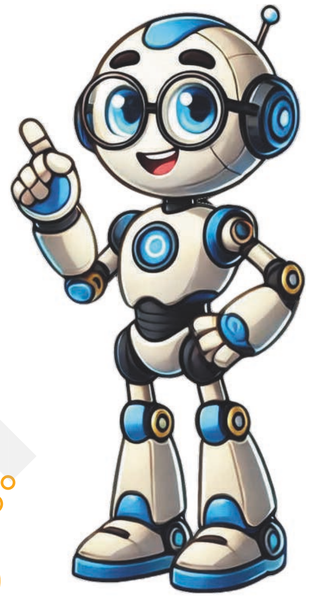
Chapter 8

Properties of Triangles

We'll cover the following key points:

- → Triangles
- → Angle sum property of triangle
- → Exterior angle property of triangle
- → Triangle inequality property
- → Pythagoras theorem



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Learning Outcomes

By the end of this chapter, students will be able to:

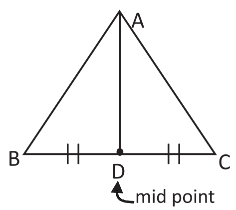
- Define and identify different types of triangles, including equilateral, isosceles, and scalene triangles.
- Understand and apply the concept of the angle sum property of a triangle, which states that the sum of the angles of a triangle is always 180°.
- Identify and understand the properties of congruent triangles, including the criteria for congruence (SSS, SAS, ASA, AAS).
- Understand and apply the properties of similar triangles, including the concept of proportional sides and equal corresponding angles.
- Calculate the perimeter of different types of triangles by adding the lengths of their sides.
- Solve problems involving the area of triangles, using the formula: Area = 1/2 × base × height.
- Understand the concept of the medians, altitudes, and perpendicular bisectors of a triangle and how to construct them.
- Understand the concept of the incentre, circumcenter, orthocenter, and centroid of a triangle and their properties.
- Use the properties of triangles in real-life applications, such as in architecture, engineering, and design.
- Apply the Pythagorean theorem to right-angled triangles and solve problems involving right triangles.

Mind Map

THE TRIANGLE AND ITS PROPERTIES

Medians of a Triangle

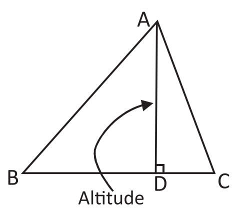
- A median connects a vertex of a triangle to the mid – point of the opposite side.



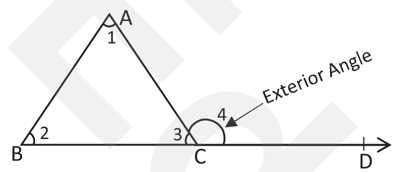
AD is median

Altitudes of a triangle

- A perpendicular from the vertex to the opposite side.



Exterior Angle of a triangle



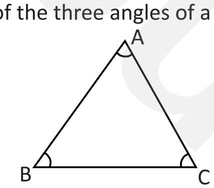
$\angle 4 = \angle 1 + \angle 2$

➢ **Property of exterior angle**

- An exterior angle of a triangle is equal to the sum of its interior opposite angles.

Angle sum property of a triangle

- The total measure of the three angles of a triangle is 180°

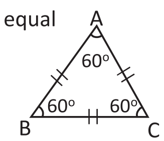


$\angle A + \angle B + \angle C = 180^\circ$

Two special triangles

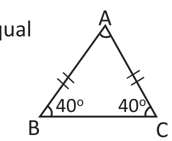
i. Equilateral Δ

- All three sides are equal



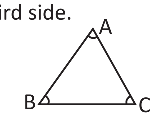
ii. Isosceles Δ

- Two sides are equal



Sum of the lengths of two sides of a triangle

- The sum of the lengths of any two sides of a triangle is greater than the third side.



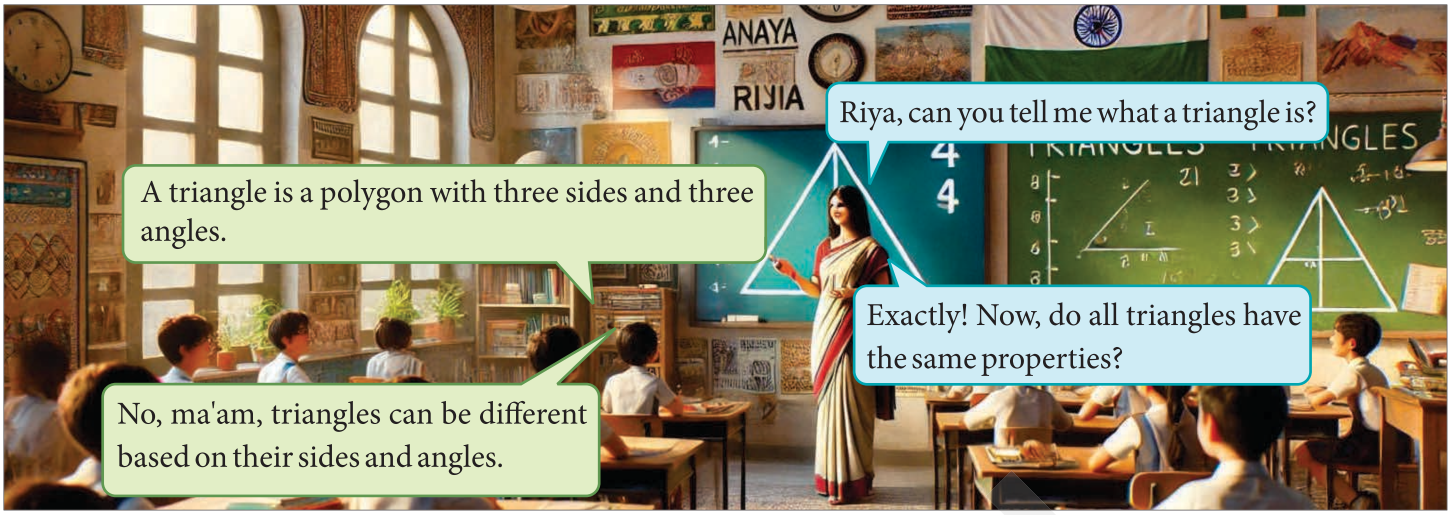
AB + BC > AC

BC + CA > AB

CA + AB > BC

Based on NCERT*

Introduction



Triangles

Let us revise a few things about triangles we have learnt earlier.

Take a Task Watch Remedial

A triangle is a closed figure made of three line segments. It has three vertices, three sides and three angles.

On the basis of sides, there are three types of triangles :

(*i*) Scalene triangle (*ii*) Isosceles triangle (*iii*) Equilateral triangle

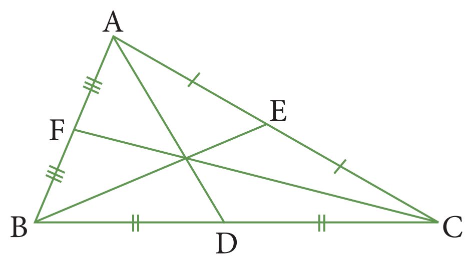
On the basis of angles, there are three types of triangles :

(*i*) Acute - angled triangle (*ii*) Obtuse- angled triangle (*iii*) Right-angled triangle

Medians of a Triangle

The line segment joining the mid-points of the sides of a triangle to the opposite vertices are called medians of the triangle.

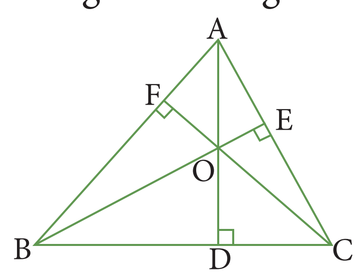
Let D, E and F are the mid-points of sides $\overline{BC}$, $\overline{AC}$ and $\overline{AB}$ respectively of ΔABC. Then, the line segments $\overline{AD}$, $\overline{BE}$ and $\overline{CF}$ are the medians of ΔABC.



Altitudes of a Triangle

In a triangle, the line segment drawn from the vertex to its opposite side so that it becomes perpendicular to its opposite side is called the altitude of the triangle. A triangle has three altitudes with respect to each side.

In the fig., AD, BE and CF are the three altitudes of ΔABC drawn respectively from A on BC, from B on AC and from C on AB.

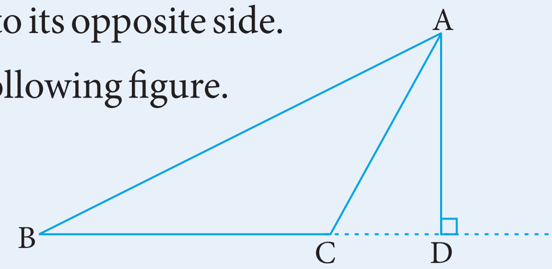


Note

1. An altitude is the shortest distance from the vertex to its opposite side.
2. An altitude might be outside the triangle as in the following figure.

   Here, $\overline{AD} \perp \overline{BC}$.

   $\overline{AD}$ is the altitude drawn from the vertex A to base $\overline{BC}$ of ΔABC.



Angle Sum Property of Triangle

Let us prove the Angle sum property of triangle that the sum of the measures of the three angles of a triangle is equal to 180°, using the property of parallel lines.

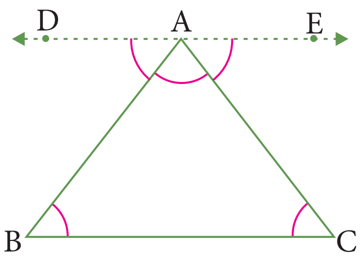
Take a Task

Watch Remedial

Given : A triangle ABC (say)

To Prove : $\angle A + \angle B + \angle C = 180°$

Construction : Through the vertex A, draw a line $\overleftrightarrow{DE}$ parallel to the base $\overline{BC}$.



Proof : Now, $\overline{BC} \parallel \overleftrightarrow{DE}$ and $\overline{AB}$ is a transversal.

$\therefore$ $\angle DAB = \angle ABC$ [Alternate angles] .... (*i*)

Similarly, $\angle EAC = \angle BCA$ [Alternate angles] .... (*ii*)

From the figure, we get

$\angle DAB + \angle BAC + \angle EAC = 180°$ [$\because$ $\overleftrightarrow{DE}$ represents a straight line and the sum of the angles is equal to a straight angle.]

i.e., $\angle ABC + \angle BAC + \angle BCA = 180°$ [Substituting the alternate angles for $\angle DAB$ and $\angle EAC$ from (*i*) and (*ii*)]

Thus, it is proved that the sum of the measures of the three angles of a triangle is equal to 180° or two right angles.

REMEMBER

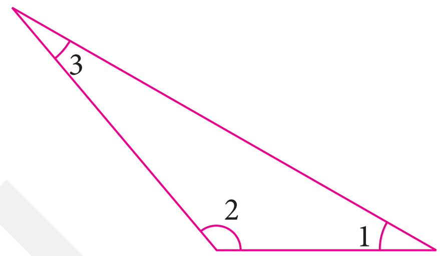
1. A triangle cannot have more than one right angle.
2. A triangle cannot have more than one obtuse angle *i.e.*, if one angle of a triangle is obtuse, then the other two are acute.
3. In a right triangle, besides the right angle, the other two angles are acute and their sum is 90°.

4. In an equilateral triangle : (*i*) all sides have same length.
(*ii*) each angle has measure 60°.

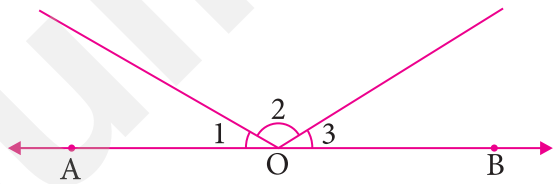
5. In an isosceles triangle : (*i*) two sides have same length.
(*ii*) base angles opposite to equal sides are equal.

Verification

Case 1 : Draw a triangle on a thick sheet of paper. Mark three angles and label them as ∠1, ∠2 and ∠3. Cut out the triangular region. Cut further into three parts so that each part represents an angle.



Now, draw a line AOB. Arrange the three cut-outs of the angles such that the vertex of each angle falls at the point O and one arm of ∠1 is along the ray OA, ∠2 is adjacent to ∠1 and ∠3 is adjacent to ∠2, as shown in the figure.



Observe that the outer arm of ∠3 is along the ray OB.

This shows that the three angles together make the straight angle AOB.

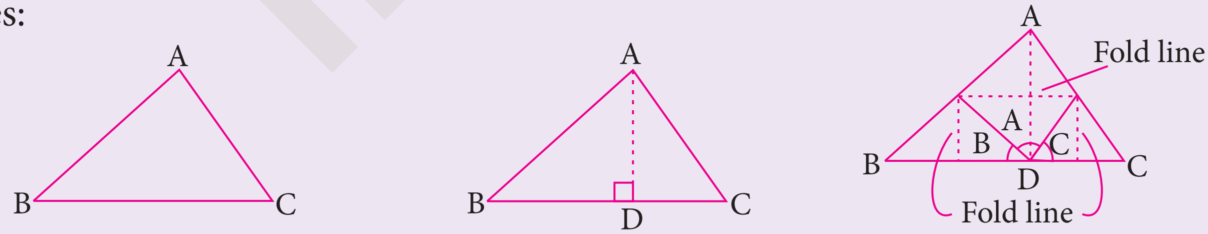
Hence, *we find that the sum of the measures of the three angles of a triangle is 180°.*

Hence verified

Project

Creativity and Innovation

Take a piece of paper and cut out a triangle ABC. Fold the altitude AD through A. Fold the three corners such that all the three vertices A, B and C touch at D as shown in the following figures:



We observe that all the three angles form together a straight angle. Hence, we find that the sum of the measures of the three angles of triangle is 180°.

Case 2 : We know that the set squares represent the triangle. So, let us measure the angles of the set squares. There are two set squares.

In figure (*i*), the set square has angles 30°, 60°, 90°.

Their sum = 30° + 60° + 90° = 180°

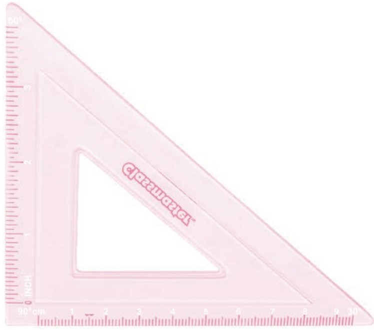


Fig. (*i*)

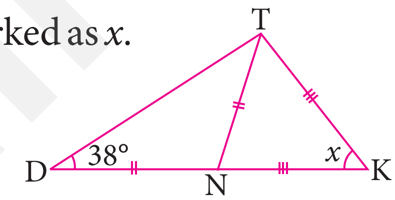
Fig. (*ii*)

In figure (*ii*), the set square has angles 45°, 45°, 90°.

In each case, we see that the sum of the angles of a triangular figure is 180°.

Hence verified.

Example 1 : In the given figure, find the measure of the angle marked as x.



Solution : In ΔTND, it is given that,

$\overline{TN} = \overline{DN}$ and $\angle D = 38°$

$\therefore \quad \angle NTD = 38°$ [$\because$ base angles are equal.]

So, the ΔTND is an isosceles triangle.

Then, $\angle TND = 180° - (\angle NTD + \angle D)$

[Using angle sum property of a Δ]

$= 180° - (38° + 38°) = 180° - 76° = 104°$

Also, $\angle DNK = 180°$ [Straight angle]

i.e., $\angle TND + \angle KNT = 180°$ [Linear pair of angles]

or $\angle KNT = 180° - \angle TND = 180° - 104° = 76°$.

In ΔTNK, since TK = NK and $\angle KNT = 76°$

$\angle KTN = 76°$ [in ΔTNK, base angles are equal.]

Now in Δ TNK, $\angle KNT + \angle KTN + x$ (i.e $\angle K$) = 180°

[Angle sum property of a triangle]

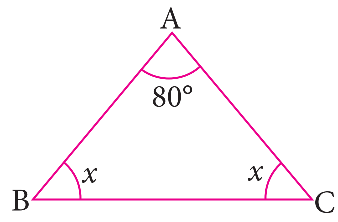
i.e., $76° + 76° + x = 180°$

or $x = 180° - 152° = 28°$

Hence, the value of x, *i.e.*, $\angle K = 28°$.

Example 2 : One of the angles of a triangle has measure of 80° and the other two angles are equal. Find the measure of the two angles.

Solution : In ΔABC, using angle sum property of the triangle,



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

$$\Rightarrow \quad 80° + x + x = 180°$$

$$\Rightarrow \quad 2x = 100°$$

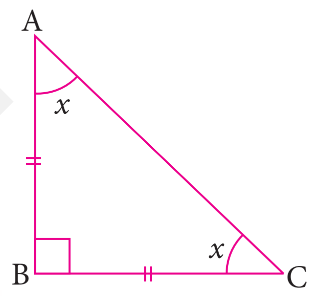
$$\Rightarrow \quad x = 50°$$

Hence, two angles are 50° and 50°.

Example 3 : Find all the three angles of a right - angled isosceles triangle.

Solution : Let ABC be an isosceles triangle such that

$\angle B = 90°$ and $\angle A = \angle C = x$.



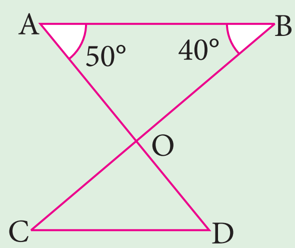
By the angle sum property of a triangle, we have

$$x + x + 90° = 180°$$

or $$2x = 180° - 90° = 90° \text{ or } x = \frac{90°}{2} = 45°$$

Therefore, $\angle A = 45°, \angle B = 90°, \angle C = 45°$.

Exercise 8.1



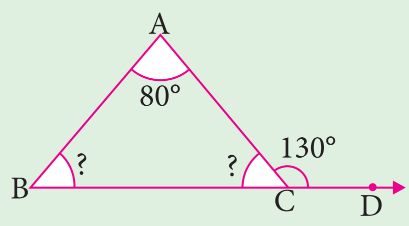
1. In the adjoining figure, if AB || CD, $\angle A = 50°$ and $\angle B = 40°$, find the measures of the remaining four angles.

   Give reasons for your answers.

2. Line Segment AB and CD intersect at O such that AC || DB.

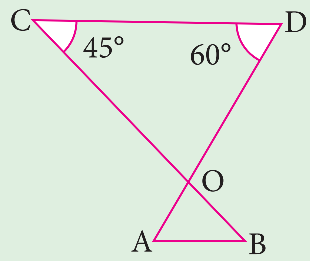
   If $\angle CAB = 35°$ and $\angle CDB = 55°$, then find the value of $\angle BOD$.

   (*i*) 110° (*ii*) 70° (*iii*) 90° (*iv*) 80°

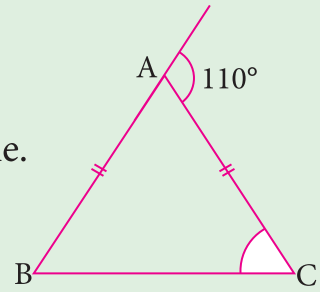


3. In the adjoining figure, measures of angles $\angle BAC$ and $\angle ACD$ are indicated. Calculate the measures▹ of the remaining angles. Is Δ ABC isosceles ? Give reason.

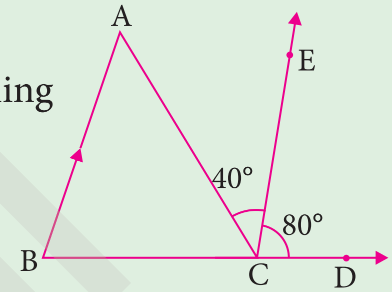
4. In the figure, AB || CD and AD, BC are the transversals. What is the measure of ∠AOB ?



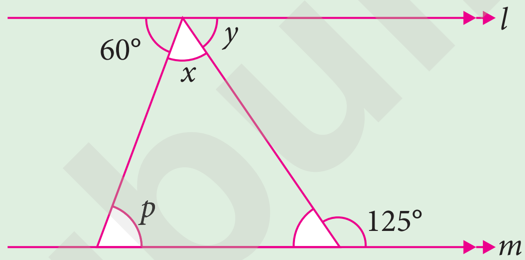
5. In the given triangle ABC, AB = AC. Find all the three angles of the triangle.



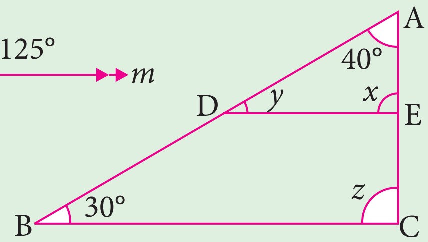
6. Find each of the angles of the triangle ABC in the adjoining figure, where BA || CE.



7. If l || m, find the values of the unknown angles in the figure given at right.



8. In the following figure, D and E are point on sides AB and AC of ΔABC respectively such that DE || BC. If ∠B = 30° and ∠A = 40° find x, y and z.



Project

Experiential Learning

Complete the given tables :

Table 1 : There are three types of triangle on the basis of sides.

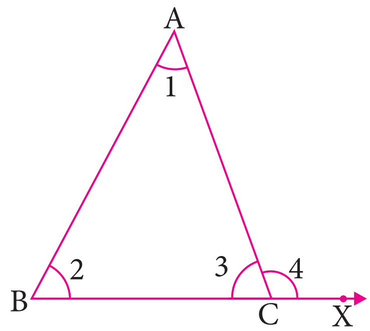
S.No.	Side 1	Side 2	Side 3	Types of the triangle
(*i*)	12 cm	12 cm	12 cm	____________ triangle
(*ii*)	18 cm	24 cm	18 cm	____________ triangle
(*iii*)	13 cm	15 cm	10 cm	____________ triangle

Table 2 : There are three types of triangle on the basis of angles.

S.No.	Angle 1	Angle 2	Angle 3	Types of the triangle
(*i*)	90°	40°	50°	____________ triangle
(*ii*)	50°	70°	60°	____________ triangle
(*iii*)	130°	30°	20°	____________ triangle

Exterior Angle Property of Triangle

If a side of a triangle is produced, the exterior angle so formed is equal to the sum of two interior opposite angles.



Proof : Let ABC be a triangle such that its side BC is produced to form ray BX. Then, $\angle ACX$ (= $\angle 4$) is the exterior angle of ΔABC at C and $\angle 1$ and $\angle 2$ are its two interior opposite angles.

We have to prove that,

$$\angle 4 = \angle 1 + \angle 2.$$

We know that the sum of the angles of a triangle is 180°.

Therefore, $\angle 1 + \angle 2 + \angle 3 = 180°$ ...(*i*)

Also, $\angle 3 + \angle 4 = 180°$ [$\because \angle 3$ and $\angle 4$ form a linear pair] ...(*ii*)

From (*i*) and (*ii*), we get

$$\angle 1 + \angle 2 + \angle 3 = \angle 3 + \angle 4$$

i.e., $\angle 1 + \angle 2 = \angle 4$

Hence, $\angle 4 = \angle 1 + \angle 2$ **Hence Proved.**

Take a Task

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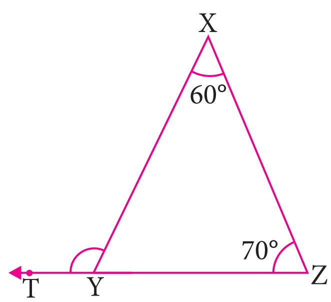
An Important Result

In the above figure, we have $\angle ACX = \angle A + \angle B$

i.e., $\angle ACX > \angle A$ or $\angle ACX > \angle B$.

Thus, in a triangle an exterior angle is greater than either of the interior opposite angles.

Example 4 : In the figure, two of the angles have measures 60° and 70°. Find the measure of $\angle XYT$.



Solution : In ΔXYZ, $\angle XYT$ is an exterior angle at Y.

So, $\angle XYT = \angle YXZ + \angle XZY$

$= 60° + 70° = 130°$

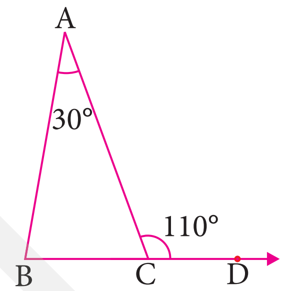
Thus, $\angle XYT = 130°$.

Example 5 : An exterior angle of a triangle is 110° and one of the interior opposite angles is 30°. Find the other two angles of the triangle.

Solution : Let ABC be a triangle whose side BC is produced to form an exterior angle ACD such that $\angle ACD = 110°$.

Also, $\angle A = 30°$.

By exterior angle theorem, we have



$$\angle ACD = \angle B + \angle A$$

i.e., $110° = \angle B + 30°$

or $\angle B = 110° - 30° = 80°$

Now, $\angle A + \angle B + \angle C = 180°$

i.e., $30° + 80° + \angle C = 180°$

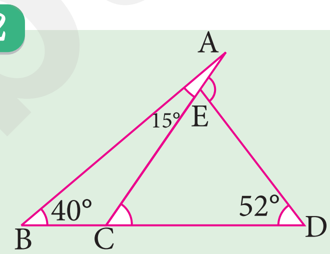
or $\angle C = 180° - (80° + 30°) = 70°$

Hence, the other two angles of the triangle are 80° and 70°.

Exercise 8.2

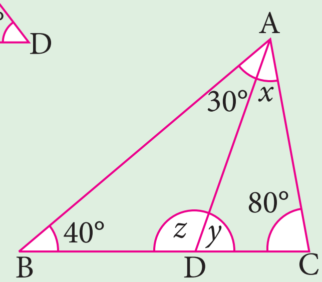
1. In the figure given at right, find :

(*i*) $\angle ACD$ (*ii*) $\angle AED$

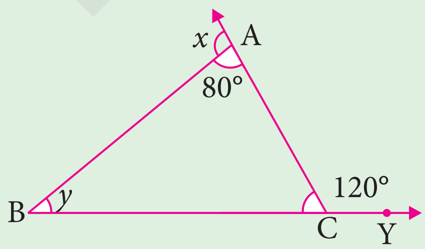


2. In the figure given below, find :

(*i*) x (*ii*) y (*iii*) z



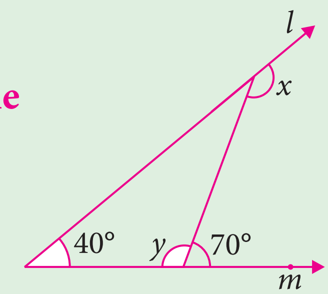
3. In the following figure, find the values of x and y.



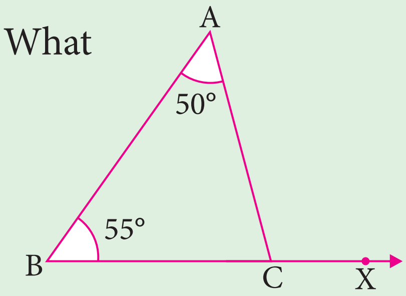
4. In the adjoining figure, the measures of some of the angles are indicated. Find x and y.

(*i*) 150°, 40° (*ii*) 110°, 70°

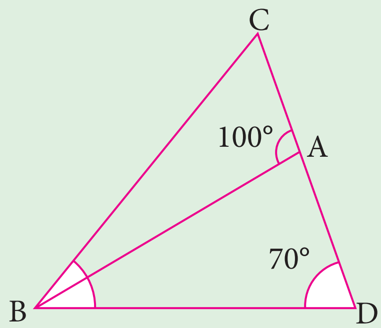
(*iii*) 70°, 110° (*iv*) 150°, 110°



5. In the figure given at right, two of the angles are indicated. What are the measures of ∠ACX and ∠ACB ?



6. In the figure given below, find ∠ABD. Also, find ∠ABC, if ∠C = 3 ∠ABC.



7. In a triangle, an exterior angle at a vertex is 95° and its one of the interior opposite angles is 55°. Find all the angles of the triangle.

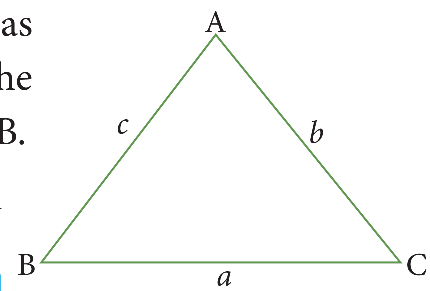
8. One of the exterior angles of a triangle is 80° and the interior opposite angles are in the ratio 5 :3. Find the angles of the triangle.

Take a Task

Watch Remedial

Triangle Inequality Property

Consider a triangle ABC as shown in the following figure. It has three sides BC, CA and AB. Let us denote the sides opposite to the vertices A, B, C by a, b, c respectively, i.e., a = BC, b = CA and c = AB.



The sides of a triangle satisfy an important property as stated in the following :

Triangle Inequality Property : The sum of any two sides of a triangle is greater than the third side.

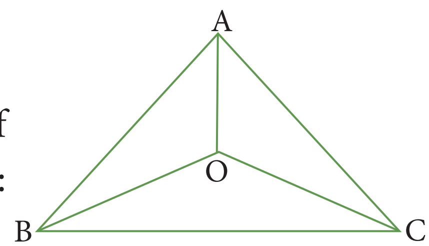
Note

In a triangle, the angle opposite to the Largest side is the largest.

According to this property , in a triangle ABC, we have

$b + c > a$; $c + a > b$ and $a + b > c$

Example 6 : O is a point in the interior of ΔABC. State which of the following statements is/are 'True' or 'False': Give reasons in support of your answer.



(*i*) OA + OB > AB (*ii*) OB + OC < BC

(*iii*) OA + OC = AC

Solution : (*i*) Since OA, OB and AB are the sides of ΔOAB

$\therefore$ $OA + OB > AB$ [Triangle Inequality Property]

$\therefore$ The given statement $(OA + OB > AB)$ is **True**.

(*ii*) Since OB, OC and BC are the sides of ΔOBC

$\therefore$ $OB + OC > BC$ [Triangle Inequality Property]

$\therefore$ The given statement $(OB + OC < BC)$ is **False**.

(*iii*) Since OA, OC and AC are the sides of ΔOAC

$\therefore$ $OA + OC > AC$ [Triangle Inequality Property]

$\therefore$ The given statement $(OA + OC = AC)$ is **False**.

Example 7 : Which of the following can be the possible lengths (in cm) of a triangle ?

(*i*) 3, 5, 3 (*ii*) 4, 3, 8

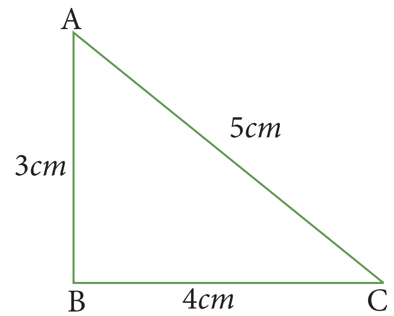
Solution : (*i*) Since $3 + 5 > 3$, $5 + 3 > 3$ and $3 + 3 > 5$, therefore (3, 5, 3) can be the possible lengths (in cm) of the sides of a triangle.

(*ii*) Since $4 + 3 < 8$, therefore (4, 3, 8) cannot be the length (in cm) of the sides of a triangle.

Example 8 : Two sides of a triangle measure 7 *cm* and 9 *cm*. Find the possible length of the third side.

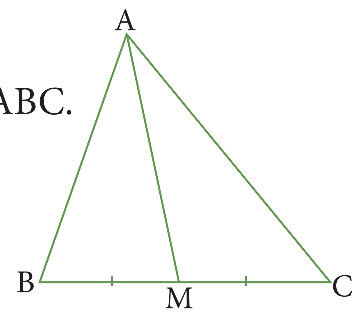
Solution : Since, the sum of any two sides of a triangle is greater than the third side, the length of third side should be less than 16 *cm*.

Example 9 : In the following figure, in Δ ABC, AB = 3 *cm*, BC = 4 *cm* and AC = 5 *cm*. Name the smallest and the largest angles of the triangle.



Solution : As the largest angle is always opposite to the longest side, **$\angle$ B is the largest angle**. Similarly, since the smallest angle is opposite to the shortest side, **$\angle$C is the smallest angle**.

Example 10 : In the given figure, AM is a median of Δ ABC. Prove that $AB + BC + CA > 2\ AM$.



Solution : In ΔAMC, we get

$$CA + MC > AM \quad ...(i)$$

In Δ ABM, we get

$$AB + MB > AM \quad ...(ii)$$

Adding (*i*) and (*ii*), we get

$$AB + (MC + MB) + CA > 2\,AM$$

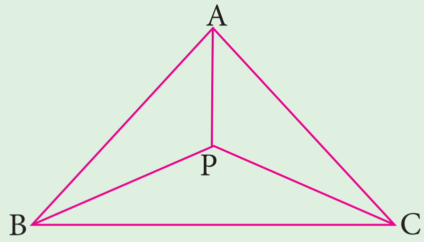
i.e., $$AB + BC + CA > 2\,AM$$ **Hence Proved.**

Exercise 8.3

1. Which of the following can be the possible lengths (in *cm*) of a triangle ?

(*i*) 4.8, 4.8, 4.8 (*ii*) 21, 22, 43 (*iii*) 5, 7, 9 (*iv*) 2, 10, 15

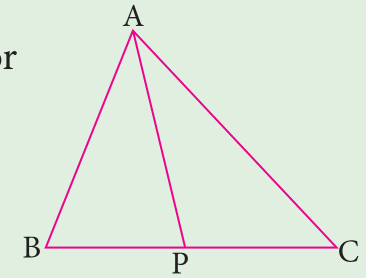
2. P is a point in the interior of ΔABC as shown in the following figure. State whether the following statements is/are true (T) or false (F):



(*i*) $AP + PB < AB$ (*ii*) $AP + PC > AC$

(*iii*) $BP + PC = BC$

3. In the given figure, P is the point on the side BC of ΔABC.



Complete each of the following statements using symbol '=', '<' or '>' so as to make it true :

(*i*) AP ______________ AB + BP

(*ii*) AP ____________ AC + PC

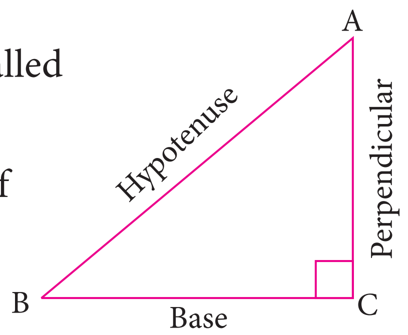
(*iii*) AP __________________ $\frac{1}{2}$ (AB + AC + BC)

4. O is a point in the exterior of ΔABC. What symbol '>', '<' or '=' will you use to complete the statement OA + OB ____________ AB ?

Write two other similar statements and show that:

$$OA + OB + OC > \frac{1}{2}(AB + BC + CA)$$

Pythagoras Theorem



A right triangle has a right angle. An important theorem called **Pythagoras Theorem** relating to a right triangle is stated as follows:

In a right triangle, the square of the hypotenuse equals the sum of the squares of its remaining two sides.

In a right triangle ABC right-angled at C i.e., AB is the hypotenuse and AC and BC are the other two sides of the triangle, we have

$$(AB)^2 = (BC)^2 + (CA)^2$$

i.e., $(\text{Hypotenuse})^2 = (\text{Base})^2 + (\text{Perpendicular})^2$

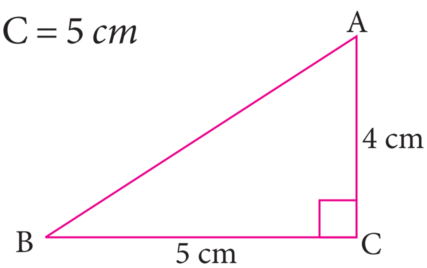
i.e., $c^2 = a^2 + b^2$, where $a = BC$, $b = CA$ and $c = AB$

> **Note**
> Hypotenuse is the side which is opposite to the right angle.

Verification of Pythagoras Theorem

In order to verify the Pythagoras theorem, we perform the following experiment :

Experiment



1. Draw a right triangle ABC, right-angled at C with sides BC = 5 *cm* and AC = 4 *cm*.
2. Measure AB.
3. Repeat the experiment by taking other right triangles ABC being right-angled at C with different measures.
4. Measure the sides a (=BC), b (=AC) and c (=AB) in each case.
5. Compute a^2, b^2 and c^2 and tabulate the result as follows :

Δ ABC	a	b	c	a^2	b^2	c^2	Is $c^2 = a^2 + b^2$?
I							
II							
III							

What do you observe ?

For each triangle, it is observed that, $c^2 = a^2 + b^2$

Thus, we conclude that :

Take a Task

Watch Remedial

In a right triangle ABC, right-angled at C, $c^2 = a^2 + b^2$.

Similarly: In ΔABC, if $\angle B = 90°$, then $b^2 = a^2 + c^2$.

In Δ ABC, if $\angle A = 90°$, then $a^2 = b^2 + c^2$.

Hence in a right-triangle, the square of the hypotenuse equals the sum of the squares of its other two sides.

Hence, the Pythagoras Theorem is **verified**.

Pythagorean Triplets

By definition, three positive integers a, b and c are called Pythagorean triplets, if $c^2 = a^2 + b^2$.

Once we get the Pythagorean triplets (a, b, c), we may divide or multiply all the three numbers by the same constant to get new triplets.

For example : $a = 2.5, b = 6, c = 6.5$ form the Pythagorean triplets.

Now multiplying them by any number, say by 2, we get

$$a = 2.5 \times 2 = 5 \rightarrow (5)^2 = 25 \qquad b = 6 \times 2 = 12 \rightarrow (12)^2 = 144$$

$$c = 6.5 \times 2 = 13 \rightarrow (13)^2 = 169$$

i.e., $169 = 25 + 144$

$\therefore$ 25, 144, 169 are the new Pythagoras triplets formed from the triplets 2.5, 6, 6.5.

Example 11 : The hypotenuse of a right triangle is 13*cm* long. If one of the remaining two sides is of 5 *cm* length, the length of the other side is:

(*i*) 18 *cm* (*ii*) 24 *cm* (*iii*) 12 *cm* (*iv*) 6 *cm*

Solution : Let ABC be a right triangle, right-angled at C.

Then, AB = 13 cm and BC = 5 cm.

Now, by Pythagoras theorem, we have

$$AB^2 = BC^2 + AC^2 \quad i.e., (13)^2 = 5^2 + AC^2$$

or $169 = 25 + AC^2$ or $AC^2 = 169 - 25 = 144$

or $AC \times AC = 12 \times 12$ or $AC = 12\ cm$

Hence, the length of the required side of the right triangle is 12 *cm*.

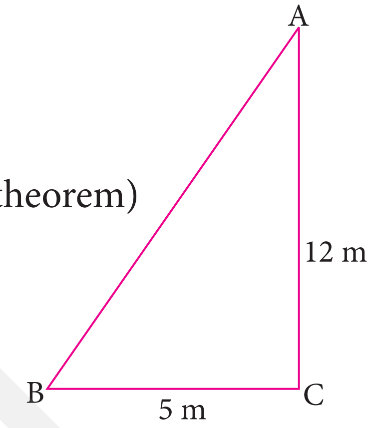
So, the option (*iii*) is correct.

Example 12 : A ladder is placed in such a way that its foot is at a distance of 5 *m* from a wall and its top reaches a window 12 *m* above the ground. Determine the length of the ladder.

Solution : Let AB be the ladder and B be the window .

Then, BC= 5 *m* and AC = 12 *m*.

Since ABC is a right triangle, right-angled at C



$\therefore \quad AB^2 = AC^2 + BC^2$ (Pythagoras theorem)

i.e., $\quad AB^2 = 5^2 + (12)^2 = 25 + 144 = 169$

or $\quad AB \times AB = 13 \times 13$ or $AB = 13\ m$

Hence, the length of the ladder is 13 *m*

Exercise 8.4

1. The hypotenuse of a right triangle is 25 *cm* and its perpendicular distance is 7 *cm*, find the length of its base.
2. Perimeter of a rectangle is 34 *cm*. If its breadth is of 5 *cm*, find the length of each diagonal of it.
3. The sides of two triangles are given below. Determine which of them is the right triangle:

   (*i*) $a = 6\ cm, b = 8\ cm, c = 10\ cm$ (*ii*) $a = 5\ cm, b = 8\ cm, c = 11\ cm$
4. ABC is an isosceles right triangle, right- angled at C.

   Prove that : $AB^2 = 2AC^2$
5. A ladder of 15 m long reaches a window which is 9 m above the ground on one side of a street. Keeping its foot at the same point, the ladder is turned to other side of the street to reach a window of 12 m high. Find the width of the street.
6. A man goes 10 m due east and then 24 m due north. Find the distance from the starting point.
7. A tree broke at a point but did not separate. Its top touched the ground at a distance of 6 m from its base. If the point where it broke be at a height 2.5 m from the ground, what was the total height of the tree before it broke ?

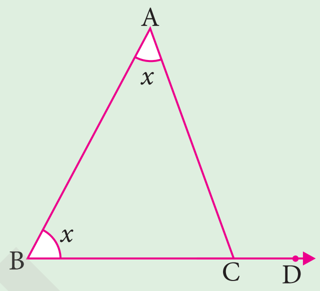
Chapter-end Exercise

Gap Analyzer™

A. Multiple Choice Questions (MCQs)

Tick (✓) the correct option.

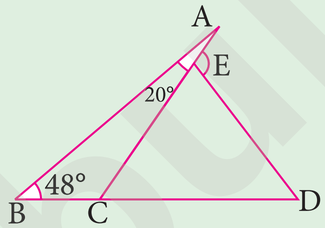
1. In the given figure, if ∠ACD is $\frac{5}{6}$ of a straight angle, the value of x is:



(*a*) 60° ☐ (*b*) 70° ☐

(*c*) 75° ☐ (*d*) 60° ☐

2. In the given figure, if ∠CDE = ∠DEC, then ∠AED = ?



(*a*) 124° ☐

(*b*) 112° ☐

(*c*) 68° ☐

(*d*) 120° ☐

3. A person goes 12 *m* due east and then 5 *m* due north. The distance from the starting point is:

(*a*) 17 *m* ☐ (*b*) 5 *m* ☐ (*c*) 14 *m* ☐ (*d*) 13 *m*

4. If x, y and z are base, perpendicular and hypotenuse of a right triangle respectively, then according to the Pythagoras Theorem, we get:

(*a*) $x^2 = y^2 + z^2$ ☐ (*b*) $y^2 = z^2 + x^2$ ☐ (*c*) $z^2 = x^2 + y^2$ ☐ (*d*) All of these ☐

B. True / False:

Knowledge Application

1. In a right-angled triangle, only one angle is acute. ☐
2. An isosceles triangle can be an obtuse- angled triangle also. ☐
3. A triangle can be formed whose angles are 120°, 30°, 30°. ☐
4. Sum of two sides of a triangle is greater than or equal to the third side. ☐
5. If two angles of a triangle are 65° and 45°, then third angle is 20°. ☐

C. Match the Columns:

	Column A		Column B
(*a*)	The number of altitudes in a triangle is ________ .	(*i*)	equal
(*b*)	In an isosceles triangle, the angle opposite to equal sides are _______ .	(*ii*)	3
(*c*)	The number of elements of a triangle are ______.	(*iii*)	greater
(*d*)	The sum of the two sides of a triangle is _________ than the third side.	(*iv*)	6

D. Answer the following questions :

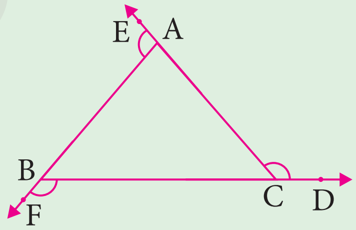
1. Which of the following can be the sides of a triangle ?

   (*i*) 2 *cm*, 3 *cm*, 5 *cm* (*ii*) 4 *cm*, 3 *cm*, 5 *cm*

   (*iii*) 6 *cm*, 8 *cm*, 7*cm* (*iv*) 45 *mm*, 50 *mm*, 135 *mm*

2. In the following figure, the sides BC, CA and AB of ΔABC are produced in the order forming exterior angles ∠ACD, ∠BAE and ∠CBF.

   Show that ∠ACD + ∠BAE + ∠CBF = 360°.



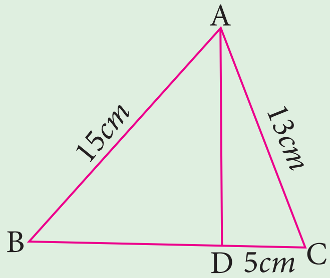
3. In ΔABC, ∠A = 50° and BC is produced to a point D. The bisectors of ∠ABC and ∠ACD meet at E and AB || CE. Find ∠E.

4. The sides AB and AC of ΔABC are produced to P and Q respectively. The bisectors of exterior angles at B and C of ΔABC meet at O.

   Prove that $\angle BOC = 90° - \frac{1}{2}\angle A$.

5. Two poles of height 15 *m* and 30 *m* stand upright on a playground. If their feet are 36 *m* apart, find the distance between their top.

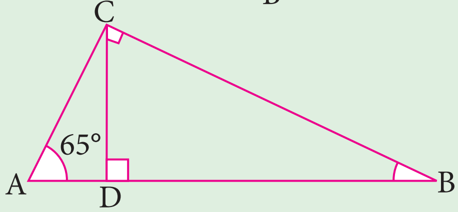
6. In the figure, AD ⊥ BC, AB = 15 *cm*, CD = 5 *cm* and AC = 13 *cm*. Calculate the lengths of sides AD and BC.



7. In the following figure, ABC is a right triangle, right- angled at C, and CD ⊥AB. Also ∠A = 65°.

   Find : (*i*) ∠ACD (*ii*) ∠BCD

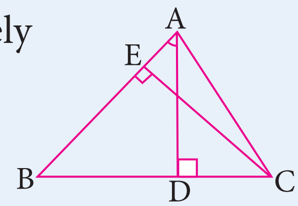
   (*iii*) ∠CBD



Mental Maths

Critical Thinking

1. If the angles of a triangle are in the ratio 2 : 3 : 4, determine the three angles.
2. In the following Fig, $AC \perp CE$ and $\angle A : \angle B : \angle C = 3 : 2 : 1$.
   Find the value of $\angle ECD$.
3. In the following figure, AD and CE are respectively perpendiculars to sides BC and AB of ΔABC.
   If $\angle ECD = 50°$, find $\angle BAD$.



HOTS (Higher Order Thinking Skills)

Critical Thinking

1. One angle of a triangle is the sum of its two other angles. If one of these two angles is half of the third angle, find all the angles of the triangle.
2. A 5 m long ladder reaches a window of height 4 m on one side of the road. The ladder is then turned over to the opposite side of the road and is found to reach another window of height 3 m . Find the width of the road.

Assertion and Reason

Experiential Learning

In each of the following questions, an Assertion (A) and a corresponding Reason (R) supporting it is given.
Study both the statements and state which of the following is correct:
(*a*) Both A and R are true and R is the correct explanation of A.
(*b*) Both A and R are true but R is not the correct explanation of A.
(*c*) A is true but R is false.
(*d*) A is false but R is true.

1. **Assertion (A) :** An obtuse-angled triangle has one obtuse angle.
   Reason (R) : An acute-angled triangle has all three acute angles.
2. **Assertion (A) :** A triangle cannot have more than one right angle.
   Reason (R) : The sum of the measures of the three angles of a triangle is equal to 360°.
3. **Assertion (A) :** In a triangle an exterior angle is smaller than either of the interior opposite angles.
   Reason (R) : An exterior angle and the interior adjacent angle form a linear pair of angles.
4. **Assertion (A) :** Attitude of a triangle bisects the side.
   Reason (R) : All angles of an equilateral triangle are acute.
5. **Assertion (A) :** A right-angled triangle can be an isosceles triangle also.
   Reason (R) : A triangle can be formed whose angles are 120°, 30° and 30°.