Cambridge IGCSE · Mathematics 0580 · Notes

Circle theorems

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Read first: **Geometrical terms and symmetry**

What you need to know

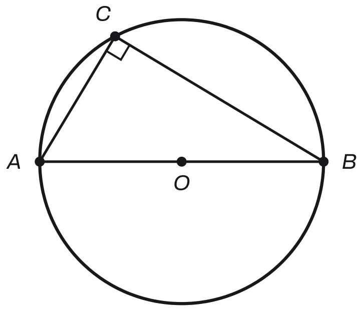
By the end of this topic you should be able to work out unknown angles in circle diagrams and give the reason for each step, using these facts:

1. **The angle in a semicircle is 90°.** An angle at the circumference that stands on a diameter is a right angle.
2. **The angle between a tangent and a radius is 90°.**
3. **Extended only: the angle at the centre is twice the angle at the circumference**, when both stand on the same arc.
4. **Extended only: angles in the same segment are equal.**
5. **Extended only: opposite angles of a cyclic quadrilateral add up to 180°** (they are supplementary).
6. **Extended only: the alternate segment theorem.** The angle between a tangent and a chord equals the angle in the alternate segment.
7. **Extended only: use the symmetry properties of circles**: equal chords are the same distance from the centre, the perpendicular bisector of a chord passes through the centre, and the two tangents from an external point are equal in length.

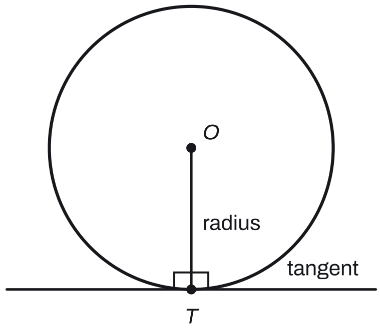
Questions expect a **reason** in the words of the syllabus for each fact you use, so learn the names in bold. The circle vocabulary (chord, tangent, arc, segment and so on) is in the topic Geometrical terms and symmetry.

Understand it

The two Core theorems



angle in a semicircle = 90°



angle between tangent and radius = 90°

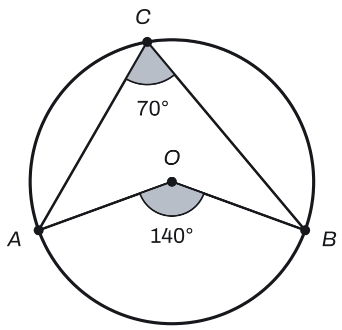
Angle in a semicircle. Join the two ends of a diameter AB to any point C on the circle. Angle ACB is always 90°, wherever C is. Why: OA, OB and OC are all radii, so triangles OAC and OBC are both isosceles. If their base angles are a and b, the big triangle ABC has angles a, b and $a+b$, which add to 180°, so $a+b=90^\circ$.

Tangent and radius. A tangent touches the circle at one point, T. The radius drawn to T meets the tangent at 90°. So a tangent and a radius together always give you a right-angled triangle to work in.

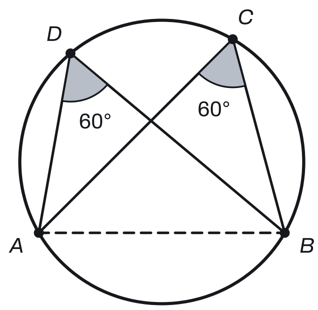
A third fact is used constantly with both: **two radii make an isosceles triangle**. If OA and OB are radii, angles OAB and OBA are equal. The reason to write is "base angles of an isosceles triangle are equal" (and say $OA = OB$, radii).

Angle at the centre

Extended only. Take a chord or arc AB. The angle it makes at the centre, AOB, is **twice** the angle it makes at any point C on the rest of the circumference.



angle at centre = 2 × angle at circumference



angles in the same segment are equal

Why: draw the diameter from C through O. It splits the figure into two isosceles triangles, and an exterior angle of each is twice its base angle; adding the two halves gives angle $AOB = 2\times$ angle ACB.

Watch which arc the angles stand on. If C is on the **minor** arc, the angle at the centre that goes with it is the **reflex** angle AOB. For example, if C is on the short arc and angle $ACB = 118^\circ$, then reflex $AOB = 236^\circ$ and the ordinary angle $AOB = 360 - 236 = 124^\circ$.

The angle in a semicircle is the special case where AB is a diameter: the angle at the centre is 180°, so the angle at the circumference is 90°.

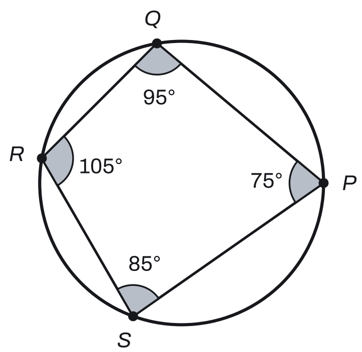
Angles in the same segment

Extended only. A chord AB cuts the circle into two segments. Every angle at the circumference standing on AB from the **same** side (the same segment) is equal, because each one is half the same angle at the centre. In the diagram, $ACB = ADB = 60^\circ$.

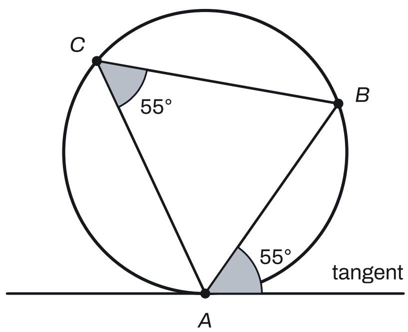
In an exam diagram, look for two lines from the ends of a chord meeting at a point on the circle, and another pair from the same chord on the same side: a "bow tie" shape of crossing chords.

Cyclic quadrilaterals

Extended only. A **cyclic quadrilateral** has all four vertices on one circle. Its **opposite angles add up to** 180°. Why: the two opposite angles stand on the two arcs that make up the whole circle, whose angles at the centre add up to 360°, so the angles at the circumference add up to 180°.



opposite angles add up to 180°



alternate segment theorem

Two consequences:

- An **exterior angle** of a cyclic quadrilateral equals the **interior opposite angle** (both are 180° minus the same angle).
- The **converse**: if a quadrilateral's opposite angles add up to 180°, its vertices lie on a circle, so it **is** cyclic. The angles of an ordinary quadrilateral add up to 360° too, so that alone proves nothing; it's the opposite pairs that matter.

Opposite angles are **not** equal (a common wrong idea), and the quadrilateral must have all four corners on the circle. If one corner is the centre O, it is not cyclic.

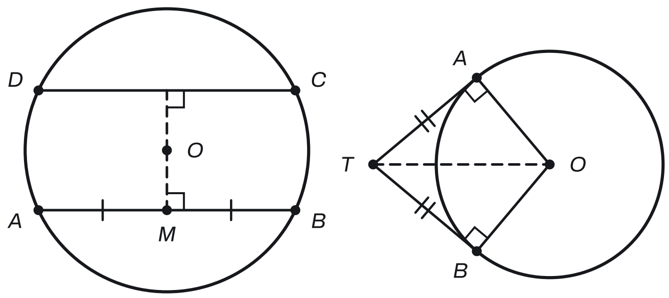
The alternate segment theorem

Extended only. At a point A on the circle, draw a tangent and a chord AB. The angle between the tangent and the chord equals any angle at the circumference standing on AB **in the other segment** (the alternate segment, on the far side of the chord from that angle). In the diagram both are 55°.

To find the right pair: start at the angle between tangent and chord, follow the chord AB to its other end, then go across to the point C on the far side of the circle and back to A. The angle at C is the equal one. It is **not** the angle next to the tangent on the same side, and it is not usually a right angle.

Symmetry properties

Extended only.



equal chords are the same distance from the centre; OM bisects AB at 90°

tangents from an external point are equal: TA = TB

- **The perpendicular bisector of a chord passes through the centre.** So the line from O to the midpoint M of a chord meets the chord at 90°, and the line from O perpendicular to a chord cuts it in half. Triangle OMA is right-angled, which lets you use Pythagoras: a chord of length 16 in a circle of radius 10 is $\sqrt{10^2 - 8^2} = 6$ from the centre.
- **Equal chords are equidistant from the centre** (the same perpendicular distance from O).
- **Tangents from an external point are equal in length.** From T, the tangents TA and TB are equal, so triangle TAB is isosceles. The shape $OATB$ is a kite with two right angles, and OT is its line of symmetry. The angles at O and T in the kite add up to $360 - 90 - 90 = 180^\circ$.

A tangent length comes from Pythagoras in triangle OAT: radius 5 and $OT = 13$ give $TA = \sqrt{13^2 - 5^2} = 12$.

Key facts and formulas

None of these is on the List of formulas; learn them all, with the words to write as the reason. Only the circle's circumference and area formulas are given.

Formula	Status
Angle in a semicircle $= 90^\circ$	Learn it
Angle between tangent and radius $= 90^\circ$	Learn it
Two radii make an isosceles triangle: base angles are equal	Learn it
Extended: angle at the centre $= 2\times$ angle at the circumference (same arc)	Learn it
Extended: angles in the same segment are equal	Learn it
Extended: opposite angles of a cyclic quadrilateral add up to 180°	Learn it
Extended: exterior angle of a cyclic quadrilateral $=$ interior opposite angle	Learn it
Extended: alternate segment theorem: angle between tangent and chord $=$ angle in the alternate segment	Learn it
Extended: tangents from an external point are equal in length	Learn it
Extended: the perpendicular bisector of a chord passes through the centre; equal chords are equidistant from the centre	Learn it
Angle sum of a triangle $= 180^\circ$; of a quadrilateral $= 360^\circ$; angles on a straight line $= 180^\circ$; at a point $= 360^\circ$	Learn it
Pythagoras: $a^2 + b^2 = c^2$	Learn it
Circumference $= 2\pi r$; area $= \pi r^2$	Given

How to do it

In the questions we have tagged for this topic (54 questions, 2021–2025), each theorem was needed this often. 35 of the 54 questions use more than one, so the counts add up to more than 54.

Question type	Questions
Angle in a semicircle	23
Tangent and radius	18
Cyclic quadrilateral	17

Question type	Questions
Alternate segment theorem	15
Angle at the centre	12
Angles in the same segment	11
Circle facts with lengths and areas	10
Tangents from an external point	5

The method is the same for every type:

1. **Mark every angle you know on the diagram**, including the ones the question gives in words.
2. **Look for the features**: a diameter (semicircle), a tangent meeting a radius, two radii (isosceles), four points on the circle joined up (cyclic quadrilateral), a "bow tie" of crossing chords (same segment), a tangent with a chord (alternate segment), two tangents from one point.
3. **Work one angle at a time**, writing each new angle on the diagram and, when asked, its reason.
4. **Check** that each triangle adds to 180° and each straight line to 180°.

1. Angle in a semicircle (23 questions)

1. Spot the diameter: a line through the centre, or one the question calls a diameter.
2. The angle at the circumference opposite it is 90°.
3. Finish with the angle sum of a triangle, often $90-$ the given angle.

For example, AB is a diameter and angle $CAB = 27^\circ$: angle $ACB = 90^\circ$, so angle $ABC = 180 - 90 - 27 = 63^\circ$.

Variations you will meet:

- **"Explain why angle ABC is 90°"** (Core, often 1 mark): write "angle in a semicircle $= 90^\circ$". "It is a right-angled triangle", "AC is a diameter" or "triangle in a semicircle" do not score.
- **Isosceles triangles with the centre**: O is the midpoint of the diameter, so $OB = OA = OC$ and triangles OAB and OBC are isosceles. A 44° angle at O gives base angles $(180 - 44) \div 2 = 68^\circ$.
- **Draw a triangle with a right angle at a point on the circle**: join the point to both ends of a diameter.
- **Which line is a diameter?** Look for the right angle at the circumference: the side opposite it is the diameter. And a triangle in a circle is right-angled only if one side is a diameter.
- **Combined with lengths**: the right angle lets you use Pythagoras or trigonometry, for example to find the diameter and then the circumference (type 7).

2. Tangent and radius (18 questions)

1. Find the radius (from O) that meets the tangent at the point of contact. Mark the 90°.
2. Use the triangle or quadrilateral it makes: angle sum 180° (triangle) or 360° (quadrilateral).

For example, O is the centre, AB is the tangent at B and angle $OAB = 41^\circ$: angle $OBA = 90^\circ$, so angle $AOB = 180 - 90 - 41 = 49^\circ$.

Variations you will meet:

- **The complement**: the angle between a tangent and a chord from the point of contact, and the angle between that chord and the radius, add up to 90°.
- **Isosceles triangle OBC** (two radii) with the tangent at B: find the base angles, then subtract from 90°.
- **Draw a tangent at a point**: a ruled line through the point at right angles to the radius, touching the circle only there.
- **Name the line**: a line touching the circle once is a **tangent**; a line joining two points on the circle is a **chord**.

3. Cyclic quadrilateral (17 questions)

Extended only.

1. Check all four corners are on the circle (none is the centre).
2. Opposite angle $= 180^\circ$ minus the given angle.

Variations you will meet:

- **Angles as expressions or a ratio.** Opposite angles $3x$ and $x + 40$: $4x + 40 = 180$, so $x = 35$. If the ratio of two opposite angles is $4 : 5$, they are $\frac{4}{9} \times 180 = 80^\circ$ and $\frac{5}{9} \times 180 = 100^\circ$.
- **Exterior angle**: when a side is extended, the exterior angle equals the interior opposite angle. Or use angles on a straight line first, then opposite angles.
- **"Show that $PQRS$ is a cyclic quadrilateral"** with angles in terms of x. Use all four angles: their sum is 360°, so solve for x. Then work out each angle and show that the **opposite pairs** add up to 180°, and state the reason. With angles $2x + 8$, $x + 50$, $3x - 8$ and $4x - 50$ (in order round the shape), $10x = 360$ gives $x = 36$, so the angles are 80°, 86°, 100° and 94°, and $80 + 100 = 180$, $86 + 94 = 180$. Don't start by assuming it is cyclic.
- **"Give a reason why this is a cyclic quadrilateral"**: "opposite angles add up to 180°", after checking they do.
- **With the centre**: first use the angle at the centre to get one angle of the quadrilateral, then the opposite one.

4. Alternate segment theorem (15 questions)

Extended only.

1. Find the tangent, its point of contact A and a chord AB from that point.
2. The angle between the tangent and AB equals the angle at C in the opposite segment, where C is joined to both A and B.
3. Use the other angle between the tangent and the other chord AC the same way: it equals angle ABC.

Variations you will meet:

- **A tangent with an isosceles triangle** ($AB = AC$ or two tangents): use the theorem for one angle, then base angles.
- **Tangent and parallel lines**: a chord parallel to the tangent makes alternate angles with it; combined with the theorem this makes triangle ABC isosceles.
- **The other side of the point of contact**: angles on the straight tangent line add up to 180°, so the angle on the other side can be found first.
- **Reason to write**: "alternate segment theorem". It is not the same as "alternate angles" (parallel lines); the examiners refuse "alternate" on its own for either.

5. Angle at the centre (12 questions)

Extended only.

1. Find the two lines from the ends of an arc to the centre and to a point on the circumference.
2. Angle at the centre $= 2\times$ angle at the circumference (or halve to go the other way).
3. Check that both angles stand on the **same** arc; if the circumference point is on the minor arc, use the reflex angle at the centre.

Variations you will meet:

- **Radii first**: an angle such as $OBA = 48^\circ$ in isosceles triangle OAB gives $AOB = 180 - 2 \times 48 = 84^\circ$, then the angle at the circumference is 42°.
- **With a cyclic quadrilateral**: angle $AOC = 148^\circ$ gives 74° at the circumference on the major arc, and $180 - 74 = 106^\circ$ on the minor arc.
- **With two tangents from T**: angle $ATB = 180^\circ$ minus angle AOB (the kite $OATB$ has two right angles). So an angle of 70° at the circumference gives $AOB = 140^\circ$ and $ATB = 40^\circ$.
- **Diameters as radii**: when two diameters cross at O, the four triangles are isosceles.

6. Angles in the same segment (11 questions)

Extended only.

1. Find a chord and two angles at the circumference standing on it, on the same side.
2. They are equal. Look for crossing chords: the "bow tie" gives two pairs of equal angles.

Variations you will meet:

- **Crossing chords** AC and BD meeting at X: angle $BAC =$ angle BDC and angle $ABD =$ angle ACD. The angle at X then comes from the angle sum of a triangle.
- **Parallel chords**: combine with alternate angles, for example two base angles of 35° in the triangle at X give $180 - 2 \times 35 = 110^\circ$.

- **Reason to write**: "angles in the same segment are equal". "Same arc" is accepted too, but "same chord" on its own does not score.

7. Circle facts with lengths and areas (10 questions)

1. Use a circle theorem to find a right angle (semicircle, tangent and radius, or radius to the midpoint of a chord).
2. Then use Pythagoras or trigonometry in that right-angled triangle, and the given circumference and area formulas where needed.

Variations you will meet:

- **Diameter from a semicircle triangle**: if the diameter $AB = 15$ cm and chord $BC = 7$ cm, the right angle at C gives $AC = \sqrt{15^2 - 7^2} = \sqrt{176} = 13.3$ cm. The circumference is $\pi \times 15 = 47.1$ cm.
- **Similar triangles from crossing chords** (Extended): when chords AC and BD cross at X, triangles AXB and DXC are similar (their angles are equal by the same-segment theorem and vertically opposite angles). So $\frac{AX}{DX} = \frac{BX}{CX}$. With $AX = 6$, $BX = 4$ and $DX = 9$: $CX = \frac{4\times 9}{6} = 6$. The ratio of areas is the square of the ratio of lengths.
- **Chord and radius** (Extended): the perpendicular from the centre bisects the chord, giving a right-angled triangle with the radius as hypotenuse.
- **Two tangents** (Extended): with OA and OT known, $\cos(\text{angle } AOT) = \frac{OA}{OT}$ in the right-angled triangle OAT.

8. Tangents from an external point (5 questions)

Extended only.

1. $TA = TB$, so triangle TAB is isosceles: its base angles are $(180 - \text{angle } ATB) \div 2$.
2. $OA \perp TA$ and $OB \perp TB$, so in quadrilateral $OATB$: angle $AOB = 180^\circ$ minus angle ATB.

Variations you will meet:

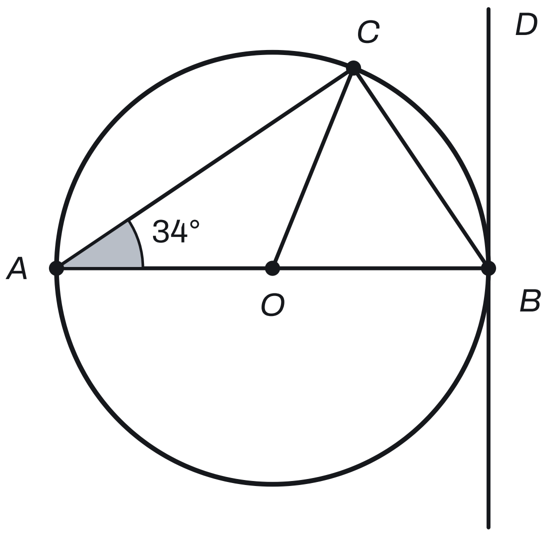
- **"Give a reason why triangle SVR is isosceles"** (two tangents from S): "tangents from an external point are equal in length".
- **Congruent triangles OAT and OBT**: OT is common, $OA = OB$ (radii), and the right angles give the RHS condition. So OT bisects angle ATB and angle AOB.

Worked examples

The bold codes show where marks are earned, as in Cambridge mark schemes. The number is how many marks.

- **M1** method mark: for a correct method, even if the numbers slip.
- **A1** accuracy mark: for a correct answer; it needs the M mark before it.
- **B1** mark for a correct result on its own, with no method needed.

Example 1



A, B and C lie on the circle, centre O. AB is a diameter and DB is the tangent to the circle at B. Angle $CAB = 34^\circ$.

(a) Find angle ACB. Give a geometrical reason for your answer. **[2]**

(b) Find angle ABC. **[1]**

(c) Find angle CBD. Give a geometrical reason for your answer. **[2]**

(d) Find angle BOC. **[2]**

(a) Angle $ACB = 90^\circ$ **B1**, because the angle in a semicircle $= 90^\circ$. **B1**

(b) Angle $ABC = 180 - 90 - 34 = 56^\circ$ (angle sum of a triangle). **B1**

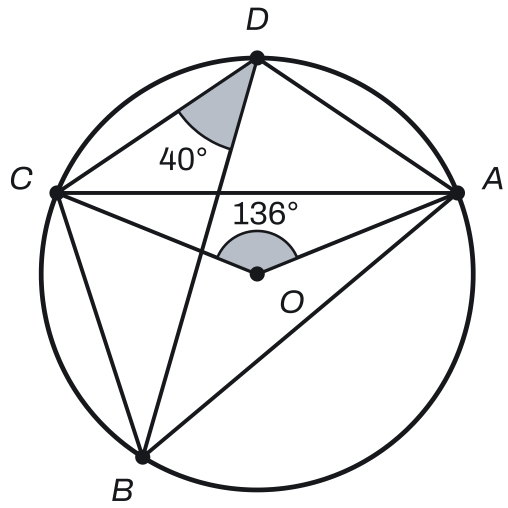
(c) The angle between the tangent and the radius is 90°, so angle $ABD = 90^\circ$. **B1** for the reason. Then angle $CBD = 90 - 56 = 34^\circ$. **B1**

(d) $OB = OC$ (radii), so triangle OBC is isosceles and angle $OCB =$ angle $OBC = 56^\circ$. **M1** Angle $BOC = 180 - 56 - 56 = 68^\circ$. **A1**

(Notice that $68 = 2 \times 34$: on an Extended paper, the angle at the centre gives this in one step.)

Example 2

Extended.



A, B, C and D lie on the circle, centre O. Angle $AOC = 136^\circ$ and angle $BDC = 40^\circ$.

(a) Find angle ABC. Give a geometrical reason. **[2]**

(b) Find angle ADC. Give a geometrical reason. **[2]**

(c) Find angle BAC and angle ACB. **[2]**

(d) Find angle OAC. **[1]**

(a) Angle $ABC = 136 \div 2 = 68^\circ$ **B1**, because the angle at the centre is twice the angle at the circumference. **B1**

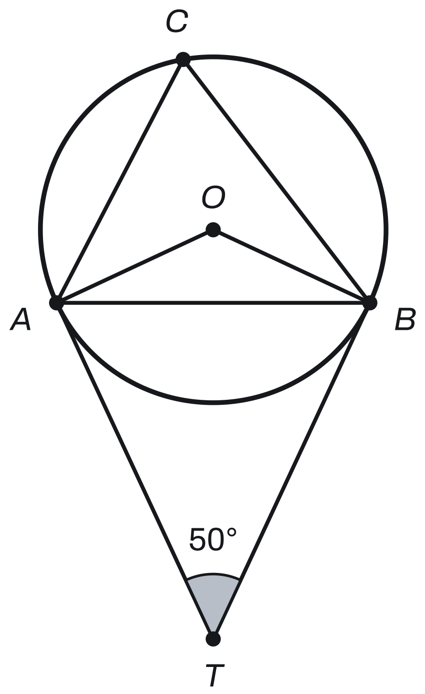
(b) $ABCD$ is a cyclic quadrilateral, so angle $ADC = 180 - 68 = 112^\circ$ **B1**, because opposite angles of a cyclic quadrilateral add up to 180°. **B1**

(c) Angle $BAC =$ angle $BDC = 40^\circ$ (angles in the same segment are equal). **B1** Then angle $ACB = 180 - 68 - 40 = 72^\circ$. **B1**

(d) $OA = OC$, so angle $OAC = (180 - 136) \div 2 = 22^\circ$. **B1**

Example 3

Extended.



TA and TB are tangents to the circle, centre O, at A and B. C lies on the major arc AB. Angle $ATB = 50^\circ$.

(a) Find angle TAB. Give a geometrical reason for the first step. **[2]**

(b) Find angle ACB. Give a geometrical reason. **[2]**

(c) Find angle AOB. **[1]**

(d) Find angle OAB. **[1]**

(a) $TA = TB$ because tangents from an external point are equal in length **B1**, so triangle TAB is isosceles and angle $TAB = (180 - 50) \div 2 = 65^\circ$. **B1**

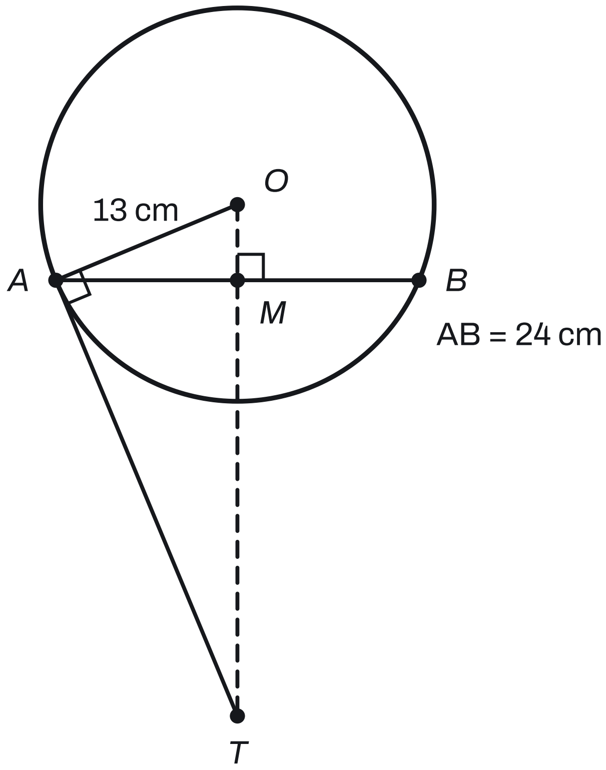
(b) Angle $ACB =$ angle $TAB = 65^\circ$ **B1**, by the alternate segment theorem. **B1**

(c) In quadrilateral $OATB$, angles OAT and OBT are 90° (tangent and radius), so angle $AOB = 360 - 90 - 90 - 50 = 130^\circ$. **B1** (Check: $2 \times 65 = 130$, the angle at the centre.)

(d) Angle $OAB = 90 - 65 = 25^\circ$ (or $(180 - 130) \div 2$ in isosceles triangle OAB). **B1**

Example 4

Extended.



The circle has centre O and radius 13 cm. AB is a chord of length 24 cm and M is its midpoint. The tangent to the circle at A meets the line OM, extended, at T.

(a) Explain why angle $OMA = 90^\circ$, and find OM. **[3]**

(b) Another chord, CD, is also 24 cm long. Write down its distance from O, with a reason. **[1]**

(c) Find angle AOM, correct to 1 decimal place. **[2]**

(d) Find the length of the tangent AT. **[3]**

(a) The perpendicular bisector of a chord passes through the centre, so the line from O to the midpoint of AB is perpendicular to AB. **B1** $AM = 12$ cm, so $OM = \sqrt{13^2 - 12^2} = \sqrt{25} = 5$ cm. **M1 A1**

(b) 5 cm, because equal chords are equidistant from the centre. **B1**

(c) $\cos(\text{angle } AOM) = \frac{5}{13}$ **M1**, so angle $AOM = 67.4^\circ$. **A1**

(d) Angle $OAT = 90^\circ$ (tangent and radius). **B1** In triangle OAT, $\tan(\text{angle } AOT) = \frac{AT}{13}$, and $\tan(\text{angle } AOM) = \frac{AM}{OM} = \frac{12}{5}$. **M1** So $AT = 13 \times \frac{12}{5} = 31.2$ cm. **A1**

Using the exact $\frac{12}{5}$ instead of the rounded angle keeps the answer accurate.

Common mistakes

- **Writing the reason in your own words.** Examiners reject "the angle opposite the diameter", "it is a right-angled triangle", "triangle in a semicircle" and "AC is a diameter". Write the syllabus wording: "angle in a semicircle $= 90^\circ$", "angle between tangent and radius $= 90^\circ$", and so on.
- **Leaving out key words.** "Opposite angles add to 180°" without "cyclic quadrilateral", or "tangent $= 90^\circ$" without "radius", loses the mark. "Alternate" alone, "alternative angles" or "z angles" are not accepted.
- **Giving one reason when the question says "reasons".** If you used the angle in a semicircle **and** the angle sum of a triangle, write both.
- **Saying opposite angles of a cyclic quadrilateral are equal.** They add up to 180°. This error turns 68° into 112° (and the reverse) every year.
- **Halving the wrong angle at the centre.** Check which arc each angle stands on; with a point on the minor arc, use the reflex angle.
- **Using the alternate segment theorem on the wrong angle.** The equal angle is across the chord in the far segment, not next to the tangent. Mark the chord first and follow it.
- **Assuming what isn't given.** A line is not a diameter unless it passes through O or the question says so; a triangle is not isosceles unless two sides are radii or tangents from one point, or equal sides are marked; lines are not parallel unless marked.
- **Treating a quadrilateral as cyclic before proving it.** In a "show that it is cyclic" question, use the angle sum of 360° first.
- **Writing calculations instead of reasons.** "$180 - 90 - 29$" is working, not a geometrical reason.
- **Unlabelled angles in working.** Write "angle $ABD = 55$", not just "55", so method marks can be given.

How to get the marks

- **"Give a geometrical reason"** usually earns one mark of its own, separate from the angle. Use the exact phrases in Key facts; a reason with the right angle but the wrong words scores only the angle mark.
- **"Give a geometrical reason for each step"** means one reason per new angle, in order, such as, with diameter AB and angle $CAB = 32^\circ$ given: angle $ACB = 90^\circ$ (angle in a semicircle); angle $ABC = 58^\circ$ (angle sum of a triangle); angle $ADC = 58^\circ$ (angles in the same segment, both standing on AC).
- **"Find"** or **"Work out"** with no reason asked: the answer earns the marks, but writing each angle you find on the diagram or in the working earns method marks if the final answer is wrong.
- **Name angles with three letters**, such as angle OBA. A single letter at a point with several angles is ambiguous and may not be credited.
- **Follow-through:** many parts are marked on your earlier answers, so keep going even if you doubt part (a).
- **Accuracy:** angles are usually exact whole numbers here. When trigonometry is needed, give angles to 1 decimal place and lengths to 3 significant figures unless told otherwise.
- **"Show that"** (for example "show that $PQRS$ is cyclic"): every step and the final conclusion with its reason must be written.

- **Drawing**: a tangent must be ruled and touch the circle at the point only; a triangle with a right angle at a point uses both ends of a diameter.

Quick check

1. AB is a diameter of a circle and C is a point on the circle. Angle $ABC = 28^\circ$. Find angle CAB and give the reasons.
2. *Extended.* TP is a tangent from T to a circle, centre O, radius 8 cm, touching at P. $OT = 17$ cm. Find TP .
3. *Extended.* $PQRS$ is a cyclic quadrilateral. Angle $P = 3x^\circ$ and angle $R = (x + 20)^\circ$. Find x and angle R.
4. *Extended.* A tangent touches a circle at A. The chord AB makes an angle of 72° with the tangent. C is on the circle in the alternate segment and $AC = BC$. Find angle ACB and angle CAB.
5. *Extended.* A, B and C lie on a circle, centre O, with B on the minor arc AC. Angle $ABC = 122^\circ$. Find the obtuse angle AOC.

Answers

1. Angle $ACB = 90^\circ$ (angle in a semicircle), so angle $CAB = 180 - 90 - 28 = 62^\circ$ (angle sum of a triangle).
2. Angle $OPT = 90^\circ$ (tangent and radius), so $TP = \sqrt{17^2 - 8^2} = \sqrt{225} = 15$ cm.
3. Opposite angles: $3x + x + 20 = 180$, so $4x = 160$ and $x = 40$. Angle $R = 40 + 20 = 60^\circ$ (and angle $P = 120^\circ$).
4. Angle $ACB = 72^\circ$ (alternate segment theorem). Triangle ACB is isosceles, so angle $CAB = (180 - 72) \div 2 = 54^\circ$.
5. B is on the minor arc, so the reflex angle $AOC = 2 \times 122 = 244^\circ$ (angle at the centre). The obtuse angle $AOC = 360 - 244 = 116^\circ$.

Past questions to try

- **0580/22/M/J/25 Q12**: angle in a semicircle, with both reasons written.
- **0580/23/O/N/25 Q13**: two tangents, a radius and parallel lines.
- **0580/42/M/J/25 Q18**: same segment and cyclic quadrilateral in one diagram.
- **0580/22/F/M/21 Q15**: the alternate segment theorem with an isosceles triangle.