Write your name, centre number and candidate number in the boxes below.

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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Circular measure

Time allowed: 2 hours

Subject code **0606**

Additional Mathematics

Questions from Paper 1 and Paper 2

You must have: a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.
Questions 2-6, 8-9 (Paper 1): no calculator.
Questions 1, 7, 10 (Paper 2): calculator allowed.

Total marks

/ 77

Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.
- Unless a question says otherwise, give answers that are not exact to 3 significant figures, and angles in degrees to 1 decimal place.

Information

- This paper has 10 questions worth 77 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

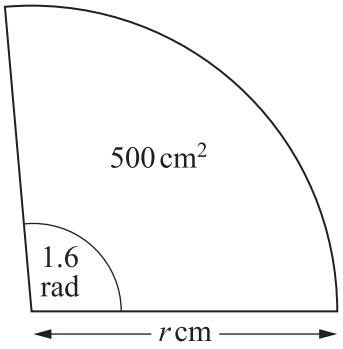
Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

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Print at 100% (Actual size) so diagrams keep their real measurements.

1



The diagram shows a sector of a circle of radius r cm. The angle of the sector is 1.6 radians and the area of the sector is $500\,\text{cm}^2$.

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

(ii) Hence find the perimeter of the sector. [2]

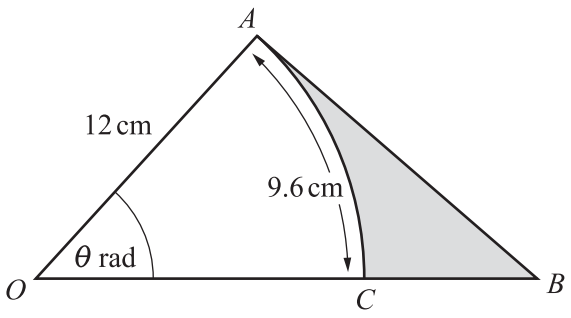
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Circular measure Click for more variations

1	**(i)**	$500 = \frac{1}{2}r^2(1.6)$	**M1**	
		25 only	**A1**	± 25 is **A0**
	(ii)	*their* 25 + *their* 25 + *their* 25 × 1.6 or better	**M1**	*their* 25 must be positive
		90	**A1**	

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2



The diagram shows the right-angled triangle OAB. The point C lies on the line OB. Angle $OAB = \frac{\pi}{2}$ radians and angle $AOB = \theta$ radians. AC is an arc of the circle, centre O, radius 12 cm and AC has length 9.6 cm.

(i) Find the value of θ. [2]

(ii) Find the area of the shaded region. [4]

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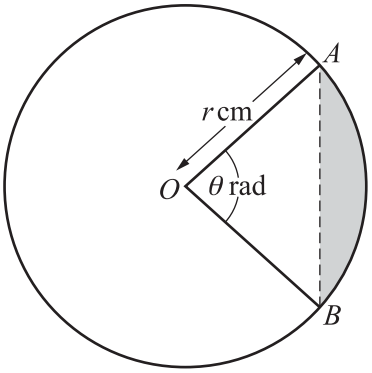
Circular measure Click for more variations

2(i)	$9.6 = 12\theta$	**M1**	For use of arc length
	$\theta = 0.8$	**A1**	

2(ii)	Either $\tan\theta = \frac{AB}{12}$, $\left(AB = 12.36\right)$ Or $OB = \frac{12}{\cos\theta}$ $\left(OB = 17.22\right)$	**M1**	For attempt to find AB or OB using *their* θ May be implied by a correct triangle area Allow if using degrees consistently
	Either Area $\Delta OAB = \frac{1}{2} \times 12 \times$ *their* 12.36 Or Area $\Delta OAB = \frac{1}{2} \times 12 \times$ *their* $17.22 \times \sin\theta$ $\left(= 74.1 \text{ or } 74.2\right)$	**M1**	Allow if using degrees consistently For attempt to find area of triangle using *their* θ
	Area of sector $OAC = \frac{1}{2} \times 12^2 \times 0.8$ $= 57.6$	**B1**	Allow unsimplified
	Area of shaded region = 16.5 or 16.6	**A1**	

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3



The diagram shows a circle with centre O and radius r cm. The minor arc AB is such that angle AOB is θ radians. The area of the minor sector AOB is 48 cm^2.

(i) Show that $\theta = \frac{96}{r^2}$. [2]

(ii) Given that the minor arc AB has length 12 cm, find the value of r and of θ. [3]

(iii) Using your values of r and θ, find the area of the shaded region. [2]

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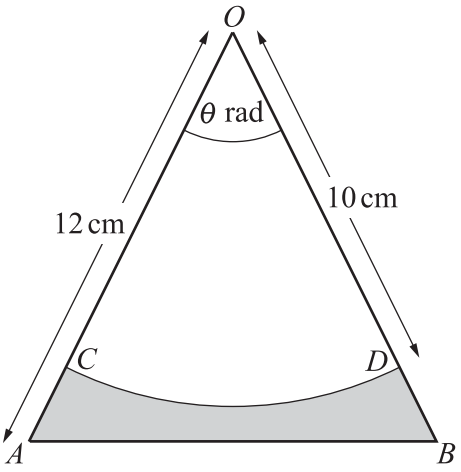
Circular measure Click for more variations

3(i)	$\frac{1}{2}r^2\theta = 48$	**B1**	
	$\theta = \frac{96}{r^2}$	**B1**	**Dep** Must have previous B1
3(ii)	$r\theta = 12$	**B1**	For statement of arc length
	$r \times \frac{96}{r^2} = 12$	**M1**	For attempt to use part **(i)** to find either r or θ
	$r = 8$ and $\theta = 1.5$	**A1**	For both

3(iii)	Area = $48 - \left(\frac{1}{2}r^2 \sin\theta\right)$	**M1**	For a complete method including a correct attempt for the area of the triangle using their r and θ
	=16.1	**A1**	

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4



The diagram shows an isosceles triangle OAB such that $OA = OB = 12\,\text{cm}$ and angle $AOB = \theta$ radians. Points C and D lie on OA and OB respectively such that CD is an arc of the circle, centre O, radius 10 cm. The area of the sector $OCD = 35\,\text{cm}^2$.

(a) Show that $\theta = 0.7$. [1]

(b) Find the perimeter of the shaded region. [4]

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

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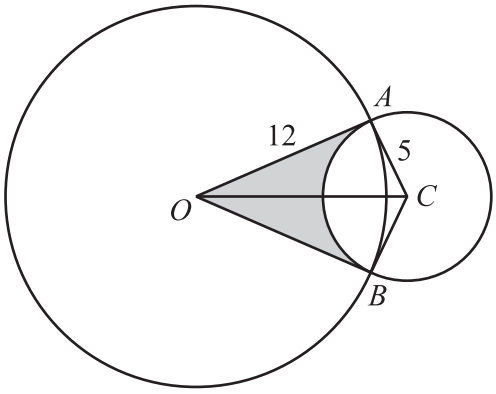
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4(a)	$\frac{1}{2}\times 10^2\times\theta = 35$ so $\theta = 0.7$	**B1**	

4(b)	Arc length CD: 7	**B1**	
	$\sin(0.35) = \frac{AB/2}{12}$	**M1**	For a complete method to find AB, could be using cosine rule
	$AB = 8.23(0)$	**A1**	
	Perimeter $= 7 + 4 + 8.23 = 19.2$	**A1**	
4(c)	Area of triangle $= \frac{1}{2}12^2 \sin 0.7$	**M1**	For complete attempt at triangle area, may use equivalent method
	Area of triangle $= 46.4$	**A1**	
	Shaded area $= 11.4$	**A1**	Follow through on *their* area of the triangle

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5 In this question, all lengths are in centimetres and all angles are in radians.



The diagram shows a circle with centre O and radius 12, and a circle with centre C and radius 5. The circles intersect at the points A and B, such that OA and OB are tangents to the circle with centre C.

(a) Show that the obtuse angle ACB is 2.35 radians, correct to 2 decimal places. [2]

(b) Find the perimeter of the shaded region. [2]

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

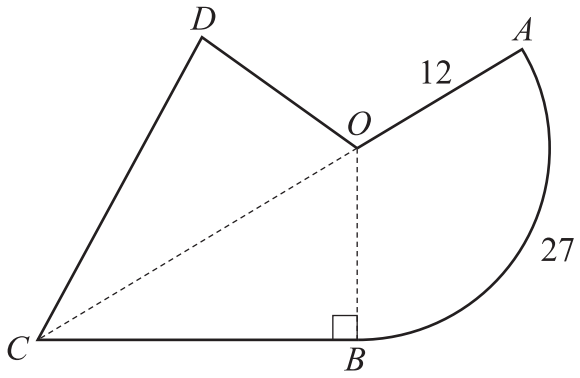
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Circular measure Click for more variations

5(a)	$ACB = 2\tan^{-1}\left(\frac{12}{5}\right)$ oe	**M1**	
	$ACB = (2\times 1.176\ldots)$ = 2.35 to 2 dp	**A1**	Must see justification to 2 dp
5(b)	Arc length = $5\times ACB$	**B1**	
	Perimeter = 35.8	**B1**	Allow awrt 35.8
5(c)	Area = $(12\times 5)-\left(\frac{1}{2}\times 5^2\times 2.35\right)$	**M2**	**M1** for area of kite or area of sector **M1 dep** for kite area – sector area
	30.6	**A1**	Allow greater accuracy Any use of fractions gets **A0**

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6 In this question all lengths are in centimetres and all angles are in radians.



The diagram shows a badge which consists of a minor sector, OAB, of the circle with centre O and radius 12, and a kite $OBCD$, where $OB = OD$ and $CD = CB$. The arc AB has length 27. The line OB is perpendicular to the line CB, and COA is a straight line.

(a) Find the perimeter of the badge. [4]

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(b) Find the area of the badge. [3]

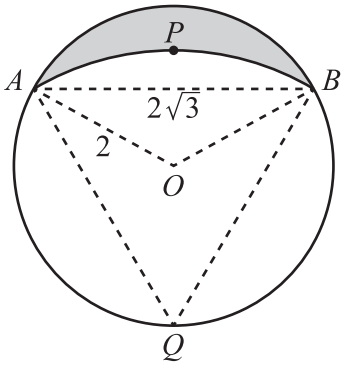
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Circular measure Click for more variations

6(a)	$27 = 12\theta$ $\theta = \frac{9}{4}$ oe	**B1**	$\angle AOB = \theta$
	Either $\tan(\pi - \theta) = \frac{CB}{12}$ soi Or $\frac{CB}{\sin(\pi - \theta)} = \frac{12}{\sin\left(\theta - \frac{\pi}{2}\right)}$	**M1**	Allow with *their* θ.
	Perimeter = $24 + 27 + 2(14.86..)$	**M1**	Allow with *their CB*.
	Perimeter = awrt 80.7	**A1**	From correct working only
6(b)	$\left(\frac{1}{2} \times 12^2 \times \textit{their } \theta\right) + (12 \times \textit{their } CB)$ 340 oe or 341 oe	**3**	**M1** for each area **A1** for awrt 340 or 341

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7 In this question the units are metres.



The diagram shows a circle, centre O and radius 2.
The chord AB has length $2\sqrt{3}$.
The point Q lies on the circle such that $AQ = BQ$.
The arc APB is part of a circle, centre Q.

(a) Find the exact value of angle AQB in radians. [2]

(b) Hence find the area of the shaded region. Give your answer in terms of π. [6]

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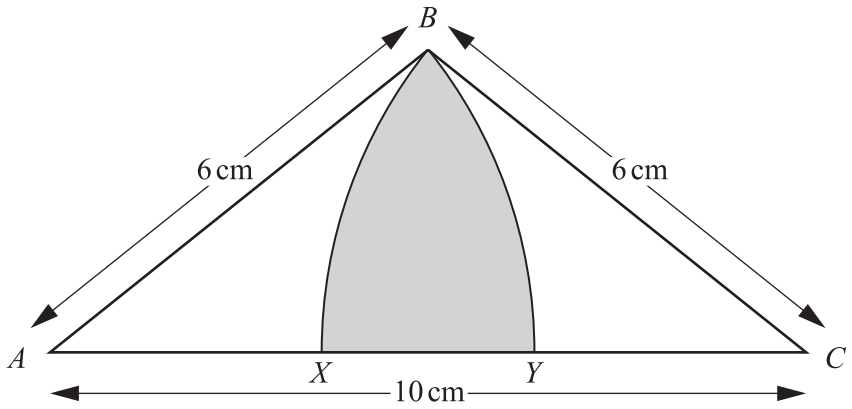
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7(a)	$\frac{\pi}{3}$	**2**	**M1** for angle AOB: $\frac{2\pi}{3}$ or angle AQO: $\frac{\pi}{6}$ or angle OAB: $\frac{\pi}{6}$ or e.g. cos $(AOB) = -\frac{1}{2}$ or $\sin\left(\frac{1}{2}AOB\right) = \frac{\sqrt{3}}{2}$ or AQ or $BQ = 2\sqrt{3}$ If 0 scored, **SC1** for answer of 1.047 rads
7(b)	$2\sqrt{3} - \frac{2\pi}{3}$ or $\frac{6\sqrt{3} - 2\pi}{3}$ oe nfww	**6**	**B5** correct calculation that simplifies to give shaded area e.g. $\left(\frac{4\pi}{3} - \sqrt{3}\right) - \left(2\pi - 3\sqrt{3}\right)$ OR **B1** for sector AOB: $\frac{1}{2} \times 2^2 \times \frac{2\pi}{3}$ oe **B1** for ΔAOB or ΔAOQ or ΔBOQ: $\frac{1}{2} \times 2^2 \times \sin\frac{2\pi}{3}$ or $\frac{1}{2} \times 2 \times 2\sqrt{3} \sin\frac{\pi}{6}$ oe **B1** for sector AQB: $\frac{1}{2} \times \left(2\sqrt{3}\right)^2 \times \frac{\pi}{3}$ oe **B1** for ΔAQB: $\frac{1}{2}\left(2\sqrt{3}\right)^2 \sin\frac{\pi}{3}$ oe OR **B2 FT** *their* exact angles for a correct calculation for any two of these areas OR **B2** for sector AOB: 4.188; ΔAOB or ΔAOQ or ΔBOQ: 1.732; sector AQB: 6.282; ΔAQB: 5.195[5] from using 1.047 rads OR **B1FT** *their* exact angles for a correct calculation for any one of these areas OR **B1** for one of these areas using 1.047 rads

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8



The diagram shows an isosceles triangle ABC such that $AC = 10$ cm and $AB = BC = 6$ cm. BX is an arc of a circle, centre C, and BY is an arc of a circle, centre A.

(i) Show that angle $ABC = 1.970$ radians, correct to 3 decimal places. [2]

(ii) Find the perimeter of the shaded region. [4]

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

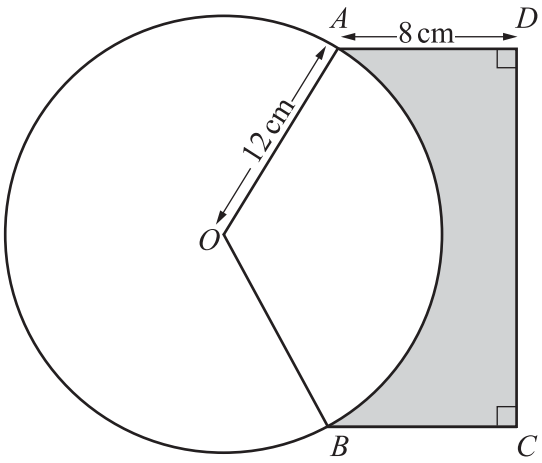
Circular measure Click for more variations

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8 **(i)**	$10^2 = 6^2 + 6^2 - 2\times 6\times 6\times \cos ABC$ or $\sin\left(\frac{ABC}{2}\right) = \frac{5}{6}$ or $ABC = \pi - \sin^{-1}\frac{10\sqrt{11}}{36}$	M1	correct cosine rule statement or correct statement for $\sin\frac{ABC}{2}$ or equating areas oe
	$ABC = 1.9702$	A1	1.9702 or better
(ii)	$XY = 2$	B1	for XY (may be implied by later work, allow on diagram)
	Arc length $6\left(\frac{\pi - 1.970}{2}\right)$ oe	B1	correct arc length (unsimplified)
	Perimeter = $2 + 2\left(6\left(\frac{\pi - 1.970}{2}\right)\right)$ $= 9.03$	M1 A1	*their* 2 + 2 × 6 × *their* angle *C*
(iii)	$\left(\frac{1}{2}\times 6^2\left(\frac{\pi - 1.970}{2}\right) - \frac{1}{2}\times 5\times\sqrt{11}\right)\times 2$	M1 M1	sector area using *their C* area of ΔABM where M is the midpoint of AC, or (Δs ABY and BXY) or ΔABC
	= 4.50 or 4.51 or better	A1	Answers to 3sf or better

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9



The diagram shows a circle, centre O, radius 12 cm. The points A and B lie on the circumference of the circle and form a rectangle with the points C and D. The length of AD is 8 cm and the area of the minor sector AOB is 150 cm^2.

(i) Show that angle AOB is 2.08 radians, correct to 2 decimal places. [2]

(ii) Find the area of the shaded region $ADCB$. [6]

(iii) Find the perimeter of the shaded region $ADCB$. [3]

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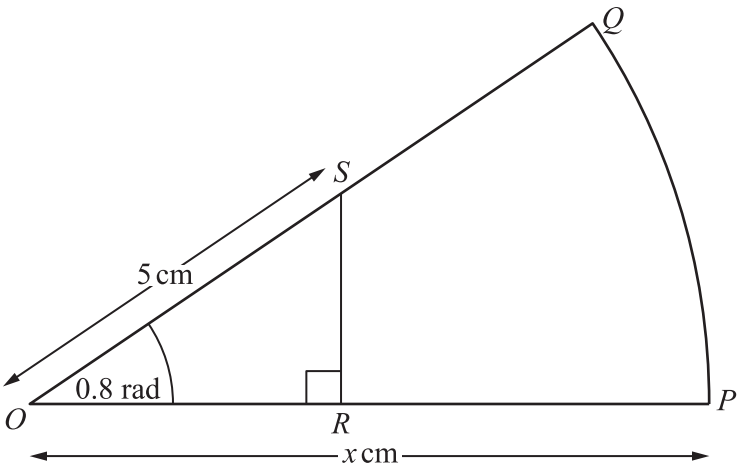
Circular measure Click for more variations

9(i)	$\frac{1}{2}\times 12^2\times\theta = 150$	**M1**	use of sector area
	$\theta = 2.083$, so $\theta = 2.08$ to 2dp	**A1**	
9(ii)	Area of triangle $AOB = \frac{1}{2}\times 12^2 \sin 2.08$	**M1**	correct method for area of triangle
	Area of segment = $150 - \frac{1}{2}\times 12^2 \times \sin 2.08$	**A1**	allow unsimplified, using $\theta = 2.08,\ 2.083$ or $\frac{150}{72}$
	$\sin 1.04 = \frac{\frac{AB}{2}}{12}$	**M1**	correct trigonometric statement using $\theta = 2.08,\ 2.083$ or $\frac{150}{72}$ with attempt to obtain AB
	AB = awrt 20.7	**A1**	
	Shaded area = *their* $AB\times 8$ – *their* segment area	**M1**	execution of a correct 'plan'(rectangle – segment)
	awrt 78.4 or 78.5	**A1**	

9(iii)	Arc AB = 25 or 24.96	**B1**	
	Perimeter= 25 + *their* AB + 16	**M1**	correct 'plan' (arc + *their* AB + 2×8)
	awrt 61.7	**A1**	

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10



The diagram shows a sector OPQ of a circle with centre O and radius x cm. Angle POQ is 0.8 radians. The point S lies on OQ such that $OS = 5$ cm. The point R lies on OP such that angle ORS is a right angle. Given that the area of triangle ORS is one-fifth of the area of sector OPQ, find

(i) the area of sector OPQ in terms of x and hence show that the value of x is 8.837 correct to 4 significant figures, [5]

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(ii) the perimeter of $PQSR$, [3]

(iii) the area of $PQSR$. [2]

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10 (i)	Area of sector $= \frac{1}{2} \times x^2 \times 0.8 \left(= 0.4x^2 \text{ cm}^2\right)$	**B1**	anywhere
	$SR = 5\sin 0.8 \left(= 3.59\right)$ or $OR = 5\cos 0.8 \left(= 3.48\right)$	**B1**	SR may be seen in stated $\frac{1}{2}ab\sin C$
	Area of triangle = $\frac{1}{2} 5\cos 0.8 \times 5\sin 0.8 = 6.247 \text{ cm}^2$	**M1**	insert correct terms into correct area formulae
	$0.08x^2 = 6.247$	**A1**	
	$x = 8.837 \text{ cm}$ AG	**A1**	
(ii)	$SQ = 8.84 - 5 \left(= 3.84 \text{ cm}\right)$		
	$PR = 8.84 - 5\cos 0.8 \left(= 5.35 \text{ or } 5.36 \text{ cm}\right)$	**B1**	two lengths from SQ, PR, PQ awrt
	$PQ = 8.84 \times 0.8 \left(= 7.07 \text{ cm}\right)$	**B1**	third length awrt
	Perimeter = 19.84 to 19.86 cm or rounded to 19.8 or 19.9	**B1**	sum
(iii)	Area $PQSR = 4 \times 6.247$	**M1**	
	$= 25 \text{ cm}^2$	**A1**	24.95 to 25

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