression for $\frac{d^2y}{dx^2}$ to determine whether the stationary point is a maximum or a minimum point. [2]

$\frac{d^2y}{dx^2} = \frac{6}{(\frac{1}{2})^4} - \frac{5}{(\frac{1}{2})^3}$

$\frac{d^2y}{dx^2} = 56.$

Positive means minimum.

(b) Find the equation of the curve. [7]

$\frac{dy}{dx} = \int 6x^{-4} - 5x^{-3}$

$\frac{dy}{dx} = \frac{-2}{x^3} + \frac{5}{2x^2} + c$

$0 = \frac{-2}{\frac{1}{8}} + \frac{5}{2(\frac{1}{4})} + c$

$0 = -16 + 10 + c$

$c = 6$

$\frac{dy}{dx} = \frac{-2}{x^3} + \frac{5}{2x^2} + 6$

$y = \int -2x^{-3} + \frac{5}{2}x^{-2} + 6$

$y = x^{-2} - \frac{5}{2x} + 6x + D$

$9 = 4 - 5 + 3 + D$

$9 = 2 + D$

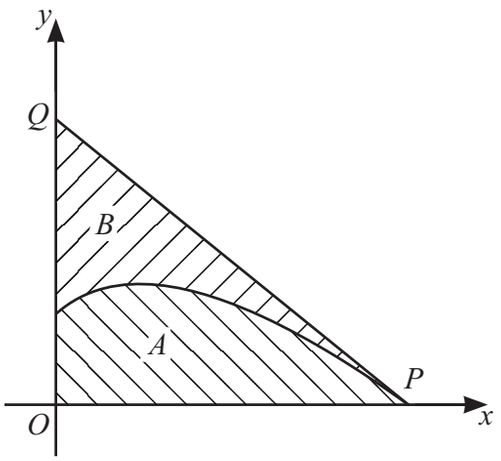
$D = 7$

$y = x^{-2} - \frac{5}{2x} + 6x + 7$

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The diagram shows the curve with equation

$$y = 4(3x+4)^{\frac{1}{2}} - 2x - 6$$

for values of x such that $0 \leqslant x \leqslant 7$. The tangent to the curve at the point $P\,(7, 0)$ meets the y-axis at the point Q. Region A is bounded by the curve and the two axes. Region B is bounded by the curve, the line segment PQ and the y-axis.

(a) Find the area of region A. [4]

Area = $\int_0^7 4(3x+4)^{\frac{1}{2}} - 2x - 6$

Area = $\left[\frac{8}{9}(3x+4)^{\frac{3}{2}} - x^2 - 6x\right]_0^7$

Area = $\frac{1000}{9} - 49 - 42 - \frac{64}{9}$

Area = 13

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(b) Find the area of region B. [5]

$\frac{dy}{dx} = 6(3x+4)^{-1/2} - 2$

$\frac{dy}{dx} = \frac{6}{5} - 2$

$\frac{dy}{dx} = -\frac{4}{5}$

Point = $(7, 0)$

$y = -\frac{4}{5}(x-7)$

$y = -\frac{4}{5}x + \frac{28}{5}$

Point B: $(0, \frac{28}{5})$

Area of Triangle = $\frac{1}{2} \times 7 \times \frac{28}{5} = \frac{98}{5}$

Area B = $\frac{98}{5} - 13$

Area B = $\frac{33}{5}$

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11 Functions f and g are defined for all real values of x by

$$\mathrm{f}(x) = 4x^2 - c \quad \text{and} \quad \mathrm{g}(x) = 2x + k,$$

where c and k are positive constants. It is given that $\mathrm{g}^{-1}(3k+1) = c$.

(a) Show that $\mathrm{gf}(x) = 8x^2 - k - 1$. [4]

$y = 2x + K$

$\frac{y-K}{2} = x$

$g^{-1}(x) = \frac{x-K}{2}$

$g^{-1}(3K+1) = \frac{3K+1-K}{2} = \frac{2K+1}{2}$

$gf(x) = 2\left(4x^2 - \frac{2K+1}{2}\right) + K$

$gf(x) = 8x^2 - 2K - 1 + K$

$gf(x) = 8x^2 - K - 1 \Rightarrow$ Proved!!

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(b) The curve with equation $y = 8x^2 - k - 1$ is transformed to the curve with equation $y = \mathrm{h}(x)$ by the following sequence of transformations.

Translation of $\begin{pmatrix} 2 \\ 3 \end{pmatrix}$
Stretch in the y-direction by scale factor k
Reflection in the x-axis

Find an expression for $\mathrm{h}(x)$ in terms of x and k. [3]

$h(x) = 8(x-2)^2 - k - 1 + 3$

$h(x) = 8k(x-2)^2 - k^2 + 2k$

$h(x) = k^2 - 2k - 8k(x-2)^2$

(c) The range of h is given by $\mathrm{h}(x) \leqslant 15$.

Find the values of c and k. [3]

$k^2 - 2k - 15 = 0$

$k^2 - 5k + 3k - 15 = 0$

$k(k-5) + 3(k-5) = 0$

$(k+3)(k-5) = 0$

$k = 5$ or $k = -3$

$k = 5$

$g(c) = 3(5) + 1$

$2c + 5 = 16$

$2c = 11$

$c = 11/2$

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MATHEMATICS **9709/12**

Paper 1 Pure Mathematics 1 **February/March 2025**

MARK SCHEME

Maximum Mark: 75

Published

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Question	Answer	Marks	Guidance
1	$[kx+13=5+3x-2x^2 \Rightarrow]\ 2x^2+(k-3)x+8\ [=0]$	**B1**	OE Eliminate y to obtain a three-term quadratic.
	Use of $b^2-4ac<0$ or $b^2-4ac=0$ with *their* coefficients of *their* new quadratic equation. Condone ± errors only.	**M1**	OE Use of '>0' scores M0, unless recovered.
	–5 and 11	**A1**	Identification of correct critical values, may only be seen in their final answer.
	$-5<k<11$	**A1**	CWO Do not allow 'or'. A0 if $\leqslant$ sign or signs used.
		4	

Question	Answer	Marks	Guidance
2(a)	$4x+\frac{5}{x^2}$	**B1**	OE
	$\left[\frac{dy}{dx}=\right]\ 9$	**B1 FT**	Correct use of $x=1$ in *their* two-term differentiated expression, defined as an expression with one correct power.
		2	

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Question	Answer	Marks	Guidance
2(b)	*Their* $\left(4x+\frac{5}{x^2}\right)=0$ and valid method as far as '$x=...$'	**M1**	Equate their derivative of the form $Ax\pm\frac{B}{x^2}$ to zero, where $A,\ B\neq 0$, and solve. If no working is seen, this can be implied by a correct answer for x.
	$x=-1.08$	**A1**	AWRT
	$y=9.96$	**A1**	AWRT
		3	

Question	Answer	Marks	Guidance
3(a)	$(2x)^4$ and $\left(\frac{\pm 3}{x}\right)^4$	**B1**	May be seen in a full expansion. This can be implied by $16x^4$ and $+\frac{81}{x^4}$ unless they are clearly using $+\frac{3}{x}$ throughout.
	$4(2x)^3\left(\frac{-3}{x}\right)+6(2x)^2\left(\frac{-3}{x}\right)^2+4(2x)\left(\frac{-3}{x}\right)^3$	**B1**	Correct combination of numerical coefficients for the middle three terms. Can be implied by a correct full expansion.
	$\left[16x^4\right]+k_1x^2+k_2\left[x^0\right]+k_3x^{-2}\left[+81x^{-4}\right]$	**M1**	OE Powers now simplified correctly with *their* $k_1,\ k_2,\ k_3\neq 0$.
	$16x^4-96x^2+216-216x^{-2}+81x^{-4}$	**A1**	OE
		4	

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Question	Answer	Marks	Guidance
3(b)	Use of (*their* 216) + 5×(*their* –96) only, to arrive at the coefficient of x^2	**M1**	Other terms may be seen.
	–264	**A1**	Accept $-264x^2$ as the final answer.
		2	

Question	Answer	Marks	Guidance
4(a)	6×0.8	**B1**	Accept $\frac{45.8}{360}\times12\pi$.
	$AB^2=10^2+10^2-2\times10\times10\cos0.8$ or $AB=2(10\sin0.4)$ or $AB=\frac{10\sin0.8}{\sin\left(\frac{\pi-0.8}{2}\right)}$	**M1**	Allow angles correctly converted to degrees for this mark. $0.8\,\text{rad} = 45.8°$, $O\hat{A}B = O\hat{B}A = 67.1°$. $\left(\frac{\pi-0.8}{2}\right)=1.17$ This mark can be implied by AWRT 7.8.
	20.6	**A1**	AWRT
		3	
4(b)	[Area of sector =] $\frac{1}{2}\times6^2\times0.8$	**B1**	
	[Area of triangle =] $\frac{1}{2}\times10^2\times\sin0.8$ or $10\sin0.4\times10\cos0.4$ or other complete method.	**M1**	OE Allow use of *their* value of θ or $\frac{1}{2}\theta$ in degrees.
	21.5	**A1**	AWRT
		3	

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Question	Answer	Marks	Guidance
5	Attempt to solve either: $5+(n-1)6=150$ or $5+(n-1)6=400$	**M1**	Attempt to determine positions of first and last terms involved
	$\frac{151}{6}$ and $\frac{401}{6}$	**A1**	OE Can be implied by 25 or 26 and 66 or 67.
	Correct use of S_n formula with *their* 66 and *their* 25	**M1**	
	$S_{66\ or\ 67}-S_{25\ or\ 26}$	**M1**	
	$S_{66}-S_{25}$	**A1**	
	11275	**A1**	
	Alternative Method for Question 5:		
	Attempt to find new *a* and *l* for reduced series	**M1**	
	155 and 395	**A1**	
	$their\ 395=their\ 155+(n-1)6$	**M1**	Attempt to find *n*, which results in 40, 41 or 42.
	$n=41$	**A1**	CWO
	$S_{their\ 41}=\frac{their\ 41}{2}(their\ 155+their\ 395)$	**M1**	OE
	11275	**A1**	
		6	

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Question	Answer	Marks	Guidance
6(a)	$(r+5,\ r+8)$	**B1**	OE Allow $x=r+5,\ y=r+8$. If values are stated without reference to x and y, take the first value to be *their* x.
		1	
6(b)	$their(r+5)^2+their(r+8)^2=15^2$	**B1 FT**	OE Following *their* answers to **(a)**, which must both contain r.
	$\left[r^2+13r-68[=0]\Rightarrow\right](r+17)(r-4)[=0]$	**M1**	Or other valid method of solution for *their* three-term quadratic.
	$[r=]4$	**A1**	CWO $r=-4\Rightarrow r=4$ scores A0.
			Special Case: After B1M0, $r=4$ scores **SCB1**, but after B1M0, $r=-4\Rightarrow r=4$ scores B0.
		3	
6(c)	$\dfrac{their(r+8)}{their(r+5)}$ from **(a)** with *their* r from **(b),** or $\dfrac{(their\ r\ \text{from}(\mathbf{b}))+8}{(their\ r\ \text{from}(\mathbf{b}))+5}$	**M1**	$r>0$ only.
	$-\dfrac{3}{4}$	**A1 FT**	OE, i.e. $-\dfrac{their(r+5)}{their(r+8)}$ or $-\dfrac{(their\ r\ \text{from}(\mathbf{b}))+8}{(their\ r\ \text{from}(\mathbf{b}))+5}$.
		2	

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Question	Answer	Marks	Guidance
7(a)	Use of $\tan^2\theta = \dfrac{\sin^2\theta}{\cos^2\theta}$	**M1**	
	Relevant use of $\cos^2\theta = 1 - \sin^2\theta$ at least once	**M1**	
	$\dfrac{8\sin^2\theta - 5\sin^4\theta}{1 - \sin^2\theta}$	**A1**	**AG** All necessary detail needed.
		3	
7(b)	Attempt to solve *their* $5\sin^4\theta - 17\sin^2\theta + 9 = 0$ using a "correct" method	***M1**	Allow ± errors in arriving at *their* quadratic in $\sin^2\theta$. This can be implied by either $\left[\sin^2\theta =\right]$ 2.744 or 0.6559.
	$\sin\theta = [\pm]0.81[0]$ or $\sqrt{\dfrac{17 - \sqrt{109}}{10}}$	**A1**	Condone inclusion of $\sin\theta = 1.65$ for this mark. Allow $\sqrt{\dfrac{17 \pm \sqrt{109}}{10}}$. This mark can be implied by correct values.
	Their 54.1, and $180 - $ *their* 54.1 or $180 + $ *their* 54.1	**DM1**	A correct method for obtaining a second angle within the range $0 < $ *their* $54.1 < 90$.
	54.1, 125.9, 234.1	**A1**	AWRT A0 for additional values between $0°$ and $270°$.
		4	

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Question	Answer	Marks	Guidance
8(a)	$ar = -120$ and $\frac{a}{1-r} = 160$	**B1**	
	$-\frac{120}{r} \times \frac{1}{1-r} = 160$ or $\frac{a}{1+\frac{120}{a}} = 160$	**M1**	Elimination of either a or r. Condone ± errors for this mark.
	$4r^2 - 4r - 3[=0]$ or $a^2 - 160a - 19200[=0]$	**A1**	OE Rearrange to arrive at a three-term quadratic.
	$r = -\frac{1}{2}$ only	**A1**	
		4	

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Question	Answer	Marks	Guidance
8(b)	[$a =$] 240	**B1 FT**	$-120 \div (their\ r)$, where $-1 < r < 1$, $r \neq 0$.
	$160 - \dfrac{240\left(1-(-\frac{1}{2})^9\right)}{1-\left(-\frac{1}{2}\right)}$	**M1**	With (*their* 240) and $(their\ r)$ as long as $-1 < r < 1$, $r \neq 0$. Condone reversed subtraction.
	Alternative Method 1 for first two marks of Question 8(b)		
	[$a =$] 240	**B1 FT**	$-120 \div (their\ r)$, where $-1 < r < 1$, $r \neq 0$.
	$\dfrac{240\times(-\frac{1}{2})^9}{1-\left(-\frac{1}{2}\right)}$	**M1**	Correctly using the 10th term as 'a' and the sum to infinity. With (*their* 240) and $(their\ r)$ as long as $-1 < r < 1$, $r \neq 0$.
	Alternative Method 2 for first two marks of Question 8(b)		
	[10th term =] $-\frac{15}{32}$, 0.46875 OE	**B1 FT**	$-120 \div (their\ r)^8$, where $-1 < r < 1$, $r \neq 0$.
	$\dfrac{-\frac{15}{32}}{1-\left(-\frac{1}{2}\right)}$	**M1**	With $(their\ a$ and $r)$, where $-1 < r < 1$, $r \neq 0$.
	$-\frac{5}{16}$ or -0.3125	**A1**	A0 for –0.313 without sight of $-\frac{5}{16}$ or –0.3125. Condone use of $r = \frac{3}{2}$ to provide a second solution.
		3	

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Question	Answer	Marks	Guidance
9(a)	$\frac{6}{\left(\frac{1}{2}\right)^4} - \frac{5}{\left(\frac{1}{2}\right)^3}$	**M1**	Substitute $x = \frac{1}{2}$ and evaluate second derivative.
	$96 - 40[= 56] > 0 \Rightarrow$ Minimum	**A1**	CWO Evidence and conclusion. **SC B1** for $\frac{\mathrm{d}^2y}{\mathrm{d}x^2} > 0$ without sight of $96 - 40$ or 56.
		2	

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Question	Answer	Marks	Guidance
9(b)	$\left\{\frac{6}{-3}x^{-3}\right\}\left\{-\frac{5}{-2}x^{-2}\right\}[+c_1]$	**B1 B1**	OE B1 for each correct { }.
	$0=\frac{6}{-3}\left(\frac{1}{2}\right)^{-3}-\frac{5}{-2}\left(\frac{1}{2}\right)^{-2}+c_1$	**M1**	Substitute $x=\frac{1}{2}$ into two terms of an integrated expression (at least one correct power), now with c_1, and equate to 0 to find c_1.
	$c_1=6$	**A1**	
	$k_1x^{-2}+k_2x^{-1}+k_3x\ \ [+c_2]$	**M1**	Integration of *their* $\frac{\mathrm{d}y}{\mathrm{d}x}$ to produce at least two terms with correct powers, $k_1, k_2 \neq 0$.
	$9=\frac{1}{\left(\frac{1}{2}\right)^2}-\frac{5}{2\left(\frac{1}{2}\right)}+6\left(\frac{1}{2}\right)+c_2$	**M1**	OE Substitute $\left(\frac{1}{2}, 9\right)$ into integrated expression (at least two correct powers) to find c_2.
	$y=x^{-2}-\frac{5}{2}x^{-1}+6x+7$	**A1**	OE Condone their final answer being $c_2=7$ if a completely correct simplified expression for the equation containing c_2 has been stated previously.
		7	

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Question	Answer	Marks	Guidance
10(a)	$\left\{\frac{2}{3}\times\frac{4}{3}(3x+4)^{\frac{3}{2}}\right\}\left\{-\frac{2x^2}{2}-6x\right\}$	**B1 B1**	B1 for each correct { }.
	$[A=]\left(\frac{8}{9}(21+4)^{\frac{3}{2}}-7^2-6\times7\right)-\left(\frac{8}{9}(4)^{\frac{3}{2}}\right)$	**M1**	Correct use of 7 and 0 in an expression with at least two terms with two correct powers.
	13	**A1**	
		4	

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Question	Answer	Marks	Guidance
10(b)	$\left(2(3x+4)^{-\frac{1}{2}}\times 3\right)-2$	**B1**	
	$y-0=\left(their\ \frac{\mathrm{d}y}{\mathrm{d}x}\ with\ x=7\right)(x-7)$	***M1**	Using $x=7$, *their* value for $\frac{\mathrm{d}y}{\mathrm{d}x}$ and then any form of the equation of a straight line using $(7, 0)$.
	Either:		
	$[Q$ is$]$ $\left(0, \frac{28}{5}\right)$	**DM1**	Use $x=0$ in *their* equation of PQ.
	[Area of OPQ =] $\frac{1}{2}\times 7\times\left(their\ \frac{28}{5}\right)$	**DM1**	
	$\left[\frac{1}{2}\times 7\times\left(their\frac{28}{5}\right)-\left(their\,13\,\text{from}(\mathbf{a})\right)\right]=\frac{33}{5}$	**A1 FT**	Only FT, following B0M1DM1DM1, from *their* **(a)** if $\left(their\,13\ \text{from}(\mathbf{a})\right)<\frac{98}{5}$ and the area is > 0.
	Or:		
	$\int\left(their\left(-\frac{4}{5}(x-7)\right)\right)\mathrm{d}x$	**DM1**	
	Evaluating $their\left(-\frac{4}{5}\left(\frac{x^2}{2}-7x\right)\right)$ with limits 7 and 0	**DM1**	

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Question	Answer	Marks	Guidance
10(b)	$\left[\left(their\text{ area of }OPQ\right)-\left(their\,13\,from\left(\boldsymbol{a}\right)\right)\right]=\frac{33}{5}$	**A1 FT**	Only FT, following B0M1DM1DM1, from their **(a)** if $\left(their\,13\,from\left(a\right)\right)<\frac{98}{5}$ and the area is > 0.
		5	

Question	Answer	Marks	Guidance
11(a)	State or imply $g^{-1}\left(x\right)=\frac{1}{2}\left(x-k\right)$ or equivalent	**B1**	
	Obtain $\frac{1}{2}\left(3k+1-k\right)=c$ and hence $2k+1=2c$	**B1**	OE
	Or:		
	$g\left(c\right)=3k+1$	**B1**	
	$[\,2c+k=3k+1\Rightarrow]\;2c=2k+1$	**B1**	OE
	Then:		
	$\left[gf\left(x\right)=\right]\;2\left(4x^2-c\right)+k$	**M1**	Allow ± errors only.
	$\left[8x^2-2c+k\Rightarrow 8x^2-\left(2k+1\right)+k\Rightarrow\right]\;gf\left(x\right)=8x^2-k-1$	**A1**	**AG** All necessary detail needed.
		4	

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Question	Answer	Marks	Guidance
11(b)	$8(x-2)^2-k-1+3$	**B1**	OE Translation coming before the stretch
	$k\left(their\left(8(x-2)^2-k-1+3\right)\right)$	**B1 FT**	OE Stretch
	$\left[h(x)=\right]-\left(k\left(their\left(8(x-2)^2-k-1+3\right)\right)\right)$	**B1 FT**	OE Reflection
		3	
11(c)	$k^2-2k=15$ or $k^2-2k\leqslant 15$	**B1**	OE
	$k=5$ only	**B1**	
	$c=\frac{11}{2}$ only	**B1**	OE
		3	

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3768021152

MATHEMATICS **9709/11**

Paper 1 Pure Mathematics 1 **May/June 2025**

1 hour 50 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- If additional space is needed, you should use the lined page at the end of this booklet; the question number or numbers must be clearly shown.
- You should use a calculator where appropriate.
- You must show all necessary working clearly; no marks will be given for unsupported answers from a calculator.
- Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place for angles in degrees, unless a different level of accuracy is specified in the question.

INFORMATION

- The total mark for this paper is 75.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **20** pages. Any blank pages are indicated.

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1 Solve the equation $6\sin\theta = 1 + \frac{2}{\sin\theta}$ for $-180° < \theta < 180°$. [4]

$6\sin\theta - 1 = 2/\sin\theta$

$6\sin^2\theta - \sin\theta - 2 = 0$

$6\sin^2\theta - 4\sin\theta + 3\sin\theta - 2 = 0$

$2\sin\theta(3\sin\theta - 2) + 1(3\sin\theta - 2) = 0$

$(2\sin\theta + 1)(3\sin\theta - 2) = 0$

$\sin\theta = -1/2$ OR $\sin\theta = 2/3$

$\alpha = \sin^{-1} = 30$, OR $\alpha = \sin^{-1} = 41.81...$

$\theta = 210, 330$ OR $\theta = 41.8, 138.2$

$-150, -30$ $-318.2, -221.8$

Hence $\theta = -30, -150, 41.8, 138.2$,

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2 The equation of a curve is such that $\frac{dy}{dx} = 4(2x-5)^3 - 9x^{\frac{1}{2}}$. The curve passes through the point $A\left(4, -\frac{11}{2}\right)$.

(a) Find the gradient of the normal to the curve at the point A. [2]

Gradient of Tangent at A = $4(2\times4-5)^3 - 9(4)^{1/2}$

Gradient of Tangent at A = 90

Gradient of Normal at A = $-1/90$

(b) Find the equation of the curve. [4]

$\frac{dy}{dx} = 4(2x-5)^3 - 9x^{1/2}$

$y = \frac{1}{2}(2x-5)^4 - 6x^{3/2} + c$

$-\frac{11}{2} = \frac{81}{2} - 48 + c$

$c = 2$

$y = \frac{1}{2}(2x-5)^4 - 6x^{3/2} + 2$

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3 The third term of a geometric progression is 18 and the sum of the first three terms is 26. It is given that the common ratio is negative.

(a) Find the tenth term of the progression. Give your answer correct to 3 significant figures. [5]

$ar^2 = 18$

$a + ar + ar^2 = 26$

$a + ar = 8$

$a(1 + r) = 8$

$\frac{18(1+r)}{r^2} = 8$

$18 + 18r = 8r^2$

$8r^2 - 18r - 18 = 0$

$4r^2 - 9r - 9 = 0$

$4r^2 - 12r + 3r - 9 = 0$

$4r(r - 3) + 3(r - 3) = 0$

$(4r + 3)(r - 3) = 0$

$r = -\frac{3}{4}$ or $r = 3$

Since r is negative

$r = -\frac{3}{4}$ $\quad a = 32.$

$T_{10} = 32\left(\frac{-3}{4}\right)^9$

$T_{10} = -2.40$

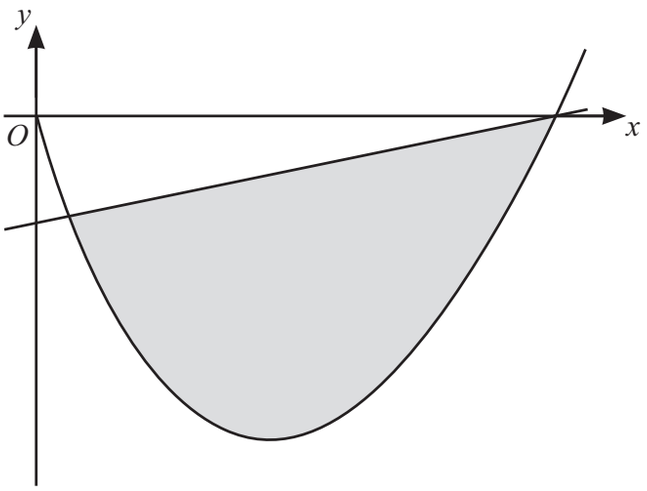
(b) Find the exact value of the sum to infinity of the progression. [2]

$S_\infty = \frac{32}{1 + \frac{3}{4}}$

$S_\infty = \frac{128}{7}$

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4



The diagram shows the curve with equation $y = 5x^{\frac{3}{2}} - 20x$ and the line with equation $y = x - 16$.
The x-coordinates of the points of intersection of the curve and line are 1 and 16.

Find the area of the shaded region between the curve and the line. [5]

Area under line = $-\int_1^{16} x - 16$

Area under line: $-\left[\frac{x^2}{2} - 16x\right]_1^{16}$

Area under line: $-[128 - 256 - \frac{1}{2} + 16]$

Area under line: $\frac{225}{2}$

Area under curve: $-\int_1^{16} 5x^{3/2} - 20x$

Area under curve: $-\left[2x^{5/2} - 10x^2\right]_1^{16}$

Area under curve: $-[2048 - 2560 - 2 + 10]$

Area under curve: 504.

Shaded Area = $\left|\frac{225}{2} - 504.\right|$

Shaded Area = $\frac{783}{2}$ OR 391.5

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5 **(a)** Find the first three terms, in ascending powers of x, in the expansion of each of the following expressions.

(i) $(2-px)^5$ [2]

$^5C_0\,(2)^5(-px)^0 + {}^5C_1\,(2)^4(-px)^1 + {}^5C_2\,(2)^3(-px)^2$

$(1\times 32\times 1) + (5\times 16\times -px) + (10\times 8\times p^2x^2)$

$= 32 - 80px + 80p^2x^2$

(ii) $\left(1-\frac{1}{2}x\right)^4$ [2]

$^4C_0\,(1)^4\left(-\frac{1}{2}x\right)^0 + {}^4C_1\,(1)^3\left(-\frac{1}{2}x\right)^1 + {}^4C_2\,(1)^2\left(-\frac{1}{2}x\right)^2$

$(1\times 1\times 1) + (4\times 1\times -\frac{1}{2}x) + (6\times 1\times \frac{1}{4}x^2)$

$= 1 - 2x + \frac{3}{2}x^2$

(b) Given that the coefficient of x^2 in the expansion of $(2-px)^5\left(1-\frac{1}{2}x\right)^4$ is 93, find the possible values of the constant p. [3]

$(32 - 80px + 80p^2x^2)\left(1 - 2x + \frac{3}{2}x^2\right)$

Coefficient of x^2: $80p^2 + 160p + 48 - 93 = 0$

$80p^2 + 160p - 45 = 0$

$16p^2 + 32p - 9 = 0$

$16p^2 + 36p - 4p - 9 = 0$

$4p(4p+9) - 1(4p+9) = 0$

$(4p-1)(4p+9) = 0$

$p = \frac{1}{4}$ OR $p = -\frac{9}{4}$

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6 The equation of a curve is $2x^2 - kxy + 2 = 0$ and the equation of a line is $y = px + 3$, where k and p are constants.

(a) Given that $k = 2$ and $p = 11$, find the coordinates of the points of intersection of the curve and the line. [4]

Curve: $2x^2 - 2xy + 2 = 0$

Line: $y = 11x + 3$

$2x^2 - 2x(11x + 3) + 2 = 0$

$2x^2 - 22x^2 - 6x + 2 = 0$

$20x^2 + 6x - 2 = 0$

$10x^2 + 3x - 1 = 0$

$10x^2 + 5x - 2x - 1 = 0$

$5x(2x + 1) - 1(2x + 1) = 0$

$(2x + 1)(5x - 1) = 0$

$x = -\frac{1}{2}$ or $x = \frac{1}{5}$

$y = -\frac{5}{2}$ or $y = \frac{26}{5}$

Points of intersection: $(-\frac{1}{2}, -\frac{5}{2})$ and $(\frac{1}{5}, \frac{26}{5})$

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(b) Given instead that $p = 4$, find the set of values of k for which the curve and the line do not intersect. [5]

Curve: $2x^2 - kxy + 2 = 0$

line: $y = 4x + 3$

$2x^2 - kx(4x+3) + 2 = 0$

$2x^2 - 4kx^2 - 3kx + 2 = 0$

$(2-4k)x^2 + (-3k)x + 2 = 0$

$b^2 - 4ac < 0$

$9k^2 - 8(2-4k) < 0$

$9k^2 - 16 + 32k < 0$

$9k^2 + 32k - 16 = 0$

$9k^2 + 36k - 4k - 16 = 0$

$9k(k+4) - 4(k+4) = 0$

$(9k-4)(k+4) = 0$

$k = 4/9$ or $k = -4$

$-4 < k < 4/9$

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7 The equation of a curve is $y = 4x^2 + \frac{9}{x^2} - 8$.

(a) A point P is moving along the curve in such a way that its y-coordinate is decreasing at 5 units per second.

Find the rate at which the x-coordinate of point P is changing when $x = 2$. [4]

$\frac{dy}{dx} = 8x - \frac{18}{x^3}$

$\frac{dy}{dx} = 8(2) - \frac{18}{(2)^3}$

$\frac{dy}{dx} = 16 - \frac{18}{8}$

$\frac{dy}{dx} = \frac{55}{4}$

$\frac{dy}{dt} = \frac{dy}{dx} \times \frac{dx}{dt}$

$-5 = \frac{55}{4} \times \frac{dx}{dt}$

$\frac{dx}{dt} = \frac{-4}{11}$

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(b) Find the coordinates of the stationary points of the curve and determine their nature. [5]

$\frac{dy}{dx} = 8x - \frac{18}{x^3}$

$\frac{d^2y}{dx^2} = 8 + \frac{54}{x^4}$

$8x - \frac{18}{x^3} = 0$

$x^4 = \frac{18}{8}$

$x^4 = \frac{9}{4}$

$x = \pm\sqrt{\frac{3}{2}}$

$y = 4\left(\frac{3}{2}\right) + \frac{9}{1.5} - 8$

$y = 4$

Nature $= 8 + \frac{54}{\frac{9}{4}} = 32$ Positive means both minimum

Co-ordinates of Stationary points $= \left(\sqrt{\frac{3}{2}}, 4\right)$ and $\left(-\sqrt{\frac{3}{2}}, 4\right)$

Nature: Both minimum

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8 The circle with equation $x^2+y^2-6x+10y-27=0$ intersects the line $x=-2$ at the points P and Q.

Find the area of the triangle formed by the tangents to the circle at P and Q, and the line $x=-2$. [8]

$y^2+10y-6(-2)+(-2)^2-27=0$

$y^2+10y-11=0$

$y^2+11y-y-11=0$

$y(y+11)-1(y+11)=0$

$(y-1)(y+11)=0$

$y=1$ OR $y=-11$

$x=-2$ OR $x=-2$

Point Q = $(-2,1)$

Point P = $(-2,-11)$

m of CQ = $\frac{-6}{5}$

m of Tangent at Q = $\frac{5}{6}$.

Point = Q = $(-2,1)$

$y-1=\frac{5}{6}(x+2)$

$y-1=\frac{5}{6}x+\frac{5}{3}$

$y=\frac{5}{6}x+\frac{8}{3}$

m of CP = $\frac{6}{5}$

m of Tangent = $-5/6$.

Point P = $(-2,-11)$

$y+11=-\frac{5}{6}(x+2)$

$y+11=-\frac{5}{6}x-\frac{5}{3}$

$y=-\frac{5}{6}x-\frac{38}{3}$

$\frac{5}{6}x+\frac{8}{3}=-\frac{5}{6}x-\frac{38}{3}$

$\frac{46}{3}=-\frac{5}{3}x$

$46=-5x$

$-\frac{46}{5}=-9.2=x$

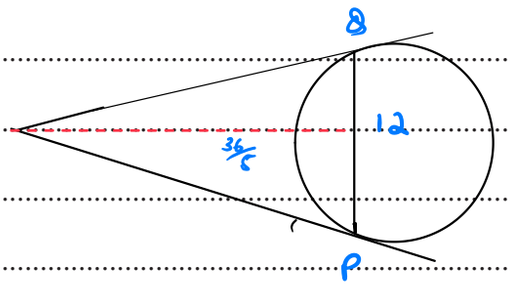
Height of Δ = 7.2.

Base = 12.

Area = $\frac{1}{2}\times 12\times 7.2$.

Area = 6×7.2

Area = 43.2



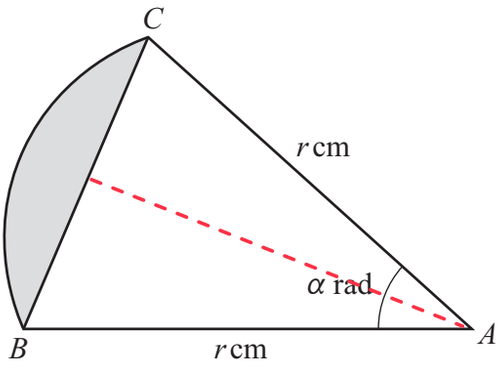
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9



The diagram shows a sector ABC of a circle with centre A and radius r cm. The angle BAC is α radians, where $0 < \alpha < \frac{1}{2}\pi$.

(a) It is given that the area of the triangle ABC is $4\,\text{cm}^2$ and the area of the sector ABC is $8\alpha\,\text{cm}^2$.

Find the exact area of the shaded segment. [4]

$\frac{1}{2}r^2 \times \sin\alpha = 4$

$\frac{1}{2}r^2 \times \alpha = 8\alpha$

$r^2 = 16$

$r = 4$

$\frac{1}{2} \times 16 \times \sin\alpha = 4$

$\sin\alpha = \frac{1}{2}$

$\alpha = \sin^{-1}\left(\frac{1}{2}\right)$

$\alpha = \frac{1}{6}\pi$

Shaded Area = Area of Sector − Area of Triangle.

Shaded Area = $8\alpha - 4$

Shaded Area = $\frac{8}{6}\pi - 4$

Shaded Area = $\frac{4}{3}\pi - 4$

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(b) It is given instead that the length of the chord BC is $\frac{1}{\sqrt{2}}r$ cm but the area of the triangle ABC is still $4\,\text{cm}^2$.

Find the area of the shaded segment. Give your answer correct to 3 significant figures. [4]

$\frac{1}{\sqrt{2}}r$

$\sin\left(\frac{1}{2}a\right) = \frac{1}{2\sqrt{2}}$

$\frac{1}{2}a = \sin^{-1}\left(\frac{1}{2\sqrt{2}}\right)$

$a = 2\sin^{-1}\left(\frac{1}{2\sqrt{2}}\right)$

$a = 0.72273$

$\frac{1}{2}r^2 \times \sin(0.72273) = 4$

$r^2 = 12.09492$

$r = 3.477$

Shaded Area = Area of Sector − Area of Triangle.

Shaded Area $= \left(\frac{1}{2}(3.477)^2 \times 0.72273\right) - 4$

Shaded Area $= 4.368732 - 4$

Shaded Area $= 0.369$.

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10 The functions f and g are defined by

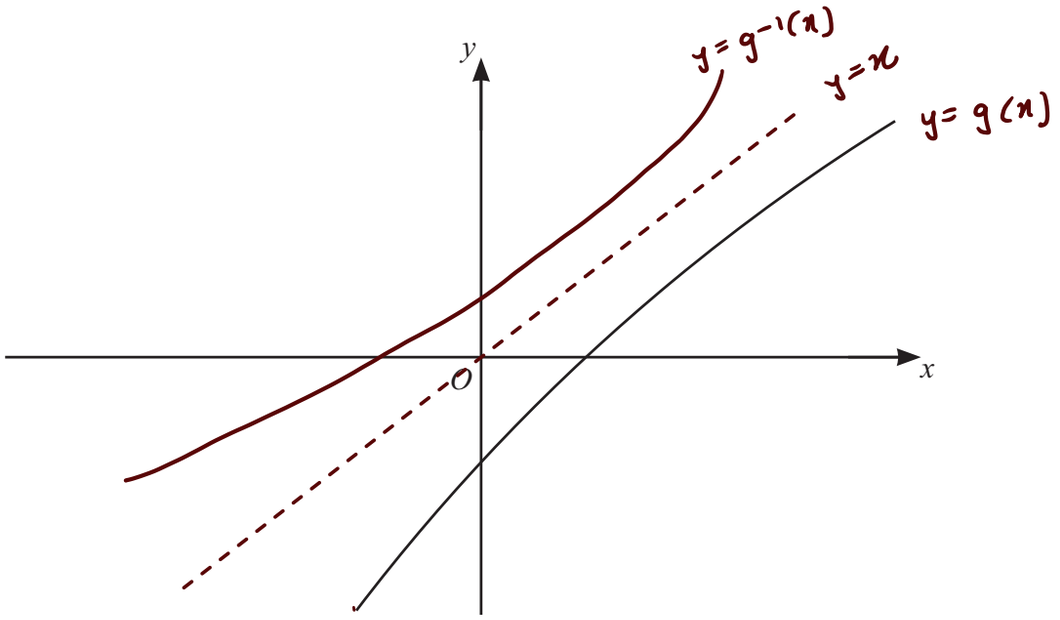
$$f(x) = \sqrt{x} \qquad \text{for } x \geqslant 0,$$

$$g(x) = 3\sqrt{x+2} - 5 \qquad \text{for } x \geqslant -2.$$

(a) Describe fully a sequence of transformations which transforms the graph of $y = f(x)$ to the graph of $y = g(x)$. You should make clear the order in which the transformations are applied. [5]

vertical stretch with factor 3

Translation with $T = \begin{pmatrix} -2 \\ -5 \end{pmatrix}$



The diagram shows the graph of $y = g(x)$.

(b) On the diagram sketch the graph of $y = g^{-1}(x)$ together with any relevant mirror line. [2]

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(c) Find an expression for $g^{-1}(x)$. [2]

$y = 3\sqrt{x+2} - 5$

$\left(\frac{y+5}{3}\right)^2 - 2 = x$

$g^{-1}(x) = \left(\frac{x+5}{3}\right)^2 - 2$

(d) State the range of g^{-1}. [1]

$g^{-1}(x) \geqslant -2$

The function h is defined by

$$h(x) = x - 2 \qquad \text{for } x \geqslant 0.$$

(e) Find the value of $g^{-1}h(4)$. [1]

$h(4) = 4 - 2 = 2$

$g^{-1}h(4) = \left(\frac{2+5}{3}\right)^2 - 2$

$g^{-1}h(4) \quad \frac{49}{9} - 2$

$g^{-1}h(4) = 31/9$

(f) Explain why the composite function hg^{-1} cannot be formed. [1]

hg^{-1} cannot be formed as the range of g^{-1} [$g^{-1}(x) \geqslant -2$] is not within the domain of h. [$x \geqslant 0$]

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Question	Answer	Marks	Guidance
1	$6\sin^2\theta - \sin\theta - 2[=0] \quad \Rightarrow \quad [(2\sin\theta+1)(3\sin\theta-2)=0]$	**M1**	For expressing as a 3-term quadratic. Terms need not all be on the same side.
	$\sin\theta = -\frac{1}{2}$ or $\sin\theta = \frac{2}{3}$	**A1**	For both. Allow AWRT 0.667.
	$\theta = -150°,\ -30°,\ 41.8°,\ 138.2°$	**A1 A1**	AWRT A1 for any correct angle from a correct value of $\sin\theta$, A1 for all 4 and no others in the interval $-180° < \theta < 180°$. **SC B1** for $\frac{-5\pi}{6}$, $\frac{-\pi}{6}$, 0.730^c, 2.41^c if use of radians is clear.
		4	

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Question	Answer	Marks	Guidance
2(a)	[Gradient of tangent] = $4\left(2\times4-5\right)^3-9\times4^{\frac{1}{2}}\left[=90\right]$	**M1**	Substitute $x = 4$ into $\frac{\mathrm{d}y}{\mathrm{d}x}$. $\frac{-11}{2} = 4\left(2\times4-5\right)^3-9\times4^{\frac{1}{2}}$ is M0 unless they reach $-\frac{1}{90}$.
	[Gradient of normal] = $-\frac{1}{90}$	**A1**	AWRT –0.0111.
		2	
2(b)	$\left[y\right]=\left\{\frac{1}{2}\left(2x-5\right)^4\right\}\left\{-6x^{\frac{3}{2}}\right\}\left[+c\right]$	**B1 B1**	Accept unsimplified.
	$-\frac{11}{2}=\frac{1}{2}\times\left(2\times4-5\right)^4-6\times4^{\frac{3}{2}}+c$	**M1**	Sub $x=4, y=-\frac{11}{2}$ into an integrated expression and attempt to find c.
	$y=\frac{1}{2}\left(2x-5\right)^4-6x^{\frac{3}{2}}+2$	**A1**	Condone $c = 2$ as final answer if 'y = …' seen previously. Fractions must be simplified. Accept f(x) in place of y.
		4	

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Question	Answer	Marks	Guidance
3(a)	$ar^2 = 18$, $a + ar + ar^2 = 26$ or $a + ar + 18 = 26$	**B1**	For first and second, or first and third equations.
	$\frac{18}{r^2} + \frac{18}{r} + 18 = 26 \Rightarrow 8r^2 - 18r - 18[=0] \Rightarrow [(4r+3)(r-3)=0]$	**M1**	For expressing as a 3-term quadratic from two expressions with sign errors only. Terms need not all be on one side.
	$r = -\frac{3}{4}$ [or $r = 3$]	**A1**	CAO Allow –0.75.
	$a = 32$	**A1**	CAO Ignore $a = 2$. May not find a, but instead use expression for a in terms of r $\left(\text{e.g. } a = \frac{18}{r^2}\right)$ and then find a in part **(b)**.
	Tenth term = −2.40	**A1**	AWRT. Ignore other values.
	Alternative Method for first three marks in Question 3(a)		
	$ar^2 = 18$, $26 = \frac{a(1-r^3)}{1-r}$	**B1**	
	$26 = \frac{\frac{18}{r^2}(1-r^3)}{1-r} \Rightarrow 8r^3 - 26r^2 + 18[=0]$	**M1**	Expressing as a 3-term cubic from two expressions with sign errors only. Terms need not all be on one side
	$r = -\frac{3}{4}$ [or $r = 3,\ 1$]	**A1**	CAO Accept –0.75.
		5	Note: **SC B1 B1 B1** is possible following B1 M0 if no method is shown for finding $r = -\frac{3}{4}$ [or $r = 3$].

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Question	Answer	Marks	Guidance
3(b)	$S_\infty = \dfrac{32}{1-\left(-\frac{3}{4}\right)}$	**M1**	FT on values of a and r, provided $-1 < r < 1$.
	$\dfrac{128}{7}$	**A1 FT**	FT on values of a and r, provided $-1 < r < 0$. Condone extra answers.
		2	

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Question	Answer	Marks	Guidance
4	Attempt to integrate $(x-16)-\left(5x^{\frac{3}{2}}-20x\right)\left[=-5x^{\frac{3}{2}}+21x-16\right]$	***M1**	Attempt to integrate both terms and subtract areas. Accept subtraction either way round.
	$\left\{\frac{1}{2}x^2-16x\right\}[-]\left\{\left(2x^{\frac{5}{2}}-10x^2\right)\right\}\left[=-2x^{\frac{5}{2}}+\frac{21}{2}x^2-16x\right]$	**B1 B1**	B1 for each integral. B2,1, 0 for $-2x^{\frac{5}{2}}+\frac{21}{2}x^2-16x$.
	Use of limits 1 and 16	**DM1**	Limits either way round. Minimum –7.5 – 384. E.g. $((\frac{1}{2}-16)-(2-10))-((128-256)-(2048-2560))$ = (15.5 + 8) – (–128 + 512) = –7.5 – 384 = –391.5 Or (–2 + 10.5 – 16) – (–2048 + 2688 – 256) = –7.5 – 384 = –391.5 Or $-504+\frac{225}{2}=-391.5$
	391.5 or $\frac{783}{2}$	**A1**	CAO **SC B1** for correct answer if M1 B1 B1 DM0 scored.

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Question	Answer	Marks	Guidance
	Alternative Method for Question 4		
	Height of triangle = 15	**B1**	
	Area of triangle = $\frac{1}{2}\times 15\times$ *their* height $= 112.5$	**M1**	
	Integrates $\pm\left(5x^{\frac{3}{2}}-20x\right)$ to $\pm\left(2x^{\frac{5}{2}}-10x^{2}\right)$	**B1**	
	Use of limits 1 and 16 on their integral and subtracts area of triangle	**DM1**	Limits either way round.
	391.5	**A1**	CAO **SC B1** for correct answer if M1 B1 B1 DM0 scored.
		5	

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Question	Answer	Marks	Guidance
5(a)(i)	$32-80px+80p^2x^2$	**B2,1,0**	B2 for all correct. B1 for any two correct. May be in a list. Ignore terms with higher powers.
		2	
5(a)(ii)	$1-2x+\frac{3}{2}x^2$	**B2,1,0**	OE B2 for all correct. B1 for any two correct. May be in a list. Ignore terms with higher powers.
		2	
5(b)	Coefficient of $x^2 = 32\times\frac{3}{2}+(-2\times-80p)+80p^2$	***M1**	3 terms FT *their* values.
	$48+160p+80p^2=93 \Rightarrow 5(4p+9)(4p-1)[=0]$	**DM1**	Set *their* 3-term coefficient to 93 and attempt to solve by factorising or other accepted method for solving their 3-term quadratic.
	$p=-\frac{9}{4}$ and $p=\frac{1}{4}$	**A1**	**SC B1** following M0 if method for solving quadratic is not shown.
		3	

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Question	Answer	Marks	Guidance
6(a)	$2x^2 - 2x(11x+3) + 2\ [=0]$	***M1**	Substitutes $k = 2$, $p = 11$ and eliminates y or x. Note: $\frac{2x^2+2}{2x} = 11x + 3$.
	$-20x^2 - 6x + 2[=0] \Rightarrow [(5x-1)(2x+1)=0]$	**DM1**	Simplifies to a 3-term quadratic. Terms need not all be on one side.
	Coordinates $\left(-\frac{1}{2}, -\frac{5}{2}\right)$, $\left(\frac{1}{5}, \frac{26}{5}\right)$	**A1 A1**	A1 for either both x-values correct or for both coordinates of one point correct. Need not be written as coordinates. Fractions must be simplified.
		4	

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Question	Answer	Marks	Guidance
6(b)	$2x^2 - kx(4x+3) + 2 = 0 \Rightarrow (2-4k)x^2 - 3kx + 2 \ [= 0]$	***M1**	Substitute and reduce to 3-term quadratic. Terms need not all be on one side. Allow $2x^2 - 4kx^2 - 3kx + 2 \ [= 0]$.
	$(2-4k)x^2 - 3kx + 2 \ [= 0]$	**A1**	Correct quadratic. All terms to one side. Allow $2x^2 - 4kx^2 - 3kx + 2 \ [= 0]$.
	$b^2 - 4ac = 9k^2 - 4 \times (2-4k) \times 2$	**DM1**	Use of $b^2 - 4ac$. Must be correct for *their a, b, c.* *a* term must have two components.
	$9k^2 + 32k - 16 \ [< 0] \Rightarrow (k+4)(9k-4) \ [< 0]$	**M1**	Attempt to solve a 3-term quadratic in *k* by factorising or other accepted method for solving their 3-term quadratic.
	$-4 < k < \frac{4}{9}$	**A1**	**SC B1** following M0 if no method shown for solving quadratic. A0 for correct answer following incorrect quadratic. Must be *k.* Allow other correct notation.
		5	

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Question	Answer	Marks	Guidance
7(a)	$\left[\frac{dy}{dx} =\right] 8x - \frac{18}{x^3}$	**B1**	OE Accept unsimplified.
	At $x = 2, \frac{dy}{dx} = \frac{55}{4}$	**M1**	OE For evaluating *their* $\frac{dy}{dx}$ or $\frac{dx}{dy}$.
	$\frac{dy}{dx} = \frac{dy}{dt} \times \frac{dt}{dx} \Rightarrow \frac{55}{4} = -5 \times \frac{dt}{dx}$	**M1**	For correct use of chain rule with ±5 and *their* $\frac{dy}{dx}$ (may be algebraic). Condone missing brackets.
	$\left[\frac{dx}{dt} =\right] -\frac{4}{11}$	**A1**	Or decreasing at a rate of $\frac{4}{11}$. AWRT −0.364.
		4	

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Question	Answer	Marks	Guidance
7(b)	$8x - \frac{18}{x^3} = 0 \left[\Rightarrow x^4 = \frac{9}{4}\right]$	**M1**	Equating *their* 2-term $\frac{\mathrm{d}y}{\mathrm{d}x}$ to zero.
	$x = \pm\sqrt{\frac{3}{2}}$ or $\pm\frac{\sqrt{6}}{2}$	**A1**	AWRT ± 1.22.
	$y = 4$ (for both)	**A1**	A0 A1 if one point correct. AWRT 4.00.
	$\left[\frac{\mathrm{d}^2y}{\mathrm{d}x^2}\right] = 8 + \frac{54}{x^4}$	**M1**	For differentiation. At least one correct term needed.
	So both are minima	**A1**	No need for reason. WWW on x-values.
		5	

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Question	Answer	Marks	Guidance
8	Centre of circle is $(3,-5)$	**B1**	Seen or implied.
	$x=-2 \Rightarrow y^2+10y-11[=0]$ $[\Rightarrow (y-1)(y+11)=0]$ or $(y+5)^2=36$.	**M1**	3-term quadratic. Terms need not all be on one side. $(3,-5)$ must be correct if it is used.
	$y=1$ and $y=-11$	**A1**	No method needed for solving quadratic.
	Gradient of line PC is $\frac{-5-1}{3-(-2)}$ $\left[=\frac{-6}{5}\right]$ or gradient of line QC is $\frac{-5+11}{3-(-2)}$ $\left[=\frac{6}{5}\right]$	**M1**	At least one correct.
	Gradient of tangent at P is $\frac{5}{6}$ or gradient of tangent at Q is $-\frac{5}{6}$	**A1**	At least one correct.
	Equation of tangent is $y-1=\frac{5}{6}(x+2)$. Crosses $y=-5$ at $x=-\frac{46}{5}$, so distance $=\frac{36}{5}$ or equations of two tangents are $y-1=\frac{5}{6}(x+2)$ and $y+11=-\frac{5}{6}(x+2)$ and these meet when $x=-\frac{46}{5}$ so distance $=\frac{36}{5}$	**M1**	Distance from point of intersection to line $x=-2$ is $6\times\frac{6}{5}$ $\left[=\frac{36}{5}\right]$. Note $y=\frac{5}{6}x+\frac{8}{3}$ and $y=\frac{-5}{6}x-\frac{38}{3}$.
	Area $=\frac{1}{2}\times 12\times \textit{their}\,\frac{36}{5}$	**M1**	Condone use of $\frac{46}{5}$.
8	$\frac{432}{10}$ or $\frac{216}{5}$ or 43.2	**A1**	
		8	

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Question	Answer	Marks	Guidance
9(a)	$\frac{1}{2}r^2\alpha = 8\alpha \Rightarrow r = 4$	**B1**	
	$\frac{1}{2}r^2\sin\alpha = 4 \Rightarrow \alpha = \frac{\pi}{6}$	**B1**	
	Area of segment $= \frac{1}{2}\times 4^2 \times \frac{\pi}{6} - 4$	**M1**	Using *their r* and *their* α. Condone $4 - \frac{1}{2}\times 4^2 \times \frac{\pi}{6}$. Allow use of $8 \times$ *their* $\alpha - 4$
	$= \frac{4}{3}\pi - 4$	**A1**	Fraction must be simplified. Allow $\frac{4\pi - 12}{3}$.
		4	
9(b)	$r^2 + r^2 - 2r^2\cos\alpha = \frac{1}{2}r^2 \Rightarrow 2\cos\alpha = \frac{3}{2}$	***M1**	Or $\alpha = 2\sin^{-1}\left(\frac{\sqrt{2}}{4}\right)$ or $2\sin^{-1}\left(\frac{1}{2\sqrt{2}}\right)$ Using $\alpha = \frac{\pi}{6}$ or $r = 4$ implies 0/4.
	$\alpha = 0.723\left[0.72273\ldots\right] \Rightarrow \frac{1}{2}r^2\sin\left(\textit{their}\,0.723\right)\left[= 4\right]$	**DM1**	Or $\alpha = 41.4 \Rightarrow \frac{1}{2}r^2\sin\left(\textit{their}\,41.4\right)\left[= 4\right]$
	$r = 3.48$ $\left[3.4777\ldots\right]$	**A1**	Accept $r^2 = 12.1$ AWRT.
	Area of segment $= \frac{1}{2}\times 3.48^2 \times 0.723 - 4 = 0.371$ $[0.37068\ldots]$	**A1**	Or $\frac{1}{2}\times 3.48^2 \times \frac{\pi}{180}\times 41.4 - 4 = 0.371$ AWRT.
		4	

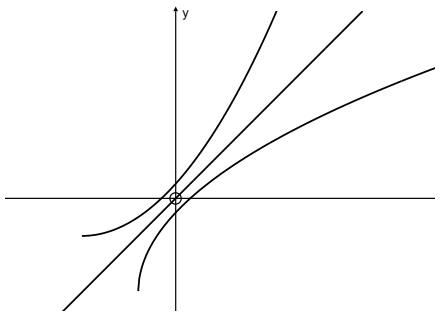
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Question	Answer	Marks	Guidance
10(a)	{Stretch}{factor 3} {parallel to y-axis/in y-direction/vertically}	**B2,1,0**	
	Translation $\begin{pmatrix} -2 \\ -5 \end{pmatrix}$	**B2,1,0**	
		B1	Transformations correct and in the correct order.
	Alternative solution for Question 10(a)		
	Translation $\begin{pmatrix} -2 \\ -\frac{5}{3} \end{pmatrix}$	**B2,1,0**	
	{Stretch} {factor 3} {parallel to y-axis/in y-direction/vertically}	**B2,1,0**	
		B1	Transformations correct and in the correct order.
		5	The translation parallel to the x-axis can be made anywhere in the sequence. Note: If 3 or more transformations are given then maximum 2/5 for any correct one.

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Question	Answer	Marks	Guidance
10(b)		**B1**	For line or curve in correct quadrants only.
		B1	Must not pass through (0, 0). Fully correct including the line $y = x$. No label needed. Approximate reflection of $y = f(x)$. Curve must not come back on itself.
		2	
10(c)	$y = 3\sqrt{x+2} - 5 \Rightarrow \frac{y+5}{3} = \sqrt{x+2}$	**M1**	Allow *x*/*y* swap.
	$[g^{-1}(x)] = \left(\frac{x+5}{3}\right)^2 - 2$	**A1**	Must be in terms of *x*. Not '$x = \ldots$'.
		2	
10(d)	[Range of g^{-1} is $g^{-1}(x)$] $\geqslant -2$	**B1 FT**	Following *their* $g^{-1}(x) = \left(\frac{x+a}{b}\right)^2 - c$ where *a*, *b*, *c* are non-zero. Not $x \geqslant -2$. Not > -2. Accept other notations, e.g. $[-2, \infty]$.
		1	

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Question	Answer	Marks	Guidance
10(e)	$[g^{-1}h(4) = g^{-1}(2)] = \frac{31}{9}$	**B1**	AWRT 3.44.
		1	
10(f)	hg^{-1} is impossible since the **range** of $\mathbf{g}^{-1}$ is $x \geqslant -2$ is **not within** the **domain** of **h**, which is $x \geqslant 0$	**B1**	Minimum acceptable: 'The range of g^{-1} is not within the domain of h'.
		1	

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CANDIDATE NAME

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1307625250

MATHEMATICS **9709/12**

Paper 1 Pure Mathematics 1 **May/June 2025**

1 hour 50 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- If additional space is needed, you should use the lined page at the end of this booklet; the question number or numbers must be clearly shown.
- You should use a calculator where appropriate.
- You must show all necessary working clearly; no marks will be given for unsupported answers from a calculator.
- Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place for angles in degrees, unless a different level of accuracy is specified in the question.

INFORMATION

- The total mark for this paper is 75.
- The number of marks for each question or part question is shown in brackets [ ].

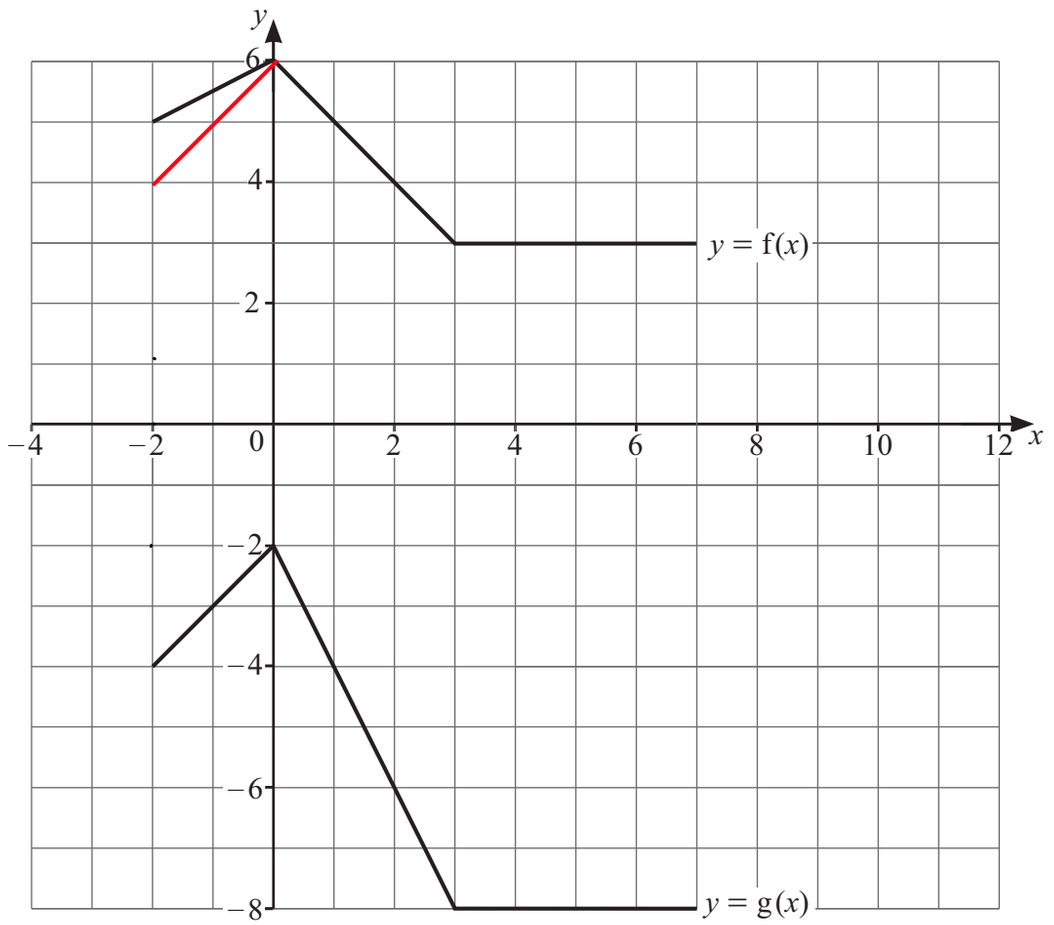
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1



The diagram shows the graphs with equations $y = f(x)$ and $y = g(x)$.

Describe fully a sequence of two transformations which transforms the graph of $y = f(x)$ to the graph of $y = g(x)$. Make clear the order in which the transformations should be applied. [4]

Translation with $T = \begin{pmatrix} 0 \\ -7 \end{pmatrix}$

Vertical stretch of factor 2.

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2 Find the coordinates of the points of intersection of the curve and the line with equations

$$2xy + 5y^2 = 24 \quad \text{and} \quad 2x + y + 4 = 0. \qquad [4]$$

$2x = -y - 4$

$y(-y-4) + 5y^2 = 24$

$-y^2 - 4y + 5y^2 - 24 = 0$

$4y^2 - 4y - 24 = 0$

$y^2 - y - 6 = 0$

$y^2 - 3y + 2y - 6 = 0$

$y(y-3) + 2(y-3) = 0$

$(y+2)(y-3) = 0$

$y = -2$ or $y = 3$

$x = -1$ or $x = -\frac{7}{2}$

Co-ordinates of points of intersection = $(-1, -2)$ and $(-\frac{7}{2}, 3)$.

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3 The coefficient of x^7 in the expansion of $\left(px^2 + \frac{4}{p}x\right)^5$ is 1280.

Find the value of the constant p. [4]

$T_{r+1} = {}^5C_r (px^2)^{5-r} \left(\frac{4}{p}x\right)^r$

$T_4 = {}^5C_3 (px^2)^2 \left(\frac{4}{p}x\right)^3$

$T_4 = 10 \times p^2 x^4 \times \frac{64}{p^3} x^3$

$T_4 = \frac{640}{p} x^7.$

Coefficient of $x^7 = \frac{640}{p} = 1280$

$= \frac{640}{1280} = p$

$= p = \frac{1}{2}$

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4 A point P is moving along the curve with equation $y = ax^{\frac{3}{2}} - 12x$ in such a way that the x-coordinate of P is increasing at a constant rate of 5 units per second.

(a) Find the rate at which the y-coordinate of P is changing when $x = 9$. Give your answer in terms of the constant a. [3]

$\frac{dy}{dx} = \frac{3}{2}ax^{\frac{1}{2}} - 12$

$\frac{dy}{dx} = \frac{9}{2}a - 12$

$\frac{dy}{dt} = \frac{dy}{dx} \times \frac{dx}{dt}$

$\frac{dy}{dt} = \left(\frac{9}{2}a - 12\right) \times 5$

$\frac{dy}{dt} = \frac{45}{2}a - 60$

(b) Given that the curve has a minimum point when $x = \frac{1}{4}$, find the value of a. [2]

$\frac{3}{2}ax^{\frac{1}{2}} - 12 = 0$

$\frac{3}{2}a \times \frac{1}{2} - 12 = 0$

$3a - 48 = 0$

$a = 16$

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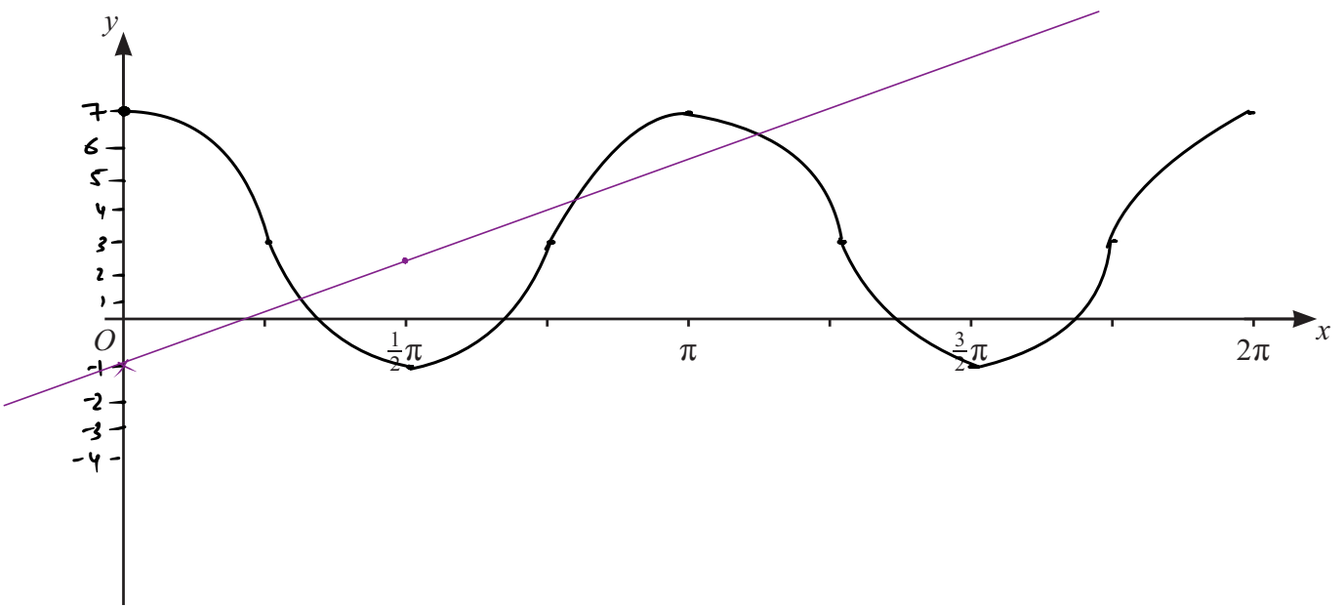
5 The equation of a curve is $y = 4\cos 2x + 3$ for $0 \leqslant x \leqslant 2\pi$.

(a) State the greatest and least possible values of y. [2]

Greatest = 3 + 4 = 7

least = 3 − 4 = −1

(b) Sketch the curve. [2]



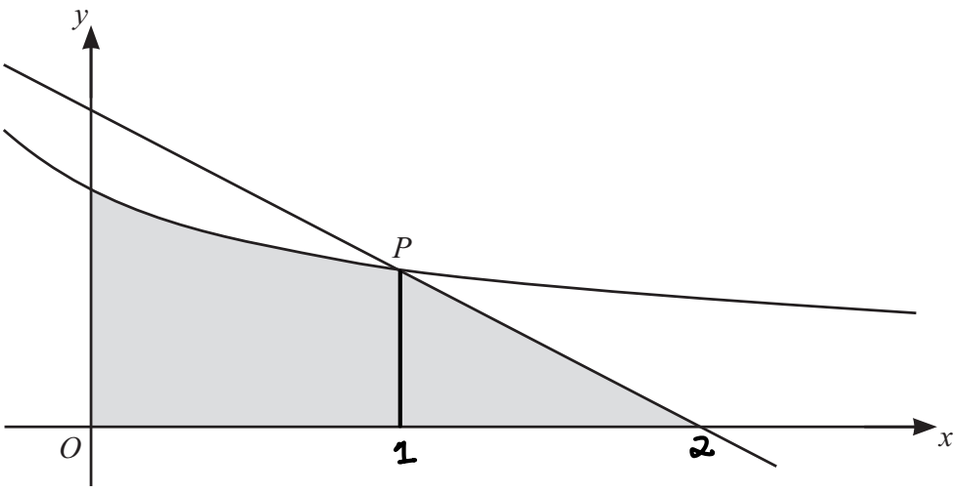
(c) Hence determine the number of solutions of the equation $4\cos 2x + 3 = 2x - 1$ for $0 \leqslant x \leqslant 2\pi$. [1]

3 Solutions.

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6



The diagram shows the curve with equation $y = \frac{9}{(5x+4)^{\frac{1}{2}}}$ and the line $y = 6-3x$. The line and the curve intersect at the point P which has y-coordinate 3.

Find the area of the shaded region. [6]

x-coordinate of P: $3 = 6-3x$

x-coordinate of P: $3x = 3$

x-coordinate of P: $x = 1$

Point P = (1, 3)

line cuts x-axis at: $0 = 6-3x$

line cuts x-axis at: $x = 2$

Area of Triangle = $\frac{1}{2} \times 1 \times 3 = \frac{3}{2}$.

Area under curve : $\int_0^1 9(5x+4)^{-\frac{1}{2}}$

Area under curve : $\left[\frac{18}{5}(5x+4)^{\frac{1}{2}}\right]_0^1$

Area under curve : $\frac{54}{5} - \frac{36}{5} = \frac{18}{5}$

Shaded Area = $\frac{18}{5} + \frac{3}{2}$

Shaded Area = $\frac{51}{10}$

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7 **(a)** Prove the identity $\dfrac{\tan\theta+7}{\tan^2\theta-3} \equiv \dfrac{\sin\theta\cos\theta+7\cos^2\theta}{1-4\cos^2\theta}$. [3]

$\frac{\sin\theta}{\cos\theta} + 7 \div \frac{\sin^2\theta}{\cos^2\theta} - 3$

$\frac{\sin\theta + 7\cos\theta}{\cos\theta} \times \frac{\cos^2\theta}{\sin^2\theta - 3\cos^2\theta}$

$= \frac{\sin\theta\cos\theta + 7\cos^2\theta}{\sin^2\theta - 3\cos^2\theta}$

$= \frac{\sin\theta\cos\theta + 7\cos^2\theta}{1-\cos^2\theta - 3\cos^2\theta}$

$= \frac{\sin\theta\cos\theta + 7\cos^2\theta}{1-4\cos^2\theta}$ → Proved!!

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(b) Hence solve the equation $\frac{\sin\theta\cos\theta+7\cos^2\theta}{1-4\cos^2\theta}=\frac{5}{\tan\theta}$ for $0°\leqslant\theta\leqslant180°$. [4]

$= \frac{\tan\theta+7}{\tan^2\theta-3} = \frac{5}{\tan\theta}$

$= \tan^2\theta+7\tan\theta = 5\tan^2\theta-15$

$= 4\tan^2\theta-7\tan\theta-15=0$

$= 4\tan^2\theta-12\tan\theta+5\tan\theta-15=0$

$= 4\tan\theta(\tan\theta-3)+5(\tan\theta-3)=0$

$= (4\tan\theta+5)(\tan\theta-3)=0$

$= \tan\theta=-5/4$ OR $\tan\theta=3$

$\alpha=\tan^{-1}(5/4)=51.3402$ OR $\alpha=\tan^{-1}(3)=71.5650$

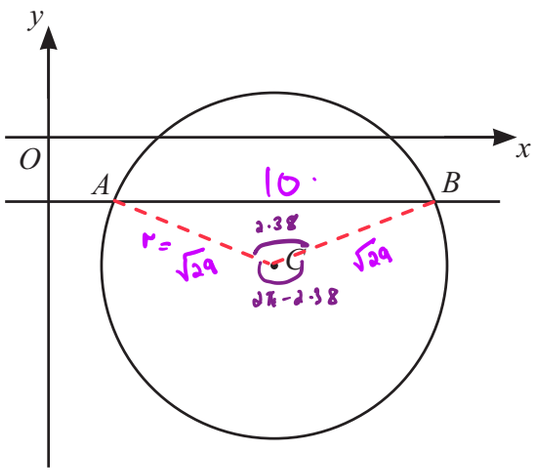
$\theta=128.66, 308.66$ OR $\theta=71.57, 251.57$.

Hence $\theta=71.6, 128.7$

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8



The diagram shows the circle with equation $x^2+y^2-14x+8y+36=0$ and the line $y=-2$. The line intersects the circle at the points A and B. The centre of the circle is C.

(a) Find the coordinates of A, B and C. [3]

Centre = $-2a = -14$ $\quad -2b = 8$

$a = 7$ $\quad b = -4$.

Centre = C = $(7, -4)$

Points A and B → $x^2 + 4 - 14x - 16 + 36 = 0$

$x^2 - 14x + 24 = 0$

$x^2 - 12x - 2x + 24 = 0$

$x(x-12) - 2(x-12) = 0$

$(x-2)(x-12) = 0$

$x = 2$ OR $x = 12$

$y = -2$ OR $y = -2$

Point A = $(2, -2)$

Point B = $(12, -2)$

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(b) Find the angle ACB in radians. Give your answer correct to 3 significant figures. [2]

$AB = 10$

$AC = CB = r = \sqrt{(7)^2 + (-4)^2 - 36} = \sqrt{29}$

$100 = 29 + 29 - 2 \times \sqrt{29} \times \sqrt{29} \times \cos C$

$\frac{100 - 29 - 29}{-2 \times 29} = \cos C$

$C = \cos^{-1}\left(\frac{42}{-58}\right) \rightarrow$ **2·38 = Angle C**

(c) The chord AB divides the circle into two segments.

Find the area of the larger segment. [4]

Area of larger segment = Area of Δ + Area of larger sector

$\left(\frac{1}{2} \times \sqrt{29} \times \sqrt{29} \times \sin 2.38\right) + \left(\frac{1}{2} \times 29 \times (2\pi - 2.38)\right]$

$= 10.006 + 56.596186$

Area = 66.602

Area = 66.6

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9 The equation of a curve is such that $\frac{d^2y}{dx^2} = -\frac{24}{x^3}$. It is given that the curve has a stationary point at $(-2, 19)$.

(a) Find an expression for $\frac{dy}{dx}$. [3]

$\int -24x^{-3}$

$\frac{dy}{dx} = \frac{12}{x^2} + c$

$0 = \frac{12}{4} + c$

$0 = 3 + c$

$c = -3$

$\frac{dy}{dx} = \frac{12}{x^2} - 3$

(b) Find the x-coordinate of the other stationary point of the curve, and determine the nature of this stationary point. [2]

$\frac{12}{x^2} - 3 = 0$

$x^2 = 4$

$x = 2$

Nature $\Rightarrow$ $\frac{-24}{(2)^3} = -3$

Negative means Maximum.

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(c) Find the equation of the curve. [3]

$\frac{dy}{dx} = \frac{12}{x^2} - 3$

$\int \frac{12}{x^2} - 3$

$y = \frac{-12}{x} - 3x + c$

$19 = \frac{-12}{-2} - 3(-2) + c$

$19 = 6 + 6 + c$

$c = 7$

$y = \frac{-12}{x} - 3x + 7$

(d) Find the equation of the normal to the curve at the point where $\frac{dy}{dx} = -\frac{9}{4}$ and x is positive. Express your answer in the form $px + qy + r = 0$, where p, q and r are integers. [4]

m of normal = $4/9$

$\frac{12}{x^2} - 3 = \frac{-9}{4}$

$\frac{12}{x^2} = \frac{3}{4}$

$x^2 = 16$

$x = 4$

$y = \frac{-12}{4} - 3(4) + 7 = -8$

Point $(4, -8)$

Equation of Normal: $y + 8 = \frac{4}{9}(x - 4)$

Equation of Normal: $9y + 72 = 4x - 16$

Equation of Normal: $4x - 9y - 88 = 0$

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10 **(a)** The first, second and third terms of an arithmetic progression are $4k$, k^2 and $8k$ respectively, where k is a non-zero constant.

(i) Find the value of k. [2]

$d = k^2 - 4k$

$d = 8k - k^2$

$k^2 - 4k = 8k - k^2$

$2k^2 - 12k = 0$

$2k(k - 6) = 0$

$k = 0$ OR $k = 6$

Since k is a non-zero constant,

$k = 6$

(ii) Find the sum of the first 20 terms of the progression. [3]

$a = 4k \rightarrow 4(6) \rightarrow 24$

$d = k^2 - 4k \rightarrow (6)^2 - 4(6) \rightarrow 36 - 24 = 12$

Sof 20 terms:

$= 10(48 + 19 \times 12)$

$= 10(276)$

$S_{20} = 2760$

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(b) The fourth and sixth terms of a geometric progression are 36 and 6 respectively. The common ratio of the progression is positive.

Find the sum to infinity of the progression. Give your answer in the form $\frac{a}{\sqrt{b}-c}$, where a, b and c are integers. [5]

$ar^3 = 36$

$ar^5 = 6$

$a = \frac{36}{r^3}$

$= \frac{36}{r^3} \times r^5 = 6$

$= 36r^2 = 6$

$r^2 = \frac{1}{6}$.

$r = \sqrt{\frac{1}{6}}$

$a = \frac{36}{\frac{1}{\sqrt{6}^3}} = 36\sqrt{6}^3 = 216\sqrt{6}$.

$S_\infty = \frac{216\sqrt{6}}{1 - \frac{1}{\sqrt{6}}} = \frac{216\sqrt{6} \times \sqrt{6}}{\sqrt{6} - 1}$

$S_\infty = \frac{1296}{\sqrt{6} - 1}$

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11 **(a)** Express x^2+4x+2 in the form $(x+a)^2+b$, where a and b are integers. [2]

$(x^2+4x+4)-2$

$(x+2)^2-2$

$a=2$

$b=-2$

The functions f and g are defined as follows.

$$f(x) = x^2+4x+2 \qquad \text{for } x \leqslant -2$$

$$g(x) = -x-4 \qquad \text{for } x \geqslant -2$$

(b) **(i)** Find an expression for $f^{-1}(x)$. [3]

$y=(x+2)^2-2$

$-2-\sqrt{y+2} = x$

$f^{-1}(x) = -2-\sqrt{x+2}$

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(ii) Find an expression for $(\mathrm{gf})^{-1}(x)$. [4]

$gf(x) = -((x+2)^2 - 2) - 4$

$gf(x) = -(x+2)^2 + 2 - 4$

$gf(x) = -(x+2)^2 - 2$

$y = -(x+2)^2 - 2$

$(x+2)^2 = -y-2$

$x = -2 + \sqrt{-y-2}$

$(gf)^{-1} x = -2 - \sqrt{-x-2}$

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CAMBRIDGE
International Education

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MATHEMATICS **9709/12**

Paper 1 Pure Mathematics 1 **May/June 2025**

MARK SCHEME

Maximum Mark: 75

Published

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Due to a series-specific issue during the live exam series, all candidates were awarded full marks for question 6. The mark scheme for these questions was not used by examiners.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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Question	Answer	Marks	Guidance
1	{Stretch} {factor 2} {'parallel to y-axis' or 'in y-direction' or 'vertically'}	**B2,1,0**	B2 for 3 correct components. B1 for 2.
	{Translation} $\begin{pmatrix} \{0\} \\ \{-14\} \end{pmatrix}$ or $\{-14\}$ {'parallel to the y-axis' or 'in the y-direction' or 'vertically'.}	**B2,1,0**	B2 for 3 correct components. B1 for 2.
	Alternative Method for Question 1		
	{Translation by} $\begin{pmatrix} \{0\} \\ \{-7\} \end{pmatrix}$ or $\{-7\}$ {'parallel to the y-axis' or 'in the y-direction' or 'vertically'}	**B2,1,0**	B2 for 3 correct components. B1 for 2.
	{Stretch} {factor 2} {'parallel to y-axis' or 'in y-direction' or 'vertically'}	**B2,1,0**	B2 for 3 correct components. B1 for 2.
		4	

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Question	Answer	Marks	Guidance
2	$2\left(\frac{-y-4}{2}\right)y+5y^2=24$ or $2\left(\frac{24-5y^2)}{2y}\right)+y+4\ [=0]$ or $2x(-4-2x)+5(-4-2x)^2=24$	***M1**	OE For eliminating x or y. Condone sign errors in the rearrangements.
	$4y^2-4y=24$ or $16x^2+72x+56\ [=0]$	**DM1**	OE For simplifying to a 3-term quadratic; terms do not all have to be on the same side. Condone sign errors in the expansions or in the collecting of terms.
	$\Rightarrow y=-2,\ y=3$ or $x=-1,\ x=-\frac{7}{2}$	**B1**	OE Not for a correct (x,y) pair. Allow from a correct quadratic (ignore any working seen).
	$(-1,\ -2),\ \left(-\frac{7}{2},\ 3\right)$	**B1**	OE Allow from a correct quadratic (ignore any working seen). Condone $x=-1$ and $y=-2$ and $x=-\frac{7}{2}$ and $y=3$.
		4	

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Question	Answer	Marks	Guidance
3	$\binom{5}{3}$ or $\binom{5}{2}$ or $10\times\left(px^2\right)^{5-3}\times\left(\frac{4}{p}x\right)^3$	**B1**	May be seen in a list. Allow with or without x's. Condone missing brackets only if recovered later.
	$10p^2\times\frac{64}{p^3}$	**B1**	This term must now be identified if given as part of a list. Allow with or without x's.
	$\frac{\textit{Their}\ \text{integer}\ k}{p}\left[x^7\right]\ =\ 1280\left[x^7\right]$	**M1**	Condone e.g. $\frac{640x^7}{p}=1280$ if x^7 then disappears in subsequent work. Must be from $a\times\left(px^2\right)^{5-3}\times\left(\frac{4}{p}x\right)^3$.
	$p=\frac{1}{2}$	**A1**	OE **SC B1** for $\binom{5}{4}$ or $\binom{5}{1}$ or $5\times\left(px^2\right)^{5-1}\times\left(\frac{4}{px}\right)^1\Rightarrow p=4$.
		4	

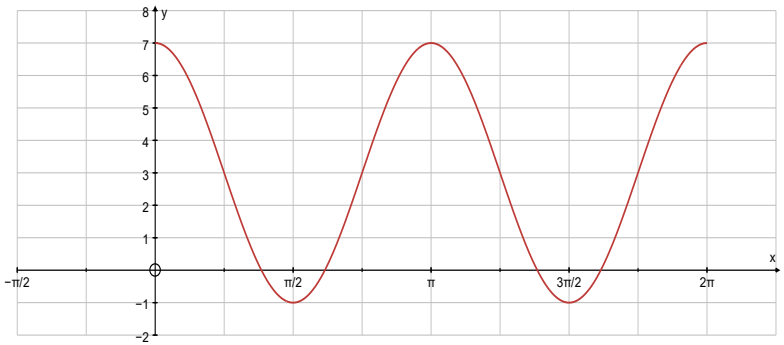
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Question	Answer	Marks	Guidance
4(a)	$\left[\frac{dy}{dx}\right] = \frac{3}{2}ax^{\frac{1}{2}} - 12$	***M1**	For attempt at differentiation; at least one correct term needed. Condone poor notation throughout.
	$\left[\frac{dy}{dt} = \frac{dy}{dx} \times \frac{dx}{dt} =\right] \left(\frac{3}{2}a \times 9^{\frac{1}{2}} - 12\right) \times 5$	**DM1**	For correct use of chain rule with 5, $x = 9$ and *their* $\frac{dy}{dx}$. Condone missing brackets and allow errors in their working.
	$\left[\frac{dy}{dt} =\right] 5\left(\frac{9}{2}a - 12\right)$ or $\frac{45}{2}a - 60$ or $22.5a - 60$ or $\frac{45a - 120}{2}$ or $\frac{15}{2}(3a - 8)$	**A1**	OE simplified form.
		3	
4(b)	$\frac{3}{2}a \times \left(\frac{1}{4}\right)^{\frac{1}{2}} - 12 = 0$	**M1**	For setting *their* 2 term $\frac{dy}{dx}$ with at least one term correct = 0 and substituting $x = 0.25$. Condone missing brackets. Allow a restart for $\frac{dy}{dx}$ if 2 terms seen and at least one term correct.
	$\Rightarrow a = 16$	**A1**	
		2	

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Question	Answer	Marks	Guidance
5(a)	[Greatest] 7, [least] −1	**B1B1**	B2 for answers of −1 and 7 only. B1 for one correct value. Ignore incorrect identification/inequality.
		2	
5(b)		**B2,1,0**	Ignore any graph outside domain $(0, 2\pi)$. B1 for two complete cycles, one from 0 to approximately π and the other finishing at approximately 2π. Starting at *their* greatest value and initially decreasing. Condone straight lines and minimum above the *x*-axis or joining points with straight lines. B2 for correct curve; condone any incorrect *x*-axis intercepts. Graph must start to level off at both 0 and 2π. Ignore any *y*-labels, but the curve should be more above the *x*-axis than below.
		2	
5(c)	3 [solutions]	**B1**	Ignore any graphs drawn
		1	

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Question	Answer	Marks	Guidance
6	$6-3x=3 \Rightarrow x$-coordinate of point of intersection = 1	**B1**	
	$\left[\frac{18}{5}(5x+4)^{\frac{1}{2}}\right]_0^1$	**B1 B1**	B1 for $k(5x+4)^{\frac{1}{2}}$
	Area $=\frac{18}{5}\times 3-\frac{18}{5}\times 2\left[=\frac{18}{5}\right]$	**M1**	
	Line crosses x-axis at $x = 2$, so triangle area $=\frac{1}{2}\times 3\times 1$	**M1**	
	Total area $=\frac{51}{10}$	**A1**	
		6	

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Question	Answer	Marks	Guidance
7(a)	For appropriate use of $\tan\theta = \dfrac{\sin\theta}{\cos\theta}$ or $\tan\theta\cos\theta = \sin\theta$ at least once	**M1**	**The first two marks can be applied in the reverse order but as soon as an error occurs, no further marks are awarded.** Candidates can work from LHS to RHS or RHS to LHS for full marks. If they work on both sides simultaneously, maximum of M1M1 only if a common correct expression is reached. Condone missing brackets. If the numerator and denominator are worked on separately, they need to be brought together for the second mark.
	For appropriate use of $\sin^2\theta + \cos^2\theta = 1$ or $1 + \tan^2\theta = \sec^2\theta$	**M1**	
	Fully correct proof	**A1**	WWW Condone missing brackets if recovered.
		3	
7(b)	$\dfrac{\tan\theta + 7}{\tan^2\theta - 3} = \dfrac{5}{\tan\theta} \Rightarrow \tan\theta(\tan\theta + 7) = 5(\tan^2\theta - 3)$	***B1**	OE Using part **(a)** and eliminating fractions.
	$\Rightarrow 4\tan^2\theta - 7\tan\theta - 15 = 0 \Rightarrow (4\tan\theta + 5)(\tan\theta - 3) = 0$	**DM1**	Factorising or other accepted method for solving *their* 3-term quadratic in $\tan\theta$. Condone errors made in forming 3-term quadratic.
	$\tan\theta = -1.25$ and $\tan\theta = 3$	**B1**	OE Independent of factorisation of the quadratic. And no extra solutions. Allow e.g. $x = \ldots$ provided $x = \tan\theta$ is seen. Can be implied by a correct final answer.
	$\theta = 71.6°$ and $\theta = 128.7°$	**B1**	AWRT No others in range $0 \leqslant \theta \leqslant 180°$. Ignore any answers outside this range. Maximum 3/4 if incorrect factorisation or formula.
		4	

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Question	Answer	Marks	Guidance
8(a)	$(2,-2)$	**B1**	Condone $x=2$ and $y=-2$ if seen together.
	$(12,-2)$	**B1**	Condone $x=12$ and $y=-2$ if seen together.
	$(7,-4)$	**B1**	
		3	If B0 B0 for the first two marks, then **SC B1** available for $x=2$ and $x=12$.
8(b)	$\tan\left(\frac{1}{2}\theta\right)=\frac{5}{2}\left[\Rightarrow \theta=2\tan^{-1}\frac{5}{2}\right]$ or $\sin\left(\frac{\theta}{2}\right)=\frac{5}{\sqrt{29}}$ or $\cos\left(\frac{\theta}{2}\right)=\frac{2}{\sqrt{29}}$ or $\theta=\pi-2\times\tan^{-1}\frac{2}{5}$ or $\pi-2\times0.381$ or $10^2=29+29-2\times\sqrt{29}\times\sqrt{29}\cos\theta\left[\Rightarrow \cos\theta=\frac{29+29-100}{2\times\sqrt{29}\times\sqrt{29}}=\frac{-21}{29}\right]$	**M1**	Or other correct method for an isosceles triangle using their A and B of the form $(\ ,-2)$ and C of the form $(\ ,-d)$, where $-d<-2$. **Note:** $\tan\theta=\frac{5}{2}\Rightarrow 0/2$ unless θ is then doubled. Using $r=29$ scores 0/2.
	$[\theta=]$ 2.38	**A1**	AWRT Final answer of 136.4° scores max 1/2. Ignore degree symbol if present.
	Alternative Method for Question 8(b)		
	$\tan\theta=\frac{\frac{-2}{5}-\frac{2}{5}}{1+\frac{-2}{5}\times\frac{2}{5}}\left[=-\frac{20}{21}\right]$	**M1**	Use of $\tan\theta=\frac{m_2-m_1}{1+m_2m_1}$, where m_1 and m_2 are the gradients of *their* AC and BC, where A, B and C are of the required form.
	$[\theta=]$ 2.38	**A1**	AWRT Ignore degree symbol if present.
		2	

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Question	Answer	Marks	Guidance
8(c)	[Length AC = Length BC = $\sqrt{5^2+2^2}$] $=\sqrt{29}$ [=5.385…]	**B1**	Sight of $\sqrt{29}$. SOI. Condone 5.4. Could be found in parts **(a)** or **(b)**, but do not award unless it is seen in part **(c).**
	[Area of large sector =] $\frac{1}{2}\times\sqrt{29}\times\sqrt{29}\times(2\pi - \textit{their}\ \theta)$ $[=56.587..]$ or [Area of small sector =] $\frac{1}{2}\times\sqrt{29}\times\sqrt{29}\times \textit{their}\ \theta$ [= 34.518…]	**M1**	Use of correct sector formula with *their* identified radius (e.g. 29) and *their* $(2\pi-\theta)$ or *their* θ. May be embedded as part of the segment formula.
	Area of triangle = $\frac{1}{2}\times\sqrt{29}\times\sqrt{29}\times\sin\theta$ or $\frac{1}{2}\times10\times2$ $[=10]$	**M1**	Use of correct triangle formula with *their* identified radius (e.g. 29) and *their* θ. May be embedded as part of the segment formula.
	[Segment area =] 66.6	**A1**	AWRT [Area of circle – smaller segment $=\pi\times29-34.52+10$]
		4	

Question	Answer	Marks	Guidance
9(a)	$\left[\frac{\mathrm{d}y}{\mathrm{d}x}=\right]\ \frac{-24x^{-2}}{-2}$ $\left[=\frac{12}{x^2}\right][+c]$	**B1**	May be unsimplified.
	$\frac{12}{(-2)^2}+c=0$ $[\Rightarrow\ c=-3]$	**M1**	Substituting $x=-2$ into *their* $\frac{\mathrm{d}y}{\mathrm{d}x}$ of the form $kx^{-2}+c$, and setting = 0. Condone missing bracket.
	$\left[\frac{\mathrm{d}y}{\mathrm{d}x}=\right]\ \frac{12}{x^2}-3$ or $12x^{-2}-3$	**A1**	$\frac{-24}{-2}$ must be simplified to 12, but accept $c=-3$ as the final answer.
		3	

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Question	Answer	Marks	Guidance
9(b)	$\left[\frac{12}{x^2}-3=0 \Rightarrow x^2=4 \Rightarrow x=\pm 2 \Rightarrow\right] x=2$	**B1**	May be done by inspection or calculator, but must be WWW. Condone ±2.
	$\left[\frac{\mathrm{d}^2y}{\mathrm{d}x^2}=\right]-\frac{24}{(2)^3}$ or -3 or $<0 \Rightarrow$ maximum	**B1**	WWW. Or other valid method. Ignore any working for $x=-2$.
		2	
9(c)	$[y=]-12x^{-1}+\textit{their } cx\left[=-\frac{12}{x}-3x\right][+d]$	**B1FT**	May be unsimplified. FT *their* nonzero *c*.
	$19=-\frac{12}{-2}-3\times(-2)+d \quad [\Rightarrow d=7]$	**M1**	Substituting $(-2, 19)$ into their integrated expression (defined by having at least one correct power) and including $+d$.
	$y=-\frac{12}{x}-3x+7$	**A1**	Accept $d=7$ as final answer if $y=\ldots$ seen previously. Allow $'f(x)='$ in place of $'y='$.
		3	

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Question	Answer	Marks	Guidance
9(d)	$\frac{12}{x^2}-3=-\frac{9}{4} \Rightarrow \frac{12}{x^2}=\frac{3}{4} \Rightarrow x=...$ $\left[\Rightarrow x^2=16 \Rightarrow x=4, y=-8\right]$	***M1**	Setting *their* $\frac{\mathrm{d}y}{\mathrm{d}x}$ of the form $kx^{-2}+c=-\frac{9}{4}$, and correctly solving for x from their equation where $x^2>0$.
	Gradient of normal $=\frac{4}{9}$	**B1**	
	$\frac{y+8}{(x-4)}=\frac{4}{9}$	**DM1**	For using *their* stated positive x and *their* stated y and a changed gradient to correctly form a line equation; condone $-\frac{4}{9}$ or $\frac{9}{4}$.
	$4x-9y-88=0$	**A1**	OE in correct form.
		4	

Question	Answer	Marks	Guidance
10(a)(i)	$8k-k^2=k^2-4k$ or $2k^2=4k+8k$ or $4k+2\left(k^2-4k\right)=8k$	**M1**	OE Forming an equation in k only, clearly using the first 3 terms of an AP.
	$[2k(k-6)=0 \Rightarrow]\ k=6$ [or $k=0$]	**A1**	Condone extra 'solution' $k=0$. Note: can be done by inspection or with no working. 2 / 2
		2	

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Question	Answer	Marks	Guidance
10(a)(ii)	$d\ \left[=8k-k^2\ \text{or}2k\ \text{ or }\ k^2-4k\right]=12$ and $a\left[=4k\right]=24$	***M1**	Using a correct method to find a and d from *their* k. SOI. May have been found in **(a)(i)** but must be used in **(ii)**.
	$S_{20}=\frac{20}{2}\left(2\times24+19\times12\right)$ or $=\frac{20}{2}\left(24\ +\ 252\right)$	**DM1**	Use of correct sum formula with $n=20$ and *their a* and *d*.
	$S_{20}=2760$	**A1**	
		3	
10(b)	$ar^3=36$ and $ar^5=6$ or $r^2=\frac{1}{6}$	**B1**	SOI WWW
	$r=\sqrt{\frac{6}{36}}\left[=\frac{1}{\sqrt{6}}\ \text{or}\ \frac{\sqrt{6}}{6}\right]$	***M1**	Using a correct method to find r. Condone ±.
	$a=\frac{36}{\left(\frac{1}{\sqrt{6}}\right)^3}\left[=36\times\sqrt{6}^3,\ 216\sqrt{6}\ \text{or}\ \frac{1296}{\sqrt{6}}\right]$	***M1**	Using a correct method to find a. Condone ±.
	$S_\infty=\frac{216\sqrt{6}}{1-\frac{1}{\sqrt{6}}}$	**DM1**	Using the correct formula with *their a* and *their* $\left\|r\right\|<1$.
	$[S_\infty=]\ \frac{1296}{\sqrt{6}-1}\ \text{or}\ \frac{7776}{\sqrt{216}-6}$	**A1**	OE in the required form. $r=0.408\Rightarrow a=529\Rightarrow S_\infty=894$ scores 4/5.
		5	

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Question	Answer	Marks	Guidance
11(a)	$\{(x+2)^2\}\{-2\}$	**B1B1**	B1 for each correct { }. Allow $a=2$, $b=-2$. If contradictory, give preference to the expression.
		2	
11(b)(i)	$y=(x+2)^2-2 \Rightarrow\ y+2=(x+2)^2$	***M1**	Equating y or $\mathrm{f}^{-1}(x)$ or f^{-1} or $\mathrm{f}(x)$ to *their* completed square form and first step. x and y may be interchanged at this stage. Condone ± errors.
	$x=[\pm]\sqrt{y+2}-2$	**DM1**	Condone ± errors during simplification.
	$[\mathrm{f}^{-1}(x)=]-\sqrt{x+2}-2$	**A1**	Do not condone $x=$ or $f(x)=$.
		3	

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Question	Answer	Marks	Guidance
11(b)(ii)	$[\text{gf}(x) =] - \{\textit{their}$ completed square form$\} - 4$ or $-\left(x^2 + 4x + 2\right) - 4$	***M1**	Using $\text{fg}(x) = \{(-x-4)+2\}^2 - 2$ scores 0/4.
	$[gf(x) =] - (x+2)^2 - 2$	**A1**	
	$x = [\pm]\sqrt{-y-2} - 2$	**DM1**	Finding x from *their* completed square form, which must contain a $-(x+k)^2$ term. Condone $\pm$ errors only during simplification. $x = -\sqrt{y+2} - 2$ is DM0 (Square rooting then $\div$ or $\times -1$) x and y may be interchanged at this stage.
	$[(\text{gf})^{-1}(x) =] - \sqrt{-x-2} - 2$	**A1**	Do not condone $x =$.
	Alternative Method for Question 11(b)(ii)		
	$(\text{gf})^{-1} = \text{f}^{-1}\text{g}^{-1}$	***M1**	SOI Allow with *their* f^{-1} and *their* g^{-1}. Using $\text{g}^{-1}\text{f}^{-1}(x)$ scores 0/4.
	$\text{g}^{-1}(x) = -x - 4$	**A1**	
	$(\text{gf})^{-1}(x) = -\sqrt{-x-4+2} - 2$	**DM1**	Allow with *their* f^{-1} and *their* g^{-1}.
	$[(\text{gf})^{-1}(x) =] - \sqrt{-x-2} - 2$	**A1**	Do not condone $x =$
		4	

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MATHEMATICS **9709/13**

Paper 1 Pure Mathematics 1 **May/June 2025**

1 hour 50 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- If additional space is needed, you should use the lined page at the end of this booklet; the question number or numbers must be clearly shown.
- You should use a calculator where appropriate.
- You must show all necessary working clearly; no marks will be given for unsupported answers from a calculator.
- Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place for angles in degrees, unless a different level of accuracy is specified in the question.

INFORMATION

- The total mark for this paper is 75.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **16** pages.

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1 A curve has equation $y = 2x + \frac{12}{x^2}$.

Find the equation of the tangent to the curve at the point $(-2, -1)$. Give your answer in the form $y = mx + c$. [4]

$\frac{dy}{dx} = 2 - \frac{24}{x^3}$

m of Tangent $= 2 - \frac{24}{-8} \Rightarrow 2+3 = 5$

Point $(-2,-1)$

$y+1 = 5(x+2)$

$y+1 = 5x+10$

Equation of Tangent = $y = 5x+9$

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2 The first two terms of a geometric progression are

$$4\sin^2\theta, \quad 8\sin^3\theta,$$

where θ is an angle such that $0 < \theta < \frac{1}{6}\pi$.

Given that the sum to infinity of the progression is $\frac{1}{2}$, find the value of θ. Give your answer in the form $\sin^{-1} k$, where k is a rational number. [4]

$a = 4\sin^2\theta$

$r = \frac{8\sin^3\theta}{4\sin^2\theta} = 2\sin\theta$

$S_\infty = \frac{4\sin^2\theta}{1-2\sin\theta} = \frac{1}{2}$

$= 8\sin^2\theta = 1 - 2\sin\theta$

$= 8\sin^2\theta + 2\sin\theta - 1 = 0$

$= 8\sin^2\theta + 4\sin\theta - 2\sin\theta - 1 = 0$

$= 4\sin\theta(2\sin\theta + 1) - 1(2\sin\theta + 1) = 0$

$(4\sin\theta - 1)(2\sin\theta + 1) = 0$

$\sin\theta = \frac{1}{4}$ $\sin\theta = -\frac{1}{2}$

$\sin^{-1}\left(\frac{1}{4}\right)$

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3 Given that $\int_1^3 \left(\frac{a}{(4x-3)^2}+2\right)\mathrm{d}x = 12$, find the value of the constant a. [4]

$\int_1^3 \left(a(4x-3)^{-2}+2\right)dx = 12$

$\left[\frac{-a}{4}(4x-3)^{-1}+2x\right]_1^3 = 12$

$\frac{-a}{36}+6+\frac{a}{4}-2 = 12$

$\frac{2a}{9}+4 = 12$

$\frac{2a}{9} = 8$

$a = 36.$

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4 **(a)** Find the first three terms in the expansion of $\left(2-\frac{3}{2}x\right)^5$ in ascending powers of x. [3]

$^5C_0(2)^5\left(\frac{-3}{2}x\right)^0 + {}^5C_1(2)^4\left(\frac{-3}{2}x\right)^1 + {}^5C_2(2)^3\left(\frac{-3}{2}x\right)^2$

$(1\times32\times1) + (5\times16\times\frac{-3}{2}x) + (10\times8\times\frac{9}{4}x^2)$

$32-120x+180x^2$

(b) Use your answer to part **(a)**, with a suitable value of x, to find an approximation to 1.985^5. [3]

$2-\frac{3}{2}x = 1.985$

$0.015 = \frac{3}{2}x$

$0.01 = x$

$= 32-120(0.01)+180(0.01)^2$

$= 30.818$

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5 Solve the equation

$$4\sin\theta\tan\theta = 1 + 5\cos\theta$$

for $-180° < \theta < 180°$. [6]

$= \frac{4\sin^2\theta}{\cos\theta} = 1 + 5\cos\theta$

$= 4\sin^2\theta = \cos\theta + 5\cos^2\theta$

$= 4 - 4\cos^2\theta = \cos\theta + 5\cos^2\theta$

$= 9\cos^2\theta + \cos\theta - 4 = 0$

$= \cos\theta = 0.6134$ OR $\cos\theta = -0.7245$

$\alpha = \cos^{-1}(0.6134) = 52.1642$ OR $\alpha = \cos^{-1}(0.7245) = 43.5727$

$\theta = 52.2, 307.8$ OR $\theta = 136.4, 223.6$

$-307.8, -52.2$ OR $-223.6, -136.4$

Hence $\theta = -136.4, -52.2, 52.2, 136.4$

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6 An arithmetic progression has first term a and common difference 2. The Nth term is 55 and the sum of the first $3N$ terms is 5760.

Find the values of N and a. [6]

$a = a$

$d = 2$

$a + (N-1)2 = 55$

$a + 2N - 2 = 55$

$a + 2N = 57 \rightarrow i \quad a = 53 - 2N$

$S_{3N} = \frac{3N}{2}[2a + (3N-1)2]$

$= 3N[a + (3N-1)] = 5760$

$= 3N(57 - 2N + 3N - 1) = 5760$

$= 56N + N^2 = 1920$

$= N^2 + 56N - 1920 = 0$

$N = 24 \quad$ or $\quad N = -80$

Since N can't be negative

$\boxed{N = 24}$

$a = 57 - 2N$

$a = 57 - 2(24)$

$\boxed{a = 9}$

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7 A curve is such that $\frac{dy}{dx} = 3x^2 + 10x - 8$.

(a) Find the set of values of x for which y decreases as x increases. [3]

$3x^2 + 10x - 8 = 0$

$3x^2 + 12x - 2x - 8 = 0$

$3x(x+4) - 2(x+4) = 0$

$(3x-2)(x+4) = 0$

$x = \frac{2}{3}$ and $x = -4$

The function is increasing when $-4 < x < \frac{2}{3}$

(b) It is given that the maximum point of the curve has y-coordinate 27.

Find the equation of the curve. [4]

$\frac{d^2y}{dx^2} = 6x + 10$

$\frac{d^2y}{dx^2}$ $6(-4) + 10 = -14$ → Maximum

Maximum point = $(-4, 27)$

$\int 3x^2 + 10x - 8$

$y = \frac{3x^3}{3} + \frac{10x^2}{2} - 8x + c$

$y = x^3 + 5x^2 - 8x + c$

$27 = (-4)^3 + 5(-4)^2 - 8(-4) + c$

$27 = -64 + 80 + 32 + c$

$27 = 48 + c$

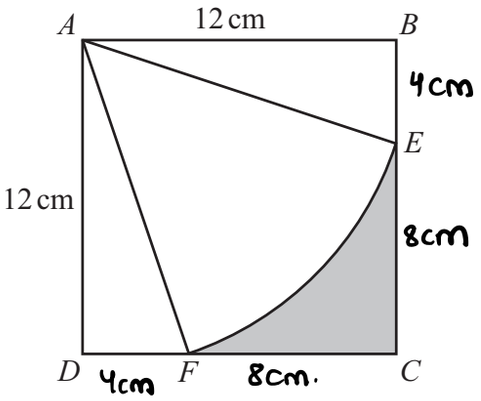
$c = -21$

$y = x^3 + 5x^2 - 8x - 21$

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8



The diagram shows a square $ABCD$ where each side has length 12 cm. Points E and F lie on the sides BC and CD respectively and are such that $BE = \frac{1}{3}BC$ and $DF = \frac{1}{3}DC$. The arc EF is part of a circle with centre A. The shaded region is bounded by the arc EF and the line segments EC and FC.

(a) Show that the size of angle EAF is 0.9273 radians, correct to 4 significant figures. [2]

$\tan^{-1}\left(\frac{4}{12}\right) = EAB = 0.32175$

$2 \times EAB = 0.6435$

$\pi/2 - 0.6435 = 0.9273$

(b) Find the perimeter of the shaded region. [3]

$r = \sqrt{12^2+4^2} = \sqrt{160}$

$r\theta = \sqrt{160} \times 0.9273 = 11.7295$

Perimeter: $SEF + CF + EC$

Perimeter $= 11.7295 + 8 + 8$

Perimeter $= 27.7295$

(c) Find the area of the shaded region. [3]

Shaded Area = Area of Square − Area of Sector − 2(Area of Δ)

Shaded Area $= (12)^2 - \left(\frac{1}{2} \times 160 \times 0.9273\right) - 2\left(\frac{1}{2} \times 4 \times 12\right)$

Shaded Area $= 144 - 74.184 - 48$

Shaded Area $= 21.816$

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9 Three points P, Q and R have coordinates $P(-13, 5)$, $Q(5, 1)$ and $R(2, k)$, where k is a constant. It is given that the angle PRQ is a right angle.

(a) Show that one of the possible values of k is 10, and find the other possible value. [4]

length of $PQ = \sqrt{(-4)^2 + (18)^2}$

$PQ = \sqrt{340}$

$PQ^2 = 340$

length of $QR = \sqrt{(k-1)^2 + 9}$

$QR^2 = k^2 - 2k + 10$

length of $PR = \sqrt{(k-5)^2 + 225}$

$PR^2 = k^2 - 10k + 250$

$PR^2 + QR^2 = PQ^2$

$k^2 - 10k + 250 + k^2 - 2k + 10 - 340 = 0$

$2k^2 - 12k - 80 = 0$

$k^2 - 6k - 40 = 0$

$k^2 - 10k + 4k - 40 = 0$

$k(k-10) + 4(k-10) = 0$

$(k+4)(k-10) = 0$

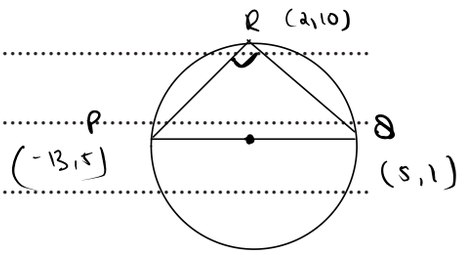
$k = -4$ OR $k = 10$

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(b) It is now given that $k = 10$. A circle passes through the points P, Q and R.

Find the equation of the tangent to the circle at R. Give your answer in the form $ax + by + c = 0$, where a, b and c are integers. [5]



Centre = $(-4, 3)$

Point R = $(2, 10)$

m of CR = $\frac{7}{6}$

m of Tangent = $-6/7$

$y - 10 = -6/7(x - 2)$

$7y - 70 = -6x + 12$

$7y = -6x + 82$

$6x + 7y - 82 = 0$

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10 A curve C has equation $y = \frac{9}{2x-5} + 2x - 5$.

(a) Find the coordinates of the two stationary points. [4]

$y = 9(2x-5)^{-1} + 2x - 5$

$\frac{dy}{dx} = \frac{-18}{(2x-5)^2} + 2$

$0 = \frac{-18}{(2x-5)^2} + 2$

$9 = (2x-5)^2$

$2x - 5 = 3 \quad \text{OR} \quad 2x - 5 = -3$

$x = 4 \quad \text{OR} \quad x = 1$

$y = 6 \quad \text{OR} \quad y = -6$

coordinates of stationary points = (1, -6) and (4, 6)

(b) Find $\frac{d^2y}{dx^2}$ and hence determine the nature of each stationary point. [3]

$-18(2x-5)^{-2}$

$\frac{d^2y}{dx^2} = \frac{72}{(2x-5)^3} \qquad \frac{72}{-27}$

For $x = 1 \rightarrow \frac{72}{(2-5)^3} = -\frac{8}{3}$ Negative means Maximum

For $x = 4 \rightarrow \frac{72}{(8-5)^3} = \frac{8}{3}$ Positive means Minimum.

→ (1, -6) = Maximum

→ (4, 6) = Minimum.

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(c) The curve C is transformed to the curve C_1 using a translation of $\begin{pmatrix} -3 \\ 7 \end{pmatrix}$ followed by reflection in the x-axis.

(i) State the coordinates of the maximum point of C_1. [1]

Maximum → (4, 6)

Maximum of C_1 = (1, −13)

(ii) Find the equation of C_1 in the form $y = \frac{a}{bx+c} + dx + e$, where a, b, c, d and e are integers. [3]

$y = \frac{9}{2x-5} + 2x - 5$

$C_1 = \frac{9}{2(x+3)-5} \; 2(x+3) - 5 + 7$

Equation of $C_1 = \frac{-9}{2x+1} - 2x - 8$

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11 The function f is defined by $f(x) = x^2 + 4ax + a$ for $x \in \mathbb{R}$, where a is a constant.

The function g is such that $g^{-1}(x) = \sqrt[3]{2x-4}$ for $x \in \mathbb{R}$.

(a) Given that the range of f is $f(x) \geqslant -33$, find the possible values of a. [4]

$x^2 + 4ax + a \geq -33$

$x^2 + 4ax + a + 33 \geq 0$

$b^2 - 4ac = 0$

$16a^2 - 4a - 132 = 0$

$4a^2 - a - 33 = 0$

$4a^2 - 12a + 11a - 33 = 0$

$4a(a-3) + 11(a-3) = 0$

$(a-3)(4a+11) = 0$

$a = 3$ or $a = -11/4$

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(b) Given instead that $fgg(0) = 96$, find the value of a. [6]

$g^{-1}(x) = \sqrt[3]{2x-4}$

$x^3 = 2y - 4$

$\frac{x^3+4}{2} = y$

$g(x) = \frac{x^3+4}{2}$

$g(0) = 2$

$gg(0) = \frac{2^3+4}{2} = 6$

$fgg(0) = 96$

$36 + 24a + a = 96$

$25a = 60$

$a = \frac{12}{5}$

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MATHEMATICS **9709/13**

Paper 1 Pure Mathematics 1 **May/June 2025**

MARK SCHEME

Maximum Mark: 75

Published

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Question	Answer	Marks	Guidance
1	$2+(12)(-2)x^{-3}$	**B1**	Correct differential but can be unsimplified.
	$2+(12)(-2)(-2)^{-3}$ $[=5]$	***M1**	Substitute $x=-2$ into *their* differential, which must contain x^{-3}.
	Either $(their\ 5)=\dfrac{y-(-1)}{x-(-2)}$ or $-1=(their\,5)\times(-2)+c \Rightarrow c=$	**DM1**	Attempt to find equation of tangent through $(-2,\ -1)$ with their numerical gradient obtained as described above.
	$y=5x+9$	**A1**	
		4	

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Question	Answer	Marks	Guidance
2	$r = \frac{8\sin^3\theta}{4\sin^2\theta}$ $\left[= 2\sin\theta\right]$	**B1**	A correct unsimplified expression for *r,* this may only be seen in a correct S_∞
	$\frac{4\sin^2\theta}{1-2\sin\theta} = \frac{1}{2}$	***M1**	OE Correct S_∞ with *their* expression for *r*.
	Or		
	$r = \frac{8\sin^3\theta}{4\sin^2\theta}$ and $\frac{4\sin^2\theta}{1-r} = \frac{1}{2}$	**B1**	
	$1 - 8\sin^2\theta = \frac{8\sin^3\theta}{4\sin^2\theta}$	***M1**	
	Then		
	Expect $8\sin^2\theta + 2\sin\theta - 1$ $\left[= 0\right]$	**DM1**	OE and attempt to solve. Attempt to solve a three-term quadratic to find at least one value of $\sin\theta$. This can be implied by a final answer of $\theta = 0.253^{\text{c}}$ AWRT
	$\left[\theta =\right] \sin^{-1}\frac{1}{4}, 0.25$	**A1**	OE Clearly identify one answer only. Accept $\sin\theta = \frac{1}{4} \Rightarrow k = \frac{1}{4}$ etc.
		4	

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Question	Answer	Marks	Guidance
3	$\left(\frac{1}{-1\times 4}\right)a(4x-3)^{-1}+2x$	**B1**	OE Do not accept $(-2+1)$ as equivalent to -1.
	Apply correct limits, $x=3$ & 1, to *their* integral	***M1**	*Their* integral must contain $(4x-3)^{-1}$. Condone using $x=1$ and 3.
	$\frac{-a}{36}+6-\left(\frac{-a}{4}+2\right)=12 \Rightarrow \left[\frac{8a}{36}+4=12\right]$	**DM1**	OE Equate *their* linear unsimplified expression in a to 12.
	$a=36$	**A1**	
		4	

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Question	Answer	Marks	Guidance
4(a)	$\{32[x^0]\}\{-120x\}\{+180x^2\}$	**B1B1B1**	Coefficients must be simplified. Ignore further terms in the expansion. **SC B3:** $2^5\left(1-\frac{15}{4}x+\frac{45}{8}x^2\ldots.\right)$ can be awarded full marks, ISW.
		3	
4(b)	$x=0.01$ or $\frac{1}{100}$	**B1**	Identify 0.01 as the only value to substitute, condone any method.
	$\left(Their\,32-120x+180x^2\right)$ with $x=\left(their\,0.01\right)$	**M1**	Clear use of *their* x-value from *their* solution of $2-\frac{3}{2}x=1.985$ and *their* answer to **(a)**. Expect $32 – 120(0.01) + 180(0.01)^2 = 32 – 1.2+ 0.018$. Condone substitution into further terms in the expansion.
	30.8[18]	**A1**	Correct answer to at least 3sf coming from substitution into three or more terms. 'Correct' answers without appropriate working get A0.
		3	

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Question	Answer	Marks	Guidance
5	Replace $\tan\theta$ with $\frac{\sin\theta}{\cos\theta}$	**M1**	
	Replace $\sin^2\theta$ with $1-\cos^2\theta$ leading to a 3-term quadratic	***M1**	To obtain a 3-term quadratic in $\cos\theta$. Accept a cubic that has a common factor of $\cos\theta$. Condone +/–sign errors during simplification.
	$9\cos^2\theta+\cos\theta-4\ [=0]$	**A1**	OE
	Attempt to solve (*their* quadratic in $\cos\theta$) using a valid method	**DM1**	Only available for solution of a three-term quadratic. Correct values of $\cos\theta$ are 0.6134 and -0.7245.
	Any two of $\pm52.2,\ \pm136.4$	**A1**	AWRT as final answers. Any two correct answers between $-180°$ and $180°$ as *their* final answers.
	All four values	**A1**	Condone other answers outside the range but no others between $-180°$ and $180°$. **SC** after M1 *M1 A1 DM0, correct answers can score B1 B1.
		6	

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Question	Answer	Marks	Guidance
6	$a+2(N-1)=55$	**B1**	SOI
	$\frac{1}{2}\times 3N(2a+2(3N-1))=5760$	**B1**	SOI
	Eliminate either a or N	**M1**	Using a valid substitution, expect either $a=57-2N$ or $N=\frac{(57-a)}{2}$. Condone +/–sign errors in *their* substitution or during simplification.
	$N^2+56N-1920$ or $a^2-226a+1953\ [=0]$	**A1**	All terms need not be collected on one side.
	$N=24,\ a=9$	**A1 A1**	Ignore presence of extra solutions for N and a.
		6	

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Question	Answer	Marks	Guidance
7(a)	$3x^2+10x-8<0$ or $3\left(x+\frac{5}{3}\right)^2-\frac{49}{3}<0$	***B1**	OE Condone = or $\leqslant 0$, but use of > or $\geqslant$ can only score B0B1B0. If there is no < , = or $\leqslant 0$, then a correct final answer implies < 0 here.
	-4 and $\frac{2}{3}$	**B1**	
	$-4<x<\frac{2}{3}$	**DB1 FT**	OE Use of $\leqslant$ sign(s) gets DB0. Condone $x>-4$, $x<\frac{2}{3}$, $x>-4$ and $x<\frac{2}{3}$ but not $x>-4$ or $x<\frac{2}{3}$. FT on *their* critical values.
		3	
7(b)	Identify $x=-4$ as the x-value of the maximum point.	**B1 FT**	SOI FT on *their* lower critical value from part **(a).**
	$[y=]\frac{3}{3}x^3+\frac{10}{2}x^2-8x[+c]$	**B1**	Correct integration of the three terms given. Condone $f(x)=$.
	Use of $y=27$, $x=$ *their* $\left(-4 \text{ or } \frac{2}{3}\right)$ in *their* integral.	**M1**	*Their* integral must be a cubic, *their* $\left(-4 \text{ or } \frac{2}{3}\right)$ must come from **(a)** or a restart.
	$c=-21 \Rightarrow y=x^3+5x^2-8x-21$	**A1**	Do not ISW if they continue to find a straight line. Condone omission of final statement if y or $f(x)=x^3+5x^2-8x+c$ has been seen earlier.
		4	

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Question	Answer	Marks	Guidance
8(a)	$\frac{1}{2}\pi - 2\left(\tan^{-1}\frac{4}{12}\text{ or }\sin^{-1}\frac{4}{\sqrt{160}}\text{ or }\cos^{-1}\frac{12}{\sqrt{160}}\right)$ Or $2\sin^{-1}\left(\frac{\frac{1}{2}EF}{AE}\left[=\frac{\sqrt{32}}{\sqrt{160}}=\frac{\sqrt{2}}{\sqrt{10}}\right]\right)$ or other valid method.	**M1**	Attempt a complete valid method for finding angle EAF. $\sqrt{160}$ may be replaced by 12.65 AWRT and $\sqrt{32}$ by 5.657 AWRT. Working in degrees should give $E\hat{A}F = 53.13°$ which converts to the correct value in radians.
	[$E\hat{A}F = 0.927295\ldots$=] 0.9273	**A1**	AG If decimals are used, at least one of 0.32175.., 0.6435 or 0.92729.. must be seen in the first method and 5.6569 and 12.649 or 0.46364 seen in the second method for the correct level of accuracy. **Note:** $E\hat{A}F = 53.14°$ does not convert to the correct answer, so A0.
	Alternative Method for Question 8(a)		
	$12^2 - (24+24+32) = \frac{1}{2}(\text{their}AE \times \text{their}\ AF)\sin E\hat{A}F$ $\sin E\hat{A}F = \frac{2\{12^2-(24+24+32)\}}{(\text{their}AE \times \text{their}\ AF)}$ $E\hat{A}F = \sin^{-1}\frac{2\{12^2-(24+24+32)\}}{(\text{their}AE \times \text{their}\ AF)}$	**M1**	Attempt a complete valid method for finding angle EAF. Area of ABCD – (Area Δs ADF, ABE &CEF) = Area ΔAEF. $E\hat{A}F = \sin^{-1}\left(\text{their}\ \frac{4}{5}\right)$. Using the cosine rule should lead to $\cos^{-1}\frac{3}{5}$.
	$\left[E\hat{A}F = \sin^{-1}\frac{4}{5}=\right]\frac{\frac{1}{2}EF}{AE}$	**A1**	AG
		2	

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Question	Answer	Marks	Guidance
8(b)	[AE or AF =] $\sqrt{160}$ or $\frac{4}{\sin E\hat{A}B}$	**B1**	OE Expect AWRT 12.65.
	$[r\theta =]$ $(their\ 12.65)\times 0.9273$	**M1**	Use of $r\theta$ with $(their\ \sqrt{160})$. Note: using r = 12 scores M0.
	$[11.729... + 8 + 8 =]$ 27.7 AWRT	**A1**	
		3	
8(c)	$\frac{1}{2}(their\ 12.65)^2 \times 0.9273$ [= 74.184]	**M1**	Use $\frac{1}{2}r^2\theta$ for area of sector with $(their\ 12.65)$. Note: using r = 12 scores M0.
	$144 - 24 - 24 - \left\{\frac{1}{2}(their 12.65)^2 \times 0.9273\right\}$	**M1**	Attempt a complete method for finding area of shaded region. Condone use of r = 12.
	[Area =] 21.8	**A1**	AWRT
	Alternative Method for Question 8(c)		
	$\frac{1}{2}(their\ 12.65)^2 (0.9273 - \sin 0.9273)$ [=10.183]	**M1**	Area of the segment with $(their\ 12.65)$. Note: using r =12 scores M0.
	$32 - \frac{1}{2}(their 12.65)^2 (0.9273 - \sin 0.9273)$	**M1**	Attempt a complete method for finding area of shaded region, condone use of r = 12.
	[Area =] 21.8	**A1**	AWRT
		3	

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Question	Answer	Marks	Guidance
9(a)	Gradient of $PR = \frac{k-5}{2+13}$ or gradient of $RQ = \frac{k-1}{2-5}$	**B1**	Obtain at least one relevant gradient.
	(*their* gradient of PR) × (*their* gradient of RQ) = -1 and attempt to simplify	**M1**	Clear of fractions and expand brackets. Expect $k^2 - 6k + 5 = 45$ OE. Condone +/–sign errors during simplification.
	$k^2 - 6k - 40$ $[= 0]$	**A1**	OE
	$k = 10,\ k = -4$	**A1**	
	Alternative Method for Question 9(a)		
	$PR^2 = (k-5)^2 + (2+13)^2$ or $RQ^2 = (k-1)^2 + (2-5)^2$	**B1**	Obtain at least one of PR^2 and RQ^2. These expressions may be seen under a square root sign.
	$(their\ PR^2) + (their\ RQ^2) = 18^2 + 4^2$ and attempt to simplify	**M1**	Expect $2k^2 - 12k + 260 = 340$ OE. Condone +/–sign errors.
	$2k^2 - 12k - 80$ $[= 0]$	**A1**	OE
	$k = 10,\ k = -4$	**A1**	

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Question	Answer	Marks	Guidance
9(a)	**Alternative Method 2 for Question 9(a)**		
	$x^2 + y^2 + 8x - 6y - 60 = 0$	**B1**	OE
	$2^2 + k^2 + 8\times 2 - 6\times k - 60 = 0$	**M1**	Substitution of $(2, k)$ into their circle equation.
	$k^2 - 6k - 40$ $[= 0]$	**A1**	OE
	$k = 10,\ k = -4$	**A1**	
		4	If none of the above marks are awarded, then **SC B1** for using $k = 10$ to find the gradients of QR (–3) and PR $\left(\frac{1}{3}\right)$ and showing that their product is –1 (or other similar verification), and then stating that this shows that 10 is a possible value for k.

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Question	Answer	Marks	Guidance
9(b)	[Centre is] $(-4, 3)$	**B1**	SOI
	Radius gradient $= \dfrac{(their\ 3)-10}{(their\ -4)-2}$ $\left[=\dfrac{7}{6}\right]$	***M1**	Attempt at finding the gradient of the radius using $(2, 10)$ and their centre, but not P, Q, the mid-point of PR or QR.
	Either $\dfrac{-1}{\left(their\ \dfrac{7}{6}\right)}=\dfrac{y-10}{x-2}$ Or $10=\dfrac{-1}{\left(their\ \dfrac{7}{6}\right)}\times 2+c \Rightarrow c=...$	**DM1**	OE Correct method to find the equation of the tangent using $\dfrac{-1}{their\ \text{radius gradient}}$ and $(2, 10)$.
	$y-10=-\dfrac{6}{7}(x-2)$ or $y=\left(-\dfrac{6}{7}\right)x+\dfrac{82}{7}$	**A1**	OE Correct equation but not stated in the required form.
	$6x+7y-82=0$ or $82-6x-7y=0$	**A1**	All correct terms on one side, but condone them being in the wrong order.
	Alternative Method for Question 9(b)		
	$x^2+y^2+8x-6y-60=0$	**B1**	OE Equation of the circle.
	$2x+2y\dfrac{\mathrm{d}y}{\mathrm{d}x}+8-6\dfrac{\mathrm{d}y}{\mathrm{d}x}=0$ Or $\dfrac{\mathrm{d}y}{\mathrm{d}x}=\dfrac{-2x-8}{2}\left(85-x^2-8x-16\right)^{-\frac{1}{2}}$	***M1**	Differentiate implicitly to arrive at an expression with two terms containing $\dfrac{\mathrm{d}y}{\mathrm{d}x}$. Or rearrange to make y the subject and differentiate to arrive at an expression of the form $\mathrm{f}'(x)\times\mathrm{f}(x)$.

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Question	Answer	Marks	Guidance
9(b)	$2(2)+2(10)\frac{\mathrm{d}y}{\mathrm{d}x}+8-6\frac{\mathrm{d}y}{\mathrm{d}x}=0$ Or $\frac{\mathrm{d}y}{\mathrm{d}x}=\frac{-2(2)-8}{2}\left(85-(2)^2-8(2)-16\right)^{-\frac{1}{2}}$	**DM1**	Substitute (2,10) into their implicit differential. Or substitute $x=2$ into their expression for $\frac{\mathrm{d}y}{\mathrm{d}x}$.
	$y-10=-\frac{6}{7}(x-2)$ or $y=-\frac{6}{7}x+\frac{82}{7}$	**A1**	OE Correct equation but not stated in the required form.
	$6x+7y-82=0$	**A1**	All correct terms on one side, but condone them being in the wrong order.
		5	

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Question	Answer	Marks	Guidance
10(a)	$-9\times2(2x-5)^{-2}+2$	**B1**	Correct differential.
	$\left(their -18(2x-5)^{-2}+2\right)=0$ and rearrange to form a quadratic. $\left[\left(2x-5\right)^2=9 \text{ or } 8x^2-40x+32=0\right]$	**M1**	Equating a two term $\frac{\mathrm{d}y}{\mathrm{d}x}$ to 0 and dealing correctly with the negative power. Their two term $\frac{\mathrm{d}y}{\mathrm{d}x}$ must contain $(2x-5)^{-2}$.
	$(1,\ -6)$ **and** $(4, 6)$	**A1, A1**	A1 for two correct x-values or one correct point, second A1 for all correct.
		4	
10(b)	$-18\times-2\times2(2x-5)^{-3}$ $\left[=72(2x-5)^{-3} \text{ or } \frac{144x-360}{\left(2x-5\right)^4}\right]$	**B1 FT**	Following through on *their* first derivative which must contain $(2x-5)^{-2}$.
	Use $\left(their\ x=1 \text{ and } x=4\right)$ in $(their\ 72\left(2x-5\right)^{-3})$ To determine the nature of both turning points.	**M1**	Substitute x-coordinate of each stationary point and determine their nature. Nature of the turning points must correctly follow from *their* values of $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$.
	For $x=1$, $\left[\frac{\mathrm{d}^2y}{\mathrm{d}x^2}=\right]$ $-\frac{72}{27}$ or $<0 \implies$ maximum For $x=4$, $\left[\frac{\mathrm{d}^2y}{\mathrm{d}x^2}=\right]$ $\frac{72}{27}$ or $>0 \implies$ minimum	**A1**	CWO
		3	

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Question	Answer	Marks	Guidance
10(c)(i)	$(1,\ -13)$	**B1**	
		1	
10(c)(ii)	$[y=]\dfrac{9}{2(x\pm3)-5}+2(x\pm3)-5\pm7$	**M1**	Application of $\begin{pmatrix}-3\\7\end{pmatrix}$ to the original expression for C but condone $+/-$ sign errors.
	$[y=]-\left(\dfrac{9}{2(x\pm3)-5}+2(x\pm3)-5\pm7\right)$	**M1**	**SC B1** for $[y=]-\left(\dfrac{9}{2x-5}+2x-5\right)$.
	$y=-\dfrac{9}{2x+1}-2x-8$	**A1**	Answer must be in this format; the '$y=$' can be implied by earlier inclusion.
		3	

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Question	Answer	Marks	Guidance
11(a)	$\left[f\left(x\right)=\right](x+2a)^2-4a^2+a$	**B1**	
	$\left(their\left(-4a^2+a\right)\right)=-33$	**M1**	Condone $\geqslant$ or $>$.
	$4a^2-a-33$ [= 0]	**B1**	Condone $\leqslant$ or $<$.
	$-\frac{11}{4}$, 3	**A1**	OE Do not ISW if their final answer is given as a range or if one of the answers is rejected.
	Alternative Method for Question 11(a)		
	$x=-2a$, $y=-4a^2+a$	**B1**	The co-ordinates of the minimum point (likely to be either from differentiation or completing the square).
	$\left(their-4a^2+a\right)=-33$	**M1**	*Their y*-coordinate equated to -33. Condone $\geqslant$ or $>$.
	$-4a^2+a+33\left[=0\right]$	**B1**	OE Condone $\geqslant$ or $>$.
	$-\frac{11}{4}$, 3	**A1**	OE Do not ISW if their final answer is given as a range or if one of the answers is rejected.

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Question	Answer	Marks	Guidance
11(a)	**Alternative Method 2 for Question 11(a)**		
	$x^2+4ax+a+33$ [=0]	**B1**	Condone $\geqslant$ or $>$.
	$(4a)^2-4[1](a+33)$ [= 0]	**M1**	Condone $\geqslant$ or $>$.
	$16a^2-4a-132$ [=0]	**B1**	OE Condone $\geqslant$ or $>$. Accept $4a^2-a-33$ or multiples thereof.
	$-\frac{11}{4}$, 3	**A1**	OE Do not ISW if their final answer is given as a range or if one of the answers is rejected.
		4	

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Question	Answer	Marks	Guidance
11(b)	$[\mathrm{g}(x) =]\ \frac{1}{2}\left(x^3+4\right)$	**B1**	Expression for $\mathrm{g}(x)$. SOI
	Either		
	$[\mathrm{g}(0) =]\ \frac{1}{2}\left((0)^3 \pm 4\right) \quad [g(0)=2]$	**M1**	Replacing x with 0 in *their* $\mathrm{g}(x)$.
	$\mathrm{gg}(0) = 6$	**A1**	
	$\mathrm{f}(\textit{their}\,6)\ [=36+24a+a]$	**M1**	
	Or		
	$\mathrm{fg}(x) = \left(\frac{x^3+4}{2}\right)^2 + 4a\left(\frac{x^3+4}{2}\right) + a$ or $\mathrm{gg}(x) = \frac{\left(\frac{x^3+4}{2}\right)^3 + 4}{2} \quad \left[= \frac{\left(x^3+4\right)^3}{16} + 2\right]$	**M1**	Either composite function using *their* $\mathrm{g}(x)$.
	$\mathrm{fgg}(x) = \left\{\frac{\left(x^3+4\right)^3}{16} + 2\right\}^2 + 4a\left\{\frac{\left(x^3+4\right)^3}{16} + 2\right\} + a$	**A1**	Complete algebraic expression for $\mathrm{fgg}(x)$.
	$\mathrm{fgg}(0) = \left\{\frac{(0+4)^3}{16} + 2\right\}^2 + 4a\left\{\frac{(0+4)^3}{16} + 2\right\} + a$	**M1**	Replacing x with 0 in *their* $\mathrm{fgg}(x)$.

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Question	Answer	Marks	Guidance
11(b)	**Then**		
	$36 + 24a + a = 96$	**A1**	OE
	$[a =] \frac{12}{5}$	**A1**	OE
		6	

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MATHEMATICS **9709/15**

Paper 1 Pure Mathematics 1 **May/June 2025**

1 hour 50 minutes

You must answer on the question paper.

You will need: List of formulae (MF19)

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- If additional space is needed, you should use the lined page at the end of this booklet; the question number or numbers must be clearly shown.
- You should use a calculator where appropriate.
- You must show all necessary working clearly; no marks will be given for unsupported answers from a calculator.
- Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place for angles in degrees, unless a different level of accuracy is specified in the question.

INFORMATION

- The total mark for this paper is 75.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **20** pages. Any blank pages are indicated.

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1 The equation of a curve is such that $\frac{dy}{dx} = 12(2x-5)^2 + 8x$. It is given that the curve passes through the point (2, 4).

Find an equation of the curve. [4]

$y = \int 12(2x-5)^2 + 8x$

$y = 2(2x-5)^3 + 4x^2 + c$

$4 = 2(-1) + 16 + c$

$c = -10$

$y = 2(2x-5)^3 + 4x^2 - 10$

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2 In the expansion of $(3+ax)^5 + (6-x)^4$, the coefficient of x^2 is six times the coefficient of x.

Find the possible values of the constant a. [5]

$(3+ax)^5 = {}^5C_0\,(3)^5(ax)^0 + {}^5C_1(3)^4(ax)^1 + {}^5C_2\,(3)^3(ax)^2$

$= (1 \times 243 \times 1) + (5 \times 81 \times ax) + (10 \times 27 \times a^2x^2)$

$= 243 + 405ax + 270a^2x^2$

$(6-x)^4 = {}^4C_0\,(6)^4(-x)^0 + {}^4C_1(6)^3(-x)^1 + {}^4C_2\,(6)^2(-x)^2$

$= (1 \times 1296 \times 1) + (4 \times 216 \times -x) + (6 \times 36 \times x^2)$

$= 1296 - 864x + 216x^2$

Coefficient of $x^2 = 270a^2 + 216$

Coefficient of $x = 405a - 864$

$270a^2 + 216 = 6(405a - 864)$

$45a^2 + 36 = 405a - 864$

$45a^2 - 405a + 36 + 864 = 0$

$45a^2 - 405a + 900 = 0$

$a^2 - 9a + 20 = 0$

$a^2 - 4a - 5a + 20 = 0$

$a(a-4) - 5(a-4) = 0$

$(a-5)(a-4) = 0$

$a = 5$ or $a = 4$ Possible values of a.

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3 **(a)** Use completing the square to find the exact solutions of the equation $4x^2 - 4x - 1 = 0$. [2]

$(2x-1)^2 - 2 = 0$

$(2x-1)^2 = 2$

$(2x-1) = \sqrt{2}$

$x = \frac{\pm\sqrt{2}+1}{2}$

$x = \frac{1}{2} \pm \sqrt{\frac{1}{2}}$

(b) Hence solve the equation $4\tan\theta = 4 + \frac{1}{\tan\theta}$ for $0° < \theta < 180°$. [3]

$4\tan\theta - 4 = \frac{1}{\tan\theta}$

$4\tan^2\theta - 4\tan\theta - 1 = 0$

$\tan\theta = \frac{1}{2} \pm \sqrt{\frac{1}{2}}$

$\alpha = \tan^{-1}\left(\frac{1}{2} \pm \sqrt{\frac{1}{2}}\right) = 50.36, +11.7$

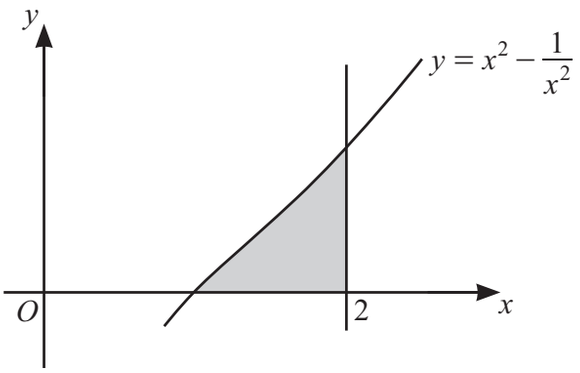
$\theta = 50.36, 230.36, 168.3, 348.3$

Hence $\theta = 50.4$ and 168.3

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The diagram shows part of the curve $y = x^2 - \frac{1}{x^2}$. The shaded region is bounded by the curve, the line $x = 2$ and the x-axis.

Find the volume formed when the shaded region is rotated through 360° about the x-axis, giving your answer correct to 2 decimal places. [5]

$x^3 - \frac{1}{x^2} = 0$

$x^4 - 1 = 0$

$x = \pm 1$

$x = 1$

Volume $= \pi \int_1^2 \left(x^4 - 2 + \frac{1}{x^4}\right)$

Volume $= \pi \left[\frac{x^5}{5} - 2x - \frac{1}{3}x^{-3}\right]_1^2$

Volume $= \pi \left[\frac{32}{5} - 4 - \frac{1}{24} - \frac{1}{5} + 2 + \frac{1}{3}\right]$

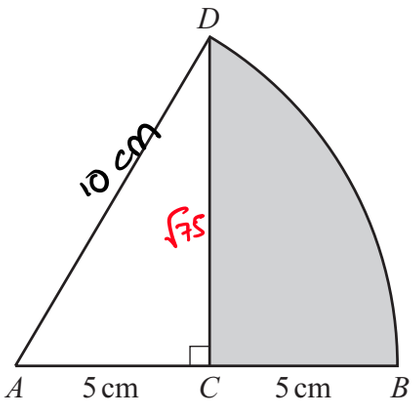
Volume $= 4.49\pi$

Volume $= 14.11$

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The diagram shows a sector ABD of a circle with centre A and radius 10 cm. The perpendicular bisector of AB passes through D.

(a) Find the perimeter of the shaded region BCD, giving your answer correct to 1 decimal place. [4]

Centre = $\cos A = \frac{5}{12}$ $A = \cos^{-1}(5/10)$

centre = $\frac{1}{3}\pi$

$DC = \sqrt{10^2 - 5^2}$

$DC = \sqrt{100 - 25}$

$DC = \sqrt{75}$

SofDB = $10 \times \frac{1}{3}\pi$

SofDB = $\frac{10}{3}\pi$

Perimeter = DC + CD + SofDB

Perimeter = $\sqrt{75} + 5 + \frac{10}{3}\pi$

Perimeter = 24.1

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(b) Find the area of the shaded region *BCD*, giving your answer correct to 1 decimal place. [2]

Area of Shaded Region = Area of Sector - Area of Triangle.

Area of Shaded Region = $\left(\frac{1}{2} \times 60 \times \frac{1}{3}\pi\right) - \left(\frac{1}{2} \times 5 \times \sqrt{75}\right)$

Area of Shaded Region = $\frac{50}{3}\pi - \frac{25}{2}\sqrt{3}$

Area of Shaded Region = 30.7

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6 Each year, on her birthday, Ananya receives some money from each of her parents.

On Ananya's first birthday, her father gives her \$10. Every subsequent year, her father gives her \$5 more than he gave her the previous year.

On Ananya's first birthday, her mother also gives her \$10. Every subsequent year, her mother gives her 20% more than she gave her the previous year.

(a) Show that on Ananya's eleventh birthday she receives more from her mother than from her father. [3]

Arithmetic Progression

$a = 10$

$d = 5$

$T_{11} = 10 + 10(5)$

$T_{11} = 60\$$

Geometric progression:

$a = 10$

$r = 1.2$

$T_{11} = 10(1.2)^{10}$

$T_{11} = 61.92 = 62\$$

Money recieved from her father = 60\$

Money recieved from her mother = 62\$

→ Proved that money recieved from mother is more than her father

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(b) Find the total amount of money Ananya receives up to and including her eighteenth birthday. [5]

Total recieved from father = $\frac{18}{2}[20 + 17(5)]$

Total recieved from father = 945 $

Total recieved from her mother = $\frac{10(1 - 1.2^{19})}{1 - 1.2}$

Total recieved from her mother = 1281.2 $

Total recieved = 945 + 1281.2 $

Total recieved = 2226.2 $

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7 In the parallelogram $ABCD$, the coordinates of A are (3, 7), the coordinates of B are (6, p) and the coordinates of D are (1, p). It is given that the gradient of AB is $-\frac{2}{3}$.

(a) Find the value of p. [2]

Gradient = $\frac{p-7}{3} = \frac{-2}{3}$

$p-7=-2$

$p=5$

(b) Find the coordinates of C. [2]

$\frac{-2}{3} = \frac{y-5}{x-1} \Rightarrow 3y+2x=17$.

$1 = \frac{y-5}{x-6} \Rightarrow y=x-1$

$3(x-1)+2x=17$

$3x-3+2x=17$

$5x=20$

$x=4$

$y=3$

Point C = (4, 3)

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(c) Find the area of the triangle formed by the perpendicular bisector of AB and the x- and y-axes. [5]

Midpoint of AB $(4.5, 6)$

Gradient: $\frac{3}{2}$.

Equation: $y - 6 = \frac{3}{2}(x - 4.5)$

$2y - 12 = 3x - 13.5$

$2y = 3x - 1.5$

$y = \frac{3}{2}x - \frac{3}{4}$

Intersection with x-axis: $(\frac{1}{2}, 0)$

Intersection with y-axis: $(0, -\frac{3}{4})$

Origin: $(0, 0)$

Distance: $\sqrt{\frac{9}{16} + \frac{1}{4}} = \sqrt{\frac{13}{16}}$

Distance: $\sqrt{\frac{9}{16}} = \frac{3}{4}$

Distance: $\sqrt{\frac{1}{4}} = \frac{1}{2}$

Area: $\frac{1}{2} \times \frac{1}{2} \times \frac{3}{4}$

Area: $\frac{3}{16}$ cm²

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8 The equation of a curve is $y = x^3 + ax^2 + bx + 5$. The curve has a stationary point at (1, 9).

(a) Find the values of the constants a and b. [5]

$\frac{dy}{dx} = 3x^2 + 2ax + b$

$3 + 2a + b = 0$

$2a + b = -3 \rightarrow i$

$9 = 1 + a + b + 5$

$a + b = 3 \rightarrow ii$

$-2a - b = 3$

$a + b = 3$

$-a = 6$

$a = -6$

$a + b = 3$

$-6 + b = 3$

$b = 9$

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(b) Find the coordinates of the other stationary point. [3]

$3x^2 - 12x + 9 = 0$

$3x^2 - 3x - 9x + 9 = 0$

$3x(x-1) - 9(x-1) = 0$

$(3x-9)(x-1) = 0$

$x = 3$ or $x = 1$

$y = (3)^3 - 6(3)^2 + 9(3) + 5$

$y = 5$

Co-ordinates of other stationary point: $(3, 5)$

(c) A point P is moving along part of the curve in such a way that the y-coordinate of P is increasing at a constant rate of 6 units per second.

Find the rate at which the x-coordinate of P is increasing when $x = 5$. [3]

$\frac{dy}{dx} = 3(5)^2 - 12(5) + 9 = 0$

$\frac{dy}{dx} = 24$

$\frac{dy}{dt} = \frac{dy}{dx} \times \frac{dx}{dt}$

$6 = 24 \times \frac{dx}{dt}$

$\frac{1}{4} = \frac{dx}{dt}$

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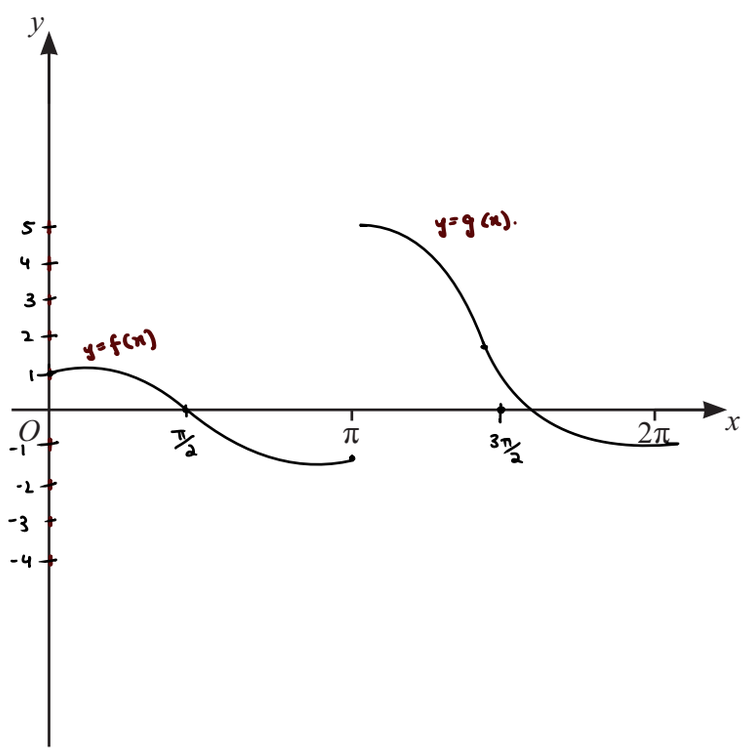
9 Functions f and g are defined as follows.

$$f(x) = \cos x \text{ for } 0 \leqslant x \leqslant \pi$$
$$g(x) = 3\cos(x - \pi) + 2 \text{ for } \pi \leqslant x \leqslant 2\pi$$

(a) Describe fully the transformations that have been combined to transform the graph of $y = f(x)$ to the graph of $y = g(x)$. [4]

vertical stretch with factor 3
Translation $T = \begin{pmatrix} \pi \\ 2 \end{pmatrix}$

(b) On the given axes, sketch the graphs of $y = f(x)$ and $y = g(x)$. [4]



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(c) Find $g^{-1}f\left(\frac{1}{3}\pi\right)$. [4]

$f\left(\frac{1}{3}\pi\right) = \cos\left(\frac{1}{3}\pi\right) = \frac{1}{2}$.

$y = 3\cos(x-\pi) + 2$.

$\frac{y-2}{3} = \cos(x-\pi)$

$\cos^{-1}\left(\frac{x-2}{3}\right) + \pi = g^{-1}(x)$

$g^{-1}\left(\frac{1}{2}\right) = \cos^{-1}\left(\frac{-1.5}{3}\right) + \pi$

$g^{-1}\left(f\frac{1}{3}\pi\right) = \frac{5}{3}\pi$

(d) Explain why the composite function fg cannot be formed. [1]

fg cannot be formed because the domain of f $[0 \leq x \leq \pi]$ doesnot include entire range g. $[-1 \leq g(x) < 5]$

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10 The equation of a circle is $x^2 + y^2 + 4x - 8y - 12 = 0$.

(a) Find an equation of the tangent to the circle at the point (2, 8), giving your answer in the form $ax + by + c = 0$. [4]

Centre → $-2a = 4$ $\quad -2b = -8$

$a = -2$ $\quad b = 4$

Centre = $(-2, 4)$

m of CP = $\frac{8-4}{2+2} = \frac{4}{4} = 1$

m of Tangent = -1

Point = $(2, 8)$

Equation of Tangent → $y - 8 = -1(x - 2)$

Equation of Tangent → $y - 8 = -x + 2$

Equation of Tangent → $y = -x + 10$

Equation of Tangent → $x + y - 10 = 0$

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(b) Given that the line $x+3y=k$ does **not** intersect the circle, show that $k^2-20k-220>0$. [5]

Eqn of Circle $= x^2+y^2+4x-8y-12=0$

Line $= x+3y=k$

Line $= y = \frac{k-x}{3}$

$= x^2 + \frac{k^2-2kx+x^2}{9} + 4x - \frac{8k+8x}{3} - 12 = 0$

$9x^2 + k^2 - 2kx + x^2 + 36x - 24k + 24x - 108 = 0$

$10x^2 + (-2k+36+24)x + (k^2-24k-108) = 0$

$10x^2 + (60-2k)x + (k^2-24k-108) = 0$

$b^2-4ac < 0$

$(60-2k)^2 - 4(10)(k^2-24k-108) < 0$

$3600 - 240k + 4k^2 - 40k^2 + 960k + 4320 < 0$

$-36k^2 - 720k + 7920 < 0$

$36k^2 + 720k - 7920 > 0$

$k^2 - 20k - 220 > 0$ → Proved!!

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MATHEMATICS **9709/15**

Paper 1 Pure Mathematics 1 **May/June 2025**

MARK SCHEME

Maximum Mark: 75

Published

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Question	Answer	Marks	Guidance
1	$[y=]\left\{\frac{12}{3\times 2}(2x-5)^3\right\}\left\{+\frac{8}{2}x^2\right\}[+c]$	**B1 B1**	OE Terms may be unsimplified. May see $[y=]\{16x^3\}\{-116x^2\}\{+300x\}[+c]$.
	$4 = 2\times(2\times 2 - 5)^3 + 4\times 2^2 + c$ [$\Rightarrow c = -10$]	**M1**	Sub (2, 4) correctly into *their* integrated expression with a '+ c'.
	y or f or $\mathrm{f}(x) = 2(2x-5)^3 + 4x^2 - 10$	**A1**	May see $y = 16x^3 - 116x^2 + 300x - 260$. '$y =$' or '$\mathrm{f}(x) =$' or 'f =' can be implied if seen in working.
		4	

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Question	Answer	Marks	Guidance
2	x^2 coeff = $10\times3^3\times a^2$ and $6\times6^2\times(-1)^2$ allow correct terms with x^2	**B1**	Expect $270a^2$ and 216. Terms may be seen separately. Allow if seen in an expansion. Combinations must be evaluated.
	x coeff = $5\times3^4\times a$ and $4\times6^3\times(-1)$ allow correct terms with x	**B1**	Expect $405a$ and -864. Terms may be seen separately. Allow if seen in an expansion. Combinations must be evaluated.
	$270a^2+216=6(405a-864)$	**M1**	OE For forming a correct quadratic equation using *their* 4 terms only.
	$45a^2-405a+900=0 \Rightarrow 45(a-4)(a-5)=0$	**DM1**	For evidence of a correct method of solving. If quadratic formula used a full substitution must be seen.
	$a=4$ or $a=5$	**A1**	Only dependent on the first M1.
		5	

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Question	Answer	Marks	Guidance
3(a)	$4\left(x-\frac{1}{2}\right)^2\left[-2=0\right]$ or $(2x-1)^2\left[-2=0\right]$ or $\left(x-\frac{1}{2}\right)^2\left[-\frac{1}{2}=0\right]$	**M1**	OE Must deal with the coefficient of x^2 and x correctly to produce an $(ax+b)^2$ term.
	$x=\frac{1}{2}\pm\sqrt{\frac{1}{2}}$	**A1**	OE, e.g. $x=\frac{1}{2}\left(1\pm\sqrt{2}\right)$. **SC B1** only for correct solutions from another method.
		2	
3(b)	$\tan\theta=\frac{1}{2}\left(1\pm\sqrt{2}\right)$	**M1**	Setting $\tan\theta=$ *their* x for at least one value of *their* x. May restart and solve the quadratic in $\tan\theta$.
	[θ =] 50.4, 168.3 AWRT and no other answers in the range $0<\theta<180$	**A1 A1**	**SC A1** only for AWRT 0.879 and 2.94 radians. **SC M0 B1 B1** for answers only. **SC M0 B1**(only) for both answers only in radians.
		3	

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Question	Answer	Marks	Guidance
4	Intersects x-axis when $x^4 = 1 \Rightarrow x = 1$	**B1**	WWW May be seen without working. May be seen as a limit in the integration. Allow ± 1 if $x = 1$ is seen as the lower limit in the integration.
	$V = [\pi]\int y^2 \mathrm{d}x = [\pi]\int\left(x^2 - \frac{1}{x^2}\right)^2 \mathrm{d}x = [\pi]\int\left(x^4 - 2 + \frac{1}{x^4}\right)\mathrm{d}x$ with attempt at integration	***M1**	With some attempt at squaring (accept $x^4 \pm \frac{1}{x^4}$ as evidence).
	$\frac{1}{5}x^5 - 2x - \frac{1}{3x^3}$	**A1**	
	$[\pi]\left\{\left(\frac{1}{5}\times 2^5 - 2\times 2 - \frac{1}{3\times 2^3}\right) - \left(\frac{1}{5} - 2 - \frac{1}{3}\right)\right\}$	**DM1**	Use of limits, $x = 2$ and *their* $x = 1$, min evidence if correct answer: $\frac{283}{120} + \frac{32}{15}$. If answer incorrect, substitution of limits must be clear. DM0 for use of the limit $x = 0$.
	$\pi \times 4.49\ldots = 14.11$	**A1**	AWRT, WWW Allow $\frac{539}{120}\pi$ or 14.1, dependent on the first M1 and A1.
		5	

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Question	Answer	Marks	Guidance
5(a)	Angle $CAD = \frac{\pi}{3}$ or 60°, $CD = \sqrt{75}$ or $5\sqrt{3}$	**B1**	OE For either $C\hat{A}D$ or CD. Allow $C\hat{A}D = 1.05$, $CD = 8.7$ or 8.66.
	[Perimeter =] $\left\{10 \times \frac{\pi}{3}\right\}\left\{+\sqrt{75}+5\right\}$ or $\left\{\frac{60}{360} \times 2\pi(10)\right\}\left\{+\sqrt{75}+5\right\}$	**B1 B1**	OE B1 for the two sides and B1 for arc length (allow 10.5).
	= 24.1 cm	**B1**	
		4	
5(b)	Area = $\frac{1}{2} \times 10^2 \times \frac{\pi}{3} - \frac{1}{2} \times 5 \times \sqrt{75}$ or $\frac{60}{360} \times \pi \times 10^2 - \frac{1}{2} \times 5 \times \sqrt{75}$	**M1**	OE Use of sector area formula minus triangle area formulae, with *their* angle CAD and *their* side CD.
	= 30.7 cm^2	**A1**	
		2	

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Question	Answer	Marks	Guidance
6(a)	Eleventh birthday: Father $10+10\times5$ [= 60]	**M1**	For correct use of AP formula OE.
	Mother 10×1.2^{10} [= 61.9(2)]	**M1**	For correct use of GP formula OE.
	60 and 61.9	**A1**	Both answers. Accept 2 sf answers.
		3	
6(b)	Father $\frac{18}{2}\left(2\times10+17\times5\right)=945$	**M1A1**	A1 may be implied by a correct final answer.
	Mother $\frac{10\left(1-1.2^{18}\right)}{\left(1-1.2\right)}=1281.17$	**M1A1**	A1 may be implied by a correct final answer.
	Total = 2226.17	**A1**	Accept 3 or more sf answers. Ignore $S_{17}\left(=1909.3\right)$ as an extra answer.
		5	

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Question	Answer	Marks	Guidance
7(a)	$\frac{7-p}{3-6}=-\frac{2}{3}$ or use of straight line equations with $m=-\frac{2}{3}$, $(x,y)=(3,7)$ with (6, p) substituted.	**M1**	OE Expect $y-7=\left(-\frac{2}{3}\right)(x-3)$ with (6, p) substituted or $y=\frac{-2}{3}x+9$ with (6, p) substituted.
	$p = 5$	**A1**	
		2	
7(b)	({4}, {*their 2p-7*})	**B1**	WWW
		B1FT	Extra solutions lose both marks.
		2	
7(c)	Mid-point AB is (4.5, 6)	**B1**	
	Gradient of perp bisector $\left[=\frac{-1}{-\frac{2}{3}}\right]=\frac{3}{2}$	**B1**	
	Equation $y-6=\frac{3}{2}(x-4.5)$	**M1**	OE. Must be using *their* mid-point and *their* perpendicular gradient.
	Crosses axes at (0, −0.75), (0.5, 0)	**DM1**	Correct use of *their* perpendicular bisector equation to find the x- and y-intercept.
	Area = 0.1875 (accept 3 sf accuracy)	**A1**	OE, e.g. $\frac{3}{16}$. Last 2 marks can be gained by integrating the line equation between zero and 0.5.
		5	

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Question	Answer	Marks	Guidance
8(a)	$9 = 1 + a + b + 5$	**B1**	
	$\frac{dy}{dx} = 3x^2 + 2ax + b$	**B1**	
	Gradient = 0 at (1, 9) so $0 = 3 + 2a + b$	**M1**	Setting *their* $\frac{dy}{dx}$ to zero and substituting $x = 1$.
	Attempt to solve *their* linear equations simultaneously	**DM1**	Can be implied by their answers.
	$a = -6$, $b = 9$	**A1**	WWW
		5	
8(b)	$\frac{dy}{dx} = 3x^2 - 12x + 9 = 0$	**M1**	Setting *their* $\frac{dy}{dx}$ to zero.
	Solution [leading to $x = 1$ or $x = 3$]	**DM1**	Solving *their* 3-term quadratic
	(3, 5) or $x = 3$, $y = 5$	**A1**	WWW Ignore $(1, 9)$ if given as a second answer. Only dependent on the first M1.
		3	

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Question	Answer	Marks	Guidance
8(c)	At $x = 5$, $\frac{dy}{dx} = 3\times5^2 - 12\times5 + 9$	**M1**	Substituting $x = 5$ into *their* $\frac{dy}{dx}$. May be implied.
	$6 = \textit{their}\ 24 \times \frac{dx}{dt}$ or $\textit{their}\ 24 = 6 \times \frac{dt}{dx}$	**M1**	OE Use of chain rule SOI $\left(\frac{dy}{dt} = \frac{dy}{dx} \times \frac{dx}{dt}\right)$. Linking correctly $\frac{dx}{dt}$ (or $\frac{dt}{dx}$), *their* 24 and 6.
	$\frac{dx}{dt} = \frac{1}{4}$	**A1**	OE
		3	

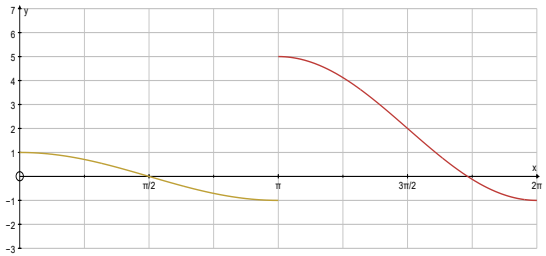
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Question	Answer	Marks	Guidance
9(a)	{Stretch}{factor 3} {in y-direction}	**B2,1,0**	If 2 or more stretches or extra transformations, give B0 for stretches.
	{Translation or shift} $\begin{pmatrix}\{\pi\}\\\{2\}\end{pmatrix}$	**B2,1,0**	Translation may be split to $\begin{pmatrix}\pi\\0\end{pmatrix}$ before the stretch and $\begin{pmatrix}0\\2\end{pmatrix}$ after the stretch. If both vectors correct but 'translation'/'shift' not stated, then B1 only for the translations.
	Alternative Method for Question 9(a)		
	{Translation or shift} $\begin{pmatrix}\{\pi\}\\\left\{\frac{2}{3}\right\}\end{pmatrix}$ or $\begin{pmatrix}\pi\\0\end{pmatrix}$ and $\begin{pmatrix}0\\\frac{2}{3}\end{pmatrix}$	**B2,1,0**	If two or more stretches or any extra incorrect transformation is given, then B0 for the stretches. If order incorrect, maximum of 3/4.
	followed by {stretch} {factor 3} {in y direction}	**B2,1,0**	
		4	

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Question	Answer	Marks	Guidance
9(b)		**B1†**	Graph of f(x) with correct domain.
		B1†	For g(x) being a decreasing function in the domain π to 2π.
		B1	Domain π to 2π for g(x).
		B1	Range for g approximately correct (should be from 5 to −1).
		4	†Sketches must be curves and have zero gradient at the ends of the given domains.
9(c)	$[g^{-1}]\,f\left(\frac{\pi}{3}\right) = [g^{-1}]\left(\frac{1}{2}\right)$	**B1**	May be implied by correct substitution later.
	$[g^{-1}(x)$ or $y =] \cos^{-1}\left(\frac{x-2}{3}\right)+\pi$ or $[x =] \cos^{-1}\left(\frac{y-2}{3}\right)+\pi$	**M1**	Finding inverse of g. Allow one sign error. Alt: $3\cos(x-\pi)+2=\frac{1}{2}$
	$[g^{-1}\left(\frac{1}{2}\right) =] \cos^{-1}\left(\frac{\frac{1}{2}-2}{3}\right)+\pi$	**DM1**	Substituting *their* $x=\frac{1}{2}$ into *their* expression for $g^{-1}(x)$. Alt: Use of arccos for $\cos(x-\pi)=-\frac{1}{2} \Rightarrow x-\pi=\frac{2\pi}{3}$
	$[g^{-1}(x) =] \frac{2\pi}{3}+\pi=\frac{5\pi}{3}$ or 5.24 AWRT	**A1**	
		4	

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Question	Answer	Marks	Guidance
9(d)	The domain of f does not include the whole of the range of g	**B1**	OE, but must mention range of g and domain of f.
	Alternative Method for Question 9(d)		
	Show clearly that a particular value or set of values in the domain of g gives a value of $g(x)$ which is outside the domain of f	**B1**	Value of x for substitution into $g(x)$ must be in the ranges: $\pi \leqslant x < 4.322$ or $5.447 < x \leqslant 2\pi$.
		1	

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Question	Answer	Marks	Guidance
10(a)	Centre is (–2, 4)	**B1**	
	Gradient of perpendicular = $\frac{8-4}{2-(-2)}$ [= 1]	**M1**	OE, e.g. using equation of the radius.
	Equation of tangent is $y - 8 = -1(x - 2)$	**M1**	Using a correct point and *their* tangent gradient from an attempt to find $\frac{dy}{dx}$, or the negative reciprocal of *their* perpendicular gradient.
	$x + y - 10 = 0$ or $-x - y + 10 = 0$	**A1**	CAO – this form is required. Answer without working, allow maximum of 2/4.
	Alternative Method for Question 10(a)		
	$y = [\pm]\left(28 - x^2 - 4x\right)^{\frac{1}{2}} + 4$ or $y = [\pm]\left(32 - (x+2)^2\right)^{\frac{1}{2}} + 4$	**B1**	OE; a correct expression for y.
	$\frac{dy}{dx} = [\pm]\frac{1}{2}\left(28 - x^2 - 4x\right)^{\frac{-1}{2}}(-2x - 4)$ [= – 1 at $x = 2$]	**M1**	OE Differentiating y with no more than one sign error.
	Equation of tangent is $y - 8 = -1(x - 2)$	**M1**	Using a correct point and *their* tangent gradient from an attempt to find $\frac{dy}{dx}$, or the negative reciprocal of *their* perpendicular gradient.
	$x + y - 10 = 0$ or $-x - y + 10 = 0$	**A1**	CAO – this form is required. Answer without working, allow maximum of 2/4.

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Question	Answer	Marks	Guidance
	Alternative Method 2 for Question 10(a)		
	$2x + 2y\frac{dy}{dx} + 4 - 8\frac{dy}{dx} = 0$	**B1**	Differentiating implicitly.
	$\frac{dy}{dx} = \frac{(2x+4)}{(8-2y)}$ $\left[= -1 \text{ at } (2, 8)\right]$	**M1**	Rearranging to make $\frac{dy}{dx}$ the subject, May substitute (2, 8) and then rearrange to find $\frac{dy}{dx}$.
	Equation of tangent is $y - 8 = -1(x - 2)$	**M1**	Using a correct point and *their* tangent gradient from an attempt to find $\frac{dy}{dx}$, or the negative reciprocal of *their* perpendicular gradient.
	$x + y - 10 = 0$ or $-x - y + 10 = 0$	**A1**	CAO – this form is required. Answer without working, allow maximum of 2/4.
		4	

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Question	Answer	Marks	Guidance
10(b)	$(k-3y)^2+y^2+4(k-3y)-8y-12=0$ or $(k-3y+2)^2+(y-4)^2=32$	**M1***	Sub $x=k-3y$ or $y=\frac{k-x}{3}$ into circle equation. $y=\frac{k-x}{3}$ gives: $\frac{(k-x)^2}{9}-8\frac{k-x}{3}+x^2+4x-12=0$ or $(x+2)^2+\left(\frac{k-x}{3}-4\right)^2=32.$
	$9y^2-6ky-20y+y^2+k^2+4k-12=0$	**DM1**	OE All squared brackets expanded to give a quadratic equation in y (or x, which gives: $9x^2+60x-2kx+k^2+x^2-24k-108=0$ or $\frac{x^2+k^2-2kx}{9}-\frac{8k-8x}{3}+16+x^2+4x+4=32.$)
	$b^2-4ac=(6k+20)^2-4\times10\times(k^2+4k-12)$	**M1****	OE Factorising out y (or x) from *their* quadratic (this is the quadratic where the previous DM1 or possibly DM0 was awarded) to identify 'b' and then finding the discriminant. From equation in x, this is: $(60-2k)^2-(4)(10)(k^2-24k-108).$
	$-4k^2+80k+880<0$	**DM1**	OE Simplify the discriminant and setting it to less than zero. From eliminating y this is: $-36k^2+720k+7920<0$ Only dependent on the previous M1.
	$k^2-20k-220>0$	**A1**	AG WWW

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Question	Answer	Marks	Guidance
10(b)	**Alternative Method for Question 10(b)**		
	Centre of circle (–2, 4) and radius of circle is $\sqrt{32}$	**B1**	
	Distance of $x+3y-k$ from $(-2,4)=\frac{1(-2)+3(4)-k}{\sqrt{(1^2+3^2}}$	**M1***	Correct use of 'distance of a line from a point formula' with *their* centre coordinates.
	Setting $\frac{1(-2)+3(4)-k}{\sqrt{(1^2+3^2)}}>\sqrt{32}$	**DM1**	Setting distance to be greater than *their* radius.
	Squaring both sides	**DM1**	Removing the square roots.
	Rearranging to $k^2-20k-220>0$	**A1**	AG
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