Hence, four pairs of adjacent angles are,
(∠AOC, ∠AOD), (∠AOC, ∠BOC), (∠COB, ∠DOB) and (∠AOD, ∠BOD).

Example 8 : In the adjoining figure, lines AB and CD intersect at O. If ∠3 = 70°, find all other angles.

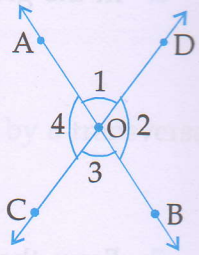
Solution : Since CD is a straight line and OB stands on it, therefore, ∠2 and ∠3 form linear pair of angles.

$\therefore \quad \angle 2 + \angle 3 = 180°$

$\Rightarrow \quad \angle 2 + 70° = 180°$ (∠3 = 70° given)

$\Rightarrow \quad \angle 2 = 180° - 70°$

$\Rightarrow \quad \angle 2 = 110°$



Since ∠3 and ∠1 are vertically opposite angles.

$\therefore \quad \angle 1 = \angle 3$,

But $\quad \angle 3 = 70°$

$\Rightarrow \quad \angle 1 = 70°$

Also, ∠2 and ∠4 are vertically opposite angles

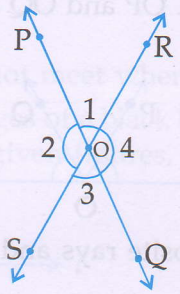
$\therefore \quad \angle 4 = \angle 2$

$\Rightarrow \quad \angle 4 = 110°$ [$\because$ ∠2 = 110°]

Hence, ∠1 = 70°, ∠2 = 110°, ∠3 = 70° and ∠4 = 110°.

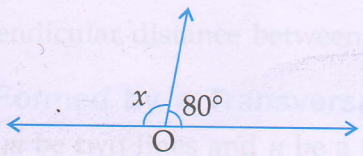
EXERCISE 11.1

1. Find the complementary and supplementary angle of each of the following :
   (*i*) 26° (*ii*) 62° (*iii*) 9° (*iv*) 51° (*v*) 37°
2. Find the complement of each of the following :
   (*i*) 72° (*ii*) 19° (*iii*) 88° (*iv*) 25°
3. In the given figure, lines PQ and RS intersect at point O. If ∠1 = 53°, find all other angles.

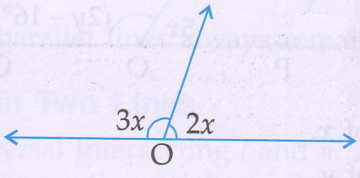


4. Find the value of x in each of the following figures given below :

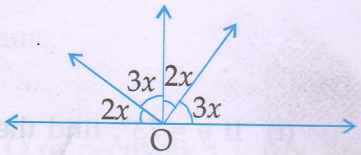
(*i*)



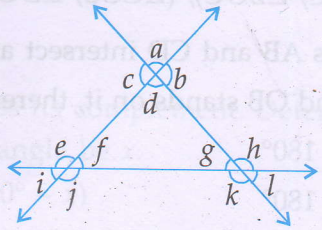
(*ii*)



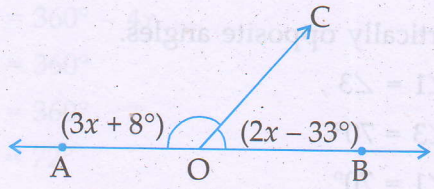
(*iii*)



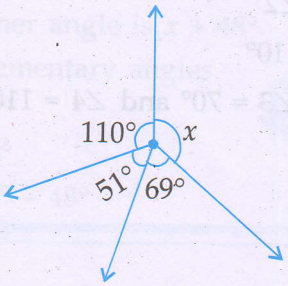
5. In the given figure, name each linear pair of angles and pair of vertically opposite angles.



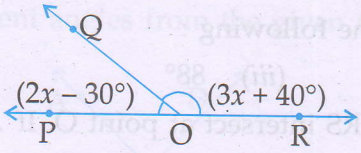
6. In the given figure, what value of x will make AOB a straight line ?



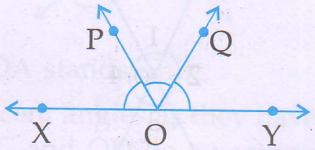
7. From the given figure, find the value of x.



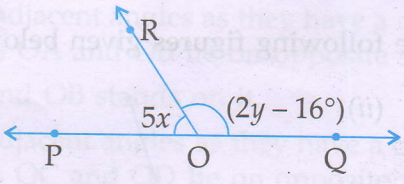
8. In the given figure, POR is a straight line and the ray OQ stands on it. Find the value of x. Also, find $\angle POQ$ and $\angle QOR$.



9. In the given figure, XOY is a straight line. OP and OQ stand on line XY. Write all the pairs of adjacent angles and all the linear pairs of angles.



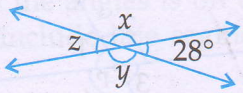
10. In the given figure, OP and OQ are opposite rays and OR stands on PQ.



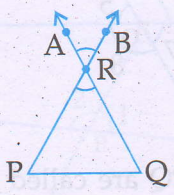
(*i*) If $y = 73°$, find the value of x.

(*ii*) If $x = 14°$, find the value of y.

11. From the adjacent figure, find the values of x, y and z.



12. In ΔPQR, sides PR and QR are extended to B and A respectively. If ∠ARB = 62°, find ∠PRQ and ∠BRQ.

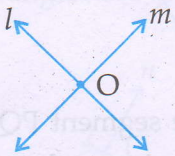


PAIRS OF LINES

We shall now study about intersecting lines, transversal and parallel lines, also angles made by a transversal with two lines.

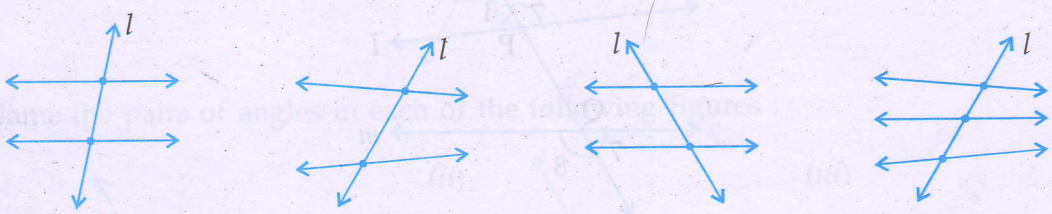
Intersecting Lines

Two lines l and m intersect if they have a point in common. This common point is called the **point of intersection**. In the given figure, two lines l and m intersect at O, which is the point of intersection.



Transversal

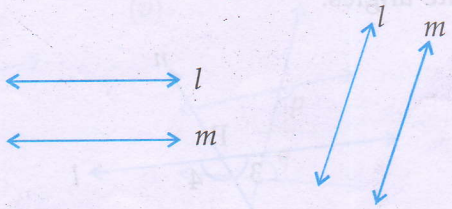
A line which intersects two or more given lines in a plane at **different** points is called a **transversal** to the given lines. In each of the figures given below, l is a transversal.



Parallel Lines

Two lines in a plane are parallel, if they do not meet when produced infinitely in either direction.

The opposite edges of a room, the opposite edges of a black board, railway lines, the opposite edges of a ruler etc. are all examples of parallel lines. In the given figures, $l \parallel m$ or $m \parallel l$.



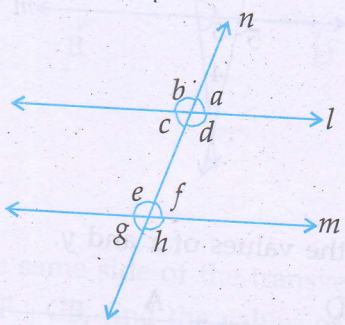
The perpendicular distance between two parallel lines always remains the same.

Angles Formed by a Transversal with Two Lines

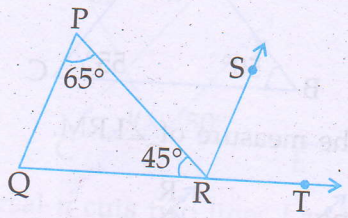
Let l and m be two lines and n be a transversal intersecting l and m at P and Q respectively. Clearly, lines l, m and n make eight angles. In the given figure, these eight angles marked 1 to 8 have their special names.

EXERCISE 11.2

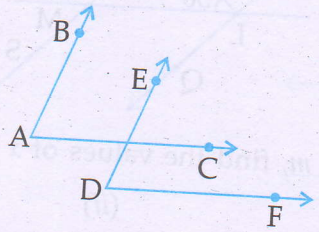
1. In the given figure, $l \parallel m$ and n is a transversal. If $\angle c = 72°$, find the measure of each of the angles a, b, d, e, f, g and h.



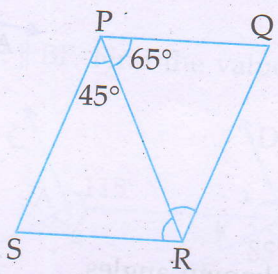
2. In the given figure, QP ∥ RS, $\angle P = 65°$, $\angle R = 45°$, then find $\angle SRT$.



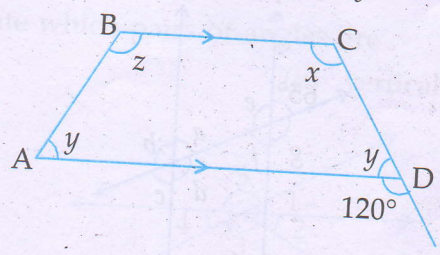
3. In the figure given below, AB ∥ DE and AC ∥ DF, prove that $\angle BAC = \angle EDF$.



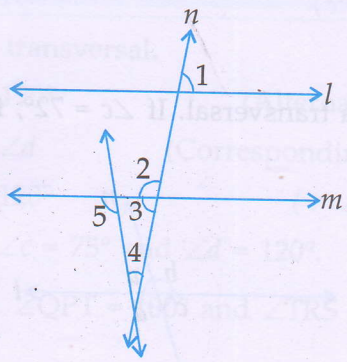
4. In the given figure, PQ ∥ SR and SP ∥ RQ. PR is a diagonal. If $\angle QPR = 65°$ and $\angle SPR = 45°$, find $\angle SRQ$.



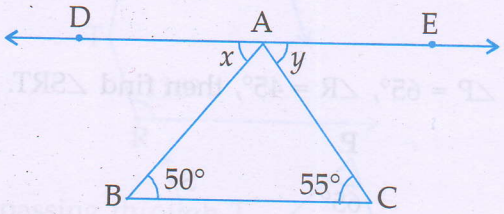
5. In the given figure, BC ∥ AD. Find the measure of $\angle x$, $\angle y$ and $\angle z$.



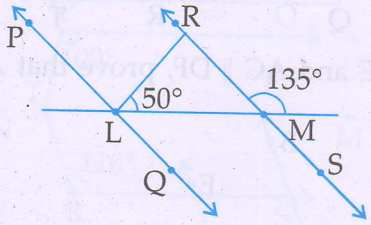
6. In the given figure, $l \parallel m$ and n is a transversal. If $\angle 1 = 80°$ and $\angle 5 = 100°$, find the measures of $\angle 2$, and $\angle 4$.



7. In the given figure, BC $\parallel$ DE. Find the values of x and y.

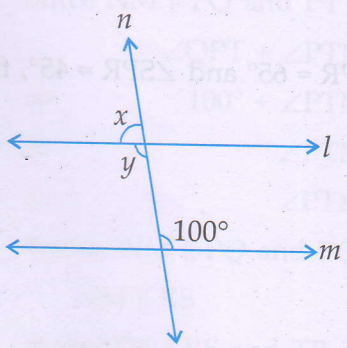


8. In the given figure, PQ $\parallel$ RS, find the measure of $\angle$LRM.

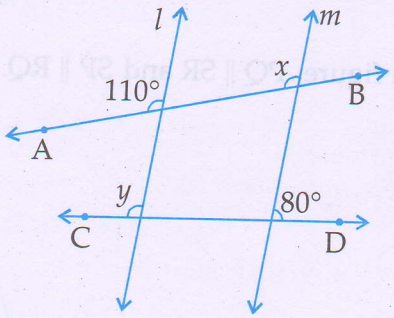


9. In each of the following figures, $l \parallel m$, find the values of x and y.

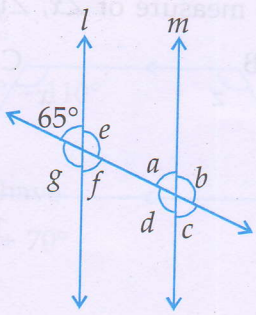
(*i*)



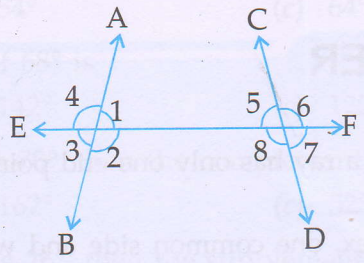
(*ii*)



10. In the given figure, $l \parallel m$, find the unknown angles.

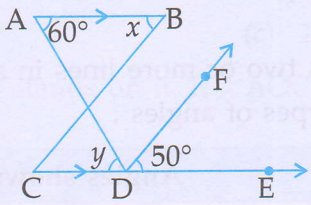


11. Using the given figure, name the following angles :



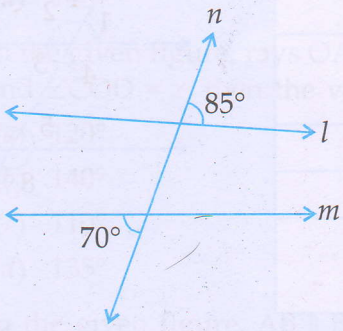
(*i*) Corresponding angles
(*ii*) Alternate interior angles
(*iii*) Alternate angle of $\angle 2$
(*iv*) Angle corresponding to $\angle 7$
(*v*) Pairs of interior angles on the same side of the transversal.

12. In the given figure AB $\parallel$ CE and DF $\parallel$ CB, find the values of x and y.

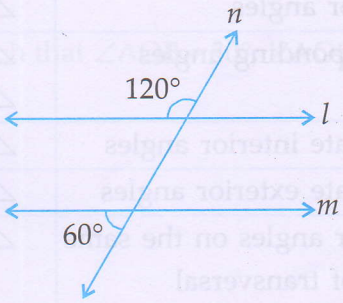


13. In the following figures, a transversal n cuts two lines l and m.

(*i*)

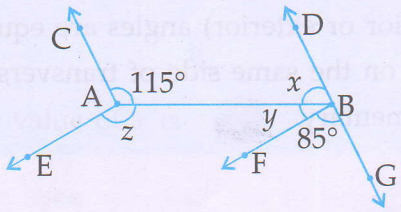


(*ii*)



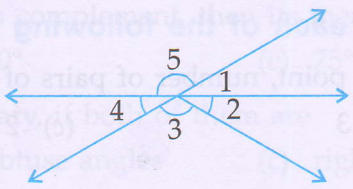
Is line $l \parallel m$?

14. In the given figure, AC $\parallel$ BD and AE $\parallel$ BF. Find the values of x, y and z.



15. In the adjoining figure, indicate which pairs of angles are :

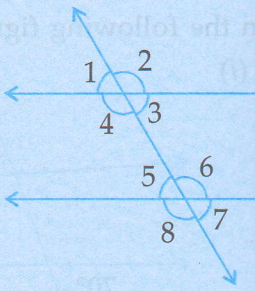
(*i*) linear pairs of angles
(*ii*) vertically opposite angles



FACTS TO REMEMBER

- A line segment has two end points, a ray has only one end point and a line has no end points on e side.
- Two angles having a common vertex, one common side and which do not overlap are called adj angles.
- The measure of two complementary angles add up to 90°.
- The measure of two supplementary angles add up to 180°.
- If two lines intersect, then two pairs of angles formed without a common arm are called vert opposite angles.
- Vertically opposite angles are always equal.
- When two lines drawn on sheet of paper do not meet, however far produced, they are called pa lines.
- A transversal is a line that intersects two or more lines in a plane at distinct points.
- A transversal gives rise to several types of angles :

Types of angles	Angles shown
Interior angles	$\angle 3, \angle 4, \angle 5, \angle 6$
Exterior angles	$\angle 1, \angle 2, \angle 7, \angle 8$
Corresponding angles	$\angle 1$ and $\angle 5$; $\angle 4$ and $\angle 8$; $\angle 2$ and $\angle 6$; $\angle 3$ and $\angle 7$.
Alternate interior angles	$\angle 3$ and $\angle 5$; $\angle 4$ and $\angle 6$
Alternate exterior angles	$\angle 1$ and $\angle 7$; $\angle 2$ and $\angle 8$
Interior angles on the same sides of transversal	$\angle 4$ and $\angle 5$; $\angle 3$ and $\angle 6$



- When a transversal intersects two parallel lines :
  (*i*) each pair of corresponding angles are equal.
  (*ii*) each pair of alternate (interior or exterior) angles are equal.
  (*iii*) each pair of interior angles on the same side of transversal are supplementary.
- Linear pair of angles are supplementary.

MULTIPLE CHOICE QUESTIONS

Choose the correct alternatives in each of the following :

1. When two lines intersect at a point, number of pairs of adjacent angles formed are
   (*a*) 4 (*b*) 3 (*c*) 2 (*d*) 6

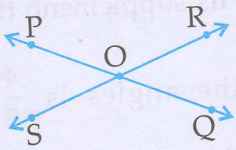
2. The complement of an angle of 36° is
(a) 34° (b) 54° (c) 64° (d) 144°

3. The supplement of an angle of 68° is
(a) 22° (b) 142° (c) 122° (d) 112°

4. The supplement of an angle is 70°, then the complement of that angle is
(a) 32° (b) 162° (c) 52° (d) does not exist

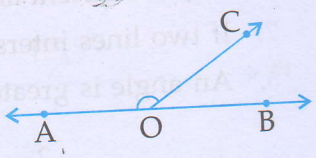
5. The complement of an angle is 26°, then the supplement of that angle is
(a) 64° (b) 154° (c) 116° (d) does not exist

6. In the given figure, two straight lines intersect at point O, if $\angle POS = 45°$, then $\angle QOR$ is equal to

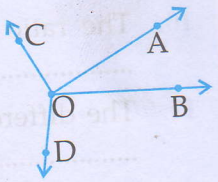


(a) 135° (b) 55° (c) 155° (d) 45°

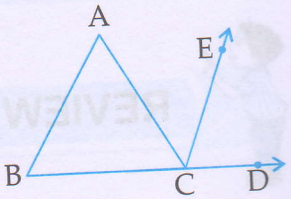
7. AOB is a straight line, a ray OC stands on it. If $\angle AOC = 145°$, then $\angle BOC$ is equal to
(a) 55°
(b) 45°
(c) 35°
(d) 145°



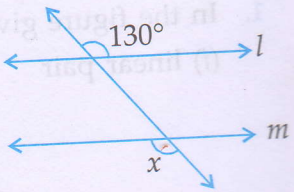
8. In the given figure, rays OA, OB, OC and OD are such that $\angle AOB = 30°$, $\angle AOC = 90°$, $\angle BOD = 100°$ and $\angle COD = x$, then the value of x is
(a) 120°
(b) 140°
(c) 110°
(d) 135°



9. In the given figure, AB || EC, $\angle A = 60°$ and $\angle ECD = 70°$, then $\angle ACB$ is equal to
(a) 50°
(b) 60°
(c) 70°
(d) 40°



10. In the given figure, $l \parallel m$, the value of x is
(a) 50°
(b) 130°
(c) 120°
(d) 100°



11. An angle is equal to 5 times its complement, then its measure is
(a) 25° (b) 50° (c) 75° (d) 60°

12. Two angles can be supplementary, if both of them are
(a) acute angles (b) obtuse angles (c) right angles (d) straight angles

MENTAL MATHS CORNER

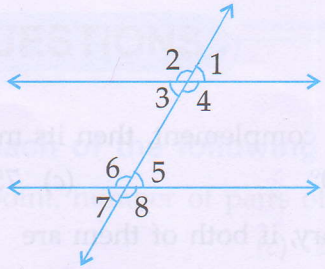
Fill in the blanks :

1. If two angles of a linear pair are equal, then measure of each angle is ..... .
2. If the magnitude of an angle is same as its complement, then measure of the angle is ..... .
3. If the magnitude of an angle is same as its supplement, then the angle is ..... .
4. Two angles are such that one of the angles is $\frac{4}{5}$ of its supplement, then the angle is ..... and its supplement is ..... .
5. Two angles forming a linear pair are ..... .
6. If two adjacent angles are supplementary, they form a ..... .
7. If two lines intersect at a point, then the ..... are always equal.
8. An angle is greater than 45°, then its complementary angle is ..... than 45°.
9. An angle is $\frac{2}{3}$ of its complement, then the angle is ..... and its complement is ..... .
10. The ratio of two angles of a linear pair is 2 : 3. Then the angles are ..... and ..... .
11. The difference between the measures of two angles of a linear pair is 80°, then the smaller angle is ..... .
12. The supplement of 180° is ..... .

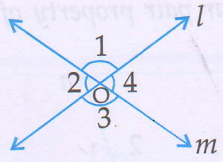
REVIEW EXERCISE

1. In the figure given below, write down each

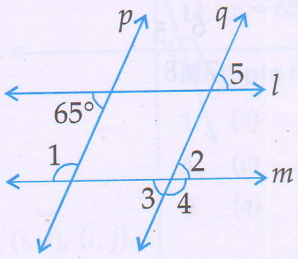
   (*i*) linear pair (*ii*) pair of vertically opposite angles.



2. In the figure given below, line l and m intersect at O. If $\angle 4 = 70°$, find all other angles.

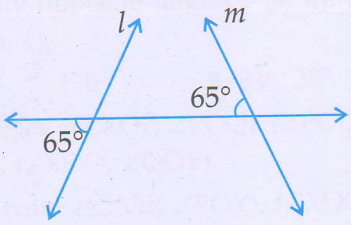


3. In the given figure, $l \parallel m$, $p \parallel q$, find $\angle 1$, $\angle 2$, $\angle 3$, $\angle 4$ and $\angle 5$.

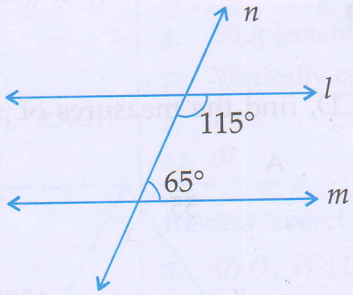


4. In the figures given below, decide whether $l \parallel m$.

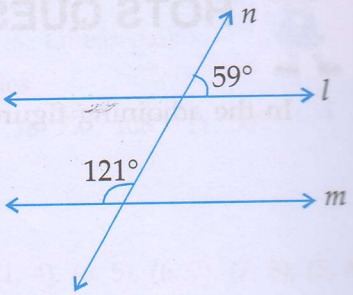
(i)



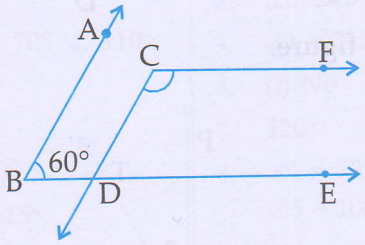
(ii)



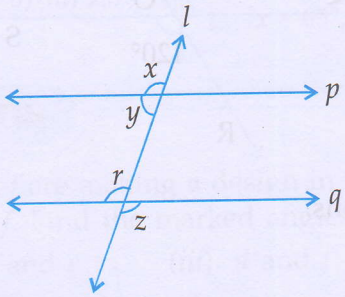
(iii)



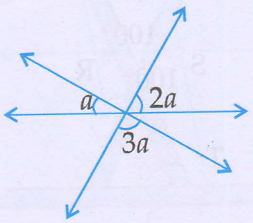
5. In the given figure, AB $\parallel$ CD, BE $\parallel$ CF and $\angle ABD = 60°$. Find the value of $\angle FCD$.



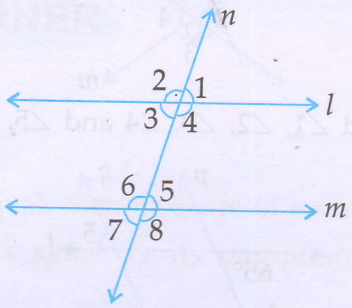
6. In the given figure, $p \parallel q$. If $\angle z = 110°$, find $\angle x$, $\angle y$ and $\angle r$.



7. From the given figure, find the value of a.

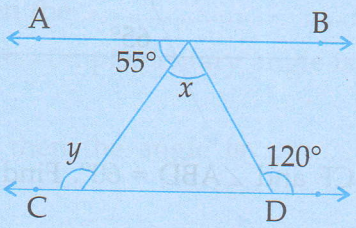


8. In the given figure, $l \parallel m$. If $\angle 1$ and $\angle 2$ are in the ratio 2 : 3, find all the angles.
(**Hint :** *Let $\angle 1 = 2x$, $\angle 2 = 3x$ and use linear pair property of angles)*

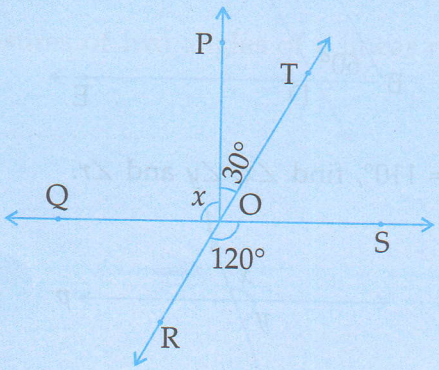


HOTS QUESTIONS

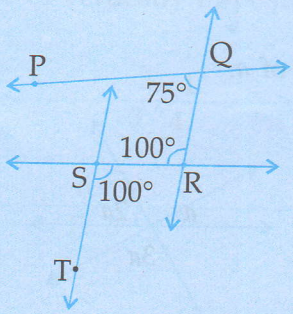
1. In the adjoining figure, if AB ∥ CD, find the measures of x and y.



2. Find the value of x from the given figure.



3. Which lines are parallel? Give reasons.



ANSWERS

Exercise 11.1

1. (*i*) 64°, 154° (*ii*) 28°, 118° (*iii*) 81°, 171° (*iv*) 39°,129° (*v*) 53°, 143°
2. (*i*) 18° (*ii*) 71° (*iii*) 2° (*iv*) 65°
3. $\angle 2 = 127°$, $\angle 3 = 53°$, $\angle 4 = 127°$
4. (*i*) 100° (*ii*) 36° (*iii*) 18°
5. Linear pair : (*a*, *c*), (*c*, *d*), (*d*, *b*), (*a*, *b*), (*e*, *f*), (*i*, *e*), (*i*, *j*), (*j*, *f*), (*g*, *h*), (*g*, *k*), (*k*, *l*), (*l*, *h*).
   Vertically opposite angles : (*a*, *d*), (*c*, *b*), (*e*, *j*), (*i*, *f*), (*g*, *l*), (*h*, *k*).
6. 41° 7. 130° 8. 34°, 38°, 142°
9. Adj. angles : ($\angle$XOP, $\angle$POQ), ($\angle$POQ, $\angle$QOY), ($\angle$XOP, $\angle$POY), ($\angle$XOQ, $\angle$QOY).
   Linear pair : ($\angle$XOP, $\angle$POY), ($\angle$XOQ, $\angle$QOY).
10. (*i*) $x = 10°$ (*ii*) $y = 63°$ 11. 152°, 152°, 28°.
12. 62°, 118°

Exercise 11.2

1. 72°, 108°, 108°, 108°, 72°, 72°, 108° 2. 70° 4. 110°
5. 120°, 60°, 120° 6. 100°, 80°, 20°
7. $x = 50°$, $y = 55°$ 8. 85°
9. (*i*) $x = 80°$, $y = 100°$ (*ii*) $x = 110°$, $y = 100°$
10. $a = 65°$, $b = 115°$, $c = 65°$, $d = 115°$, $e = 115°$, $f = 65°$, $g = 115°$
11. (*i*) (4, 5), (1, 6), (3, 8), (2, 7) (*ii*) (1, 8), (2, 5) (*iii*) $\angle 5$ (*iv*) $\angle 2$ (*v*) (1, 5), (2, 8)
12. $x = 50°$, $y = 60°$ 13. (*i*) No (*ii*) Yes
14. $x = 65°$, $y = 30°$, $z = 150°$ 15. (*i*) (1, 5), (4, 5)(*ii*) (4, 1)

Multiple Choice Questions

1. (*a*) 2. (*b*) 3. (*d*) 4. (*d*)
5. (*c*) 6. (*d*) 7. (*c*) 8. (*b*)
9. (*a*) 10. (*b*) 11. (*c*) 12. (*c*)

Mental Maths Corner

1. 90° 2. 45° 3. 90° 4. 80°, 100°
5. Supplementary 6. Linear pair
7. Vertically opposite angles
8. Less 9. 36°, 54° 10. 72°, 108° 11. 50°
12. 0°

Review Exercise

1. (*i*) (1, 2), (2, 3), (3, 4), (1, 4), (6, 5), (6, 7), (7, 8), (5, 8)
   (*ii*) (2, 4), (1, 3), (6, 8), (5, 7)
2. $\angle 2 = 70°$, $\angle 1 = 110°$, $\angle 3 = 110°$
3. $\angle 1 = 115°$, $\angle 2 = 65°$, $\angle 3 = 65°$, $\angle 4 = 115°$, $\angle 5 = 65°$
4. (*i*) No (*ii*) Yes (*iii*) Yes
5. 120° 6. $\angle x = 110°$, $\angle y = 70°$, $\angle r = 110°$ 7. 30°
8. $\angle 1 = 72°$, $\angle 2 = 108°$, $\angle 3 = 72°$, $\angle 4 = 108°$, $\angle 5 = 72°$, $\angle 6 = 108°$, $\angle 7 = 72°$, $\angle 8 = 108°$

HOTS Questions

1. $x = 65°$, $y = 125°$ 2. 90° 3. QR $\parallel$ ST

NCERT Exemplar Problems

Example 1 : Iron rods *a*, *b*, *c*, *d*, *e* and *f* are making a design in a bridge as shown in the adjoining figure, in which $a \parallel b$, $c \parallel d$, $e \parallel f$. Find the marked angles between
(*i*) *b* and *c* (*ii*) *d* and *e* (*iii*) *d* and *f* (*iv*) *c* and *f*