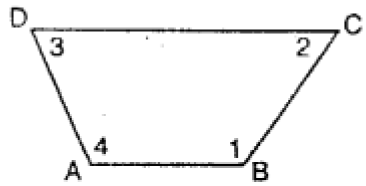
Quadrilateral

IMPORTANT POINTS

4.Quadrilateral: A quadrilateral is a plane figure enclosed by four sides. It has four sides, four interior angles and four vertices.



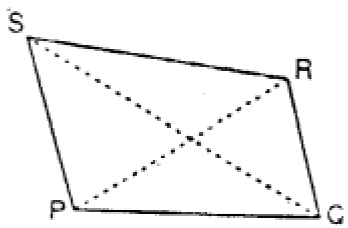
In quadrilateral ABCD, shown alongside:

(i) four sides are : AB, BC, CD and DA.

(ii) four angles are : ∠ABC,∠BCD, ∠CDA and ∠DAB ; which are numbered∠1, ∠2, ∠3 and ∠4 respectively.

(iii) four vertices are : A, B, C and D.

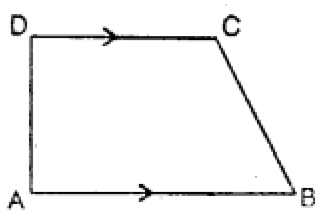
5. Diagonals of a Quadrilateral : The line segments joining the opposite vertices of a quadrilateral are called its diagonals.



The given figure shows a quadrilateral PQRS with diagonals PR and QS.

6. Types of Quadrilaterals :

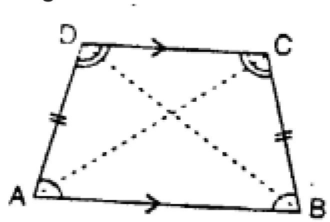
1. Trapezium: A trapezium is a quadrilateral in which one pair of opposite sides are parallel.



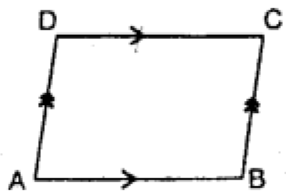
The figure, given alongside, shows a trapezium as its sides AB and DC are parallel i.e. AB || DC.

When the non-parallel sides of the trapezium are equal in length, it is called an isosceles trapezium.

The given figure shows a trapezium ABCD whose non-parallel sides AD and BC are equal in length i.e. AD = BC; therefore it is an isosceles trapezium.

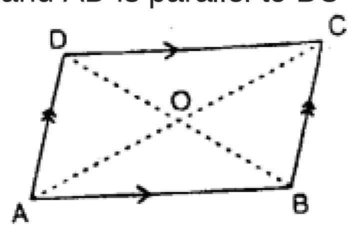


Also, in an isosceles trapezium :



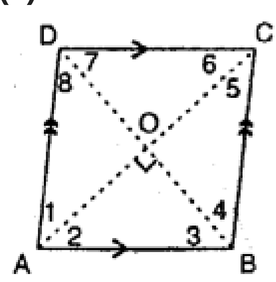
(i) base angles are equal:
i.e. ∠A = ∠B and ∠D =∠C
(ii) diagonals are equal
i.e. AC = BD.

2.Parallelogram : A parallelogram is a quadrilateral, in which both the pairs of opposite sides are parallel.
The quadrilateral ABCD, drawn alongside, is a parallelogram; since, AB is parallel to DC and AD is parallel to BC i.e.



AB || DC and AD || BC.
Also, in a parallelogram ABCD:
(i) opposite sides are equal:
i.e. AB = DC and AD = BC.
(ii) opposite angles are equal:
i.e. ∠ABC = ∠ADC and ∠BCD = ∠BAD
(iii) diagonals bisect each other :
i.e. OA = OC = $\frac{1}{2}$ AC and OB = OD = $\frac{1}{2}$ BD.

7. Some special types of Parallelograms
(a) Rhombus : A rhombus is a parallelogram in which all its sides are equal.



∴In a rhombus ABCD :
(i) opposite sides are parallel:
i.e. AB||DC and AD||BC.
(ii) all the sides are equal:
i.e. AB = BC = CD = DA.
(iii) opposite angles are equal:

i.e. ∠A = ∠C and ∠B = ∠D.
(iv) diagonals bisect each other at right angle :
i.e. OA= OC = $\frac{1}{2}$ AC ; OB = OD = $\frac{1}{2}$ BD.
and ∠AOB= ∠BOC = ∠COD = ∠AOD = 90°
(v) diagonals bisect the angles at the vertices :
i.e. ∠1 =∠2 ;∠3 = ∠4 ; ∠5 = ∠6 and ∠7 =∠8.

IMPORTANT POINTS

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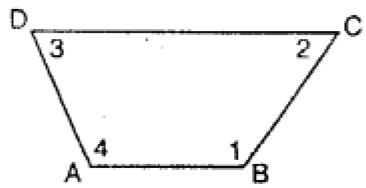

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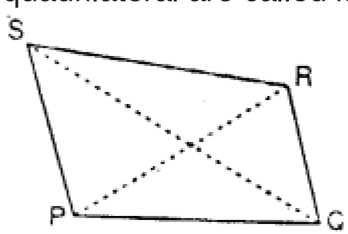

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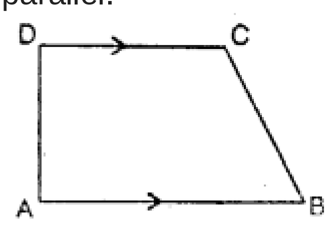

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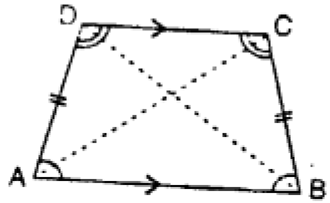

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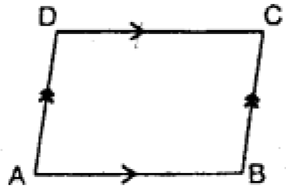

(i) base angles are equal:
i.e. ∠A = ∠B and ∠D =∠C
(ii) diagonals are equal
i.e. AC = BD.

2.Parallelogram : A parallelogram is a quadrilateral, in which both the pairs of opposite sides are parallel.
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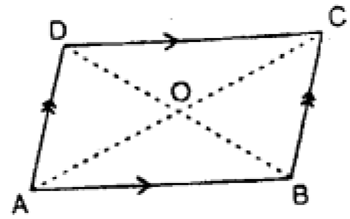

AB || DC and AD || BC.
Also, in a parallelogram ABCD:
(i) opposite sides are equal:
i.e. AB = DC and AD = BC.
(ii) opposite angles are equal:
i.e. ∠ABC = ∠ADC and ∠BCD = ∠BAD
(iii) diagonals bisect each other :
i.e. OA = OC = $\frac{1}{2}$ AC and OB = OD = $\frac{1}{2}$ BD.

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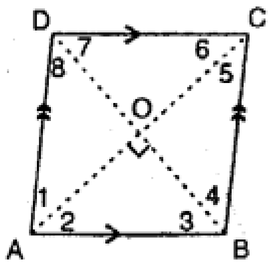
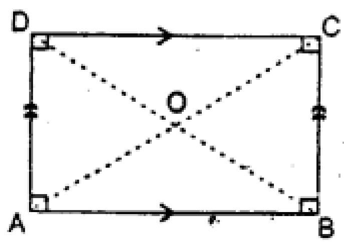
(a) Rhombus : A rhombus is a parallelogram in which all its sides are equal.



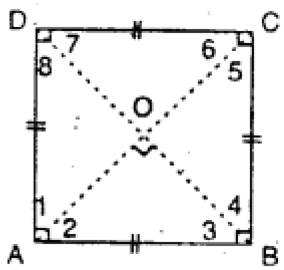
∴In a rhombus ABCD :
(i) opposite sides are parallel:
i.e. AB||DC and AD||BC.
(ii) all the sides are equal:
i.e. AB = BC = CD = DA.
(iii) opposite angles are equal:
i.e. ∠A = ∠C and ∠B = ∠D.
(iv) diagonals bisect each other at right angle :
i.e. OA= OC = $\frac{1}{2}$ AC ; OB = OD = $\frac{1}{2}$ BD.
and ∠AOB= ∠BOC = ∠COD = ∠AOD = 90°
(v) diagonals bisect the angles at the vertices :
i.e. ∠1 =∠2 ;∠3 = ∠4 ; ∠5 = ∠6 and ∠7 =∠8.

(b) Rectangle : A rectangle is a parallelogram whose any angle is 90°.
A rectangle is also defined as a quadrilateral whose each angle is 90°.



Note : If any angle of a parallelogram is 90° ; automatically its each angle is 90° ; the reason being that the opposite angles of a parallelogram are equal.
Also, in a rectangle:
(i) opposite sides are parallel.
(ii) opposite sides are equal.
(iii) each angle is 90°.
(iv) diagonals are equal.
(v) diagonals bisect each other.

(c) Square : A square is a parallelogram, whose all side are equal and each angle is 90°.



A square can also be defined as :
(i) a rhombus whose any angle is 90°.
(ii) a rectangle whose all sides are equal.
(iii) a quadrilateral whose all sides are equal and each angle is 90°.
∴ If ABCD is a square :
(i) all its sides are equal, i.e. AB = BC = CD = DA
(ii) each angle of it is 90°.
i.e. ∠A = ∠B = ∠C = ∠D = 90°.
Also,
(iii) diagonals are equal.
i.e. AC = BD.
(iv) diagonals bisect each other at 90°.
i.e. OA = OC = $\frac{1}{2}$ AC;OB = OD = $\frac{1}{2}$ BD
and ∠AOB = ∠BOC = ∠COD = ∠DOA = 90°.
Since, diagonals AC and BD are equal; therefore ; OA = OC = OB = OD.
(v) diagonals bisect the angles at the vertices
i.e. ∠1 = ∠2 = 45° [∵ ∠1 + ∠2 = 90°]
Similarly; ∠3 = ∠4 = 45° ;
∠5 – ∠6 = 45° and ∠7 = ∠8 = 45°.

EXERCISE 27 (A)

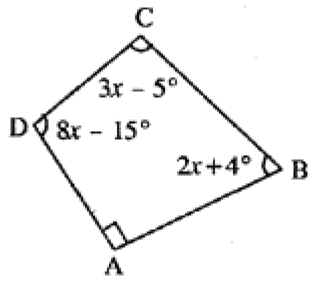
Question 1.
Two angles of a quadrilateral are 89° and 113°. If the other two angles are equal; find the equal angles.
Solution:
Let the other angle = x°
According to given,
89° + 113° + x° + x° = 360°
2x° = 360° – 202°
2x° = 158°
x° = $\frac{158}{2}$ =79°
∴other two angles = 79° each

Question 2.
Two angles of a quadrilateral are 68° and 76°. If the other two angles are in the ratio 5 : 7; find the measure of each of them.

Solution:
Two angles are 68° and 76°
Let other two angles be 5x and 7x
$\therefore 68° + 76° + 5x + 7x = 360°$
$12x + 144° = 360°$
$12x = 360° - 144°$
$12x = 216°$
$x = 18°$
angles are 5x and 7x
i.e. $5 \times 18°$ and $7 \times 18°$ i.e. 90° and 126°

Question 3.
Angles of a quadrilateral are (4x)°, 5(x+2)°, (7x-20)° and 6(x+3)°. Find
(i) the value of x.
(ii) each angle of the quadrilateral.
Solution:
Angles of quadrilateral are,
$(4x)°$, $5(x+2)°$, $(7x-20)°$ and $6(x+3)°$.
$4x+5(x+2)+(7x-20)+6(x+3) = 360°$
$4x+5x+10+7x-20+6x+18 = 360°$ $22x+8 = 360°$
$22x = 360°-8°$
$22x = 352°$
$x = 16°$
Hence angles are,
$(4x)° = (4 \times 16)° = 64°$,
$5(x+2)° = 5(16+2)° = 90°$,
$(7x-20)° = (7 \times 16-20)° = 92°$
$6(x+3)° = 6(16+3) = 114°$

Question 4.
Use the information given in the following figure to find :
(i) x
(ii) ∠B and ∠C



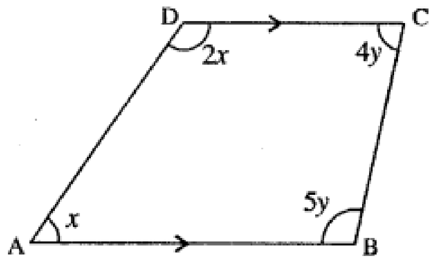
Solution:
$\because \angle A = 90°$ (Given)
$\angle B = (2x+4°)$
$\angle C = (3x-5°)$

∠D = (8x – 15°)
∠A + ∠B + ∠C + ∠D = 360°
90° + (2x + 4°) + (3x – 5°) + (8x – 15°) = 360°
90° + 2x + 4° + 3x – 5° + 8x – 15° = 360°
⇒ 74° + 13x = 360°
⇒13x = 360° – 74°
⇒ 13x = 286°
⇒ x = 22°
∵ ∠B = 2x + 4 = 2. x 22° + 4 – 48°
∠C = 3x – 5 = 3×22° -5 = 61°
Hence (i) 22° (ii) ∠B = 48°, ∠C = 61°

Question 5.

In quadrilateral ABCD, side AB is parallel to side DC. If ∠A : ∠D = 1 : 2 and ∠C : ∠B = 4:5
(i) Calculate each angle of the quadrilateral.
(ii) Assign a special name to quadrilateral ABCD.

Solution:

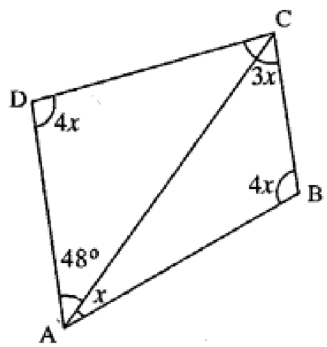


∵∠A : ∠D = 1:2
Let ∠A = x and ∠B = 2x
∵∠C : ∠B = 4 : 5 Let ∠C = 4y and ∠B = 5y
∵AB || DC
∠A + ∠D = 180° x + 2x = 180°
3x = 180° x = 60°
∴A = 60°
∠D = 2x = 2 x 60 = 120° Again ∠B + ∠C = 180°
5y + 4y= 180°
9y = 180°
y = 20°
∴∠B = 5y- = 5 x 20 = 100°
∠C = 4y = 4 x 20 = 80°
Hence ∠A = 60° ; ∠B = 100° ; ∠C = 80° and ∠D = 120°

Question 6.

From the following figure find ;
(i) x,
(ii) ∠ABC,
(iii) ∠ACD.

Solution:
(i) In Quadrilateral ABCD,

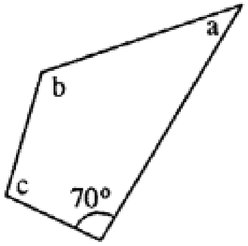


x + 4x + 3x + 4x + 48° = 360°
12x = 360° – 48°
12x =312
(ii) ∠ABC = 4x
4 x 26 = 104°
(iii) ∠ACD = 180°-4x-48°
= 180°-4×26°-48°
= 180°-104°-48°
= 180°-152° = 28°

Question 7.
Given : In quadrilateral ABCD ; ∠C = 64°, ∠D = ∠C – 8° ;
∠A = 5(a+2)° and ∠B = 2(2a+7)°.
Calculate ∠A.
Solution:
∵∠C = 64° (Given)
∴∠D = ∠C- 8°
= 64°- 8°
= 56°
∠A = 5 (a + 2)°
∠B = 2(2a + 7)°
Now ∠A + ∠B + ∠C + ∠D = 360°
5(a + 2)° + 2(2a + 7)° + 64°+ 56° = 360°
5a + 10 + 4a + 14° + 64° + 56° = 360°
9a + 144° = 360°
9a = 360°-144°
9a = 216°
a = 24°
∴∠A = 5(a + 2)
= 5(24 + 2)
= 130°

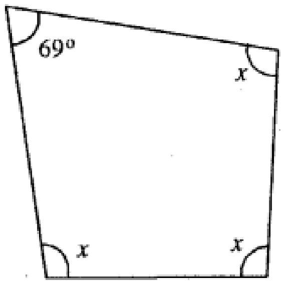
Question 8.
In the given figure :

∠b = 2a + 15
and ∠c = 3a+5; find the values of b and c.



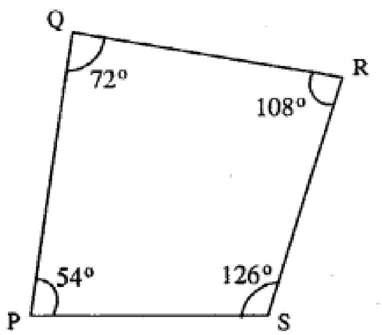
Solution:
∠b = 2a + 15
& ∠c = 3a + 5
∵Sum of angles of quadrilateral = 360°
70° + a + 2a + 15 + 3a + 5 – 360°
6a+90° = 360°
6a = 270°
a = 45°
∴ b = 2a+15= 2×45+15 = 105°
c = 3a+5 = 3×45+5 = 140°
105° and 140°

Question 9.
Three angles of a quadrilateral are equal. If the fourth angle is 69°; find the measure of equal angles.
Solution:
Let each equal angle be
x° x + x + x + 69° = 360°



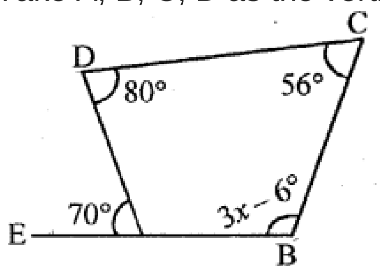
3x = 360°-69 3x =291 x = 97°
Each equal angle = 97°

Question 10.
In quadrilateral PQRS, ∠P : ∠Q : ∠R : ∠S = 3 : 4 : 6 : 7.
Calculate each angle of the quadrilateral and then prove that PQ and SR are parallel to each other. Is PS also parallel to QR ?
Solution:



∵∠P : ∠Q : ∠R : ∠S = 3 : 4 : 6 : 7
Let ∠P = 3x
∠Q = 4x
∠R = 6x & ∠S = 7x
∴∠P+∠Q+∠R+∠S = 360°
3x + 4x + 6x + Ix = 360°
20x = 360°
x = 18°
∴ ∠P = 3x = 3×18 = 54°
∠Q = 4x = 4×18 = 72°
∠R = 6x = 6×18 = 108°
∠S = 7x = 7×18 = 126°
∠Q + ∠R = 72°+108° = 180° or ∠P +∠S = 54°+126° = 180°
Hence PQ || RS
As ∠P + ∠Q = 72° +54° = 126°
Which is * 180°.
∴PS and QR are not parallel.

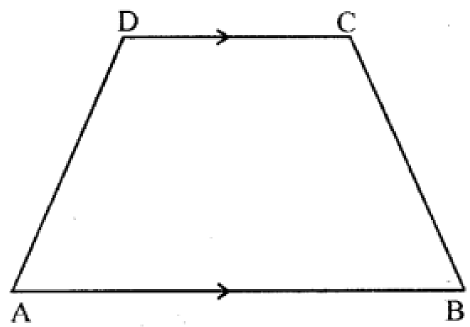
Question 11.
Use the information given in the following figure to find the value of x.
Solution:
Take A, B, C, D as the vertices of quadrilateral and BA is produced to E (say).



Since ∠EAD = 70°
∴∠DAB = 180° – 70° = 110° [∵ EAB is a straight line and AD stands on it]
∴∠EAD + ∠DAB = 180°
∴110° + 80° + 56° + 3x = 360°
[∵ sum of interior angles of a quadrilateral = 360°]
∴3x = 360° – 110° – 80° – 56° + 6°

$3x = 360° – 240° = 120°$
$\therefore x = 40°$

Question 12.
The following figure shows a quadrilateral in which sides AB and DC are parallel. If ∠A : ∠D = 4 : 5, ∠B = (3x – 15)° and ∠C = (4x + 20)°, find each angle of the quadrilateral ABCD.



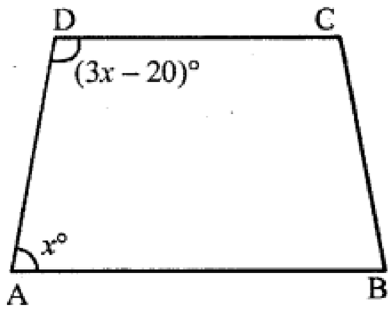
Solution:
Let ∠A = 4x
∠D = 5x
Since ∠A + ∠D = 180° [∵ AB || DC]
∴4x + 5x = 180°
⇒ 9x = 180° ⇒x = 20°
∴∠A = 4 (20) = 80°, ∠D = 5 (20) = 100° Again ∠B + ∠C = 180° [∵ AB || DC]
∴ 3x – 15° + 4x + 20° = 180°
7x = 180°-5°
⇒ 7x = 175° ⇒ x = 25°
∴∠B = 75°-15° = 60° and ∠C = 4(25) + 20 = 100° + 20° = 120°

EXERCISE 27 (B)

Question 1.
In a trapezium ABCD, side AB is parallel to side DC. If ∠A = 78° and ∠C = 120°, find angles B and D.

Solution:
∵ AB || DC and BC is transversal
∴∠B and ∠C, ∠A and ∠D are Cointerior angles with their sum = 180°
i.e. ∠B + ∠C = 180°
⇒ ∠B + 120° = 180°
⇒ ∠B = 180° – 120°
⇒ ∠B = 60°
Also ∠A + ∠D = 180°
⇒ 78° + ∠D = 180°
⇒ ∠D = 180° – 78°
∠D = 102°

Question 2.
In a trapezium ABCD, side AB is parallel to side DC. If ∠A = x° and ∠D = (3x – 20)°; find the value of x.
Solution:
∵AB || DC and BC is transversal
∴∠A and ∠B are Co-interior angles with their sum = 180°
i.e. ∠A + ∠D = 180°



⇒ x° + (3x – 20)° = 180°
⇒ x° + 3x° – 20° = 180°
⇒ 4x° = 180° + 20°
x° = $\frac{200}{4}$ = 50°
∴Value of x = 50°

Question 3.
The angles A, B, C and D of a trapezium ABCD are in the ratio 3 : 4 : 5 : 6.
Le. ∠A : ∠B : ∠C : ∠D = 3:4: 5 : 6. Find all the angles of the trapezium. Also, name the two sides of this trapezium which are parallel to each other. Give reason for your answer
Solution:

As the trapezium ABCD is a quadrilateral,

∴ Sum of its interior angles = 360°

⇒ $\angle A + \angle B + \angle C + \angle D = 360°$

⇒ $3x + 4x + 5x + 6x = 360°$

⇒ $18x = 360°$

⇒ $x = \frac{360°}{18} = 20°$

∴ $\angle A = 3x = 3 \times 20° = 60°$

and $\angle B = 4x = 4 \times 20° = 80°$

and $\angle C = 5x = 5 \times 20° = 100°$

and $\angle D = 6x = 6 \times 20° = 120°$

AB is parallel to DC.

∵ $\angle A + \angle D = 180°$,

$\angle A$ and $\angle D$ are co-interior angles whose sum = 180°

Question 4.

In an isosceles trapezium one pair of opposite sides are ….. to each Other and the other pair of opposite sides are ….. to each other.

Solution:

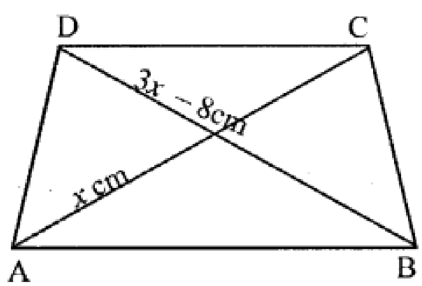
In an isosceles trapezium one pair of opposite sides are **parallel** to each other and the other pair of opposite sides are **equal** to each other.

Question 5.

Two diagonals of an isosceles trapezium are x cm and (3x – 8) cm. Find the value of x.

Solution:

∵The diagonals of an isosceles trapezium are of equal length



∴$3x - 8 = x$

⇒ $3x - x = 8$ cm

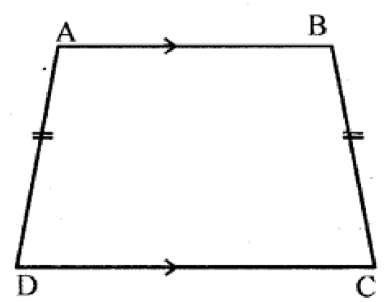
⇒ $2x = 8$ cm

⇒ x = 4 cm
∴ The value of x is 4 cm

Question 6.
Angle A of an isosceles trapezium is 115° ; find the angles B, C and D.
Solution:

Since, the base angles of an isosceles trapezium are equal,

∴ $\angle A = \angle B = 115°$



Also, ∠A and ∠D are co-interior angles and their sum = 180°

∴ $\angle A + \angle D = 180°$

⇒ $115° + \angle D = 180°$

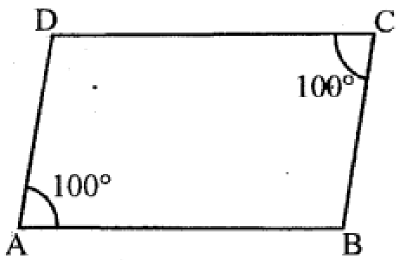
⇒ $\angle D = 180° - 115°$

⇒ $\angle D = 650°$

Also, $\angle D = \angle C = 65°$

∴ $\angle B = 115°$, $\angle C = 65°$ and $\angle D = 65°$

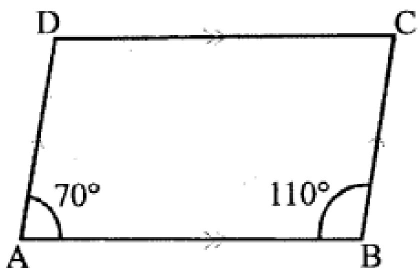
Question 7.
Two opposite angles of a parallelogram are 100° each. Find each of the other two opposite angles.
Solution:
Given : Two opposite angles of a parallelogram are 100° each



∵ Adjacent angles of a parallelogram are supplementary,
∴$\angle A + \angle B = 180°$

⇒ 100° + ∠B = 180°
⇒ ∠B = 180° – 100°
⇒ ∠B = 80°
Also, opposite angles of a parallelogram are equal
∴∠D = ∠B = 80°
∴∠B = ∠D = 80°

Question 8.
Two adjacent angles of a parallelogram are 70° and 110° respectively. Find the other two angles of it.
Solution:
Given two adjacent angles of a parallelogram are 70° and 110° respectively.



Since, we know that opposite angles of a parallelogram are equal
∴∠C = ∠A = 70° and ∠D = ∠B = 110°

Question 9.
The angles A, B, C and D of a quadrilateral are in the ratio 2:3: 2 : 3. Show this quadrilateral is a parallelogram.
Solution:

Given, Angles of a quadrilateral are in the ratio 2 : 3 : 2 : 3

i.e. A : B : C : D are in the ratio 2 : 3 : 2 : 3

To prove - Quadrilateral ABCD is a parallelogram

Prooft - Let us take $\angle A = 2x$, $\angle B = 3x$, $\angle C = 2x$ and $\angle D = 3x$

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

$\Rightarrow \angle A + \angle B + \angle C + \angle D = 360°$

$\Rightarrow 2x + 3x + 2x + 3x = 360°$

$\Rightarrow 10x = 360°$

$\Rightarrow x = \dfrac{360°}{10} = 36°$

$\therefore \angle A = \angle C = 2x = 2 \times 360° = 72°$

$\angle B = \angle D = 3x = 3 \times 36° = 108°$

Now, A quadrilateral ABCD is considered as a parallelogram.

(*i*) When opposite angles are equal,

i.e. $\angle A = \angle C = 72°$ and $\angle B = \angle D = 108°$

(*ii*) When adjacent angles are supplementary

i.e. $\angle A + \angle B = 180°$

and $\angle C = \angle D = 180°$

$\Rightarrow 72° + 108°$ and $72° + 108° = 180°$

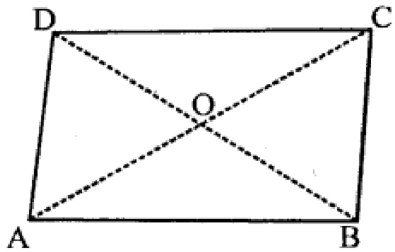
$\Rightarrow 180° = 180°$ and $180° = 180°$

Since, quadrilateral ABCD fulfils the conditions

$\therefore$ Quadrilateral ABCD is a parallelogram.

Question 10.

In a parallelogram ABCD, its diagonals AC and BD intersect each other at point O.



If AC = 12 cm and BD = 9 cm ; find; lengths of OA and OD.

Solution:

∵ When diagonal AC and BD intersect each other at point O,

then $OA = OC = \frac{1}{2} AC$

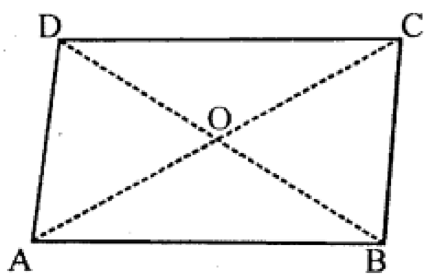
and $OB = OD = \frac{1}{2} BD$

$\therefore OA = \frac{1}{2} \times AC = \frac{1}{2} \times 12 = 6$ cm

and $OB = \frac{1}{2} \times BD = \frac{1}{2} \times 9 = 4.5$ cm

Question 11.

In parallelogram ABCD, its diagonals intersect at point O. If OA = 6 cm and OB = 7.5 cm, find the length of AC and BD.



Solution:

∵ When diagonal AC and BD intersect each other at point O,

then $OA = OC = \frac{1}{2} AC$

and $OB = OD = \frac{1}{2} BD$

$\therefore OA = \frac{1}{2} \times AC \Rightarrow AC = 2 \times OA$

$\Rightarrow AC = 2 \times 6 \text{ cm} = 12 \text{ cm}$,

and $OB = \frac{1}{2} \times BD \Rightarrow BD = 2 \times OB$

$\Rightarrow BD = 2 \times 7.5 \text{ cm} \Rightarrow BD = 15 \text{ cm}$

Question 12.

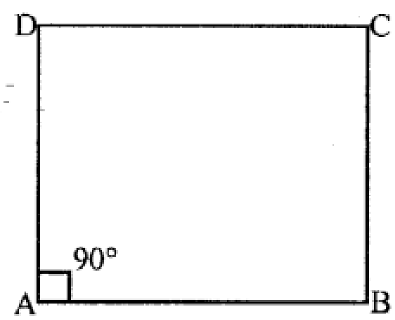
In parallelogram ABCD, ∠A = 90°

(i) What is the measure of angle B.

(ii) Write the special name of the parallelogram.

Solution:

In parallelogram ABCD, ∠A = 90°



(i) ∵ In a parallelogram, adjacent angles are supplementary

$\therefore \angle A + \angle B = 180°$

$\Rightarrow 90° + \angle B = 180°$

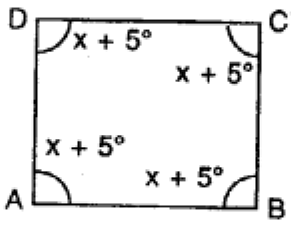
$\Rightarrow \angle B = 180° - 90°$

$\Rightarrow \angle B = 90°$

(ii) The name of the given parallelogram is a rectangle.

Question 13.
One diagonal of a rectangle is 18 cm. What is the length of its other diagonal?
Solution:
∵ In a rectangle, diagonals are equal
⇒ AC = BD
Given, one diagonal of a rectangle = 18cm
∴ Other diagonal of a rectangle will be = 18cm
i.e. AC = BD = 18cm.

Question 14.
Each angle of a quadrilateral is x + 5°. Find:
(i) the value of x
(ii) each angle of the quadrilateral.
Give the special name of the quadrilateral taken.

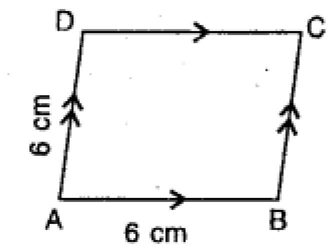


Solution:
(i) We have,
$\angle A + \angle B + \angle C + \angle D = 360°$
∵ We know that the sum of interior angles of a quadrilateral is 360°
$\therefore \angle A + \angle B + \angle C + \angle D = 360°$
$\Rightarrow x + 5° + x + 5° + x + 5° + x + 5° = 360°$
$\Rightarrow 4x + 20° = 360°$
$\Rightarrow 4x = 360° - 20°$
$\Rightarrow x = \frac{340°}{4} = 85°$
(ii) Each angle of the quadrilateral ABCD $= x + 5°$
$= 85° + 5°$
$= 90°$
The name of the given quadrilateral is a rectangle.

Question 15.
If three angles of a quadrilateral are 90° each, show that the given quadrilateral is a rectangle.
Solution:
The given quadrilateral ABCD will be a rectangle, if its each angle is 90°
Since, the sum of interior angles of a quadrilateral is 360°.
$\therefore \angle A + \angle B + \angle C + \angle D = 360°$
$\Rightarrow 90° + 90° + 90° + \angle D = 360°$
$\Rightarrow 270° + \angle D = 360°$
$\Rightarrow \angle D = 360° – 270°$
$\Rightarrow \angle D = 90°$
Since, each angle of the quadrilateral is 90°.
∴The given quadrilateral is a rectangle.

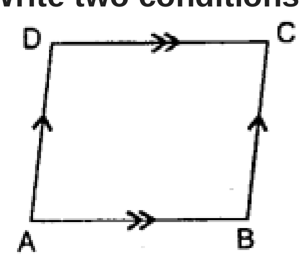
Question 16.
The diagnols of a rhombus are 6 .cm and 8 cm. State the angle at which these diagnols intersect.
Solution:
The diagnols of a Rhombus always intersect at 90°.

Question 17.
Write, giving reason, the name of the figure drawn alongside. Under what condition will this figure be a square.



Solution:
Since, all the sides of the given figure are equal.
i.e. AB = BC = CD = DA = 6 cm
∴ The given figure is a rhombus.
This figure shall be considered as a square, if any angle is 90°.

Question 18.
Write two conditions that will make the adjoining figure a square.



Solution:
The conditions that will make the ad-joining figure a square are :
(i) All the sides must be equal.
(ii) Any angle is 90°.