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CHAPTER NOTES

Quadrilaterals Class 9 Notes | CBSE Maths

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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 Quadrilaterals simply

What can the board exam ask?

Most important formulas

Quiz me on this chapter

Ask Ira anything...



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Quadrilaterals Class 9 Notes | CBSE Maths

Quadrilaterals is a chapter of CBSE Class 9 Maths (2026-27 syllabus), part of Unit IV, Geometry, where the course structure lists it as "4-gons (Quadrilaterals)". It starts with a precise definition of a 4-gon and its angle sum, then proves the properties of a parallelogram and the tests that show a 4-gon is a parallelogram. It covers rectangles, rhombuses and squares, the reflection and rotation symmetries of 4-gons, and why any 4-gon can tile a plane.

The second half is about midpoints. You prove the midpoint theorem and its converse, show that the medians of a triangle meet at one point that divides each of them in the ratio $2 : 1$, and prove that joining the midpoints of any 4-gon gives a parallelogram. You also use coordinates to find midpoints and the fourth vertex of a parallelogram. School exams test these as short proofs, angle and length calculations and coordinate problems, and the same congruence and midpoint arguments come back in the Class 10 chapters on triangles and coordinate geometry.

Quick Answer - Quadrilaterals in 3

A **4-gon** joins four points, no three on a line. The interior angles add to 360° . A diagonal cuts a quadrilateral into two triangles. Opposite sides are equal, opposite angles are equal. Each of these facts, or one pair of sides is parallel, defines a parallelogram. The **midpoint theorem**: the line segment joining the midpoints of two sides of a triangle is parallel to the third side and half its length. The medians of a triangle meet at one point, each in the ratio $2 : 1$ from the vertex.



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All Key Formulas at a Glance

Result	Statement	Remember
Angle sum of a 4-gon	$\angle A + \angle B + \angle C + \angle D = 360^\circ$	Two triangles, $2 \times 180^\circ$
Parallelogram: sides and angles	$AB = CD, AD = BC; \angle A = \angle C, \angle B = \angle D$	Adjacent angles add to 180°
Parallelogram: diagonals	$OA = OC$ and $OB = OD$	Diagonals bisect each other
Tests for a parallelogram	Opposite sides equal, or opposite angles equal, or diagonals bisect each other, or one pair of sides equal and parallel	Any one test is enough
Rectangle	Parallelogram with equal diagonals	
Rhombus	Parallelogram with equal sides	
Midpoint theorem	E, F midpoints of AB, AC $EF = BC/2$	
Medians and centroid	$AG : GD = 2 : 1$	
Midpoint 4-gon	Midpoints of the sides of a quadrilateral form a parallelogram	
Midpoint formula	$M = ((x_1 + x_2)/2, (y_1 + y_2)/2)$	
Fourth vertex of parallelogram ABCD	$D = (x_A + x_C - x_B, y_A + y_C - y_B)$	



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Key Concepts

1. What a 4-gon Is and Why Its Angles Add to 360°

Take four points A, B, C and D in a plane, with no three of them on one straight line. Join them in order by the segments AB, BC, CD and DA. If these four segments meet only at their shared end points, so that AB does not cross CD and BC does not cross DA, the closed figure ABCD is a **4-gon**, also called a **quadrilateral**.

Part of 4-gon ABCD	What it is
Vertices	A, B, C, D
Sides	AB, BC, CD, DA
Angles	$\angle A$ ($\angle DAB$), $\angle B$ ($\angle ABC$), $\angle C$ ($\angle BCD$), $\angle D$ ($\angle CDA$)
Diagonals	AC and BD
Adjacent sides	Sides with
Opposite sides	Sides with
Opposite angles	$\angle A$ and $\angle C$,

The name ABCD gives the order of the vertices. Different names give different 4-gons.

A 4-gon is **convex** when each angle is less than 180°. A 4-gon has one reflex angle.

Angle sum property. The angles of a 4-gon add up to 360°.

Proof. Choose a diagonal that lies inside the 4-gon, say AC. At vertex A, $\angle DAB = \angle BAC + \angle CAD$, and at vertex C, $\angle BCD = \angle BCA + \angle ACD$. The four triangles make up exactly the four angles of the 4-gon.

$$\angle A + \angle B + \angle C + \angle D = 180^\circ + 180^\circ = 360^\circ$$

Consequences:



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- A 4-gon cannot have all four angles acute, because four angles each less than 90° add to less than 360° .
- It cannot have four obtuse angles either, since they would add to more than 360° . At most three angles can be obtuse.
- If three angles are known, the fourth is 360° minus their sum.

A 4-gon is not rigid. A frame of four hinged sticks can change shape while its sides stay the same, unlike a triangle. A diagonal brace splits it into two rigid triangles, which is why gates use one.

2. The Parallelogram and Its Properties

A **parallelogram** is a 4-gon in which both pairs of opposite sides are parallel: $AB \parallel DC$ and $AD \parallel BC$.

Every property of a parallelogram comes from these two facts.

Theorem 1. A diagonal divides a parallelogram into two congruent triangles.

Proof. In parallelogram ABCD, draw diagonal AC.

- $AB \parallel DC$ and AC is a transversal, so $\angle BAC = \angle DCA$ (alternate angles).
- $AD \parallel BC$ and AC is a transversal, so $\angle BCA = \angle DAC$ (alternate angles).
- $AC = CA$ (common side).

So $\triangle ABC \cong \triangle CDA$ by the ASA rule. The corresponding sides are equal.

Theorem 2. In a parallelogram, opposite sides are equal. $AB = DC$ and $BC = DA$.

Theorem 3. In a parallelogram, opposite angles are equal. $\angle A = \angle C$ and $\angle B = \angle D$.
Also $\angle A = \angle BAC + \angle CAD = \angle DCA + \angle BCA = \angle C$ (angles at a point, or directly.)

Adjacent angles are supplementary. $AD \parallel BC$ and AB is a transversal, so $\angle A + \angle B = 180^\circ$. The same holds for $\angle C + \angle D$.
If one angle of a parallelogram is 70° , the angles are $70^\circ, 110^\circ, 70^\circ, 110^\circ$.

Theorem 4. The diagonals of a parallelogram bisect each other.



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Proof. Let the diagonals AC and BD meet at O. In $\triangle AOB$ and $\triangle COD$:

- $AB = CD$ (opposite sides of a parallelogram)
- $\angle OAB = \angle OCD$ (alternate angles, $AB \parallel DC$, transversal AC)
- $\angle OBA = \angle ODC$ (alternate angles, $AB \parallel DC$, transversal BD)

So $\triangle AOB \cong \triangle COD$ (ASA), and by CPCT, $OA = OC$ and $OB = OD$. O is the midpoint of both diagonals.

The diagonals of a general parallelogram are unequal and not perpendicular. Those extra facts belong to the rectangle and the rhombus.

3. Tests for a Parallelogram (Characterisations)

A **converse** of a theorem swaps its hypothesis and conclusion. "If ABCD is a parallelogram, then its opposite sides are equal" has the converse "If a quadrilateral has its opposite sides equal, then it is a parallelogram". A converse must be proved separately. For the parallelogram, four useful converses are:

Test 1. If both pairs of opposite sides of a quadrilateral are equal, it is a parallelogram.

Given $AB = CD$ and $AD = BC$. Draw diagonal AC. So $\triangle ABC \cong \triangle CDA$ (SSS). By CPCT, $\angle BAC = \angle DCA$. $AB \parallel DC$ with transversal AC, so $AB \parallel DC$. Also $\angle DAC = \angle BCA$. $AD \parallel BC$ with transversal AC, so $AD \parallel BC$. Both pairs of opposite sides are parallel.

Test 2. If both pairs of opposite angles of a quadrilateral are equal, it is a parallelogram.

Given $\angle A = \angle C$ and $\angle B = \angle D$. The angle sum of a quadrilateral is 360° and $\angle A + \angle B = 180^\circ$. These are co-interior angles, so $AD \parallel BC$. In the same way, $\angle A + \angle D = 180^\circ$, so $AB \parallel DC$. Both pairs of opposite sides are parallel.

Test 3. If the diagonals of a 4-gon bisect each other, it is a parallelogram.

Given $OA = OC$ and $OB = OD$, where O is the intersection of diagonals AC and BD. $\angle AOB = \angle COD$ (vertically opposite angles). So $\triangle AOB \cong \triangle COD$ (SAS). By CPCT, $\angle OAB = \angle OCD$. These are alternate angles, so $AB \parallel DC$. Similarly, $\triangle AOD \cong \triangle COB$ gives $AD \parallel BC$.

Test 4. If one pair of opposite sides of a 4-gon is equal and parallel, it is a parallelogram.



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Given $AB = CD$ and $AB \parallel CD$. Draw diagonal AC . $\angle BAC = \angle DCA$ (alternate angles), $AB = CD$ and AC is common, so $\triangle ABC \cong \triangle CDA$ (SAS). By CPCT, $\angle BCA = \angle DAC$, which are alternate angles, so $BC \parallel AD$.

Test 4 is the quickest in many proofs, because you only need to look at one pair of sides.

Conditions that are NOT enough.

- **One pair of opposite sides parallel** only gives a trapezium.
- **One pair of opposite sides equal and the other pair parallel** is also not enough. An isosceles trapezium has $AB \parallel DC$ and $AD = BC$, but $AB \neq DC$.
- **Equal diagonals** do not make a parallelogram. An isosceles trapezium has equal diagonals.

Before trusting a converse, try to build a counter example. One counter example is enough to show it is false.

4. Rectangle, Rhombus, Square and Parallelogram

Special parallelograms add one more condition to every property from Concept 2.

Rectangle. A parallelogram with one right angle. If one angle is equal, all four angles are then equal.

- **The diagonals of a rectangle are equal.** $\triangle CBA = 90^\circ$. So the triangles are congruent.
- **Converse: a parallelogram with equal diagonals is a rectangle.** $\triangle CBA$ (SSS: $AD = BC$, AB common, $BD = AC$)

Rhombus. A parallelogram with a pair of adjacent sides equal. If one pair of adjacent sides are equal, all four sides are then equal.

- **The diagonals of a rhombus bisect each other at right angles.** $OB = OD$ and AO is common. So the triangles $\triangle AOB$ and $\triangle AOD$ form a linear pair, so each is 90° .
- **Each diagonal bisects the angles at its ends.**
- **Converse: a parallelogram whose diagonals bisect each other at right angles is a rhombus.** $\angle AOD = 90^\circ$, then $\triangle AOB \cong \triangle AOD$ (SAS: AO common, $OB = OD$, $\angle AOB = \angle AOD = 90^\circ$)



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- With diagonals d_1 and d_2 , the four right triangles at O have legs $d_1/2$ and $d_2/2$, so by Pythagoras, **side² = (d₁/2)² + (d₂/2)²**.

Square. A rectangle with all sides equal, so it is both a rectangle and a rhombus. Its diagonals are equal, bisect each other at right angles and bisect the 90° angles into 45°.

Other 4-gons.

- **Trapezium:** exactly one pair of opposite sides parallel. The two angles along each non-parallel side are co-interior, so each such pair adds to 180°.
- **Isosceles trapezium:** a trapezium whose non-parallel sides are equal. Its base angles are equal and its diagonals are equal.
- **Kite:** two pairs of equal adjacent sides (AB = AD and CB = CD). Its diagonals are perpendicular, and diagonal AC bisects diagonal BD.

Property	Parallelogram	Rectangle	Rhombus	Square
Opposite sides parallel and equal	Yes	Yes	Yes	Yes
All sides equal	No	No	Yes	Yes
All angles 90°	No	Yes	No	Yes
Diagonals bisect each other	Yes	Yes	Yes	Yes
Diagonals equal	No	Yes	No	Yes
Diagonals perpendicular	No	No	Yes	Yes
Diagonals bisect vertex angles	No	No	No	Yes

“No” in this table means “not in general”.

Illustration. A rhombus has diagonals 16 cm and 30 cm. Each side = $\sqrt{(64 + 225)} = \sqrt{289} = 17$ cm and the area = $\frac{1}{2} \times 16 \times 30 = 240$ cm².

5. Central Symmetry, Reflection and Rotational Symmetry

A figure has **central symmetry** about a point O if for every point P on the figure, there is a point P' with O as the midpoint of PP' also lies on the figure. This is the same as saying that a rotation of 180° about O maps the figure onto itself.



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through 180° (a half-turn) about O maps the figure onto itself.

Every parallelogram has central symmetry about the meeting point O of its diagonals. Since $OA = OC$ and $OB = OD$, the half-turn about O sends A to C, C to A, B to D and D to B. So it sends side AB to side CD and side BC to side DA, and the parallelogram lands on itself.

The converse also holds. If a half-turn about O maps a 4-gon onto itself, it must swap opposite vertices, so O is the midpoint of AC and of BD. The diagonals bisect each other, so by Test 3 the 4-gon is a parallelogram. In short: **a 4-gon has central symmetry exactly when it is a parallelogram**, and the centre is where the diagonals meet.

Reflection (line) symmetry means a line divides the figure into two mirror halves. **Rotation symmetry** means a turn through less than 360° about a centre maps the figure onto itself.

4-gon	Lines of symmetry	Where the lines are	Smallest rotation that
Parallelogram (not a rectangle or rhombus)	0		
Rectangle (not a square)	2		
Rhombus (not a square)	2		
Square	4		
Kite (not a rhombus)	1		
Isosceles trapezium	1		

A common trap: a diagonal of a rectangle rectangle along a diagonal does not make

Any 4-gon can tile a plane. Tiling means c gaps and no overlaps. Give 4-gon ABCD a half-turn about the midpoint of a side; the copy fits



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exactly along that side. Repeat across every side. At each meeting point, four copies bring together the four different angles A, B, C and D, which add to 360° , a full turn. So there is no gap and no overlap, even for a concave 4-gon.

6. The Midpoint Theorem and Its Converse

Midpoint theorem. The line segment joining the midpoints of two sides of a triangle is parallel to the third side and is half of it.

Proof. In $\triangle ABC$, let E be the midpoint of AB and F the midpoint of AC. We show $EF \parallel BC$ and $EF = BC/2$.

1. Extend EF beyond F to a point D so that $FD = EF$. Join CD.
2. In $\triangle AEF$ and $\triangle CDF$: $AF = CF$ (F is the midpoint of AC), $EF = DF$ (construction), and $\angle AFE = \angle CFD$ (vertically opposite). So $\triangle AEF \cong \triangle CDF$ (SAS)
3. By CPCT, $CD = AE$, and $AE = EB$, so $CD = EB$.
4. Also by CPCT, $\angle EAF = \angle DCF$. These are alternate angles, so $AE \parallel CD$, that is, $EB \parallel CD$.
5. In 4-gon EBCD, one pair of opposite sides are parallel and equal. So EBCD is a parallelogram.
6. So $ED \parallel BC$, which means $EF \parallel BC$, and $EF = BC/2$.

Converse of the midpoint theorem. The line segment joining the midpoints of two sides of a triangle, parallel to another side, bisects the third side.

Proof. In $\triangle ABC$, E is the midpoint of AB, and F' be the midpoint of AC. By the midpoint theorem, $EF' \parallel BC$ and $EF' = BC/2$. Similarly, $EF \parallel BC$ and $EF = BC/2$. Since there is only one line parallel to BC (Playfair's axiom), so $EF = EF'$, and F is the midpoint of AC.

Uses of the theorem.

- Joining the three midpoints D, E, F of the sides of $\triangle ABC$, each with sides equal to half of the side of $\triangle ABC$.
- In a trapezium, the line through the midpoints of the parallel sides, passes through the midpoint of the non-parallel sides.



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- Through the midpoint of the hypotenuse of a right triangle, a line parallel to one leg meets the other leg at its midpoint and is perpendicular to it. This shows the midpoint of the hypotenuse is equally far from all three vertices (Example 11).

Illustration. In $\triangle PQR$, $PQ = 10$ cm, $QR = 14$ cm and $RP = 8$ cm. X and Y are the midpoints of PQ and PR . Then $XY \parallel QR$ and $XY = 14/2 = 7$ cm.

7. The Midpoint 4-gon and the Medians of a Triangle

Theorem: the 4-gon formed by joining the midpoints of the sides of any 4-gon, in order, is a parallelogram.

Proof. Let P , Q , R and S be the midpoints of AB , BC , CD and DA of 4-gon $ABCD$. Draw diagonal AC .

- In $\triangle ABC$, P and Q are midpoints of AB and BC so $PQ \parallel AC$ and $PQ = AC/2$ (midpoint theorem).
- In $\triangle ADC$, S and R are midpoints of AD and DC so $SR \parallel AC$ and $SR = AC/2$.
- So $PQ \parallel SR$ and $PQ = SR$. By Test 4, $PQRS$ is a parallelogram.

Using diagonal BD in the same way gives $PS \parallel QR$ and $PS = QR$.
 $BD/2 + AC/2 + BD/2 = AC + BD$, the sum of the diagonals.

Original 4-gon ABCD	Midpoint 4-gon PQRS
Any 4-gon	Parallelogram
Diagonals perpendicular (rhombus, kite)	Rectangle
Diagonals equal (rectangle, isosceles trapezium)	Rhombus
Square	Square

Medians of a triangle. A median joins a vertex to the midpoint of the opposite side. Every triangle has three medians.



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Theorem: the three medians of a triangle pass through one point, and this point divides each median in the ratio 2 : 1 from the vertex. The common point is the **centroid**, usually named G.

Proof. In $\triangle ABC$, let E be the midpoint of AC and F the midpoint of AB. Let the medians BE and CF meet at G. Let P be the midpoint of BG and Q the midpoint of CG.

1. In $\triangle ABC$, F and E are midpoints of AB and AC, so $FE \parallel BC$ and $FE = BC/2$.
2. In $\triangle GBC$, P and Q are midpoints of GB and GC, so $PQ \parallel BC$ and $PQ = BC/2$.
3. So $FE \parallel PQ$ and $FE = PQ$. By Test 4, FEQP is a parallelogram.
4. Its diagonals are FQ and EP. F, G, Q lie on median CF, and E, G, P lie on median BE, so the diagonals meet at G. The diagonals of a parallelogram bisect each other, so $GE = GP$ and $GF = GQ$.
5. P is the midpoint of BG, so $BP = PG = GE$. So $BG = 2 GE$, that is, $BG : GE = 2 : 1$. In the same way $CQ = QG = GF$, so $CG : GF = 2 : 1$.
6. Apply the same argument to medians BA and CA. So AD also passes through G, and $AG : GD = 2 : 1$.

So the three medians are **concurrent** at G.

Illustration. Median AD of $\triangle ABC$ is 15 cm.

8. Midpoints and Parallelograms

The **midpoint** of the segment joining $A(x_1, y_1)$ and $B(x_2, y_2)$ is

$$M = ((x_1 + x_2)/2, (y_1 + y_2)/2)$$

The midpoint of (2, 7) and (8, -3) is $((2 + 8)/2, (7 - 3)/2) = (5, 2)$.

Finding the fourth vertex of a parallelogram. If the diagonals of a parallelogram bisect each other, so they have the same midpoint.

$$(x_A + x_C)/2 = (x_B + x_D)/2 \text{ and } (y_A + y_C)/2 = (y_B + y_D)/2$$

So $x_D = x_A + x_C - x_B$ and $y_D = y_A + y_C - y_B$. The same method can be used to find the fourth vertex if three vertices are given. The same method can be used to find the fourth vertex if three vertices are given.



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The order of the letters matters: in ABCD, D is opposite B. Three points given with no order allow three different parallelograms.

Testing a 4-gon with coordinates.

- Parallelogram: the midpoints of AC and BD are the same point (Test 3).
- Rectangle: a parallelogram whose diagonals are equal, checked with the distance formula $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$.
- Rhombus: a parallelogram with a pair of equal adjacent sides.
- Square: both of the above.



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Formula and Theorem Sheet

Result	Statement
Angle sum of a 4-gon	$\angle A + \angle B + \angle C + \angle D = 360^\circ$
Diagonal of a parallelogram	$\triangle ABC \cong \triangle CDA$
Parallelogram sides and angles	$AB = CD, BC = DA; \angle A = \angle C, \angle B = \angle D; \angle A + \angle B = 180^\circ$
Parallelogram diagonals	$OA = OC, OB = OD$
Test 1	Both pairs of opposite sides equal $\Rightarrow$ parallelogram
Test 2	Both pairs of opposite angles equal $\Rightarrow$ parallelogram
Test 3	Diagona
Test 4	One pai paralle
Rectangle	Diagona rectang
Rhombus	Diagona $(d_1/2)^2 +$
Central symmetry	A 4-gon paralle
Midpoint theorem	$EF \parallel BC,$
Converse of midpoint theorem	Line thro
Midpoint 4-gon	PQRS is
Centroid	Medians
Midpoint formula	$((x_1 + x_2$



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Result	Statement
Fourth vertex	$D = (x_A + x_C - x_B, y_A + y_C - y_B)$

Important Definitions

Term	Definition
4-gon (quadrilateral)	A closed figure formed by joining four points, no three collinear, in order by four segments that meet only at their end points
Diagonal	A segment joining two opposite vertices of a 4-gon
Parallelogram	A 4-gon with both
Rectangle	A parallelogram w
Rhombus	A parallelogram w
Square	A rectangle with a
Trapezium	A 4-gon with exac
Kite	A 4-gon with two
Median	A segment joining side
Centroid	The point where t
Central symmetry	A figure has centr onto itself



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Solved Examples

Example 1: Angles in a ratio

The angles of a 4-gon are in the ratio 3 : 5 : 9 : 13. Find all the angles.

Solution: Let the angles be $3x$, $5x$, $9x$ and $13x$. By the angle sum property, $3x + 5x + 9x + 13x = 360^\circ$, so $30x = 360^\circ$ and $x = 12^\circ$.

The angles are **36° , 60° , 108° and 156°** . Check: $36 + 60 + 108 + 156 = 360$.

Example 2: Angles of a parallelogram

In a parallelogram, one angle is 24° less than twice its adjacent angle. Find all four angles.

Solution: Let one angle be x . Its adjacent angle is $2x - 24^\circ$. Adjacent angles of a parallelogram are supplementary, so $x + 2x - 24^\circ = 180^\circ$

The adjacent angle is $2(68^\circ) - 24^\circ = 112^\circ$.
 68° and 112° .

Example 3: Sides from a perimeter

The perimeter of a parallelogram is 56 cm. Find the lengths of its sides.

Solution: Let the adjacent sides be $3k$ and $4k$. Then $2(3k + 4k) = 56$ and $k = 4$.

The sides are **12 cm, 16 cm, 12 cm and 16 cm**.

Example 4: Diagonals that bisect

The diagonals of parallelogram ABCD meet at O. If $AO = 3y - 2$ (all in cm). Find the lengths of AC and BD.

Solution: The diagonals of a parallelogram bisect each other.

$2x + 3 = 5x - 6$ gives $3x = 9$, $x = 3$. So $OA = 7$ cm.

$y + 4 = 3y - 2$ gives $2y = 6$, $y = 3$. So $OB = 11$ cm.



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Example 5: Side of a rhombus from its diagonals

The diagonals of a rhombus are 24 cm and 10 cm. Find its side and perimeter.

Solution: The diagonals of a rhombus bisect each other at right angles, so they form four right triangles with legs 12 cm and 5 cm.

$\text{side}^2 = 12^2 + 5^2 = 144 + 25 = 169$, so side = **13 cm**. Perimeter = $4 \times 13 = \mathbf{52 \text{ cm}}$.

Example 6: Bisectors of adjacent angles

In parallelogram ABCD, the bisectors of $\angle A$ and $\angle B$ meet at P. Prove that $\angle APB = 90^\circ$.

Solution: $AD \parallel BC$, so $\angle A + \angle B = 180^\circ$ (co-interior angles). Halving, $\angle PAB + \angle PBA = (1/2)\angle A + (1/2)\angle B = 90^\circ$.

In $\triangle APB$, $\angle APB = 180^\circ - (\angle PAB + \angle PBA) = 180^\circ - 90^\circ = 90^\circ$. Doing this at all four corners shows that, when the parallelogram is not a rhombus, the bisectors of adjacent angles meet at right angles, a rectangle.

Example 7: Perimeter of the midpoint

The sides of $\triangle ABC$ are 8 cm, 10 cm and 12 cm. Find the perimeter of $\triangle DEF$.

Solution: By the midpoint theorem, each side of $\triangle DEF$ is half the corresponding side of $\triangle ABC$. So the sides of $\triangle DEF$ are 4 cm, 5 cm and 6 cm.

Perimeter = $4 + 5 + 6 = \mathbf{15 \text{ cm}}$, half the perimeter of $\triangle ABC$.

Example 8: Parts of a median

In $\triangle PQR$, the median PM is 12 cm long and G is the centroid. Find PG.

Solution: The centroid divides each median in the ratio 2:1. So $PG = \frac{1}{3} \times 12 = \mathbf{4 \text{ cm}}$. Check: $GM = \frac{2}{3} \times 12 = 8 \text{ cm}$.

Example 9: Fourth vertex of a parallelogram

A(1, 2), B(4, 3) and C(6, 6) are three vertices of a parallelogram ABCD. Find the coordinates of D.



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Solution: The diagonals AC and BD have the same midpoint. Midpoint of AC = $((1 + 6)/2, (2 + 6)/2) = (3.5, 4)$.

Let D = (x, y). Midpoint of BD = $((4 + x)/2, (3 + y)/2)$. So $(4 + x)/2 = 3.5$, giving $x = 3$, and $(3 + y)/2 = 4$, giving $y = 5$.

D = (3, 5). Shortcut check: $x_D = 1 + 6 - 4 = 3$ and $y_D = 2 + 6 - 3 = 5$.

Example 10: Parallelogram or rectangle

Show that A(-2, -1), B(1, 0), C(4, 3) and D(1, 2) are the vertices of a parallelogram. Is it a rectangle?

Solution: Midpoint of AC = $((-2 + 4)/2, (-1 + 3)/2) = (1, 1)$. Midpoint of BD = $((1 + 1)/2, (0 + 2)/2) = (1, 1)$.

The diagonals bisect each other, so ABCD is a parallelogram.

$AC = \sqrt{6^2 + 4^2} = \sqrt{52}$ and $BD = \sqrt{0^2 + 2^2} = 2$. Since $AC \neq BD$, ABCD is not a rectangle.

Example 11: Midpoint of the hypotenuse

$\triangle ABC$ is right-angled at C. A line through the midpoint M of AC at D. Prove that (i) D is the midpoint of BC.

Solution: (i) M is the midpoint of AB and MD is a line segment. M is the midpoint of AC.

(ii) $MD \parallel BC$ with transversal AC, so $\angle ADM = \angle BCM$.

(iii) In $\triangle ADM$ and $\triangle CDM$: $AD = CD$ (from (i)), $\angle ADM = \angle CDM$ (SAS) and $CM = AM$. Since M is the midpoint of AC, $AM = CM$.

Example 12: Trisecting a diagonal

In parallelogram ABCD, E and F are the midpoints of AD and BC respectively. EC and BF meet diagonal BD at P and Q respectively. Prove that P and Q trisect BD.

Solution: Let AF meet BD at P and EC meet BD at Q. In $\triangle ABP$ and $\triangle CQD$, $\angle ABP = \angle CQD$ (alternate angles), $\angle BAP = \angle DCQ$ (alternate angles), and $AB = CD$ (opposite sides of a parallelogram). $\therefore \triangle ABP \cong \triangle CQD$ (AAS). $\therefore BP = DQ$. Similarly, $BQ = DP$. $\therefore BP = PQ = DQ$. $\therefore P$ and Q trisect BD.



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$AE = AB/2$ and $CF = CD/2$, and $AB = CD$, so $AE = CF$. Also $AE \parallel CF$ (parts of $AB \parallel DC$). One pair of opposite sides of $AECF$ is equal and parallel, so $AECF$ is a parallelogram and $AF \parallel EC$.

In $\triangle DQC$, F is the midpoint of DC and $FP \parallel CQ$. By the converse of the midpoint theorem, P is the midpoint of DQ , so $DP = PQ$.

In $\triangle BPA$, E is the midpoint of AB and $EQ \parallel AP$. So Q is the midpoint of BP , and $BQ = PQ$.

So $DP = PQ = QB$, and BD is divided into three equal parts.

Competency-Based Questions (with answers)

1. Case-based: The folding gate

A shop has a folding metal gate made of steel rods. It is in the shape of a parallelogram $ABCD$ in which $AB = CD = 40$ cm and $AD = BC = 60$ cm. The gate opens and closes.

(a) What shape is each unit, whatever the position of the gate? (Test 1).

(b) When the gate is half open, $\angle A = 55^\circ$. Find $\angle B$ and $\angle D = 125^\circ$.

(c) At one position the two diagonals of a parallelogram with equal diagonals is a rectangle.

2. Assertion-Reason

Assertion (A): A 4-gon whose diagonals are equal is a rectangle.

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: (d). R is a true theorem. A is its converse. A parallelogram with equal diagonals is not a rectangle. Equal diagonals is already known to be a parallelogram.



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3. Assertion-Reason

Assertion (A): If the diagonals of a 4-gon bisect each other at right angles, the 4-gon is a rhombus. **Reason (R):** A parallelogram whose diagonals are perpendicular is a rhombus.

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). Diagonals that bisect each other make the 4-gon a parallelogram (Test 3). R then applies, because those diagonals are perpendicular, so the parallelogram is a rhombus.

4. Assertion-Reason

Assertion (A): In $\triangle ABC$, D and E are the midpoints of AB and AC. If $DE = 6$ cm, then $BC = 12$ cm. **Reason (R):** The medians of a triangle divide each other in the ratio $2 : 1$.

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: (b). A is true by the midpoint theorem. R is true, but it plays no part in finding BC.

5. Error analysis: Aman's proof

Aman writes: "In 4-gon ABCD, $AB \parallel DC$ and $AD \parallel BC$.

Find the error. One pair of sides parallel and one pair of sides equal, for example with parallel sides $AB \parallel DC$ and $AD = BC$, satisfies both conditions and is not a parallelogram. Sides need to be both equal and parallel (Test 4).

6. Coordinate case: The park plan

On a town map, three corners of a parallelogram are marked at $(1, 2)$, $(4, 3)$ and $(2, 5)$. The fourth corner is taken in order round the park.

(a) Find the fourth corner S. S is opposite to the corner at $(1, 2)$.

(b) A fountain is placed where the paths intersect. Find the coordinates of the fountain, the common midpoint of PR and QS: $((2 + 9)/2, (1 + 6)/2) = (5.5, 3.5)$. Check with QS: $((7 + 4)/2, (2 +$



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$$5)/2) = (5.5, 3.5).$$

7. Paper-folding activity: Midpoints of a 4-gon

Riya cuts out an irregular 4-gon, marks the midpoints of its four sides by folding each side end to end, and joins them in order. She measures the new 4-gon and finds that its opposite sides are equal.

(a) What shape will she always get? A parallelogram, for any 4-gon, by the midpoint 4-gon theorem.

(b) She repeats this on a rhombus. What does she get, and why? A rectangle. The sides of the midpoint 4-gon are parallel to the diagonals of the rhombus, and those diagonals are perpendicular, so adjacent sides of the new 4-gon are perpendicular.

(c) The diagonals of her original 4-gon are 14 cm and 11 cm. Find the perimeter of the midpoint 4-gon. Perimeter = sum of the diagonals =

8. Reasoning: Forming converses

Write the converse of "If a 4-gon is a square, then its diagonals are equal" and decide whether it is true.

Answer: Converse: "If the diagonals of a 4-gon are equal, then it is a square." It is false. Take a kite ABCD whose diagonals AC and BD meet at O with BO = OD = 5 cm, AO = 3 cm, and CO = 7 cm. The diagonals are equal, but the sides are not, so it is not even a parallelogram. Therefore, the converse is false.

Important Questions for Chapter 8

1-Mark Questions

- Three angles of a 4-gon are 90° , 90° and 90° . Find the fourth angle.
- One angle of a parallelogram is 65° . Find the other three angles.
- In $\triangle ABC$, D and E are the midpoints of AB and AC respectively. DE = 3 cm. Find BC.
- How many lines of symmetry does a rhombus have? How many diagonals?



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5. Find the midpoint of the segment joining $(-3, 4)$ and $(5, -2)$. $((-3 + 5)/2, (4 - 2)/2) = (1, 1)$.

2-Mark Questions

1. Can a 4-gon have angles 110° , 80° , 70° and 95° ? Give a reason. No. The sum is 355° , and the angles of a 4-gon must add to 360° .
2. Show that the diagonals of a rhombus are perpendicular to each other. Let the diagonals of rhombus ABCD meet at O. In $\triangle AOB$ and $\triangle AOD$, $AB = AD$, $OB = OD$ (diagonals bisect each other) and AO is common, so the triangles are congruent (SSS). Then $\angle AOB = \angle AOD$, and they form a linear pair, so each is 90° .
3. The median AD of $\triangle ABC$ is 9 cm. Find the distance of the centroid from A and from D. $AG = (2/3) \times 9 = 6$ cm and $GD = 3$ cm.
4. Three vertices of parallelogram ABCD are $A(3, -1)$, $B(5, 2)$ and $C(2, 4)$. Find D. $D = (3 + 2 - 5, -1 + 4 - 2) = (0, 1)$.

3-Mark Questions

1. Prove that a diagonal of a parallelogram bisects the other diagonal. In parallelogram ABCD with diagonal AC: $\angle DAC$ (alternate angles, $AD \parallel BC$), and $\angle BAC$ (alternate angles, $AB \parallel DC$). So $\angle DAC = \angle BAC$. In $\triangle AOD$ and $\triangle COB$, $\angle AOD = \angle COB$ (vertically opposite angles), $\angle DAC = \angle BAC$, and $AO = CO$ (diagonals bisect each other). So $\triangle AOD \cong \triangle COB$ (ASA). So $AO = CO$ and $BO = DO$. So ABCD is a parallelogram.
2. Show that if the diagonals of a 4-gon bisect each other, then the 4-gon is a parallelogram. Let ABCD be a quadrilateral with diagonals AC and BD intersecting at O such that $AO = CO$ and $BO = DO$. In $\triangle AOB$ and $\triangle COD$, $AO = CO$, $BO = DO$, and $\angle AOB = \angle COD$ (vertically opposite angles). So $\triangle AOB \cong \triangle COD$ (SAS). So $\angle OAB = \angle OCD$ (alternate angles), $AB \parallel DC$. Similarly, $AD \parallel BC$. So ABCD is a parallelogram.
3. ABCD is a rectangle and P, Q, R, S are the midpoints of the sides AB, BC, CD, DA respectively. Show that PQRS is a rhombus. By the midpoint theorem in $\triangle ABC$, $PQ \parallel AC$ and $PQ = AC/2$. Similarly, $SR \parallel AC$ and $SR = AC/2$. So $PQ \parallel SR$ and $PQ = SR$. Similarly, $PS \parallel QR$ and $PS = QR$. So PQRS is a parallelogram. In $\triangle ABD$, PS is the median to the hypotenuse BD. So $PS = BD/2$. Similarly, $QR = BD/2$. So $PS = QR$. A parallelogram with two adjacent sides equal is a rhombus. So PQRS is a rhombus.

5-Mark Questions

1. State and prove the midpoint theorem. The midpoint theorem states that the line segment joining the midpoints of two sides of a triangle is parallel to the third side and is half its length. Proof: Let E and F be the midpoints of sides AB and AC respectively in $\triangle ABC$. Join EF. In $\triangle AEF$ and $\triangle ABC$, $AE = AB/2$, $AF = AC/2$, and $\angle A$ is common. So $\triangle AEF \sim \triangle ABC$ (SAS). So $EF \parallel BC$ and $EF = BC/2$ (Test 4). So EF is parallel to BC and EF is half of BC. Similarly, the segment joining the midpoints of the other two sides is also parallel to the third side and half its length. So the segment joining the midpoints of the sides of a triangle is parallel to the third side and is half its length. perimeter 14 cm.



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2. **Prove that the 4-gon formed by joining the midpoints of the sides of a 4-gon, in order, is a parallelogram. When is it a rectangle?** With P, Q, R, S the midpoints of AB, BC, CD, DA: in $\triangle ABC$, $PQ \parallel AC$ and $PQ = AC/2$; in $\triangle ADC$, $SR \parallel AC$ and $SR = AC/2$. So $PQ = SR$ and $PQ \parallel SR$, and PQRS is a parallelogram by Test 4. $PQ \parallel AC$ and $PS \parallel BD$, so $\angle SPQ = 90^\circ$ exactly when $AC \perp BD$. The midpoint 4-gon is a rectangle when the diagonals of ABCD are perpendicular, as in a rhombus or a kite.

Common Mistakes and Examiner Tips

1. **Using a converse without proof.** A 4-gon with equal diagonals need not be a rectangle. Use only the proved tests.
 2. **Writing "opposite sides parallel" as a test when only one pair is known.** One parallel pair gives a trapezium. You need both pairs parallel, or one pair both equal and parallel.
 3. **Mixing up which pair is equal and parallel.** $AB \parallel DC$ with $AD = BC$ is not a parallelogram.
 4. **Assuming a parallelogram has equal diagonals.** A parallelogram with equal diagonals is a rectangle. Equal diagonals belong to rectangles, not parallelograms.
 5. **Taking a diagonal of a rectangle as a line segment.** In a square rectangle join the midpoints of opposite sides.
 6. **Getting the 2 : 1 ratio the wrong way round.** $AG = (2/3)AD$, $GD = (1/3)AD$. Write the ratio correctly.
 7. **Doubling instead of halving in the midpoint theorem.** The midpoint segment is half the base.
 8. **Wrong vertex order in the fourth-vertex rule.** Using $A + B - C$ gives the parallelogram with different vertex order.
 9. **Skipping reasons in proofs.** Give every step a reason (e.g., vertically opposite angles, corresponding angles, etc.).
 10. **Using 180° as the angle sum of a 4-gon.** The angle sum of a 4-gon is 360° .



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Quick Revision Points

- A 4-gon: four points, no three collinear, joined in order by sides that meet only at their ends
- Angle sum of any 4-gon = 360° ; at most three of its angles can be obtuse
- A diagonal splits a parallelogram into two congruent triangles (ASA)
- Parallelogram: opposite sides equal, opposite angles equal, adjacent angles supplementary
- Tests: both pairs of opposite sides equal, or both pairs of opposite angles equal, or diagonals bisect each other, or one pair of sides equal and parallel
- Rectangle: all angles 90° , diagonals equal; a parallelogram with equal diagonals is a rectangle
- Rhombus: all sides equal, diagonals perpendicular bisectors of each other and angle bisectors
- Square: rectangle and rhombus together; 4 lines of symmetry, rotation by 90°
- A 4-gon has central symmetry exactly when it is a parallelogram; the centre is where the diagonals meet
- Any 4-gon tiles the plane: the four angles at a vertex sum to 360°
- Midpoint theorem: $EF \parallel BC$ and $EF = \frac{1}{2}BC$
- Midpoints of the sides of any 4-gon form a parallelogram
- Midpoint 4-gon of a rhombus is a rectangle
- Medians are concurrent at the centroid
- Midpoint = $((x_1 + x_2)/2, (y_1 + y_2)/2)$
- Fourth vertex of ABCD: $D = (x_A + x_C - x_B, y_A + y_C - y_B)$



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Weightage and Exam Pattern

Class 9 has no board exam. Quadrilaterals is a chapter in the yearly exam and the annual exam. In the CBSE 2021-22, the chapter appears as "4-gons (Quadrilaterals)" and carries **6 marks** out of the 80-mark theory paper and the practical paper. It does not split the 25 marks between the first and second assessment.

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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 CBSE question paper design weights questions by typology: about 54% remembering and understanding, 24% applying, and 22% analysing, evaluating and creating. Here that means properties of special 4-gons, calculations and proofs such as the parallelogram tests and

The course structure also expects drawing and discover patterns involving triangles and 4. Question 7. Internal assessment includes a prescribed books. The midpoint theorem and chapters on triangles and coordinate geometry



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