Class: 9
Subject: Mathematics
Topic: Triangle
No. of Questions: 20

Q1 The angles of a quadrilateral are in the ratio 3 : 5 : 9 : 13. Find all the angles of the quadrilateral.

Sol. Suppose the measures of four angles are 3x, 5x, 9x, and 13x.

$\therefore 3x+5x+9x+13x = 360°$ [Angle sum property of a quadrilateral]

$\Rightarrow 30x = 360°$

$\Rightarrow x = \frac{360°}{30} = 12°$

$\Rightarrow 3x = 3 \times 12° = 36°$

$5x = 5\times12° = 60°$

$9x = 9 \times 12° = 108°$

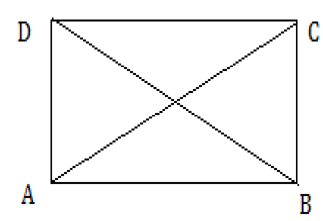
$13x = 13 \times 12° = 156°$

$\therefore$ the angles of the quadrilateral are 36°, 60°, 108° and 156°

Q2. If the diagonal of a parallelogram are equal, then show that it is a rectangle.

Sol. Given: ABCD is a parallelogram in which AC = BD.

To Prove: ABCD is a rectangle.



Proof: In ΔABC and ΔABD

AB = AB [Common]

BC = AD [Opposite sides of a parallelogram]

AC = BD [Given]

$\therefore$ ΔABC ≅ ΔBAD [SSS congruence]

∠ABC = ∠BAD _________(i) [CPCT]

Since, ABCD is a parallelogram, thus,

∠ABC+ ∠BAD = 180° _____(ii) [Consecutive interior angles]

∠ABC + ∠ABC = 180°

$\therefore$ 2∠ABC = 180° [from (i) and (ii)]

$\Rightarrow$ ∠ ABC = ∠BAD = 90°

This shows that ABCD is a parallelogram one of whose angle is 90°.

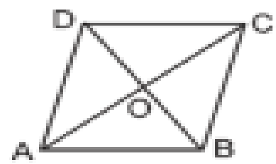
Hence, ABCD is a rectangle

Q3. Show that if the diagonals of a quadrilateral bisect each other at right angles, then it is a rhombus.

Sol. Given: A quadrilateral ABCD, in which diagonals AC and BD bisect each other at right angles

To prove: ABCD is a rhombus.

As shows in the figure



Proof: In ΔAOB and ΔBOC

AO = OC [Diagonals AC and BD bisect each other]

$\angle AOB = \angle COB$ [Each= 90°]

$BO = BO$ [Common]

$\therefore \Delta AOB \cong \Delta BOC$ [SAS Congruence]

$AB = BC$ _____(i) [CPCT]

Since, ABCD is a quadrilateral in which

AB = BC ______[From (i)]

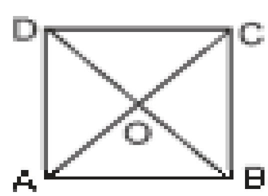
Hence, ABCD is a rhombus. [∵ if the diagonals of a quadrilateral bisect each other, them it is a parallelogram are equal]

Q4. Show that the diagonals of a square are equal and bisect each other at right angles.

Sol. Given: ABCD is a square in which AC and BD are diagonals.

To Prove: AC = BD and AC bisects BD at right angles, i.e., AC ⊥ BD. AO = OC, OB = OD

As shown in the figure



Proof: In Δ ABC and Δ BAD,

AB = AB [Common]

BC = AD [Sides of a square]

$\angle ABC = \angle BAD = 90°$ [Angles of a square]

$\therefore \Delta ABC \cong \Delta BAD$ [SAS congruence]

$\Rightarrow AC = BD$ [CPCT]

Now, in ΔAOB and ΔCOD,

$AB = DC$ [Sides of a square]

$\angle AOB = \angle COD$ [Vertically opposite angle]

$\angle OAB = \angle COD$ [Alternate angles]

$\therefore \Delta AOB \cong \Delta COD$ [AAS congruence]

$\angle AO = \angle OC$ [CPCT]

Similarly by taking Δ AOD and ΔBOC, we can show that OB= OD.

In ΔABC, $\angle BAC + \angle BCA = 90°$ [$\because \angle B = 90°$]

$\Rightarrow 2\angle BAC = 90°$ [$\angle BAC = \angle BCA$ as $BC = AD$]

$\Rightarrow \angle BCA = 45°$ or $\angle BCO = 45°$

Similarly $\angle CBO = 45°$

In ΔBCO.

$\angle BCO + \angle CBO + \angle BOC = 180°$

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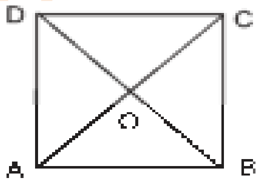
⇒ 90°+∠BOC = 180°
⇒ ∠BOC = 90°
⇒ BO ⊥ OC ⇒ BO ⊥ AC
Hence, AC = BD, AC ⊥BD, AO = OC and OB= OD.

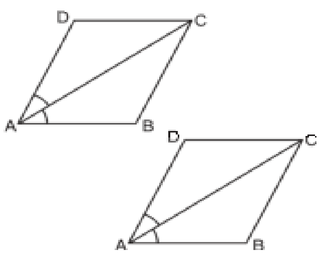
Q5. Show that if the diagonals of a quadrilateral are equal and bisect each other at right angles, then it is a square.

Sol. Given: A quadrilateral ABCD, in which diagonals AC and BD are equal and bisect each other at right angles.
To Prove: ABCD is a square.
As shows in the figure
Proof: Since ABCD is a quadrilateral whose diagonals bisect each other, so it is a parallelogram. Also, its diagonals bisect each other at right angles, therefore, ABCD is a rhombus.
⇒ AB = BC = CD = DA [Sides of a rhombus]
In ΔABC and Δ BAD, we have



AB = AB [Common]
BC = AD [Sides of a rhombus]
AC = BD [Given]
∴ ΔABC ≅ ΔBAD [SSS congruence]
∴ ∠ABC = ∠BAD [CPCT]
But, ∠ABC+∠BAD = 180° [Consecutive interior angles]
∠ABC = ∠BAD = 90 °
∠A = ∠B = ∠C = ∠D= 90° [Opposite angles of a ∥ gm]
⇒ ABCD is a rhombus whose angles are of 90° each.

Q6. Diagonals AC of a parallelogram ABCD bisect ∠A (see Fig.) Show that
(a) It bisects ∠C also.
(b) ABCD is a rhombus.



Sol. Given: A parallelogram ABCD, in which diagonal AC bisects ∠A, i.e., ∠DAC = ∠BAC
To prove: (a) Diagonal AC bisects ∠C i.e., ∠DCA = ∠BCA

(b)ABCD is a rhombus.

Proof: (a) ∠DAC = ∠BCA [Alternative angles]

∠BAC = ∠DCA [Alternative angles]

But, ∠DAC = ∠BAC [Given]

∴ ∠BCA = ∠DCA

Hence, AC bisects ∠DCB

Or, AC bisect ∠C

(b)In ΔABC and ΔCDA

AC = AC [Common]

∠BAC = ∠DAC [Given]

And ∠BCA = ∠DAC [Proved above]

∴ ΔABC ≅ ΔADC [ASA congruence]

∴ BC = DC [CPCT]

But AB = DC [Given]

∴ AB = BC = DC= AD

Hence, ABCD is a rhombus [∵ opposite angles are equal]

Q7. ABCD is a rhombus show that diagonals AC bisect ∠A as well as ∠C and diagonal BD bisect ∠B as well as ∠D

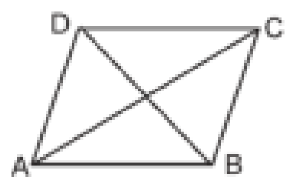
Sol. Given: ABCD is a rhombus, i.e., AB= BC= CD= DA.

To Prove: ∠DAC = ∠BAC,

∠BCA = ∠DCA

∠ADB = ∠CDB, ∠ABD = ∠CBD

As shows in the figure



Proof: In Δ ABC and Δ CDA, we have

AB = AD [Sides of a rhombus]

AC = AC [Common]

BC = CD [Sides of a rhombus]

Δ ABC ≅ Δ ADC [SSS congruence]

So, ∠DAC = ∠BAC

∠BCA = ∠DCA [CPCT]

Similarly, ∠ADB = ∠CDB and ∠ABD = ∠CBD.

Hence, diagonals AC bisect ∠A as well as ∠C and diagonal BD bisects ∠B well as ∠D.

Q8. ABCD is a rectangle in which diagonals AC bisect ∠A as well as ∠C.

Show that: (i) ABCD is a square (ii) diagonals BD bisect ∠B as well as ∠D.

Sol. Given: ABCD is a rectangle in which diagonal AC bisect ∠A as well as ∠C

To Prove: (i) ABCD is a square. (ii)Diagonals BD bisect s ∠B as well as ∠D

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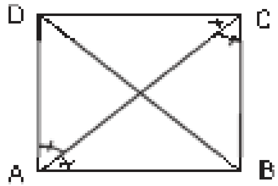
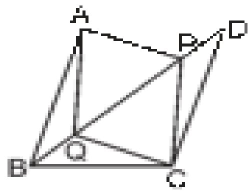
As shows in the figure

Proof: (i) In ΔABC and Δ ADC, we have



∠BAC = ∠DAC [Given]
∠BCA = ∠DCA [Given]
AC = AC [Common]
∴ ΔABC ≅ ΔADC [ASA congruence]
∴ AB = AD and CB = CD [CPCT]
But, in a rectangular opposite sides are equal,
i.e., AB = DC and BC and AD
∴ AB = BC = CD = DA
Hence, ABCD is a square
(ii) In Δ ABD and ΔACB, we have
AD = CD [Sides of square]
AB = CD [Sides of a square]
BD = BD [Common]
∴ ΔABD ≅ ΔCBD [SSS congruence]
So, ∠ABD = ∠CBD [CPCT]
∠ADB = ∠ CDB [CPCT]
Hence, diagonals BD bisect ∠B as well as ∠D

Q9. In parallelogram ABCD, two points P and Q are taken on diagonals BD such that DP = BQ (See Fig.) Show that:



(i) ΔAPD ≅ ΔCQB
(ii) AP = CQ
(iii) ΔAQB ≅ ΔCPD
(iv) AQ = CP
(v) APCQ is a parallelogram

Sol. Given: ABCD is a parallelogram and P and Q are points on diagonals BD such that DP = BQ.
To prove:
(i) ΔAPD ≅ ΔCQB
(ii) AP = CQ
(iii) ΔAQB ≅ ΔCPD

(iv) AQ = CP

(v) APCQ is a parallelogram

Proof:

(i) In ΔAPD and ΔCQB, we have

AD = BC [Opposite sides of a ∥ gm]

DP = BQ [Given]

∠ADP = ∠CBQ [Alternative angles]

∴ ΔAPD ≅ Δ CQB [SAS congruence]

(ii) ∴ AP = CQ [CPCT]

(iii) In Δ AQB and ΔCQB, we have

AB = CD [Opposite sides of a ∥ gm]

DP = BQ [Given]

∠ABQ = ∠CDP [Alternative angles]

∴ ΔAQB ≅ ΔCPD [SAS congruence]

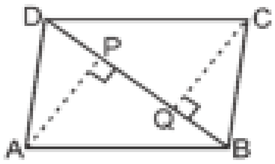
(iv) ∴ AQ = CP [CPCT]

(v) Since in APCQ, opposite sides are equal, therefore it is a parallelogram.

Q10. ABCD is a parallelogram and AP and CQ are perpendicular from vertices A and C on diagonals BD (see Fig.) Show that

(i) ΔAPB ≅ Δ CQD

(ii) AP = CQ



Sol. Given: ABCD is a parallelogram and AP and CQ are perpendicular from vertices A and C on BD.

To Prove:

(i) ΔAPB ≅ Δ CQD

(ii) AP = CQ

Proof:

(i) In ΔAPB and ΔCQD, we have

∠ABP = ∠CDQ [Alternate angle]

AB = CD [Opposite sides of a parallelogram]

∠APB = ∠CQD [Each = 90°]

∴ ΔAPB = ΔCQD [ASA congruence]

(ii) So, AP = CQ [CPCT]

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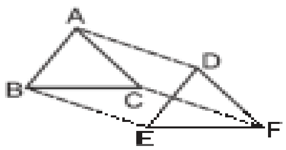
Q11. In ΔABC and ΔDEF, AB = DE, AB∥DE, BC = EF and BC ∥ EF. Vertices A, B and C are joined to vertices to vertices D, E and F respectively (see Fig.) Show that



(i) Quadrilateral ABED is a parallelogram
(ii) Quadrilateral BEFC is a parallelogram
(iii) AD ∥ CF and AD = CF
(iv) Quadrilateral ACFD is a parallelogram
(v) AC = DF
(vi) ΔABC ≅ ΔDEF

Sol. Given: In ΔABC and ΔDEF, AB = DE, AB ∥ DE, BC = EF and BC ∥ EF. Vertices A, B and C are joined to vertices D, E and F.

To Prove:

(i) Quadrilateral ABED is a parallelogram
(ii) Quadrilateral BEFC is a parallelogram
(iii) AD ∥ CF and AD = CF
(iv) Quadrilateral ACFD is a parallelogram
(v) AC = DF
(vi) ΔABC ≅ ΔDEF

Proof: (i) In quadrilateral ABED, we have

AB = DE and AB ∥ DE, [Given]

⇒ ABED is a parallelogram. [One pair of opposite sides is parallel and equal]

(ii)In quadrilateral BEFC, we have

BC = EF and BC ∥ EF [Given]

⇒ BEFC is a parallelogram. [One pair of opposite sides is parallel and equal]

(iii) BE = CF and BE ∥ BECF [BEFC is Parallelogram]

AD = BE and AD ∥ BE [ABED is a parallelogram]

⇒ AD = CF and AD ∥ CF

(iv) ACFD is a parallelogram [One pair of opposite sides is parallel and equal]

(v) AC = DF [Opposite sides of parallelogram ACFD]

(vi) In ΔABC and Δ DEF, we have

AB = DE [Given]

BC = EF [Given]

AC = DF [Prove above]

∴ ΔABC ≅ ΔDEF [SSS axiom]

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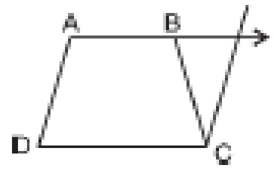
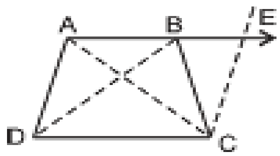
Q12. ABCD is a trapezium in which AB ∥ CD and AD = BC (see Fig.).
Show that
(i) ∠A = ∠B
(ii) ∠C = ∠D
(iii) ΔABC ≅ ΔBAD
(iv) Diagonal AC = BD



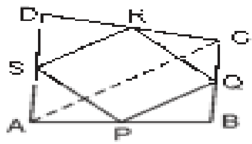
Sol. Given: In trapezium ABCD, AB ∥ CD and AD = BC.
To Prove:
(i) ∠A = ∠B
(ii) ∠C = ∠D
(iii) ΔABC ≅ ΔBAD
(iv) Diagonal AC = BD



Construction: Join AC and BD Extend AB and draw a line through C parallel to AD meeting AB produced at E.
Proof:
(i) Since AB ∥ DC
⇒ AE ∥ DC ... (i)
And AD ∥ CE ... (ii) [Construction]
⇒ ADCE is parallelogram [Opposite pairs of sides are parallel]
∠A + ∠E = 180 ° ... (iii) [Consecutive interior angles]
∠B + ∠CBE = 180° ... (iv) [Linear pair]
AD = CE ... (v) [Opposite sides of a ∥ gm]
AD = BC ... (vi) [Given]
⇒ BC = CE [From (v) and (vi)]
⇒ ∠E = ∠CBE ...... (vii) [Angles opposite to equal sides]
∴ ∠B +∠E = 180° ...(viii) [From (iv)and (vii)]
Now from (iii) and (viii) we have
∠A+∠E = ∠B+∠E
⇒ ∠A = ∠B
(ii) ∠A + ∠D = 180° [Consecutive interior angles]
∠B + ∠C = 180° [Consecutive interior angles]
⇒ ∠A+∠D = ∠B +∠C [∵ ∠A = ∠B]
⇒ ∠D = ∠C
Or ∠C = ∠D
(iii) In ΔABC and ΔBAD, We have
AD = BC [Given]

$\angle A = \angle B$ [Proved]
$AB = CD$ [Common]
$\therefore \Delta ABC \cong \Delta BAD$ [ASA congruence]
(iv) Diagonal AC = Diagonal BD [CPCT]

Q13. ABCD is a quadrilateral in which P, Q, R and S are mid-points of the sides, AB, BC, CD and DA respectively. (See Fig.). AC is a diagonal. Show that:

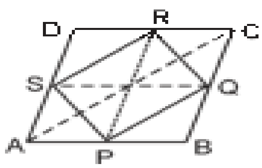


(i) $SR \parallel AC$ and $SR = \frac{1}{2} AC$
(ii) $PQ = SR$
(iii) PQRS is a parallelogram.

Sol. Given: ABCD is a quadrilateral in which P, Q, R and S are mid-points of AB, BC, CD and DA. AC is diagonal.
To Prove:
(i) $SR \parallel AC$ and $SR = \frac{1}{2} AC$
(ii) $PQ = SR$
(iii) PQRS is a parallelogram.
Proof: (i) In ΔABC, P is the mid-point of AB and Q is the mid-point of BC.
$\therefore PQ \parallel AC$ and $PQ = \frac{1}{2} AC$ ... (1) [Mid-point theorem]
In ΔADC, R is the mid-point of CD and S is the mid-point of AD
$\therefore SR \parallel AC$ and $SR = \frac{1}{2} AC$ ... (2) [Mid-point theorem]
(ii) From (1) and (2), we get
$PQ \parallel SR$ and $PQ = SR$
(iii) Now in quadrilateral PQRS, its one pair of opposite sides PQ and SR is equal and parallel.
$\therefore$ PQRS is a parallelogram.

Q14. ABCD is a rhombus and P, Q, R and S are the mid-points of the sides AB, BC, CD and DA respectively. Show that the quadrilateral PQRS is a rectangle.

Sol. Given: ABCD is a rhombus in which P, Q, R and S are mid points of sides AB, BC, CD and DA respectively:
To Prove: PQRS is a rectangle.
Construction: Join AC, PR and SQ.
Proof: In ΔABC



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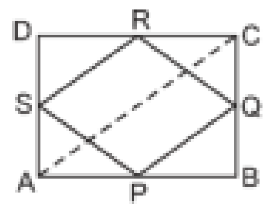
P is mid-point of AB [Given]
Q is mid-point of BC [Given]
$\Rightarrow$ PQ ∥ AC and PQ $= \frac{1}{2}$ AC ... (i) [Mid-point theorem]
Similarly, in ΔDAC,
SR ∥ AC and SR $= \frac{1}{2}$ AC ... (ii)
From (i) and (ii), we have PQ ∥ SR and PQ = SR
$\Rightarrow$ PQRS is a parallelogram [One pair of opposite sides is parallel and equal]
Since ABQS is a parallelogram
$\Rightarrow$ AB = SQ [Opposite sides of a ∥ gm]
Similarly, since PBCR is a parallelogram.
$\Rightarrow$ BC = PR
Thus, SQ = PR [AB = BC]
Since SQ and PR are diagonal of parallelogram PQRS, which are equal.
$\Rightarrow$ PQRS is a rectangle.

Q15. ABCD is a rectangle and P, Q, R and S are mid-points of the sides AB, BC, CD and DA respectively. Show that quadrilateral PQRS is a rhombus.

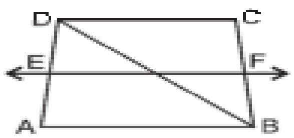
Sol. Given: A rectangle ABCD in which P, Q, R, S are the mid-points of AB, BC, CD and DA respectively, PQ, QR, RS and SP are joined.
To prove: PQRS is a rhombus.
Construction: Join AC
Proof: In ΔABC, P and Q are mid-points of the sides AB and BC.
∴ PQ ∥ AC and PQ $= \frac{1}{2}$ AC ... (i) [Mid-point theorem]
Similarly, in ΔADC,
SR ∥ AC and SR $= \frac{1}{2}$ AC ... (ii)
From (i) and (ii), we get
PQ ∥ SR and PQ = SR ... (iii)
Now in quadrilateral PQRS, its one pair of opposite sides PQ and SR is parallel and equal [From (iii)]
∴ PQRS is a parallelogram.
Now AD = BC ... (iv) [Opposite sides of a rectangle ABCD]
∴ $\frac{1}{2}$ AD $= \frac{1}{2}$ BC



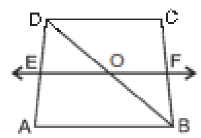
$\Rightarrow$ AS = BQ
In ΔAPS and ΔBPQ
AP = BP [∵ P is the mid-point of AB]
AS = BQ [Prove above]
∠PAS = ∠PBQ [Each = 90°]

ΔAPS ≅ ΔBPQ [SAS axiom]
∴ PS = PQ ... (v)
From (iii) and (v), we have
PQRS is a rhombus.

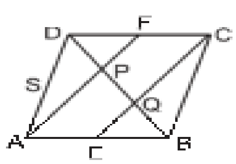
Q16. ABCD is a trapezium in which AB ∥ DC, BD is a diagonal and E is the mid-point of AD. A line is drawn through E parallel to AB intersecting BC at F (See Fig.). Show that F is the mid-point of BC.



Sol. Given: A trapezium ABCD with AD ∥ DC, E is the mid-point of AD and EF ∥ AB.
To Prove: AB ∥ DC and EF ∥ AB
Proof: AB ∥ DC and EF ∥ AB
⇒ AB, EF and DC are parallel.
Intercepts made by parallel lines AB, EF and DC on transversal AD are equal.
∴ Intercepts made by those parallel lines on transversal BC are also equal.
i.e., BF = FC
⇒ F is the mid-point of BC.



Q17. In a parallelogram ABCD, E and F are the mid-points of sides AB and CD respectively (see Fig.). Show that the line segments. AF and EC trisect the diagonals BD.



Sol. Given: A parallelogram ABCD, in which E and F are mid-points of sides AB and DC respectively.
To prove: DP = PQ = QB
Proof: Since E and F are mid-point of AB and DC respectively
⇒ $AE = \frac{1}{2}AB$ and $CF = \frac{1}{2}DC$ ... (i)
But, AB = DC and AB ∥ DC ... (ii) [Opposite sides of parallelogram]
∴ AE = CF and AE ∥ CF.
⇒ AECF is a parallelogram. [One pair of opposite sides is parallel and equal]

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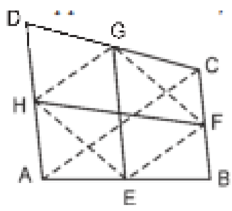
In ΔBAP,
E is the mid-point of AB
EQ ∥ AP
⇒ Q is mid-point of PB [Converse of mid-point theorem]
⇒ PQ = QB ... (iii)
Similarly, In ΔDQC,
P is the mid-point of DQ
DP = PQ ... (iv)
From (iii) and (iv), we have
DP= PQ = QB
Or line segments AF and EC trisect the diagonal BD.

Q18. Show that the line segments joining the mid-points of the opposite sides of a quadrilateral bisect each other.

Sol. Given: ABCD is a quadrilateral in which EG and FH are the line segments joining the mid-points of opposite sides.
To Prove: EG and FH bisect each other.
Construction: Join EF, FG, GH, HE and AC.
Proof: In ΔABC, E and F are mid-points of AB and BC respectively.



∴ EF = $\frac{1}{2}$ AC and EF ∥ AC ... (i)
In ΔADC, H and G are mid-points of AD and CD respectively.
∴ HG = $\frac{1}{2}$ AC and HG ∥ AC ... (ii)
From (i) and (ii), we get
EF = HG and EF ∥ HG
∴ EFGH is a parallelogram [∵ a quadrilateral is a parallelogram if its one pair of opposite sides is equal and parallel]
Now, EG and FH are diagonals of the parallelogram EFGH.
∴ EG and FH bisect each other [Diagonals of a parallelogram bisect each other]

Q19. ABC is a triangle right angled at C. A line through the mid-point M of hypotenuse AB and parallel to BC intersects AC at D. Show that
(i) D is the mid-point of AC.
(ii) MD ⊥ BC
(iii) CM = MA = $\frac{1}{2}$ AB

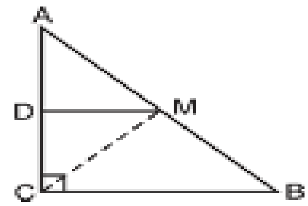
Sol. Given: A triangle ABC, in which ∠C = 90° and M is the mid-point of B and BC ∥ DM.

To Prove:

(i) D is the mid-point of AC.

(ii) MD ⊥ BC

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



Construction: Join CM.

Proof: (i) In ΔABC,

M is the mid-point of AB [Given]

BC ∥ DM [Given]

D is the mid-points of AC [Converse of mid-point theorem]

(ii) ∠ADM = ∠ACB [∵ Corresponding angles]

But ∠ACB = 90° [Given]

∴ ∠ADM = 90°

But ∠ADM+∠CDM = 180° [Linear pair]

∴ ∠CDM = 90°

Hence, MD ⊥ AC

(iii)AD = DC ... (i) [∵ D is the mid-point of AC]

Now, in ΔADM and ΔCMD, we have

∠ADM = ∠CDM [Each = 90°]

AD = DC [From (i)]

DM = DM [Common]

∴ ΔADM ≅ ΔCMD [SAS congruence]

⇒ CM = MA ... (ii) [CPCT]

Since M is mid-point of AB,

∴ $MA = \frac{1}{2} AB$ ... (iii)

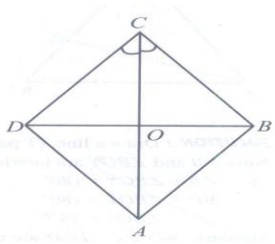
Hence, $CM = MA = \frac{1}{2} AB$ [From (ii) and (iii)]

Q20. In a quadrilateral ABCD, AC bisect ∠C and BC = CD.

Prove that:

(i) AB = AD

(ii) AC is the perpendicular bisect of BD.



Sol. (i) In triangle ADC and ABC,

CD = CB [Given]

CA = CA [Common]

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$\angle DCA = \angle BCA$ [Given]

$\therefore$ $\Delta DCA \cong \Delta BCA$ [By SAS rule of congruency]

$\therefore$ $AD = AB$

(ii)In triangle DCO and BCO

$CD = CB$ [Proved in (i) above]

$CO = CO$ [common]

$\angle DCO = \angle BCO$ [Given]

$\therefore \Delta DCO \cong \Delta BCO$

Since $\angle COD$ and $\angle COB$ are linear pair angles, therefore $\angle DOC + \angle BOC = 180°$

$\Rightarrow \angle COD + \angle COF = 180°$

$\Rightarrow \angle COD = 90°$

$\therefore$ CO is perpendicular to DB

$\therefore$ CA is perpendicular to DB