



ChapterNotes

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CHAPTER NOTES

Circles Class 10 Notes | CBSE Maths Chapter 10

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Ask me anything from this chapter. A concept, a numerical, or that one doubt you did not want to raise in class. Pick one to start:

Explain Circles simply

What can the board exam ask?

Most important formulas

Quiz me on this chapter

Ask Ira anything...



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Circles Class 10 Notes | CBSE Maths Chapter 10

Circles is Chapter 10 of CBSE Class 10 Maths. In Class 9 you learnt what a circle, a chord, an arc and a sector are. This chapter asks a new question: what can happen when a straight line and a circle lie in the same plane? The answer leads to the tangent, a line that touches the circle at exactly one point, and to two theorems about tangents that the whole chapter is built on.

The chapter covers non-intersecting lines, secants and tangents, the number of tangents from a point, the length of a tangent, Theorem 10.1 (the tangent is perpendicular to the radius at the point of contact) and Theorem 10.2 (tangents from an external point are equal). For board exams it is a proof chapter: you must be able to write both theorem proofs step by step, and then use them to find lengths and angles in figures with concentric circles, quadrilaterals and triangles drawn around a circle.

Quick Answer - Circles in 30 Seconds

A line can meet a circle in no point (non-intersecting), one point (**tangent**). A tangent is a secant touching at one point. **Theorem 10.1:** the tangent at a point is perpendicular to the radius at that point. **Theorem 10.2:** the two tangents from an external point to a circle are equal. almost every question in the chapter.

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All Key Formulas at a Glance

Idea	Result	Use it when
Theorem 10.1	$OP \perp \text{tangent at P, so } \angle OPT = 90^\circ$	Any figure with a radius drawn to a point of contact
Theorem 10.2	$PQ = PR$ (tangents from external point P)	Two tangents from the same outside point
Length of a tangent	$PT^2 = OP^2 - r^2$	Distance from the centre and radius are known
Centre on the angle bisector	$\angle OPQ = \angle OPR$ and $\angle POQ = \angle POR$	Splitting angles at the external point or at the centre
Tangent angle and centre angle	$\angle QPR + \angle QOP$	
Angle with the chord of contact	$\angle PTQ = 2 \angle OPQ$	
Concentric circles	Chord of large circle perpendicular to chord of smaller = $2\sqrt{r^2 - R^2}$ where R is radius of the point of contact	
Quadrilateral around a circle	$AB + CD = AC + BD$	
Parallelogram around a circle	It is a rhombus	
Parallel tangents cut by a third tangent	$\angle AOB = 90^\circ$	



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Key Concepts

1. A Line and a Circle: Three Possible Positions

From Class 9, a **circle** is the collection of all points in a plane that are at a constant distance (the **radius**) from a fixed point (the **centre**). This chapter asks how a straight line PQ can sit relative to a circle in the same plane. Only three things can happen:

Position	Common points	Name
The line stays outside the circle	None	Non-intersecting line
The line cuts the circle at A and B	Two	Secant
The line touches the circle at A only	Exactly one	Tangent

There is no fourth possibility. Keep **secant** in mind. The chord is only the segment AB between

Tangents in daily life. The rope on either side of the pulley is tangent to the circle of the pulley. A wheel on an axle, the wheel, and the spoke pointing to the ground, the road. That second picture is Theorem 10.1.

“Tangent” comes from the Latin word *tangere*. It was popularized by Danish mathematician Thomas Fineke in 1657.

2. The Tangent as a Special Secant

Activity 1. A straight wire AB is fixed at a point A. In most positions it cuts the circle at P and at Q. As you move B closer to P, and in exactly one position it touches the circle at P. So a tangent is a secant that touches the circle at exactly one point.

Activity 2. Draw a secant and lines parallel to it. As the lines move closer to the secant, the chords they cut get shorter. On each side, the line that touches the circle. So **there cannot be more than one tangent** on each side.



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Both activities lead to the NCERT statement: **the tangent to a circle is a special case of the secant, when the two end points of its corresponding chord coincide.**

The common point of the tangent and the circle is the **point of contact**, and the tangent is said to **touch** the circle there. Since there is one tangent at each of the infinitely many points of a circle, a circle has **infinitely many tangents** (NCERT Exercise 10.1, Question 1).

3. Theorem 10.1: The Tangent Is Perpendicular to the Radius

Statement. The tangent at any point of a circle is perpendicular to the radius through the point of contact.

Given: a circle with centre O and a tangent XY to the circle at a point P.

To prove: $OP \perp XY$.

Proof.

1. Take any point Q on XY other than P, and draw the line segment OQ.
2. Q must lie outside the circle. If Q were inside, the line OQ would be a secant, not a tangent.
3. Since Q is outside the circle, OQ is longer than OP.
4. This is true for every point Q on XY except P. So OP is the shortest distance from O to the points of the line XY.
5. The shortest distance from a point to a line is perpendicular to the line. Hence $OP \perp XY$.

Remarks. At any point on a circle there can be only one tangent line. This line is perpendicular to OP at P. The line containing the radius OP is sometimes called the **normal** to the circle.

How the theorem is used. Whenever a radius is perpendicular to a line, the line is a tangent. The right triangle it creates usually leads to a solution.

4. Number of Tangents from a Point

NCERT Activity 3 tries drawing tangents from an external point.



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Where P lies	Tangents through P	Reason
Inside the circle	None	Every line through an inside point cuts the circle in two points
On the circle	One and only one	Theorem 10.1: only one line is perpendicular to OP at P
Outside the circle	Exactly two	One tangent touches on each side of the line OP

Length of a tangent. If the tangents from an outside point P touch the circle at T₁ and T₂, the segments PT₁ and PT₂ are the **lengths of the tangents** from P: the segment from the external point to the point of contact.

The working formula. Let the circle have centre O and radius r. Let P be an outside point. Let PT be a tangent at T. Join OT and OP. By Theorem 10.1, ∠OTP = 90°. OT is perpendicular to PT. OT is the radius and OP is the hypotenuse OP.

- $PT^2 = OP^2 - r^2$ (length of the tangent)
- $r^2 = OP^2 - PT^2$ (radius)
- $OP^2 = r^2 + PT^2$ (distance of P from the centre)

OP is the hypotenuse, so it is always the longest side.

Radius r	Distance OP	Length of tangent PT
7 cm	25 cm	24 cm
3 cm	5 cm	4 cm
5 cm	13 cm	12 cm

5. Theorem 10.2: Tangents from an external point

Statement. The lengths of tangents drawn from an external point to a circle are equal.



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Given: a circle with centre O, a point P outside the circle, and two tangents PQ and PR to the circle from P, touching it at Q and R.

To prove: $PQ = PR$.

Construction: join OP, OQ and OR.

Proof.

1. $\angle OQP = 90^\circ$ and $\angle ORP = 90^\circ$, because each is the angle between a radius and the tangent at its point of contact (Theorem 10.1).
2. In right triangles OQP and ORP: $OQ = OR$ (radii of the same circle) and $OP = OP$ (common hypotenuse).
3. So $\triangle OQP \cong \triangle ORP$ by the RHS congruence rule.
4. Therefore $PQ = PR$ (CPCT).

Second proof, by Pythagoras. $PQ^2 = OP^2 - OQ^2$

Extra results from the same congruence.

equal:

- $\angle OPQ = \angle OPR$. So OP is the **bisector** of $\angle QPR$ between the two tangents.
- $\angle POQ = \angle POR$. So OP also bisects the angle subtended at the centre by the two tangents.

6. Angles Made by Two Tangents

Let TP and TQ be tangents from an external point T to a circle with centre O. Three angle facts follow.

(a) The angle between the tangents is supplementary to the angle subtended at the centre by the line segment joining the points of contact.

In quadrilateral OPTQ, $\angle OPT = \angle OQT = 90^\circ$. So $\angle PTQ + \angle POQ = 360^\circ - 90^\circ - 90^\circ = 180^\circ$.

In words: the angle between the two tangents is supplementary to the angle subtended at the centre by the line segment joining the points of contact.
NCERT Exercise 10.2, Question 10.



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$\angle PTQ$ (between tangents)	$\angle POQ$ (at the centre)	$\angle POT = \angle QOT$	$\angle PTO = \angle QTO$
70°	110°	55°	35°
80°	100°	50°	40°
90°	90°	45°	45°

(b) $\angle PTQ = 2\angle OPQ$

This is NCERT Example 2, proved in the Solved Examples. $TP = TQ$ makes triangle TPQ isosceles, and $\angle OPT = 90^\circ$ turns its base angle into half of $\angle PTQ$.

(c) OT is the perpendicular bisector of the chord of contact PQ

Call PQ , the segment joining the points of contact, the chord of contact. Triangle TPQ is isosceles and TO bisects its vertex angle, uses this.

7. Concentric Circles and a Chord

Two circles with the same centre are **concentric**. A smaller circle at P , then $OP \perp AB$ (Theorem 10.2) chord bisects it, so **$AP = PB$** . This is NCERT

Length of that chord. Let the radii be R (large) and r (small). $OP = r$, so $AP = \sqrt{R^2 - r^2}$ and

$$AB = 2\sqrt{R^2 - r^2}$$

With $R = 5$ cm and $r = 3$ cm, $AB = 2\sqrt{25 - 9} = 8$ cm.

8. Polygons Drawn Around a Circle

A polygon **circumscribes** a circle when every side is a tangent to the circle at an external point, and by Theorem 10.2 its two tangents from each vertex are equal.

Quadrilateral circumscribing a circle

Let a circle touch the sides AB , BC , CD and DA at P , Q , R and S respectively. The tangents from each vertex give $AP = AS$, $BP = BQ$, $CQ = CR$, and $DR = DS$.



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$$AB + CD = (AP + PB) + (CR + RD) = AS + BQ + CQ + DS = (AS + DS) + (BQ + CQ) = \mathbf{AD + BC}.$$

So the sums of opposite sides are equal. If $AB = 6$ cm, $BC = 7$ cm and $CD = 4$ cm, then $AD = 6 + 4 - 7 = 3$ cm.

Parallelogram circumscribing a circle. In a parallelogram $AB = CD$ and $AD = BC$. Putting these into $AB + CD = AD + BC$ gives $2AB = 2AD$, so $AB = AD$. A parallelogram with two adjacent sides equal has all four sides equal, so it is a **rhombus** (NCERT Exercise 10.2, Question 11). A rectangle that is not a square cannot circumscribe a circle.

Angles at the centre. Opposite sides of a quadrilateral circumscribing a circle subtend supplementary angles at the centre: $\angle AOB + \angle COD = 180^\circ$ and $\angle BOC + \angle AOD = 180^\circ$ (NCERT Exercise 10.2, Question 13, proved below).

Triangle circumscribing a circle

Let a circle touch BC at D , CA at E and AB at F . Then $AF = AE$, $BD = BF$ and $CD = CE$.

$$AE = AF, BD = BF, CD = CE.$$

Call these x , y and z : $AF = AE = x$, $BF = BD = y$, $CD = CE = z$. Adding, the perimeter is $2(x + y + z)$.

$$x = s - BC, y = s - CA, z = s - AB.$$

Area and the radius. Join the centre O to A , B and C . Each has height r (the radius is perpendicular to the side). Area of $\triangle OAB = \frac{1}{2} r (AB)$. Similarly, area of $\triangle OBC = \frac{1}{2} r (BC)$ and area of $\triangle OCA = \frac{1}{2} r (CA)$. Adding, area of $\triangle ABC = \frac{1}{2} r (AB + BC + CA) = \frac{1}{2} r \times s$. NCERT Exercise 10.2, Question 14. Use Heron's formula from Class 9, to find two sides of a triangle circumscribing a circle.



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Formula and Theorem Sheet

Result	Statement or formula
Positions of a line	0 common points: non-intersecting; 2: secant; 1: tangent
Parallel tangents	At most two tangents are parallel to a given secant
Theorem 10.1	Tangent at any point $\perp$ radius through the point of contact; exactly one tangent at each point
Tangents through a point	Inside: 0; on the circle: 1; outside: 2
Length of tangent	$PT^2 = OP^2 - r^2$
Theorem 10.2	Tangents from an external point are equal: $PQ = PR$; OP bisects $\angle QPR$
Two tangents TP, TQ	$\angle OPT = \angle OPT$ perpendicular to OP
Concentric circles	Chords of the larger circle touching the smaller circle are parallel
Circumscribing quadrilateral	$AB + CD = AC + BD$ sum of opposite sides are equal
Circumscribing parallelogram	Muscatelli's theorem
Parallel tangents cut by a third tangent at A, B	$\angle AOC = 90^\circ$
Circumscribing triangle	Tangents from an external point are equal

Important Definitions

- Circle:** the collection of all points in a plane at a fixed distance from a fixed point (centre).
- Non-intersecting line:** a line that has no common point with the circle.



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- **Secant:** a line that intersects a circle in two distinct points.
- **Chord:** the line segment joining the two points where a secant meets the circle.
- **Tangent:** a line that intersects the circle at only one point. It is a special case of a secant when the two end points of its corresponding chord coincide.
- **Point of contact:** the common point of a tangent and the circle. The tangent is said to touch the circle at this point.
- **Normal:** the line containing the radius through the point of contact. It is perpendicular to the tangent at that point.
- **Length of a tangent:** the length of the segment of the tangent from the external point to the point of contact with the circle.
- **Concentric circles:** circles in the same plane with the same centre and different radii.
- **Circumscribing polygon:** a polygon all of whose sides touch a circle. The circle is then said to be inscribed in the polygon.

Solved Examples (NCERT)

Example 1: Length of a tangent (NCERT)

A tangent PQ at a point P of a circle of radius 5 cm is drawn so that OQ = 12 cm. Length PQ is: (A) 12 cm (B) 13 cm (C) 14 cm (D) 11 cm

Solution: OP is the radius to the point of contact. In right-angled triangle OPQ, the hypotenuse is OQ.

$$PQ^2 = OQ^2 - OP^2 = 12^2 - 5^2 = 144 - 25 = 119$$

$PQ = \sqrt{119}$ cm. **Answer: (D).** Option (B) is incorrect as it treats PQ as the hypotenuse.

Example 2: Finding the radius (NCERT)

(i) From a point Q, the length of the tangent to a circle is 24 cm and the distance of Q from the centre is 25 cm. The radius of the circle is

(ii) The length of a tangent from a point A at a distance of 17 cm from the centre of a circle is 15 cm. Find the radius of the circle.



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Solution: Let the tangent touch the circle at P. By Theorem 10.1, $\angle OPQ = 90^\circ$, so OQ is the hypotenuse.

(i) $r^2 = OQ^2 - PQ^2 = 625 - 576 = 49$, so $r = 7$ cm. **Answer: (A).**

(ii) Here the external point is A, with $OA = 5$ cm and the tangent length 4 cm. $r^2 = OA^2 - 4^2 = 25 - 16 = 9$, so $r = 3$ cm.

Example 3: Angle between tangents from the angle at the centre (NCERT Exercise 10.2, Q2)

If TP and TQ are the two tangents to a circle with centre O so that $\angle POQ = 110^\circ$, then $\angle PTQ$ is equal to (A) 60° (B) 70° (C) 80° (D) 90° .

Solution: In quadrilateral OPTQ, $\angle OPT = \angle OQT = 90^\circ$ (Theorem 10.1). The angle sum of a quadrilateral is 360° .

$\angle PTQ = 360^\circ - 90^\circ - 90^\circ - 110^\circ = 70^\circ$. **Answer: (B).**

Example 4: Angle at the centre from Exercise 10.2, Q3

If tangents PA and PB from a point P to a circle with centre O are such that $\angle APB = 80^\circ$, then $\angle POA$ is equal to (A) 50° (B) 60° (C) 70° (D) 80° .

Solution: OP bisects $\angle APB$ (the centre lies on the angle bisector).
 $\angle OPA = 80^\circ/2 = 40^\circ$.

In triangle OAP, $\angle OAP = 90^\circ$ (Theorem 10.1).

Example 5: Chord of the larger of two concentric circles

Prove that in two concentric circles, the chord of the larger circle, which touches the smaller circle, is bisected at the point of contact.

Given: two concentric circles C_1 and C_2 with centre O, where C_1 is the larger circle and C_2 is the smaller circle. A chord AB of C_1 touches C_2 at P.

To prove: $AP = BP$.

Proof: Join OP. AB is a tangent to C_2 at P and OP is a radius of C_2 .
 $\therefore OP \perp AB$ (Theorem 10.2).



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Now AB is a chord of C_1 and $OP \perp AB$. The perpendicular from the centre of a circle to a chord bisects the chord. So OP bisects AB, that is, **AP = BP**.

Example 6: Length of that chord (NCERT Exercise 10.2, Q7)

Two concentric circles are of radii 5 cm and 3 cm. Find the length of the chord of the larger circle which touches the smaller circle.

Solution: Let the chord AB of the larger circle touch the smaller circle at P, and let O be the centre. By Theorem 10.1, $OP \perp AB$, and by Example 5, P is the midpoint of AB.

In right triangle OPA: OA = 5 cm (radius of the larger circle), OP = 3 cm (radius of the smaller circle).

$$AP = \sqrt{(OA^2 - OP^2)} = \sqrt{(25 - 9)} = \sqrt{16} = 4 \text{ cm.}$$

$$AB = 2 \times AP = 8 \text{ cm.}$$

Example 7: $\angle PTQ = 2\angle OPQ$ (NCERT Exercise 10.2, Q8)

Two tangents TP and TQ are drawn to a circle from an external point T. Prove that $\angle PTQ = 2\angle OPQ$.

Proof: Let $\angle PTQ = \theta$.

By Theorem 10.2, TP = TQ, so triangle TPO is congruent to triangle TQO.

$$\angle TPQ = \angle TQP = \frac{1}{2}(180^\circ - \theta) = 90^\circ - \theta/2.$$

By Theorem 10.1, $\angle OPT = 90^\circ$. So

$$\angle OPQ = \angle OPT - \angle TPQ = 90^\circ - (90^\circ - \theta/2) = \theta/2.$$

This gives **$\angle PTQ = 2\angle OPQ$** .

Example 8: Tangents at the ends of a chord

PQ is a chord of length 8 cm of a circle of radius 5 cm. Tangents at P and Q intersect at point T. Find the length TP.

Solution (similar triangles): Join OT and PQ. OT is the line segment joining the centre to the point of intersection of the tangents. OT is the bisector of $\angle PTQ$, so $OT \perp PQ$ and OT bisects PQ. Hence PR = RQ = 4 cm.



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In right triangle ORP: $OR = \sqrt{(OP^2 - PR^2)} = \sqrt{(25 - 16)} = 3 \text{ cm}$.

Now $\angle TPR + \angle RPO = 90^\circ$ (because $\angle TPO = 90^\circ$, Theorem 10.1), and $\angle TPR + \angle PTR = 90^\circ$ (angle sum of triangle TRP, which is right-angled at R). So $\angle RPO = \angle PTR$.

Therefore right triangle TRP is similar to right triangle PRO by AA similarity. This gives

$TP/PO = RP/RO$, that is $TP/5 = 4/3$, so **TP = 20/3 cm**.

Second method (Pythagoras): Let $TP = x$ and $TR = y$.

From right triangle PRT: $x^2 = y^2 + 16 \dots (1)$

From right triangle OPT: $x^2 + 5^2 = (y + 3)^2 \dots (2)$

Subtracting (1) from (2): $25 = 6y + 9 - 16 = 6y - 7$, so $y = 32/6 = 16/3$.

Then $x^2 = (16/3)^2 + 16 = 256/9 + 144/9 = 400/9$, so $x = 20/3$.

Example 9: Tangents at the ends of a diameter and the point of contact (NCERT Exercise 10.1)

(i) Prove that the tangents drawn at the ends of a diameter are parallel.

(ii) Prove that the perpendicular at the point of contact to the tangent passes through the centre.

Proof of (i): Let AB be a diameter of a circle with centre O. Let PQ and RS be tangents at A and B respectively. By Theorem 10.1, $OA \perp PQ$ and $OB \perp RS$. So $\angle OAP = 90^\circ$ and $\angle OBS = 90^\circ$. These are alternate angles. So lines PQ and RS, and they are equal. Hence PQ is parallel to RS.

Proof of (ii): Let AB be the tangent at P to a circle with centre O. Then OP is the perpendicular from the centre to the tangent. So OP is the line OP, which passes through the centre O.

Example 10: Quadrilateral circumscribing a circle and Q11)

(i) A quadrilateral ABCD is drawn to circumscribe a circle. Prove that $AB + CD = AD + BC$.



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(ii) Prove that the parallelogram circumscribing a circle is a rhombus.

Proof of (i): Let the circle touch AB, BC, CD and DA at P, Q, R and S. Tangents from an external point are equal (Theorem 10.2), so

$$AP = AS, BP = BQ, CR = CQ, DR = DS.$$

Adding these four equations: $AP + BP + CR + DR = AS + BQ + CQ + DS$.

Grouping: $(AP + PB) + (CR + RD) = (AS + SD) + (BQ + QC)$, that is **$AB + CD = AD + BC$** .

Proof of (ii): Let ABCD be a parallelogram circumscribing a circle. By part (i), $AB + CD = AD + BC$. Opposite sides of a parallelogram are equal, so $CD = AB$ and $BC = AD$. Then $2AB = 2AD$, so $AB = AD$. So $AB = BC = CD = DA$, and ABCD is a **rhombus**.

Example 11: Parallel tangents and a third tangent (NCERT Exercise 10.2, Q9)

XY and X'Y' are two parallel tangents to a circle of contact C intersecting XY at A and X'Y' at B.

Proof: Let XY touch the circle at P and X'Y' touch the circle at Q.

From A, the tangents AP and AC are drawn. $\therefore \angle PAC = \frac{1}{2} \angle XOY$.

From B, the tangents BQ and BC are drawn. $\therefore \angle QBC = \frac{1}{2} \angle XOY$.

$XY \parallel X'Y'$ and AB is a transversal, so $\angle PAC$ and $\angle QBC$ are alternate angles.
transversal: $\angle PAC + \angle QBC = 180^\circ$.

$$\text{So } \angle OAB + \angle OBA = \frac{1}{2}(\angle PAC + \angle QBC) = 90^\circ$$

In triangle AOB, $\angle AOB = 180^\circ - 90^\circ = 90^\circ$.

Example 12: Triangle circumscribing a circle

A triangle ABC is drawn to circumscribe a circle of radius 4 cm such that the radius is perpendicular to the side BC. Find the sides AB and AC.



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Solution: Let the circle with centre O touch AB at F and AC at E. Tangents from each vertex are equal:

$$BF = BD = 8 \text{ cm}, CE = CD = 6 \text{ cm}, AF = AE = x \text{ cm (say)}.$$

$$\text{So } AB = x + 8, AC = x + 6 \text{ and } BC = 8 + 6 = 14 \text{ cm}.$$

Step 1: area by splitting at the centre O (main method). Join OA, OB and OC. OD, OE and OF are radii of 4 cm, each perpendicular to its side (Theorem 10.1), so each is the height of one of the three small triangles. So

$$\text{ar(ABC)} = \text{ar(OBC)} + \text{ar(OCA)} + \text{ar(OAB)} = \frac{1}{2} \times 4 \times [14 + (x + 6) + (x + 8)] = 2(2x + 28) = 4(x + 14).$$

Step 2: a second expression for the same area. The area in Step 1 still contains the unknown x, so one more equation is needed. The standard way is Heron's formula from Class 9, $\text{area} = \sqrt{s(s-a)(s-b)(s-c)}$. Semi-perimeter $s = (14 + 8 + 13)/2 = 14.5$ and $s - AB = 6$, so

$$\text{ar(ABC)} = \sqrt{[(x + 14)(x)(8)(6)]} = \sqrt{[48x(x + 14)]}$$

Step 3: equate and solve. $\sqrt{[48x(x + 14)]} = 4(x + 14)$ by 16(x + 14), which is not zero: $3x = x + 14$

$$AB = 7 + 8 = 15 \text{ cm and } AC = 7 + 6 = 13 \text{ cm}$$

Check: sides 15, 14 and 13 give $s = 21$ and $4 \times 21 = 84 \text{ cm}^2$. Both agree.

Example 13: Opposite sides subtend equal angles at the centre of the circle (10.2, Q13)

Prove that opposite sides of a quadrilateral circumscribing a circle subtend equal angles at the centre of the circle.

Proof: Let ABCD circumscribe a circle with centre O. Join OA, OB, OC, OD and OP, OQ, OR, OS.

In right triangles OAP and OAS: $OP = OS$ (radii), $OA = OA$ (common), $\Delta OAP \cong \Delta OAS$ (RHS), giving $\angle AOP = \angle AOS$



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In the same way: $\angle BOP = \angle BOQ$ (angle 2), $\angle COQ = \angle COR$ (angle 3), $\angle DOR = \angle DOS$ (angle 4).

The eight angles round O add up to 360° : $2(\text{angle } 1 + \text{angle } 2 + \text{angle } 3 + \text{angle } 4) = 360^\circ$, so $\text{angle } 1 + \text{angle } 2 + \text{angle } 3 + \text{angle } 4 = 180^\circ$.

Now $\angle AOB = \text{angle } 1 + \text{angle } 2$ and $\angle COD = \text{angle } 3 + \text{angle } 4$. So $\angle AOB + \angle COD = 180^\circ$. Similarly $\angle BOC + \angle AOD = (\text{angle } 2 + \text{angle } 3) + (\text{angle } 4 + \text{angle } 1) = 180^\circ$.

Competency-Based Questions (with answers)

1. Case-based: The gate and the circular park

A circular park has radius 9 m and centre O. A gate G stands 15 m from O. Two straight fences are laid from G so that each just touches the park boundary, one at A and one at B.

(a) Find the length of each fence. $\angle OAG = 90^\circ$. $OG = 15$ m, $OA = 9$ m. $AG = \sqrt{15^2 - 9^2} = \sqrt{144} = 12$ m. By Theorem 10.2, $GB = 12$ m.

(b) Find the area of the region OAGB enclosed by the fences and the radii OA and OB. The region is made of two congruent right triangles OAG and OBG.

(c) Find the straight distance AB. OG is the perpendicular bisector of AB. Area of triangle OAG = $\frac{1}{2} \times OA \times AG = \frac{1}{2} \times 9 \times 12 = 54$ m². Area of triangle OGB = 54 m². Area of sector OAGB = $\frac{1}{2} \times \pi \times 9^2 \times \frac{120}{180} = 54\pi$ m². Area of region OAGB = $54 + 54 - 54\pi = 108 - 54\pi$ m². $AB = 2 \times AG = 2 \times 12 = 24$ m.

2. Case-based: The fountain in the park

A triangular lawn ABC has $AB = 12$ m, $BC = 16$ m, $CA = 20$ m. A fountain is placed at the intersection of the angle bisectors of the triangle. Its edge touches all three sides: BC at D, CA at E, and AB at F.

(a) Which pairs of segments are equal? Are the segments from the same external point equal.

(b) Find AF, BD and CE. Half the perimeter of triangle ABC = $\frac{1}{2}(12 + 16 + 20) = 24$ m. $BD = 24 - CA = 5$ m, $CE = 24 - AB = 12$ m, $AF = 24 - BC = 8$ m.

3. Source-based: The pulley and the well

Read the passage adapted from the textbook.

A pulley is used in taking out water from the well. Here the rope on both sides of the pulley, if



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considered as a ray, is like a tangent to the circle representing the pulley." The textbook also notes that a wheel moves along a line which is a tangent to the circle representing the wheel, and the radius through the point of contact with the ground appears to be at right angles to it.

(a) Which theorem does the wheel observation illustrate? Theorem 10.1: the tangent at any point of a circle is perpendicular to the radius through the point of contact.

(b) A wheel of radius 35 cm rests on the road at point P. A pebble on the road is 84 cm from P. How far is the pebble from the centre of the wheel? The radius to P is perpendicular to the road, so distance = $\sqrt{(35^2 + 84^2)} = \sqrt{(1225 + 7056)} = \sqrt{8281} = 91$ cm.

4. Assertion-Reason

Assertion (A): No tangent can be drawn to a circle from a point inside it.

Reason (R): Every line through a point inside a circle intersects the circle in two points.

Options: (a) Both A and R are true and R is the correct explanation of A. (b) Both A and R are true but R is not the correct explanation of A. (c) A is true but R is false. (d) A is false but R is true.

Answer: (a). Both are true. Since every line through a point inside a circle intersects the circle in two points, no line can be a tangent, which is exactly why A holds.

5. Assertion-Reason

Assertion (A): The tangents drawn at the ends of a diameter of a circle are parallel.

Reason (R): The tangent at any point of a circle is perpendicular to the radius through the point of contact.

Options: (a) Both A and R are true and R is the correct explanation of A. (b) Both A and R are true but R is not the correct explanation of A. (c) A is true but R is false. (d) A is false but R is true.

Answer: (a). Both tangents are perpendicular to the same line and hence they are parallel.

6. Assertion-Reason

Assertion (A): If PA and PB are tangents to a circle from an external point P, then $\angle APB = 120^\circ$.

Reason (R): The angle between two tangents drawn from an external point to a circle is bisected by the line segment joining the point to the centre.



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Options: (a) Both A and R are true and R is the correct explanation of A. (b) Both A and R are true but R is not the correct explanation of A. (c) A is true but R is false. (d) A is false but R is true.

Answer: (c). A is true: $\angle AOB = 360^\circ - 90^\circ - 90^\circ - 60^\circ = 120^\circ$. R is false: the two angles are supplementary (sum 180°), not complementary (sum 90°).

7. Error analysis: The wrong tangent length

A student is told that a point P is 10 cm from the centre of a circle of radius 6 cm, and writes: "Length of tangent = $\sqrt{(10^2 + 6^2)} = \sqrt{136}$ cm." Find the error and correct it.

Answer: The student treated the tangent as the hypotenuse. The right angle is at the point of contact T (Theorem 10.1), so OP = 10 cm is the hypotenuse. $PT = \sqrt{(10^2 - 6^2)} = \sqrt{64} = 8$ cm. Quick check: a tangent length must be shorter than the distance OP.

8. Competency MCQ: The incircle of a right triangle

A circle touches all three sides of triangle ABC. Its radius is: (a) 1 cm (b) 2 cm (c) 3 cm (d) 4 cm.

Answer: (b). $AC = \sqrt{(36 + 64)} = 10$ cm. The legs, form a square of side r at B. Tangent from P to AC: $(6 - r) + (8 - r) = 10$, so $r = 2$ cm.



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Important Questions for

1-Mark Questions

1. How many tangents can a circle have?
2. A point P is 13 cm from the centre of a circle of radius 5 cm. Length of tangent from P. $\sqrt{(169 - 25)} = \sqrt{144} = 12$ cm.
3. PA and PB are tangents from P to a circle with centre O. $\angle AOB = 50^\circ$. Find $\angle APB$.
 $180^\circ - 50^\circ = 130^\circ$.
4. Fill in the blank: A circle can have _____ tangents.

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2-Mark Questions

1. **Prove that the tangents drawn at the ends of a chord of a circle make equal angles with the chord.** Let the tangents at the ends P and Q of chord PQ meet at T. By Theorem 10.2, $TP = TQ$, so triangle TPQ is isosceles. Angles opposite equal sides are equal, so $\angle TPQ = \angle TQP$.
2. **Two concentric circles have radii 13 cm and 5 cm. Find the length of the chord of the larger circle that touches the smaller circle.** Half chord = $\sqrt{(169 - 25)} = 12$ cm, so the chord is 24 cm (the point of contact bisects it).
3. **PA and PB are tangents from P to a circle, and $\angle APB = 60^\circ$. Prove that triangle PAB is equilateral.** $PA = PB$ (Theorem 10.2), so $\angle PAB = \angle PBA = (180^\circ - 60^\circ)/2 = 60^\circ$. All three angles are 60° , so triangle PAB is equilateral.
4. **A quadrilateral ABCD circumscribes a circle. $AB = 8$ cm, $BC = 10$ cm and $CD = 9$ cm. Find AD.** $AB + CD = AD + BC$, so $17 = AD + 10$ and $AD = 7$ cm.

3-Mark Questions

1. **Prove that the tangent at any point of a circle is perpendicular to the radius at the point of contact.** Let XY touch the circle at P and join OP. Q lies outside the circle, and XQ and YQ are tangents to the circle. This holds for every point of XY except the shortest segment from a point to a line.
2. **A circle is inscribed in triangle ABC with AB at P, BC at Q and CA at R. Find AP, BQ and CR.** Then $x + y = 10$, $y + z = 8$, $z + x = 12$. Adding, $2x + 2y + 2z = 20$, so $x + y + z = 10$. Then $z = 10 - 10 = 0$. $AP = 7$ cm, $BQ = 3$ cm, $CR = 0$ cm.
3. **A circle touches the side BC of triangle ABC at P, AB at Q and AC at R respectively. Prove that $AQ = \frac{1}{2}(\text{perimeter of } \triangle ABC)$.** $AQ = AR$, $BQ = BP$ and $CP = CR$. Perimeter of $\triangle ABC = AB + BC + CA = AQ + BQ + BP + PC + CR + CA = AQ + AR = 2AQ$. So $AQ = \frac{1}{2}(\text{perimeter of } \triangle ABC)$.

5-Mark Questions

1. **From a point T outside a circle of centre O, two tangents TP and TQ are drawn. $OT = 10$ cm. Find (i) TP, (ii) the area of the circle.** (i) $\angle OPT = 90^\circ$, so $TP = \sqrt{(100 - 64)} = 6$ cm. (ii) Area of circle = $\pi r^2 = \pi \times 6^2 = 36\pi$ cm².
Let it meet PQ at R. Area of triangle OPT = $\frac{1}{2} \times OT \times PR = \frac{1}{2} \times 10 \times PR = 4.8$ cm. $PQ = 2 \times 4.8 = 9.6$ cm.



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2. **XY and X'Y' are two parallel tangents to a circle with centre O, and another tangent AB with point of contact C intersects XY at A and X'Y' at B. Prove that $\angle AOB = 90^\circ$. If the radius is 5 cm and $AC = 4$ cm, find BC.** Proof as in Example 11: OA and OB bisect the co-interior angles at A and B, whose sum is 180° , so $\angle OAB + \angle OBA = 90^\circ$ and $\angle AOB = 90^\circ$. *Extension (goes beyond the Circles exercises: it also uses similar triangles from the Triangles chapter).* For the length: $OC \perp AB$ (Theorem 10.1), and OC is the altitude to the hypotenuse of right triangle AOB. In right triangle OCA, $\angle AOC = 90^\circ - \angle OAC = \angle OBC$, so right triangles OCA and BCO are similar (AA). Then $AC/OC = OC/BC$, giving $OC^2 = AC \times BC$. So $25 = 4 \times BC$ and $BC = 6.25$ cm.

Common Mistakes and Examiner Tips

- Adding squares for the tangent length.** The right angle is at the point of contact, so the line from the external point to the centre is the hypotenuse. $PT^2 = OP^2 - r^2$, never $OP^2 + r^2$.
- Using the diameter as the radius.** A diameter of 10 cm means $r = 5$ cm. Write r before calculating.
- Stopping at half the chord.** In concentric circles, the distance from the centre to the chord is half the chord. Double it at the end.
- Calling the two angles complementary.** Angles at the centre add up to 180° (supplementary). In a cyclic quadrilateral OPTQ.
- Skipping the reason for the right angle.** "Tangent is perpendicular to the radius at the point of contact" every time. In proofs the reason is "Theorem 10.1".
- Proving Theorem 10.2 with SAS or SSS.** In right triangles OPT and OQT, hypotenuse OP common, side OQ common, $\angle OPT = \angle OQT = 90^\circ$ (Theorem 10.1), hypotenuse OP common, side OQ common.
- Stating Theorem 10.1 loosely.** "Tangent to a circle is perpendicular to the radius at the point of contact".
- Pairing the wrong tangent segments.** In two tangents from an external point, the segments share a vertex: $AP = AS$, not $AP = AQ$. Before adding.
- Giving one tangent from a point inside the circle.** It is not possible.
- Writing a proof without a set-up.** Start with a neat labelled figure.



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Quick Revision Points

- A line and a circle: no common point (non-intersecting), two (secant), one (tangent)
- Tangent: a secant whose two chord end points coincide
- A circle has infinitely many tangents, exactly one at each point
- At most two tangents are parallel to a given secant, one on each side
- Theorem 10.1: tangent at any point $\perp$ radius through the point of contact
- Tangents at the two ends of a diameter are parallel
- Tangents through a point: inside 0, on 1, outside 2
- Length of a tangent: segment from the external point to the point of contact
- $PT^2 = OP^2 - r^2$; OP is always the longest side
- Theorem 10.2: tangents from an external point are equal (RHS congruence)
- The centre lies on the bisector of the angle between the tangents
- $\angle PTQ + \angle POQ = 180^\circ$ for tangents TP, TQ
- $\angle PTQ = 2\angle OPQ$
- OT is the perpendicular bisector of the chord of contact
- Concentric circles: chord of larger touches smaller at two points
- Quadrilateral around a circle: $AB + CD = AD + BC$
- Parallelogram around a circle is a rhombus
- Opposite sides of a circumscribing quadrilateral are equal
- Parallel tangents cut by a third tangent



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Question type	What is usually asked
MCQ and Assertion-Reason	Tangent length, radius or distance from the centre by Pythagoras; angle between tangents from the angle at the centre; number of tangents from a point; parallel tangents
Short answers	Concentric-circle chord; missing side of a circumscribing quadrilateral; equal angles with the chord; simple angle proofs
Proofs	Theorem 10.1 and Theorem 10.2 with full reasons; $AB + CD = AD + BC$; parallelogram is a rhombus; $\angle AOB = 90^\circ$ with parallel tangents; supplementary angles at the centre
Case-based	A real setting such as a wheel, a pulley, a park with a gate or a lawn with a fountain, split into parts on tangent lengths and angles

Practise the two theorem proofs, NCERT Ex 10.1 and 10.2, writing the reason beside each step.



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