# Chapter-8

# Quadrilaterals

## Exercise 8.1

5marks Questions

**1. The angles of a quadrilateral are in the ratio 3 : 5 : 9 : 13. Find all the angles of the quadrilateral.**

Solution:

Let the common ratio between the angles be x.

We know that the sum of the interior angles of the quadrilateral = 360°

Now,

$3x+5x+9x+13x = 360°$

$\Rightarrow 30x = 360°$

$\Rightarrow x = 12°$

, Angles of the quadrilateral are:

$3x = 3\times12° = 36°$

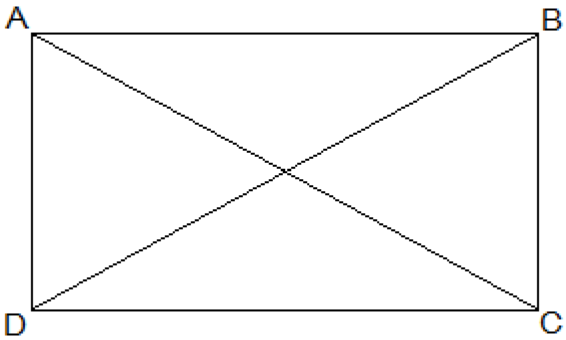
$5x = 5\times12° = 60°$

$9x = 9\times12° = 108°$

$13x = 13\times12° = 156°$

**2. If the diagonals of a parallelogram are equal, then show that it is a rectangle.**

Solution:




Given that,

AC = BD

To show that ABCD is a rectangle if the diagonals of a parallelogram are equal

To show ABCD is a rectangle, we have to prove that one of its interior angles is right-angled.

Proof,

In $\Delta ABC$ and $\Delta BAD$,

AB = BA (Common)

BC = AD (Opposite sides of a parallelogram are equal)

AC = BD (Given)

Therefore, $\Delta ABC \cong \Delta BAD$ [SSS congruency]

$\angle A = \angle B$ [Corresponding parts of Congruent Triangles]

also,

$\angle A + \angle B = 180°$ (Sum of the angles on the same side of the transversal)

$\Rightarrow 2\angle A = 180°$

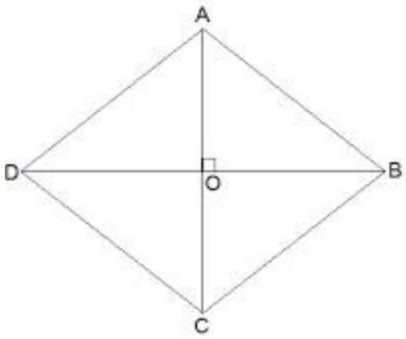
$\Rightarrow \angle A = 90° = \angle B$

Therefore, ABCD is a rectangle.

Hence Proved.

**3. Show that if the diagonals of a quadrilateral bisect each other at right angles, then it is a rhombus.**

Solution:




Let ABCD be a quadrilateral whose diagonals bisect each other at right angles.

Given that,

OA = OC

OB = OD

and ∠AOB = ∠BOC = ∠OCD = ∠ODA = 90°

To show that if the diagonals of a quadrilateral bisect each other at right angles, then it is a rhombus, we have to prove that ABCD is a parallelogram and AB = BC = CD = AD

Proof,

In ΔAOB and ΔCOB,

OA = OC (Given)

∠AOB = ∠COB (Opposite sides of a parallelogram are equal)

OB = OB (Common)

Therefore, ΔAOB ≅ ΔCOB [SAS congruency]

Thus, AB = BC [CPCT]

Similarly, we can prove,

BC = CD

CD = AD

AD = AB

, AB = BC = CD = AD

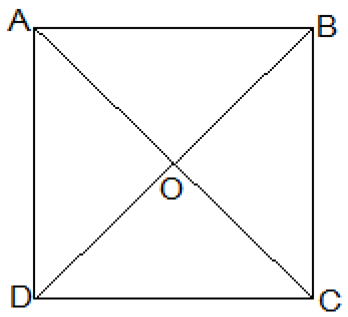
Opposite sides of a quadrilateral are equal. Hence, it is a parallelogram.

ABCD is rhombus as it is a parallelogram whose diagonals intersect at a right angle.

Hence Proved.

**4. Show that the diagonals of a square are equal and bisect each other at right angles.**

Solution:




Let ABCD be a square and its diagonals AC and BD intersect each other at O.

To show that,

AC = BD

AO = OC

and ∠AOB = 90°

Proof,

In ΔABC and ΔBAD,

AB = BA (Common)

∠ABC = ∠BAD = 90°

BC = AD (Given)

ΔABC ≅ ΔBAD [SAS congruency]

Thus,

AC = BD [CPCT]

diagonals are equal.

Now,

In ΔAOB and ΔCOD,

∠BAO = ∠DCO (Alternate interior angles)

∠AOB = ∠COD (Vertically opposite)

AB = CD (Given)

, ΔAOB ≅ ΔCOD [AAS congruency]

Thus,

AO = CO [CPCT].

, Diagonal bisect each other.

Now,

In ΔAOB and ΔCOB,

OB = OB (Given)

AO = CO (diagonals are bisected)

AB = CB (Sides of the square)

, ΔAOB ≅ ΔCOB [SSS congruency]

also, ∠AOB = ∠COB

∠AOB+∠COB = 180° (Linear pair)

Thus, ∠AOB = ∠COB = 90°

, Diagonals bisect each other at right angles

**5. Diagonal AC of a parallelogram ABCD bisects ∠A (see Fig. 8.19). Show that**

**(i) it bisects ∠C also,**

**(ii) ABCD is a rhombus.**

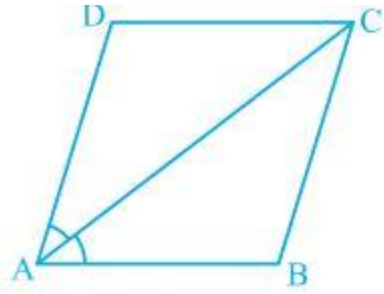



Fig. 8.19

Solution:

(i) In ΔADC and ΔCBA,

AD = CB (Opposite sides of a parallelogram)

DC = BA (Opposite sides of a parallelogram)

AC = CA (Common Side)

, ΔADC ≅ ΔCBA [SSS congruency]

Thus,

∠ACD = ∠CAB by CPCT

and ∠CAB = ∠CAD (Given)

⇒ ∠ACD = ∠BCA

Thus,

AC bisects ∠C also.

(ii) ∠ACD = ∠CAD (Proved above)

⇒ AD = CD (Opposite sides of equal angles of a triangle are equal)

Also, AB = BC = CD = DA (Opposite sides of a parallelogram)

Thus,

ABCD is a rhombus.

**6. In parallelogram ABCD, two points P and Q are taken on diagonal BD such that DP = BQ (see Fig. 8.20). Show that:**

**(i) ΔAPD ≅ ΔCQB**

**(ii) AP = CQ**

**(iii) ΔAQB ≅ ΔCPD**

**(iv) AQ = CP**

**(v) APCQ is a parallelogram**

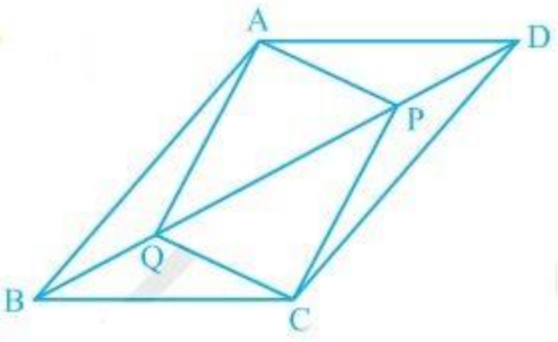



**Fig. 8.20**

Solution:

(i) In ΔAPD and ΔCQB,

DP = BQ (Given)

∠ADP = ∠CBQ (Alternate interior angles)

AD = BC (Opposite sides of a parallelogram)

Thus, ΔAPD ≅ ΔCQB [SAS congruency]

(ii) AP = CQ by CPCT as ΔAPD ≅ ΔCQB.

(iii) In ΔAQB and ΔCPD,

BQ = DP (Given)

∠ABQ = ∠CDP (Alternate interior angles)

AB = CD (Opposite sides of a parallelogram)

Thus, ΔAQB ≅ ΔCPD [SAS congruency]

(iv) As ΔAQB ≅ ΔCPD

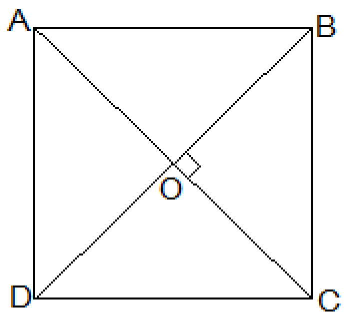
AQ = CP [CPCT]

(v) From the questions (ii) and (iv), it is clear that APCQ has equal opposite sides and also has equal and opposite angles. , APCQ is a parallelogram.

2marks Questions

**1. ABCD is a rhombus. Show that diagonal AC bisects ∠A as well as ∠C and diagonal BD bisects ∠B as well as ∠D.**

Solution:




Given that,

ABCD is a rhombus.

AC and BD are its diagonals.

Proof,

AD = CD (Sides of a rhombus)

∠DAC = ∠DCA (Angles opposite of equal sides of a triangle are equal.)

also, AB || CD

⇒∠DAC = ∠BCA (Alternate interior angles)

⇒∠DCA = ∠BCA

, AC bisects ∠C.

Similarly,

We can prove that diagonal AC bisects ∠A.

Following the same method,

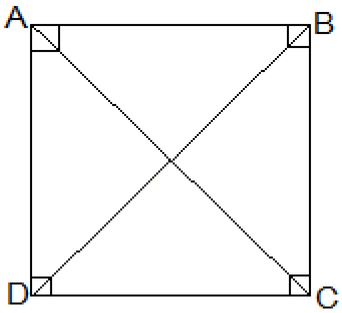
We can prove that the diagonal BD bisects ∠B and ∠D.

**2 ABCD is a rectangle in which diagonal AC bisects ∠A as well as ∠C. Show that:**

**(i) ABCD is a square**

**(ii) Diagonal BD bisects ∠B as well as ∠D.**

Solution:




(i) ∠DAC = ∠DCA (AC bisects ∠A as well as ∠C)

⇒ AD = CD (Sides opposite to equal angles of a triangle are equal)

also, CD = AB (Opposite sides of a rectangle)

,AB = BC = CD = AD

Thus, ABCD is a square.

(ii) In ΔBCD,

BC = CD

⇒ ∠CDB = ∠CBD (Angles opposite to equal sides are equal)

also, ∠CDB = ∠ABD (Alternate interior angles)

⇒ ∠CBD = ∠ABD

Thus, BD bisects ∠B

Now,

∠CBD = ∠ADB

⇒ ∠CDB = ∠ADB

Thus, BD bisects ∠B as well as ∠D.

**3. ABCD is a parallelogram and AP and CQ are perpendiculars from vertices A and C on diagonal BD (see Fig. 8.21). Show that**

**(i) ΔAPB ≅ ΔCQD**

**(ii) AP = CQ**

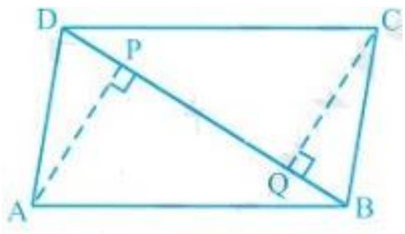



Fig. 8.21

Solution:

(i) In ΔAPB and ΔCQD,

∠ABP = ∠CDQ (Alternate interior angles)

∠APB = ∠CQD (= 90° as AP and CQ are perpendiculars)

AB = CD (ABCD is a parallelogram)

, ΔAPB ≅ ΔCQD [AAS congruency]

(ii) As ΔAPB ≅ ΔCQD.

, AP = CQ [CPCT]

## 8marks Question

**1. In ΔABC and ΔDEF, AB = DE, AB || DE, BC = EF and BC || EF. Vertices A, B and C are joined to vertices D, E and F, respectively (see Fig. 8.22).**

**Show that**

**(i) quadrilateral ABED is a parallelogram**

**(ii) quadrilateral BEFC is a parallelogram**

**(iii) AD || CF and AD = CF**

**(iv) quadrilateral ACFD is a parallelogram**

**(v) AC = DF**

**(vi) ΔABC ≅ ΔDEF.**

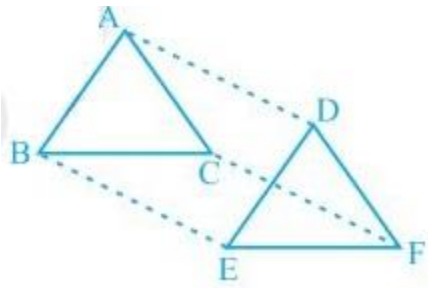



Fig. 8.22

Solution:

(i) AB = DE and AB || DE (Given)

Two opposite sides of a quadrilateral are equal and parallel to each other.

Thus, quadrilateral ABED is a parallelogram

(ii) Again BC = EF and BC || EF.

Thus, quadrilateral BEFC is a parallelogram.

(iii) Since ABED and BEFC are parallelograms.

⇒ AD = BE and BE = CF (Opposite sides of a parallelogram are equal)

, AD = CF.

Also, AD || BE and BE || CF (Opposite sides of a parallelogram are parallel)

, AD || CF

(iv) AD and CF are opposite sides of quadrilateral ACFD which are equal and parallel to each other. Thus, it is a parallelogram.

(v) Since ACFD is a parallelogram

AC || DF and AC = DF

(vi) In ΔABC and ΔDEF,

AB = DE (Given)

BC = EF (Given)

AC = DF (Opposite sides of a parallelogram)

, ΔABC ≅ ΔDEF [SSS congruency]

**2. ABCD is a trapezium in which AB || CD and AD = BC (see Fig. 8.23). Show that**

**(i) ∠A = ∠B**

**(ii) ∠C = ∠D**

**(iii) ΔABC ≅ ΔBAD**

**(iv) diagonal AC = diagonal BD**

**[Hint: Extend AB and draw a line through C parallel to DA intersecting AB produced at E.]**

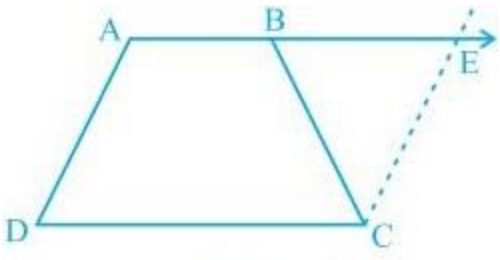



Fig. 8.23

Solution:

To Construct: Draw a line through C parallel to DA intersecting AB produced at E.

(i) CE = AD (Opposite sides of a parallelogram)

AD = BC (Given)

, BC = CE

$\Rightarrow \angle CBE = \angle CEB$

also,

$\angle A + \angle CBE = 180°$ (Angles on the same side of transversal and $\angle CBE = \angle CEB$)

$\angle B + \angle CBE = 180°$ ( As Linear pair)

$\Rightarrow \angle A = \angle B$

(ii) $\angle A + \angle D = \angle B + \angle C = 180°$ (Angles on the same side of transversal)

$\Rightarrow \angle A + \angle D = \angle A + \angle C$ ($\angle A = \angle B$)

$\Rightarrow \angle D = \angle C$

(iii) In $\Delta ABC$ and $\Delta BAD$,

AB = AB (Common)

$\angle DBA = \angle CBA$

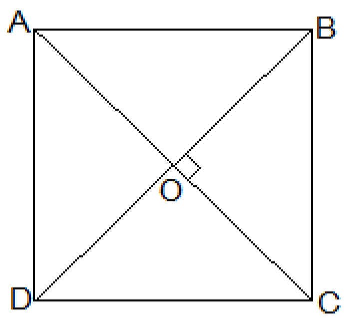
AD = BC (Given)

, $\Delta ABC \cong \Delta BAD$ [SAS congruency]

(iv) Diagonal AC = diagonal BD by CPCT as $\Delta ABC \cong \Delta BAD$.

**3. Show that if the diagonals of a quadrilateral are equal and bisect each other at right angles, then it is a square.**

Solution:




Given that,

Let ABCD be a quadrilateral and its diagonals AC and BD bisect each other at a right angle at O.

To prove that,

The Quadrilateral ABCD is a square.

Proof,

In $\Delta AOB$ and $\Delta COD$,

AO = CO (Diagonals bisect each other)

$\angle AOB = \angle COD$ (Vertically opposite)

OB = OD (Diagonals bisect each other)

, $\Delta AOB \cong \Delta COD$ [SAS congruency]

Thus,

AB = CD [CPCT] — (i)

also,

$\angle OAB = \angle OCD$ (Alternate interior angles)

$\Rightarrow$ AB || CD

Now,

In $\Delta AOD$ and $\Delta COD$,

AO = CO (Diagonals bisect each other)

$\angle AOD = \angle COD$ (Vertically opposite)

OD = OD (Common)

, $\Delta AOD \cong \Delta COD$ [SAS congruency]

Thus,

AD = CD [CPCT] — (ii)

also,

AD = BC and AD = CD

$\Rightarrow$ AD = BC = CD = AB — (ii)

also, $\angle ADC = \angle BCD$ [CPCT]

and $\angle ADC + \angle BCD = 180°$ (co-interior angles)

$\Rightarrow 2\angle ADC = 180°$

$\Rightarrow \angle ADC = 90°$ — (iii)

One of the interior angles is a right angle.

Thus, from (i), (ii) and (iii), given quadrilateral ABCD is a square.

Hence Proved.

## Exercise 8.2

### 2marks Question

**1. ABCD is a trapezium in which AB || DC, BD is a diagonal and E is the mid-point of AD. A line is drawn through E parallel to AB intersecting BC at F (see Fig. 8.30). Show that F is the mid-point of BC.**

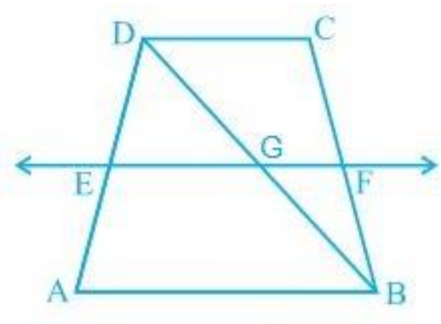



Fig. 8.30

Solution:

Given that,

ABCD is a trapezium in which AB || DC, BD is a diagonal and E is the mid-point of AD.

To prove,

F is the mid-point of BC.

Proof,

BD intersected EF at G.

In ΔBAD,

E is the mid point of AD and also EG || AB.

Thus, G is the mid point of BD (Converse of mid point theorem)

Now,

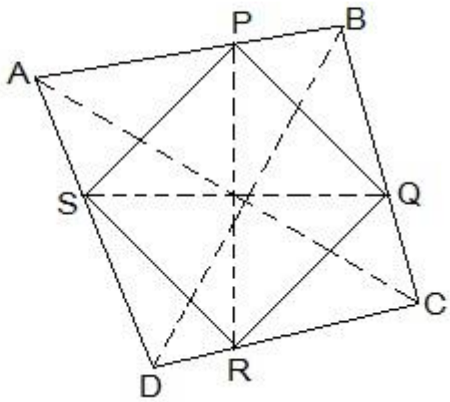
In ΔBDC,

G is the mid point of BD and also GF || AB || DC.

Thus, F is the mid point of BC (Converse of mid point theorem)

**2. Show that the line segments joining the mid-points of the opposite sides of a quadrilateral bisect each other.**

Solution:




Let ABCD be a quadrilateral and P, Q, R and S the mid points of AB, BC, CD and DA, respectively.

Now,

In ΔACD,

R and S are the mid points of CD and DA, respectively.

, SR || AC.

Similarly we can show that,

PQ || AC,

PS || BD and

QR || BD

, PQRS is parallelogram.

PR and QS are the diagonals of the parallelogram PQRS. So, they will bisect each other.

## 5marks Questions

**1. ABCD is a quadrilateral in which P, Q, R and S are mid-points of the sides AB, BC, CD and DA (see Fig 8.29). AC is a diagonal. Show that:**
**(i) SR || AC and SR = 1/2 AC**
**(ii) PQ = SR**
**(iii) PQRS is a parallelogram.**

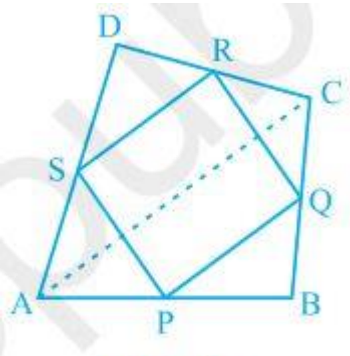



Fig. 8.29

Solution:

(i) In ΔDAC,

R is the mid point of DC and S is the mid point of DA.

Thus by mid point theorem, SR || AC and SR = ½ AC

(ii) In ΔBAC,

P is the mid point of AB and Q is the mid point of BC.

Thus by mid point theorem, PQ || AC and PQ = ½ AC

also, SR = ½ AC

, PQ = SR

(iii) SR || AC —————————- from question (i)

and, PQ || AC —————————- from question (ii)

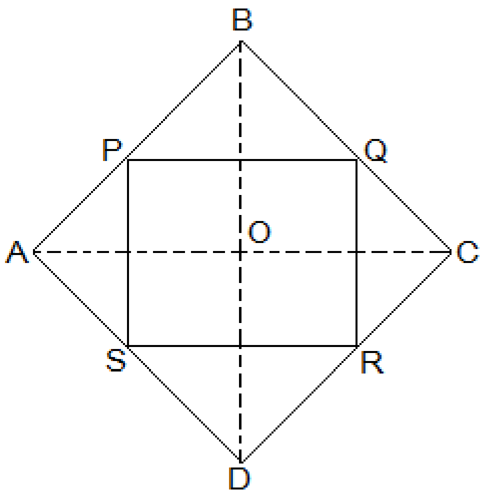
⇒ SR || PQ – from (i) and (ii)

also, PQ = SR

, PQRS is a parallelogram.

**2. ABCD is a rhombus and P, Q, R and S are the mid-points of the sides AB, BC, CD and DA, respectively. Show that the quadrilateral PQRS is a rectangle.**

Solution:




Given in the question,

ABCD is a rhombus and P, Q, R and S are the mid-points of the sides AB, BC, CD and DA, respectively.

To Prove,

PQRS is a rectangle.

Construction,

Join AC and BD.

Proof:

In $\Delta DRS$ and $\Delta BPQ$,

DS = BQ (Halves of the opposite sides of the rhombus)

$\angle SDR = \angle QBP$ (Opposite angles of the rhombus)

DR = BP (Halves of the opposite sides of the rhombus)

, $\Delta DRS \cong \Delta BPQ$ [SAS congruency]

RS = PQ [CPCT]———————- (i)

In $\Delta QCR$ and $\Delta SAP$,

RC = PA (Halves of the opposite sides of the rhombus)

$\angle RCQ = \angle PAS$ (Opposite angles of the rhombus)

CQ = AS (Halves of the opposite sides of the rhombus)

, $\Delta QCR \cong \Delta SAP$ [SAS congruency]

RQ = SP [CPCT]———————- (ii)

Now,

In $\Delta CDB$,

R and Q are the mid points of CD and BC, respectively.

$\Rightarrow QR \parallel BD$

also,

P and S are the mid points of AD and AB, respectively.

$\Rightarrow PS \parallel BD$

$\Rightarrow QR \parallel PS$

, PQRS is a parallelogram.

also, $\angle PQR = 90°$

Now,

In PQRS,

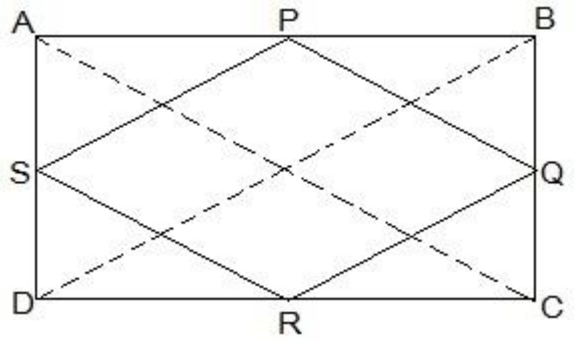
RS = PQ and RQ = SP from (i) and (ii)

∠Q = 90°

, PQRS is a rectangle.

**3. ABCD is a rectangle and P, Q, R and S are mid-points of the sides AB, BC, CD and DA, respectively. Show that the quadrilateral PQRS is a rhombus.**

Solution:




Given in the question,

ABCD is a rectangle and P, Q, R and S are mid-points of the sides AB, BC, CD and DA, respectively.

Construction,

Join AC and BD.

To Prove,

PQRS is a rhombus.

Proof:

In ΔABC

P and Q are the mid-points of AB and BC, respectively

, PQ || AC and PQ = ½ AC (Midpoint theorem) — (i)

In ΔADC,

SR || AC and SR = ½ AC (Midpoint theorem) — (ii)

So, PQ || SR and PQ = SR

As in quadrilateral PQRS one pair of opposite sides is equal and parallel to each other, so, it is a parallelogram.

, PS || QR and PS = QR (Opposite sides of parallelogram) — (iii)

Now,

In ΔBCD,

Q and R are mid points of side BC and CD, respectively.

, QR || BD and QR = ½ BD (Midpoint theorem) — (iv)

AC = BD (Diagonals of a rectangle are equal) — (v)

From equations (i), (ii), (iii), (iv) and (v),

PQ = QR = SR = PS

So, PQRS is a rhombus.

Hence Proved

**4.In a parallelogram ABCD, E and F are the mid-points of sides AB and CD, respectively (see Fig. 8.31). Show that the line segments AF and EC trisect the diagonal BD.**

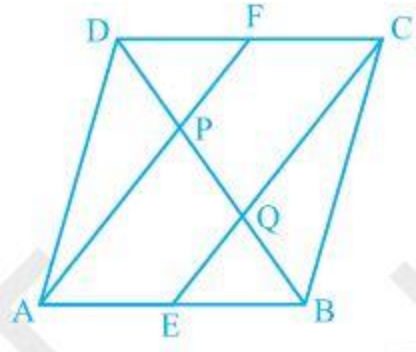



Fig. 8.31

Solution:

Given that,

ABCD is a parallelogram. E and F are the mid-points of sides AB and CD, respectively.

To show,

AF and EC trisect the diagonal BD.

Proof,

ABCD is a parallelogram

, AB || CD

also, AE || FC

Now,

AB = CD (Opposite sides of parallelogram ABCD)

$\Rightarrow \frac{1}{2}$ AB = $\frac{1}{2}$ CD

$\Rightarrow$ AE = FC (E and F are midpoints of side AB and CD)

AECF is a parallelogram (AE and CF are parallel and equal to each other)

AF || EC (Opposite sides of a parallelogram)

Now,

In ΔDQC,

F is mid point of side DC and FP || CQ (as AF || EC).

P is the mid-point of DQ (Converse of mid-point theorem)

$\Rightarrow$ DP = PQ — (i)

Similarly,

In ΔAPB,

E is midpoint of side AB and EQ || AP (as AF || EC).

Q is the mid-point of PB (Converse of mid-point theorem)

$\Rightarrow$ PQ = QB — (ii)

From equations (i) and (i),

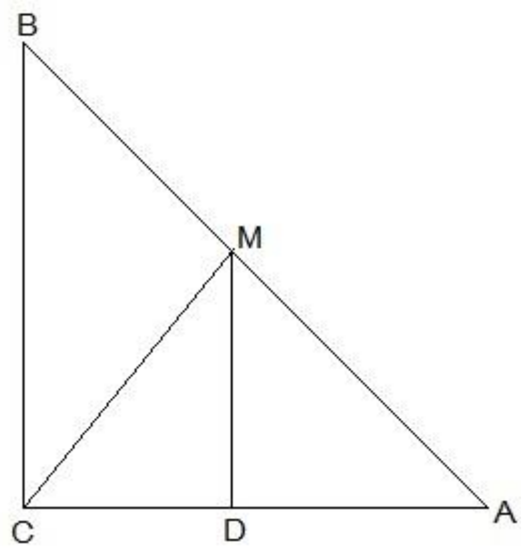
DP = PQ = BQ

Hence, the line segments AF and EC trisect the diagonal BD.

Hence Proved.

**5. ABC is a triangle right angled at C. A line through the mid-point M of hypotenuse AB and parallel to BC intersects AC at D. Show that**
**(i) D is the mid-point of AC**
**(ii) MD ⊥ AC**
**(iii) CM = MA = ½ AB**

Solution:




(i) In ΔACB,

M is the midpoint of AB and MD || BC

, D is the midpoint of AC (Converse of mid point theorem)

(ii) ∠ACB = ∠ADM (Corresponding angles)

also, ∠ACB = 90°

, ∠ADM = 90° and MD ⊥ AC

(iii) In ΔAMD and ΔCMD,

AD = CD (D is the midpoint of side AC)

$\angle ADM = \angle CDM$ (Each 90°)

DM = DM (common)

, $\Delta AMD \cong \Delta CMD$ [SAS congruency]

AM = CM [CPCT]

also, AM = ½ AB (M is midpoint of AB)

Hence, CM = MA = ½ AB