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CHAPTER NOTES

Lines and Angles Class 9 Notes | CBSE Maths

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Hi, I am **Ira**. I teach this syllabus all day, so **Lines and Angles** is very much my home ground.

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 Lines and Angles simply

What can the board exam ask?

Most important formulas

Quiz me on this chapter

Ask Ira anything...



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Lines and Angles Class 9 Notes | CBSE Maths

Lines and Angles is a chapter of CBSE Class 9 Maths (2026-27 syllabus), part of Unit IV, Geometry. It starts with rays and angles, how angles are measured and classified, and the pairs of angles that appear whenever two lines meet: adjacent angles, linear pairs and vertically opposite angles. It then moves to parallel lines cut by a transversal, the corresponding, alternate and co-interior angles, and ends with what these facts tell us about the angles of a triangle.

The chapter is where Class 9 geometry turns into proof. School exams ask you to state and apply the linear pair theorem and its converse, prove that vertically opposite angles are equal, find unknown angles across parallel lines, test whether two lines are parallel, and argue by contradiction that a triangle cannot have two obtuse angles. Every later geometry chapter, from congruent triangles to circles, uses these angle facts as its first steps, and so do the Class 10 board chapters on triangles and circles.

Quick Answer - Lines and Angles

An **angle** is formed by two rays with a common endpoint. A right angle is 90° and a straight angle is two right angles or 180° . If a ray stands on a line, the two adjacent angles are supplementary or reflex. If a ray stands on a line, the two adjacent angles are supplementary or reflex. Conversely, when two lines intersect, vertically opposite angles are equal. A transversal line across two **parallel lines** makes corresponding angles, alternate angles and co-interior angles add to 180° ; each angle in a triangle add to 180° , so every triangle has an interior angle sum of 180° .



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All Key Formulas at a Glance

Fact	Rule	Remember
Right and straight angle	Right angle = 90° ; straight angle = 2 right angles = 180°	Complete turn = 360°
Complementary angles	$x + y = 90^\circ$	Complement of x is $90^\circ - x$
Supplementary angles	$x + y = 180^\circ$	Supplement of x is $180^\circ - x$
Reflex angle	Reflex $\angle AOB = 360^\circ - \angle AOB$	Lies between 180° and 360°
Linear pair theorem	Ray OC on line AB: $\angle AOC + \angle COB = 180^\circ$	Converse: sum 180° means AOB is a line
Angles around a point	Sum = 360°	
Vertically opposite angles	$\angle AOC = \angle BOD$ $\angle BOC = \angle AOD$	
Corresponding angles ($l \parallel m$)	Equal	
Alternate interior angles ($l \parallel m$)	Equal	
Co-interior angles ($l \parallel m$)	Sum = 180°	
Transitivity of parallelism	$a \parallel b$ and $b \parallel c \implies a \parallel c$	
Angle sum of a triangle	$\angle A + \angle B + \angle C = 180^\circ$	



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Key Concepts

1. Points, Lines, Line Segments and Rays

Geometry starts with three ideas we understand without a formal definition: a **point** (a position with no size), a **line** (straight, with no thickness, going on without end in both directions) and a **plane** (a flat surface going on without end). All figures in this chapter lie in one plane.

- A **line** AB passes through points A and B and extends endlessly both ways. It has no end points and cannot be measured. Lines are also named with a single small letter, such as line l.
- A **line segment** AB is the part of the line between A and B, including both. It has two end points and a definite length, written AB.
- A **ray** OA starts at the point O and goes on without end in one direction, through A. It has exactly one end point. The starting point is always written first, so ray OA and ray AO are different rays.

Collinear points. Three or more points that lie on the same line are called **collinear**. Exactly one line passes through them. "AOB is a straight line" means the same as "A, O, B are collinear".

Opposite rays. If O lies on line AB between A and B, then ray OA and ray OB are **opposite rays** and together they form line AB.

Intersecting and parallel lines. Two distinct lines that intersect at a single point are **intersecting lines** (or **intersecting lines**) or never meet, however far they are extended, are **parallel lines**.

2. Angles and Their Measures

An **angle** is formed by two rays that have a common endpoint, called the **vertex** and the two rays are the **arms** of the angle. An angle is written $\angle AOB$ or $\angle BOA$. The vertex always comes in the middle.

The **measure** of an angle is the amount of rotation from one ray to the other at the vertex. It is measured in **degrees** with the symbol $^\circ$. The total angle around a point, if it started, is 360° .

Right angle and straight angle.

- A **right angle** is a quarter turn and measures 90° . Two lines that intersect at a right angle are **perpendicular**, written $l \perp m$.



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- A **straight angle** is formed when the two arms are opposite rays, so that they lie along one line pointing in opposite directions. It is a half turn and measures **180°**.
- So a straight angle equals **two right angles**: $2 \times 90^\circ = 180^\circ$. A complete turn equals four right angles: $4 \times 90^\circ = 360^\circ$.

Classifying angles by measure.

Type	Measure
Acute angle	More than 0° and less than 90°
Right angle	Exactly 90°
Obtuse angle	More than 90° and less than 180°
Straight angle	Exactly 180°
Reflex angle	More than 180° and less than 360°
Complete angle	Exactly 360°

Reflex angle. Two rays OA and OB with a common vertex O form a smaller one, $\angle AOB$, and the larger one on the other side of OA and OB, a full turn, so

reflex $\angle AOB = 360^\circ - \angle AOB$

For example, if $\angle AOB = 125^\circ$, then reflex $\angle AOB = 360^\circ - 125^\circ = 235^\circ$. $\angle AOB$, it means the smaller angle (less than 180°) and reflex $\angle AOB$, it means the larger angle (more than 180°) as reflex.

3. Pairs of Angles

Learn each definition word for word, because they are very important.

Complementary angles. Two angles whose sum is 90°. If one angle is x, the other is 90° - x. Two acute angles have complements.

Supplementary angles. Two angles whose sum is 180°. If one angle is x, the other is 180° - x. For example, 110° and 70° are supplementary.



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Adjacent angles. Two angles are adjacent if all three conditions hold:

1. they have a **common vertex**,
2. they have a **common arm**, and
3. their **non-common arms lie on opposite sides** of the common arm.

If ray OC lies inside $\angle AOB$, then $\angle AOC$ and $\angle COB$ are adjacent, with common vertex O and common arm OC. Their sum is $\angle AOB$: $\angle AOC + \angle COB = \angle AOB$. Two angles that share only a vertex, or that overlap, are not adjacent.

Linear pair. Two adjacent angles form a **linear pair** when their non-common arms are opposite rays, that is, when the non-common arms together form a straight line. Picture a straight line AB with a point O on it and a ray OC standing on the line, going upward from O. The two angles $\angle AOC$ and $\angle COB$ form a linear pair.

Vertically opposite angles. When two lines AB and CD intersect at O, four angles are formed around O. The angles facing each other are called vertically opposite angles. There are exactly two such pairs: $\angle AOC$ and $\angle BOD$, and $\angle AOD$ and $\angle BOC$.

Every linear pair is supplementary, but supplementary angles are not necessarily a linear pair. For example, two angles of 100° and 80° in two different corners of a rectangle are supplementary but not a linear pair.

4. The Linear Pair Theorem and Its Converse

Linear pair theorem. If a ray stands on a line, the sum of the two adjacent angles so formed is 180° .

Given: A line AB, a point O on it between A and B.

To prove: $\angle AOC + \angle COB = 180^\circ$.

Proof: Rays OA and OB are opposite rays, so ray OC lies between OA and OB, so $\angle AOC$ and $\angle COB$ form a linear pair. $\therefore \angle AOC + \angle COB = \angle AOB = 180^\circ$. $\therefore$ The angle sum of two adjacent angles so formed is 180° .

Some books take this statement as a basic fact. It is a very useful tool behind almost every proof in this chapter.

Converse of the linear pair theorem. If two adjacent angles sum up to 180° , then their common arms form a straight line.

Given: Adjacent angles $\angle AOC$ and $\angle COB$ such that $\angle AOC + \angle COB = 180^\circ$.

To prove: A, O and B are collinear, so AOB is a line.



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Proof (by contradiction): Suppose OB is not the ray opposite to OA. Extend AO beyond O to get the opposite ray, and call it OB'; it lies on the same side of OC as OB. Now AOB' is a line and OC stands on it, so by the linear pair theorem, $\angle AOC + \angle COB' = 180^\circ$. We are given $\angle AOC + \angle COB = 180^\circ$. Comparing, $\angle COB' = \angle COB$. Two rays OB and OB' on the same side of OC making the same angle with OC must be the same ray. So OB and OB' coincide, which contradicts our supposition. $\therefore$ AOB is a straight line.

The converse is the test used to prove three points are collinear: show that two adjacent angles at the middle point add to 180° .

Consequences worth remembering.

- **Angles around a point add to 360° .** Extend any one ray backwards through the point to make a line; the angles on each side add to 180° , giving $180^\circ + 180^\circ = 360^\circ$ in total.
- **The bisectors of the two angles of a linear pair are perpendicular.** If $\angle AOC = x$ and $\angle COB = y$ with $x + y = 180^\circ$, the angle between the bisectors is $x/2 + y/2 = (x + y)/2 = 90^\circ$.

5. Intersecting Lines and Vertical Angles

When two lines AB and CD cross at O, four angles are formed. Next to each other they form linear pairs; angles opposite each other are vertical angles.

Theorem. If two lines intersect each other, the vertical angles are equal.

Given: Lines AB and CD intersect at O.

To prove: $\angle AOC = \angle BOD$ and $\angle AOD = \angle BOC$

Proof:

1. Ray OC stands on line AB. So $\angle AOC + \angle COB = 180^\circ$ (linear pair).
2. Ray OB stands on line CD. So $\angle COB + \angle BOD = 180^\circ$ (linear pair).
3. From (1) and (2), $\angle AOC + \angle COB = \angle COB + \angle BOD$.
4. Subtracting $\angle COB$ from both sides, $\angle AOC = \angle BOD$.
5. In the same way, ray OA stands on line CD, so $\angle AOD + \angle BOD = 180^\circ$ and $\angle AOC + \angle COB = 180^\circ$. Subtracting $\angle BOD$ from both sides, $\angle AOD = \angle BOC$.

What this means in practice. Once you know one angle, you know all four. If $\angle AOC = 50^\circ$, then $\angle BOD = 50^\circ$ (vertical angles) and $\angle AOD = \angle BOC = 130^\circ$ (linear pairs).

Proof by contradiction



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A proof by contradiction works in three steps:

1. **Assume the opposite** of what you want to prove.
2. **Reason correctly** from that assumption, using known facts.
3. **Reach a statement that cannot be true**: it clashes with a known fact, with the given data, or with the assumption itself. So the assumption was false, and the original statement is true.

Example: two distinct lines meet in at most one point. Suppose two distinct lines l and m meet at two different points P and Q . Then both l and m pass through P and Q . But exactly one line passes through two distinct points, so l and m are the same line. This contradicts the fact that they are distinct. $\therefore$ Two distinct lines have at most one common point.

The converse of the linear pair theorem (Concept 4) and the triangle facts in Concept 7 are also proved this way. Always write "Suppose..." at the start and "This contradicts..., so our supposition is false" at the end. Both sentences are part of the proof.

6. Parallel Lines and a Transversal

Two lines in the same plane are **parallel** if they do not intersect in either direction. We write $l \parallel m$. The distance between two parallel lines is like the two rails of a straight railway track.

A **transversal** is a line that intersects two or more lines. A transversal cutting two lines makes **eight angles**, four at each intersection.

Naming the eight angles

Picture two horizontal lines, l on top and m on bottom, and a transversal t cutting l at P and m at Q . At P , call the angles

- $\angle 1$ above l on the left of t , $\angle 2$ above l on the right of t
- $\angle 3$ below l on the right of t , $\angle 4$ below l on the left of t

At Q , in the same positions: $\angle 5$ above m on the right of t , $\angle 6$ above m on the left of t , $\angle 7$ below m on the right, $\angle 8$ below m on the left.



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Type of angle or pair	Angles	How to spot it
Exterior angles	$\angle 1, \angle 2, \angle 7, \angle 8$	Outside the strip between l and m
Interior angles	$\angle 3, \angle 4, \angle 5, \angle 6$	Inside the strip between l and m
Corresponding angles (4 pairs)	$\angle 1$ and $\angle 5$, $\angle 2$ and $\angle 6$, $\angle 3$ and $\angle 7$, $\angle 4$ and $\angle 8$	Same position at each crossing
Alternate interior angles (2 pairs)	$\angle 4$ and $\angle 6$, $\angle 3$ and $\angle 5$	Between the lines, on opposite sides of t
Alternate exterior angles (2 pairs)	$\angle 1$ and $\angle 7$, $\angle 2$ and $\angle 8$	Outside the lines, on opposite sides of t
Co-interior angles (2 pairs)	$\angle 4$ and $\angle 5$, $\angle 3$ and $\angle 6$	Between the lines, on the same side of t

Co-interior angles are also called **interior angles**. These names describe positions and apply to any two lines, whether the lines are parallel.

The corresponding angles property

If a transversal intersects two parallel lines, the corresponding angles are equal. Conversely, **if a transversal intersects two lines such that a pair of corresponding angles is equal, then the two lines are parallel.**

In the usual school treatment these two statements are taken as axioms. The corresponding angles axiom and its converse are used to prove other angle facts are proved from them.

Alternate interior angles are equal

Theorem. If a transversal intersects two parallel lines, then the alternate interior angles are equal.

Proof: With $l \parallel m$ and the labels above, $\angle 4$ and $\angle 6$ are corresponding angles, $l \parallel m$. So $\angle 4 = \angle 6$.



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$\angle 5$ (corresponding), so $\angle 3 = \angle 5$.

Co-interior angles are supplementary

Theorem. If a transversal intersects two parallel lines, then each pair of interior angles on the same side of the transversal is supplementary.

Proof: $\angle 4 = \angle 8$ (corresponding angles, $l \parallel m$). At Q, $\angle 5$ and $\angle 8$ form a linear pair (they share the left part of m, and their other arms are opposite parts of t), so $\angle 5 + \angle 8 = 180^\circ$. Replacing $\angle 8$ by $\angle 4$, $\angle 4 + \angle 5 = 180^\circ$. Similarly $\angle 3 + \angle 6 = 180^\circ$.

The converses: tests for parallel lines

Each theorem has a true converse. If a transversal cuts two lines and **any one** of these holds, the lines are parallel:

- a pair of corresponding angles is equal, or
- a pair of alternate interior angles is equal, or
- a pair of co-interior angles adds to 180°

Proof of the alternate-angle test: Suppose $\angle 4 = \angle 8$, a pair of equal corresponding angles, and $l \parallel m$ is an axiom, $l \parallel m$.

Proof of the co-interior test: Suppose $\angle 4 + \angle 5 = 180^\circ$, a pair of equal corresponding angles, and $l \parallel m$ is an axiom, $l \parallel m$.

Transitivity of parallelism

Theorem. Lines which are parallel to the same line are parallel to each other.

Given: Distinct lines a, b and c with $a \parallel b$ and $b \parallel c$.

To prove: $a \parallel c$.

Proof: Draw a transversal t cutting a, b and c in the same (corresponding) position. Let $\angle x$ be the corresponding angle to $\angle y$ on line b, $\angle z = \angle y$ (corresponding angles). So $\angle x = \angle z$. Since $\angle x$ and $\angle z$ are corresponding angles on lines a and c, and they are equal, so $a \parallel c$ (converse of corresponding angles test).

7. Angle Facts of a Triangle

Angle sum property. The sum of the angles in a triangle is 180° .



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Given: A triangle ABC.

To prove: $\angle A + \angle B + \angle C = 180^\circ$.

Construction: Through A, draw a line PQ parallel to BC, with P on the same side of A as B and Q on the same side as C.

Proof:

1. $PQ \parallel BC$ and AB is a transversal, so $\angle PAB = \angle ABC$ (alternate interior angles).
2. $PQ \parallel BC$ and AC is a transversal, so $\angle QAC = \angle ACB$ (alternate interior angles).
3. PAQ is a straight line, so the angles at A on one side of it add to 180° : $\angle PAB + \angle BAC + \angle QAC = 180^\circ$.
4. Substituting from steps 1 and 2: $\angle ABC + \angle BAC + \angle ACB = 180^\circ$. $\therefore \angle A + \angle B + \angle C = 180^\circ$.

Exterior angle property

If side BC of triangle ABC is extended beyond C to a point D, the angle $\angle ACD$ is an **exterior angle** of the triangle. The two angles of the triangle are **interior angles**.

An exterior angle of a triangle equals the sum of the two interior opposite angles.

Proof: $\angle ACD + \angle ACB = 180^\circ$ (linear pair, sum). Comparing, $\angle ACD = \angle A + \angle B$. It follows that the exterior angle is equal to the sum of the two interior opposite angles.

What the angle sum rules out

A triangle cannot have two obtuse angles. If a triangle has two obtuse angles, their sum is greater than 180° . Then $\angle A + \angle B > 180^\circ$, and adding $\angle C > 0^\circ$ to both sides, we get $\angle A + \angle B + \angle C > 180^\circ$, which contradicts the angle sum property. The same argument shows that a triangle cannot have one right and one obtuse angle.

Every triangle has at least two acute angles. If a triangle has one obtuse angle, the other two must each be less than 90° . If a triangle has one right angle, the other two must each be less than 90° .

A triangle cannot have all three angles less than 60° . If all three angles are less than 60° , their sum is less than $60^\circ + 60^\circ + 60^\circ = 180^\circ$, which contradicts the angle sum property. Therefore, at least one angle is 60° or more. In the same way, it can be shown that at least one angle is 60° or less. If all three angles are less than 60° , their sum is less than 180° , which contradicts the angle sum property.



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Classifying triangles by angles. A triangle is **acute-angled** (all angles acute), **right-angled** (one angle 90°) or **obtuse-angled** (one angle obtuse). In a right-angled triangle the two acute angles are complementary.



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Formula and Theorem Sheet

Result	Statement	How it is justified
Linear pair theorem	Ray OC stands on line AB: $\angle AOC + \angle COB = 180^\circ$	The two angles make up a straight angle
Converse of linear pair	Adjacent angles add to 180° : the non-common arms form a line	Proof by contradiction
Angles around a point	Sum = 360°	Two straight angles
Vertically opposite angles	Lines AB, CD meet at O: $\angle AOC = \angle BOD$, $\angle AOD = \angle BOC$	Two linear pairs sharing an angle
Corresponding angles	$l \parallel m$: each pair of corresponding angles are equal	
Alternate interior angles	$l \parallel m$: each pair of alternate interior angles are equal conversely	
Co-interior angles	$l \parallel m$: each pair of co-interior angles add to 180° conversely	
Transitivity	$a \parallel b$ and $b \parallel c$ gives $a \parallel c$	
Angle sum of a triangle	$\angle A + \angle B + \angle C = 180^\circ$	
Exterior angle	Exterior angle = sum of two interior opposite angles	
Triangle restrictions	At least two acute angles; at most one obtuse angle; no angle $> 180^\circ$	



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Important Definitions

- **Angle:** the figure formed by two rays with a common starting point; the rays are the arms and the common point is the vertex.
- **Complementary angles:** two angles whose sum is 90° .
- **Supplementary angles:** two angles whose sum is 180° .
- **Adjacent angles:** two angles with a common vertex and a common arm, whose non-common arms lie on opposite sides of the common arm.
- **Linear pair:** two adjacent angles whose non-common arms are opposite rays.
- **Vertically opposite angles:** the pairs of non-adjacent angles formed at the point where two lines intersect.
- **Perpendicular lines:** two lines that intersect at a right angle.
- **Parallel lines:** two lines in the same plane that do not intersect, however far they are extended.
- **Transversal:** a line that intersects two or more lines.
- **Corresponding angles:** angles in the same position relative to two lines and a transversal.
- **Alternate interior angles:** a pair of angles on opposite sides of a transversal, not adjacent to each other.
- **Co-interior angles:** a pair of angles between two lines and a transversal.



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Solved Examples

Example 1: An angle and its complement

Question: An angle is 24° more than its complement.

Solution: Let the angle be x . Its complement is $90^\circ - x$.

$$x = (90^\circ - x) + 24^\circ$$

$$2x = 114^\circ$$

$$x = 57^\circ$$

Check: the complement is $90^\circ - 57^\circ = 33^\circ$.

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Example 2: Supplement four times the complement

Question: The supplement of an angle is four times its complement. Find the angle.

Solution: Let the angle be x . Then

$$180^\circ - x = 4(90^\circ - x)$$

$$180^\circ - x = 360^\circ - 4x$$

$$3x = 180^\circ$$

$$x = 60^\circ$$

Check: supplement = 120° , complement = 30° , and $4 \times 30^\circ = 120^\circ$. $\therefore$ The angle is **60°** .

Example 3: A linear pair with algebra

Question: Ray OC stands on line AB. $\angle AOC = (3x + 10)^\circ$ and $\angle COB = (2x - 5)^\circ$. Find x and both angles.

Solution: $\angle AOC$ and $\angle COB$ form a linear pair

$$(3x + 10) + (2x - 5) = 180$$

$$5x + 5 = 180$$

$$x = 35$$

$$\angle AOC = 3(35) + 10 = \mathbf{115^\circ} \text{ and } \angle COB = 2(35) - 5 = \mathbf{65^\circ}$$

Example 4: Using the converse to test for a line

Question: Points A and B lie on opposite sides of line OC. (a) If $\angle AOC = 108^\circ$ and $\angle COB = 72^\circ$, is AOB a straight line? (b) What if $\angle AOC = 110^\circ$ and $\angle COB = 68^\circ$?

Solution: $\angle AOC$ and $\angle COB$ are adjacent (conform to the definition of a linear pair).
(a) $108^\circ + 72^\circ = 180^\circ$. By the converse of the linear pair theorem, AOB is a straight line.
(b) $110^\circ + 68^\circ = 178^\circ \neq 180^\circ$. So AOB is not a straight line.



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Example 5: Vertically opposite angles and a reflex angle

Question: Lines AB and CD intersect at O. Ray OE lies inside $\angle BOC$. $\angle AOC + \angle BOE = 75^\circ$ and $\angle BOD = 45^\circ$. Find $\angle BOE$ and reflex $\angle COE$.

Solution:

1. $\angle AOC = \angle BOD = 45^\circ$ (vertically opposite angles).
2. $\angle BOE = 75^\circ - \angle AOC = 75^\circ - 45^\circ = 30^\circ$.
3. Rays OC and OE stand on line AB on the same side, so $\angle AOC + \angle COE + \angle EOB = 180^\circ$. So $\angle COE = 180^\circ - 45^\circ - 30^\circ = 105^\circ$.
4. Reflex $\angle COE = 360^\circ - 105^\circ = 255^\circ$.

Example 6: All four angles at a crossing

Question: Two lines intersect. One angle formed is $(2x + 15)^\circ$ and the angle vertically opposite to it is $(3x - 20)^\circ$. Find all four angles.

Solution: Vertically opposite angles are equal.

$$2x + 15 = 3x - 20, \text{ so } x = 35.$$

The angle is $2(35) + 15 = 85^\circ$, and its opposite angle is $3(35) - 20 = 95^\circ$.
The angle vertically opposite to 85° is 95° and the angle vertically opposite to 95° is 85° .

$\therefore$ The four angles are **$85^\circ, 95^\circ, 85^\circ$ and 95°** .

Example 7: All eight angles from one transversal

Question: Lines $l \parallel m$ are cut by transversal n . $\angle 1 = 65^\circ$. Find the other seven angles.

Solution:



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Angle	Value	Reason
$\angle 2$	115°	Linear pair with $\angle 1$
$\angle 3$	65°	Vertically opposite to $\angle 1$
$\angle 4$	115°	Vertically opposite to $\angle 2$
$\angle 5$	65°	Corresponding to $\angle 1$ ($l \parallel m$)
$\angle 6$	115°	Corresponding to $\angle 2$, or alternate to $\angle 4$
$\angle 7$	65°	Corresponding to $\angle 3$
$\angle 8$	115°	Corresponding to $\angle 4$

Example 8: Co-interior angles with parallel lines

Question: Lines $l \parallel m$ are cut by a transversal. The co-interior angles are $(2x + 20)^\circ$ and $(3x - 40)^\circ$. Find x .

Solution: Co-interior angles between parallel lines are supplementary.

$$(2x + 20) + (3x - 40) = 180$$

$$5x - 20 = 180$$

$$x = 40$$

The angles are $2(40) + 20 = 100^\circ$ and $3(40) - 40 = 80^\circ$.

Example 9: Are the lines parallel?

Question: A transversal cuts lines p and q . The alternate interior angles are 58° and 58° . (Are the lines parallel?)

Solution:

(a) Alternate interior angles are equal, so $p \parallel q$.

(b) $105^\circ + 70^\circ = 175^\circ \neq 180^\circ$. So p is not parallel to q .
transversal where these two angles lie, be



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Example 10: The angle at a bend between parallel lines

Question: $AB \parallel CD$. Point E lies between the two lines. A and C are on the same side (the right side) of B and D, and E is also to the right of B and D. $\angle ABE = 40^\circ$ and $\angle CDE = 35^\circ$. Find $\angle BED$.

Solution:

1. **Construction:** through E, draw line EF parallel to AB, with F on the left side of E. Since $AB \parallel CD$, by transitivity $EF \parallel CD$ too.
2. $EF \parallel AB$ and BE is a transversal. $\angle BEF$ and $\angle ABE$ are alternate interior angles, so $\angle BEF = \angle ABE = 40^\circ$.
3. $EF \parallel CD$ and DE is a transversal. $\angle FED$ and $\angle CDE$ are alternate interior angles, so $\angle FED = \angle CDE = 35^\circ$.
4. Ray EF lies inside $\angle BED$, so $\angle BED = \angle BEF + \angle FED = 40^\circ + 35^\circ = 75^\circ$.

The general result for this arrangement: $\angle BED = \angle ABE + \angle CDE$

Example 11: Triangle angles in a triangle

Question: (a) The angles of a triangle are $3k$, $5k$, $7k$. Find all three angles of the triangle.
(b) An exterior angle of a triangle is 110° and the interior opposite angles are 44° and 66° . Find all three angles of the triangle.

Solution:

(a) Let the angles be $3k$, $5k$, $7k$. Then $15k = 180^\circ$. So $k = 12^\circ$. The angles are 36° , 60° , and 84° . All three are acute, so the triangle is **acute-angled**.

(b) Let the interior opposite angles be $2k$ and $3k$. Then $2k + 3k = 110^\circ$. So $k = 22^\circ$. These angles are 44° and 66° . The third angle is $180^\circ - 110^\circ = 70^\circ$. The angles are 44° , 66° , and 70° .

Example 12: Bisectors of co-interior angles

Question: $AB \parallel CD$, and a transversal cuts them at B and D. The bisectors of $\angle BPQ$ and $\angle DQP$ are drawn. Prove that these two bisectors are parallel.

Solution:

1. $\angle BPQ$ and $\angle DQP$ are interior angles on the same side of the transversal. So $\angle BPQ + \angle DQP = 180^\circ$.



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2. PR bisects $\angle BPQ$, so $\angle RPQ = \frac{1}{2}\angle BPQ$. QR bisects $\angle DQP$, so $\angle RQP = \frac{1}{2}\angle DQP$.
3. Adding: $\angle RPQ + \angle RQP = \frac{1}{2}(\angle BPQ + \angle DQP) = \frac{1}{2} \times 180^\circ = 90^\circ$.
4. In triangle PQR, $\angle PRQ = 180^\circ - (\angle RPQ + \angle RQP) = 180^\circ - 90^\circ = 90^\circ$. Hence proved.

Competency-Based Questions (with answers)

1. Case-based: The level crossing

A straight road crosses a straight railway line. The two rails run east to west and are parallel: the first rail is the northern one, the second rail the southern one. On the north side of the first rail, the road makes an angle of 70° with it, measured on the east side of the road.

(a) What angle does the road make with the second rail in the same position (north of the rail, east of the road)? The road is a transversal line. So, the corresponding angles are equal. So the angle is 70° .

(b) Find the angle on the north side of the second rail, which is a linear pair with the 70° angle: $180^\circ - 70^\circ = 110^\circ$.

2. Case-based: A pair of scissors

The two blades of a pair of scissors are straight lines. They are opened so that the angle between them is 142° at the vertex. Find the angle between the edges.

(a) What is the angle between the cutting edges? The two blades lie along two straight lines crossing at O, so the angle between the cutting edges is a linear pair with the angle between the handles. It is 38° .

(b) Find the angle between one handle and the other handle. The angle between the handles is a linear pair with the 38° angle: $180^\circ - 38^\circ = 142^\circ$.

(c) The handles are opened further until the angle between them is 90° . What is the relation between the two blades? The blades are then perpendicular.



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3. Assertion-Reason

Options for Questions 3 to 5: (a) A and R true, R explains A; (b) A and R true, R does not explain A; (c) A true, R false; (d) A false, R true.

Assertion (A): Two angles measuring 130° and 50° always form a linear pair. **Reason (R):** The two angles of a linear pair are supplementary.

Answer: (d) A is false, but R is true. 130° and 50° are supplementary, but a linear pair also needs the angles to be adjacent with their non-common arms forming a line. Two separate angles with these measures need not even share a vertex.

4. Assertion-Reason

Assertion (A): If two lines intersect and one of the angles formed is 90° , then each of the other three angles is 90° . **Reason (R):** Vertically opposite angles are equal, and angles of a linear pair add to 180° .

Answer: (a) Both A and R are true, and R explains A. If one angle is 90° , each neighbour is $180^\circ - 90^\circ = 90^\circ$; each neighbour is $180^\circ - 90^\circ = 90^\circ$.

5. Assertion-Reason

Assertion (A): A triangle cannot have two exterior angles each greater than each of its interior angles.

Answer: (b) Both A and R are true, but R is not the reason for A. The angle sum property: two angles each more than 90° is a true fact about exterior angles, but it is not the reason for A.

6. Error analysis: Riya's triangle

Riya says she has drawn a triangle whose interior angles are 55° , 50° , and 50° . She claims that a triangle with all angles less than 60° is possible because the sum of the angles is 155° .

(a) Find the sum of her three measured angles.

(b) Explain why her claim must be wrong. If the interior angles were less than 60° , their sum would be less than 180° . The sum of the interior angles of a triangle must be 180° or more.



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7. Reasoning: Light between two parallel mirrors

Two plane mirrors are placed parallel to each other, facing each other. A ray of light PQ strikes the first mirror at Q, reflects along QR to strike the second mirror at R, and reflects again along RS. At each mirror, the angle of incidence equals the angle of reflection, both measured from the normal (the line perpendicular to the mirror at that point).

(a) Why are the normals at Q and R parallel? Each normal is perpendicular to its own mirror. A line perpendicular to one of two parallel lines is perpendicular to the other too (corresponding angles, 90° each). So the second mirror makes equal corresponding angles of 90° with both normals, and the normals are parallel.

(b) Show that $RS \parallel PQ$. Let the normals be QM and RN. With QR as transversal to the parallel normals, $\angle MQR = \angle NRQ$ (alternate angles). Incidence equals reflection at each mirror, so $\angle PQR = 2\angle MQR$ and $\angle QRS = 2\angle NRQ$. Hence $\angle PQR = \angle QRS$. These are equal alternate angles made by transversal QR with PQ and RS, so $PQ \parallel RS$.

8. Competency MCQ: Which angle

Question: Which set of angles can be the angles of a triangle?
(iii) $35^\circ, 65^\circ, 80^\circ$ (iv) $45^\circ, 45^\circ, 45^\circ$

Answer: (iii). Its sum is $35 + 65 + 80 = 180$.
(ii) contains a negative angle and has two angles are below 60° , which is impossible.

Important Questions for

1-Mark Questions

1. How many end points does a ray have?
2. Find the reflex angle of 142° . $360^\circ - 142^\circ$
3. Find the supplement of the complement of 125° .
4. Two lines intersect and one of the angles is 47° , find the other three angles.
5. If $a \parallel b$ and $b \parallel c$, what is the relation between a and c (are they parallel to each other).



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2-Mark Questions

- Two supplementary angles differ by 34° . Find the angles.** $x + y = 180^\circ$ and $x - y = 34^\circ$.
Adding: $2x = 214^\circ$, so $x = 107^\circ$ and $y = 73^\circ$.
- Prove that the bisectors of the angles of a linear pair are perpendicular.** Let ray OC stand on line AB, with $\angle AOC = x$ and $\angle COB = y$, so $x + y = 180^\circ$. Let OP bisect $\angle AOC$ and OQ bisect $\angle COB$. Then $\angle POC = x/2$ and $\angle COQ = y/2$, and OC lies between OP and OQ. So $\angle POQ = x/2 + y/2 = (x + y)/2 = 90^\circ$. Hence $OP \perp OQ$.
- Lines $l \parallel m$ are cut by a transversal. One of the interior angles is 4 times its co-interior partner. Find both.** $x + 4x = 180^\circ$, so $x = 36^\circ$. The angles are 36° and 144° .
- Can a triangle have two right angles? Justify.** No. Two right angles already add to 180° . The third angle must be more than 0° , so the sum would exceed 180° , contradicting the angle sum property.

3-Mark Questions

- Two lines intersect so that the sum of two adjacent angles is 180° .** Vertically opposite angles are equal. One angle forms a linear pair with a 75° angle. Find the other angles.
Let the angles be x and y . $x + y = 180^\circ$ and $x = y$.
 $2x = 180^\circ$, so $x = 90^\circ$ and $y = 90^\circ$.
The other angles are 90° and 90° .
- Lines PQ and RS intersect at O. $\angle POR = 5k^\circ$ and $\angle ROQ = 7k^\circ$.** Find the angles.
Form a linear pair: $5k + 7k = 180^\circ$, $k = 15$.
 $\angle POR = 75^\circ$ and $\angle ROQ = 105^\circ$.
Other angles: $\angle SOP = 105^\circ$ and $\angle ROQ = 105^\circ$.
- In triangle ABC, side BC is extended to D. $\angle A = 72^\circ$ and $\angle B = 56^\circ$.** Find $\angle ACD$.
Exterior angle property: $\angle A + \angle B = \angle ACD$.
 $72^\circ + 56^\circ = \angle ACD$.
 $128^\circ = \angle ACD$. Check: $72 + 56 + 128 = 256 \neq 180$.
Wait, the sum of angles in a triangle is 180° .
 $72 + 56 + \angle C = 180$.
 $128 + \angle C = 180$.
 $\angle C = 52^\circ$.
Exterior angle $\angle ACD = 180^\circ - \angle C = 180^\circ - 52^\circ = 128^\circ$.
Check: $72 + 56 + 52 = 180$.
- A transversal cuts two lines so that a pair of alternate angles are equal.** Prove that the lines are parallel.
Let the transversal be PQ and the lines be AB and CD.
Let $\angle 4$ (at P) and $\angle 6$ (at Q) be alternate angles.
If $\angle 4 = \angle 6$, then AB $\parallel$ CD (Alternate angles axiom).



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5-Mark Questions

- 1. Prove that the sum of the angles of a triangle is 180° . Hence prove that an exterior angle of a triangle equals the sum of the two interior opposite angles.** Let ABC be a triangle. Through A draw $PQ \parallel BC$, with P on the side of B and Q on the side of C. With AB as transversal, $\angle PAB = \angle ABC$ (alternate interior angles). With AC as transversal, $\angle QAC = \angle ACB$ (alternate interior angles). PAQ is a line, so $\angle PAB + \angle BAC + \angle QAC = 180^\circ$. Substituting, $\angle ABC + \angle BAC + \angle ACB = 180^\circ$. For the second part, extend BC to D. $\angle ACD + \angle ACB = 180^\circ$ (linear pair). Also $\angle A + \angle B + \angle ACB = 180^\circ$. So $\angle ACD = \angle A + \angle B$.
- 2. In triangle PQR, side QR is extended to S. The bisectors of $\angle PQR$ and $\angle PRS$ meet at T. Prove that $\angle QTR = \frac{1}{2}\angle QPR$.** In triangle PQR, $\angle PRS$ is an exterior angle, so $\angle PRS = \angle QPR + \angle PQR$. Halving: $\frac{1}{2}\angle PRS = \frac{1}{2}\angle QPR + \frac{1}{2}\angle PQR$, that is, $\angle TRS = \frac{1}{2}\angle QPR + \angle TQR \dots (1)$, since RT and QT are the bisectors. In triangle TQR, $\angle TRS$ is an exterior angle (QRS is a line), so $\angle TRS = \angle TQR + \angle QTR \dots (2)$. From (1) and (2), $\angle TQR + \angle QTR = \frac{1}{2}\angle QPR + \angle TQR$, so $\angle QTR = \frac{1}{2}\angle QPR$. Hence proved.

Common Mistakes and Explanations

- 1. Calling any supplementary pair a linear pair.** Only two rays with a common vertex and common arms forming a line. Supplementary angles can be formed by two different pairs of rays.
- 2. Using parallel-line equalities for lines that are not parallel.** Alternate angles are equal only when the lines are parallel. You cannot assume it from how a sketch looks.
- 3. Mixing up alternate and co-interior angles.** Alternate angles are on opposite sides of the transversal and alternate lines. Co-interior angles are on the same side of the transversal and add to 180° . Check the side before using.
- 4. Writing a theorem where its converse is true.** To prove lines parallel, use "angle-angle" or "angle-side-angle". To prove angles equal, use "parallel lines".
- 5. Missing reasons in proofs.** Every step must have a reason (e.g., alternate angles, alternate interior angles, linear pair, etc.).
- 6. Forgetting the reflex angle.** When the angle is greater than 180° , subtract from 360° . Giving the smaller angle is incorrect.
- 7. Stopping after finding x.** If the question asks for an expression, give it. If it asks for a value, check the sum (180° or 360°).



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8. **Skipping the construction in the angle sum proof.** Write "Through A, draw $PQ \parallel BC$ " as a separate line labelled Construction. Without the parallel line the alternate angles have nothing to stand on.
9. **A contradiction proof without the assumption stated.** Begin with "Suppose, if possible, ..." and end with "This contradicts ..., so our supposition is false." Both sentences are part of the proof.
10. **Trusting the sketch.** A line that looks straight or two lines that look parallel may not be. Decide from the given angle measures, as in Example 4, where 178° looks straight but is not.

Quick Revision Points

- Angle: two rays with a common starting point (vertex); the vertex is the middle letter of the name.
- Right angle 90° ; straight angle 180° = two right angles.
- Acute: 0° to 90° ; obtuse: 90° to 180° ; reflex: 180° to 360° .
- Complementary: sum 90° . Supplementary: sum 180° .
- Adjacent angles: common vertex, common arm.
- Linear pair: adjacent angles whose other arms form a straight line.
- Converse: adjacent angles adding to 180° imply collinearity.
- Angles on one side of a line at a point: sum 180° .
- Two intersecting lines: vertically opposite angles are equal.
- Proof by contradiction: suppose the opposite of what you want to prove.
- Parallel lines: in one plane, never meet. Transversal makes 8 angles.
- If $l \parallel m$: corresponding angles equal, alternate angles equal, co-interior angles sum 180° .
- Any one of these conditions holding means lines are parallel.
- Transitivity: $a \parallel b$ and $b \parallel c$ give $a \parallel c$.
- Angle sum of a triangle is 180° ; proof uses parallel lines.



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- Exterior angle = sum of the two interior opposite angles; it is larger than each of them.
- A triangle has at least two acute angles and cannot have two obtuse angles or two right angles.
- A triangle cannot have all three angles below 60° or all three above 60° .

Weightage and Exam Pattern

Class 9 has no board exam. Lines and Angles is assessed in school exams: periodic tests, the half-yearly exam and the annual exam. In the CBSE Class IX Mathematics course structure for 2026-27, the chapter is part of **Unit IV, Geometry, which carries 25 marks** out of the 80-mark theory paper and is allotted 69 teaching periods. The unit has five chapters: Introduction to Euclid's Geometry, Lines and Angles, Triangles (Congruence Theorems), 4-gons (Quadrilaterals) and Circles. The course structure does not split the 25 marks between these chapters. Internal assessment carries a separate 20 marks.

Unit
I. Number System
II. Algebra
III. Coordinate Geometry
IV. Geometry
V. Mensuration
VI. Statistics and Probability

The CBSE question paper design weights understanding, 24% applying, and 22% at definitions and classification, finding unknown lines and the contradiction arguments about

These angle facts return in the Class 10 board begin with steps such as "alternate angles



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