

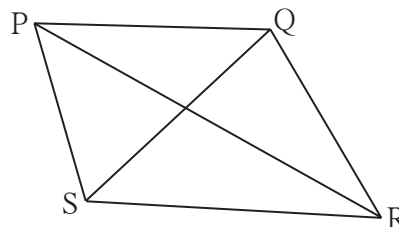
## 8

# Quadrilateral : Constructions and Types



Let's recall.

- Construct the triangles with given measures.
  - $\triangle ABC : l(AB) = 5 \text{ cm}, l(BC) = 5.5 \text{ cm}, l(AC) = 6 \text{ cm}$
  - $\triangle DEF : m\angle D = 35^\circ, m\angle F = 100^\circ, l(DF) = 4.8 \text{ cm}$
  - $\triangle MNP : l(MP) = 6.2 \text{ cm}, l(NP) = 4.5 \text{ cm}, m\angle P = 75^\circ$
  - $\triangle XYZ : m\angle Y = 90^\circ, l(XY) = 4.2 \text{ cm}, l(XZ) = 7 \text{ cm}$
- Every quadrilateral has 4 angles, 4 sides and 2 diagonals. So there are 10 elements of each quadrilateral.



Let's learn.

## Construction of a quadrilateral

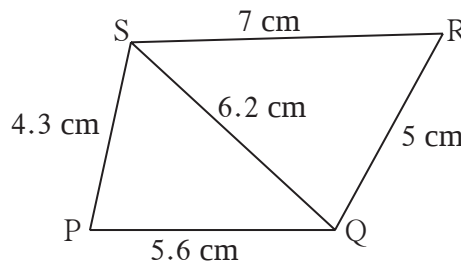
We can construct a quadrilateral if we know the measures of some specific 5 elements out of 10. Constructions of triangles are the basis of constructions of quadrilaterals. This will be clear from the following examples.

**(I) To construct a quadrilateral if the lengths of four sides and a diagonal is given.**

**Ex.** Construct  $\square PQRS$  such that ,  $l(PQ) = 5.6 \text{ cm}$  ,  $l(QR) = 5 \text{ cm}$ ,  $l(PS) = 4.3 \text{ cm}$ ,  $l(RS) = 7 \text{ cm}$ ,  $l(QS) = 6.2 \text{ cm}$

**Solution :** Let us draw a rough figure and show the given information in it. From the figure we see that the sides of  $\triangle SPQ$  and  $\triangle SRQ$  are known.

So if we construct  $\triangle SPQ$  and  $\triangle SRQ$  of given measures, we get  $\square PQRS$ . Construct the given quadrilateral on your own.



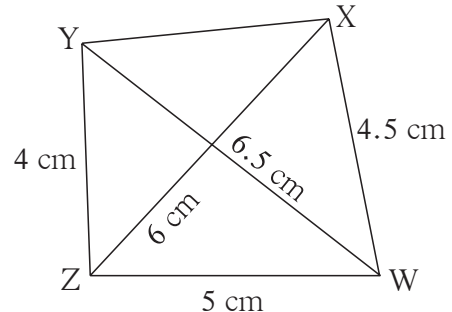
**(II) To construct a quadrilateral if three sides and two diagonals are given.**

**Ex.** Construct  $\square WXYZ$  such that,  $l(YZ) = 4 \text{ cm}$ ,  $l(ZX) = 6 \text{ cm}$ ,  
 $l(WX) = 4.5 \text{ cm}$ ,  $l(ZW) = 5 \text{ cm}$ ,  $l(YW) = 6.5 \text{ cm}$

**Solution:** Let us draw a rough figure and show the given measures in it.

From the figure we see that all sides of  $\triangle WXZ$  and  $\triangle WZY$  are known. So let us draw  $\triangle WXZ$  and  $\triangle WZY$  using given measures. We will get  $\square WXYZ$  after drawing segment  $XY$ .

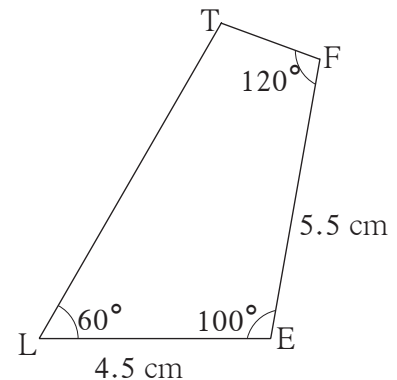
Construct this quadrilateral on your own.



**(III) To construct a quadrilateral if two adjacent sides and any three angles are given.**

**Ex.** Construct  $\square LEFT$  such that,  $l(EL) = 4.5 \text{ cm}$ ,  $l(EF) = 5.5 \text{ cm}$ ,  $m\angle L = 60^\circ$ ,  
 $m\angle E = 100^\circ$ ,  $m\angle F = 120^\circ$

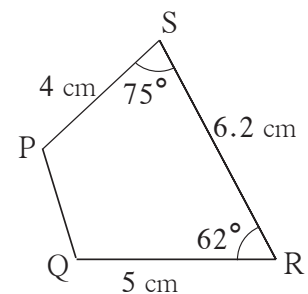
**Solution:** Let us show the given information in a rough figure. From the figure we see that seg LE of length 4.5 cm can be drawn and after drawing seg EF making an angle of  $100^\circ$  at the point E of seg LE, we get three points L, E and F. Let us draw a rays making an angle of  $60^\circ$  at the point L and a ray making an angle of  $120^\circ$  at the point F. The intersection of these two rays is point T. Now you can construct this  $\square LEFT$ .



**(IV) To construct a quadrilateral if three sides and two angles included by them are given.**

**Ex.** Construct  $\square PQRS$  such that,  $l(QR) = 5 \text{ cm}$ ,  $l(RS) = 6.2 \text{ cm}$ ,  $l(SP) = 4 \text{ cm}$ ,  
 $m\angle R = 62^\circ$ ,  $m\angle S = 75^\circ$

**Solution:** Let us draw a rough figure, show the given information in that figure. From the figure we see that after drawing seg QR, if seg RS is drawn making an angle of  $62^\circ$  at the point R, we can get points Q, R and S of the quadrilateral.



We will get point P on ray SP at a distance of 4 cm from S, which makes an angle of  $75^\circ$  at point S. We get  $\square PQRS$  of given measure after joining points P and Q. Now you can do this construction .

### Practice Set 8.1

1. Construct the following quadrilaterals of given measures.

- (1) In  $\square MORE$ ,  $l(MO) = 5.8$  cm,  $l(OR) = 4.4$  cm,  $m\angle M = 58^\circ$ ,  $m\angle O = 105^\circ$ ,  $m\angle R = 90^\circ$ .
- (2) Construct  $\square DEFG$  such that  $l(DE) = 4.5$  cm,  $l(EF) = 6.5$  cm,  $l(DG) = 5.5$  cm,  $l(DF) = 7.2$  cm,  $l(EG) = 7.8$  cm.
- (3) In  $\square ABCD$ ,  $l(AB) = 6.4$  cm,  $l(BC) = 4.8$  cm,  $m\angle A = 70^\circ$ ,  $m\angle B = 50^\circ$ ,  $m\angle C = 140^\circ$ .
- (4) Construct  $\square LMNO$  such that  $l(LM) = l(LO) = 6$  cm,  $l(ON) = l(NM) = 4.5$  cm,  $l(OM) = 7.5$  cm.



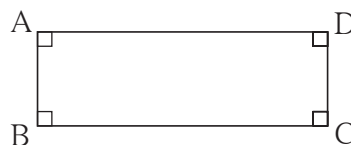
**Let's recall.**

By putting some conditions on sides and angles of a quadrilateral, we get different types of quadrilaterals. You already know two types of quadrilaterals, namely rectangle and square. Now we will study some more properties of these types and of some more types of quadrilaterals through activities.

### Rectangle

**If all angles of a quadrilateral are right angles, it is called a rectangle.**

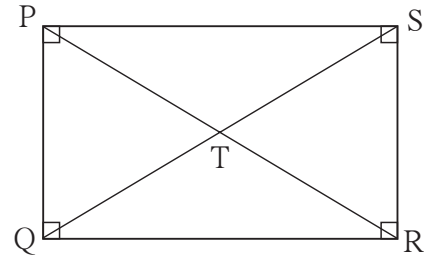
Among the five elements given to construct a quadrilateral, at least two have to be lengths of adjacent sides. You can construct a quadrilateral if two adjacent sides and three angles are given.



From the definition, we know that all angles of a rectangle are right angles. So if you know two adjacent sides, then you can construct a rectangle.

**Activity I :** Construct a rectangle PQRS by taking two convenient adjacent sides. Name the point of intersection of diagonals as T. Using divider and ruler, measure the following lengths.

- (1) lengths of opposite sides, seg QR and seg PS.
- (2) length of seg PQ and seg SR
- (3) length of diagonals PR and QS
- (4) lengths of seg PT and seg TR, which are parts of the diagonal PR.
- (5) lengths of seg QT and seg TS, which are parts of the diagonal QS.



Observe the measures. Discuss about the measures obtained by your classmates. You will come to know the following properties of a rectangle through the discussion.

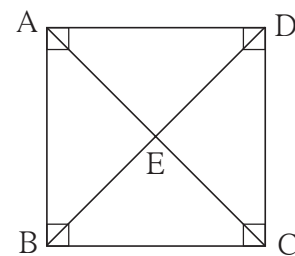
- Opposite sides of a rectangle are congruent.
- Diagonals of a rectangle are congruent.
- Diagonals of a rectangle bisect each other.

### Square

**If all sides and all angles of a quadrilateral are congruent, it is called a square.**

**Activity II :** Draw a square of convenient length of side. Name the point of intersection of its diagonals as E. Using the apparatus in a compass box, measure the following lengths.

- (1) lengths of diagonals AC and diagonal BD.
- (2) lengths of two parts of each diagonal made by point E.
- (3) all the angles made at the point E.
- (4) parts of each angle of the square made by each diagonal. (e.g,  $\angle ADB$  and  $\angle CDB$ ).



Observe the measures. Also observe the measures obtained by your classmates and discuss about them.

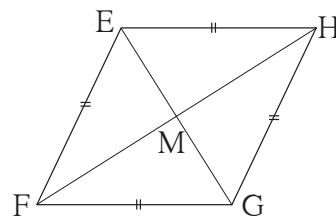
You will get the following properties of a square.

- Diagonals are of equal length. That is they are congruent.
- Diagonals bisect each other.
- Diagonals are perpendicular to each other.
- Diagonals bisect the opposite angles.

## Rhombus

If all sides of a quadrilateral are of equal length (congruent), it is called a rhombus.

**Activity III :** Draw a rhombus EFGH by taking convenient length of side and convenient measure of an angle.  
Draw its diagonals and name their point of intersection as M.



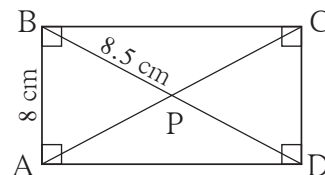
- (1) Measure the opposite angles of the quadrilateral and angles at the point M.
- (2) Measure the two parts of every angle made by the diagonal.
- (3) Measure the lengths of both diagonals. Measure the two parts of diagonals made by point M.

From these measures you will get the following properties of a rhombus.

- Opposite angles are congruent.
  - Diagonals bisect opposite angles of a rhombus.
  - Diagonals bisect each other and they are perpendicular to each other.
- You will see that your classmates also have got the same properties.

## Solved Examples

**Ex. (1)** P is the point of intersection of diagonals of rectangle ABCD. (i) If  $l(AB) = 8$  cm then  $l(DC) = ?$ , (ii) If  $l(BP) = 8.5$  cm then find  $l(BD)$  and  $l(BC)$



**Solution:** Let us draw a rough figure and show the given information in it.

(i) Opposite sides of a rectangle are congruent.

$$\therefore l(DC) = l(AB) = 8 \text{ cm}$$

(ii) Diagonals of a rectangle bisect each other.

$$\therefore l(BD) = 2 \times l(BP) = 2 \times 8.5 = 17 \text{ cm}$$

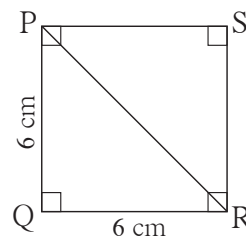
$\triangle BCD$  is a right angled triangle. Using Pythagoras theorem we get,

$$l(BC)^2 = l(BD)^2 - l(CD)^2 = 17^2 - 8^2 = 289 - 64 = 225$$

$$\therefore l(BC) = \sqrt{225} = 15 \text{ cm}$$

**Ex.(2)** Find the length of a diagonal of a square of side 6 cm.

**Solution:** Suppose  $\square PQRS$  is a square of side 6 cm.  
Seg PR is a diagonal.



$$\begin{aligned}\text{In } \triangle PQR, \text{ using Pythagoras theorem, } l(PR)^2 &= l(PQ)^2 + l(QR)^2 \\ &= (6)^2 + (6)^2 = 36 + 36 = 72\end{aligned}$$

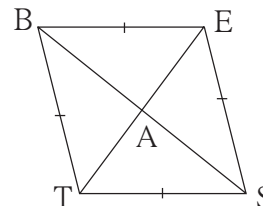
$$\therefore l(PR) = \sqrt{72}, \quad \therefore \text{length of the diagonal is } \sqrt{72} \text{ cm.}$$

**Ex. (3)** Diagonals of a rhombus BEST intersect at A.

(i) If  $m\angle BTS = 110^\circ$ , then find  $m\angle TBS$

(ii) If  $l(TE) = 24$ ,  $l(BS) = 70$ , then find  $l(TS) = ?$

**Solution:** Let us draw rough figure of  $\square BEST$  and show the point A.



(i) Opposite angles of a rhombus are congruent.

$$\therefore m\angle BES = m\angle BTS = 110^\circ$$

$$\text{Now, } m\angle BTS + m\angle BES + m\angle TBE + m\angle TSE = 360^\circ$$

$$\therefore 110^\circ + 110^\circ + m\angle TBE + m\angle TSE = 360^\circ$$

$$\therefore m\angle TBE + m\angle TSE = 360^\circ - 220^\circ = 140^\circ$$

$$\therefore 2 m\angle TBE = 140^\circ \dots \because \text{Opposite angles of a rhombus are congruent.}$$

$$\therefore m\angle TBE = 70^\circ$$

$$\therefore m\angle TBS = \frac{1}{2} \times 70^\circ = 35^\circ \dots \because \text{diagonal of a rhombus bisects the opposite angles}$$

(ii) Diagonals of a rhombus are perpendicular bisectors of each other.

$$\therefore \text{In } \triangle TAS, m\angle TAS = 90^\circ$$

$$l(TA) = \frac{1}{2} l(TE) = \frac{1}{2} \times 24 = 12, \quad l(AS) = \frac{1}{2} l(BS) = \frac{1}{2} \times 70 = 35$$

By Pythagoras theorem,

$$l(TS)^2 = l(TA)^2 + l(AS)^2 = (12)^2 + (35)^2 = 144 + 1225 = 1369$$

$$\therefore l(TS) = \sqrt{1369} = 37$$

### Practice Set 8.2

1. Draw a rectangle ABCD such that  $l(AB) = 6.0$  cm and  $l(BC) = 4.5$  cm.
2. Draw a square WXYZ with side 5.2 cm.
3. Draw a rhombus KLMN such that its side is 4 cm and  $m\angle K = 75^\circ$ .
4. If diagonal of a rectangle is 26 cm and one side is 24 cm, find the other side.

5. Lengths of diagonals of a rhombus ABCD are 16 cm and 12 cm. Find the side and perimeter of the rhombus.
6. Find the length of diagonal of a square with side 8 cm
7. Measure of one angle of a rhombus is  $50^\circ$ , find the measures of remaining three angles.

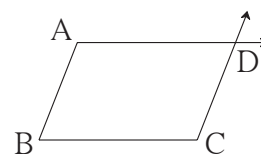
### Parallelogram

**A quadrilateral having opposite sides parallel is called a parallelogram.**

How can we draw a parallelogram?

Draw seg AB and seg BC making an angle of any measure as shown in the adjacent figure.

You know how to draw a line parallel to a given line through a point which is outside it.

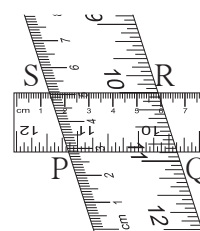


Using the method, draw a line through point C and parallel to the seg AB. Similarly, draw a line parallel to seg BC and passing through point A. Name the point of intersection of the lines as D. □ABCD is a parallelogram. We know that interior angles made by a transversal of parallel lines are supplementary. So in the above figure  $m\angle A + m\angle B = 180^\circ$ ,  $m\angle B + m\angle C = 180^\circ$ ,  $m\angle C + m\angle D = 180^\circ$  and  $m\angle D + m\angle A = 180^\circ$  so we get a property of angles of a parallelogram that-

- Adjacent angles of a parallelogram are supplementary.

To know some more properties, draw a parallelogram PQRS as per the **activity**. Take two rulers of different widths, place one ruler horizontally and draw lines along its edges. Now place the other ruler in slant position over the lines drawn and draw lines along its edges. We get a parallelogram. Draw the diagonals of it and name the point of intersection as T.

- (1) Measure the opposite angles of the parallelogram.
- (2) Measure the lengths of opposite sides
- (3) Measure the lengths of diagonals.
- (4) Measure the lengths of parts of the diagonals made by point T.



From these measures you will get the following properties of a parallelogram.

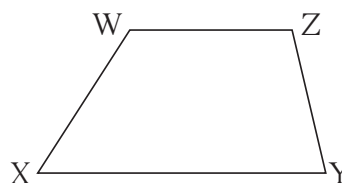
- Opposite angles are congruent.
- Opposite sides are congruent.
- Diagonals bisect each other.

Verify the above properties by drawing some more parallelograms.

## Trapezium

If only one pair of opposite sides of a quadrilateral is parallel then it is called a trapezium.

In  $\square WXYZ$ , only one pair of opposite sides, seg WZ and seg XY is parallel. So by definition  $\square WXYZ$  is a trapezium.



With the property of interior angles formed by two parallel lines and their transversal we get  $m\angle W + m\angle X = 180^\circ$  and  $m\angle Y + m\angle Z = 180^\circ$

In a trapezium, out of four pairs of adjacent angles, two are supplementary.

## Kite

See the figure of  $\square ABCD$ . Diagonal BD of the quadrilateral bisects the diagonal AC.

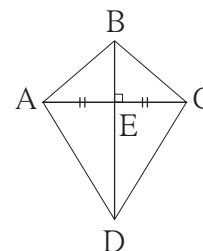
If one diagonal is the perpendicular bisector of the other diagonal then the quadrilateral is called a kite.

In the adjacent figure of  $\square ABCD$ , verify with a divider that  $\text{seg } AB \cong \text{seg } CB$  and  $\text{seg } AD \cong \text{seg } CD$ .

Similarly measure  $\angle BAD$  and  $\angle BCD$  and verify that they are congruent.

Thus we get two properties of a kite.

- Two pairs of adjacent sides are congruent.
- One pair of opposite angles is congruent.



## Solved Examples

**Ex. (1)** Measures of adjacent angles of a parallelogram are  $(5x - 7)^\circ$  and  $(4x + 25)^\circ$ . Find the measures of these angles.

**Solution:** Adjacent angles of a parallelogram are supplementary.

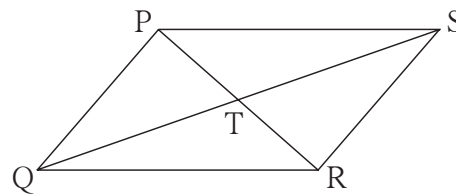
$$\begin{aligned} \therefore (5x - 7) + (4x + 25) &= 180 & \therefore 9x &= 180 - 18 = 162 \\ \therefore 9x + 18 &= 180 & \therefore x &= 18 \end{aligned}$$

$$\therefore \text{measure of one angle} = (5x - 7)^\circ = 5 \times 18 - 7 = 90 - 7 = 83^\circ$$

$$\text{Measure of the other angle} = (4x + 25)^\circ = 4 \times 18 + 25 = 72 + 25 = 97^\circ$$

**Ex. (2)** □ PQRS is a parallelogram. T is the point of intersection of its diagonals. Referring the figure, write the answers of questions given below.

- (i) If  $l(PS) = 5.4$  cm, then  $l(QR) = ?$
- (ii) If  $l(TS) = 3.5$  cm, then  $l(QS) = ?$
- (iii) If  $m\angle QRS = 118^\circ$ , find  $m\angle QPS$ .
- (iv) If  $m\angle SRP = 72^\circ$ , find  $m\angle RPQ$ .



**Solution :** In parallelogram PQRS,

- (i)  $l(QR) = l(PS) = 5.4$  cm ..... opposite sides are congruent
- (ii)  $l(QS) = 2 \times l(TS) = 2 \times 3.5 = 7$  cm ..... diagonals bisect each other
- (iii)  $m\angle QPS = m\angle QRS = 118^\circ$  ..... opposite angles are congruent
- (iv)  $m\angle RPQ = m\angle SRP = 72^\circ$  ..... alternate angles are congruent

**Ex . (3)** Ratio of measures of angles of □ CWPR is 7:9:3:5 then find the measures of its angles and write the type of the quadrilateral.

**Solution:** Suppose,  $m\angle C : m\angle W : m\angle P : m\angle R = 7:9:3:5$

let the measures of  $\angle C$ ,  $\angle W$ ,  $\angle P$  and  $\angle R$   
be  $7x$ ,  $9x$ ,  $3x$  and  $5x$  respectively.

$$\therefore 7x + 9x + 3x + 5x = 360^\circ$$

$$\therefore 24x = 360^\circ \quad \therefore x = 15$$

$$\therefore m\angle C = 7 \times 15 = 105^\circ, m\angle W = 9 \times 15 = 135^\circ$$

$$m\angle P = 3 \times 15 = 45^\circ \text{ and } m\angle R = 5 \times 15 = 75^\circ$$

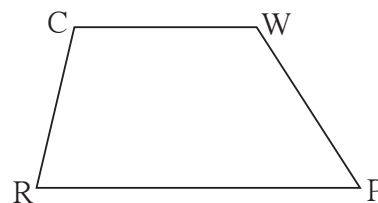
$$\therefore m\angle C + m\angle R = 105^\circ + 75^\circ = 180^\circ \quad \therefore \text{side } CW \parallel \text{side } RP$$

$$m\angle C + m\angle W = 105^\circ + 135^\circ = 240^\circ \neq 180^\circ$$

$\therefore$  side CR is not parallel to side WP.

$\therefore$  only one pair of opposite sides of □ CWPR is parallel.

$\therefore$  □ CWPR is a trapezium.



### Practice Set 8.3

1. Measures of opposite angles of a parallelogram are  $(3x-2)^\circ$  and  $(50 - x)^\circ$ . Find the measure of its each angle.

2. Referring the adjacent figure of a parallelogram, write the answers of questions given below.

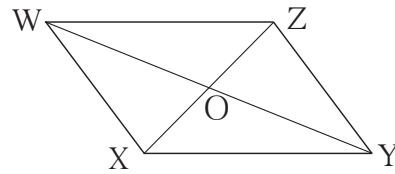
(1) If  $l(WZ) = 4.5$  cm then  $l(XY) = ?$

(2) If  $l(YZ) = 8.2$  cm then  $l(XW) = ?$

(3) If  $l(OX) = 2.5$  cm then  $l(OZ) = ?$

(4) If  $l(WO) = 3.3$  cm then  $l(WY) = ?$

(5) If  $m\angle WZY = 120^\circ$  then  $m\angle WXY = ?$  and  $m\angle XWZ = ?$



3. Construct a parallelogram ABCD such that  $l(BC) = 7$  cm,  $m\angle ABC = 40^\circ$ ,  $l(AB) = 3$  cm.

4. Ratio of consecutive angles of a quadrilateral is 1:2:3:4. Find the measure of its each angle. Write, with reason, what type of a quadrilateral it is.

5. Construct  $\square$  BARC such that  $l(BA) = l(BC) = 4.2$  cm,  $l(AC) = 6.0$  cm,  $l(AR) = l(CR) = 5.6$  cm

6\*. Construct  $\square$  PQRS, such that  $l(PQ) = 3.5$  cm,  $l(QR) = 5.6$  cm,  $l(RS) = 3.5$  cm,  $m\angle Q = 110^\circ$ ,  $m\angle R = 70^\circ$ .

If it is given that  $\square$  PQRS is a parallelogram, which of the given information is unnecessary ?



## Answers

### Practice Set 8.2

4. 10 cm    5. side 10 cm, perimeter 40 cm.    6.  $\sqrt{128}$  cm    7.  $130^\circ$ ,  $50^\circ$ ,  $130^\circ$

### Practice Set 8.3

1.  $37^\circ$ ,  $143^\circ$ ,  $37^\circ$ ,  $143^\circ$

2. (1) 4.5 cm    (2) 8.2 cm    (3) 2.5 cm    (4) 6.6 cm    (5)  $120^\circ$ ,  $60^\circ$

4.  $36^\circ$ ,  $72^\circ$ ,  $108^\circ$ ,  $144^\circ$ , a trapezium

