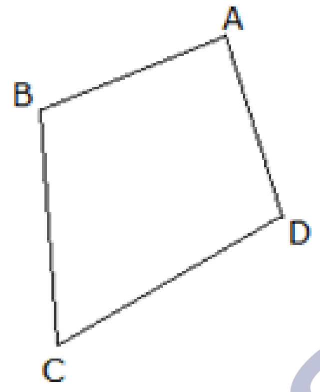
# MATHEMATICS

## Chapter 8: Quadrilaterals

# Quadrilaterals

## Quadrilateral

A **quadrilateral** is a closed figure obtained by joining four points (with no three points collinear) in an order.




Here, ABCD is a quadrilateral.

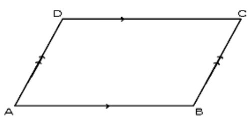
**Parts of a quadrilateral**

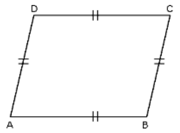
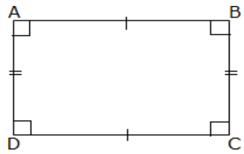
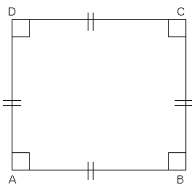
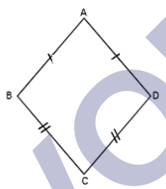
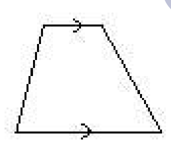
- A quadrilateral has four sides, four angles and four vertices.
- Two sides of a quadrilateral having no common end point are called its **opposite sides**.
- Two sides of a quadrilateral having a common end point are called its **adjacent sides**.
- Two angles of a quadrilateral having common arm are called its **adjacent angles**.
- Two angles of a quadrilateral not having a common arm are called its **opposite angles**.
- A **diagonal** is a line segment obtained on joining the opposite vertices.

**Angle sum property of a quadrilateral**

Sum of all the angles of a quadrilateral is 360°. This is known as the **angle sum property of a quadrilateral**.

**Types of quadrilaterals and their properties:**

| Name of a quadrilateral | Properties |
|---|---|
| Parallelogram: A quadrilateral with each pair of opposite sides parallel.   | i. Opposite sides are equal.<br>ii. Opposite angles are equal.<br>iii. Diagonals bisect one another. |

| | |
|---|---|
| **Rhombus**: A parallelogram with sides of equal length.  | i. All properties of a parallelogram.<br>ii. Diagonals are perpendicular to each other. |
| **Rectangle**: A parallelogram with all angles right angle.  | i. All the properties of a parallelogram.<br>ii. Each of the angles is a right angle.<br>iii. Diagonals are equal. |
| Square: A rectangle with sides of equal length.  | All the properties of a parallelogram, a rhombus and a rectangle. |
| **Kite**: A quadrilateral with exactly two pairs of equal consecutive sides.  | i. The diagonals are perpendicular to one another.<br>ii. One of the diagonals bisects the other.<br>iii. If ABCD is a kite, then $\angle B = \angle D$ but $\angle A \neq \angle C$ |
| **Trapezium**: A quadrilateral with one pair of opposite sides parallel is called trapezium.  | One pair of opposite sides parallel. |

**Important facts about quadrilaterals**

- If the non-parallel sides of trapezium are equal, it is known as **isosceles trapezium**.
- Square, rectangle and rhombus are all parallelograms.
- Kite and trapezium are not parallelograms.
- A square is a rectangle.
- A square is a rhombus.
- A parallelogram is a trapezium.

**A quadrilateral is a parallelogram if:**

- **i.** each pair of opposite sides of a quadrilateral is equal, or
- **ii.** each pair of opposite angles is equal, or
- **iii.** the diagonals of a quadrilateral bisect other, or
- **iv.** each pair of opposite sides is equal and parallel.

**Mid-Point Theorem**

The line segment joining the mid-points of any two sides of a triangle is parallel to the third side and equal to half of it.

**Converse of mid-point theorem**

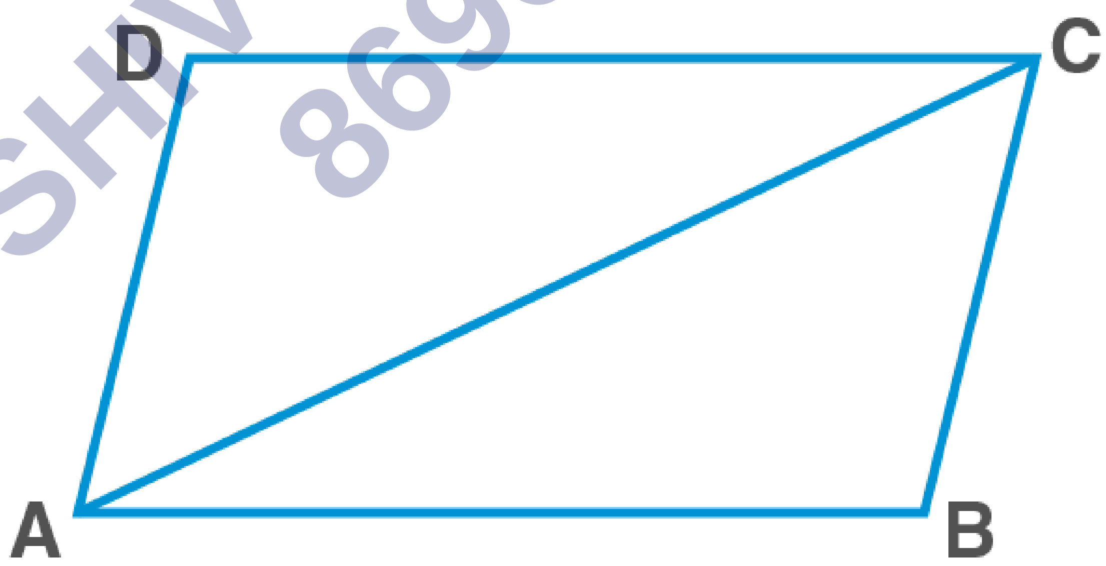
The line drawn through the mid-point of one side of a triangle, parallel to another side, bisects the third side.

**Formation of a new quadrilateral using the given data**

- If the diagonals of a parallelogram are equal, then it is a rectangle.
- If the diagonals of a quadrilateral bisect each other at right angles, then it is a rhombus.
- If the diagonals of a quadrilateral are equal and bisect each other at right angles, then it is a square.

If there are three or more parallel lines and the intercepts made by them on a transversal are equal, then the corresponding intercepts on any other transversal are also equal.

## Parallelogram: Opposite sides of a parallelogram are equal




In ΔABC and ΔCDA

AC = AC [Common / transversal]

∠BCA = ∠DAC [alternate angles]

∠BAC = ∠DCA [alternate angles]

ΔABC ≅ ΔCDA [ASA rule]

Hence,

AB = DC and AD= BC [ C.P.C.T.C]

Opposite angles in a parallelogram are equal


In parallelogram ABCD

AB || CD; and AC is the transversal

Hence, ∠1 = ∠3 .... (1) (alternate interior angles)

BC || DA; and AC is the transversal

Hence, ∠2 = ∠4 .... (2) (alternate interior angles)

Adding (1) and (2)

∠1 + ∠2 = ∠3 + ∠4

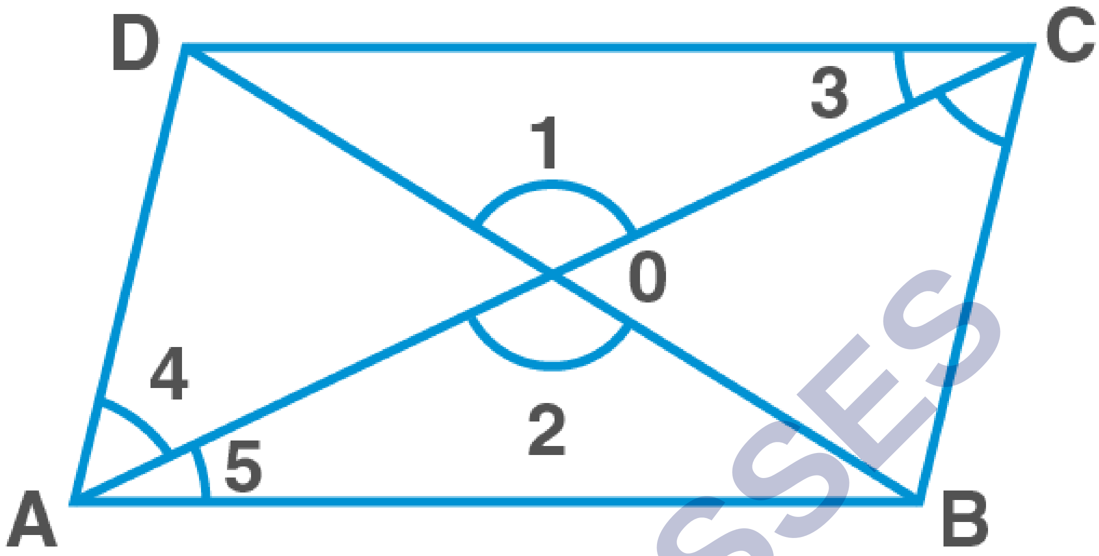
∠BAD = ∠BCD

Similarly,

∠ADC = ∠ABC

**Properties of diagonal of a parallelogram**

Diagonals of a parallelogram bisect each other.




In ΔAOB and ΔCOD,

∠3 = ∠5 [alternate interior angles]

∠1 = ∠2 [vertically opposite angles]

AB = CD [opp. Sides of parallelogram]

ΔAOB ≅ ΔCOD [AAS rule]

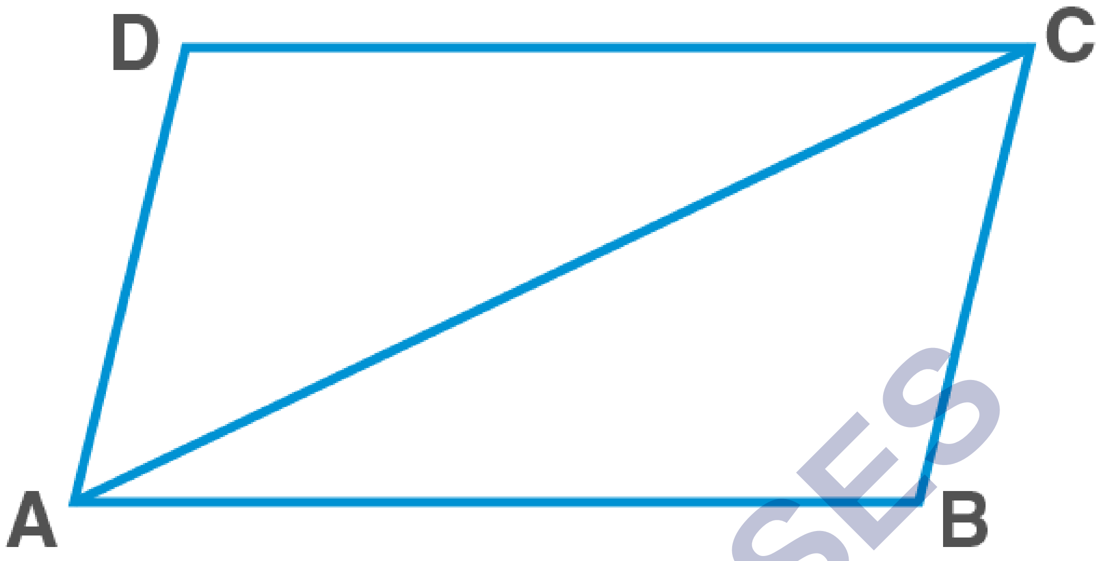
OB = OD and OA = OC [C.P.C.T]

Hence, proved

Conversely,

If the diagonals of a quadrilateral bisect each other, then it is a parallelogram.

Diagonal of a parallelogram divides it into two congruent triangles.




In ΔABC and ΔCDA,

AB = CD [Opposite sides of parallelogram]

BC = AD [Opposite sides of parallelogram]

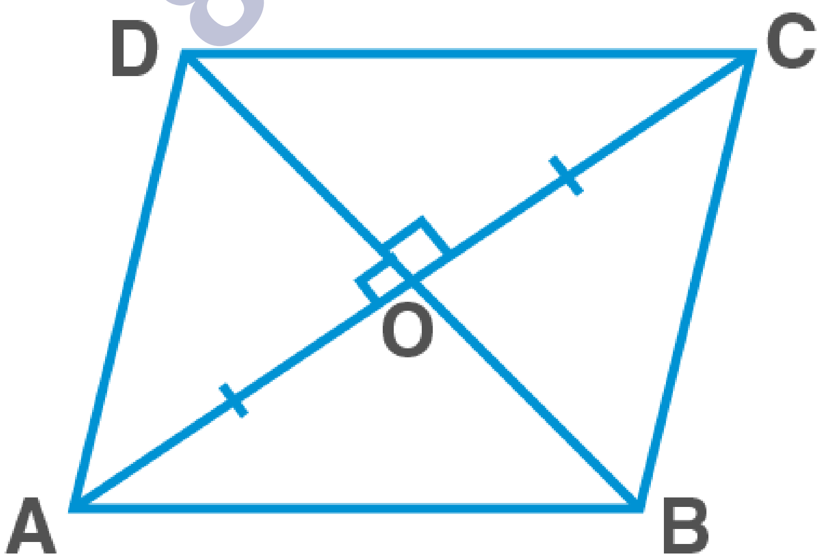
AC = AC [Common side]

ΔABC ≅ ΔCDA [by SSS rule]

Hence, proved.

**Diagonals of a rhombus bisect each other at right angles**

Diagonals of a rhombus bisect each – other at right angles



In ΔAOD and ΔCOD,

OA = OC [Diagonals of parallelogram bisect each other]

OD = OD [Common side]

AD = CD [Adjacent sides of a rhombus]

ΔAOD ≅ ΔCOD [SSS rule]

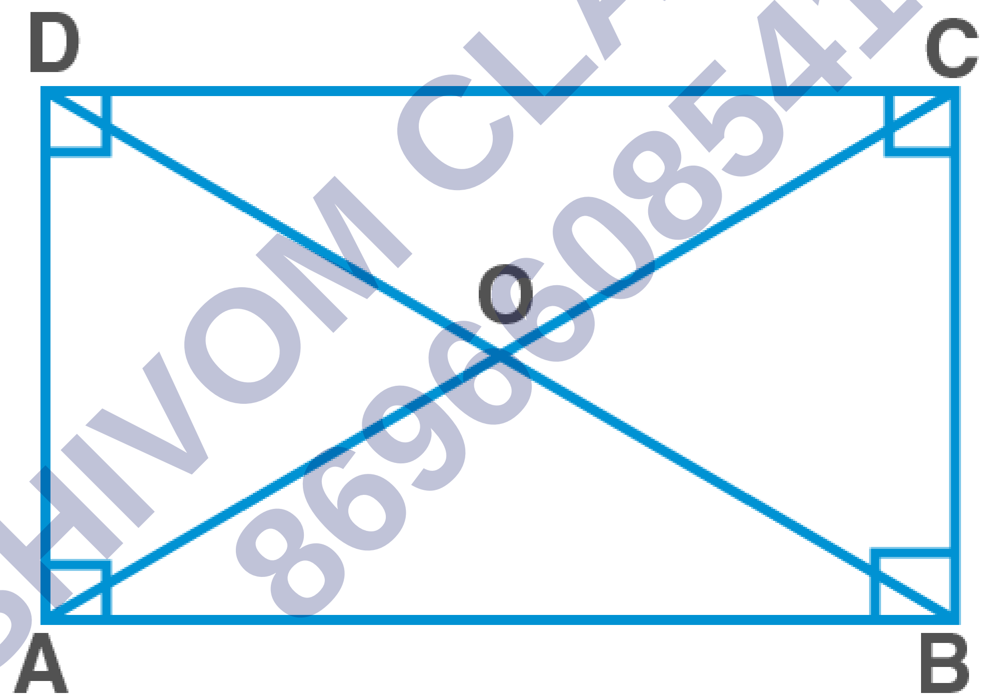
∠AOD = ∠DOC [C.P.C.T]

∠AOD + ∠DOC = 180 [∵ AOC is a straight line]

Hence, ∠AOD = ∠DOC = 90

Hence proved.

**Diagonals of a rectangle bisect each other and are equal**




Rectangle ABCD

In ΔABC and ΔBAD,

AB = BA [Common side]

BC = AD [Opposite sides of a rectangle]

∠ABC = ∠BAD [Each = 900 ∵ ABCD is a Rectangle]

ΔABC ≅ ΔBAD [SAS rule]

∴AC = BD [C.P.C.T]

Consider ΔOAD and ΔOCB,

AD = CB [Opposite sides of a rectangle]

∠OAD = ∠OCB [∵ AD||BC and transversal AC intersects them]

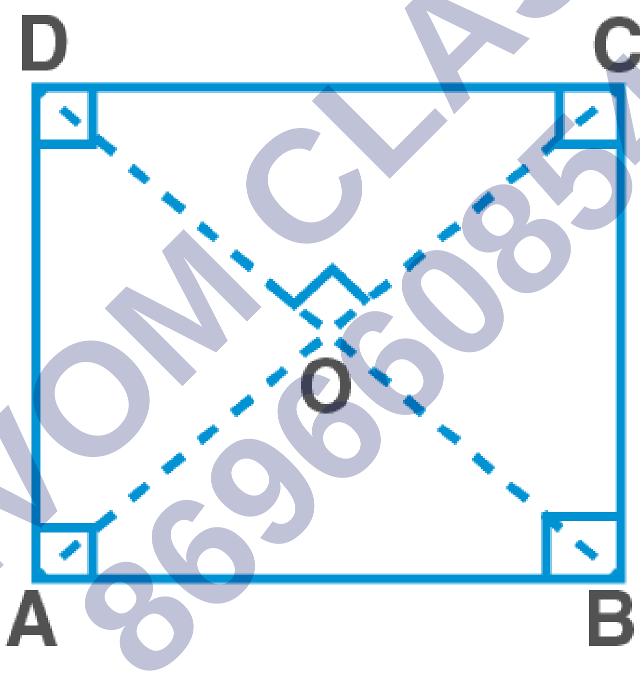
∠ODA = ∠OBC [∵ AD||BC and transversal BD intersects them]

ΔOAD ≅ ΔOCB [ASA rule]

∴OA = OC [C.P.C.T]

Similarly, we can prove OB=OD

**Diagonals of a square bisect each other at right angles and are equal**






In ΔABC and ΔBAD,

AB = BA [Common side]

BC = AD [Opposite sides of a Square]

∠ABC = ∠BAD [Each = 900 ∵ ABCD is a Square]

ΔABC ≅ ΔBAD [SAS rule]

∴ AC = BD [C.P.C.T]

Consider ΔOAD and ΔOCB,

AD = CB [Opposite sides of a Square]

∠OAD = ∠OCB [∵ AD||BC and transversal AC intersects them]

∠ODA = ∠OBC [∵ AD||BC and transversal BD intersects them]

ΔOAD ≅ ΔOCB [ASA rule]

∴ OA = OC [C.P.C.T]

Similarly, we can prove OB=OD

In ΔOBA and ΔODA,

OB = OD [ proved above]

BA = DA [Sides of a Square]

OA = OA [ Common side]

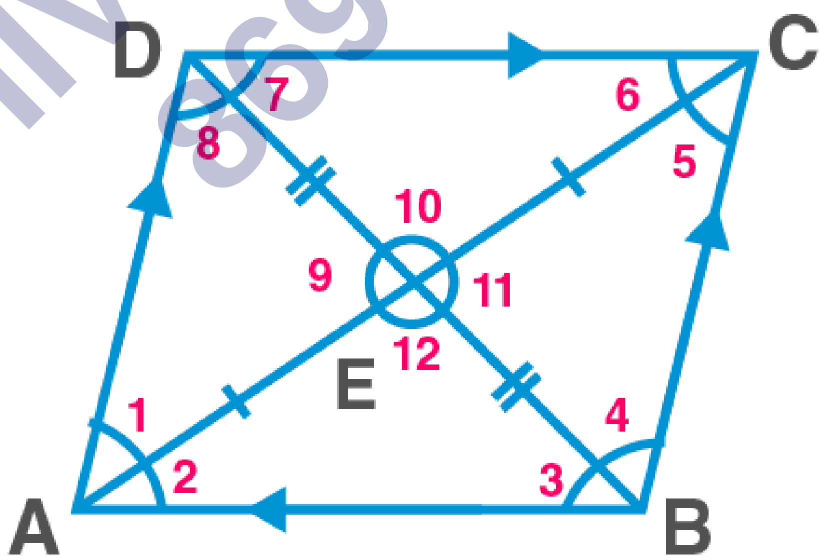
ΔOBA ≅ ΔODA, [ SSS rule]

∴ ∠AOB = ∠AOD [ C.P.C.T]

But ∠AOB + ∠AOD = 1800 [ Linear pair]

∴ ∠AOB = ∠AOD = $90^0$

Important results related to parallelograms




Opposite sides of a parallelogram are parallel and equal.

AB||CD, AD||BC, AB = CD, AD = BC

Opposite angles of a parallelogram are equal adjacent angels are supplementary.

$\angle A = \angle C$, $\angle B = \angle D$,

$\angle A + \angle B = 1800$, $\angle B + \angle C = 1800$, $\angle C + \angle D = 1800$, $\angle D + \angle A = 1800$

A diagonal of parallelogram divides it into two congruent triangles.

$\Delta ABC \cong \Delta CDA$ [With respect to AC as diagonal]

$\Delta ADB \cong \Delta CBD$ [With respect to BD as diagonal]

The diagonals of a parallelogram bisect each other.

AE = CE, BE = DE

$\angle 1 = \angle 5$ (alternate interior angles)

$\angle 2 = \angle 6$ (alternate interior angles)

$\angle 3 = \angle 7$ (alternate interior angles)

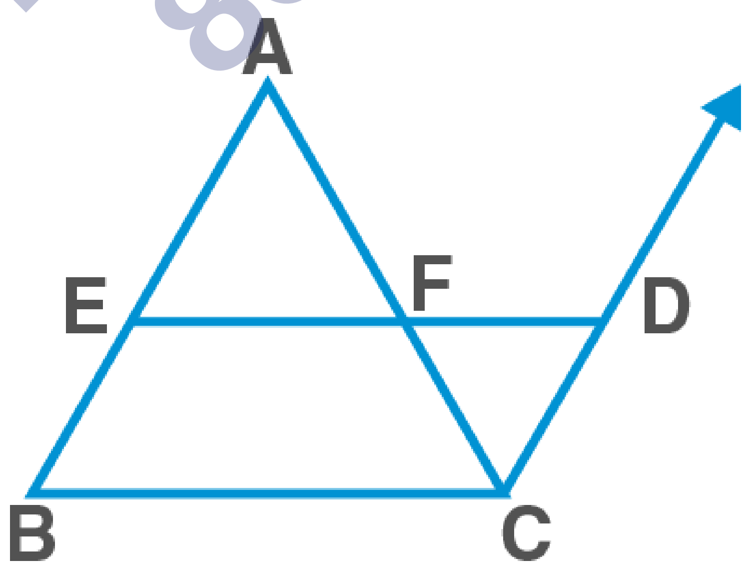
$\angle 4 = \angle 8$ (alternate interior angles)

$\angle 9 = \angle 11$ (vertically opp. angles)

$\angle 10 = \angle 12$ (vertically opp. angles)

**The Mid-Point Theorem**

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




In $\Delta ABC$, E – the midpoint of AB; F – the midpoint of AC

Construction: Produce EF to D such that EF = DF.

In ΔAEF and ΔCDF,

AF = CF [F is the midpoint of AC]

∠AFE = ∠CFD [ V.O.A]

EF = DF [Construction]

∴ ΔAEF ≅ ΔCDF [SAS rule]

Hence,

∠EAF = ∠DCF …. (1)

DC = EA = EB [E is the midpoint of AB]

DC ∥ EA ∥ AB [Since, (1), alternate interior angles]

DC ∥ EB

So EBCD is a parallelogram

Therefore, BC = ED and BC ∥ ED

Since ED = EF + FD = 2EF = BC [ ∵ EF=FD]

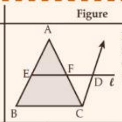
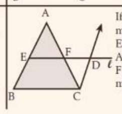
We have, EF = 12 BC and EF||BC

Hence proved.

**Class : 9th mathematics**
**Chapter- 8: Quadrilaterals**

# Quadrilaterals

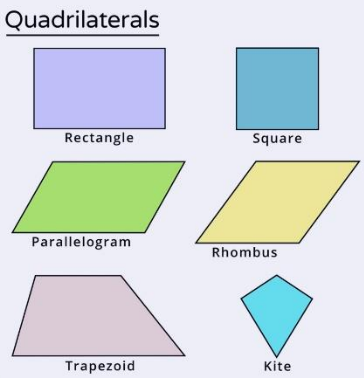
## Mid-point theorem

| Statement | Figure | |
|---|---|---|
| The line-segment joining the mid-points of two sides of a triangle is parallel to the third side. |  | If E and F are mid-point of AB and AC, then EF \|\| BC |
| The line drawn through the mid-point of one side of a triangle, parallel to another side bisects the third side |  | If E is the mid-point of AB EF \|\| BC, then AF = FC, F is the mid-point of AC |

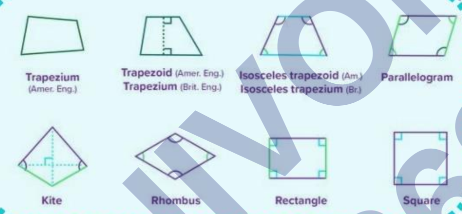
## Quadrilateral

Figure formed by joining four points in an order

It has four - vertices, angles and sides each



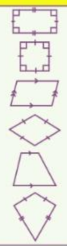

## Types




| Sides and angles | Square | Rectangle | Rhombus | Parallelogram | Trapezium |
|---|---|---|---|---|---|
| All sides are equal | Yes | No | Yes | No | No |
| Opposite sides are parallel | Yes | Yes | Yes | Yes | Yes |
| Opposite sides are equal | Yes | Yes | Yes | Yes | No |
| All the angles are of the same measure | Yes | Yes | No | No | No |
| Opposite angles are of equal measure | Yes | Yes | Yes | Yes | No |
| Diagonals bisect each other | Yes | Yes | Yes | Yes | No |
| Two adjacent angles are supplementary | Yes | Yes | Yes | Yes | No |

## Properties

| Quadrilateral | Properties |
|---|---|
| Rectangle | 4 right angles and opposite sides equal |
| Square | 4 right angles and 4 equal sides |
| Parallelogram | Two pairs of parallel sides and opposite sides equal |
| Rhombus | Parallelogram with 4 equal sides |
| Trapezoid | Two sides are parallel |
| Kite | Two pairs of adjacent sides of the same length |



# Important Questions

## Multiple Choice questions-

Question 1. A diagonal of a Rectangle is inclines to one side of the rectangle at an angle of 25°. The Acute Angle between the diagonals is:

(a) 115°

(b) 50°

(c) 40°

(d) 25°

Question 2. The diagonals of a rectangle PQRS intersects at O. If ∠QOR = 44°, ∠OPS =?

(a) 82°

(b) 52°

(c) 68°

(d) 75°

Question 3. If angles A, B, C and D of the quadrilateral ABCD, taken in order, are in the ratio 3:7:6:4, then ABCD is

(a) Rhombus

(b) Parallelogram

(c) Trapezium

(d) Kite

Question 4. All the angles of a convex quadrilateral are congruent. However, not all its sides are congruent. What type of quadrilateral is it?

(a) Parallelogram

(b) Square

(c) Rectangle

(d) Trapezium

Question 5. In a Quadrilateral ABCD, AB = BC and CD = DA, then the quadrilateral is a

(a) Triangle

(b) Kite

(c) Rhombus

(d) Rectangle

Question 6. The angles of a quadrilateral are (5x)°, (3x + 10)°, (6x – 20)° and (x

+ 25)°. Now, the measure of each angle of the quadrilateral will be

(a) 115°, 79°, 118°, 48°

(b) 100° 79°, 118°, 63°

(c) 110°, 84°, 106°, 60°

(d) 75°, 89°, 128°, 68°

Question 7. The diagonals of rhombus are 12 cm and 16 cm. The length of the side of rhombus is:

(a) 12cm

(b) 16cm

(c) 8cm

(d) 10cm

Question 8. In quadrilateral PQRS, if ∠P = 60° and ∠Q: ∠R : ∠S = 2 : 3 : 7, then ∠S =

(a) 175°

(b) 210°

(c) 150°

(d) 135°

Question 9. In parallelogram ABCD, if ∠A = 2x + 15°, ∠B = 3x – 25°, then value of x is:

(a) 91°

(b) 89°

(c) 34°

(d) 38°

Question 10. If ABCD is a trapezium in which AB || CD and AD = BC, then:

(a) ∠A = ∠B

(b) ∠A > ∠B

(c) ∠A < ∠B

(d) None of the above

## Very Short:

1. If one angle of a parallelogram is twice of its adjacent angle, find the angles of the parallelogram.

2. If the diagonals of a quadrilateral bisect each other at right angles, then name the

quadrilateral.

3. Three angles of a quadrilateral are equal, and the fourth angle is equal to 144o. Find each of the equal angles of the quadrilateral.

4. If ABCD is a parallelogram, then what is the measure of ∠A – ∠C?

5. PQRS is a parallelogram, in which PQ = 12 cm and its perimeter is 40 cm. Find the length of each side of the parallelogram.

6. Two consecutive angles of a parallelogram are (x + 60)° and (2x + 30)°. What special name can you give to this parallelogram?

7. ONKA is a square with ∠KON = 45°. Determine ∠KOA.

8. In quadrilateral PQRS, if ∠P = 60° and ∠Q : ∠R : ∠S = 2 : 3 : 7, then find the measure of ∠S.

## Short Questions:

1. ABCD is a parallelogram in which ∠ADC = 75° and side AB is produced to point E as shown in the figure. Find x + y.
2. If the diagonals of a parallelogram are equal, then show that it is a rectangle.
3. In the figure, ABCD is a rhombus, whose diagonals meet at O. Find the values of x and y.
4. ABCD is a parallelogram and AP and CQ are perpendiculars from vertices A and C on diagonal BD (see fig.). Show that:

   (i) ΔAPB = ΔCQD

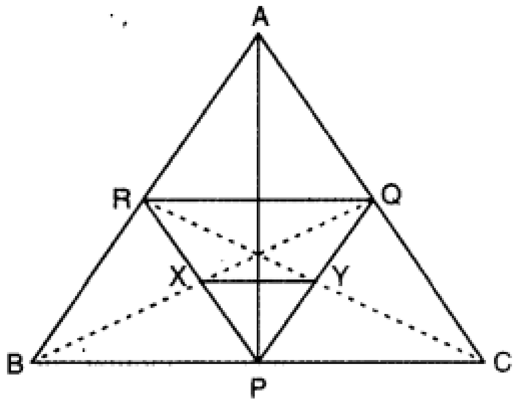
   (ii) AP = CQ
5. The diagonals of a quadrilateral ABCD are perpendicular to each other. Show that the quadrilateral formed by joining the mid-points of its sides is a rectangle.


6. In the fig., D, E and F are, respectively the mid-points of sides BC, CA and AB of an equilateral triangle ABC. Prove that DEF is also an equilateral triangle.

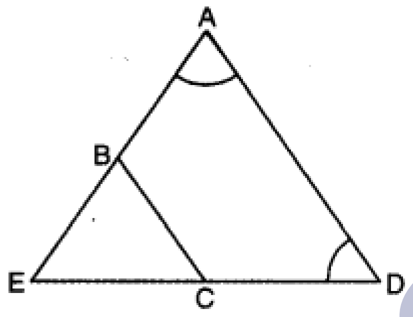
B D C

## Long Questions:

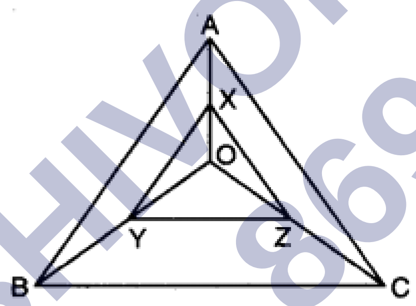
1. In the figure, P, Q and R are the mid-points of the sides BC, AC and AB of ΔABC. If BQ and PR intersect at X and CR and PQ intersect at Y, then show that $XY = \frac{1}{4}$ BC



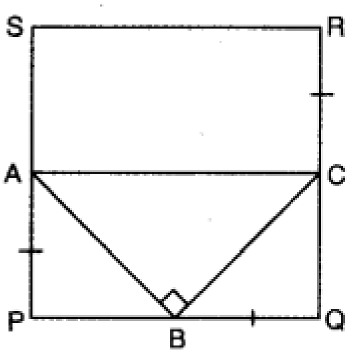

2. In the given figure, AE = DE and BC || AD. Prove that the points A, B, C and D are concyclic. Also, prove that the diagonals of the quadrilateral ABCD are equal.




3. In ΔABC, AB = 8cm, BC = 9 cm and AC = 10cm. X, Y and Z are mid-points of AO, BO and CO respectively as shown in the figure. Find the lengths of the sides of ΔXYZ.




4. PQRS is a square and ∠ABC = 90° as shown in the figure. If AP = BQ = CR, then prove that ∠BAC = 45°




5. ABCD is a parallelogram. If the bisectors DP and CP of angles D and C meet at P on side AB, then show that P is the mid-point of side AB.

## Assertion and Reason Questions-

**1.** In these questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

**Assertion:** ABCD is a square. AC and BD intersect at O. The measure of +AOB = 90°.

**Reason:** Diagonals of a square bisect each other at right angles.

**2.** In these questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

c) Assertion is correct statement but reason is wrong statement.

d) Assertion is wrong statement but reason is correct statement.

**Assertion:** The consecutive sides of a quadrilateral have one common point.

**Reason:** The opposite sides of a quadrilateral have two common point.

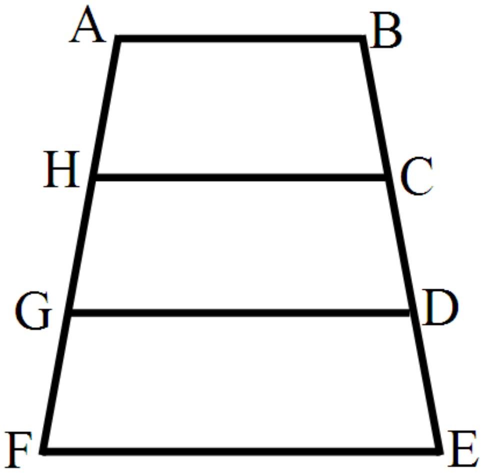


## Case Study Questions-

**1.** Read the Source/ Text given below and answer these questions:

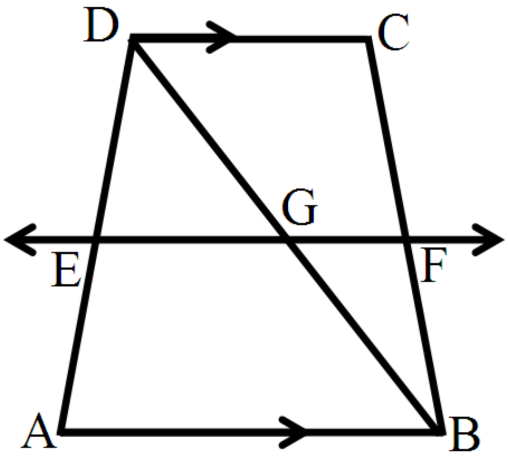

Sohan wants to show gratitude towards his teacher by giving her a card made by him. He has three pieces of trapezium pasted one above the other as shown in fig. These pieces are arranged in a way that AB || HC || GD || FE. Also BC =

CD = DE and AH = HG = GF = 6cm. He wants to decorate the card by putting up a colored tape on the nonparallel sides of the trapezium.




i. Find the total length of colored tape required if DE = 4cm.
   a. 20cm
   b. 30cm
   c. 40cm
   d. 50cm
ii. ABHC is a trapezium in which AB || HC and ∠A=∠B=45∘. Find angles C and H of the trapezium.
   a. 135, 130
   b. 130, 135
   c. 135, 135
   d. 130, 130
iii. What is the difference between trapezium and parallelogram?
   a. Trapezium has 2 sides, and parallelogram has 4 sides.
   b. Trapezium has 4 sides, and parallelogram has 2 sides.
   c. Trapezium has 1 pair of parallel sides, and parallelogram has 2 pairs of parallel sides.
   d. Trapezium has 2 pairs of parallel sides, and parallelogram has 1 pair of parallel sides.
iv. Diagonals in isosceles trapezoid are ________.
   a. parallel.
   b. opposite.
   c. vertical.
   d. equal.

v. ABCD is a trapezium where AB || DC, BD is the diagonal and E is the midpoint of AD. A line is drawn through E parallel to AB intersecting BC at F. Which of these is true?




a. BF = FC

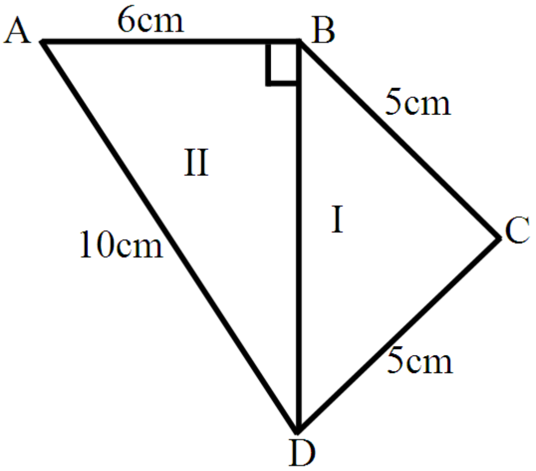
b. EA = FB

c. CF = DE

d. None of these

**2.** Read the Source/ Text given below and answer any four questions:

Chocolate is in the form of a quadrilateral with sides 6cm and 10cm, 5cm and 5cm(as shown in the figure) is cut into two parts on one of its diagonal by a lady. Part-I is given to her maid and part II is equally divided among a driver and gardener.




i. Length of BD:
   a. 9cm
   b. 8cm
   c. 7cm
   d. 6cm
ii. Area of △ABC:
   a. $24cm^2$
   b. $12cm^2$
   c. $42cm^2$
   d. $21cm^2$
iii. The sum of all the angles of a quadrilateral is equal to:
   a. 180°
   b. 270°
   c. 360°
   d. 90°
iv. A diagonal of a parallelogram divides it into two congruent:
   a. Square.
   b. Parallelogram.
   c. Triangles.
   d. Rectangle.
v. Each angle of the rectangle is:
   a. More than 90°
   b. Less than 90°
   c. Equal to 90°

d. Equal to 45°

## Answer Key:

## MCQ:

1. (b) 50°
2. (c) 68°
3. (c) Trapezium
4. (c) Rectangle
5. (b) Kite
6. (a) 115°, 79°, 118°, 48°
7. (d) 10cm
8. (a) 175°
9. (d) 38°
10. (a) ∠A = ∠B

## Very Short Answer:

1. Let the two adjacent angles be x and 2x.

   In a parallelogram, sum of the adjacent angles are 180°

   $\therefore x + 2x = 180°$

   $\Rightarrow 3x = 180°$

   $\Rightarrow x = 60°$

   Thus, the two adjacent angles are 120° and 60°. Hence, the angles of the parallelogram are 120°, 60°, 120° and 60°.

2. Rhombus.
3. Let each equal angle of given quadrilateral be x.

   We know that sum of all interior angles of a quadrilateral is 360°

   $\therefore x + x + x + 144° = 360°$

   $3x = 360° - 144°$

   $3x = 216°$

   $x = 72°$

   Hence, each equal angle of the quadrilateral is of 72o measures.

4. ∠A – ∠C = 0° (opposite angles of parallelogram are equal]
5. 


Here, PQ = SR = 12 cm

Let PS = x and PS = QR

$\therefore x + 12 + x + 12 = \text{Perimeter}$

2x + 24 = 40

2x = 16

x= 8

Hence, length of each side of the parallelogram is 12cm, 8 cm, 12cm and 8cm.

6. We know that consecutive interior angles of a parallelogram are supplementary.

∴ (x + 60° + (2x + 30)° = 180°

⇒ 3x° + 90° = 180°

⇒ 3x° = 90°

⇒ x° = 30°

Thus, two consecutive angles are (30 + 60)°, 12 x 30 + 30)”. i.e., 90° and 90°.

Hence, the special name of the given parallelogram is rectangle.

7. Since ONKA is a square

∴ ∠AON = 90°

We know that diagonal of a square bisects its ∠s

⇒ ∠AOK = ∠KON = 45°

Hence, ∠KOA = 45°

Now, ∠A + ∠B + ∠C = 180°

⇒ ∠A + 70° + 70° = 180°

[∵ ∠B = 70°]

⇒ ∠A = 180° – 70° – 70° = 40°

8. Let ∠Q = 2x, ∠R = 3x and ∠S = 7x

Now, ∠P + ∠Q + ∠R + ∠S = 360°

⇒ 60° + 2x + 3x + 7x = 360°

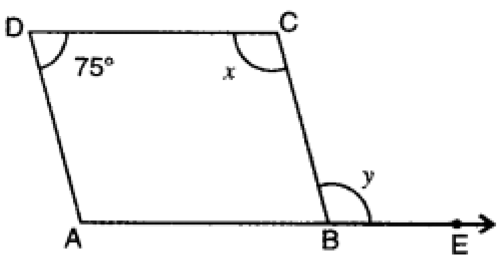
⇒ 12x = 300°

$X = \frac{300°}{12} = 25°$

∠S = 7x = 7 x 25° = 175°

## Short Answer:

**Ans: 1.**




Here, ∠C and ∠D are adjacent angles of the parallelogram.

∴ ∠C + ∠D = 180°

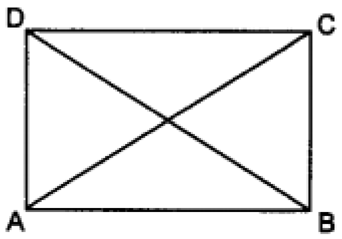
⇒ x + 75° = 180°

⇒ x = 105°

Also, y = x = 105° [alt. int. angles]

Thus, x + y = 105° + 105° = 210°

**Ans: 2**.




Given: A parallelogram ABCD, in which AC = BD.

To Prove: ΔBCD is a rectangle.

Proof: In ΔABC and ΔBAD

AB = AB (common]

AC = BD (given]

BC = AD (opp. sides of a ||gm]

⇒ ΔABC ≅ ΔBAD

[by SSS congruence axiom]

⇒ ∠ABC = ∠BAD (c.p.c.t.)

Also, ∠ABC + ∠BAD = 180° (co-interior angles)

∠ABC + ∠ABC = 180° [ ∵ ∠ABC = ∠BAD]

2∠ABC = 180°

∠ABC = 1/2 x 180° = 90°

Hence, parallelogram ABCD is a rectangle.

**Ans: 3.** Since diagonals of a rhombus bisect each other at right angle.

In ∴ ΔAOB, we have

∠OAB + ∠x + 90° = 180°

∠x = 180° – 90° – 35°

= 55°

Also,

∠DAO = ∠BAO = 35°

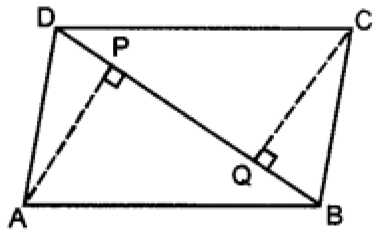
∠y + ∠DAO + ∠BAO + ∠x = 180°

⇒ ∠y + 35° + 35° + 55° = 180°

⇒ ∠y = 180° – 125o = 55°

Hence, the values of x and y are x = 55°, y = 55

**Ans: 4.**




Given: In ||gm ABCD, AP and CQ are perpendiculars from the vertices A and C on the diagonal BD.

To Prove: (i) ΔAPB ≅ ΔCQD

(ii) AP = CQ

Proof: (i) In ΔAPB and ΔCQD

AB = DC (opp. sides of a ||gm ABCD]

∠APB = ∠DQC (each = 90°)

∠ABP = ∠CDQ (alt. int. ∠s]

⇒ ΔAPB ≅ ΔCQD [by AAS congruence axiom]

(ii) ⇒ AP = CQ [c.p.c.t.]

**Ans: 5.** Given: A quadrilateral ABCD whose diagonals AC and BD are perpendicular to each other at O. P, Q, R and S are mid-points of side AB, BC, CD and DA respectively are joined are formed quadrilateral PQRS.

To Prove: PQRS is a rectangle.

Proof: In ΔABC, P and Q are mid-points of AB and BC respectively.

∴ PQ || AC and PQ = $\frac{1}{2}$ AC … (i) (mid-point theorem]

Further, in SACD, R and S are mid-points of CD and DA respectively.

SR || AC and SR = $\frac{1}{2}$ AC … (ii) (mid-point theorem]

From (i) and (ii), we have PQ || SR and PQ = SR

Thus, one pair of opposite sides of quadrilateral PQRS are parallel and equal.

∴ PQRS is a parallelogram.

Since PQ|| AC PM || NO

In ΔABD, P and S are mid-points of AB and AD respectively.

PS || BD (mid-point theorem]

⇒ PN || MO

∴ Opposite sides of quadrilateral PMON are parallel.

∴ PMON is a parallelogram.

∠ MPN = ∠ MON (opposite angles of ||gm are equal]

But ∠MON = 90° [given]

∴ ∠MPN = 90° ⇒ ∠QPS = 90°

Thus, PQRS is a parallelogram whose one angle is 90°

∴ PQRS is a rectangle.

**Ans: 6.** Since line segment joining the mid-points of two sides of a triangle is half of the third side.

Therefore, D and E are mid-points of BC and AC respectively.

⇒ DE = $\frac{1}{2}$AB ...(i)

E and F are the mid-points of AC and AB respectively.

∴ EF = $\frac{1}{2}$BC ... (ii)

F and D are the mid-points of AB and BC respectively.

∴ FD = $\frac{1}{2}$ AC ... (iii)

Now, SABC is an equilateral triangle.

⇒ AB = BC = CA

⇒ $\frac{1}{2}$AB = $\frac{1}{2}$BC = $\frac{1}{2}$CA

⇒ DE = EF = FD (using (i), (ii) and (iii)]

Hence, DEF is an equilateral triangle

## Long Answer:

**Ans: 1**. Here, in ΔABC, R and Q are the mid-points of AB and AC respectively.

∴ By using mid-point theorem, we have

RQ || BC and RQ = $\frac{1}{2}$ BC

∴ RQ = BP = PC [∵ P is the mid-point of BC]

∴ RQ || BP and RQ || PC

In quadrilateral BPQR

RQ || BP, RQ = BP (proved above)

∴ BPQR is a parallelogram. [∵ one pair of opp. sides is parallel as well as equal]

∴ X is the mid-point of PR. [∵ diagonals of a ||gm bisect each other]

Now, in quadrilateral PCQR

RQ || PC and RQ = PC [proved above)

∴ PCQR is a parallelogram [∵ one pair of opp. sides is parallel as well as equal]

∴ Y is the mid-point of PQ [∵ diagonals of a ||gm bisect each other]

In ΔPQR

∴ X and Y are mid-points of PR and PQ respectively.

$\therefore XY \parallel RQ$ and $XY = \frac{1}{2}RQ$ [by using mid-point theorem]

$XY = \frac{1}{2}\left(\frac{1}{2}BC\right)$ [$\because RQ = \frac{1}{2}BC$]

$\Rightarrow XY = \frac{1}{4}BC$

**Ans: 2.** Since AE = DE

∠D = ∠A .... (i) [∵ ∠s opp. to equal sides of a Δ]

Again, BC || AD

∠EBC = ∠A .... (ii) (corresponding ∠s]

From (i) and (ii), we have

∠D = ∠EBC .... (iii)

But ∠EBC + ∠ABC = 180° (a linear pair]

∠D + ∠ABC = 180° (using (iii)]

Now, a pair of opposite angles of quadrilateral ABCD is supplementary

Thus, ABCD is a cyclic quadrilateral i.e., A, B, C and D'are concyclic. In ΔABD and ΔDCA

∠ABD = ∠ACD [∠s in the same segment for cyclic quad. ABCD]

∠BAD = ∠CDA [using (i)]

AD = AD (common]

So, by using AAS congruence axiom, we have

ΔABD ≅ ΔDCA

Hence, BD = CA [c.p.c.t.]

**Ans: 3.** Here, in ΔABC, AB = 8cm, BC = 9cm, AC = 10cm.

In ΔAOB, X and Y are the mid-points of AO and BO.

∴ By using mid-point theorem, we have

$XY = \frac{1}{2}AB = \frac{1}{2} \times 8cm = 4cm$

Similarly, in Δ$\tau$BOC, Y and Z are the mid-points of BO and CO.

∴ By using mid-point theorem, we have

$YZ = \frac{1}{2}BC = \frac{1}{2} \times 9cm = 4.5cm$

And, in Δ$\tau$COA, Z and X are the mid-points of CO and AO.

$\therefore ZX = \frac{1}{2} AC = \frac{1}{2} \times 10cm = 5cm$

Hence, the lengths of the sides of ΔXYZ are XY = 4cm, YZ = 4.5 cm and ZX = 5cm.

**Ans: 4.** Since PQRS is a square.

∴ PQ = QR ... (I) [∵ sides of a square are equal]

Also, BQ = CR ... (ii) [given]

Subtracting (ii) from (i), we obtain

PQ – BQ = QR – CR

⇒ PB = QC ... (iii)

In Δ$\tau$APB and Δ$\tau$BQC

AP = BQ

[given ∠APB = ∠BQC = 90°](each angle of a square is 90°)

PB = QC (using (iii)]

So, by using SAS congruence axiom, we have

ΔAPB ≅ ΔBQC

∴ AB = BC [c.p.c.t.]

Now, in ΔABC

AB = BC [proved above]

∴ ∠ACB = ∠BAC = x° (say) [∠s opp. to equal sides]

Also, ∠B + ∠ACB + ∠BAC = 180°

⇒ 90° + x + x = 180°

⇒ 2x° = 90°

x° = 45°

Hence, ∠BAC = 45°

**Ans: 5.**


Since DP and CP are angle bisectors of ∠D and ∠C respectively.

: ∠1 = ∠2 and ∠3 = ∠4

Now, AB || DC and CP is a transversal

∴ ∠5 = ∠1 [alt. int. ∠s]

But ∠1 = ∠2 [given]

∴ ∠5 = ∠2

Now, in ABCP, ∠5 = ∠2

⇒ BC = BP ... (I) [sides opp. to equal ∠s of a A]

Again, AB || DC and DP is a transversal.

∴ ∠6= ∠3 (alt. int. Δs]

But ∠4 = ∠3 [given]

∴ ∠6 = ∠4

Now, in ΔADP, ∠6 = ∠4

⇒ DA = AP .... (ii) (sides opp. to equal ∠s of a A]

Also, BC = DA... (iii) (opp. sides of parallelogram)

From (i), (ii) and (iii), we have

BP = AP

Hence, P is the mid-point of side AB.

## Assertion and Reason Answers-

**1.** a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

**2.** c) Assertion is correct statement but reason is wrong statement.

## Case Study Answers-

**1.**

| | | |
|---|---|---|
| (i) | (b) | 30cm |
| (ii) | (c) | 135, 135 |
| (iii) | (c) | Trapezium has 1 pair of parallel sides, and parallelogram has 2 pairs of parallel sides. |
| (iv) | (d) | equal. |
| (v) | (a) | BF = FC |

**2.**

| | | |
|---|---|---|
| (i) | (b) | 8cm |
| (ii) | (a) | $24cm^2$ |
| (iii) | (c) | 360° |
| (iv) | (c) | Triangles. |
| (v) | (c) | Equal to 90° |