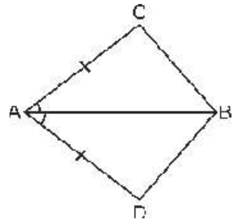
7 TRIANGLES

EXERCISE 7.1

Q.1. *In quadrilateral ACBD, AC = AD and AB bisects ∠A (see Fig.). Show that ΔABC ≅ ΔABD. What can you say about BC and BD?*



Sol. In ΔABC and ΔABD, we have

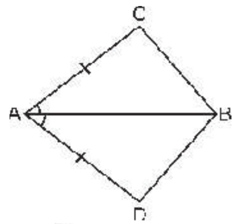
AC = AD [Given]

∠CAB = ∠DAB [∵ AB bisects ∠A]

AB = AB [Common]

∴ ΔABC ≅ ΔABD. [By SAS congruence] **Proved.**

Therefore, BC = BD. (CPCT). **Ans.**

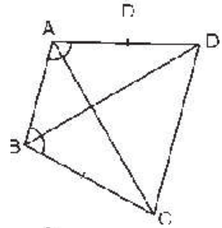


Q.2. *ABCD is a quadrilateral in which AD = BC and ∠DAB = ∠CBA (see Fig.). Prove that*

(i) ΔABD ≅ ΔBAC

(ii) BD = AC

(iii) ∠ABD = ∠BAC



Sol. In the given figure, ABCD is a quadrilateral in which AD = BC and ∠DAB = ∠CBA.

In ΔABD and ΔBAC, we have

AD = BC [Given]

∠DAB = ∠CBA [Given]

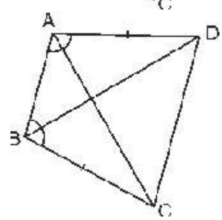
AB = AB [Common]

∴ ΔABD ≅ ΔBAC [By SAS congruence]

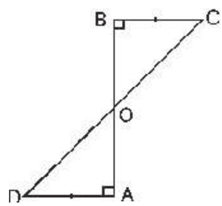
∴ BD = AC [CPCT]

and ∠ABD = ∠BAC [CPCT]

Proved



Q.3. *AD and BC are equal perpendiculars to a line segment AB (see Fig.). Show that CD bisects AB.*



Sol. In ΔAOD and ΔBOC, we have,

∠AOD = ∠BOC [Vertically opposite angles)

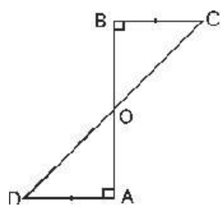
∠CBO = ∠DAO [Each = 90°]

and AD = BC [Given]

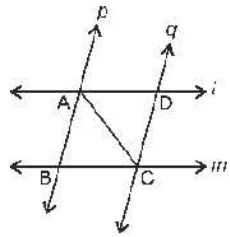
∴ ΔAOD ≅ ΔBOC [By AAS congruence]

Also, AO = BO [CPCT]

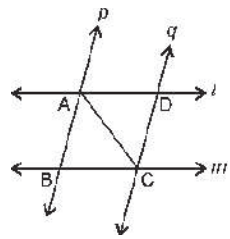
Hence, CD bisects AB **Proved.**



Q.4. *l and m are two parallel lines intersected by another pair of parallel lines p and q (see Fig.). Show that $\Delta ABC \cong \Delta CDA$.*



Sol. In the given figure, ABCD is a parallelogram in which AC is a diagonal, i.e., AB || DC and BC || AD.



In Δ ABC and Δ CDA, we have,

$\angle BAC = \angle DCA$ [Alternate angles]

$\angle BCA = \angle DAC$ [Alternate angles]

$AC = AC$ [Common]

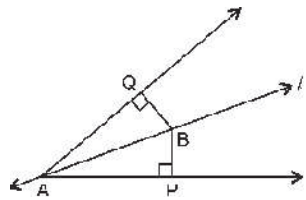
$\therefore$ $\Delta ABC \cong \Delta CDA$ [By ASA congruence]

Proved.

Q.5. *Line l is the bisector of an angle A and B is any point on l. BP and BQ are perpendiculars from B to the arms of $\angle A$ (see Fig.). Show that :*

(i) $\Delta APB \cong \Delta AQB$

(ii) BP = BQ or B is equidistant from the arms of $\angle A$.



Sol. In Δ APB and Δ AQB, we have

$\angle PAB = \angle QAB$ [l is the bisector of $\angle$ A]

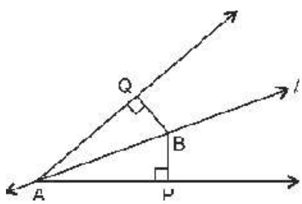
$\angle APB = \angle AQB$ [Each = 90°]

$AB = AB$ [Common]

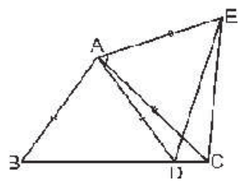
$\therefore$ $\Delta APB \cong \Delta AQB$ [By AAS congruence]

Also, $BP = BQ$ [By CPCT]

i.e., B is equidistant from the arms of $\angle A$. **Proved**



Q.6. *In the figure, AC = AE, AB = AD and $\angle BAD = \angle EAC$. Show that BC = DE.*



Sol. $\angle BAD = \angle EAC$ [Given]

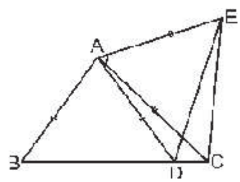
$\Rightarrow$ $\angle BAD + \angle DAC = \angle EAC + \angle DAC$ [Adding $\angle DAC$ to both sides]

$\Rightarrow$ $\angle BAC = \angle EAC$ ... (i)

Now, in ΔABC and ΔADE, we have

$AB = AD$ [Given]

$AC = AE$ [Given)

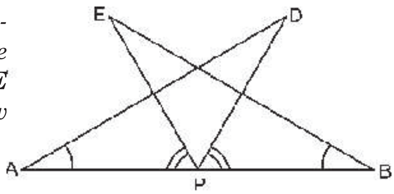


$\Rightarrow$ $\angle BAC = \angle DAE$ [From (i)]

$\therefore$ $\Delta ABC \cong \Delta ADE$ [By SAS congruence]

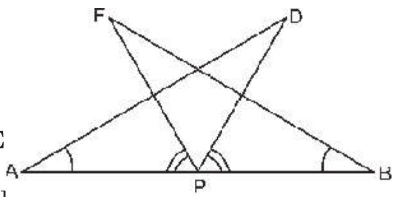
$\Rightarrow$ $BC = DE.$ [CPCT] **Proved.**

Q.7. *AB is a line segment and P is its mid-point. D and E are points on the same side of AB such that $\angle BAD = \angle ABE$ and $\angle EPA = \angle DPB$ (see Fig.). Show that*



(i) $\Delta DAP \cong \Delta EBP$ (ii) $AD = BE$

Sol. In ΔDAP and ΔEBP, we have



AP = BP [Q P is the mid-point of line segment AB]

$\angle$BAD = $\angle$ABE [Given]

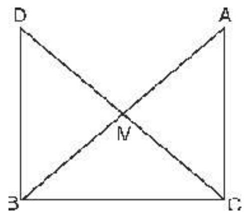
$\angle$EPB = $\angle$DPA

[Q $\angle$EPA = $\angle$DPB $\Rightarrow$ $\angle$EPA + $\angle$DPE = $\angle$DPB + $\angle$DPE]

$\therefore$ Δ DPA $\cong$ Δ EPB [ASA]

$\Rightarrow$ AD = BE [By CPCT] **Proved.**

Q.8. *In right triangle ABC, right angled at C, M is the mid-point of hypotenuse AB. C is joined to M and produced to a point D such that DM = CM. Point D is joined to point B (see Fig.). Show that :*



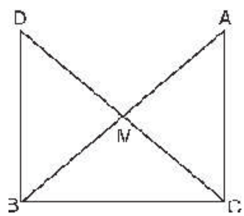
(i) $\Delta AMC \cong \Delta BMD$

(ii) $\angle DBC$ is a right angle.

(iii) $\Delta DBC \cong \Delta ACB$

(iv) $CM = \frac{1}{2} AB$

Sol. In ΔBMB and ΔDMC, we have



(i) DM = CM [Given]

BM = AM

[Q M is the mid-point of AB]

$\angle$DMB = $\angle$AMC

[Vertically opposite angles]

$\therefore$ ΔAMC $\cong$ ΔBMD [By SAS]

Proved.

(ii) AC || BD [Q $\angle$DBM and $\angle$CAM are alternate angles]

$\Rightarrow$ $\angle$DBC + $\angle$ACB = 180° [Sum of co-interior angles]

[Q $\angle$ACB = 90°] **Proved.**

$\Rightarrow$ $\angle$DBC = 90° **Proved.**

(iii) In ΔDBC and ΔACB, we have

DB = AC [CPCT]

BC = BC [Common]

$\angle$DBC = $\angle$ACB [Each = 90°]

$\therefore$ ΔDBC $\cong$ ΔACB [By SAS] **Proved.**

(iv) $\therefore$ AB = CD [CPCT]

$\Rightarrow$ $\frac{1}{2}$ AB = $\frac{1}{2}$ CD

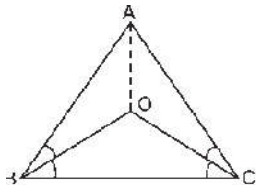
Hence, $\frac{1}{2}$ AB = CM [Q CM = $\frac{1}{2}$ CD] **Proved.**

EXERCISE 7.2

Q.1. *In an isosceles triangle ABC, with AB = AC, the bisectors of $\angle B$ and $\angle C$ intersect each other at O. Join A to O. Show that :*

(i) OB = OC (ii) AO bisects $\angle A$.

Sol. (i) $AB = AC \Rightarrow \angle ABC = \angle ACB$ [Angles opposite to equal sides are equal]



$\frac{1}{2}\angle ABC = \frac{1}{2}\angle ACB$

$\Rightarrow \angle CBO = \angle BCO$

[Q OB and OC are bisectors of $\angle B$ and $\angle C$ respectively]

$\Rightarrow$ OB = OC [Sides opposite to equal angles are equal]

Again, $\angle\frac{1}{2}ABC = \frac{1}{2}\angle ACB$

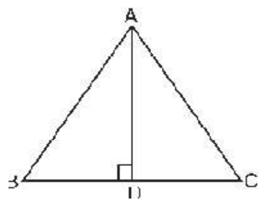
$\Rightarrow \angle ABO = \angle ACO$ [$\therefore$ OB and OC are bisectors of $\angle B$ and $\angle C$ respectively]

In ΔABO and ΔACO, we have

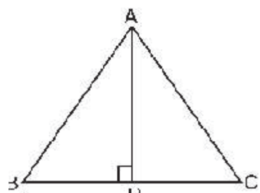
$AB = AC$	[Given]
$OB = OC$	[Proved above]
$\angle ABO = \angle ACO$	[Proved above]
$\therefore \Delta ABO \cong \Delta ACO$	[SAS congruence]
$\Rightarrow \Delta ABO = \angle CAO$	[CPCT]

$\Rightarrow$ AO bisects $\angle A$ **Proved.**

Q.2. *In ΔABC, AD is the perpendicular bisector of BC (see Fig.). Show that ΔABC is an isosceles triangle in which AB = AC.*



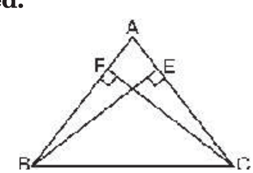
Sol. In ΔABD and ΔACD, we have



$\angle ADB = \angle ADC$	[Each = 90°]
$BD = CD$	[Q AD bisects BC]
$AD = AD$	[Common]
$\therefore \Delta ABD \cong \Delta ACD$	[SAS]
$\therefore AB = AC$	[CPCT]

Hence, ΔABC is an isosceles triangle. **Proved.**

Q.3. *ABC is an isosceles triangle in which altitudes BE and CF are drawn to equal sides AC and AB respectively (see Fig.). Show that these altitudes are equal.*



Sol. In ΔABC,

AB = AC [Given]

$\Rightarrow \angle B = \angle C$ [Angles opposite to equal sides of a triangle are equal]

Now, in right triangles BFC and CEB,

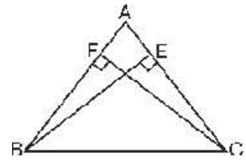
$\angle BFC = \angle CEB$ [Each = 90°]

$\angle FBC = \angle ECB$ [Pproved above]

$BC = BC$ [Common]

$\therefore \quad \Delta BFC \cong \Delta CEB$ [AAS]

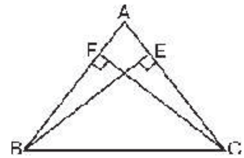
Hence, $BE = CF$ [CPCT] **Proved.**



Q.4. *ABC is a triangle in which altitudes BE and CF to sides AC and AB are equal (see Fig.). Show that*

(i) $\Delta ABE \cong \Delta ACF$

(ii) $AB = AC$, i.e., ABC is an isosceles triangle.



Sol. (i) In ΔABE and ACF, we have

$BE = CF$ [Given]

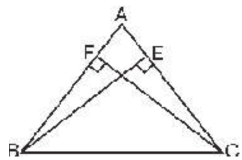
$\angle BAE = \angle CAF$ [Common]

$\angle BEA = \angle CFA$ [Each = 90°]

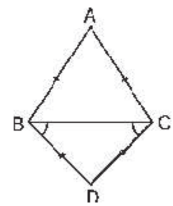
So, $\Delta ABE \cong \angle ACF$ [AAS] **Proved.**

(ii) Also, $AB = AC$ [CPCT]

i.e., ABC is an isosceles triangle **Proved.**



Q.5. *ABC and DBC are two isosceles triangles on the same base BC (see Fig.). Show that $\angle ABD = \angle ACD$.*



Sol. In isosceles ΔABC, we have

$AB = AC$

$\angle ABC = \angle ACB$ ...(i)

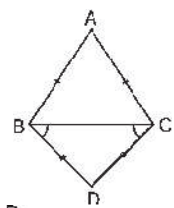
[Angles opposite to equal sides are equal]

Now, in isosceles ΔDCB, we have

$BD = CD$

$\angle DBC = \angle DCB$ ...(ii)

[Angles opposite to equal sides are equal]

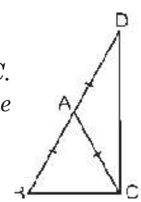


Adding (i) and (ii), we have

$\angle ABC + \angle DBC = \angle ACB + \angle DCB$

$\Rightarrow \quad \angle ABD = \angle ACD$ **Proved.**

Q.6. *ΔABC is an isosceles triangle in which $AB = AC$. Side BA is produced to D such that $AD = AB$ (see Fig.). Show that $\angle BCD$ is a right angle.*



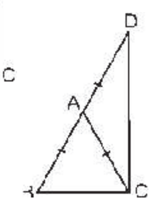
Sol. $AB = AC$ [Given]

$\angle ACB = \angle ABC$ ...(i)

[Angles opposite to equal sides are equal]

$AB = AD$ [Given]

$\therefore \quad AD = AC$ [Q $AB = AC$]



$\therefore \quad \angle ACD = \angle ADC$ ...(ii) [Angles opposite to equal sides are equal]

Adding (i) and (ii)

$\angle ACB + \angle ACD = \angle ABC + \angle ADC$

$\Rightarrow \quad \angle BCD = \angle ABC + \angle ADC$ ...(iii)

Now, in ΔBCD, we have

$\angle BCD + \angle DBC + \angle BDC = 180°$ [Angle sum property of a triangle]

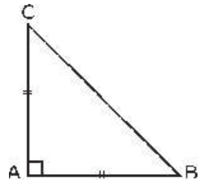
$\therefore \quad \angle BCD + \angle BCD = 180°$

$\Rightarrow \quad 2\angle BCD = 180°$

$\Rightarrow \quad \angle BCD = 90°$

Hence, $\angle BCD = 90°$ or a right angle **Proved.**

Q.7. *ABC is a right angled triangle in which $\angle A = 90°$ and $AB = AC$. Find $\angle B$ and $\angle C$.*



Sol. In ΔABC, we have

$$\left.\begin{aligned}\angle A &= 90° \\ \text{and } AB &= AC\end{aligned}\right\}\text{[Given]}$$

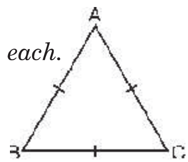
We know that angles opposite to equal sides of an isosceles triangle are equal.

So, $\angle B = \angle C$

Since, $\angle A = 90°$, therefore sum of remaining two angles = 90°.

Hence, $\angle \mathbf{B} = \angle \mathbf{C} = \mathbf{45°}$ **Answer.**

Q.8. *Show that the angles of an equilateral triangle are 60° each.*



Sol. As ΔABC is an equilateral.

So, $AB = BC = AC$

Now, $AB = AC$

$\Rightarrow \angle ACB = \angle ABC \quad \ldots(i)$

[Angles opposite to equal sides of a triangle are equal]

Again, $BC = AC$

$\Rightarrow \angle BAC = \angle ABC \quad \ldots(ii)$ [same reason]

Now, in ΔABC,

$\angle ABC + \angle ACB + \angle BAC = 180°$ [Angle sum property of a triangle]

$\Rightarrow \angle ABC + \angle ABC + \angle ABC = 180°$ [From (i) and (ii)]

$\Rightarrow 3\angle ABC = 180°$

$$\Rightarrow \angle ABC = \frac{180°}{3} = 60°$$

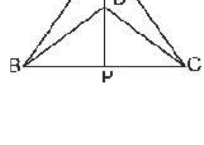
Also, from (i) and (ii)

$\angle ACB = 60°$ and $\angle BAC = 60°$

Hence, each angle of an equilateral triangle is 60° **Proved.**

EXERCISE 7.3

Q.1. *ΔABC and ΔDBC are two isosceles triangles on the same base BC and vertices A and D are on the same side of BC (see Fig.). If AD is extended to intersect BC at P, show that*

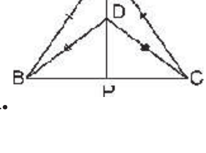


(i) $\Delta ABD \cong \Delta ACD$

(ii) $\Delta ABP \cong \Delta ACP$

(iii) AP bisects $\angle A$ as well as $\angle D$.

(iv) AP is the perpendicular bisector of BC.



Sol. (i) In ΔABD and ΔACD, we have

$AB = AC$ [Given]

$BD = CD$ [Given]

$AD = AD$ [Common]

$\therefore \Delta ABD \cong \Delta ACD$ [SSS congruence] **Proved.**

(ii) In ΔABP and ΔACP, we have

$AB = AC$ [Given]

$\angle BAP = \angle CAP$ [Q $\angle BAD = \angle CAD$, by CPCT]

$AP = AP$ [Common]

$\therefore$ $\Delta ABP \cong \Delta ACP$ [SAS congruence] **Proved.**

(iii) $\Delta ABD \cong \Delta ADC$ [From part (i)]

$\Rightarrow$ $\angle ADB = \angle ADC$ (CPCT)

$\Rightarrow 180° - \angle ADB = 180° - \angle ADC$

$\Rightarrow$ Also, from part (ii), $\angle BAPD = \angle CAP$ [CPCT]

$\therefore$ AP bisects ĐA as well as $\angle D$. **Proved.**

(iv) Now, $BP = CP$

and $\angle BPA = \angle CPA$ [By CPCT]

But $\angle BPA + \angle CPA = 180°$ [Linear pair]

So, $2\angle BPA = 180°$

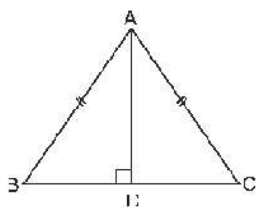
Or, $\angle BPA = 90°$

Since BP = CP, therefore AP is perpendicular bisector of BC.

Proved.

Q.2. *AD is an altitude of an isosceles triangle ABC in which AB = AC. Show that*

(i) AD bisects BC *(ii) AD bisects $\angle A$.*



Sol. (i) In ΔABD and ΔACD, we have

$\angle ADB = \angle ADC$ [Each = 90°]

$AB = AC$ [Given]

$AD = AD$ [Common]

$\therefore$ $\Delta ABD \cong \Delta ACD$ [RHS congruence]

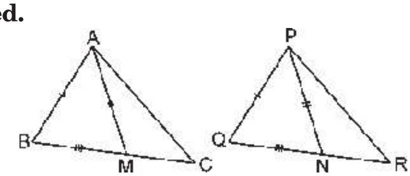
$\therefore$ $BD = CD$ [CPCT]

Hence, AD bisects BC.

(ii) Also, $\angle BAD = \angle CAD$

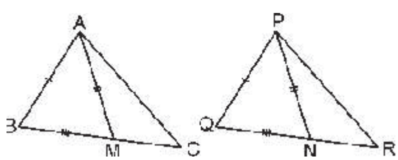
Hence, AD bisects $\angle A$.. **Proved.**

Q.3. *Two sides AB and BC and median AM of one triangle ABC are respectively equal to sides PQ and QR and median PN of ΔPQR (see Fig.). Show that :*



(i) $\Delta ABM \cong \Delta PQN$ (ii) $\Delta ABC \cong \Delta PQR$

Sol. (i) In ΔABM and ΔPQN, we have



$BM = QN$

[Q $BC = QR$

$\Rightarrow \frac{1}{2}BC = \frac{1}{2}QR$]

$AB = PQ$ [Given]

$AM = PN$ [Given]

$\therefore$ $\Delta ABM \cong \Delta PQN$ [SSS congruence] **Proved.**

$\Rightarrow \angle ABM = \angle PQN$ [CPCT]

(ii) Now, in ΔABC and ΔPQR, we have

$AB = PQ$ [Given]

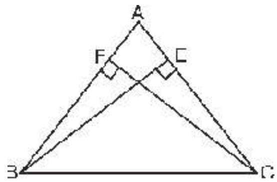
$\angle ABC = \angle PQR$ [Proved above]

$BC = QR$ [Given]

$\therefore$ $\Delta ABC \cong \Delta PQR$ [SAS congruence] **Proved.**

Q.4. *BE and CF are two equal altitudes of a triangle ABC. Using RHS congruence rule, prove that the triangle ABC is isosceles.*

Sol. BE and CF are altitudes of a ΔABC.



$\therefore$ $\angle BEC = \angle CFB = 90°$

Now, in right triangles BEB and CFB, we have

Hyp. BC = Hyp. BC [Common]

Side BE= Side CF [Given]

$\therefore$ $\Delta BEC \cong \Delta CFB$ [By RHS congruence rule]

$\therefore$ $\angle BCE = \angle CBF$ [CPCT]

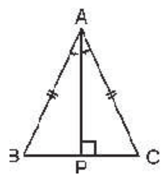
Now, in ΔABC, $\angle B = \angle C$

$\therefore$ $AB = AC$ [Sides opposite to equal angles are equal]

Hence, ΔABC is an isosceles triangle. **Proved.**

Q.5. *ABC is an isosceles triangle with AB = AC. Draw AP $\perp$ BC to show that $\angle B = \angle C$.*

Sol. Draw AP $\perp$ BC.



In ΔABP and ΔACP, we have

$AB = AC$ [Given]

$\angle APB = \angle APC$ [Each = 90°]

$AB = AP$ [Common]

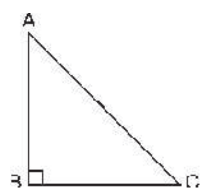
$\therefore$ $\Delta ABP \cong \Delta ACP$ [By RHS congruence rule]

Also, $\angle B = \angle C$ **Proved.** [CPCT]

EXERCISE 7.4

Q.1. *Show that in a right angled triangle, the hypotenuse is the longest side.*

Sol. ABC is a right triangle, right angled at B.



Now, $\angle A + \angle C = 90°$

$\Rightarrow$ Angles A and C are each less than 90°.

Now, $\angle B > \angle A$

$\Rightarrow$ $AC > BC$ ...(i)

[Side opposite to greater angle is longer]

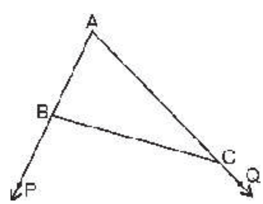
Again, $\angle B > \angle C$

$\Rightarrow$ $AC > AB$ ...(ii)

[Side opposite to greater angle is longer]

Hence, from (i) and (ii), we can say that AC (Hypotenuse) is the longest side. **Proved**

Q.2. *In the figure, sides AB and AC of ΔABC are extended to points P and Q respectively. Also, $\angle PBC < \angle QCB$. Show that AC > AB.*



Sol. $\angle ABC + \angle PBC = 180°$ [Linear pair]

$\Rightarrow$ $\angle ABC = 180° - \angle PBC$ ...(i)

Similarly, $\angle ACB = 180° - \angle QCB$ ...(ii)

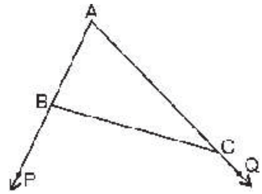
It is given that $\angle PBC < \angle QCB$

$\therefore \quad 180° - \angle QCB < 180° - \angle PBC$

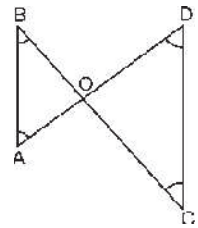
Or $\quad \angle ACB < \angle ABC$ [From (i) and (ii)]

$\Rightarrow \quad AB < AC$

$\Rightarrow \quad AC > AB$ **Proved.**



Q.3. *In the figure, $\angle B < \angle A$ and $\angle C < \angle D$. Show that $AD < BC$.*



Sol. $\angle B < \angle A$ [Given]

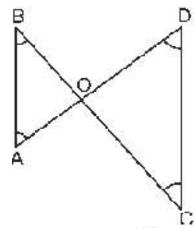
$BO > AO$ ...(i)

[Side opposite to greater angle is longer]

$\angle C < \angle D$ [Given]

$\Rightarrow \quad CO > DO$ ...(ii)

[Same reason]



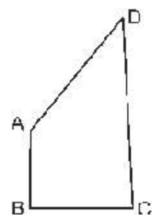
Adding (i) and (ii)

$BO + CO > AO + DO$

$\Rightarrow \quad BC > AD$

$AD < BC$ **Proved.**

Q.4. *AB and CD are respectively the smallest and longest sides of a quadrilateral ABCD (see Fig.). Show that $\angle A > \angle C$ and $\angle B > \angle D$.*



Sol. Join AC.

Mark the angles as shown in the figure.

In ΔABC,

$BC > AB$ [AB is the shortest side]

$\Rightarrow \quad \angle 2 > \angle 4$ ...(i)

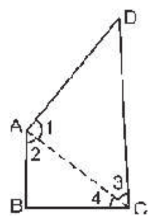
[Angle opposite to longer side is greater]

In ΔADC,

$CD > AD$ [CD is the longest side]

$\angle 1 > \angle 3$ ...(ii)

[Angle opposite to longer side is greater]



Adding (i) and (ii), we have

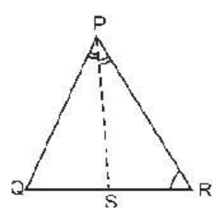
$\angle 2 + \angle 1 > \angle 4 + \angle 3$

$\Rightarrow \quad \angle A > \angle C$ **Proved.**

Similarly, by joining BD, we can prove that

$\angle B > \angle D$.

Q.5. *In the figure, $PR > PQ$ and PS bisects $\angle QPR$. Prove that $\angle PSR > \angle PSQ$.*



Sol. $PR > PQ$

$\angle PQR > \angle PRQ$ ...(i)

[Angle opposite to longer side is greater]

$\angle QPS > \angle RPS$ [$\because$ PS bisects $\angle QPR$] ...(ii)

In ΔPQS, $\angle PQS + \angle QPS + \angle PSQ = 180°$

$\Rightarrow \angle PSQ = 180° - (\angle PQS + \angle QPS)$ ...(iii)

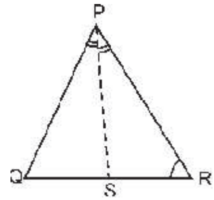
Similarly in ΔPRS, $\Delta PSR = 180° - (\angle PRS + \angle RPS)$

$\Rightarrow \angle PSR = 180° - (\angle PRS + \angle QPS)$ [from (ii) ... (iv)

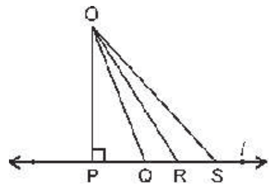
From (i), we know that $\angle PQS < \angle PSR$

So from (iii) and Iiv), $\angle PSQ < \angle PSR$

$\Rightarrow \angle PSR > \angle PSQ$ **Proved**



Q.6. *Show that of all the segments drawn from a given point not on it, the perpendicular line segment is the shortest.*



Sol. We have A line $\overleftrightarrow{l}$ and O is a point not on $\overleftrightarrow{l}$.

$OP \perp \overleftrightarrow{l}$.

We have to prove that $OP < OQ$, $OP < OR$ and $OP < OS$.

In ΔOPQ, $\angle P = 90°$

$\therefore$ $\angle Q$ is an acute angle (i.e., $\angle Q < 90°$]

$\therefore$ $\angle Q < \angle P$

Hence, $OP < OQ$ [Side opposite to greater angle is longer]

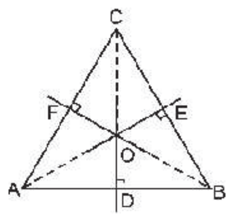
Similarly, we can prove that OP is shorter than OR, OS etc. **Proved.**

EXERCISE 7.5 (OPTIONAL)

Q.1. *ABC is a triangle. Locate a point in the interior of ΔABC which is equidistant from all the vertices of ΔABC.*

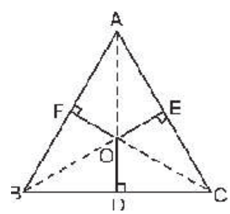
Sol. Draw perpendicular bisectors of sides AB, BC and CA, which meets at O.

Hence, O is the required point.



Q.2. *In a triangle locate a point in its interior which is equidistant from all the sides of the triangle.*

Sol.



Q.3. *In a huge park, people are concentrated at three points (see Fig.).*

A : where there are different slides and swings for children,

B : near which a man-made lake is situated,

C : which is near to a large parking and exit.

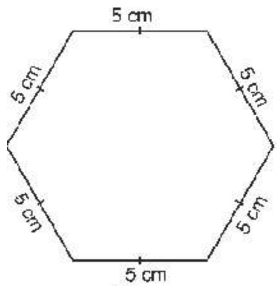
Where should an icecream parlour be set up so that maximum number of persons can approach it?

Draw bisectors ∠A, ∠B and ∠C of ΔABC. Let these angle bisectors meet at O.

O is the required point.

Sol. Join AB, BC and CA to get a triangle ABC. Draw the perpendicular bisector of AB and BC. Let they meet at O. Then O is equidistant from A, B and C. Hence, the icecream pra

Q.4. *Complete the hexagonal and star shaped Rangolies [see Fig. (i) and (ii)] by filling them with as many equilateral triangles of side 1 cm as you can. Count the number of triangles in each case. Which has more triangles?*



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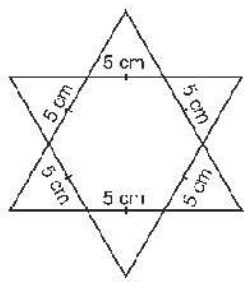
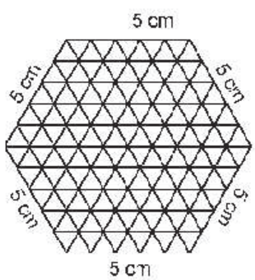
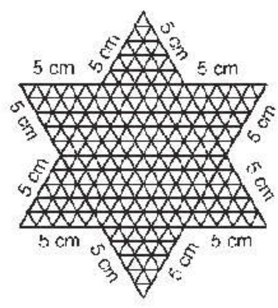


(ii)

Sol.



(i)



(ii)