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CHAPTER NOTES

Triangles Congruence Theorems Class 9 Notes | CBSE Maths

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Your teacher for Triangles Congruen...



Hi, I am **Ira**. I teach this syllabus all day, so **Triangles Congruence Theorems** 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 Triangles Congruence Theorems simply

What can the board exam ask?

Most important formulas

Quiz me on this chapter

Ask Ira anything...



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Triangles Congruence Theorems Class 9 Notes

| CBSE Maths

Triangles - Congruence Theorems is a chapter of CBSE Class 9 Maths (2026-27 syllabus), part of the Geometry unit. It starts with a practical fact: a triangle made of three rods cannot change its shape, while a four-sided frame can. From there it builds the idea of congruent triangles, the correspondence between their vertices, sides and angles, and the five congruence conditions SAS, SSS, ASA, AAS and RHS.

The chapter then uses these conditions to prove the basic properties of isosceles triangles, introduces propositions and their converses, and explains why SSA fails in general and when it does work. In school exams it is tested through congruence proofs, CPCT-based results, angle calculations in isosceles triangles and reasoning questions on converses. The proof-writing habits built here carry straight into the chapters on quadrilaterals and circles, and into Class 10 geometry.

Quick Answer - Triangles Congruence

A triangle is **rigid**: fix its three sides and angles, and when a matching of vertices makes all sides equal, it means $A \leftrightarrow P$, $B \leftrightarrow Q$, $C \leftrightarrow R$. **SAS** is taken as a rule. **RHS**. Once triangles are congruent, the corresponding opposite equal sides are equal, and corresponding angles are equal in general, but it works when the angle is included, as long as the other given side.



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All Key Formulas at a Glance

Rule or Result	What must be equal	Remember
SAS (axiom)	Two sides and the angle included between them	The angle must sit between the two sides
SSS	All three sides	This is triangle rigidity written as a rule
ASA	Two angles and the side joining their vertices	Proved from SAS by contradiction
AAS	Two angles and a side that is not between them	Third angles are then equal (angle sum 180°), so it becomes ASA
RHS	Right angle, hypotenuse and one other side	
CPCT	Corresponding parts of congruent triangles are equal	
Isosceles theorem	$AB = AC \Rightarrow \angle B = \angle C$	
Converse	$\angle B = \angle C \Rightarrow AB = AC$	
Equilateral triangle	Each angle = $180^\circ \div 3$	
AAA and SSA	Do not guarantee congruence in general	



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Key Concepts

1. Why Triangles Are Rigid

Take three straight rods and join their ends with loose pins, so each joint can turn freely. The frame will not squash. Four rods joined the same way make a square that you can push into a slanted rhombus, with the same side lengths.

This is the property called **rigidity**. A triangle is **rigid**: once the lengths of its three sides are fixed, its three angles are fixed too, and so its whole shape is fixed. A quadrilateral (a 4-gon) is not rigid: the same four side lengths can make many different shapes with different angles.

Frame	Sides fixed?	Can the shape change?	Why
Triangle (3 rods)	Yes		Three lengths allow only one shape.
Quadrilateral (4 rods)	Yes		
Quadrilateral with one diagonal rod	Yes		

Uses of triangle rigidity. Engineers use triangles to support heavy loads.

- **Bridges, roof trusses and towers:** the triangles do not sag or sway in wind.
- **Bicycle frames:** two triangles keep the frame rigid.
- **Gates and shelves:** a diagonal plank or wire turns a rectangle into a parallelogram.

Why triangles give strength and stability is that they cannot change the angles. In a triangle, changing the side lengths or the rods resist that strongly. So **three side lengths** fix the shape.



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2. Congruence and Correspondence

Two figures are **congruent** if one can be placed exactly over the other so that they cover each other completely. Congruent figures have the same shape and the same size. Two coins of the same denomination are congruent. A photo and its enlargement have the same shape but different sizes, so they are not congruent.

For triangles, placing one over the other means matching each vertex of one with a vertex of the other. This matching is called a **correspondence**.

Definition. Two triangles are congruent if, under some correspondence of their vertices, all three pairs of corresponding sides are equal and all three pairs of corresponding angles are equal.

We write $\triangle ABC \cong \triangle PQR$. The order of letters carries the correspondence:

- $A \leftrightarrow P, B \leftrightarrow Q, C \leftrightarrow R$ (first letter matches first letter, and so on).
- Sides: $AB = PQ, BC = QR, CA = RP$.
- Angles: $\angle A = \angle P, \angle B = \angle Q, \angle C = \angle R$.

So one congruence statement packs **six** equalities. For example, for $\triangle ABC \cong \triangle PQR$, the statement $\triangle ABC \cong \triangle QPR$ is generally false.

How to find the correct order. Match the vertices with equal sides. Solved Example 2 shows how to do this.

CPCT. Once two triangles are proved congruent, we can say that their corresponding parts are equal. We cite this as **CPCT: corresponding parts of congruent triangles are equal**. Proving congruence from three parts gives you the CPCT.

Step
1. Name the two triangles
2. List three equal parts, each with a reason
3. State the rule and the correspondence
4. Use CPCT for what you need



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3. The SAS Congruence Axiom

Three well-chosen parts are enough to fix a triangle. The most basic rule is SAS.

SAS congruence axiom. If two sides and the **included angle** of one triangle are equal to two sides and the included angle of another triangle, then the two triangles are congruent.

The **included angle** of two sides is the angle formed between them at their common vertex. In $\triangle ABC$:

Pair of sides	Included angle
AB and AC	$\angle A$
AB and BC	$\angle B$
BC and CA	

Why it is an axiom. SAS is accepted as true without proof. It is one of the basic postulates. You can check it by constructing a triangle with two sides and an included angle. For example, draw a line segment AB of length 5 cm. At point B, draw a ray making an angle of 60° with AB. Along this ray, mark 7 cm and draw a line segment BC. Now, draw a triangle ABC. This is the only triangle that can be drawn with these conditions. SAS is the starting rule, and every other congruence rule is based on it.

Worked illustration. In $\triangle ABC$ and $\triangle DEF$, $AB = DE$, $BC = EF$ and $\angle B = \angle E$. The angle 65° lies between AB and BC in $\triangle ABC$ and between DE and EF in $\triangle DEF$. So $\triangle ABC \cong \triangle DEF$ by SAS, and by CPCT, $\angle A = \angle D$.

A trap. If $AB = DE$, $BC = EF$ and $\angle A = \angle D$, $\triangle ABC$ is not necessarily congruent to $\triangle DEF$. For example, if $\angle A = \angle D = 30^\circ$, $AB = DE = 5$ cm, $BC = EF = 4$ cm, then $\triangle ABC$ and $\triangle DEF$ are not congruent. This is the SSA pattern, which is not a congruence rule.

4. The SSS Congruence Condition

SSS congruence. If the three sides of one triangle are equal to the three sides of another triangle, then the two triangles are congruent.

SSS is the rigidity of a triangle written in the language of congruence. It means that if the three lengths can be joined into only one shape of triangle, then the two triangles are congruent. The three lengths must fit over each other.

Proof of SSS from SAS (outline). Let $AB = DE$, $BC = EF$ and $AC = DF$. We have to prove that $\triangle ABC \cong \triangle DEF$.



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1. On the side of BC opposite to A, draw a ray from B making $\angle CBX = \angle Q$, and mark D on it with $BD = QP$.
2. In $\triangle DBC$ and $\triangle PQR$: $BD = QP$, $\angle DBC = \angle PQR$, $BC = QR$. So $\triangle DBC \cong \triangle PQR$ (SAS). By CPCT, $DC = PR$, and $\angle BDC = \angle P$.
3. Now $DB = PQ = AB$ and $DC = PR = AC$. Join AD.
4. In $\triangle ABD$, $AB = DB$, so $\angle BAD = \angle BDA$ (angles opposite equal sides). In $\triangle ACD$, $AC = DC$, so $\angle CAD = \angle CDA$.
5. Adding, $\angle BAC = \angle BDC$. This step assumes AD crosses BC between B and C. If AD passes through B or C, use only the other isosceles triangle; if AD meets BC extended, subtract the angles instead of adding.
6. In $\triangle ABC$ and $\triangle DBC$: $AB = DB$, $\angle BAC = \angle BDC$, $AC = DC$. So $\triangle ABC \cong \triangle DBC$ (SAS).
7. Since $\triangle DBC \cong \triangle PQR$, we get $\triangle ABC \cong \triangle PQR$.

Step 4 uses the isosceles triangle theorem from concept 7. That theorem is proved from SAS alone, so there is no circular reasoning.

Typical SSS setting: a kite. In quadrilateral ABCD, diagonal AC is common to $\triangle ABC$ and $\triangle ADC$. So $\triangle ABC \cong \triangle ADC$ (SSS). So diagonal AC bisects $\angle A$ (and also $\angle C$).

5. ASA and AAS Conditions

ASA congruence. If two angles and the included side of one triangle are equal to two angles and the included side of another triangle, then the two triangles are congruent. The included side is the side joining their vertices. In symbols, if $\angle A = \angle D$, $AB = DE$, and $\angle B = \angle E$, then $\triangle ABC \cong \triangle DEF$.

Proof of ASA from SAS. Given $\angle B = \angle E$, $AB = DE$, and $\angle A = \angle D$.

1. **Case $AB = DE$.** Then $AB = DE$, $\angle B = \angle E$, and $\angle A = \angle D$. So $\triangle ABC \cong \triangle DEF$ (ASA).
2. **Case $AB > DE$.** Mark P on BA with $PB = DE$. Then $\angle B = \angle E$, $PB = DE$, and $\angle A = \angle D$. So $\triangle PBC \cong \triangle DEF$ (ASA), and by CPCT $\angle PCB = \angle F$.
3. But $\angle DFE = \angle ACB$ (given). So $\angle PCB = \angle ACB$. But $\angle PCB$ is inside $\angle ACB$ and $\angle PCB$ is smaller than $\angle ACB$. This is a contradiction.
4. **Case $AB < DE$** is ruled out the same way.
5. Only $AB = DE$ is possible, and case 1 gives the result.

This is a **proof by contradiction**: assume the opposite of what you want to prove, and conclude the original claim.



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AAS congruence. If two angles and a **non-included side** of one triangle are equal to the corresponding angles and side of another, the triangles are congruent.

Why AAS works. Suppose $\angle A = \angle D$, $\angle B = \angle E$ and $BC = EF$. The angle sum of a triangle is 180° , so $\angle C = 180^\circ - \angle A - \angle B = 180^\circ - \angle D - \angle E = \angle F$.

Now $\angle B = \angle E$, $BC = EF$, $\angle C = \angle F$, which is ASA. So AAS is ASA in disguise.

Worked illustration. In $\triangle PQR$ and $\triangle XYZ$, $\angle P = \angle X = 50^\circ$, $\angle Q = \angle Y = 70^\circ$ and $QR = YZ = 8$ cm. QR is opposite $\angle P$ and YZ is opposite $\angle X$, and QR is not between $\angle P$ and $\angle Q$. So $\triangle PQR \cong \triangle XYZ$ (AAS). Also $\angle R = \angle Z = 180^\circ - 50^\circ - 70^\circ = 60^\circ$.

Why AAA fails. Three equal angles fix the shape only. Draw an equilateral triangle of side 3 cm and another of side 6 cm. Both have angles $60^\circ, 60^\circ, 60^\circ$, but one is twice as large. So AAA is not a congruence condition: at least one side must be equal.

6. The RHS Condition for Right Triangles

In a right-angled triangle, the side opposite the right angle is called the hypotenuse. (The other two sides are called the legs.)

RHS congruence. If in two right-angled triangles the hypotenuse and one side are equal to the hypotenuse and one side of another, the triangles are congruent. (H = hypotenuse, S = side.)

Proof of RHS. Let $\triangle ABC$ be right-angled at B and $\triangle DEF$ be right-angled at E . Suppose $AB = DE$.

1. Extend CB beyond B to a point G with $BC = BG$.
2. $\angle ABG = 90^\circ$, since it forms a linear pair with $\angle ABC = 90^\circ$. Also $\angle DEF = 90^\circ$, $BC = EF$. So $\triangle ABG \cong \triangle DEF$ (RHS).
3. So $AG = DF = AC$. In $\triangle AGC$, $AG = AC$, hence $\angle G = \angle C$.
4. In $\triangle ABG$ and $\triangle ABC$: $\angle AGB = \angle ACB$, $\angle BAG = \angle CAB$ (common), $AB = AB$ (common). So $\triangle ABG \cong \triangle ABC$ (AAS).
5. So $\triangle ABC \cong \triangle ABG \cong \triangle DEF$.

A quicker check using Pythagoras. In the right-angled triangles, the right-hand sides are equal, so $BC = EF$.



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Worked illustration. $\triangle ABC$ is right-angled at B and $\triangle PQR$ is right-angled at Q. $AC = PR = 13$ cm, $AB = PQ = 5$ cm. By RHS, $\triangle ABC \cong \triangle PQR$. If $BC = 12$ cm (check: $5^2 + 12^2 = 25 + 144 = 169 = 13^2$), then $QR = 12$ cm by CPCT.

7. Isosceles Triangle Theorems

A triangle with two equal sides is **isosceles**. The equal sides are the legs, the third side is the base, the angles at the ends of the base are the **base angles**, and the angle between the equal sides is the **vertex angle**.

Theorem 1. Angles opposite to equal sides of a triangle are equal.

Given: $\triangle ABC$ with $AB = AC$. **To prove:** $\angle B = \angle C$.

Proof 1 (with a bisector). Draw AD, the bisector of $\angle A$, meeting BC at D. In $\triangle BAD$ and $\triangle CAD$: $AB = AC$ (given), $\angle BAD = \angle CAD$ (AD bisects $\angle A$), $AD = AD$ (common). So $\triangle BAD \cong \triangle CAD$ (SAS), and $\angle ABD = \angle ACD$ (CPCT), that is $\angle B = \angle C$.

Proof 2 (no construction). Compare $\triangle ABC$ and $\triangle ACB$. $\angle A = \angle A$, $AC = AB$. So $\triangle ABC \cong \triangle ACB$ (SAS). At C in the second: $\angle B = \angle C$.

Theorem 2 (converse). Sides opposite to equal angles of a triangle are equal.

Given: $\triangle ABC$ with $\angle B = \angle C$. **To prove:** $AB = AC$.

Proof. Compare $\triangle ABC$ and $\triangle ACB$. $\angle B = \angle C$ (given), $\angle A = \angle A$ (common). By CPCT, $AB = AC$. (Another route: draw the bisector of $\angle A$ and use Theorem 1.)

Results that follow.

- In an isosceles triangle with $AB = AC$, the altitude from A to BC (which is also the median, $AD = DC$, from Proof 1 by CPCT) and is perpendicular to BC, so each is 90°).
- Each angle of an equilateral triangle is 60° . So all three angles are equal, and 3 angles of a triangle are equal.
- A triangle with all three angles equal is equilateral.

Angle calculations. If $AB = AC$ and the vertex angle is x° , then each base angle is $x/2$. If a base angle is y , the vertex angle is $180 - 2y$.



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Given	Base angles	Vertex angle
$\angle A = 40^\circ, AB = AC$	$(180^\circ - 40^\circ)/2 = 70^\circ$ each	40°
$\angle B = 65^\circ, AB = AC$	65° each	$180^\circ - 130^\circ = 50^\circ$
$\angle A = 90^\circ, AB = AC$	45° each	90°
Equilateral	60°	60°

8. Propositions, Converses, SSA and Diagram Accuracy

Proposition. A proposition is a statement that is either true or false. Many geometry results have the form **“If P, then Q”**. P is the **hypothesis** (what is given) and Q is the **conclusion** (what follows).

Converse. The converse of “If P, then Q” is “If Q, then P”. The converse does not always hold in all places.

Proposition
If two sides of a triangle are equal, the angles opposite them are equal.
If two triangles are congruent, they have equal areas.
If a triangle is equilateral, each of its angles is 60° .

Not every converse is true. A true proposition can have a false converse. For example, a triangle with sides 3 cm and 4 cm and a right triangle with legs 8 cm and 6 cm both have a hypotenuse of 5 cm. Their areas are $\frac{1}{2} \times 3 \times 4 = 6 \text{ cm}^2$ and $\frac{1}{2} \times 8 \times 6 = 24 \text{ cm}^2$. Their hypotenuses are $\sqrt{5^2 + 12^2} = 13 \text{ cm}$ and $\sqrt{8^2 + 6^2} = 10 \text{ cm}$. A converse always needs its own proof.



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Why SSA fails in general. SSA means two sides and a **non-included** angle are equal.

Counterexample: draw AM perpendicular to a line, with AM = 12 cm, and mark B on the line with BM = 16 cm, so $AB = \sqrt{(144 + 256)} = 20$ cm. Mark C_1 between B and M and C_2 beyond M, each 5 cm from M, so $AC_1 = AC_2 = \sqrt{(144 + 25)} = 13$ cm. Triangles ABC_1 and ABC_2 share $AB = 20$ cm and $\angle B$, and both have $AC = 13$ cm, yet $BC_1 = 11$ cm and $BC_2 = 21$ cm. They are not congruent.

The compass picture. Fix $\angle B$ and the side BA. The third vertex C lies on the other arm of $\angle B$, at distance AC from A, so C is where a circle with centre A and radius AC cuts that arm. If AC is shorter than AB, the point B is outside this circle, and the arm can cut the circle at two points, one point, or none. Two points means two different triangles: this is the **ambiguous case**.

When SSA does work. If the side opposite the given angle is **at least as long as** the other given side ($AC \geq AB$ above), then B is inside or on the circle, and the arm from B meets the circle at no more than one usable point. At most one triangle fits the data, so SSA gives congruence. Two important special cases:

- **The given angle is a right angle.** The side opposite is exactly RHS.
- **The given angle is obtuse.** The side opposite is longer than the other side, so only one triangle fits. (That fact is standard for obtuse triangles, but it's a good case as a check only.)

In exams. In a proof, the right-angle case is a special case. The general test only tells you how many triangles

The role of diagram accuracy. A proof must show what a sketch seems to show. A famous fallacy involves a point O where the bisector of $\angle A$ meets the base BC. From O to AB and AC, and uses AAS and RHS to prove congruence. The error is in the congruence step is valid. The error is in the diagram and one foot of a perpendicular lands on a line segment. Draw figures to scale and check where po



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Formula and Theorem Sheet

Result	Statement	How it is justified
CPCT	Corresponding parts of congruent triangles are equal	Definition of congruence
SAS	Two sides and the included angle equal $\Rightarrow$ congruent	Axiom
ASA	Two angles and the included side equal $\Rightarrow$ congruent	Proved from SAS by contradiction
AAS	Two angles and a corresponding non-included side equal $\Rightarrow$ congruent	Angle sum property turns it into ASA
SSS	Three sides equal $\Rightarrow$ congruent	
RHS	Right angle, hypotenuse, and one side equal $\Rightarrow$ congruent	
Isosceles theorem	$AB = AC \Rightarrow \angle B = \angle C$	
Converse	$\angle B = \angle C \Rightarrow AB = AC$	
Base angles	If $AB = AC$ and $\angle A = x$, then $\angle B = \angle C = (180^\circ - x)/2$	
Equilateral triangle	Each angle = 60° ; if all angles are 60° , then $\Rightarrow$ equilateral	
Perpendicular bisector	A point equidistant from the endpoints of a line segment lies on the perpendicular bisector, and every point on the perpendicular bisector is equidistant from the endpoints.	
Angle bisector	A point on the angle bisector is equidistant from its sides, and conversely.	



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Result	Statement	How it is justified
AAA, SSA	Not congruence conditions in general	Counterexamples
SSA valid case	Side opposite the given angle $\geq$ the other given side (includes right and obtuse angles)	Only one triangle can be drawn; in proofs quote RHS, never SSA

Important Definitions

- **Congruent triangles:** two triangles for which some correspondence of vertices makes all three pairs of corresponding sides and all three pairs of corresponding angles equal.
- **Correspondence:** a one-to-one matching of the vertices of one triangle with the vertices of another, shown by the order of letters in the names of the triangles.
- **CPCT:** corresponding parts of congruent triangles.
- **Included angle:** the angle formed at the vertex between two sides.
- **Axiom:** a statement accepted as true without proof. Congruence is taken as an axiom.
- **Hypotenuse:** the side opposite the right angle in a right-angled triangle.
- **Isosceles triangle:** a triangle with at least two equal sides.
- **Equilateral triangle:** a triangle with all three sides equal.
- **Base angles:** the two angles of an isosceles triangle opposite the equal sides, or the two angles of a triangle adjacent to the base.
- **Proposition:** a statement that is either true or false, which can be proved.
- **Converse:** the statement formed by swapping the hypothesis and conclusion of a statement.
- **Counterexample:** a single example that contradicts a general statement or conclusion, which proves the statement false.



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Solved Examples

Example 1: Reading a congruence statement

Question. $\triangle ABC \cong \triangle PQR$. In $\triangle ABC$, $AB = 6$ cm, $BC = 8$ cm, $\angle A = 70^\circ$ and $\angle B = 50^\circ$. Find PQ , QR , $\angle P$, $\angle Q$ and $\angle R$.

Solution. The correspondence is $A \leftrightarrow P$, $B \leftrightarrow Q$, $C \leftrightarrow R$.

- $PQ = AB = 6$ cm and $QR = BC = 8$ cm.
- $\angle P = \angle A = 70^\circ$ and $\angle Q = \angle B = 50^\circ$.
- $\angle C = 180^\circ - 70^\circ - 50^\circ = 60^\circ$, so $\angle R = \angle C = 60^\circ$.

Example 2: Writing the correct correspondence

Question. In $\triangle ABC$ and $\triangle XYZ$, $AB = YZ$, $BC = ZX$ and $CA = XY$. Write the correct order of vertices and name the rule.

Solution.

- AB and BC share B ; YZ and ZX share Z .
- AB matches YZ , and $B \leftrightarrow Z$, so $A \leftrightarrow Y$.
- The remaining vertices match: $C \leftrightarrow X$.
- All three sides are equal, so $\triangle ABC \cong \triangle YXZ$.

Check: $AB \leftrightarrow YZ$, $BC \leftrightarrow ZX$, $CA \leftrightarrow XY$. All the sides match.

Example 3: Segments that bisect

Question. Line segments AB and CD bisect each other at O . Name the congruent triangles.

Solution. O is the midpoint of both segments.

- In $\triangle AOC$ and $\triangle BOD$: $OA = OB$ (given), $\angle AOC = \angle BOD$ (vertical angles), $OC = OD$ (given).
- $\therefore \triangle AOC \cong \triangle BOD$ (SAS).
- $\therefore AC = BD$ (CPCT).



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- Also $\angle OAC = \angle OBD$ (CPCT). These are alternate angles made by the transversal AB with the lines AC and BD.
- Equal alternate angles mean the lines are parallel, so $AC \parallel BD$.

Example 4: The diagonal of a kite

Question. In quadrilateral ABCD, $AB = AD$ and $CB = CD$. Prove that the diagonal AC bisects $\angle A$ and $\angle C$. If $\angle BAC = 35^\circ$, find $\angle BAD$.

Solution.

- In $\triangle ABC$ and $\triangle ADC$: $AB = AD$ (given), $CB = CD$ (given), $AC = AC$ (common).
- $\therefore \triangle ABC \cong \triangle ADC$ (SSS).
- $\therefore \angle BAC = \angle DAC$ and $\angle BCA = \angle DCA$ (CPCT). So AC bisects $\angle A$ and $\angle C$.
- $\angle BAD = \angle BAC + \angle DAC = 35^\circ + 35^\circ = 70^\circ$

Example 5: A point equidistant from

Question. M is the midpoint of segment AB. Prove that PM $\perp$ AB.

Solution.

- In $\triangle PMA$ and $\triangle PMB$: $PA = PB$ (given), $MA = MB$ (M is the midpoint of AB), $PM = PM$ (common).
- $\therefore \triangle PMA \cong \triangle PMB$ (SSS), so $\angle PMA = \angle PMB$.
- $\angle PMA$ and $\angle PMB$ form a linear pair, so $\angle PMA + \angle PMB = 180^\circ$.
- $\therefore 2\angle PMA = 180^\circ$, $\angle PMA = 90^\circ$, and $PM \perp AB$.

So every point equidistant from A and B lies on the perpendicular bisector of AB (every point on the perpendicular bisector is equidistant from A and B).

Example 6: Opposite sides from two

Question. Lines l and m are parallel, and line n is a transversal. If $\angle A = 50^\circ$, find $\angle B$.

Solution. Join the diagonal AC.

- AB lies on p and DC lies on q, with $p \parallel q$. $\angle A$ and $\angle C$ are alternate angles.



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- BC lies on m and AD lies on l, with $l \parallel m$. With transversal AC, $\angle BCA = \angle DAC$ (alternate angles).
- $AC = CA$ (common).
- In $\triangle ABC$ and $\triangle CDA$: $\angle BAC = \angle DCA$, $AC = CA$, $\angle BCA = \angle DAC$.
- $\therefore \triangle ABC \cong \triangle CDA$ (ASA).

By CPCT, $AB = CD$ and $BC = DA$. This is the first step towards the parallelogram theorems in the 4-gons (Quadrilaterals) chapter.

Example 7: A point on an angle bisector

Question. Ray AP bisects $\angle BAC$. From P, $PM \perp AB$ and $PN \perp AC$, with M on AB and N on AC. Prove that $PM = PN$ and $AM = AN$.

Solution.

- In $\triangle AMP$ and $\triangle ANP$: $\angle PAM = \angle PAN$ (AP bisects $\angle BAC$), $\angle AMP = \angle ANP = 90^\circ$ ($PM \perp AB$ and $PN \perp AC$), $AP = AP$ (common).
- AP is opposite the right angles, so it is the hypotenuse.
- $\therefore PM = PN$ and $AM = AN$ (CPCT).

Example 8: Equal altitudes

Question. In $\triangle ABC$, $BE \perp AC$ and $CF \perp AB$. Prove that $BE = CF$.

Solution.

- In $\triangle BCF$ and $\triangle CBE$: $\angle BFC = \angle CEB = 90^\circ$.
- $\therefore \triangle BCF \cong \triangle CBE$ (RHS).
- $\therefore \angle FBC = \angle ECB$ (CPCT), that is $\angle ABC = \angle ACB$.
- Sides opposite equal angles are equal, $AB = AC$.

Example 9: Angles in an isosceles triangle

Question. In $\triangle ABC$, $AB = AC$. Side BC is extended to D. Find $\angle ACD$ if $\angle ABC = 115^\circ$.

Solution.

- $\angle ACB$ and $\angle ACD$ form a linear pair: $\angle ACB = 180^\circ - 115^\circ = 65^\circ$.



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- $AB = AC$, so $\angle ABC = \angle ACB = 65^\circ$.
- $\angle A = 180^\circ - 65^\circ - 65^\circ = 50^\circ$.

Answer: $\angle A = 50^\circ$, $\angle B = 65^\circ$, $\angle C = 65^\circ$.

Example 10: The right angle hidden in an extended isosceles triangle

Question. $\triangle ABC$ is isosceles with $AB = AC$. Side BA is extended beyond A to D such that $AD = AB$. Prove that $\angle BCD = 90^\circ$.

Solution. $AD = AB = AC$.

- In $\triangle ABC$, $AB = AC$, so $\angle ABC = \angle ACB$. Call each x .
- In $\triangle ACD$, $AC = AD$, so $\angle ACD = \angle ADC$. Call each y .
- $\angle BCD = \angle ACB + \angle ACD = x + y$.
- Angle sum in $\triangle BCD$: $\angle DBC + \angle BCD + \angle CDB = 180^\circ$.
- $2(x + y) = 180^\circ$, so $x + y = 90^\circ$. $\therefore \angle BCD = 90^\circ$.

Competency-Based Questions

Q1. Case study: the wobbly gate

A carpenter builds a rectangular wooden gate. After a few weeks the gate sags: its corners are no longer square and its length is shorter than its original length as before.

- Why did the shape change while the sides remained the same length?
- What single plank should the carpenter add to make the gate rigid?
- Which congruence condition expresses the rigidity of the gate?

Answer. (a) A 4-gon is not rigid. Four fixed sides can lean into a parallelogram. (b) A diagonal plank divides the gate into two triangles, and each triangle holds its shape. (c) SSS: three sides of one triangle are equal to three sides of another triangle.



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Q2. Case study: a roof truss

A roof truss is a triangle ABC with the ridge at A and the two ends of the tie beam at B and C. The two rafters AB and AC are cut to the same length. A post AD joins A to the midpoint D of BC.

- (a) Prove that $\triangle ABD \cong \triangle ACD$.
- (b) Show that the post AD is perpendicular to the tie beam.
- (c) If the rafters make an angle of 30° with the tie beam, find the angle between the two rafters at the ridge.

Answer. (a) $AB = AC$ (equal rafters), $BD = CD$ (D is the midpoint), $AD = AD$ (common). So $\triangle ABD \cong \triangle ACD$ (SSS). (b) $\angle ADB = \angle ADC$ by CPCT, and they form a linear pair, so each is 90° . (c) $\angle B = \angle C = 30^\circ$, so $\angle A = 180^\circ - 60^\circ = 120^\circ$.

Q3. Assertion and Reason

Assertion (A): If in $\triangle ABC$ and $\triangle PQR$, $AB = PQ$, $BC = QR$ and $\angle A = \angle P$, then the triangles must be congruent by SAS.

Reason (R): In the SAS rule, the equal angles must be included between the equal sides.

- (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: (d). $\angle A$ is not between AB and BC and does not guarantee congruence. R is correct.

Q4. Assertion and Reason

Assertion (A): Two triangles with $\angle A = \angle D$ and $\angle B = \angle E$ are congruent.

Reason (R): If two angles of one triangle are equal to two angles of another triangle, the triangles are congruent.

Answer: (a). Both are true. R gives $\angle C = \angle F$ (sum of angles in a triangle is 180°), and that explains A.

Q5. Assertion and Reason

Assertion (A): The statement "If all three angles of one triangle are equal to the corresponding angles of another, the triangles are congruent" is false.



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Reason (R): Two triangles can have the same angles but different sizes.

Answer: (a). Equilateral triangles of sides 3 cm and 6 cm have all angles 60° but are not congruent. R is the counterexample idea that explains A.

Q6. Source-based: proposition and converse

A student writes in her notebook: "Theorem: If a point lies on the bisector of an angle, it is equidistant from the arms of the angle. I think the converse is also true, but my teacher says I must prove it separately."

- (a) Write the converse.
- (b) Why can the converse not be taken as true just because the theorem is true?
- (c) Prove the converse, for a point P inside $\angle BAC$.

Answer. (a) If a point inside an angle is equidistant from its arms, it lies on the bisector of the angle. (b) A true proposition can have a false converse. (c) Let $PM \perp AB$ and $PN \perp AC$ with $PM = PN$. $\angle M = \angle N = 90^\circ$. $PM = PN$ is common and $\angle PMA = \angle PNB$. So $\triangle AMP \cong \triangle ANP$ by AAS. $\therefore \angle PAM = \angle PAN$. $\therefore AP$ is the angle bisector of $\angle BAC$.

Q7. Case study: two survey triangles

Two surveyors record the same data for two plots. $AB = 10$ m, $AC = 13$ m. The plots have different areas.

- (a) Which pattern of data did the surveyors use?
- (b) Explain how both plots can fit the same data.
- (c) What extra measurement would settle the matter?

Answer. (a) SSA: two sides and an angle (side AB and AC). (b) The side opposite $\angle B$ (13 m) can cut the other arm of $\angle B$ at two points. The third side BC fixes the plot by SSS. Measure $\angle C$ to fix it by ASA.

Q8. Reasoning: counting triangles

In $\triangle ABC$, $AB = 5$ cm, $\angle B = 100^\circ$ and $AC = 8$ cm. How many triangles can be formed? Give a reason.

Answer. Exactly one. The side opposite the given angle, $AB = 5$ cm. So B lies inside the circle of radius 8 cm around A, and the other arm of



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$\angle B$, starting from a point inside the circle, crosses the circle at exactly one point C. Only one triangle fits the data, so SSA gives a unique triangle in this case.

Important Questions for Exams

1 Mark Questions

Q1. If $\triangle DEF \cong \triangle LMN$, which side of $\triangle LMN$ equals EF?

Answer: MN ($E \leftrightarrow M, F \leftrightarrow N$).

Q2. Which congruence rule is taken as an axiom?

Answer: SAS.

Q3. In $\triangle PQR$, $PQ = PR$ and $\angle P = 40^\circ$. Find $\angle Q$.

Answer: $\angle Q = (180^\circ - 40^\circ)/2 = 70^\circ$.

Q4. Is AAA a congruence condition? Give

Answer: No. Equilateral triangles of sides

Q5. Write the converse of: "If a triangle is

Answer: If each angle of a triangle is 60° ,

2 Marks Questions

Q6. Why is a triangle called rigid? Give on

Answer: Once the three side lengths of a triangle cannot be deformed; a quadrilateral with four sides are built from triangles so they do not sag.

Q7. In $\triangle ABC$ and $\triangle PQR$, $AB = PQ$ and $AC = PR$. By SAS? Which would make them congruent?

Answer: SAS needs the included angle: $\angle A = \angle P$.

Q8. In $\triangle ABC$, $\angle B = \angle C = 55^\circ$. Which sides are equal?

Answer: Sides opposite equal angles are equal. $\angle A = 180^\circ - 110^\circ = 70^\circ$.



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3 Marks Questions

Q9. Prove that the angles opposite to equal sides of a triangle are equal.

Answer: Given $\triangle ABC$ with $AB = AC$. Draw the bisector AD of $\angle A$ meeting BC at D . In $\triangle BAD$ and $\triangle CAD$: $AB = AC$ (given), $\angle BAD = \angle CAD$ (construction), $AD = AD$ (common). So $\triangle BAD \cong \triangle CAD$ (SAS). Hence $\angle ABD = \angle ACD$ (CPCT), that is $\angle B = \angle C$.

Q10. In an isosceles triangle ABC with $AB = AC$, BD and CE are the medians to AC and AB (D is the midpoint of AC and E the midpoint of AB). Prove that $BD = CE$.

Answer: $AB = AC$, so $AE = AB/2 = AC/2 = AD$. In $\triangle ABD$ and $\triangle ACE$: $AB = AC$ (given), $\angle A = \angle A$ (common), $AD = AE$ (halves of equal sides). So $\triangle ABD \cong \triangle ACE$ (SAS), and $BD = CE$ (CPCT).

Q11. ABC is an isosceles triangle with $AB = AC$. Altitudes BE and CF are drawn to AC and AB . Prove that $BE = CF$.

Answer: In $\triangle ABE$ and $\triangle ACF$: $\angle AEB = \angle AFC = 90^\circ$, $\angle A = \angle A$ (common), $AB = AC$ (given, the side opposite the right angle in each). So $\triangle ABE \cong \triangle ACF$ (AAS), and $BE = CF$ (CPCT).

5 Marks Questions

Q12. State and prove the ASA congruence

Answer: Statement: two triangles are congruent if two angles and the included side of one triangle are equal to two angles and the included side of another triangle.
Proof: Let $\triangle ABC$ and $\triangle DEF$. If $\angle A = \angle D$, $\angle B = \angle E$, and $AB = DE$, then $\triangle ABC \cong \triangle DEF$ (ASA).
Proof: On BA with $PB = DE$. Then $\triangle PBC \cong \triangle DEF$ (ASA).
Since P lies between A and B , $\angle PCB = \angle E$.
The case $AB < DE$ is ruled out by the same argument. The case $AB > DE$ is ruled out by the same argument.
 $\triangle ABC \cong \triangle DEF$ by SAS.

Q13. (a) Explain with a counterexample why SSA is not a congruence criterion. State one situation where SSA does guarantee congruence.

Answer: (a) Draw a line, a point M on it and a point B at a distance of $BM = 16$ cm, so $AB = \sqrt{144 + 256} = 20$ cm. Draw a circle of radius 13 cm from M , so $AC_1 = AC_2 = \sqrt{144 + 25} = 13$ cm. So we can have $AC = 13$ cm, yet $BC_1 = 11$ cm and $BC_2 = 25$ cm. So SSA fails. (b) When the given angle is a right angle, SSA becomes RHS, which guarantees congruence.

Q14. In $\triangle ABC$, $AB = AC$. D is a point on BC . Prove that $AD \perp BC$. (c) If $\angle BAC = 80^\circ$, find $\angle BAD$.

Answer: (a) In $\triangle ABD$ and $\triangle ACD$: $AB = AC$ (given), $AD = AD$ (common), $BD = CD$ (given). So $\triangle ABD \cong \triangle ACD$ (SSS), and $\angle BAD = \angle CAD$ (CPCT).



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and they form a linear pair, so each is 90° . So $AD \perp BC$. (c) $\angle ABD = (180^\circ - 80^\circ)/2 = 50^\circ$, and $\angle BAD = 80^\circ/2 = 40^\circ$. Check in $\triangle ABD$: $50^\circ + 40^\circ + 90^\circ = 180^\circ$.

Common Mistakes and Examiner Tips

- Mistake:** writing the congruence with vertices in the wrong order, such as $\triangle ABC \cong \triangle QPR$ when A matches P. **Fix:** find the matching vertices first from the equal angles or from the common letters of equal sides, then write the letters in that order.
- Mistake:** using SAS with an angle that is not between the two sides. **Fix:** check that the angle's vertex is the common letter of the two sides (for AB and BC, it must be $\angle B$).
- Mistake:** quoting "SSA" or "ASS" as a congruence rule. **Fix:** only SAS, SSS, ASA, AAS and RHS are accepted. With two sides and a non-included angle, look for a right angle (RHS) or for more information.
- Mistake:** using CPCT before congruence. $\triangle ___ \cong \triangle ___ \text{ (rule)}"$.
- Mistake:** in AAS, matching a side opposite. **Fix:** the equal sides must be opposite the equal angles.
- Mistake:** applying RHS to triangles with hypotenuse. **Fix:** state the right angle is working.
- Mistake:** listing parts without reasons. I common, vertically opposite angles, alt
- Mistake:** assuming a converse is true b Prove it, or give one counterexample to
- Mistake:** reading equal lengths or right given or proved. Mark given equal parts figures neatly enough that points appear
- Mistake:** in isosceles angle problems, t angles are opposite the equal sides. If A vertex angle.



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Quick Revision Points

- A triangle is rigid: fixed side lengths fix its angles and shape. A quadrilateral is not rigid.

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- $\triangle ABC \cong \triangle PQR$ means $A \leftrightarrow P, B \leftrightarrow Q, C \leftrightarrow R$, with six pairs of equal parts.
- CPCT: corresponding parts of congruent triangles are equal. Use it only after proving congruence.
- SAS (two sides and the included angle) is taken as an axiom.
- ASA (two angles and the included side) is proved from SAS by contradiction.
- AAS works because equal pairs of angles force the third angles to be equal (angle sum 180°).
- RHS: right angle, hypotenuse and one side, for right-angled triangles only.
- AAA does not give congruence: equal angles, different sizes.
- SSA does not give congruence in general: the same data can fit two different triangles.
- SSA works when the side opposite the given angle is at least as long as the other given side, which covers right (RHS) and obtuse angles. In a proof, quote RHS, never SSA.
- Angles opposite equal sides are equal. Sides opposite equal angles are equal.
- With $AB = AC$ and $\angle A = x$, each base angle is $\frac{180^\circ - x}{2}$.
- Each angle of an equilateral triangle is 60° .
- Points equidistant from A and B lie on the perpendicular bisector of AB.
- Points on an angle bisector are equidistant from the sides of the angle.
- A true proposition can have a false converse.
- Never trust a sketch over the given facts. A triangle that looks like an isosceles triangle is isosceles.



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Weightage and Exam Pattern

Class 9 has no board exam. This chapter is in the yearly exam and the annual exam. It is also in the boards.

In the CBSE Class IX Mathematics course **Geometry**, with Euclid's Geometry, Lines and Angles, **carries 25 marks** out of the 80-mark theoretical part. The course structure gives marks for the unit and internal assessment (portfolio 5, lab practical 5).

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Unit	Marks (out of 80)
I. Number System	07
II. Algebra	20
III. Coordinate Geometry	04
IV. Geometry	25
V. Mensuration	14
VI. Statistics and Probability	10

The question paper design groups questions by thinking skill: remembering and understanding (43 marks, about 54%), applying (19 marks, about 24%) and analysing, evaluating and creating (18 marks, about 22%). From this chapter, congruence proofs and isosceles angle w unique triangle or spotting a flawed proof



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