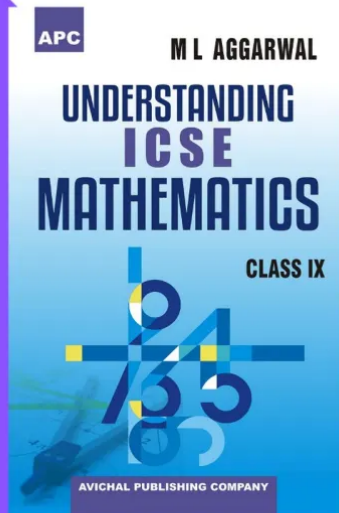


ML Aggarwal Solutions for Class 9 Maths

Chapter 13- Rectilinear Figures



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ML Agrawal Solutions

CLASS 9 MATHS

Chapter 13: Rectilinear
Figures

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ML Aggarwal Solutions for Class 9 Maths Chapter 13- Rectilinear Figures

ML Aggarwal 9th Maths Chapter 13, Class 9 Maths Chapter 13 solutions

Exercise 13.1

1. If two angles of a quadrilateral are 40° and 110° and the other two are in the ratio 3 : 4, find these angles.

Solution:

We know that,

Sum of all four angles of a quadrilateral = 360°

Sum of two given angles = $40^\circ + 110^\circ = 150^\circ$

So, the sum of remaining two angles = $360^\circ - 150^\circ = 210^\circ$

Also given,

Ratio in these angles = 3 : 4

Hence,

Third angle = $(210^\circ \times 3)/(3 + 4)$

= $(210^\circ \times 3)/7$

= 90°

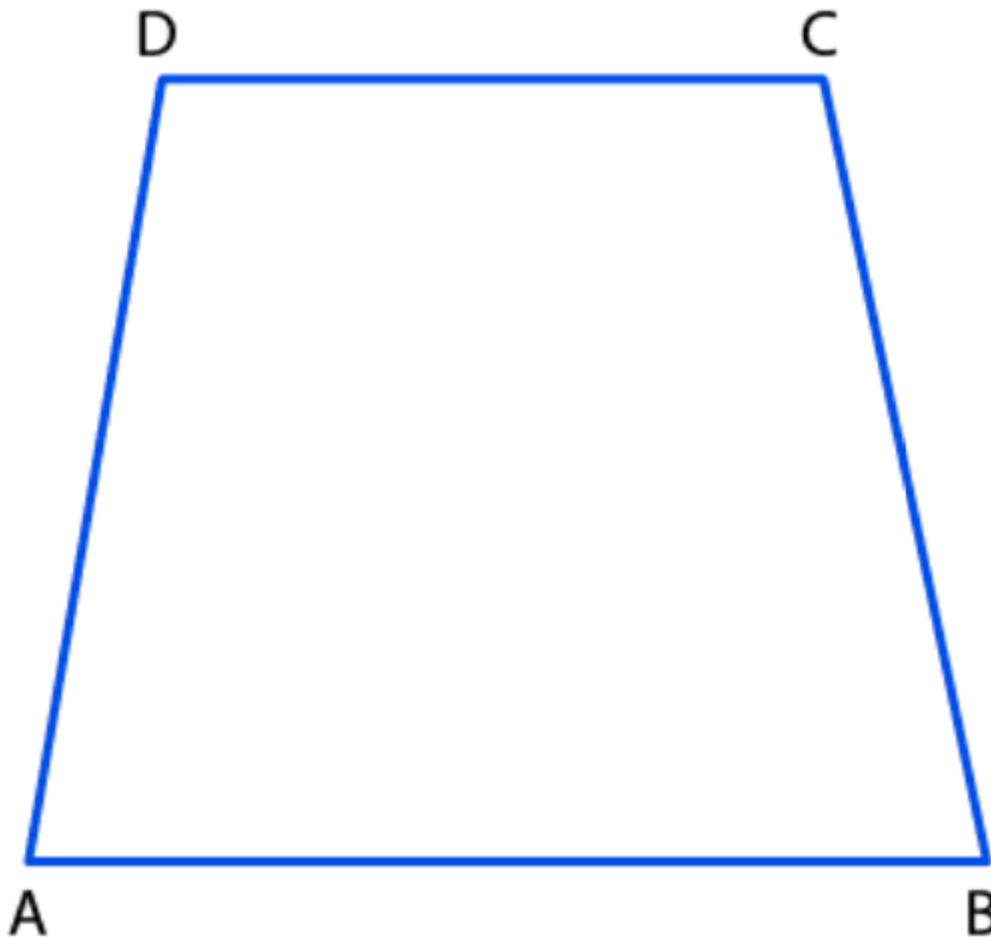
And,

Fourth angle = $(210^\circ \times 4)/(3 + 4)$

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$$= (210^\circ \times 4)/7$$

$$= 120^\circ$$



2. If the angles of a quadrilateral, taken in order, are in the ratio 1 : 2 : 3 : 4, prove that it is a trapezium.

Solution:

Given,

In trapezium ABCD in which

$$\angle A : \angle B : \angle C : \angle D = 1 : 2 : 3 : 4$$

We know,

The sum of angles of the quad. ABCD = 360°

$$\angle A = (360^\circ \times 1)/10 = 36^\circ$$

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$$\angle B = (360^\circ \times 2)/10 = 72^\circ$$

$$\angle C = (360^\circ \times 3)/10 = 108^\circ$$

$$\angle D = (360^\circ \times 4)/10 = 144^\circ$$

Now,

$$\angle A + \angle D = 36^\circ + 114^\circ = 180^\circ$$

Since, the sum of angles $\angle A$ and $\angle D$ is 180° and these are co-interior angles

Thus, $AB \parallel DC$

Therefore, ABCD is a trapezium.

3. If an angle of a parallelogram is two-thirds of its adjacent angle, find the angles of the parallelogram.

Solution:

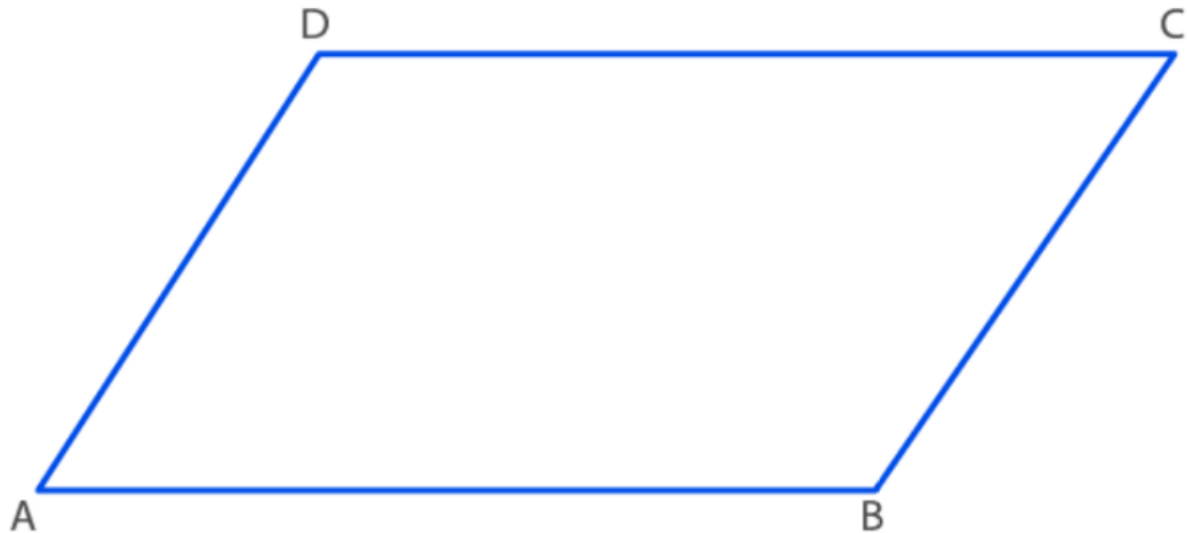
Here ABCD is a parallelogram.

Let $\angle A = x^\circ$

Then, $\angle B = (2x/3)^\circ$ (Given condition)

So,

$$\angle A + \angle B = 180^\circ \text{ (As the sum of adjacent angles in a parallelogram is } 180^\circ)$$



$$x^\circ + \frac{2}{3} x^\circ = 180^\circ \Rightarrow \frac{3x + 2x}{3} = 180$$

$$\frac{5x}{3} = 180 \Rightarrow 5x = 180 \times 3$$

$$x = \frac{180 \times 3}{5} \Rightarrow x = 36 \times 3 \Rightarrow x = 108$$

Hence, $\angle A = 108^\circ$

$$\angle B = \frac{2}{3} \times 108^\circ = 2 \times 36^\circ = 72^\circ$$

$\angle B = \angle D = 72^\circ$ (opposite angles in a parallelogram is same)

Also,

$\angle A = \angle C = 108^\circ$ (opposite angles in a parallelogram is same)

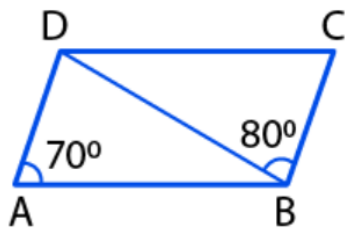
Therefore, angles of parallelogram are 108° , 72° , 108° and 72° .

4. (a) In figure (1) given below, ABCD is a parallelogram in which $\angle DAB = 70^\circ$, $\angle DBC = 80^\circ$. Calculate angles CDB and ADB.

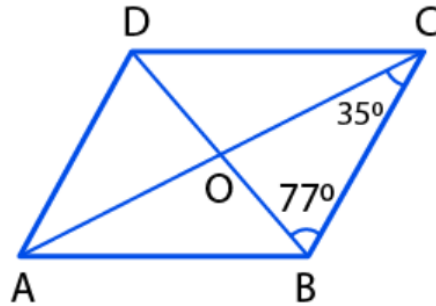
(b) In figure (2) given below, ABCD is a parallelogram. Find the angles of the AAOD.

(c) In figure (3) given below, ABCD is a rhombus. Find the value of x.

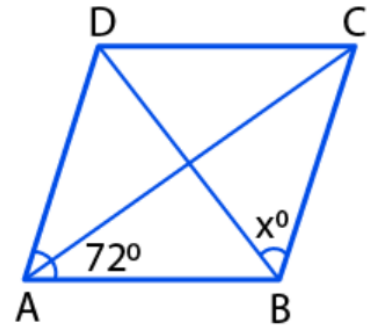
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(1)



(2)



(3)

Solution:

(a) Since, ABCD is a || gm

We have, $AB \parallel CD$

$\angle ADB = \angle DBC$ (Alternate angles)

$\angle ADB = 80^\circ$ (Given, $\angle DBC = 80^\circ$)

Now,

In $\triangle ADB$, we have

$\angle A + \angle ADB + \angle ABD = 180^\circ$ (Angle sum property of a triangle)

$$70^\circ + 80^\circ + \angle ABD = 180^\circ$$

$$150^\circ + \angle ABD = 180^\circ$$

$$\angle ABD = 180^\circ - 150^\circ = 30^\circ$$

Now, $\angle CDB = \angle ABD$ (Since, $AB \parallel CD$ and alternate angles)

So,

$$\angle CDB = 30^\circ$$

Hence, $\angle ADB = 80^\circ$ and $\angle CDB = 30^\circ$.

(b) Given, $\angle BOC = 35^\circ$ and $\angle CBO = 77^\circ$

In $\triangle BOC$, we have

$\angle BOC + \angle BCO + \angle CBO = 180^\circ$ (Angle sum property of a triangle)

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$$\angle BOC = 180^\circ - 112^\circ = 68^\circ$$

Now, in $\parallel$ gm ABCD

We have,

$$\angle AOD = \angle BOC \text{ (Vertically opposite angles)}$$

$$\text{Hence, } \angle AOD = 68^\circ.$$

(c) ABCD is a rhombus

So, $\angle A + \angle B = 180^\circ$ (Sum of adjacent angles of a rhombus is 180°)

$$72^\circ + \angle B = 180^\circ \text{ (Given, } \angle A = 72^\circ)$$

$$\angle B = 180^\circ - 72^\circ = 108^\circ$$

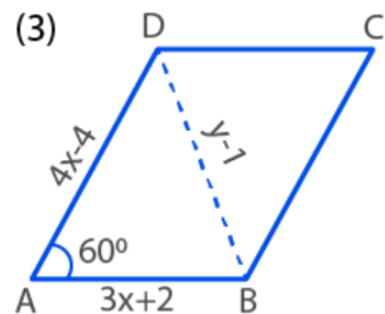
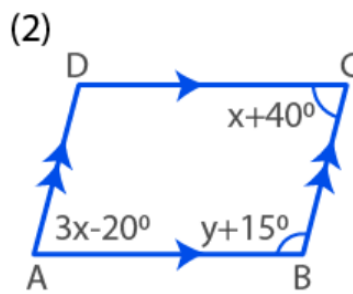
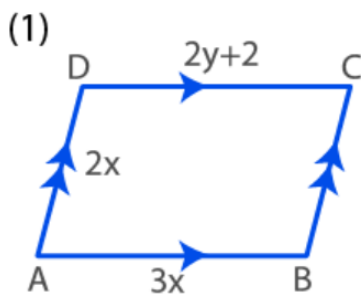
Hence,

$$x = \frac{1}{2} B = \frac{1}{2} \times 108^\circ = 54^\circ$$

5. (a) In figure (1) given below, ABCD is a parallelogram with perimeter 40. Find the values of x and y.

(b) In figure (2) given below. ABCD is a parallelogram. Find the values of x and y.

(c) In figure (3) given below. ABCD is a rhombus. Find x and y.



Solution:

(a) Since, ABCD is a parallelogram

So, $AB = CD$ and $BC = AD$

$$\Rightarrow 3x = 2y + 2$$

$$3x - 2y = 2 \dots (i)$$

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$$\text{Also, } AB + BC + CD + DA = 40$$

$$\Rightarrow 3x + 2x + 2y + 2 + 2x = 40$$

$$7x + 2y = 40 - 2$$

$$7x + 2y = 38 \dots (ii)$$

Now, adding (i) and (ii) we get

$$3x - 2y = 2$$

$$7x + 2y = 38$$

$$10x = 40$$

$$\Rightarrow x = 40/10 = 4$$

On substituting the value of x in (i), we get

$$3(4) - 2y = 2$$

$$12 - 2y = 2$$

$$2y = 12 - 2$$

$$\Rightarrow y = 10/2 = 5$$

Hence, $x = 4$ and $y = 5$

(b) In parallelogram ABCD, we have

$\angle A = \angle C$ (Opposite angles are same in || gm)

$$3x - 20^\circ = x + 40^\circ$$

$$3x - x = 40^\circ + 20^\circ$$

$$2x = 60^\circ$$

$$x = 60^\circ/2 = 30^\circ \dots (i)$$

Also, $\angle A + \angle B = 180^\circ$ (Sum of adjacent angles in || gm is equal to 180°)

$$3x - 20^\circ + y + 15^\circ = 180^\circ$$

$$3x + y = 180^\circ + 20^\circ - 15^\circ$$

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$$3x + y = 185^\circ$$

$$3(30^\circ) + y = 185^\circ \text{ [Using (i)]}$$

$$90^\circ + y = 185^\circ$$

$$y = 185^\circ - 90^\circ = 95^\circ$$

Hence,

$$x = 30^\circ \text{ and } 95^\circ$$

(c) ABCD is a rhombus

So, $AB = CD$

$$3x + 2 = 4x - 4$$

$$3x - 4x = -4 - 2$$

$$-x = -6$$

$$x = 6$$

Now, in $\triangle ABD$ we have

$$\angle BAD = 60^\circ \text{ and } AB = AD$$

$$\angle ADB = \angle ABD$$

So,

$$\angle ADB = (180^\circ - \angle BAD) / 2$$

$$= (180^\circ - 60^\circ) / 2$$

$$= 120^\circ / 2 = 60^\circ$$

As $\triangle ABD$ is an equilateral triangle, all the angles of the triangle are 60°

Hence, $AB = BD$

$$3x + 2 = y - 1$$

$$3(6) + 2 = y - 1 \text{ (Substituting the value of } x)$$

$$18 + 2 = y - 1$$

$$20 = y - 1$$

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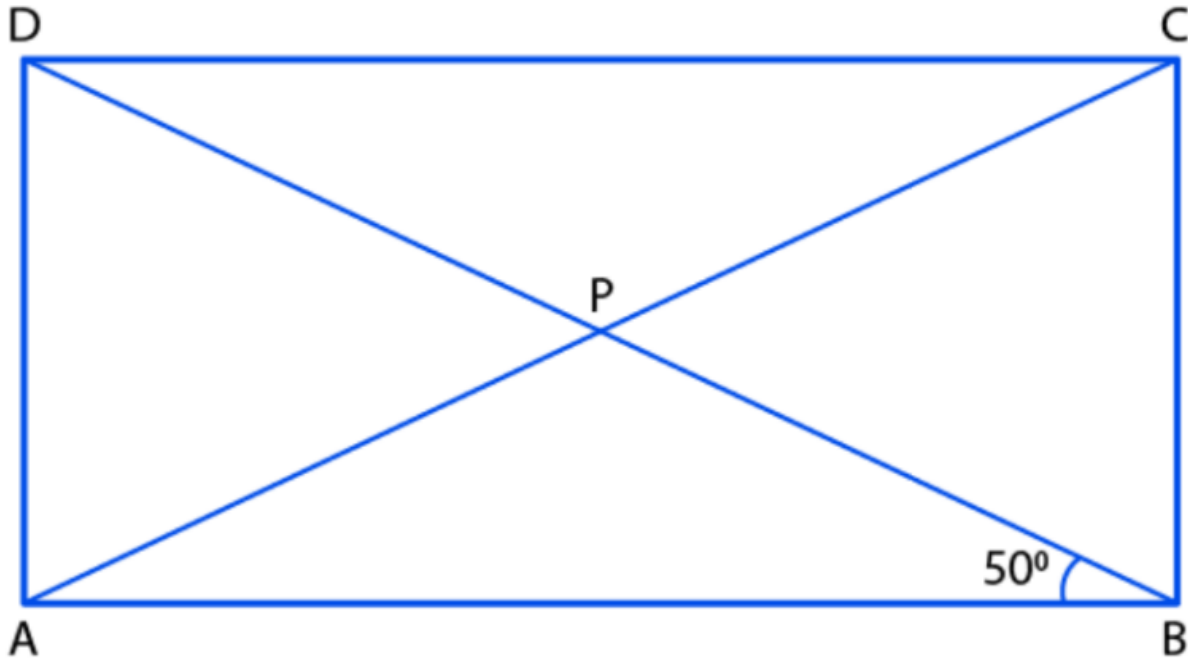
$$y = 20 + 1$$

$$y = 21$$

Thus, $x = 6$ and $y = 21$.

6. The diagonals AC and BD of a rectangle ABCD intersect each other at P. If $\angle ABD = 50^\circ$, find $\angle DPC$.

Solution:



Given, ABCD is a rectangle

We know that the diagonals of rectangle are same and bisect each other

So, we have

$$AP = BP$$

$\angle PAB = \angle PBA$ (Equal sides have equal opposite angles)

$\angle PAB = 50^\circ$ (Since, given $\angle PBA = 50^\circ$)

Now, in $\triangle APB$

$$\angle APB + \angle ABP + \angle BAP = 180^\circ$$

$$\angle APB + 50^\circ + 50^\circ = 180^\circ$$

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$$\angle APB = 180^\circ - 100^\circ$$

$$\angle APB = 80^\circ$$

Then,

$$\angle DPB = \angle APB \text{ (Vertically opposite angles)}$$

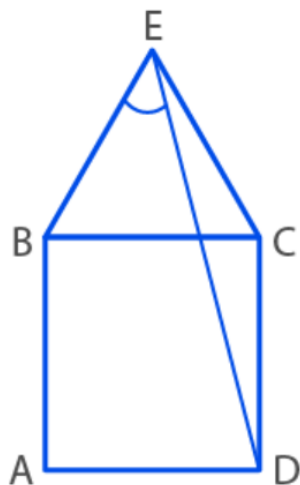
Hence,

$$\angle DPB = 80^\circ$$

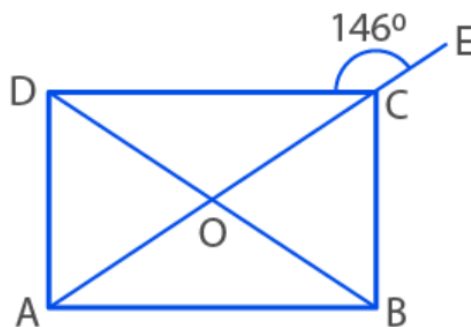
7. (a) In figure (1) given below, equilateral triangle EBC surmounts square ABCD. Find angle BED represented by x.

(b) In figure (2) given below, ABCD is a rectangle and diagonals intersect at O. AC is produced to E. If $\angle ECD = 146^\circ$, find the angles of the $\triangle AOB$.

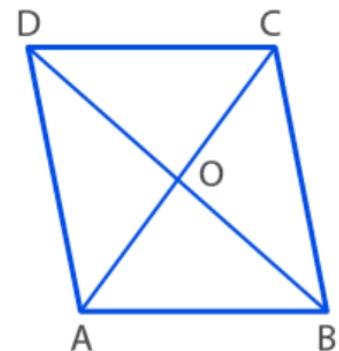
(c) In figure (3) given below, ABCD is rhombus and diagonals intersect at O. If $\angle OAB : \angle OBA = 3:2$, find the angles of the $\triangle AOD$.



(1)



(2)



(3)

Solution:

Since, EBC is an equilateral triangle, we have

$$EB = BC = EC \dots (i)$$

Also, ABCD is a square

$$\text{So, } AB = BC = CD = AD \dots (ii)$$

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From (i) and (ii), we get

$$EB = EC = AB = BC = CD = AD \dots \text{(iii)}$$

Now, in $\triangle ECD$

$$\angle ECD = \angle BCD + \angle ECB$$

$$= 90^\circ + 60^\circ$$

$$= 150^\circ \dots \text{(iv)}$$

Also, $EC = CD$ [From (iii)]

$$\text{So, } \angle DEC = \angle CDE \dots \text{(v)}$$

$$\angle ECD + \angle DEC + \angle CDE = 180^\circ \text{ [Angles sum property of a triangle]}$$

$$150^\circ + \angle DEC + \angle DEC = 180^\circ \text{ [Using (iv) and (v)]}$$

$$2 \angle DEC = 180^\circ - 150^\circ = 30^\circ$$

$$\angle DEC = 30^\circ/2$$

$$\angle DEC = 15^\circ \dots \text{(vi)}$$

Now, $\angle BEC = 60^\circ$ [BEC is an equilateral triangle]

$$\angle BED + \angle DEC = 60^\circ$$

$$x^\circ + 15^\circ = 60^\circ \text{ [From (vi)]}$$

$$x = 60^\circ - 15^\circ$$

$$x = 45^\circ$$

Hence, the value of x is 45° .

(b) Given, ABCD is a rectangle

$$\angle ECD = 146^\circ$$

As ACE is a straight line, we have

$$146^\circ + \angle ACD = 180^\circ \text{ [Linear pair]}$$

$$\angle ACD = 180^\circ - 146^\circ = 34^\circ \dots \text{(i)}$$

And, $\angle CAB = \angle ACD$ [Alternate angles] $\dots \text{(ii)}$

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From (i) and (ii), we have

$$\angle CAB = 34^\circ \Rightarrow \angle OAB = 34^\circ \dots (iii)$$

In $\triangle AOB$

$AO = OB$ [Diagonals of a rectangle are equal and bisect each other]

$$\angle OAB = \angle OBA \dots (iv) \text{ [Equal sides have equal angles opposite to them]}$$

From (iii) and (iv),

$$\angle OBA = 34^\circ \dots (v)$$

Now,

$$\angle AOB + \angle OBA + \angle OAB = 180^\circ$$

$$\angle AOB + 34^\circ + 34^\circ = 180^\circ \text{ [Using (3) and (5)]}$$

$$\angle AOB + 68^\circ = 180^\circ$$

$$\angle AOB = 180^\circ - 68^\circ = 112^\circ$$

Hence, $\angle AOB = 112^\circ$, $\angle OAB = 34^\circ$ and $\angle OBA = 34^\circ$

(c) Here, ABCD is a rhombus and diagonals intersect at O and $\angle OAB : \angle OBA = 3 : 2$

Let $\angle OAB = 2x^\circ$

Then,

$$\angle OBA = 2x^\circ$$

We know that diagonals of rhombus intersect at right angle,

So, $\angle AOB = 90^\circ$

Now, in $\triangle AOB$

$$\angle OAB + \angle OBA = 180^\circ$$

$$90^\circ + 3x^\circ + 2x^\circ = 180^\circ$$

$$90^\circ + 5x^\circ = 180^\circ$$

$$5x^\circ = 180^\circ - 90^\circ = 90^\circ$$

$$x^\circ = 90^\circ / 5 = 18^\circ$$

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Hence,

$$\angle OAB = 3x^\circ = 3 \times 18^\circ = 54^\circ$$

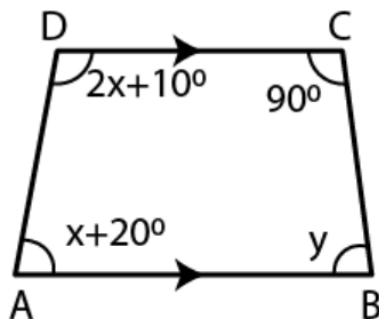
$$\angle OBA = 2x^\circ = 2 \times 18^\circ = 36^\circ \text{ and}$$

$$\angle AOB = 90^\circ$$

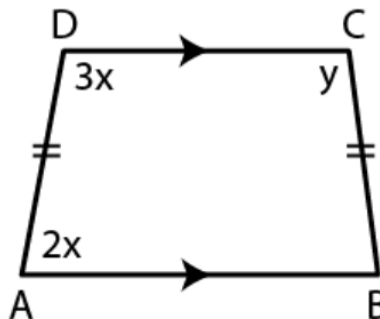
8. (a) In figure (1) given below, ABCD is a trapezium. Find the values of x and y.

(b) In figure (2) given below, ABCD is an isosceles trapezium. Find the values of x and y.

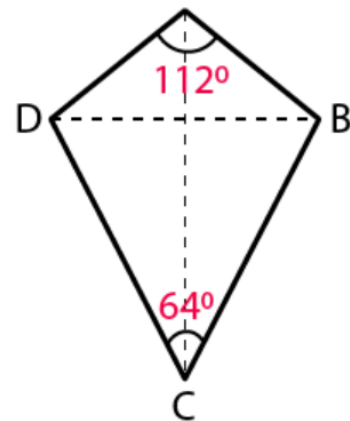
(c) In figure (3) given below, ABCD is a kite and diagonals intersect at O. If $\angle DAB = 112^\circ$ and $\angle DCB = 64^\circ$, find $\angle ODC$ and $\angle OBA$.



(1)



(2)



(3)

Solution:

(a) Given: ABCD is a trapezium

$$\angle A = x + 20^\circ, \angle B = y, \angle C = 92^\circ, \angle D = 2x + 10^\circ$$

We have,

$$\angle B + \angle C = 180^\circ \text{ [Since } AB \parallel DC \text{]}$$

$$y + 92^\circ = 180^\circ$$

$$y = 180^\circ - 92^\circ = 88^\circ$$

$$\text{Also, } \angle A + \angle D = 180^\circ$$

$$x + 20^\circ + 2x + 10^\circ = 180^\circ$$

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$$3x + 30^\circ = 180^\circ$$

$$3x = 180^\circ - 30^\circ = 150^\circ$$

$$x = 150^\circ/3 = 50^\circ$$

Hence, the value of $x = 50^\circ$ and $y = 88^\circ$.

(b) Given: ABCD is an isosceles trapezium $BC = AD$

$$\angle A = 2x, \angle C = y \text{ and } \angle D = 3x$$

Since, ABCD is a trapezium and $AB \parallel DC$

$$\Rightarrow \angle A + \angle D = 180^\circ$$

$$2x + 3x = 180^\circ$$

$$5x = 180^\circ$$

$$x = 180^\circ/5 = 36^\circ \dots (i)$$

Also, $AB = BC$ and $AB \parallel DC$

$$\text{So, } \angle A + \angle C = 180^\circ$$

$$2x + y = 180^\circ$$

$$2 \times 36^\circ + y = 180^\circ$$

$$72^\circ + y = 180^\circ$$

$$y = 180^\circ - 72^\circ = 108^\circ$$

Hence, value of $x = 36^\circ$ and $y = 108^\circ$.

(c) Given: ABCD is a kite and diagonal intersect at O.

$$\angle DAB = 112^\circ \text{ and } \angle DCB = 64^\circ$$

As AC is the diagonal of kite ABCD, we have

$$\angle DCO = 64^\circ/2 = 32^\circ$$

And, $\angle DOC = 90^\circ$ [Diagonal of kites bisect at right angles]

In $\triangle OCD$, we have

$$\angle ODC = 180^\circ - (\angle DCO + \angle DOC)$$

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$$= 180^\circ - (32^\circ + 90^\circ)$$

$$= 180^\circ - 122^\circ$$

$$= 58^\circ$$

In $\triangle DAB$, we have

$$\angle OAB = 112^\circ/2 = 56^\circ$$

$$\angle AOB = 90^\circ \text{ [Diagonal of kites bisect at right angles]}$$

In $\triangle OAB$, we have

$$\angle OBA = 180^\circ - (\angle OAB + \angle AOB)$$

$$= 180^\circ - (56^\circ + 90^\circ)$$

$$= 180^\circ - 146^\circ$$

$$= 34^\circ$$

Hence, $\angle ODC = 58^\circ$ and $\angle OBA = 34^\circ$.

9. (i) Prove that each angle of a rectangle is 90° .

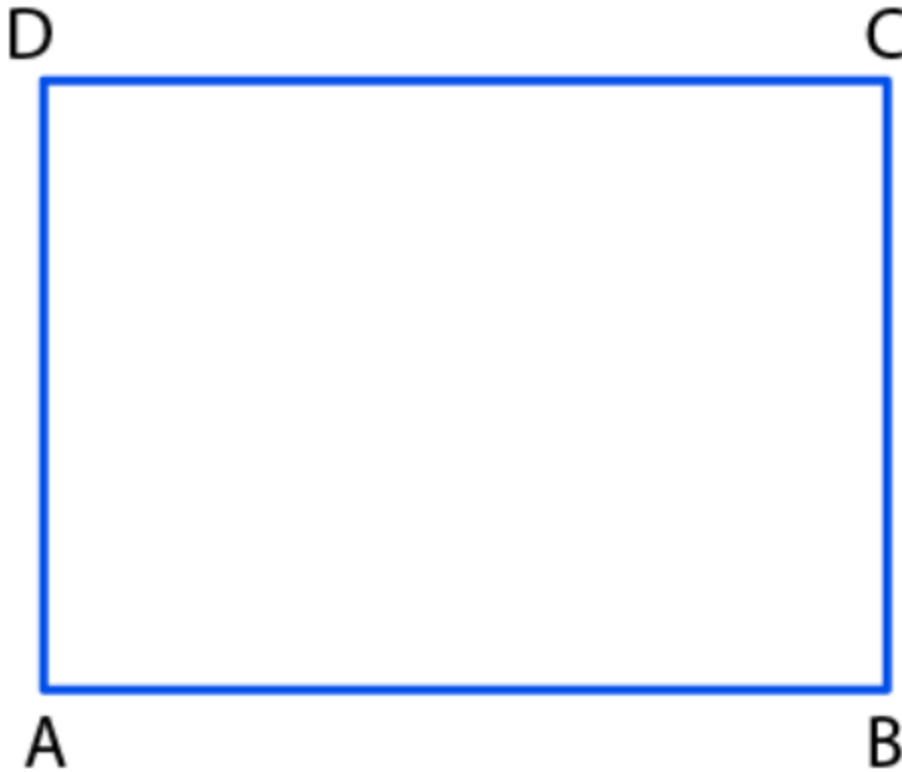
(ii) If the angle of a quadrilateral are equal, prove that it is a rectangle.

(iii) If the diagonals of a rhombus are equal, prove that it is a square.

(iv) Prove that every diagonal of a rhombus bisects the angles at the vertices.

Solution:

(i) Given: ABCD is a rectangle



To prove: Each

angle of rectangle = 90°

Proof:

In a rectangle opposite angles of a rectangle are equal

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

But, $\angle A + \angle B + \angle C + \angle D = 360^\circ$ [Sum of angles of a quadrilateral]

$$\angle A + \angle B + \angle A + \angle B = 360^\circ$$

$$2(\angle A + \angle B) = 360^\circ$$

$$(\angle A + \angle B) = 360^\circ/2$$

$$\angle A + \angle B = 180^\circ$$

But, $\angle A = \angle B$ [Angles of a rectangle]

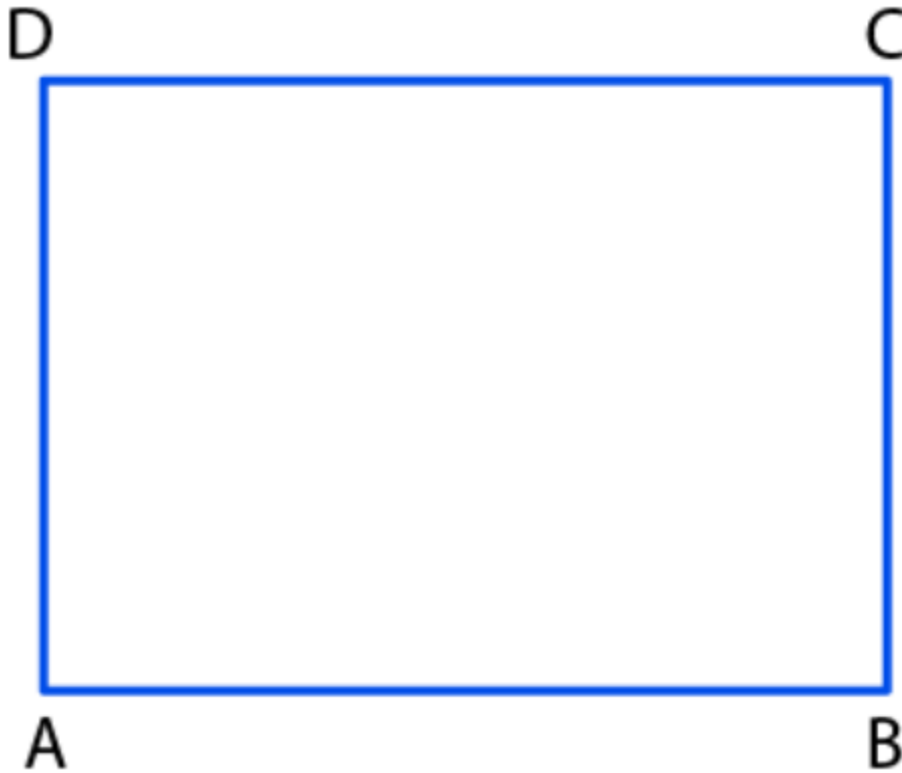
$$\text{So, } \angle A = \angle B = 90^\circ$$

Thus,

$$\angle A = \angle B = \angle C = \angle D = 90^\circ$$

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Hence, each angle of a rectangle is 90° .



(ii) Given: In

quadrilateral ABCD, we have

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

To prove: ABCD is a rectangle

Proof:

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

$$\Rightarrow \angle A = \angle C \text{ and } \angle B = \angle D$$

But these are opposite angles of the quadrilateral.

So, ABCD is a parallelogram

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

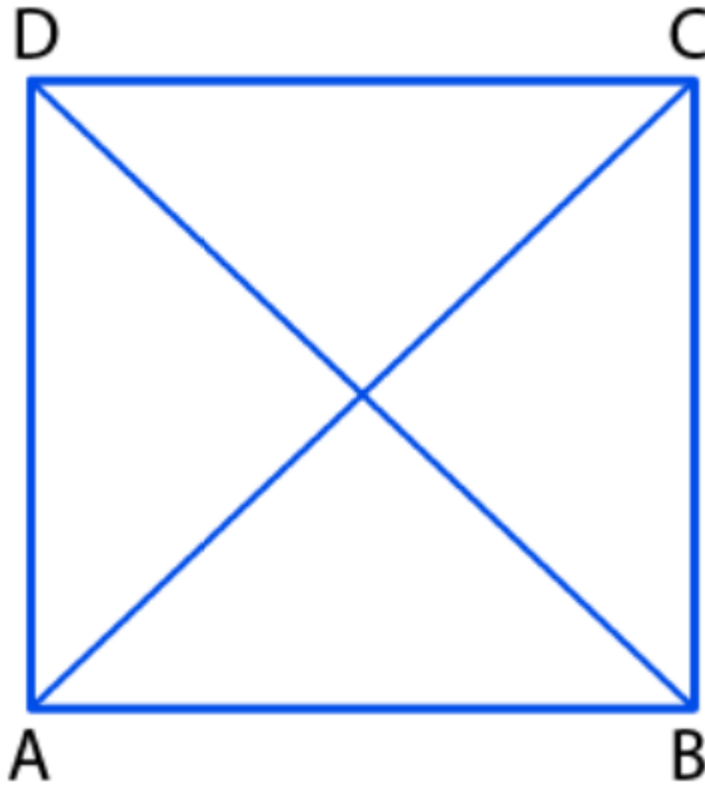
Therefore, ABCD is a rectangle.

(iii) Given: ABCD is a rhombus in which $AC = BD$

To prove: ABCD is a square

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Proof:



Join AC and BD.

Now, in $\triangle ABC$ and $\triangle DCB$ we have

$$\angle ABC = \angle DCB \text{ [Sides of a rhombus]}$$

$$\angle ACB = \angle DCB \text{ [Common]}$$

$$\angle BAC = \angle BDC \text{ [Given]}$$

So, $\triangle ABC \cong \triangle DCB$ by S.S.S axiom of congruency

Thus,

$$\angle ABC = \angle DCB \text{ [By C.P.C.T]}$$

But these are made by transversal BC on the same side of parallel lines AB and CD.

$$\text{So, } \angle ABC + \angle DCB = 180^\circ$$

$$\angle ABC = 90^\circ$$

Hence, ABCD is a square.

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(iv) Given: ABCD is rhombus.

To prove: Diagonals AC and BD bisect $\angle A$, $\angle C$, $\angle B$ and $\angle D$ respectively

Proof:

In $\triangle AOD$ and $\triangle COD$, we have

$AD = CD$ [sides of a rhombus are all equal]

$OD = OD$ [Common]

$AO = OC$ [Diagonal of rhombus bisect each other]

So, $\triangle AOD \cong \triangle COD$ by S.S.S axiom of congruency

Thus,

$\angle AOD = \angle COD$ [By C.P.C.T]

So, $\angle AOD + \angle COD = 180^\circ$ [Linear pair]

$\angle AOD = 180^\circ$

$\angle AOD = 90^\circ$

And, $\angle COD = 90^\circ$

Thus,

$OD \perp AC \Rightarrow BD \perp AC$

Also, $\angle ADO = \angle CDO$ [By C.P.C.T]

So,

OD bisect $\angle D$ BD bisect $\angle D$

Similarly, we can prove that BD bisect $\angle B$ and AC bisect the $\angle A$ and $\angle C$.

10. ABCD is a parallelogram. If the diagonal AC bisects $\angle A$, then prove that:

(i) AC bisects $\angle C$

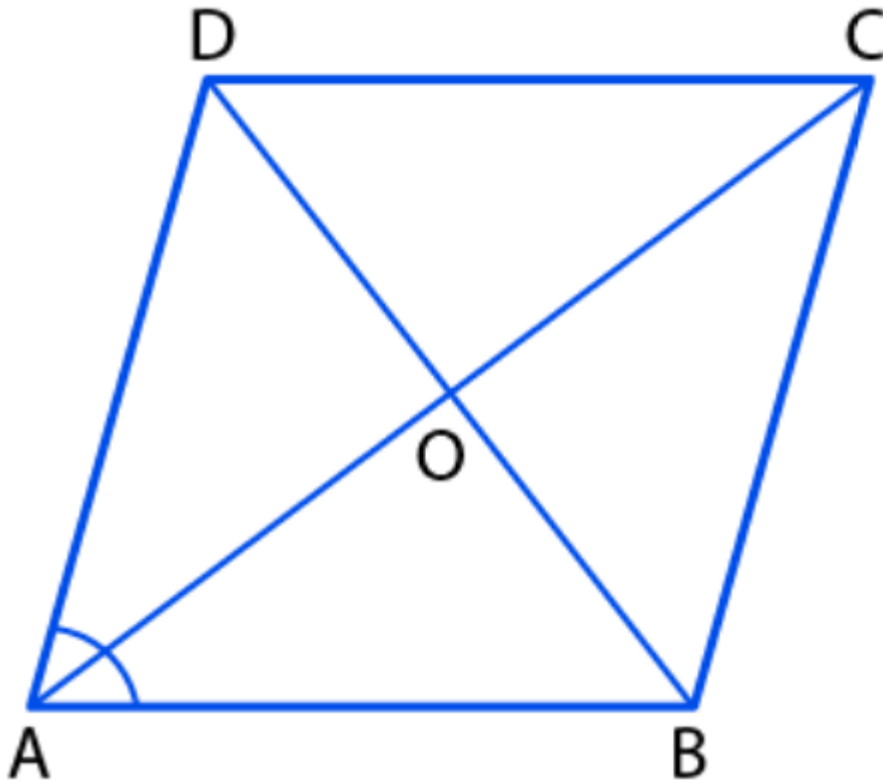
(ii) ABCD is a rhombus

(iii) $AC \perp BD$.

Solution:

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Given: In parallelogram ABCD in which diagonal AC bisects $\angle A$



bisects $\angle C$

To prove: (i) AC

(ii) ABCD is a rhombus

(iii) $AC \perp BD$

Proof:

(i) As $AB \parallel CD$, we have [Opposite sides of a $\parallel$ gm]

$$\angle DCA = \angle CAB$$

Similarly, $\angle DAC = \angle DCB$

But, $\angle CAB = \angle DAC$ [Since, AC bisects $\angle A$]

Hence,

$\angle DCA = \angle ACB$ and AC bisects $\angle C$.

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(ii) As AC bisects $\angle A$ and $\angle C$

And, $\angle A = \angle C$

Hence, ABCD is a rhombus.

(iii) Since, AC and BD are the diagonals of a rhombus and

AC and BD bisect each other at right angles

Hence, $AC \perp BD$

11. (i) Prove that

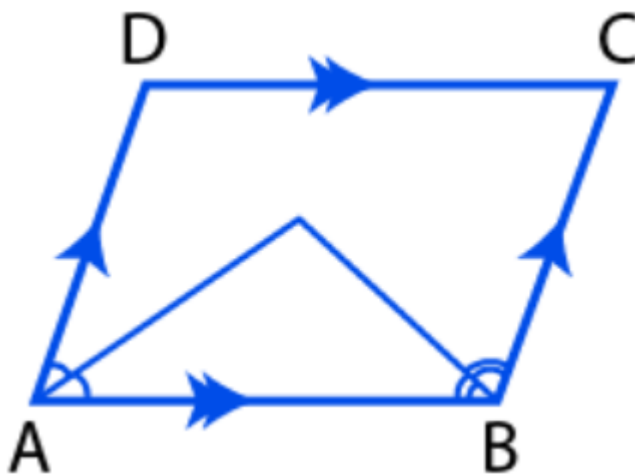
bisectors of any two adjacent angles of a parallelogram are at right angles.

(ii) Prove that bisectors of any two opposite angles of a parallelogram are parallel.

(iii) If the diagonals of a quadrilateral are equal and bisect each other at right angles, then prove that it is a square.

Solution:

(i) Given AM bisect angle A and BM bisects angle of || gm ABCD.



To prove: $\angle AMB = 90^\circ$

Proof:

We have,

$$\angle A + \angle B = 180^\circ \text{ [AD } \parallel \text{ BC and AB is the transversal]}$$

$$\Rightarrow \frac{1}{2} (\angle A + \angle B) = 180^\circ/2$$

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$$\frac{1}{2} \angle A + \frac{1}{2} \angle B = 90^\circ$$

$$\angle MAB + \angle MBA = 90^\circ \text{ [Since, AM bisects } \angle A \text{ and BM bisects } \angle B]$$

Now, in $\triangle AMB$

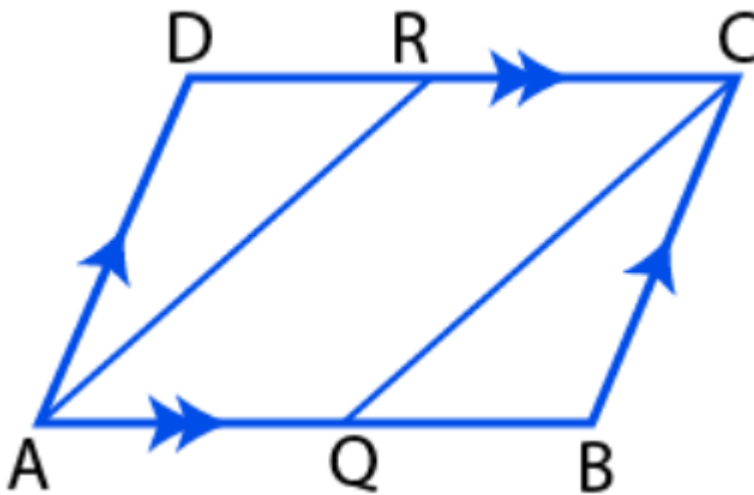
$$\angle AMB + \angle MAB + \angle MBA = 180^\circ \text{ [Angles sum property of a triangle]}$$

$$\angle AMB + 90^\circ = 180^\circ$$

$$\angle AMB = 180^\circ - 90^\circ = 90^\circ$$

Hence, bisectors of any two adjacent angles of a parallelogram are at right angles.

(ii) Given: A || gm ABCD in which bisector AR of $\angle A$ meets DC in R and bisector CQ of $\angle C$ meets AB in Q



To prove: $AR \parallel CQ$

Proof:

In || gm ABCD, we have

$$\angle A = \angle C \text{ [Opposite angles of || gm are equal]}$$

$$\frac{1}{2} \angle A = \frac{1}{2} \angle C$$

$$\angle DAR = \angle BCQ \text{ [Since, AR is bisector of } \frac{1}{2} \angle A \text{ and CQ is the bisector of } \frac{1}{2} \angle C]$$

Now, in $\triangle ADR$ and $\triangle CBQ$

$$\angle DAR = \angle BCQ \text{ [Proved above]}$$

$$AD = BC \text{ [Opposite sides of || gm ABCD are equal]}$$

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So, $\triangle ADR \cong \triangle CBQ$, by A.S.A axiom of congruency

Then by C.P.C.T, we have

$$\angle DRA = \angle BCQ$$

And,

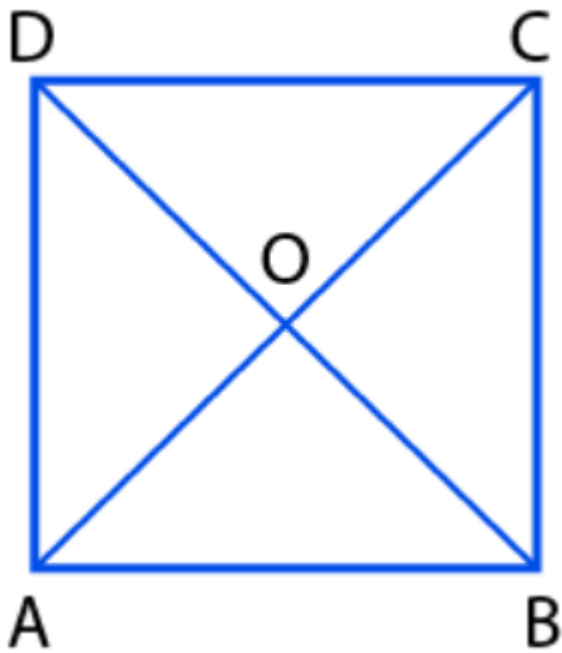
$$\angle DRA = \angle RAQ \text{ [Alternate angles since, } DC \parallel AB\text{]}$$

$$\text{Thus, } \angle RAQ = \angle BCQ$$

But these are corresponding angles,

Hence, $AR \parallel CQ$.

(iii) Given: In quadrilateral ABCD, diagonals AC and BD are equal and bisect each other at right angles



To prove: ABCD is a square

Proof:

In $\triangle AOB$ and $\triangle COD$, we have

$$AO = OC \text{ [Given]}$$

$$BO = OD \text{ [Given]}$$

$$\angle AOB = \angle COD \text{ [Vertically opposite angles]}$$

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So, $\triangle AOB \cong \triangle COD$, by S.A.S axiom of congruency

By C.P.C.T, we have

$$AB = CD$$

$$\text{and } \angle OAB = \angle OCD$$

But these are alternate angles

$$AB \parallel CD$$

Thus, ABCD is a parallelogram

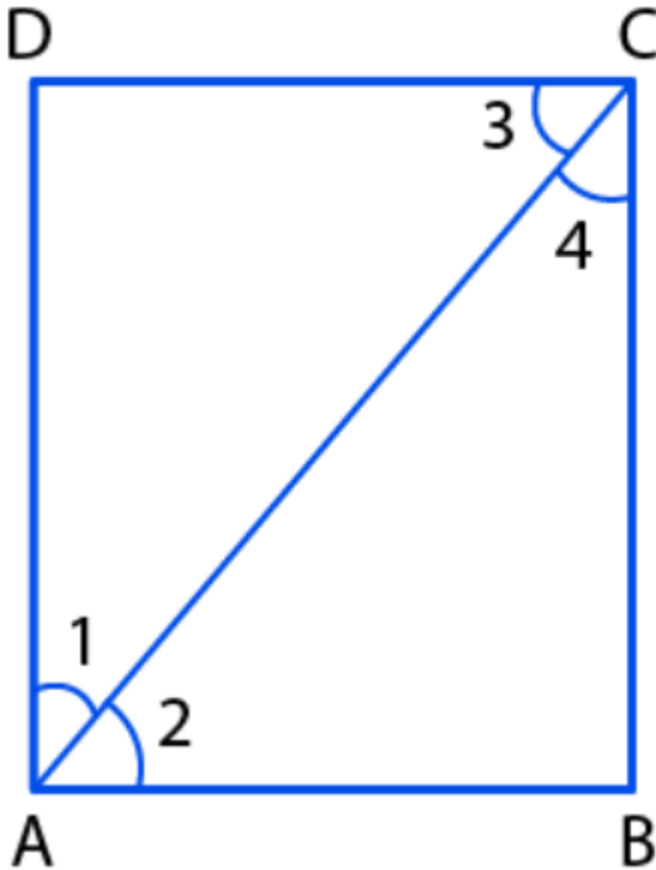
In a parallelogram, the diagonal bisect each other and are equal

Hence, ABCD is a square.

12. (i) If ABCD is a rectangle in which the diagonal BD bisect $\angle B$, then show that ABCD is a square.

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

Solution:



(i) ABCD is a rectangle and its diagonals AC bisects $\angle A$ and $\angle C$

To prove: ABCD is a square

Proof:

We know that the opposite sides of a rectangle are equal and each angle is 90°

As AC bisects $\angle A$ and $\angle C$

So, $\angle 1 = \angle 2$ and $\angle 3 = \angle 4$

But, $\angle A = \angle C = 90^\circ$

$\angle 2 = 45^\circ$ and $\angle 4 = 45^\circ$

And, $AB = BC$ [Opposite sides of equal angles]

But, $AB = CD$ and $BC = AD$

So, $AB = BC = CD = DA$

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Therefore, ABCD is a square.

(ii) In quadrilateral ABCD diagonals AC and BD are equal and bisect each other at right angle

To prove: ABCD is a square

Proof:

In $\triangle AOB$ and $\triangle BOC$, we have

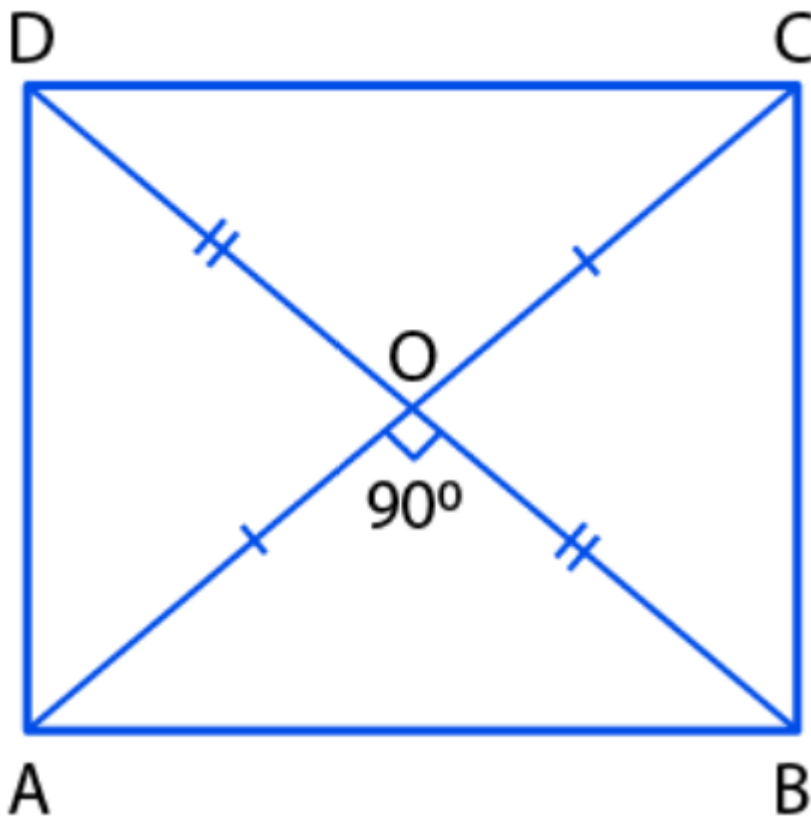
$AO = CO$ [Diagonals bisect each other at right angles]

$OB = OB$ [Common]

$\angle AOB = \angle COB$ [Each 90°]

So, $\triangle AOB \cong \triangle BOC$, by S.A.S axiom

By C.P.C.T, we have



$AB = BC \dots (i)$

Similarly, in $\triangle BOC$ and $\triangle COD$

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$OB = OD$ [Diagonals bisect each other at right angles]

$OC = OC$ [Common]

$\angle BOC = \angle COD$ [Each 90°]

So, $\triangle BOC \cong \triangle COD$, by S.A.S axiom

By C.P.C.T, we have

$BC = CD$... (ii)

From (i) and (ii), we have

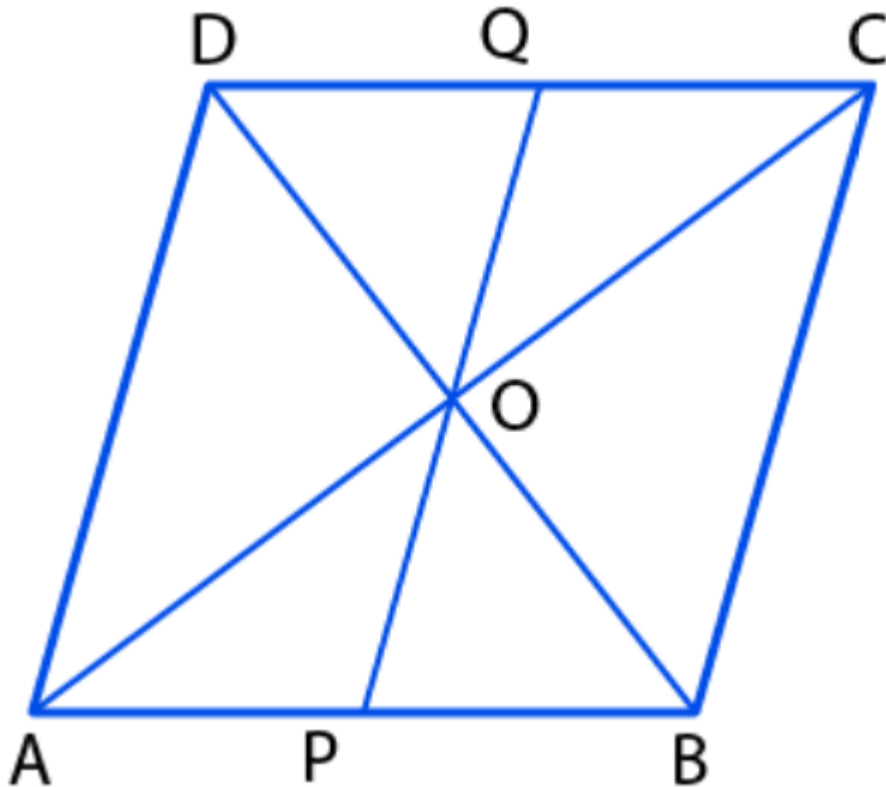
$AB = BC = CD = DA$

Hence, ABCD is a square.

13. P and Q are points on opposite sides AD and BC of a parallelogram ABCD such that PQ passes through the point of intersection O of its diagonals AC and BD. Show that PQ is bisected at O.

Solution:

Given: ABCD is a parallelogram, P and Q are the points on AB and DC. Diagonals AC and BD intersect each other at O.



To prove:

Diagonals of $\parallel$ gm ABCD bisect each other at O

So, $AO = OC$ and $BO = OD$

Now, in $\triangle AOP$ and $\triangle COQ$ we have

$AO = OC$ and $BO = OD$

Now, in $\triangle AOP$ and $\triangle COQ$

$AO = OC$ [Proved]

$\angle OAP = \angle OCQ$ [Alternate angles]

$\angle AOP = \angle COQ$ [Vertically opposite angles]

So, $\triangle AOP \cong \triangle COQ$ by S.A.S axiom

Thus, by C.P.C.T

$OP = OQ$

Hence, O bisects PQ.

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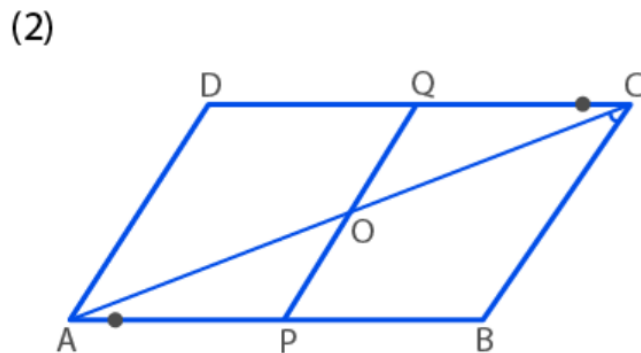
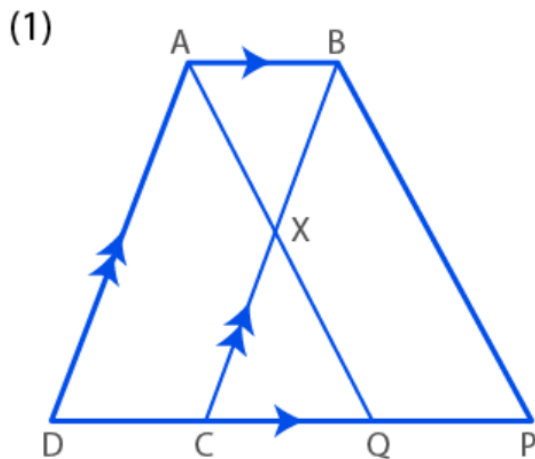
14. (a) In figure (1) given below, ABCD is a parallelogram and X is mid-point of BC. The line AX produced meets DC produced at Q. The parallelogram ABPQ is completed.

Prove that:

(i) the triangles ABX and QCX are congruent;

(ii) $DC = CQ = QP$

(b) In figure (2) given below, points P and Q have been taken on opposite sides AB and CD respectively of a parallelogram ABCD such that $AP = CQ$. Show that AC and PQ bisect each other.



Solution:

(a) Given: ABCD is parallelogram and X is mid-point of BC. The line AX produced meets DC produced at Q and ABPQ is a || gm.

To prove: (i) $\triangle ABX \cong \triangle QCX$

(ii) $DC = CQ = QP$

Proof:

In $\triangle ABX$ and $\triangle QCX$, we have

$BX = XC$ [X is the mid-point of BC]

$\angle AXB = \angle CXQ$ [Vertically opposite angles]

$\angle XCQ = \angle XBA$ [Alternate angle, since $AB \parallel CQ$]

So, $\triangle ABX \cong \triangle QCX$ by A.S.A axiom of congruence

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Now, by C.P.C.T

$$CQ = AB$$

But,

$$AB = DC \text{ and } AB = QP \text{ [As } ABCD \text{ and } ABPQ \text{ are } \parallel \text{ gms]}$$

Hence,

$$DC = CQ = QP$$

(b) In $\parallel$ gm ABCD, P and Q are points on AB and CD respectively, PQ and AC intersect each other at O and $AP = CQ$

To prove: AC and PQ bisect each other i.e. $AO = OC$ and $PO = OQ$

Proof:

In $\triangle AOP$ and $\triangle COQ$

$$AP = CQ \text{ [Given]}$$

$$\angle AOP = \angle COQ \text{ [Vertically opposite angles]}$$

$$\angle OAP = \angle OCP \text{ [Alternate angles]}$$

So, $\triangle AOP \cong \triangle COQ$ by A.A.S axiom of congruence

Now, by C.P.C.T

$$OP = OQ \text{ and } OA = OC$$

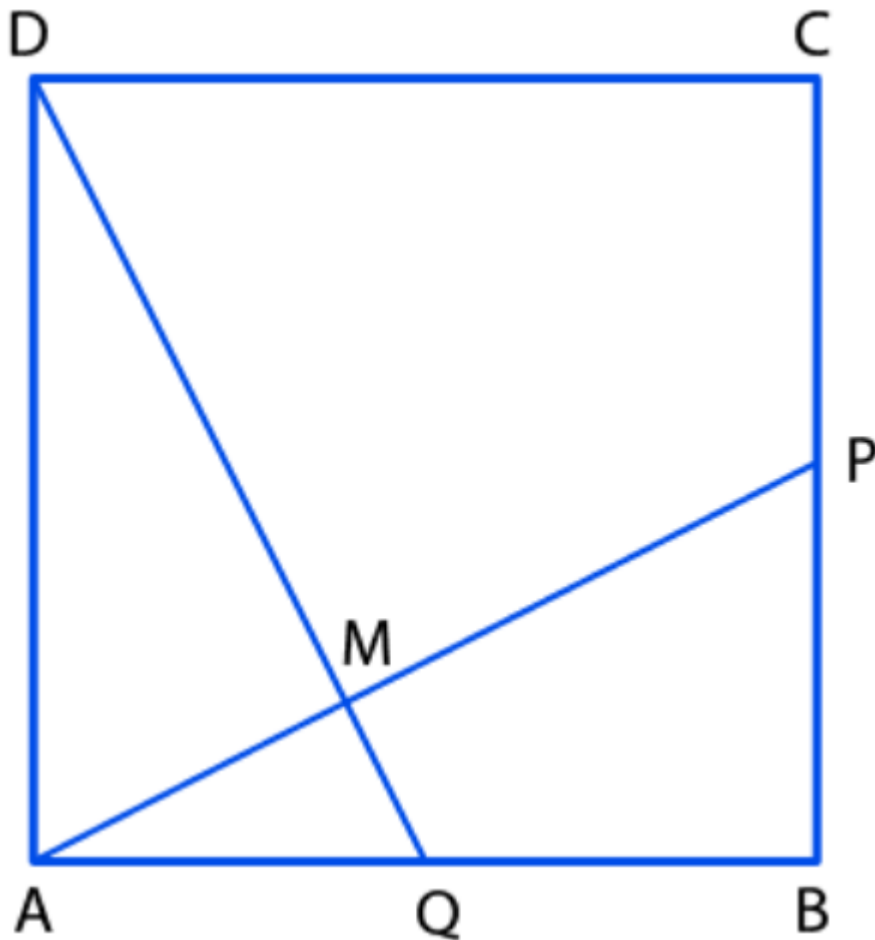
Hence proved.

15. ABCD is a square. A is joined to a point P on BC and D is joined to a point Q on AB. If $AP = DQ$, prove that AP and DQ are perpendicular to each other.

Solution:

Given: ABCD is a square. P is any point on BC and Q is any point on AB and these points are taken such that $AP = DQ$

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To prove: $AP \perp DQ$

Proof:

In $\triangle ABP$ and $\triangle ADQ$, we have

$AP = DQ$ [Given]

$AD = AB$ [Sides of square ABCD]

$\angle DAQ = \angle ABP$ [Each 90°]

So, $\triangle ABP \cong \triangle ADQ$ by R.H.S axiom of congruency

Now, by C.P.C.T

$\angle BAP = \angle ADQ$

But, $\angle BAD = 90^\circ$

$\angle BAD = \angle BAP + \angle PAD \dots (i)$

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$$90^\circ = \angle BAP + \angle PAD$$

$$\angle BAP + \angle PAD = 90^\circ$$

$$\angle BAP + \angle ADQ = 90^\circ$$

Now, in $\triangle ADM$ we have

$$(\angle MAD + \angle ADM) + \angle AMD = 180^\circ \text{ [Angles sum property of a triangle]}$$

$$90^\circ + \angle AMD = 180^\circ \text{ [From (i)]}$$

$$\angle AMD = 180^\circ - 90^\circ = 90^\circ$$

So, $DM \perp AP$

$$\Rightarrow DQ \perp AP$$

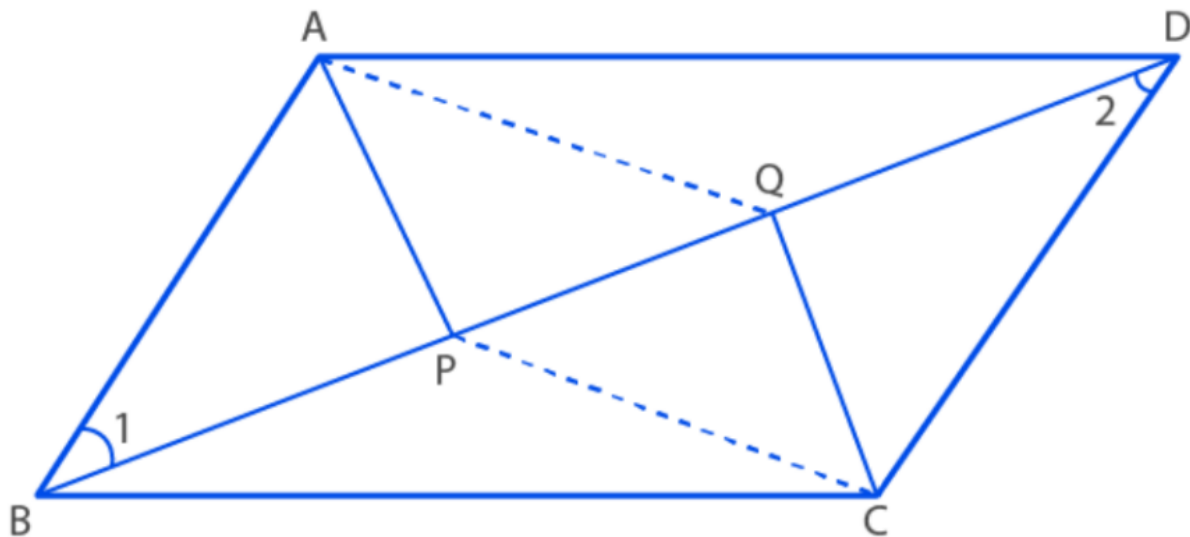
Hence, $AP \perp DQ$

16. If P and Q are points of trisection of the diagonal BD of a parallelogram ABCD, prove that $CQ \parallel AP$.

Solution:

Given: ABCD is a || gm in which $BP = PQ = QD$

To prove: $CQ \parallel AP$



Proof:

In || gm ABCD, we have

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$AB = CD$ [Opposite sides of a || gm are equal]

And BD is the transversal

So, $\angle 1 = \angle 2$ [Alternate interior angles] ... (i)

Now, in $\triangle ABP$ and $\triangle DCQ$

$AB = CD$ [Opposite sides of a || gm are equal]

$\angle 1 = \angle 2$ [From (i)]

$BP = QD$ [Given]

So, $\triangle ABP \cong \triangle DCQ$ by S.A.S axiom of congruency

Then by C.P.C.T, we have

$AP = QC$

Also, $\angle APB = \angle DQC$ [By C.P.C.T]

$-\angle APB = -\angle DQC$ [Multiplying both sides by -1]

$180^\circ - \angle APB = 180^\circ - \angle DQC$ [Adding 180° both sides]

$\angle APQ = \angle CQP$

But, these are alternate angles

Hence, $AP \parallel QC \Rightarrow CQ \parallel AP$.

17. A transversal cuts two parallel lines at A and B. The two interior angles at A are bisected and so are the two interior angles at B ; the four bisectors form a quadrilateral ABCD. Prove that

(i) ABCD is a rectangle.

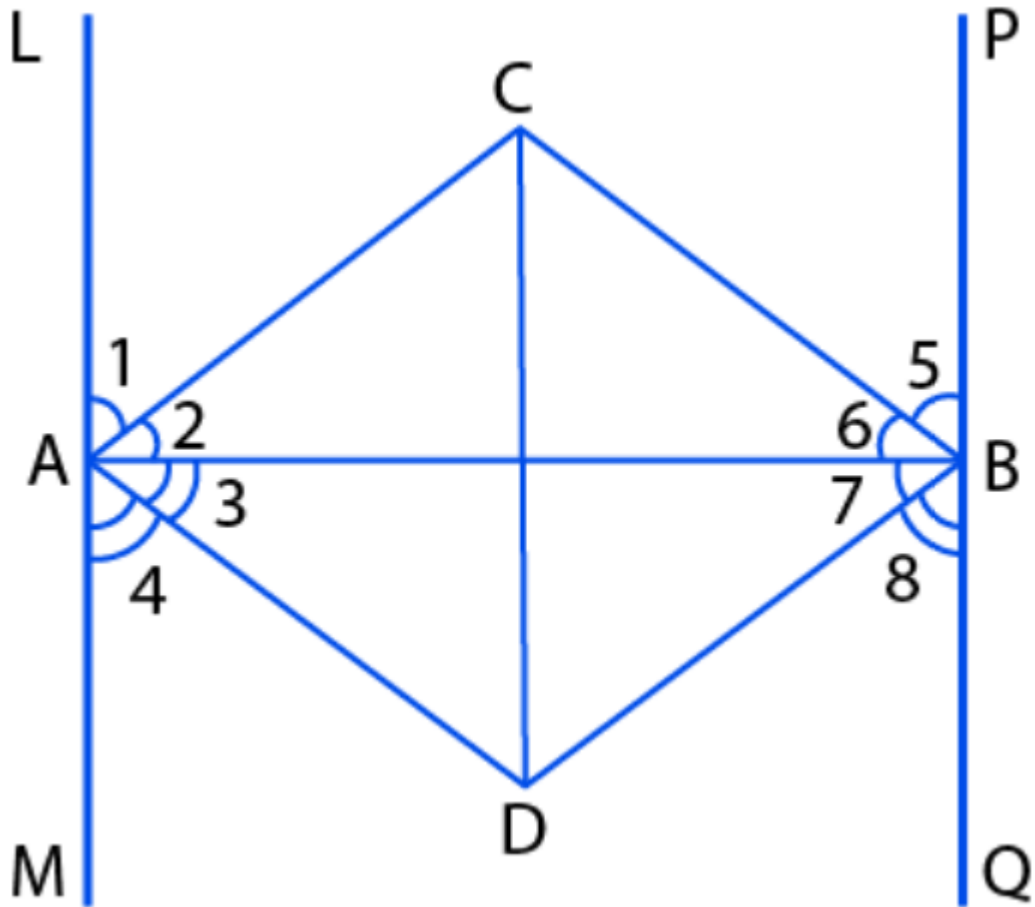
(ii) CD is parallel to the original parallel lines.

18. In a parallelogram ABCD, the bisector of $\angle A$ meets DC in E and $AB = 2 AD$. Prove that

(i) BE bisects $\angle B$

(ii) $\angle AEB =$ a right angle.

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Solution:

Given: $LM \parallel PQ$ and AB is the transversal line cutting $\angle M$ at A and PQ at B

AC , AD , BC and BD is the bisector of $\angle LAB$, $\angle BAM$, $\angle PAB$ and $\angle ABQ$ respectively.

AC and BC intersect at C and AD and BD intersect at D .

A quadrilateral $ABCD$ is formed.

To prove: (i) $ABCD$ is a rectangle

(ii) $CD \parallel LM$ and PQ

Proof:

(1) $\angle LAB + \angle BAM = 180^\circ$ [LAM is a straight line]

$\frac{1}{2} (\angle LAB + \angle BAM) = 90^\circ$

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$$\frac{1}{2} \angle LAB + \frac{1}{2} \angle BAM = 90^\circ$$

$$\angle 2 + \angle 3 = 90^\circ \text{ [Since, AC and AD is bisector of } \angle LAB \text{ \& } \angle BAM \text{ respectively]}$$

$$\angle CAD = 90^\circ$$

$$\angle A = 90^\circ$$

$$(2) \text{ Similarly, } \angle PBA + \angle QBA = 180^\circ \text{ [PBQ is a straight line]}$$

$$\frac{1}{2} (\angle PBA + \angle QBA) = 90^\circ$$

$$\frac{1}{2} \angle PBA + \frac{1}{2} \angle QBA = 90^\circ$$

$$\angle 6 + \angle 7 = 90^\circ \text{ [Since, BC and BD is bisector of } \angle PAB \text{ \& } \angle QBA \text{ respectively]}$$

$$\angle CBD = 90^\circ$$

$$\angle B = 90^\circ$$

$$(3) \angle LAB + \angle ABP = 180^\circ \text{ [Sum of co-interior angles is } 180^\circ \text{ and given } LM \parallel PQ]$$

$$\frac{1}{2} \angle LAB + \frac{1}{2} \angle ABP = 90^\circ$$

$$\angle 2 + \angle 6 = 90^\circ \text{ [Since, AC and BC is bisector of } \angle LAB \text{ \& } \angle PBA \text{ respectively]}$$

$$(4) \text{ In } \triangle ACB,$$

$$\angle 2 + \angle 6 + \angle C = 180^\circ \text{ [Angles sum property of a triangle]}$$

$$(\angle 2 + \angle 6) + \angle C = 180^\circ$$

$$90^\circ + \angle C = 180^\circ \text{ [using (3)]}$$

$$\angle C = 180^\circ - 90^\circ$$

$$\angle C = 90^\circ$$

$$(5) \angle MAB + \angle ABQ = 180^\circ \text{ [Sum of co-interior angles is } 180^\circ \text{ and given } LM \parallel PQ]$$

$$\frac{1}{2} \angle MAB + \frac{1}{2} \angle ABQ = 90^\circ$$

$$\angle 3 + \angle 7 = 90^\circ \text{ [Since, AD and BD is bisector of } \angle MAB \text{ \& } \angle ABQ \text{ respectively]}$$

$$(6) \text{ In } \triangle ADB,$$

$$\angle 3 + \angle 7 + \angle D = 180^\circ \text{ [Angles sum property of a triangle]}$$

$$(\angle 3 + \angle 7) + \angle D = 180^\circ$$

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$$90^\circ + \angle D = 180^\circ \text{ [using (5)]}$$

$$\angle D = 180^\circ - 90^\circ$$

$$\angle D = 90^\circ$$

$$(7) \angle LAB + \angle BAM = 180^\circ$$

$$\angle BAM = \angle ABP \text{ [From (1) and (2)]}$$

$$\frac{1}{2} \angle BAM = \frac{1}{2} \angle ABP$$

$$\angle 3 = \angle 6 \text{ [Since, AD and BC is bisector of } \angle BAM \text{ and } \angle ABP \text{ respectively]}$$

$$\text{Similarly, } \angle 2 = \angle 7$$

$$(8) \text{ In } \triangle ABC \text{ and } \triangle ABD,$$

$$\angle 2 = \angle 7 \text{ [From (7)]}$$

$$AB = AB \text{ [Common]}$$

$$\angle 6 = \angle 3 \text{ [From (7)]}$$

So, $\triangle ABC \cong \triangle ABD$ by A.S.A axiom of congruency

Then, by C.P.C.T we have

$$AC = DB$$

$$\text{Also, } CB = AD$$

$$(9) \angle A = \angle B = \angle C = \angle D = 90^\circ \text{ [From (1), (2), (3) and (4)]}$$

$$AC = DB \text{ [Proved in (8)]}$$

$$CB = AD \text{ [Proved in (8)]}$$

Hence, ABCD is a rectangle.

$$(10) \text{ Since, ABCD is a rectangle [From (9)]}$$

$$OA = OD \text{ [Diagonals of rectangle bisect each other]}$$

$$(11) \text{ In } \triangle AOD, \text{ we have}$$

$$OA = OD \text{ [From (10)]}$$

$$\angle 9 = \angle 3 \text{ [Angles opposite to equal sides are equal]}$$

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$$(12) \angle 3 = \angle 4 \text{ [AD bisects } \angle \text{MAB]}$$

$$(13) \angle 9 = \angle 4 \text{ [From (11) and (12)]}$$

But these are alternate angles.

$$OD \parallel LM \Rightarrow CD \parallel LM$$

Similarly, we can prove that

$$\angle 10 = \angle 8$$

But these are alternate angles,

$$\text{So, } OD \parallel PQ \Rightarrow CD \parallel PQ$$

$$(14) CD \parallel LM \text{ [Proved in (13)]}$$

$$CD \parallel PQ \text{ [Proved in (13)]}$$

18. In a parallelogram ABCD, the bisector of $\angle A$ meets DC in E and $AB = 2 AD$. Prove that:

(i) BE bisects $\angle B$

(ii) $\angle AEB$ is a right angle

Solution:

Given: ABCD is a || gm in which bisectors of angle A and B meet in E and $AB = 2 AD$

To prove: (i) BE bisects $\angle B$

$$(ii) \angle AEB = 90^\circ$$

Proof:

(1) In || gm ABCD

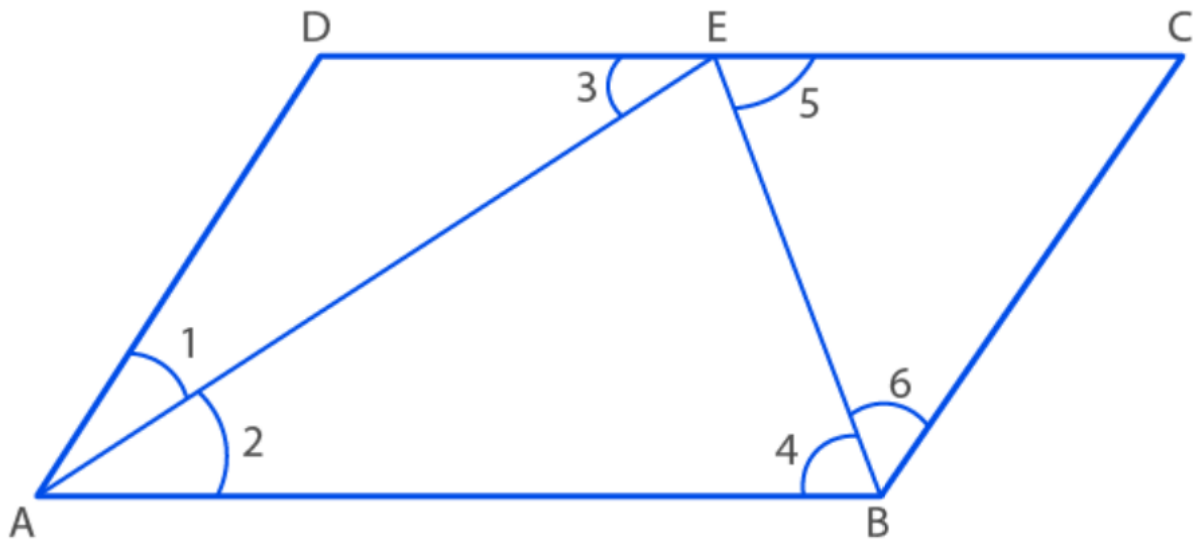
$$\angle 1 = \angle 2 \text{ [AD bisects angles } \angle A]$$

(2) $AB \parallel DC$ and AE is the transversal

$$\angle 2 = \angle 3 \text{ [Alternate angles]}$$

$$(3) \angle 1 = \angle 2 \text{ [From (1) and (2)]}$$

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(4) In $\triangle ADE$, we have

$$\angle 1 = \angle 3 \text{ [Proved in (3)]}$$

$DE = AD$ [Sides opposite to equal angles are equal]

$$\Rightarrow AD = DE$$

(5) $AB = 2 AD$ [Given]

$$AB/2 = AD$$

$$AB/2 = DE \text{ [using (4)]}$$

$$DC/2 = DE \text{ [AB = DC, opposite sides of a || gm are equal]}$$

So, E is the mid-point of D.

$$\Rightarrow DE = EC$$

(6) $AD = BC$ [Opposite sides of a || gm are equal]

$$(7) DE = BC \text{ [From (4) and (6)]}$$

$$(8) EC = BC \text{ [From (5) and (7)]}$$

(9) In $\triangle BCE$, we have

$$EC = BC \text{ [Proved in (8)]}$$

$$\angle 6 = \angle 5 \text{ [Angles opposite to equal sides are equal]}$$

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(10) $AB \parallel DC$ and BE is the transversal

$$\angle 4 = \angle 5 \text{ [Alternate angles]}$$

(11) $\angle 4 = \angle 6$ [From (9) and (10)]

So, BE is bisector of $\angle B$

(12) $\angle A + \angle B = 180^\circ$ [Sum of co-interior angles is equal to 180° , $AD \parallel BC$]

$$\frac{1}{2} \angle A + \frac{1}{2} \angle B = 180^\circ / 2$$

$$\angle 2 + \angle 4 = 90^\circ \text{ [AE is bisector of } \angle A \text{ and BE is bisector of } \angle B]$$

(13) In $\triangle APB$,

$$\angle AEB + \angle 2 + \angle 4 = 180^\circ$$

$$\angle AEB + 90^\circ = 180^\circ$$

Hence, $\angle AEB = 90^\circ$

19. ABCD is a parallelogram, bisectors of angles A and B meet at E which lie on DC. Prove that AB.

Solution:

Given: ABCD is a parallelogram in which bisector of $\angle A$ and $\angle B$ meets DC in E

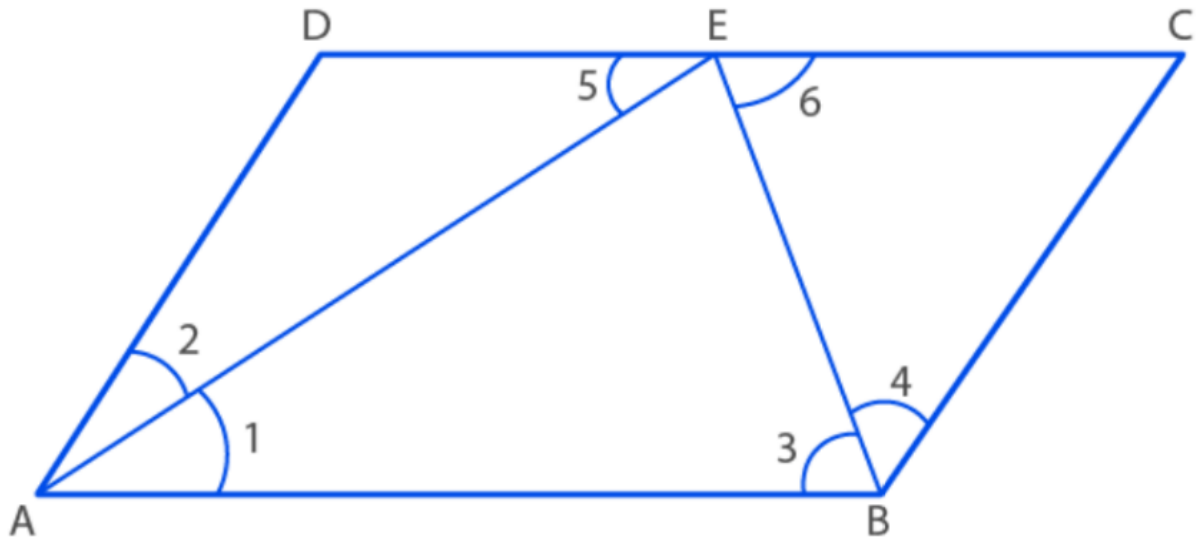
To prove: $AB = 2 AD$

Proof:

In parallelogram ABCD, we have

$$AB \parallel DC$$

$$\angle 1 = \angle 5 \text{ [Alternate angles, AE is transversal]}$$



$\angle 1 = \angle 2$ [AE is bisector of $\angle A$, given]

Thus,

$$\angle 2 = \angle 5 \dots (i)$$

Now, in $\triangle AED$

$DE = AD$ [Sides opposite to equal angles are equal]

$$\angle 3 = \angle 6 \text{ [Alternate angles]}$$

$$\angle 3 = \angle 4 \text{ [Since, BE is bisector of } \angle B \text{ (given)]}$$

$$\text{Thus, } \angle 4 = \angle 6 \dots (ii)$$

In $\triangle BCE$, we have

$BC = EC$ [Sides opposite to equal angles are equal]

$AD = BC$ [Opposite sides of $\parallel$ gm are equal]

$AD = DE = EC$ [From (i) and (ii)]

$AB = DC$ [Opposite sides of a $\parallel$ gm are equal]

$$AB = DE + EC$$

$$= AD + AD$$

Hence,

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$$AB = 2 AD$$

20. ABCD is a square and the diagonals intersect at O. If P is a point on AB such that $AO = AP$, prove that $3 \angle POB = \angle AOP$.

Solution:

Given: ABCD is a square and the diagonals intersect at O. P is the point on AB such that $AO = AP$

To prove: $3 \angle POB = \angle AOP$

Proof:

(1) In square ABCD, AC is a diagonal

$$\text{So, } \angle CAB = 45^\circ$$

$$\angle OAP = 45^\circ$$

(2) In $\triangle AOP$,

$$\angle OAP = 45^\circ \text{ [From (1)]}$$

$$AO = AP \text{ [Sides opposite to equal angles are equal]}$$

Now,

$$\angle AOP + \angle APO + \angle OAP = 180^\circ \text{ [Angles sum property of a triangle]}$$

$$\angle AOP + \angle AOP + 45^\circ = 180^\circ$$

$$2 \angle AOP = 180^\circ - 45^\circ$$

$$\angle AOP = 135^\circ/2$$

(3) $\angle AOB = 90^\circ$ [Diagonals of a square bisect at right angles]

$$\text{So, } \angle AOP + \angle POB = 90^\circ$$

$$135^\circ/2 + \angle POB = 90^\circ \text{ [From (2)]}$$

$$\angle POB = 90^\circ - 135^\circ/2$$

$$= (180^\circ - 135^\circ)/2$$

$$= 45^\circ/2$$

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$$3 \angle POB = 135^\circ/2 \text{ [Multiplying both sides by 3]}$$

Hence,

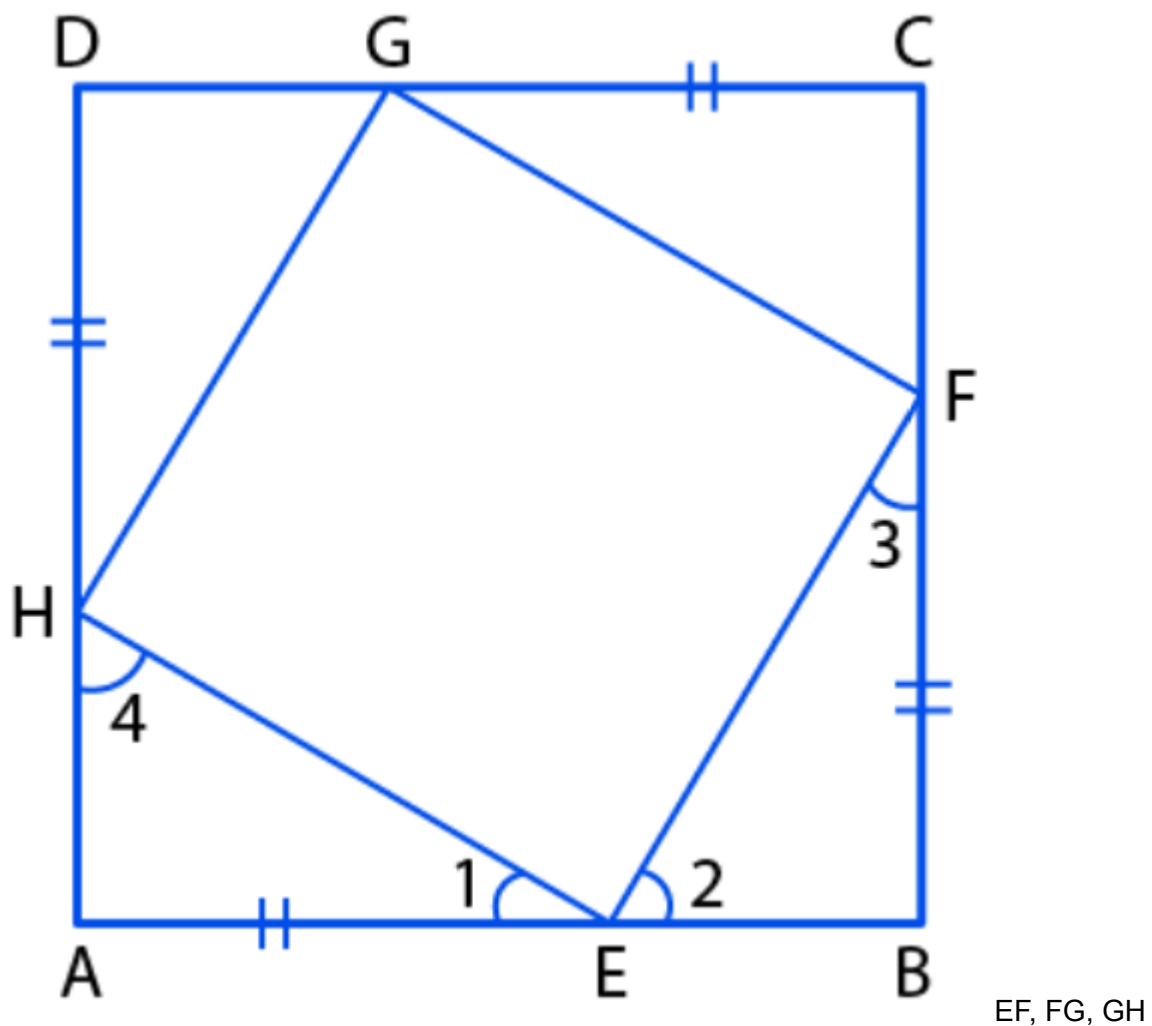
$$\angle AOP = 3 \angle POB \text{ [From (2) and (3)]}$$

21. ABCD is a square. E, F, G and H are points on the sides AB, BC, CD and DA respectively such that $AE = BF = CG = DH$. Prove that EFGH is a square.

Solution:

Given: ABCD is a square in which E, F, G and H are points on AB, BC, CD and DA

Such that $AE = BF = CG = DH$



and HE are joined

To prove: EFGH is a square

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Proof:

Since, $AE = BF = CG = DH$

So, $EB = FC = GD = HA$

Now, in $\triangle AEH$ and $\triangle BFE$

$AE = BF$ [Given]

$AH = EB$ [Proved]

$\angle A = \angle B$ [Each 90°]

So, $\triangle AEH \cong \triangle BFE$ by S.A.S axiom of congruency

Then, by C.P.C.T we have

$EH = EF$

And $\angle 4 = \angle 2$

But $\angle 1 + \angle 4 = 90^\circ$

$\angle 1 + \angle 2 = 90^\circ$

Thus, $\angle HEF = 90^\circ$

Hence, EFGH is a square.

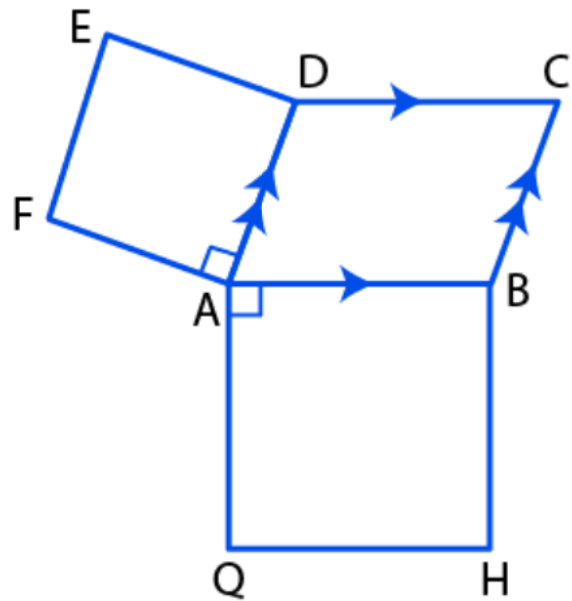
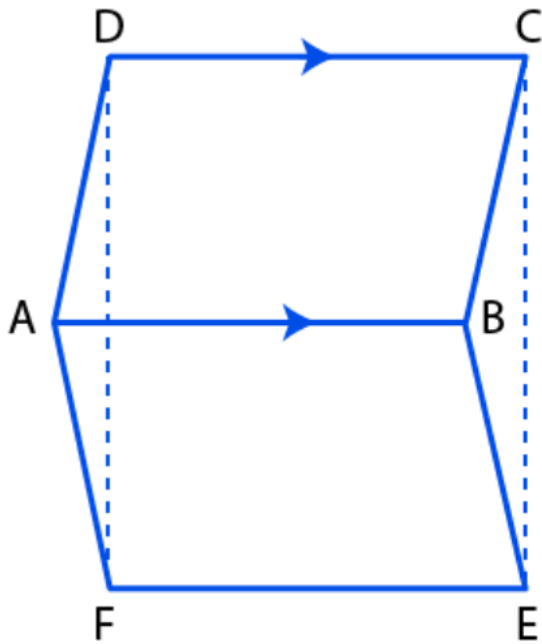
22. (a) In the Figure (1) given below, ABCD and ABEF are parallelograms. Prove that

(i) CDFE is a parallelogram

(ii) $FD = EC$

(iii) $\triangle AFD = \triangle BEC$.

(b) In the figure (2) given below, ABCD is a parallelogram, ADEF and AGHB are two squares. Prove that $FG = AC$.



Solution:

Given: ABCD and ABEF are $\parallel$ gms

To prove: (i) CDFE is a parallelogram

(ii) $FD = EC$

(iii) $\triangle AFD = \triangle BEC$

Proof:

(1) $DC \parallel AB$ and $DC = AB$ [ABCD is a $\parallel$ gm]

(2) $FE \parallel AB$ and $FE = AB$ [ABEF is a $\parallel$ gm]

(3) $DC \parallel FE$ and $DC = FE$ [From (1) and (2)]

Thus, CDFE is a $\parallel$ gm

(4) CDEF is a $\parallel$ gm

So, $FD = EC$

(5) In $\triangle AFD$ and $\triangle BEC$, we have

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$AD = BC$ [Opposite sides of $\parallel$ gm ABCD are equal]

$AF = BE$ [Opposite sides of $\parallel$ gm ABEF are equal]

$FD = BE$ [From (4)]

Hence, $\triangle AFD \cong \triangle BEC$ by S.S.S axiom of congruency

(b) Given: ABCD is a $\parallel$ gm, ADEF and AGHB are two squares

To prove: $FG = AC$

Proof:

(1) $\angle FAG + 90^\circ + 90^\circ + \angle BAD = 360^\circ$ [At a point total angle is 360°]

$$\angle FAG = 360^\circ - 90^\circ - 90^\circ - \angle BAD$$

$$\angle FAG = 180^\circ - \angle BAD$$

(2) $\angle B + \angle BAD = 180^\circ$ [Adjacent angle in $\parallel$ gm is equal to 180°]

$$\angle B = 180^\circ - \angle BAD$$

(3) $\angle FAG = \angle B$ [From (1) and (2)]

(4) In $\triangle AFG$ and $\triangle ABC$, we have

$AF = BC$ [FADE and ABCD both are squares on the same base]

Similarly, $AG = AB$

$$\angle FAG = \angle B \text{ [From (3)]}$$

So, $\triangle AFG \cong \triangle ABC$ by S.A.S axiom of congruency

Hence, by C.P.C.T

$$FG = AC$$

23. ABCD is a rhombus in which $\angle A = 60^\circ$. Find the ratio $AC : BD$.

Solution:

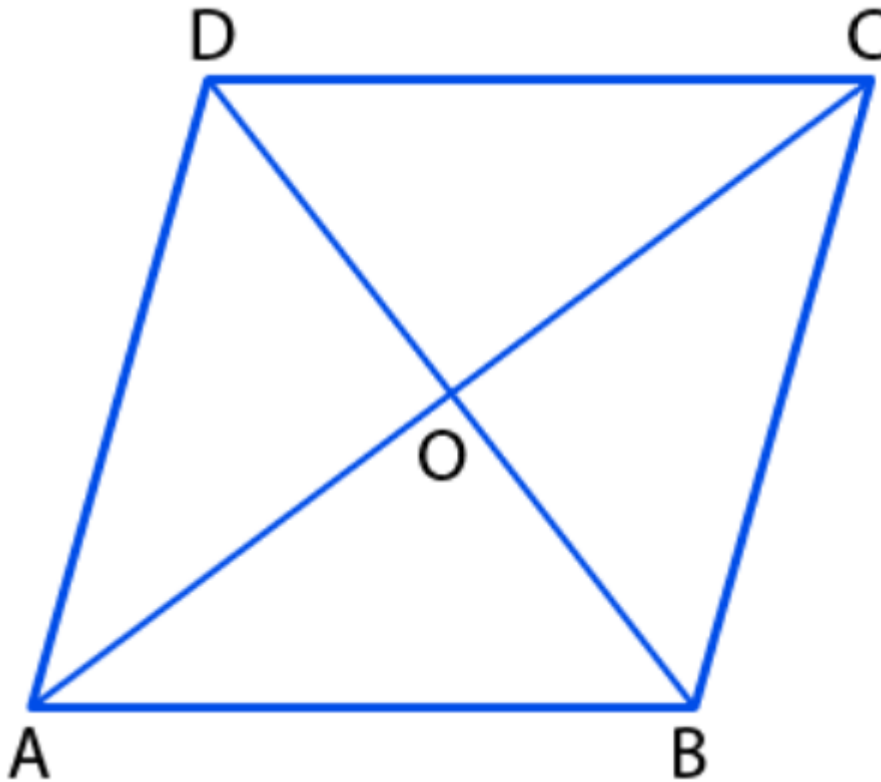
Let each side of the rhombus ABCD be a

$$\angle A = 60^\circ$$

So, ABD is an equilateral triangle

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$$\Rightarrow BD = AB = a$$



We know that, the diagonals of a rhombus bisect each other at right angles

So, in right triangle AOB, we have

$$AO^2 + OB^2 = AB^2 \text{ [By Pythagoras Theorem]}$$

$$AO^2 = AB^2 - OB^2$$

$$= a^2 - \left(\frac{1}{2}a\right)^2$$

$$= a^2 - \frac{a^2}{4}$$

$$= \frac{3a^2}{4}$$

$$AO = \sqrt{\left(\frac{3a^2}{4}\right)} = \frac{\sqrt{3}a}{2}$$

$$\text{But, } AC = 2 AO = 2 \times \frac{3a}{2} = 3a$$

Hence,

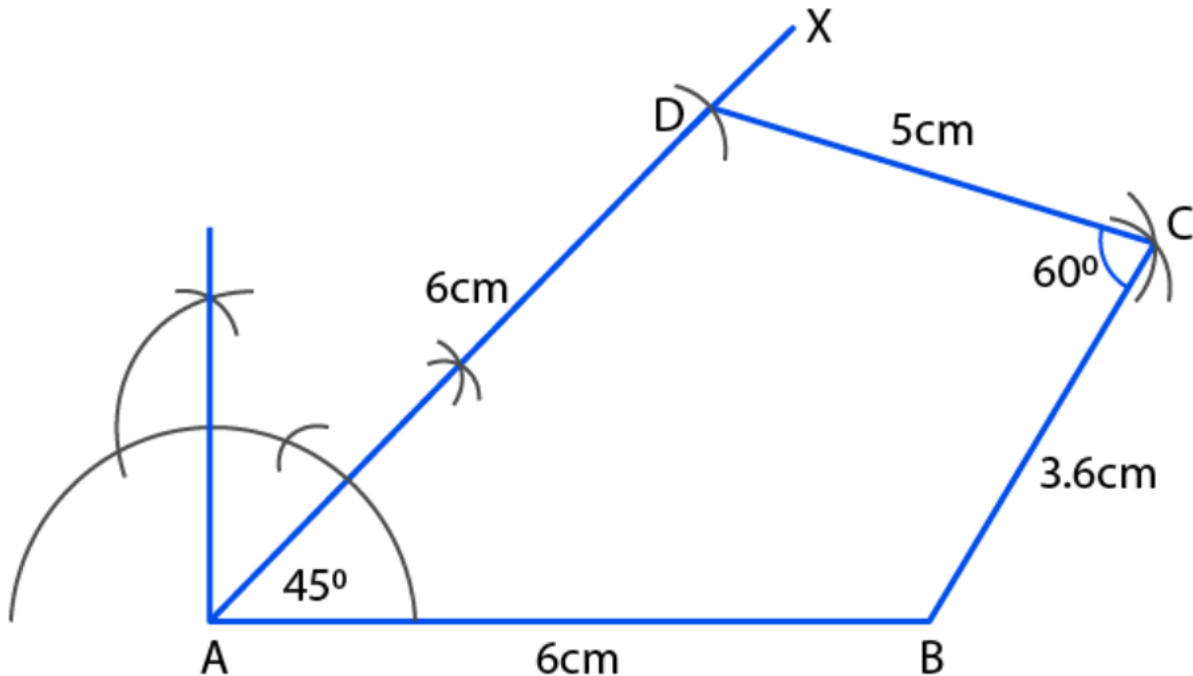
$$AC : BD = \sqrt{3}a : a = \sqrt{3} : 1$$

Exercise 13.2

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1. Using ruler and compasses only, construct the quadrilateral ABCD in which $\angle BAD = 45^\circ$, $AD = AB = 6\text{cm}$, $BC = 3.6\text{cm}$, $CD = 5\text{cm}$. Measure $\angle BCD$.

Solution:



Steps of construction:

- (i) Draw a line segment $AB = 6\text{cm}$
- (ii) At A, draw a ray AX making an angle of 45° and cut off $AD = 6\text{cm}$
- (iii) With centre B and radius 3.6cm and with centre D and radius 5cm , draw two arcs intersecting each other at C.
- (iv) Join BC and DC.

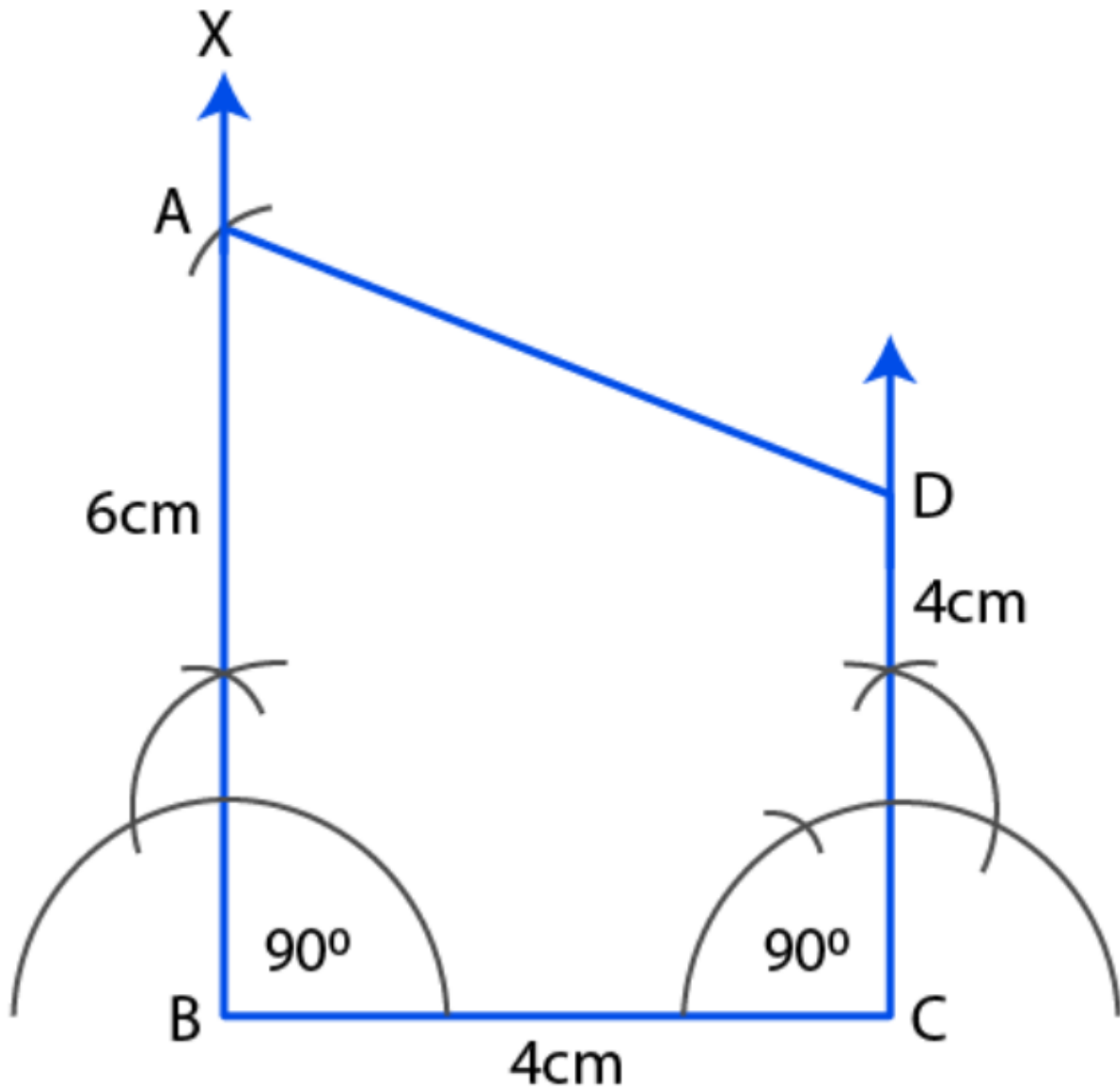
Thus, ABCD is the required quadrilateral.

On measuring $\angle BCD$, it is 60° .

2. Draw a quadrilateral ABCD with $AB = 6\text{cm}$, $BC = 4\text{cm}$, $CD = 4\text{cm}$ and $\angle B = \angle BCD = 90^\circ$.

Solution:

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Steps of construction:

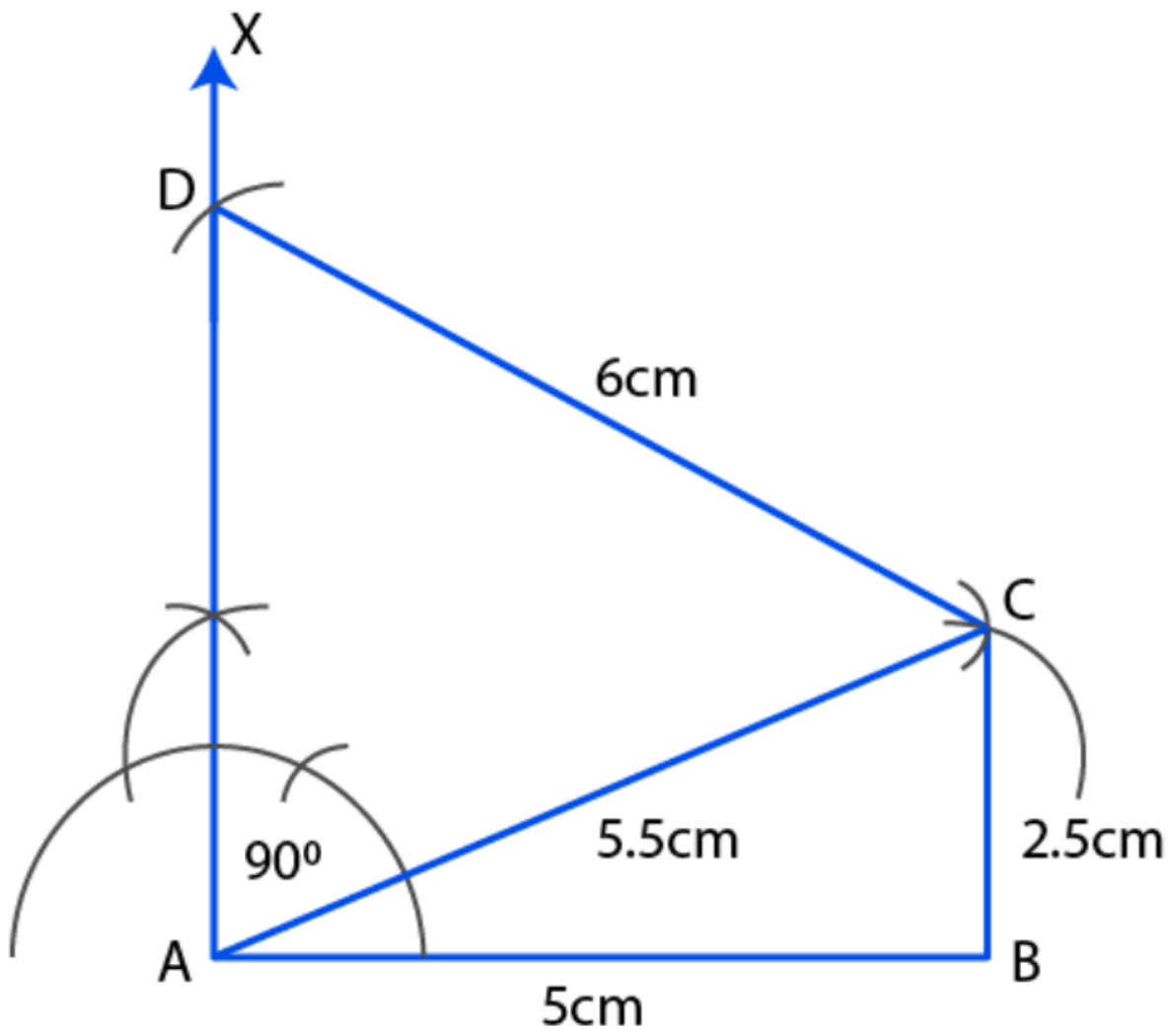
- (i) Draw a line segment $BC = 4 \text{ cm}$
- (ii) At B and C draw rays BX and CY making an angle of 90° each
- (iii) From BX, cut off $BA = 6 \text{ cm}$ and from CY, cut off $CD = 4 \text{ cm}$
- (iv) Join AD.

Thus, ABCD is the required quadrilateral.

3. Using ruler and compasses only, construct the quadrilateral ABCD given that $AB = 5 \text{ cm}$, $BC = 2.5 \text{ cm}$, $CD = 6 \text{ cm}$, $\angle BAD = 90^\circ$ and the diagonal $AC = 5.5 \text{ cm}$.

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Solution:



Steps of construction:

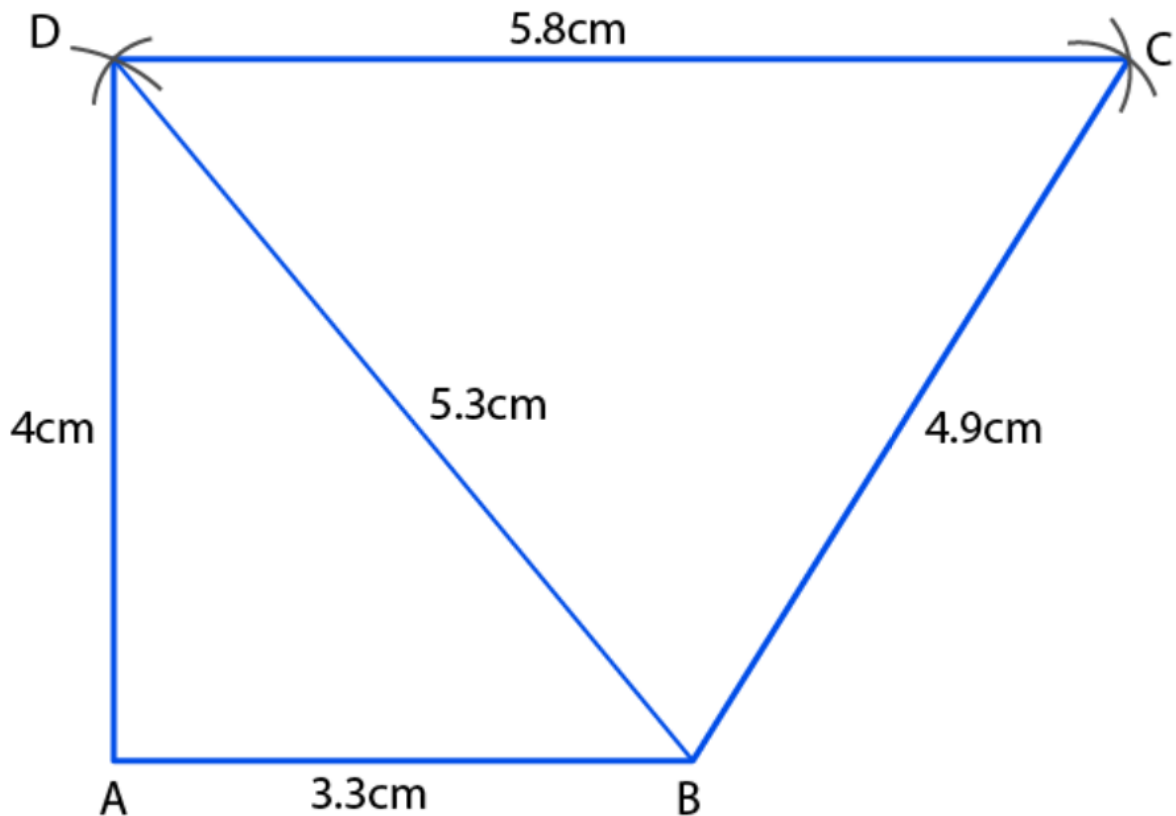
- (i) Draw a line segment $AB = 5\text{cm}$
- (ii) With centre A and radius 5.5cm and with centre B and radius 2.5cm draw arcs which intersect each other at C.
- (iii) Join AC and BC.
- (iv) At A, draw a ray AX making an angle of 90° .
- (v) With centre C and radius 6cm, draw an arc intersecting AX at D
- (vi) Join CD.

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Thus, ABCD is the required quadrilateral.

4. Construct a quadrilateral ABCD in which $AB = 3.3$ cm, $BC = 4.9$ cm, $CD = 5.8$ cm, $DA = 4$ cm and $BD = 5.3$ cm.

Solution:



Steps of construction:

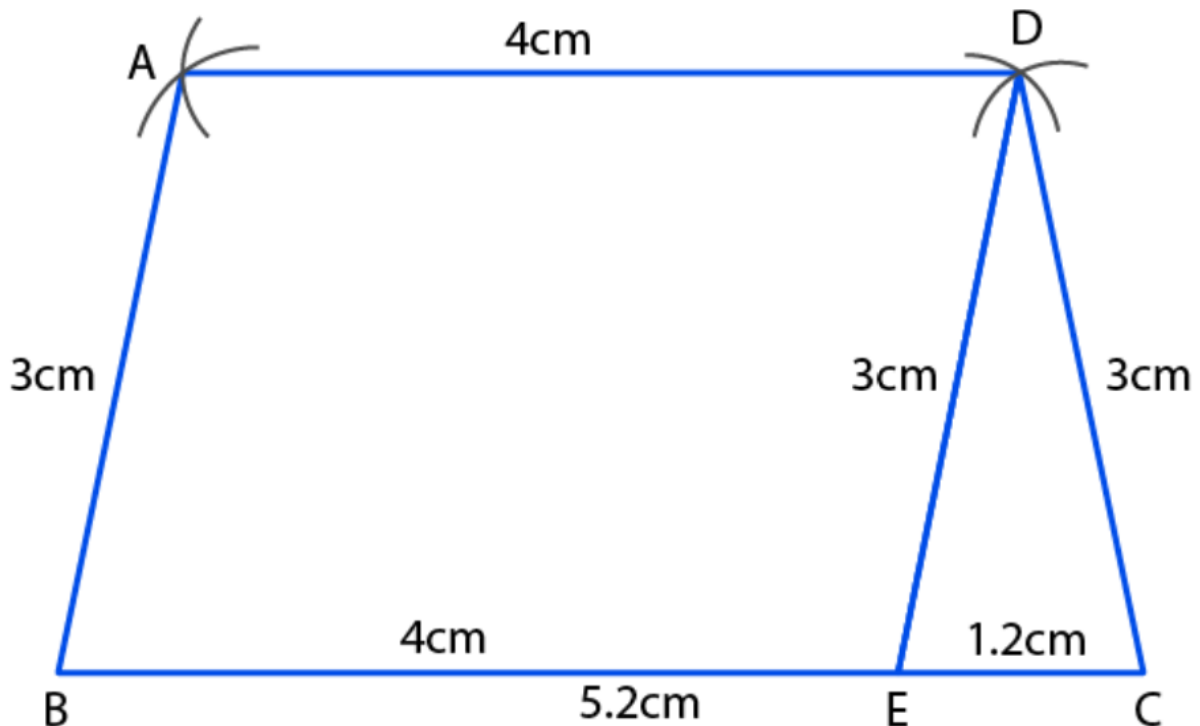
- (i) Draw a line segment $AB = 3.3$ cm
- (ii) with centre A and radius 4cm, and with centre B and radius 5.3cm, draw arcs intersecting each other at D.
- (iii) Join AD and BD.
- (iv) With centre B and radius 4.9 cm and with centre D and radius 5.8cm, draw arcs intersecting each other at C.
- (v) Join BC and DC.

Thus, ABCD is the required quadrilateral.

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5. Construct a trapezium ABCD in which $AD \parallel BC$, $AB = CD = 3$ cm, $BC = 5.2$ cm and $AD = 4$ cm.

Solution:



Steps of construction:

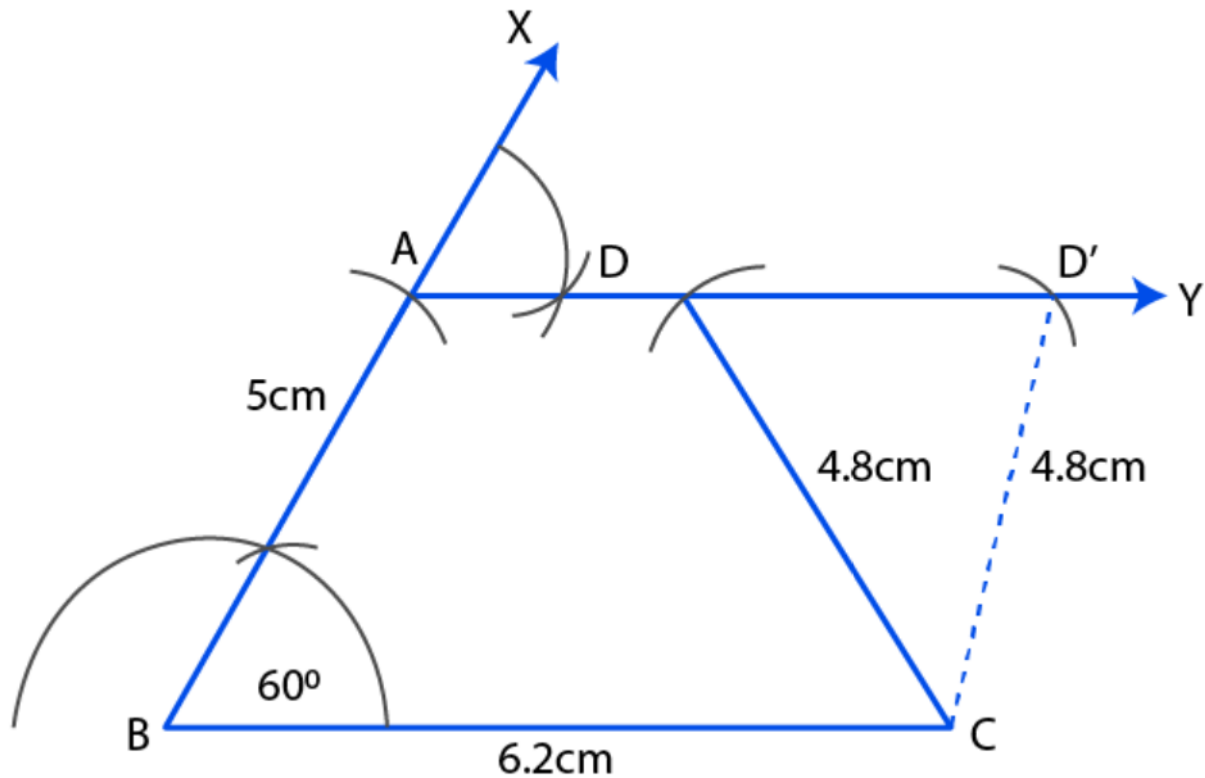
- (i) Draw a line segment $BC = 5.2$ cm
- (ii) From BC , cut off $BE = AD = 4$ cm
- (iii) With centre E and C , and radius 3 cm, draw arcs intersecting each other at D .
- (iv) Join ED and CD .
- (v) With centre D and radius 4 cm and with centre B and radius 3 cm, draw arcs intersecting each other at A .
- (vi) Join BA and DA

Thus, $ABCD$ is the required trapezium.

6. Construct a trapezium ABCD in which $AD \parallel BC$, $\angle B = 60^\circ$, $AB = 5$ cm. $BC = 6.2$ cm and $CD = 4.8$ cm.

Solution:

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Steps of construction:

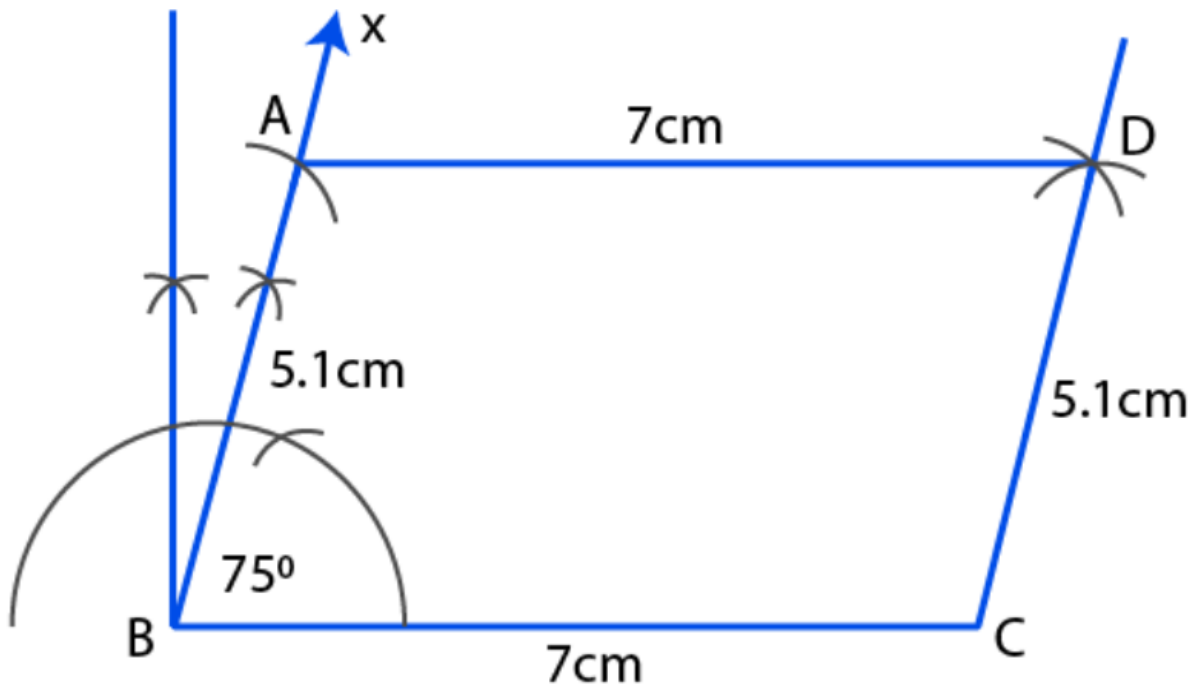
- (i) Draw a line segment $BC = 6.2\text{cm}$
- (ii) At B, draw a ray BX making an angle of 60° and cut off $AB = 5\text{cm}$
- (iii) From A, draw a line AY parallel to BC.
- (iv) With centre C and radius 4.8cm , draw an arc which intersects AY at D and D'.
- (v) Join CD and CD'

Thus, ABCD and ABCD' are the required two trapeziums.

7. Using ruler and compasses only, construct a parallelogram ABCD with $AB = 5.1\text{ cm}$, $BC = 7\text{ cm}$ and $\angle ABC = 75^\circ$.

Solution:

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Steps of construction:

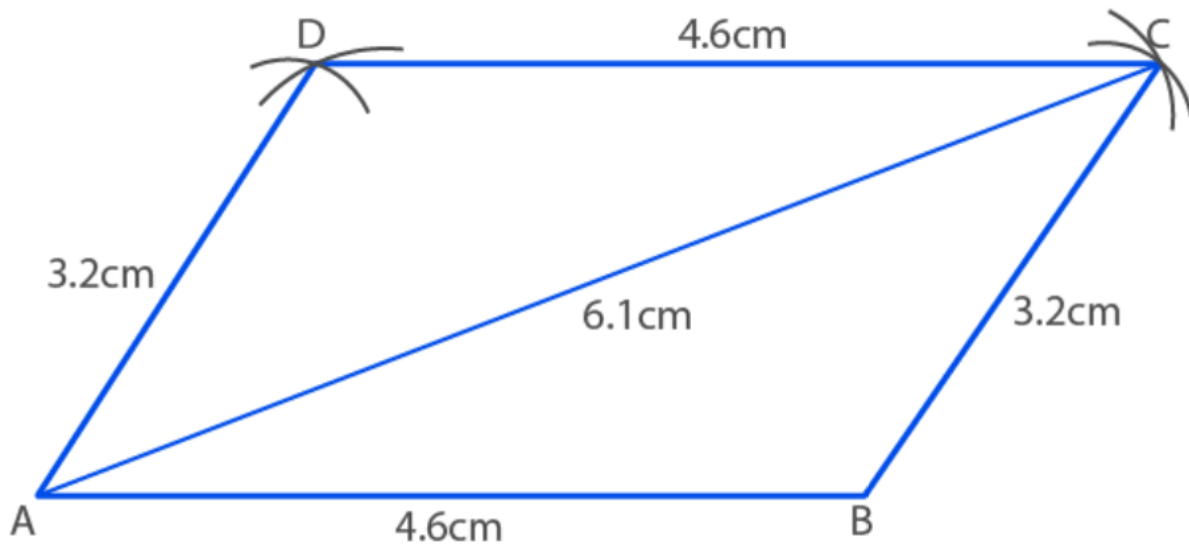
- (i) Draw a line segment $BC = 7\text{cm}$
- (ii) A to B, draw a ray Bx making an angle of 75° and cut off $AB = 5.1\text{cm}$
- (iii) With centre A and radius 7cm with centre C and radius 5.1cm , draw arcs intersecting each other at D.
- (iv) Join AD and CD.

Thus, ABCD is the required parallelogram.

8. Using ruler and compasses only, construct a parallelogram ABCD in which $AB = 4.6\text{ cm}$, $BC = 3.2\text{ cm}$ and $AC = 6.1\text{ cm}$.

Solution:

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Steps of construction:

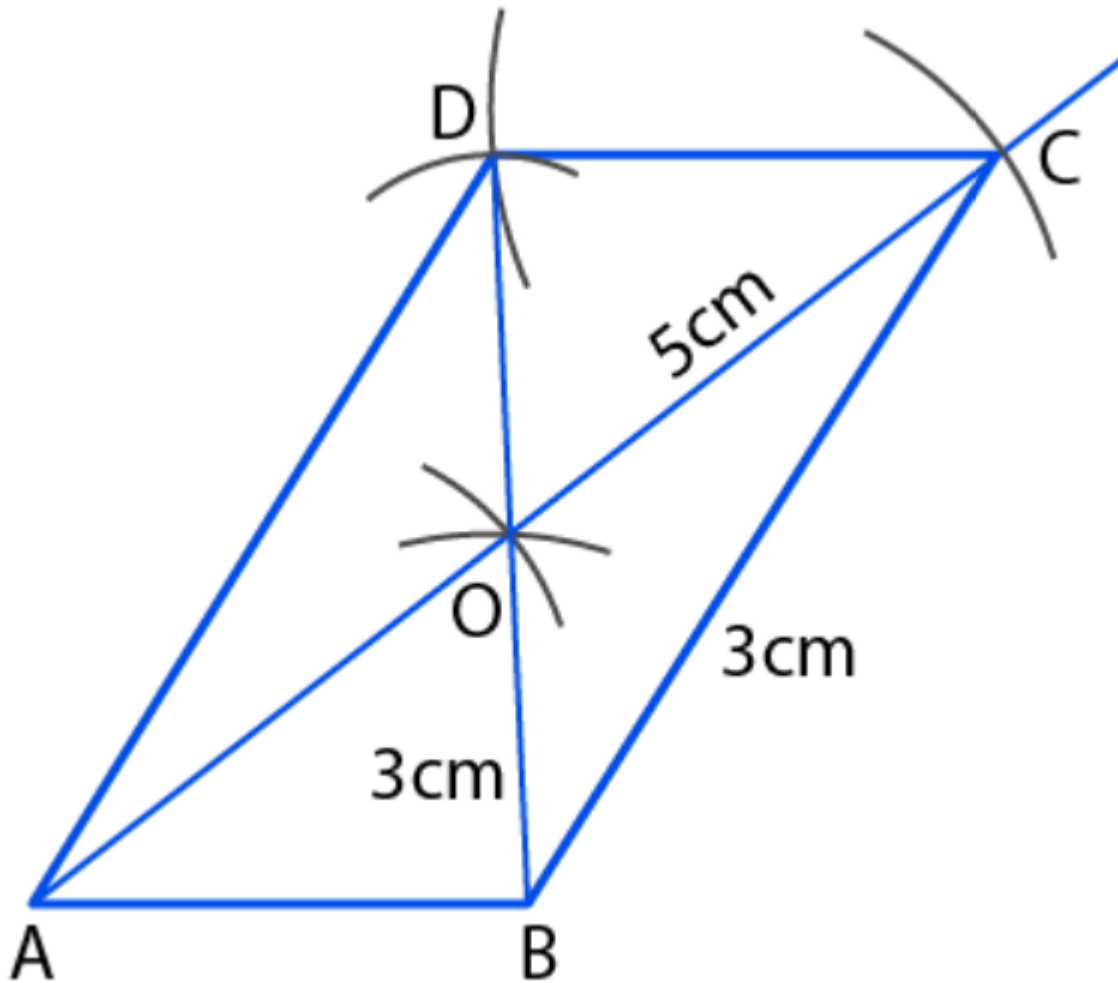
- (i) Draw a line segment $AB = 4.6\text{cm}$
- (ii) With centre A and radius 6.1cm and with centre B and radius 3.2cm , draw arcs intersecting each other at C.
- (iii) Join AC and BC.
- (iv) Again, with centre A and radius 3.2cm and with centre C and radius 4.6cm , draw arcs intersecting each other at D.
- (v) Join AD and CD.

Thus, ABCD is the required parallelogram.

9. Using ruler and compasses, construct a parallelogram ABCD give that $AB = 4\text{ cm}$, $AC = 10\text{ cm}$, $BD = 6\text{ cm}$. Measure BC.

Solution:

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Steps of construction:

(i) Construct triangle OAB such that

$$OA = \frac{1}{2} \times AC = \frac{1}{2} \times 10\text{cm} = 5\text{cm}$$

$$OB = \frac{1}{2} \times BD = \frac{1}{2} \times 6\text{cm} = 3\text{cm}$$

As, diagonals of || gm bisect each other and $AB = 4\text{cm}$

(ii) Produce AO to C such that $OA = OC = 5\text{cm}$

(iii) Produce BO to D such that $OB = OD = 3\text{cm}$

(iv) Join AD, BC and CD

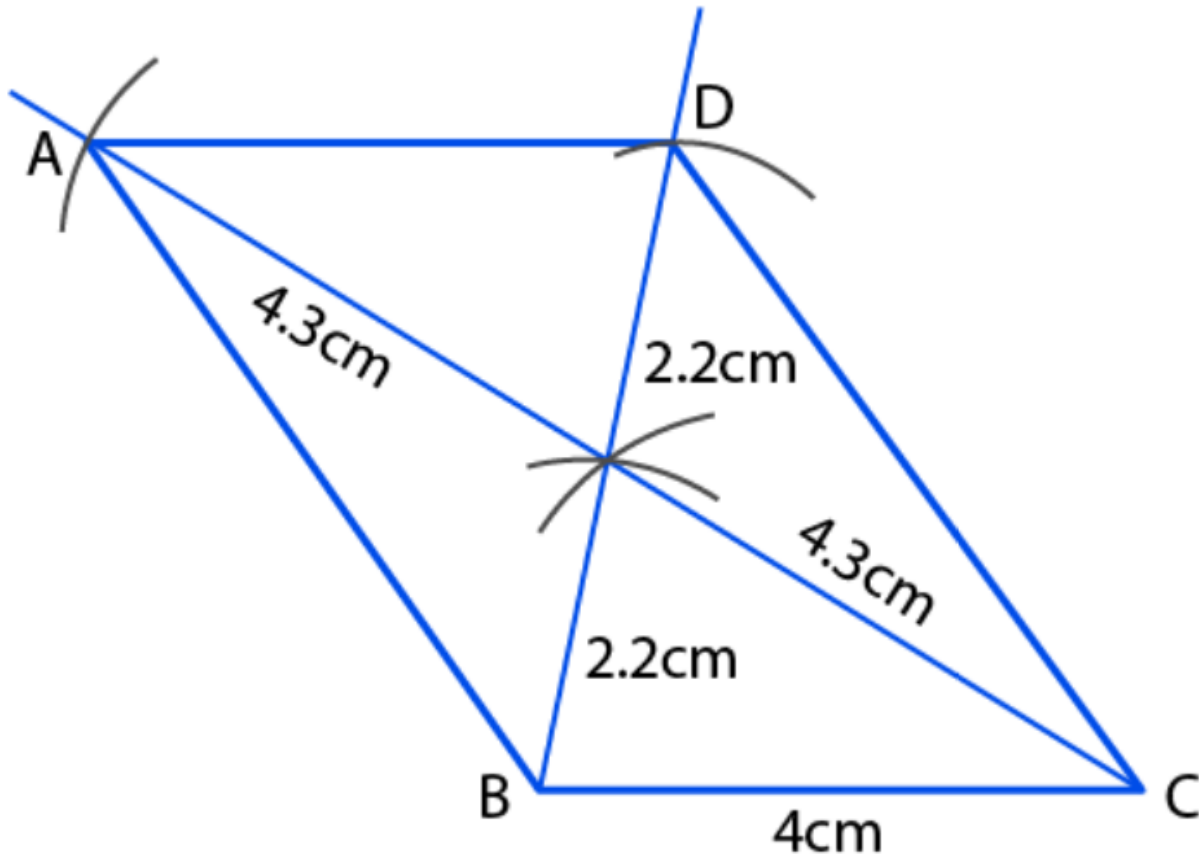
Thus, ABCD is the required parallelogram

(v) Measure BC which is equal to 7.2cm

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10. Using ruler and compasses only, construct a parallelogram ABCD such that $BC = 4\text{ cm}$, diagonal $AC = 8.6\text{ cm}$ and diagonal $BD = 4.4\text{ cm}$. Measure the side AB.

Solution:



Steps of construction:

(i) Construct triangle OBC such that

$$OB = \frac{1}{2} \times BD = \frac{1}{2} \times 4.4\text{ cm} = 2.2\text{ cm}$$

$$OC = \frac{1}{2} \times AC = \frac{1}{2} \times 8.6\text{ cm} = 4.3\text{ cm}$$

Since, diagonals of || gm bisect each other and $BC = 4\text{ cm}$

(ii) Produce BO to D such that $BO = OD = 2.2\text{ cm}$

(iii) Produce CO to A such that $CO = OA = 4.3\text{ cm}$

(iv) Join AB, AD and CD

Thus, ABCD is the required parallelogram.

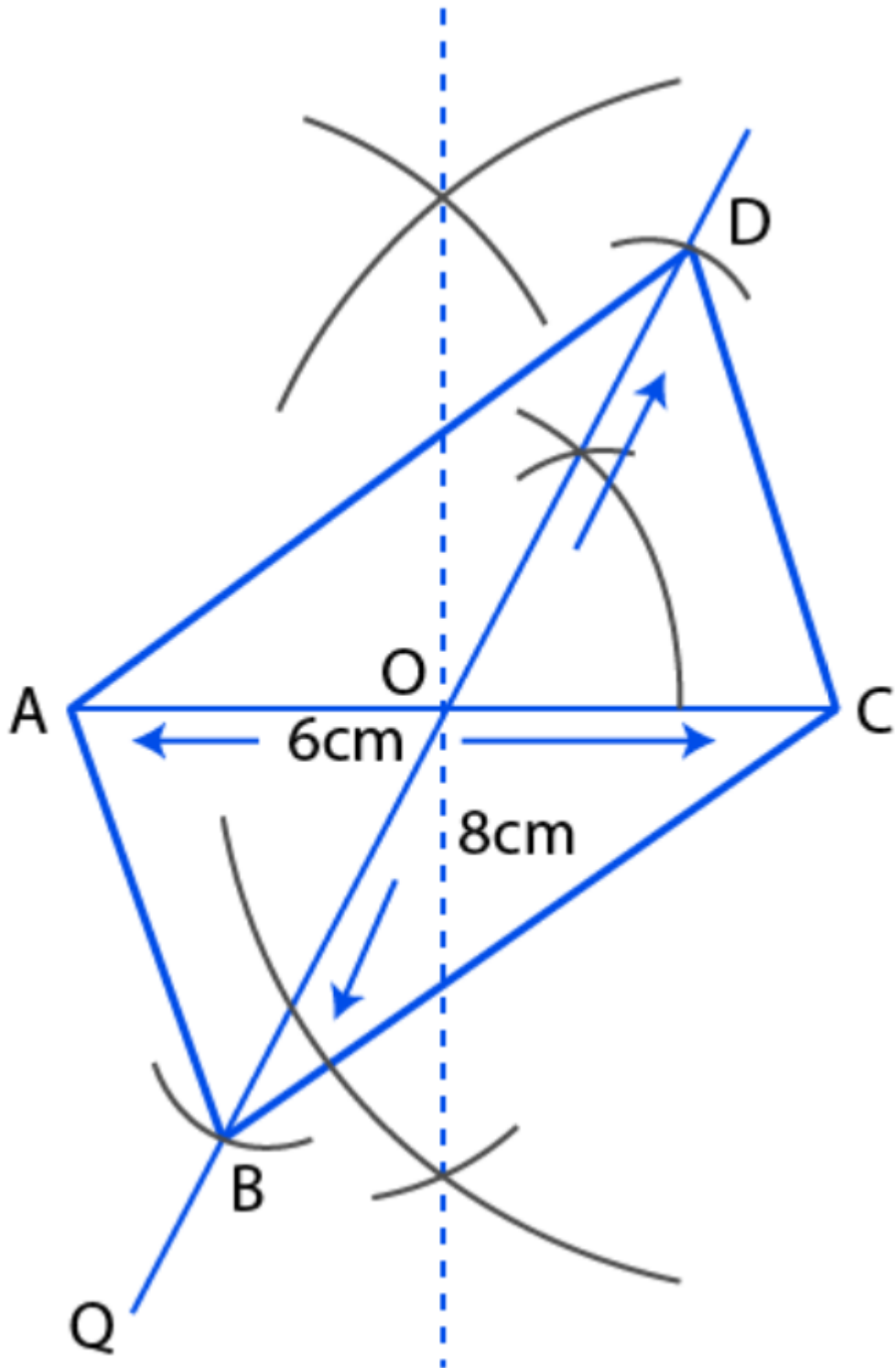
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(v) Measure the side AB, $AB = 5.6\text{cm}$

11. Use ruler and compasses to construct a parallelogram with diagonals 6 cm and 8 cm in length having given the acute angle between them is 60° . Measure one of the longer sides.

Solution:

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Steps of construction:

(i) Draw $AC = 6\text{cm}$

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(ii) Find the mid-point O of AC. [Since, diagonals of || gm bisect each other]

(iii) Draw line POQ such that $\angle POQ = 60^\circ$ and $OB = OD = \frac{1}{2} BD = \frac{1}{2} \times 8\text{cm} = 4\text{cm}$

So, from OP cut OD = 4cm and from OQ cut OB = 4cm

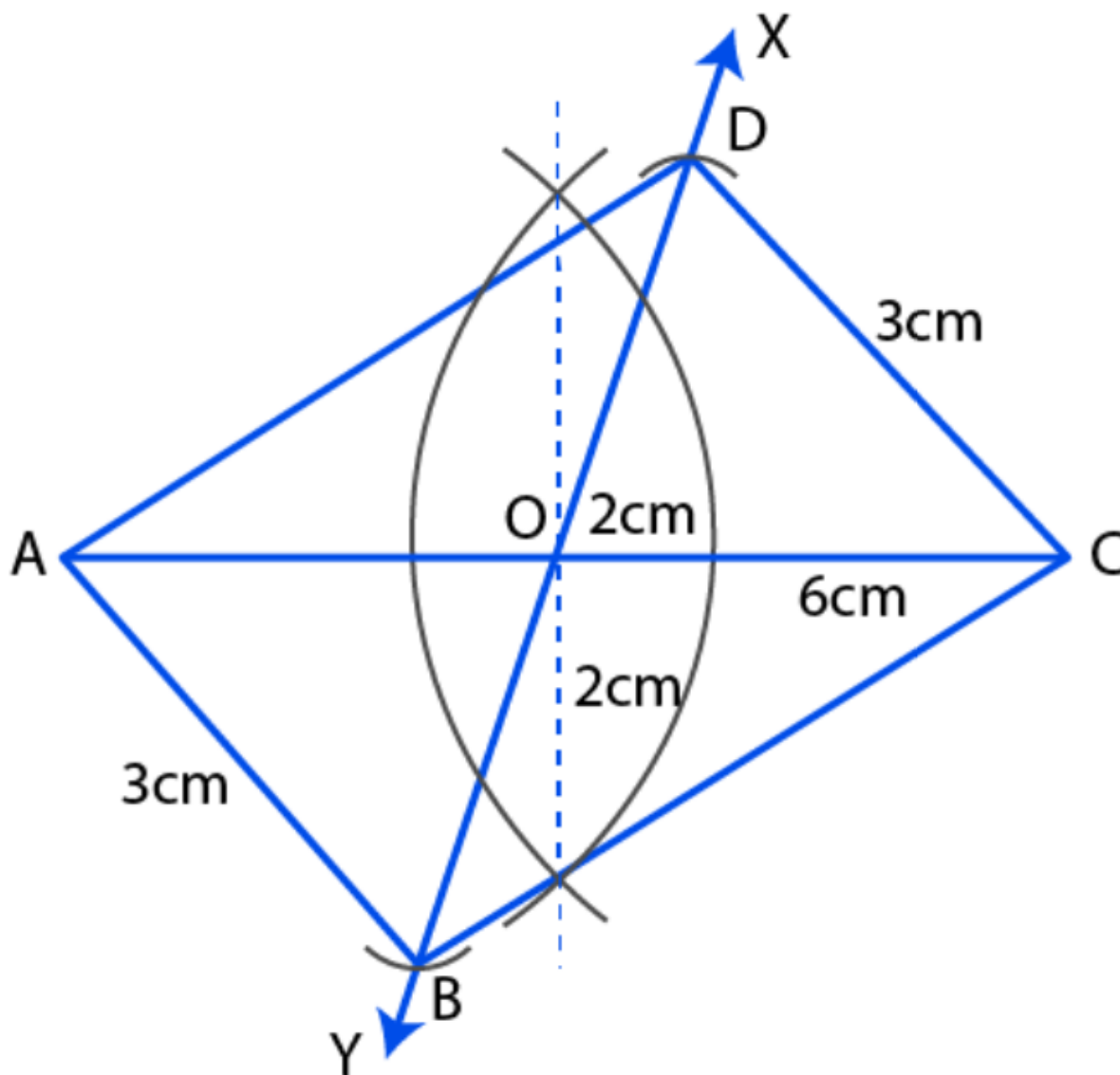
(iv) Join AB, BC, CD and DA.

Thus, ABCD is the required parallelogram.

(v) Measure the length of side AD = 6.1cm

12. Using ruler and compasses only, draw a parallelogram whose diagonals are 4 cm and 6 cm long and contain an angle of 75° . Measure and write down the length of one of the shorter sides of the parallelogram.

Solution:



Steps of construction:

- (i) Draw a line segment $AC = 6\text{cm}$
- (ii) Bisect AC at O .
- (iii) At O , draw a ray XY making an angle of 75° at O .
- (iv) From OX and OY , cut off $OD = OB = \frac{4}{2} = 2\text{cm}$
- (v) Join AB , BC , CD and DA .

Thus, $ABCD$ is the required parallelogram.

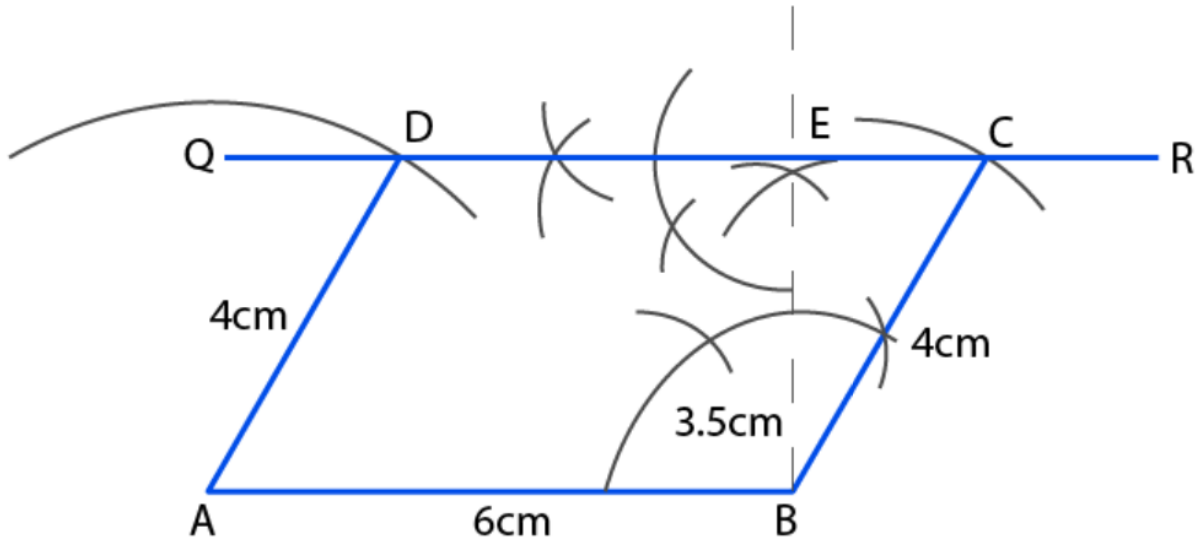
On measuring one of the shorter sides, we get

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$AB = CD = 3\text{cm}$

13. Using ruler and compasses only, construct a parallelogram ABCD with $AB = 6\text{ cm}$, altitude = 3.5 cm and side $BC = 4\text{ cm}$. Measure the acute angles of the parallelogram.

Solution:



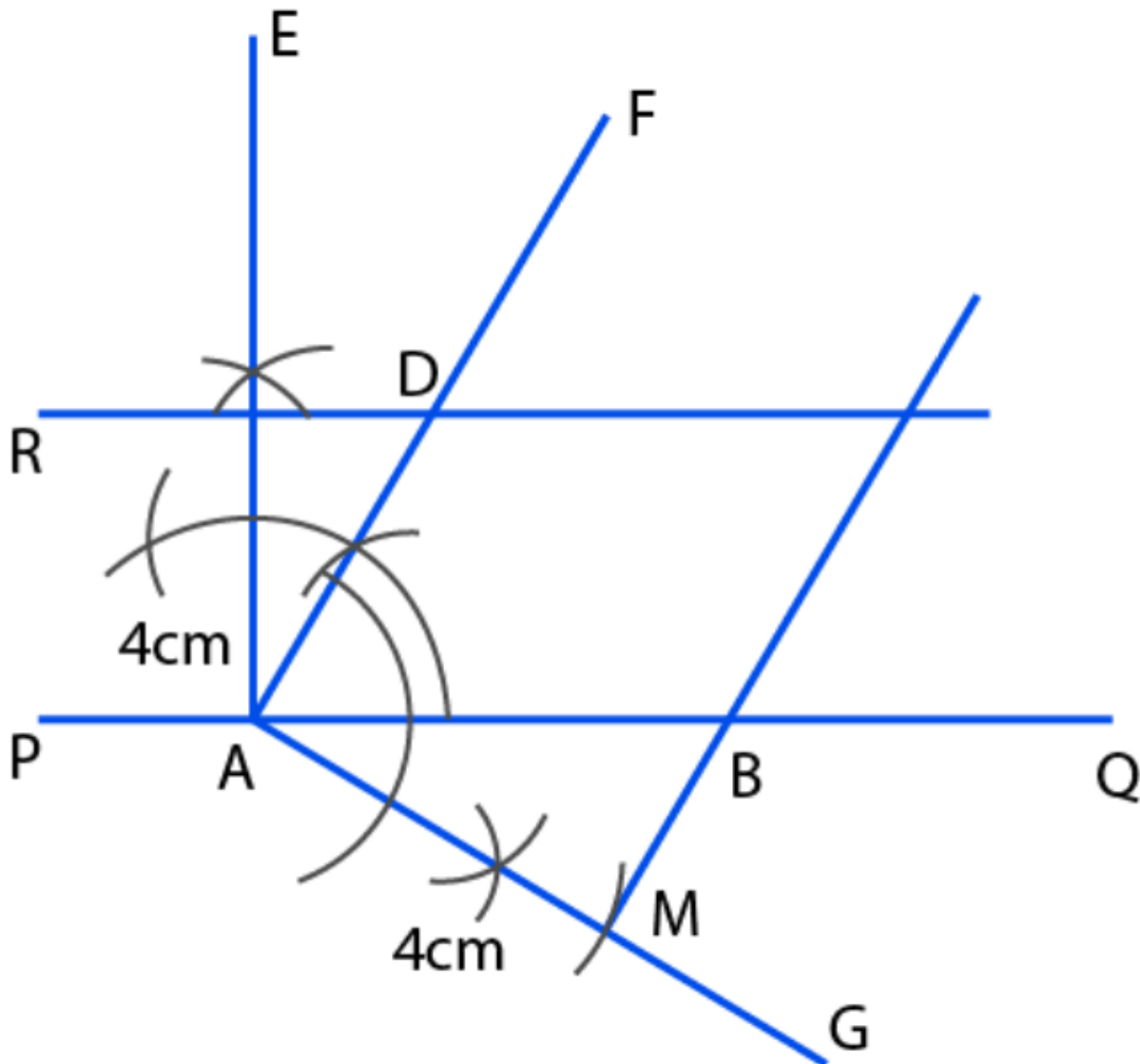
Steps of construction:

- (i) Draw $AB = 6\text{cm}$
 - (ii) At B, draw $BP \perp AB$
 - (iii) From BP, cut $BE = 3.5\text{cm} = \text{height of } \parallel \text{gm}$
 - (iv) Through E draw QR parallel to AB
 - (v) With B as centre and radius $BC = 4\text{cm}$ draw an arc which cuts QR at C.
 - (vi) Since, opposite sides of $\parallel \text{gm}$ are equal
So, $AD = BC = 4\text{cm}$
 - (vii) With A as centre and radius = 4cm draw an arc which cuts QR at D.
- Thus, ABCD is the required parallelogram.
- (viii) To measure the acute angle of parallelogram which is equal to 61° .

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14. The perpendicular distances between the pairs of opposite sides of a parallelogram ABCD are 3 cm and 4 cm and one of its angles measures 60° . Using ruler and compasses only, construct ABCD.

Solution:



Steps of construction:

- (i) Draw a straight-line PQ, take a point A on it.
- (ii) At A, construct $\angle QAF = 60^\circ$
- (iii) At A, draw $AE \perp PQ$ from AE cut off $AN = 3\text{cm}$

- (iv) Through N draw a straight line to PQ to meet AF at D.

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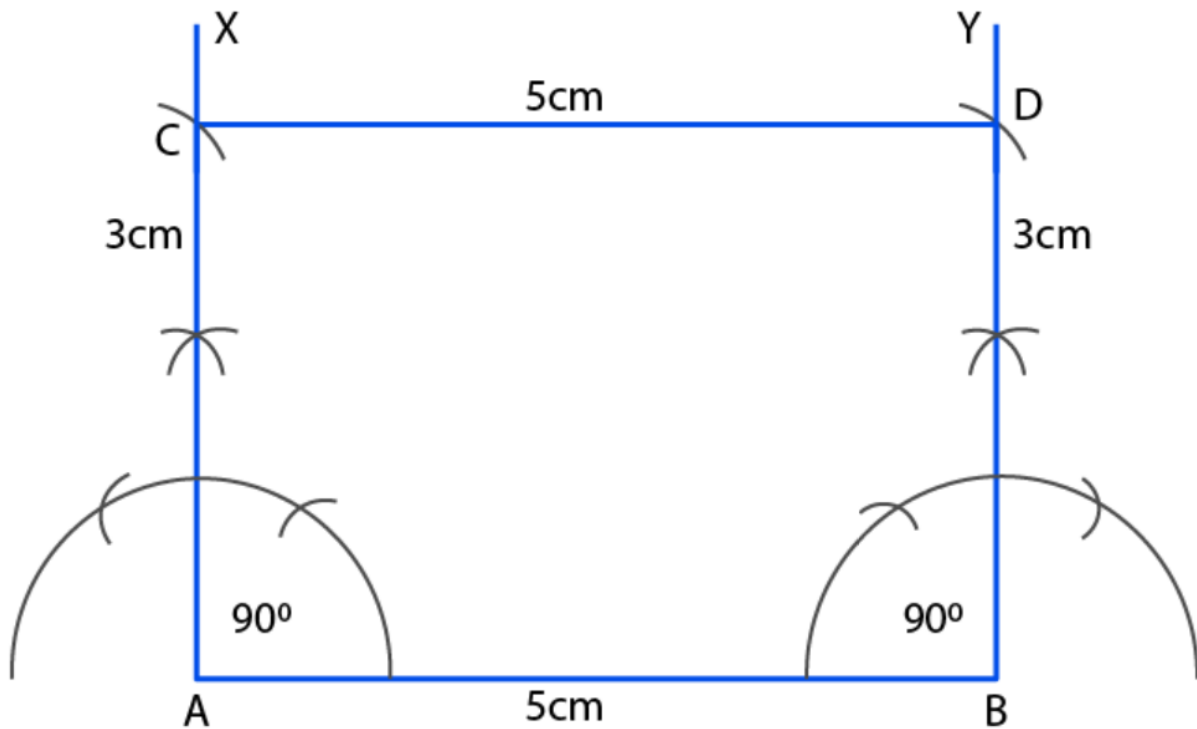
(v) At D, draw $AG \perp AD$, from AG cut off $AM = 4\text{cm}$

(vi) Through M, draw a straight line parallel to AD to meet AQ in B and ND in C.

Then, ABCD is the required parallelogram

15. Using ruler and compasses, construct a rectangle ABCD with $AB = 5\text{cm}$ and $AD = 3\text{cm}$.

Solution:



Steps of construction:

- (i) Draw a straight-line $AB = 5\text{cm}$
- (ii) At A and B construct $\angle XAB$ and $\angle YBA = 90^\circ$
- (iii) From A and B cut off AC and BD = 3cm each
- (iv) Join CD

Thus, ABCD is the required rectangle.

16. Using ruler and compasses only, construct a rectangle each of whose diagonals measures 6cm and the diagonals intersect at an angle of 45° .

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Solution:

Steps of construction:

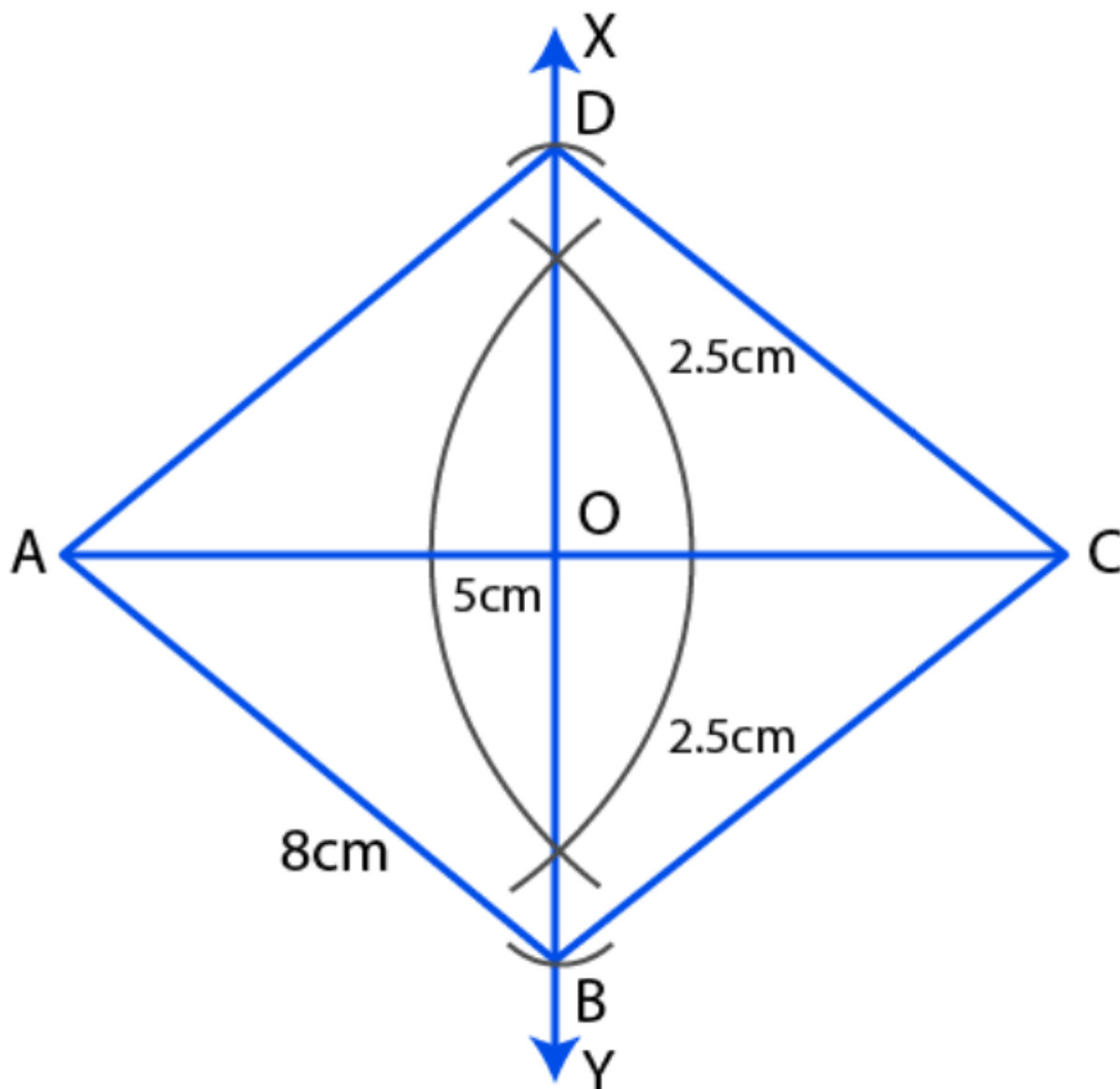
- (i) Draw a line segment $AC = 6\text{cm}$
- (ii) Bisect AC at O .
- (iii) At O , draw a ray XY making an angle of 45° at O .
- (iv) From XY , cut off $OB = OD = 6/2 = 3\text{cm}$ each
- (v) Join AB , BC CD and DA .

Thus, $ABCD$ is the required rectangle.

17. Using ruler and compasses only, construct a square having a diagonal of length 5cm. Measure its sides correct to the nearest millimeter.

Solution:

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Steps of construction:

- (i) Draw a line segment $AC = 5\text{cm}$
- (ii) Draw its perpendicular bisector XY bisecting it at O
- (iii) From XY , cut off
 $OB = OD = \frac{5}{2} = 2.5\text{cm}$
- (iv) Join AB , BC , CD and DA .

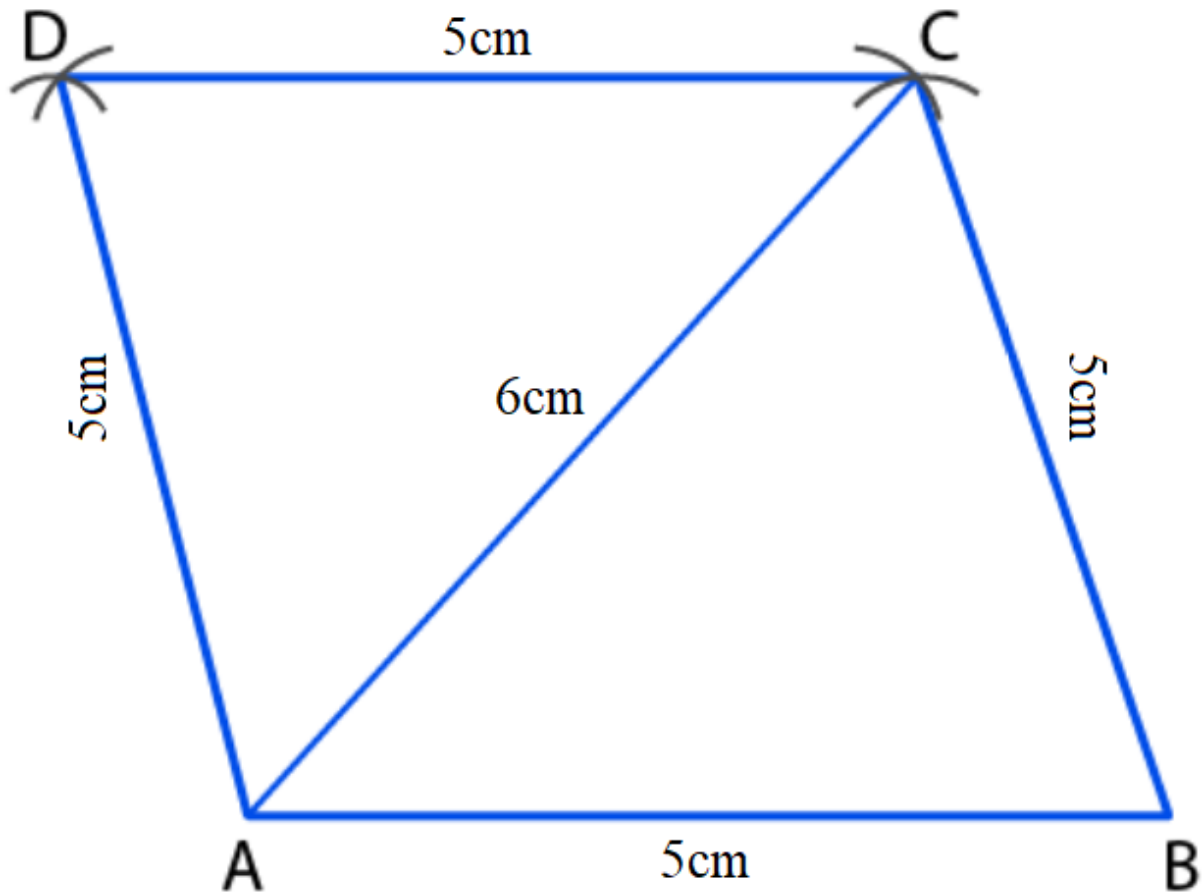
Thus, $ABCD$ is the required square

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On measuring its sides, each = 3.6cm (approximately)

18. Using ruler and compasses only construct A rhombus ABCD given that AB 5cm, AC = 6cm measure $\angle BAD$.

Solution:



Steps of construction:

- (i) Draw a line segment AB = 5cm
- (ii) With centre A and radius 6cm, with centre B and radius 5cm, draw arcs intersecting each other at C.
- (iii) Join AC and BC
- (iv) With centre A and C and radius 5cm, draw arc intersecting each other 5cm, draw arcs intersecting each other at D
- (v) Join AD and CD.

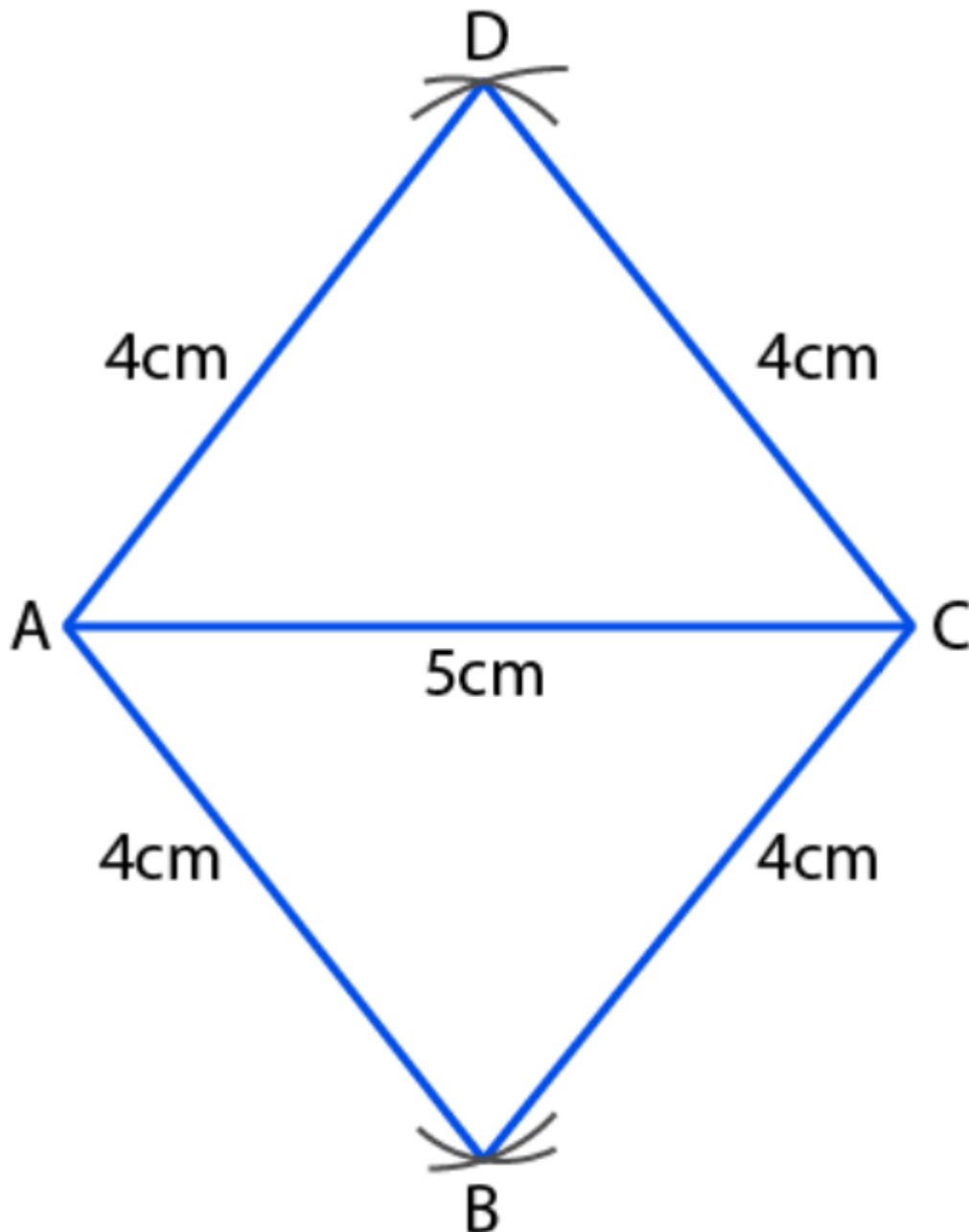
<https://www.indcareer.com/schools/ml-aggarwal-solutions-for-class-9-maths-chapter-13-rectilinear-figures/>

Thus, ABCD is a rhombus

On measuring, $\angle BAD = 106^\circ$.

19. Using ruler and compasses only, construct rhombus ABCD with sides of length 4cm and diagonal AC of length 5 cm. Measure $\angle ABC$.

Solution:



Steps of construction:

<https://www.indcareer.com/schools/ml-aggarwal-solutions-for-class-9-maths-chapter-13-rectilinear-figures/>

(i) Draw a line segment $AC = 5\text{cm}$

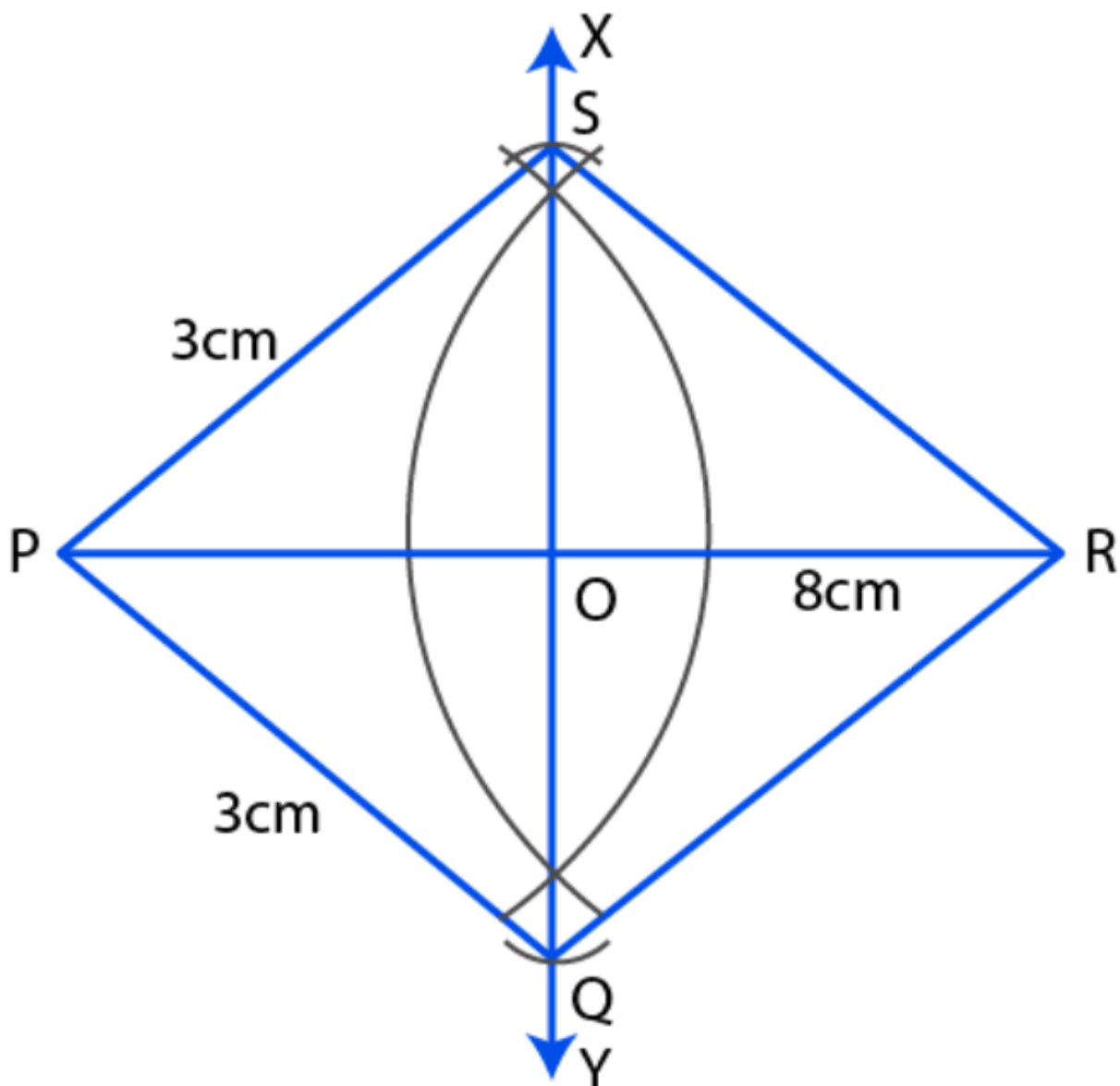
(ii) With centre A and C and radius 4cm , draw arcs intersecting each other above and below AC at D and B.

(iii) Join AB, BC, CD and DA.

Thus, ABCD is the required rhombus.

20. Construct a rhombus PQRS whose diagonals PR and QS are 8 cm and 6 cm respectively.

Solution:



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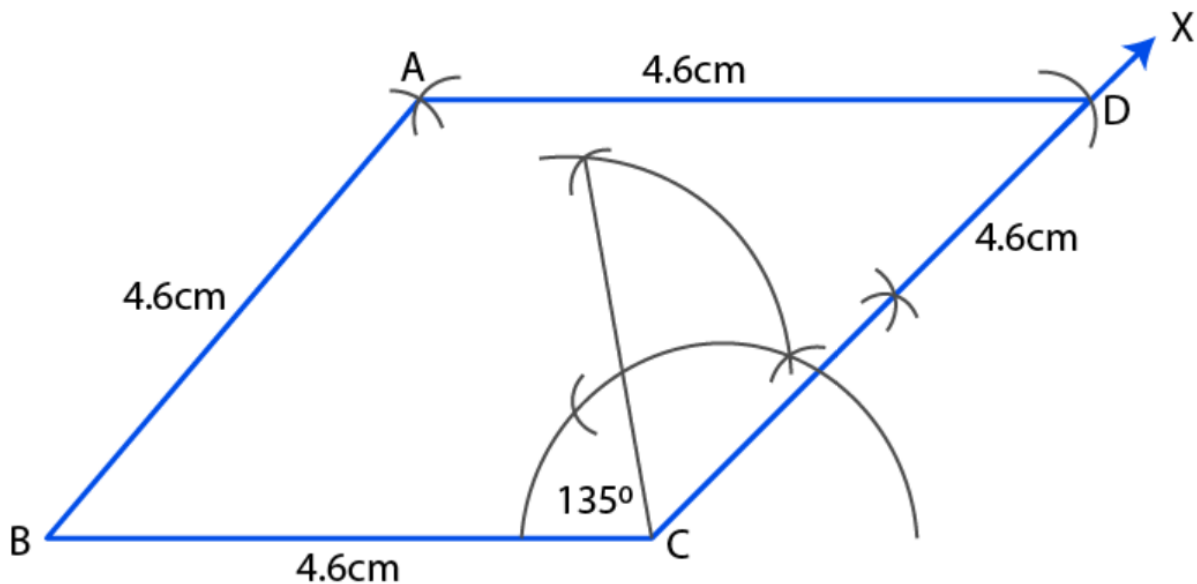
Steps of construction:

- (i) Draw a line segment $PR = 8\text{cm}$
- (ii) Draw its perpendicular bisector XY intersecting it at O .
- (iii) From XY , cut off $OQ = OS = 6/2 = 3\text{cm}$ each
- (iv) Join PQ , QR , RS and SP

Thus, $PQRS$ is the required rhombus.

21. Construct a rhombus $ABCD$ of side 4.6 cm and $\angle BCD = 135^\circ$, by using ruler and compasses only.

Solution:



Steps of construction:

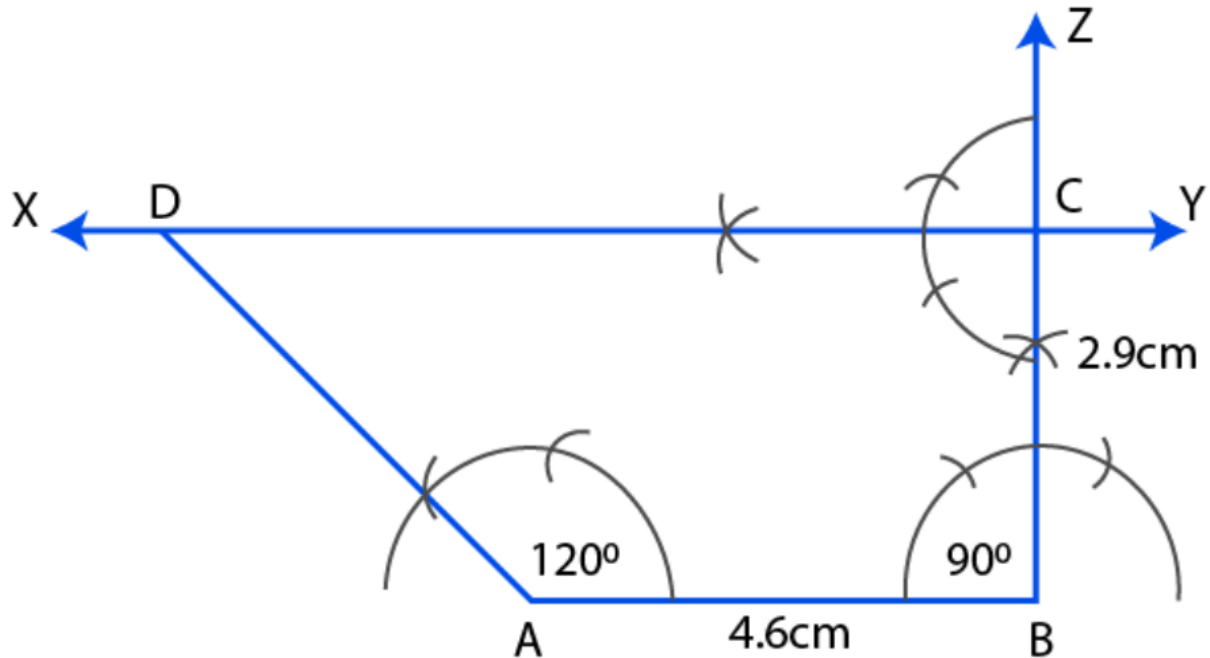
- (i) Draw a line segment $BC = 4.6\text{cm}$
- (ii) At C , draw a ray CX making an angle of 135° and cut off $CD = 4.6\text{cm}$
- (iii) With centres B and D , and radius 4.6cm draw arcs intersecting each other at A .
- (iv) Join BA and DA .

Thus, $ABCD$ is the required rhombus.

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22. Construct a trapezium in which $AB \parallel CD$, $AB = 4.6$ cm, $\angle ABC = 90^\circ$, $\angle DAB = 120^\circ$ and the distance between parallel sides is 2.9 cm.

Solution:



Steps of construction:

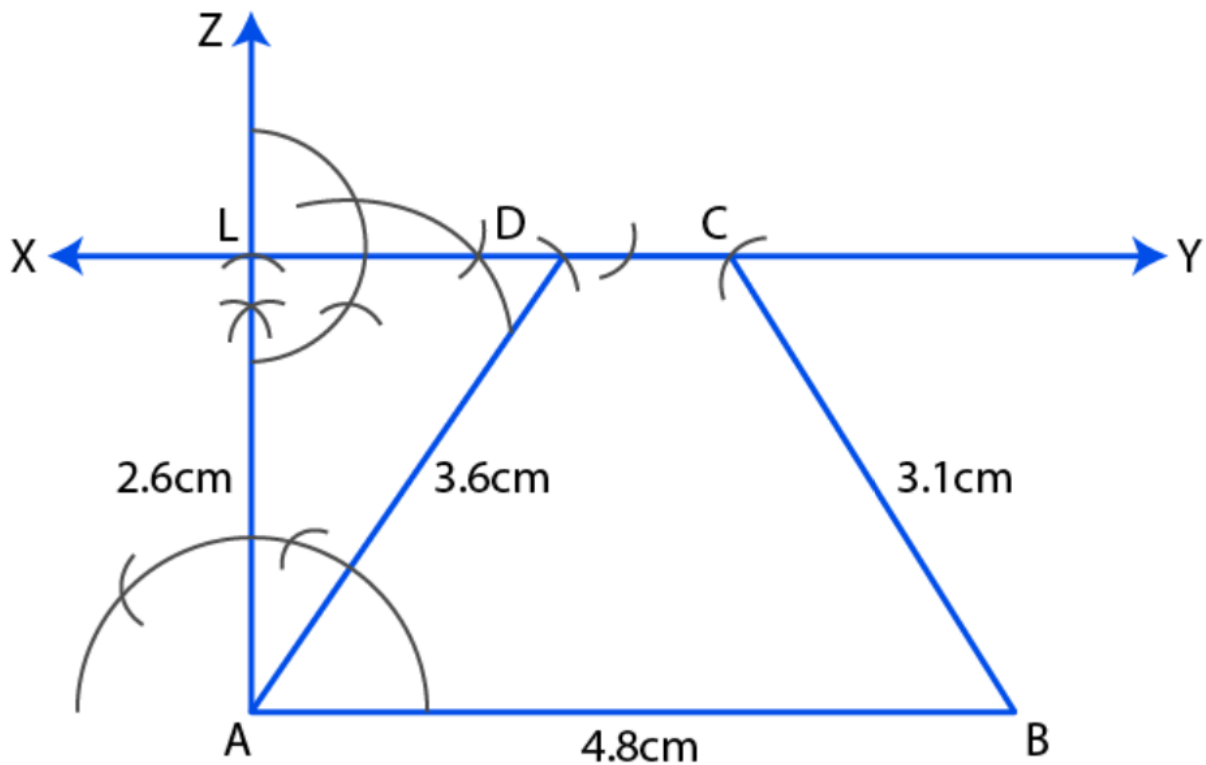
- (i) Draw a line segment $AB = 4.6$ cm
- (ii) At B, draw a ray BZ making an angle of 90° and cut off $BC = 2.9$ cm (distance between AB and CD)
- (iii) At C, draw a parallel line XY to AB.
- (iv) At A, draw a ray making an angle of 120° meeting XY at D.

Thus, ABCD is the required trapezium.

23. Construct a trapezium ABCD when one of parallel sides $AB = 4.8$ cm, height = 2.6 cm, $BC = 3.1$ cm and $AD = 3.6$ cm.

Solution:

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Step construction:

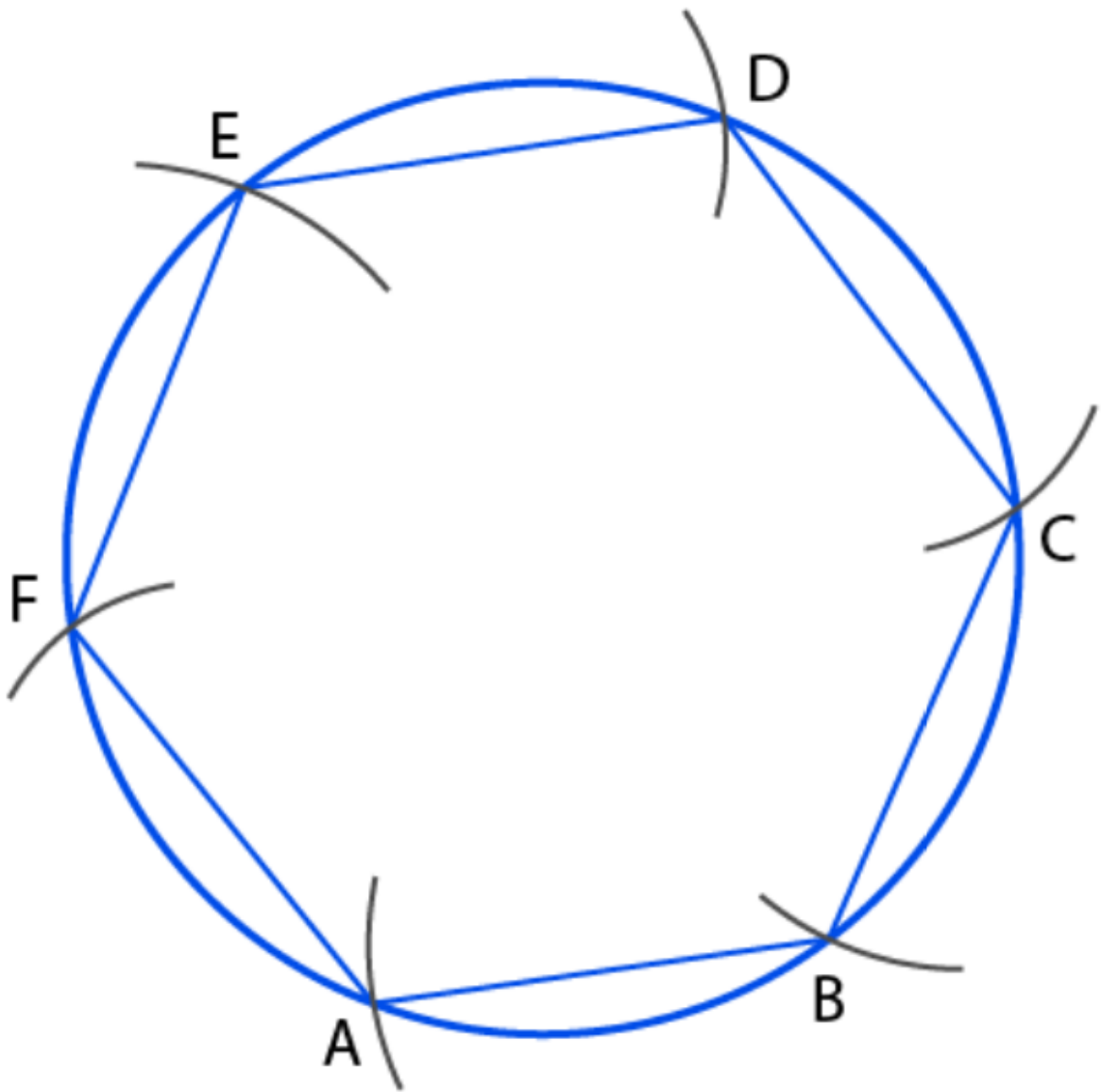
- (i) Draw a line segment $AB = 4.8\text{cm}$
- (ii) At A, draw a ray AZ making an angle of 90° cut off $AL = 2.6\text{cm}$
- (iii) At L, draw a line XY parallel to AB.
- (iv) With centre A and radius 3.6cm and with centre B and radius 3.1cm , draw arcs intersecting XY at D and C respectively.
- (v) Join AD and BC

Thus, ABCD is the required trapezium.

24. Construct a regular hexagon of side 2.5 cm.

Solution:

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Steps of construction:

- (i) With O as centre and radius = 2.5cm, draw a circle
- (ii) take any point A on the circumference of circle.
- (iii) With A as centre and radius = 2.5cm, draw an arc which cuts the circumference of circle at B.
- (iv) With B as centre and radius = 2.5cm, draw an arc which cuts the circumference of circle at C.
- (v) With C as centre and radius = 2.5cm, draw an arc which cuts the circumference of circle at D.

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(vi) With D as centre and radius = 2.5cm, draw an arc which cuts the circumference of circle at E.

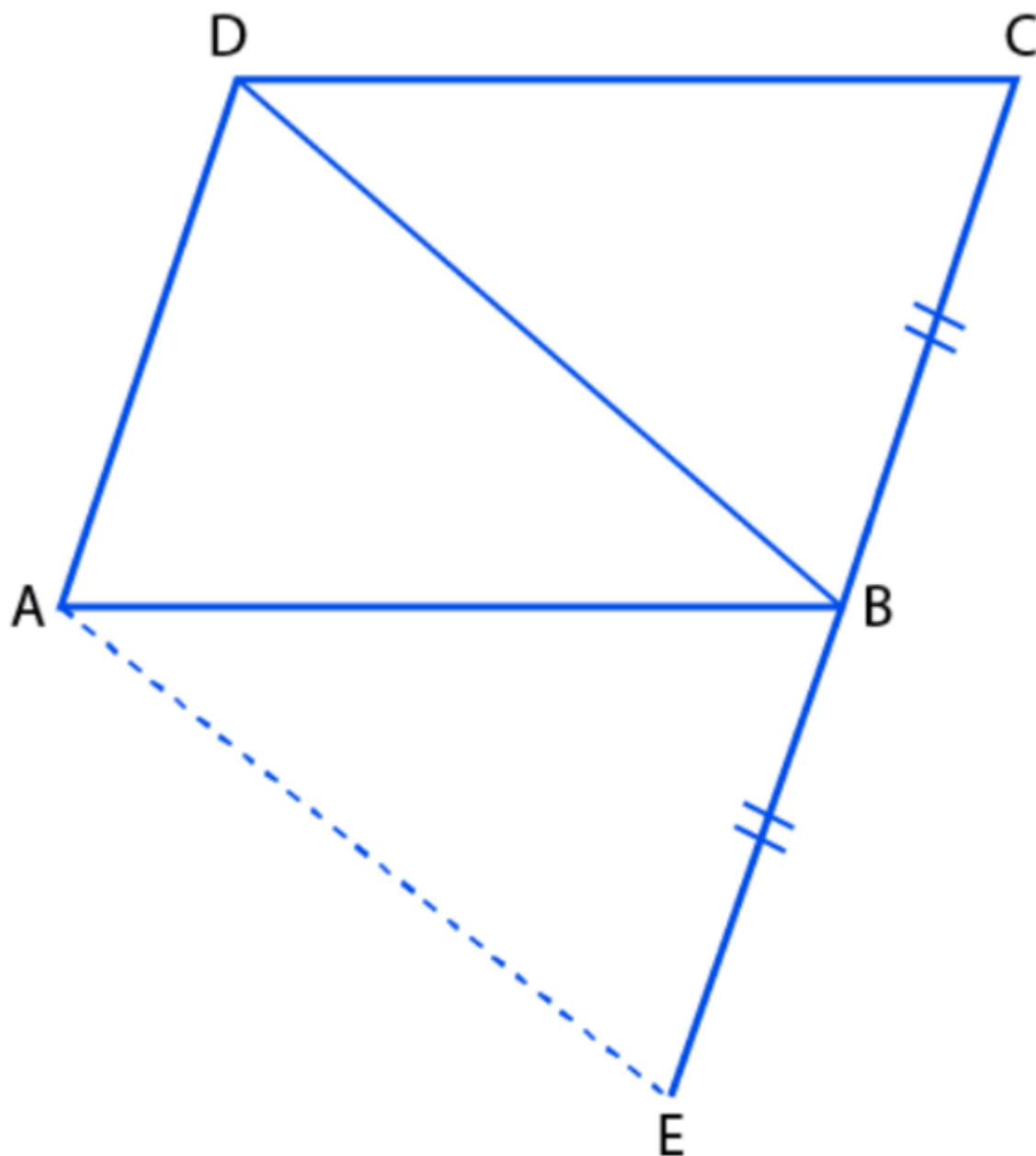
(vii) With E as centre and radius = 2.5cm, draw an arc which cuts the circumference of circle at F.

(viii) Join AB, BC, CD, DE, EF and FA.

(ix) ABCDEF is the required Hexagon.

Chapter Test

1. In the given figure, ABCD is a parallelogram. CB is produced to E such that $BE=BC$. Prove that AEBD is a parallelogram.

**Solution:**

Given ABCD is a || gm in which CB is produced to E such that $BE = BC$

BD and AE are joined

To prove: AEBD is a parallelogram

Proof:

In $\triangle AEB$ and $\triangle BDC$

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$EB = BC$ [Given]

$\angle ABE = \angle DCB$ [Corresponding angles]

$AB = DC$ [Opposite sides of $\parallel$ gm]

Thus, $\triangle AEB \cong \triangle BDC$ by S.A.S axiom

So, by C.P.C.T

But, $AD = CB = BE$ [Given]

As the opposite sides are equal and $\angle AEB = \angle DBC$

But these are corresponding angles

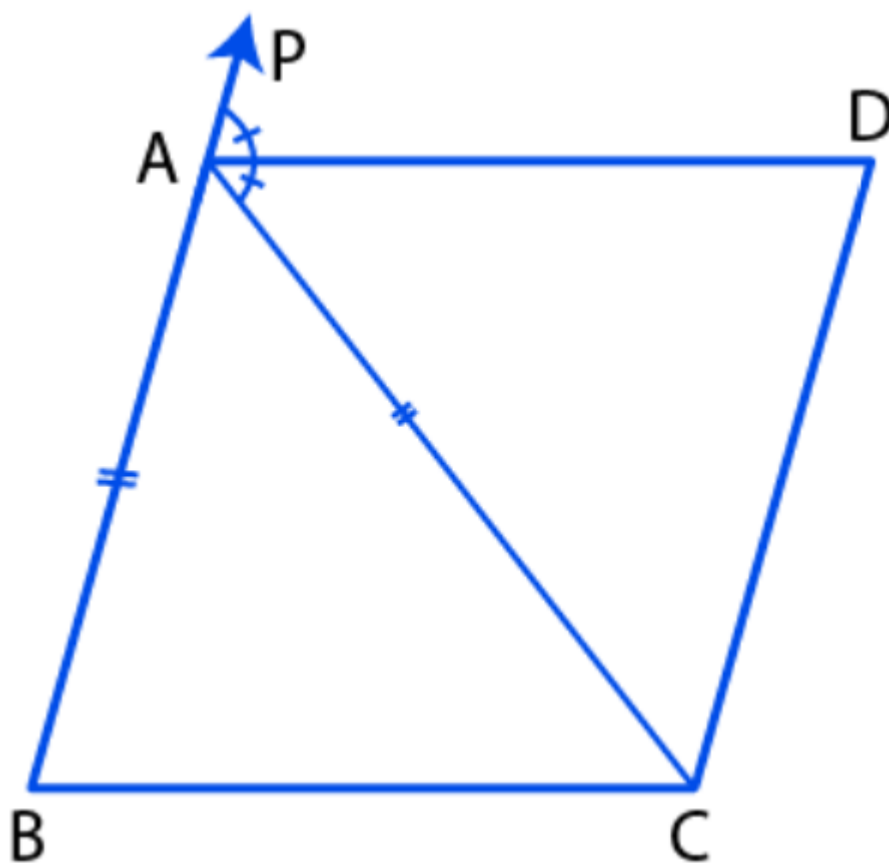
Hence, AEBC is a parallelogram.

2. In the given figure, ABC is an isosceles triangle in which $AB = AC$. AD bisects exterior angle PAC and $CD \parallel BA$. Show that (i) $\angle DAC = \angle BCA$ (ii) ABCD is a parallelogram.

Solution:

Given: In isosceles triangle ABC, $AB = AC$. AD is the bisector of ext. $\angle PAC$ and $CD \parallel BA$

To prove: (i) $\angle DAC = \angle BCA$



(ii) ABCD is a || gm

Proof:

In $\triangle ABC$

$AB = AC$ [Given]

$\angle C = \angle B$ [Angles opposite to equal sides]

Since, ext. $\angle PAC = \angle B + \angle C$

$= \angle C + \angle C$

$= 2 \angle C$

$= 2 \angle BCA$

So, $\angle DAC = 2 \angle BCA$

$\angle DAC = \angle BCA$

But these are alternate angles

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Thus, $AD \parallel BC$

But, $AB \parallel AC$

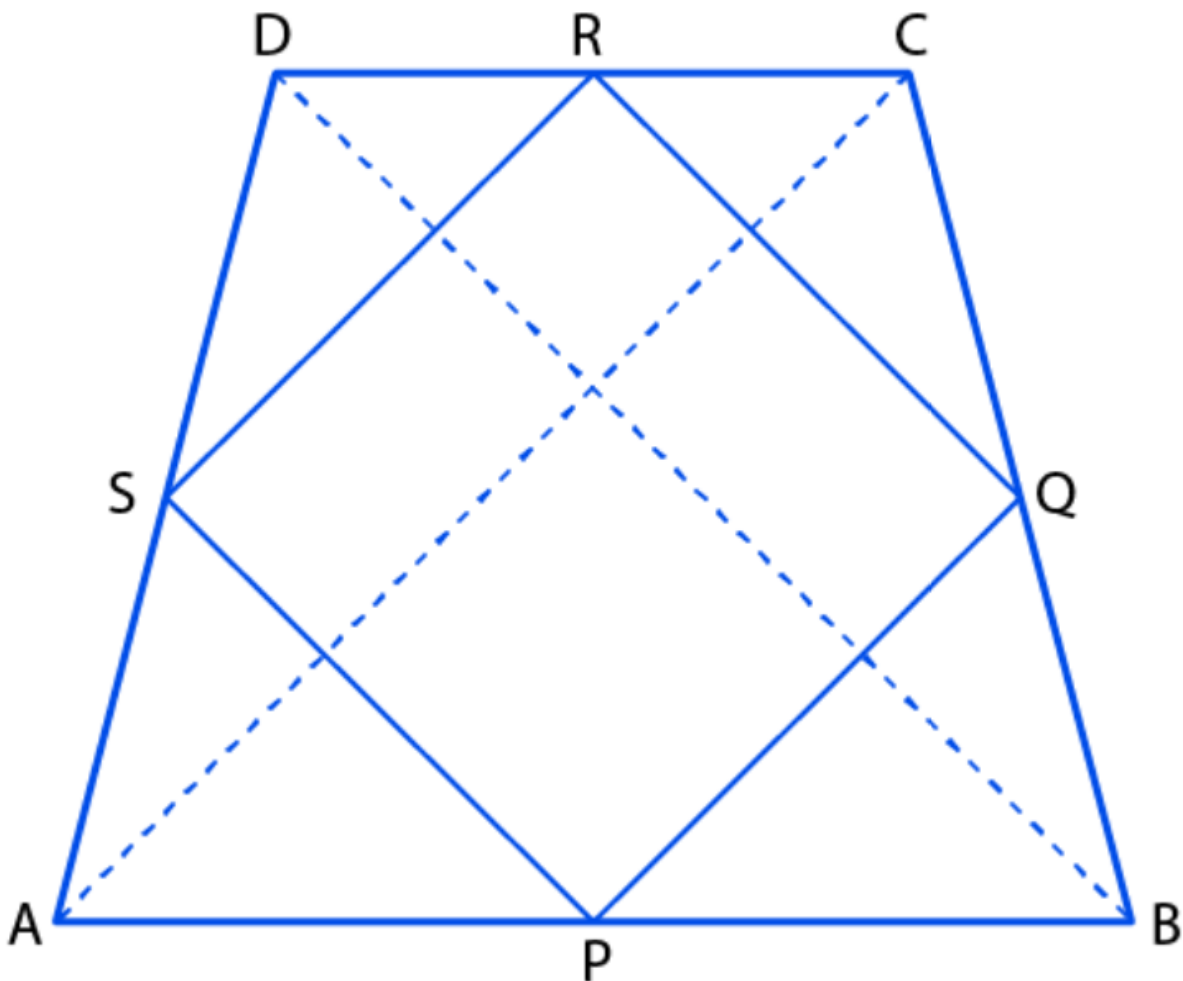
Hence, ABCD is a $\parallel$ gm.

3. Prove that the quadrilateral obtained by joining the mid-points of an isosceles trapezium is a rhombus.

Solution:

Given: ABCD is an isosceles trapezium in which $AB \parallel DC$ and $AD = BC$

P, Q, R and S are the mid-points of the sides AB, BC, CD and DA respectively PQ, QR, RS and SP are joined.



To prove: PQRS is a rhombus

Construction: Join AC and BD

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Proof:

Since, ABCD is an isosceles trapezium

Its diagonals are equal

$$AC = BD$$

Now, in $\triangle ABC$

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

So, $PQ \parallel AC$ and $PQ = \frac{1}{2} AC \dots (i)$

Similarly, in $\triangle ADC$

S and R mid-point of CD and AD

So, $SR \parallel AC$ and $SR = \frac{1}{2} AC \dots (ii)$

From (i) and (ii), we have

$$PQ \parallel SR \text{ and } PQ = SR$$

Thus, PQRS is a parallelogram.

Now, in $\triangle APS$ and $\triangle BPQ$

$$AP = BP \text{ [P is the mid-point]}$$

$$AS = BQ \text{ [Half of equal sides]}$$

$$\angle A = \angle B \text{ [As ABCD is an isosceles trapezium]}$$

So, $\triangle APS \cong \triangle BPQ$ by SAS Axiom of congruency

Thus, by C.P.C.T we have

$$PS = PQ$$

But there are the adjacent sides of a parallelogram

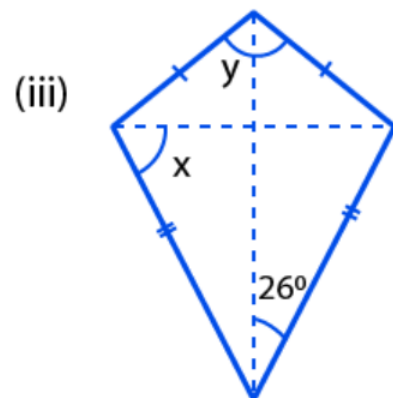
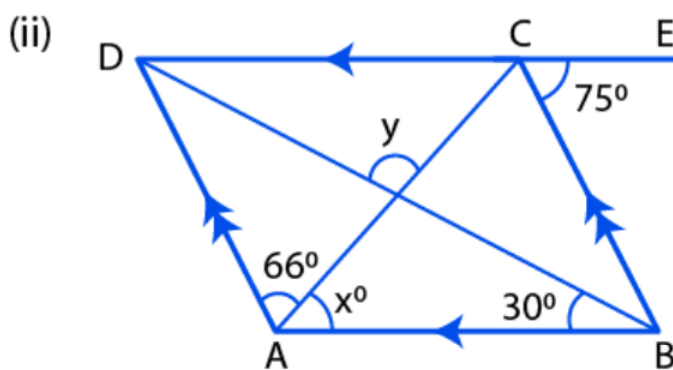
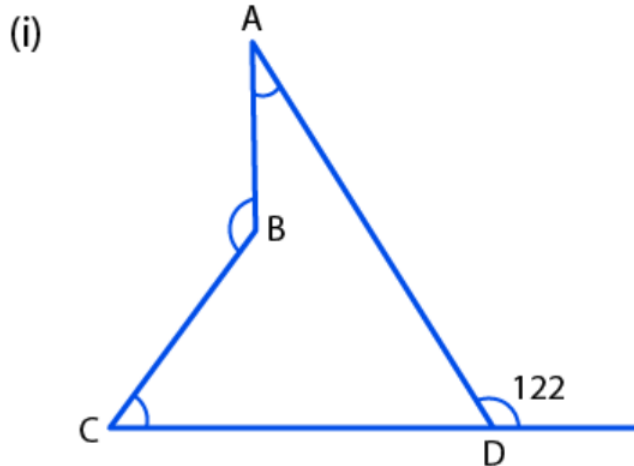
So, sides of PQRS are equal

Hence, PQRS is a rhombus

– Hence proved

4. Find the size of each lettered angle in the following figures.

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Solution:

(i) As CDE is a straight line

$$\angle ADE + \angle ADC = 180^\circ$$

$$122^\circ + \angle ADC = 180^\circ$$

$$\angle ADC = 180^\circ - 122^\circ = 58^\circ \dots (i)$$

$$\angle ABC = 360^\circ - 140^\circ = 220^\circ \dots (ii) \text{ [At any point the angle is } 360^\circ]$$

Now, in quadrilateral ABCD we have

$$\angle ADC + \angle BCD + \angle BAD + \angle ABC = 360^\circ$$

$$58^\circ + 53^\circ + x + 220^\circ = 360^\circ \text{ [Using (i) and (ii)]}$$

$$331^\circ + x = 360^\circ$$

$$x = 360^\circ - 331^\circ$$

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$$x = 29^\circ$$

(ii) As $DE \parallel AB$ [Given]

$\angle ECB = \angle CBA$ [Alternate angles]

$$75^\circ = \angle CBA$$

$$\Rightarrow \angle CBA = 75^\circ$$

Since, $AD \parallel BC$ we have

$$(x + 66^\circ) + 75^\circ = 180^\circ$$

$$x + 141^\circ = 180^\circ$$

$$x = 180^\circ - 141^\circ$$

$$x = 39^\circ \dots (i)$$

Now, in $\triangle AMB$

$$x + 30^\circ + \angle AMB = 180^\circ \text{ [Angles sum property of a triangle]}$$

$$39^\circ + 30^\circ + \angle AMB = 180^\circ \text{ [From (i)]}$$

$$69^\circ + \angle AMB = 180^\circ$$

$$\angle AMB = 180^\circ - 69^\circ = 111^\circ \dots (ii)$$

Since, $\angle AMB = y$ [Vertically opposite angles]

$$\Rightarrow y = 111^\circ$$

Hence, $x = 39^\circ$ and $y = 111^\circ$

(iii) In $\triangle ABD$

$AB = AD$ [Given]

$\angle ABD = \angle ADB$ [Angles opposite to equal sides are equal]

$\angle ABD = 42^\circ$ [Since, given $\angle ADB = 42^\circ$]

And,

$\angle ABD + \angle ADB + \angle BAD = 180^\circ$ [Angles sum property of a triangle]

$$42^\circ + 42^\circ + y = 180^\circ$$

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$$84^\circ + y = 180^\circ$$

$$y = 180^\circ - 84^\circ$$

$$y = 96^\circ$$

$$\angle BCD = 2 \times 26^\circ = 52^\circ$$

In $\triangle BCD$,

As $BC = CD$ [Given]

$\angle CBD = \angle CDB = x$ [Angles opposite to equal sides are equal]

$$\angle CBD + \angle CDB + \angle BCD = 180^\circ$$

$$x + x + 52^\circ = 180^\circ$$

$$2x + 52^\circ = 180^\circ$$

$$2x = 180^\circ - 52^\circ$$

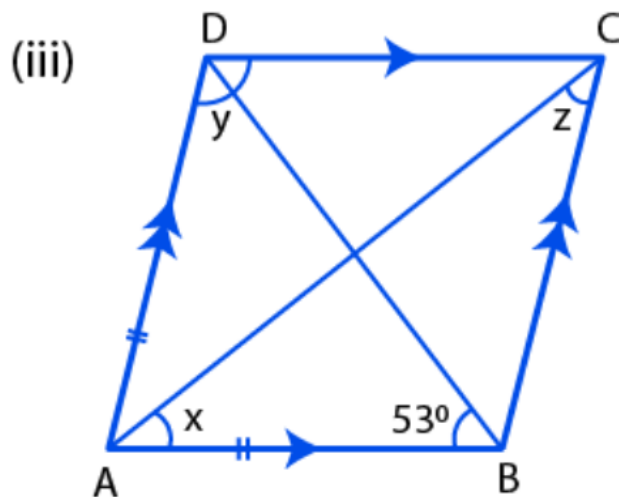
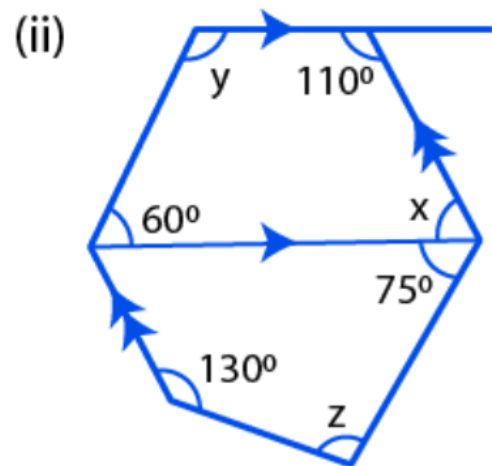
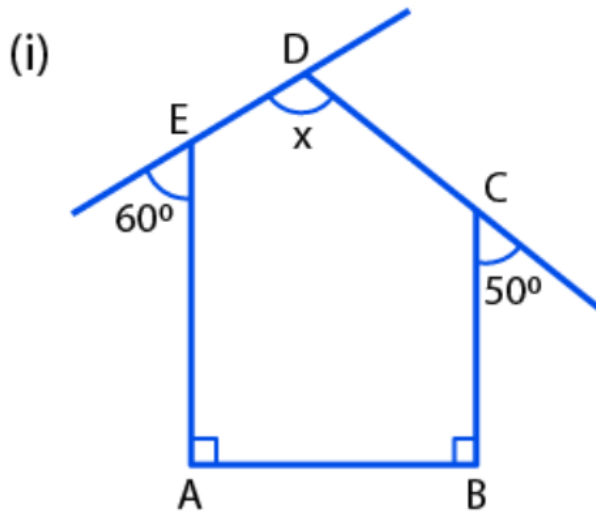
$$x = 128^\circ/2$$

$$x = 64^\circ$$

Hence, $x = 64^\circ$ and $y = 90^\circ$.

5. Find the size of each lettered angle in the following figures:

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Solution:

(i) Here, $AB \parallel CD$ and $BC \parallel AD$

So, ABCD is a $\parallel$ gm

$$y = 2 \times \angle ABD$$

$$y = 2 \times 53^\circ = 106^\circ \dots (1)$$

$$\text{Also, } y + \angle DAB = 180^\circ$$

$$\angle DAB = 180^\circ - 106^\circ$$

$$= 74^\circ$$

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Thus, $x = \frac{1}{2} \angle DAB$ [As AC bisects $\angle DAB$]

$$x = \frac{1}{2} \times 74^\circ = 37^\circ$$

$$\text{and } \angle DAC = x = 37^\circ \dots \text{(ii)}$$

$$\text{Also, } \angle DAC = z \dots \text{(iii) [Alternate angles]}$$

From (ii) and (iii),

$$z = 37^\circ$$

$$\text{Hence, } x = 37^\circ, y = 106^\circ \text{ and } z = 37^\circ$$

(ii) As ED is a straight line, we have

$$60^\circ + \angle AED = 180^\circ \text{ [Linear pair]}$$

$$\angle AED = 180^\circ - 60^\circ$$

$$\angle AED = 120^\circ \dots \text{(i)}$$

Also, as CD is a straight line

$$50^\circ + \angle BCD = 180^\circ \text{ [Linear pair]}$$

$$\angle BCD = 180^\circ - 50^\circ$$

$$\angle BCD = 130^\circ \dots \text{(ii)}$$

In pentagon ABCDE, we have

$$\angle A + \angle B + \angle AED + \angle BCD + \angle x = 540^\circ \text{ [Sum of interior angles in pentagon is } 540^\circ]$$

$$90^\circ + 90^\circ + 120^\circ + 130^\circ + x = 540^\circ$$

$$430^\circ + x = 540^\circ$$

$$x = 540^\circ - 430^\circ$$

$$x = 110^\circ$$

Hence, value of $x = 110^\circ$

(iii) In given figure, $AD \parallel BC$ [Given]

$$60^\circ + y = 180^\circ \text{ and } x + 110^\circ = 180^\circ$$

$$y = 180^\circ - 60^\circ \text{ and } x = 180^\circ - 110^\circ$$

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$$y = 120^\circ \text{ and } x = 70^\circ$$

Since, $CD \parallel AF$ [Given]

$$\angle FAD = 70^\circ \dots (i)$$

In quadrilateral ADEF,

$$\angle FAD + 75^\circ + z + 130^\circ = 360^\circ$$

$$70^\circ + 75^\circ + z + 130^\circ = 360^\circ$$

$$275^\circ + z = 360^\circ$$

$$z = 360^\circ - 275^\circ = 85^\circ$$

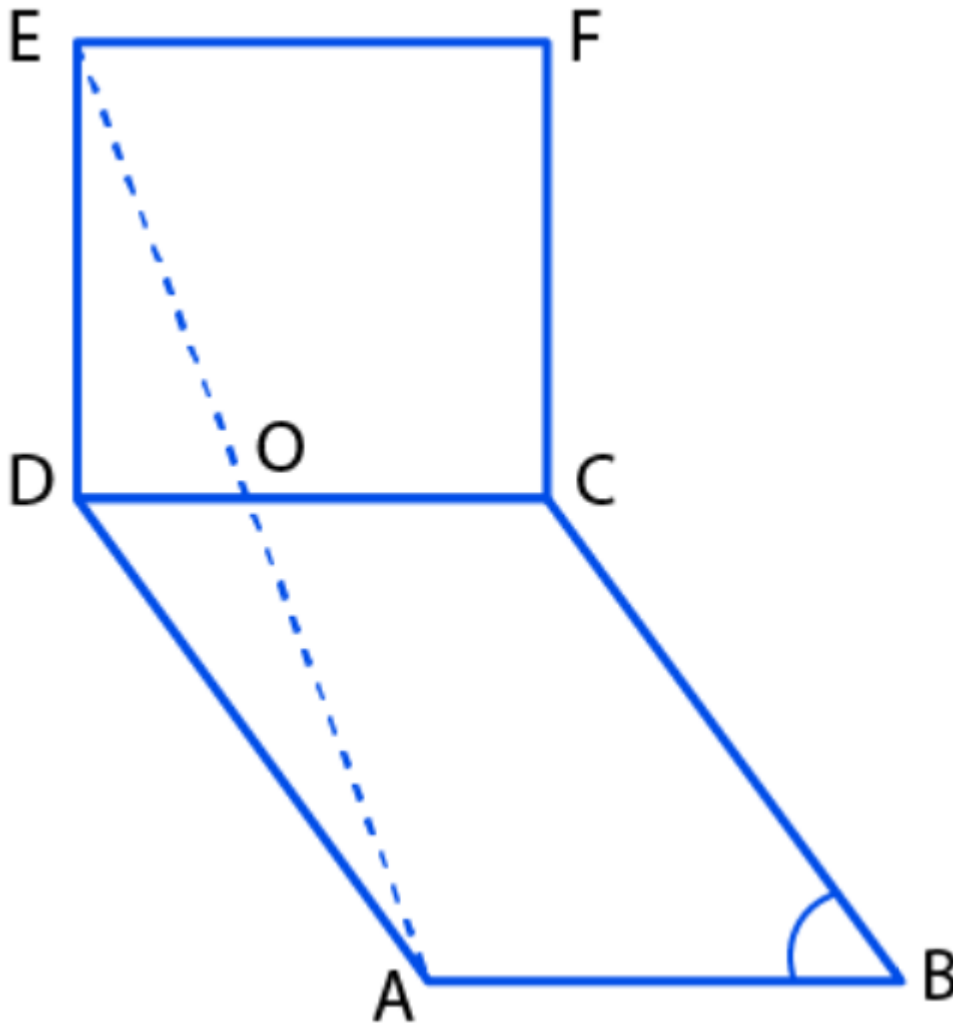
Hence,

$$x = 70^\circ, y = 120^\circ \text{ and } z = 85^\circ$$

6. In the adjoining figure, ABCD is a rhombus and DCFE is a square. If $\angle ABC = 56^\circ$, find (i) $\angle DAG$ (ii) $\angle FEG$ (iii) $\angle GAC$ (iv) $\angle AGC$.

Solution:

Here ABCD and DCFE is a rhombus and square respectively.



$$DC = AD \dots (i)$$

$$\text{Also, } DC = EF = FC = EF \dots (ii)$$

From (i) and (ii), we have

$$AB = BC = DC = AD = EF = FC = EF \dots (iii)$$

$$\angle ABC = 56^\circ \text{ [Given]}$$

$$\angle ADC = 56^\circ \text{ [Opposite angle in rhombus are equal]}$$

$$\text{So, } \angle EDA = \angle EDC + \angle ADC = 90^\circ + 56^\circ = 146^\circ$$

In $\triangle ADE$,

$$DE = AD \text{ [From (iii)]}$$

$$\angle DEA = \angle DAE \text{ [Equal sides have equal opposite angles]}$$

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$$\angle DEA = \angle DAG = (180^\circ - \angle EDA) / 2$$

$$= (180^\circ - 146^\circ) / 2$$

$$= 34^\circ / 2 = 17^\circ$$

$$\Rightarrow \angle DAG = 17^\circ$$

Also,

$$\angle DEG = 17^\circ$$

$$\angle FEG = \angle E - \angle DEG$$

$$= 90^\circ - 17^\circ$$

$$= 73^\circ$$

In rhombus ABCD,

$$\angle DAB = 180^\circ - 56^\circ = 124^\circ$$

$$\angle DAC = 124^\circ / 2 \text{ [Since, AC diagonals bisect the } \angle A]$$

$$\angle DAC = 62^\circ$$

$$\angle GAC = \angle DAC - \angle DAG$$

$$= 62^\circ - 17^\circ$$

$$= 45^\circ$$

In $\triangle EDG$,

$$\angle D + \angle DEG + \angle DGE = 180^\circ \text{ [Angles sum property of a triangle]}$$

$$90^\circ + 17^\circ + \angle DGE = 180^\circ$$

$$\angle DGE = 180^\circ - 107^\circ = 73^\circ \dots \text{(iv)}$$

$$\text{Thus, } \angle AGC = \angle DGE \dots \text{(v) [Vertically opposite angles]}$$

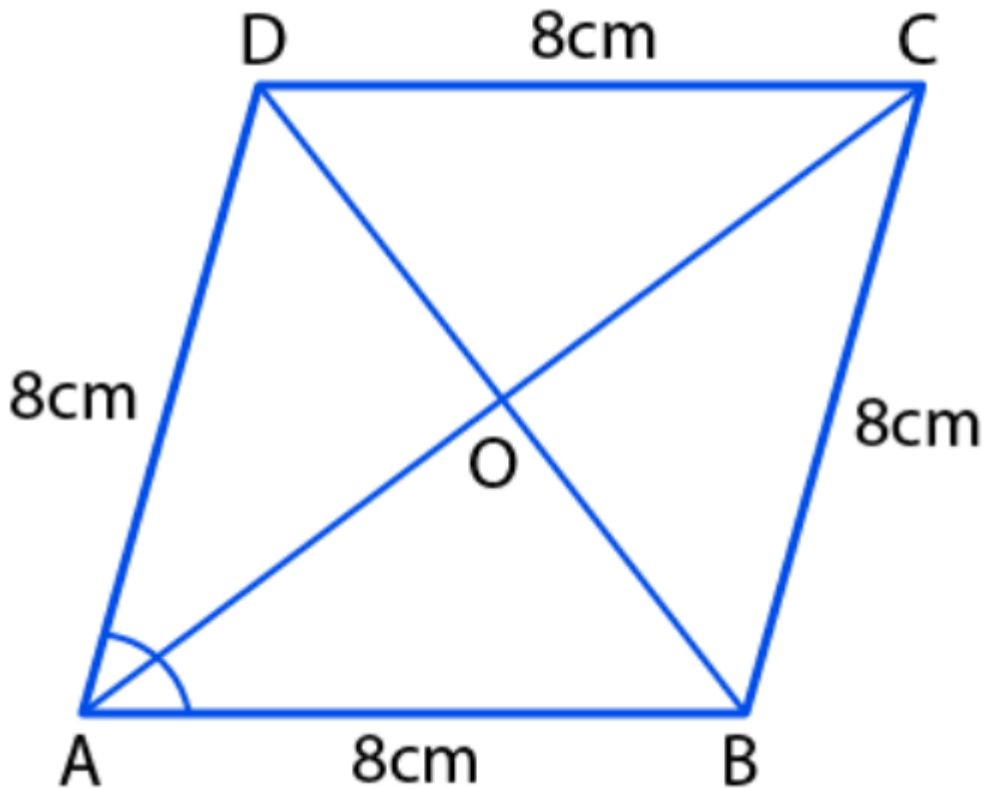
Hence from (iv) and (v), we have

$$\angle AGC = 73^\circ$$

7. If one angle of a rhombus is 60° and the length of a side is 8 cm, find the lengths of its diagonals.

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Solution:



Each side of rhombus ABCD is 8cm

So, $AB = BC = CD = DA = 8\text{cm}$

Let $\angle A = 60^\circ$

So, $\triangle ABD$ is an equilateral triangle

Then,

$AB = BD = AD = 8\text{cm}$

As we know, the diagonals of a rhombus bisect each other at right angles

$AO = OC$, $BO = OD = 4\text{cm}$ and $\angle AOB = 90^\circ$

Now, in right $\triangle AOB$

By Pythagoras theorem

$$AB^2 = AO^2 + OB^2$$

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$$8^2 = AO^2 + 4^2$$

$$64 = AO^2 + 16$$

$$AO^2 = 64 - 16 = 48$$

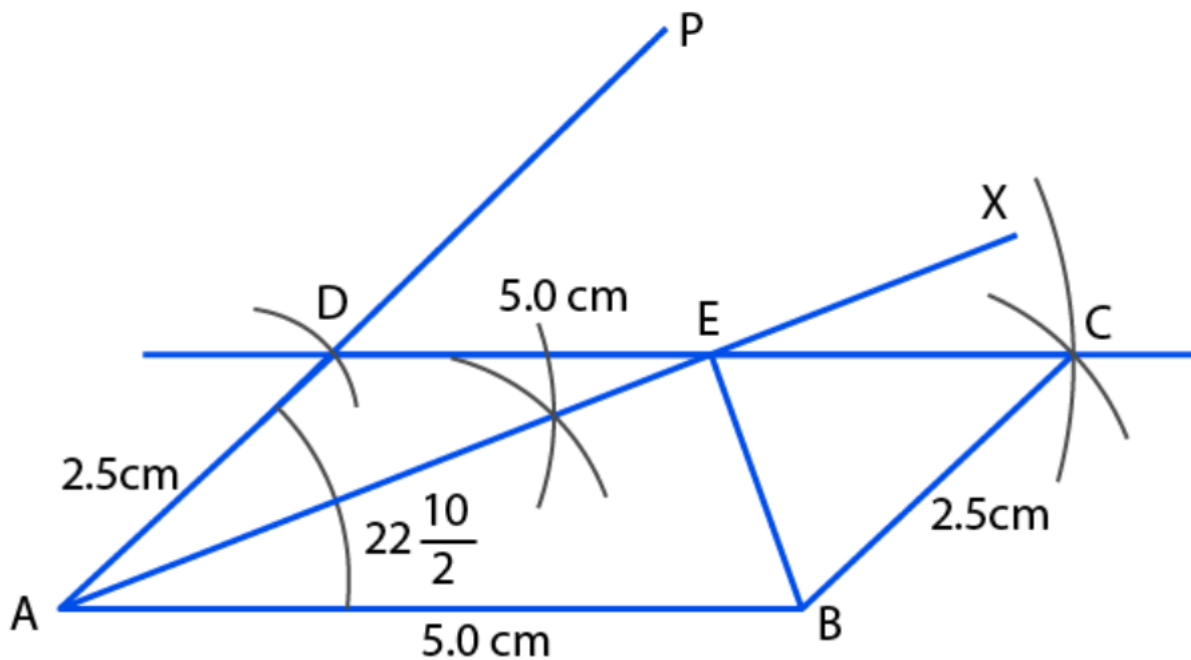
$$AO = \sqrt{48} = 4\sqrt{3}\text{cm}$$

$$\text{But, } AC = 2 AO$$

$$\text{Hence, } AC = 2 \times 4\sqrt{3} = 8\sqrt{3}\text{cm.}$$

8. Using ruler and compasses only, construct a parallelogram ABCD with AB = 5 cm, AD = 2.5 cm and $\angle BAD = 45^\circ$. If the bisector of $\angle BAD$ meets DC at E, prove that $\angle AEB$ is a right angle.

Solution:



Steps of construction:

- (i) Draw AB = 5.0cm
- (ii) Draw BAP = 45° on side AB
- (iii) Take A as centre and radius 2.5cm cut the line AP at D
- (iv) Take D as centre and radius 5.0cm draw an arc

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- (v) Take B as centre and radius equal to 2.5cm cut the arc of step (iv) at C
- (vi) Join BC and CD
- (vii) ABCD is the required parallelogram
- (viii) Draw the bisector of $\angle BAD$, which cuts the DC at E
- (ix) Join EB
- (x) Measure $\angle AEB$ which is equal to 90° .



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About ML Aggarwal

M. L. Aggarwal, is an Indian mechanical engineer, educator. His achievements include research in solutions of industrial problems related to fatigue design. Recipient Best Paper award, Manipal Institute of Technology, 2004. Member of TSTE.

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Postal Address

IndCareer.com
52, Shilpa Nagar,
Somalwada
Nagpur - 440015
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