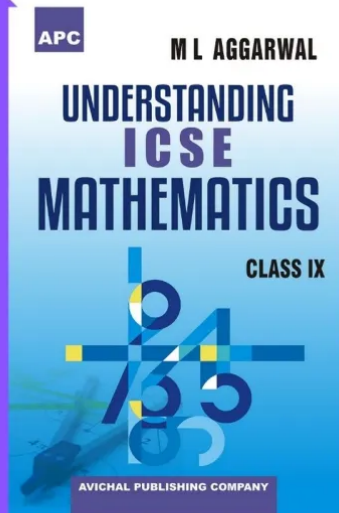


ML Aggarwal Solutions for Class 9 Maths

Chapter 14- Theorems on Area



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CLASS 9 MATHS

Chapter 14: Theorems on
Area

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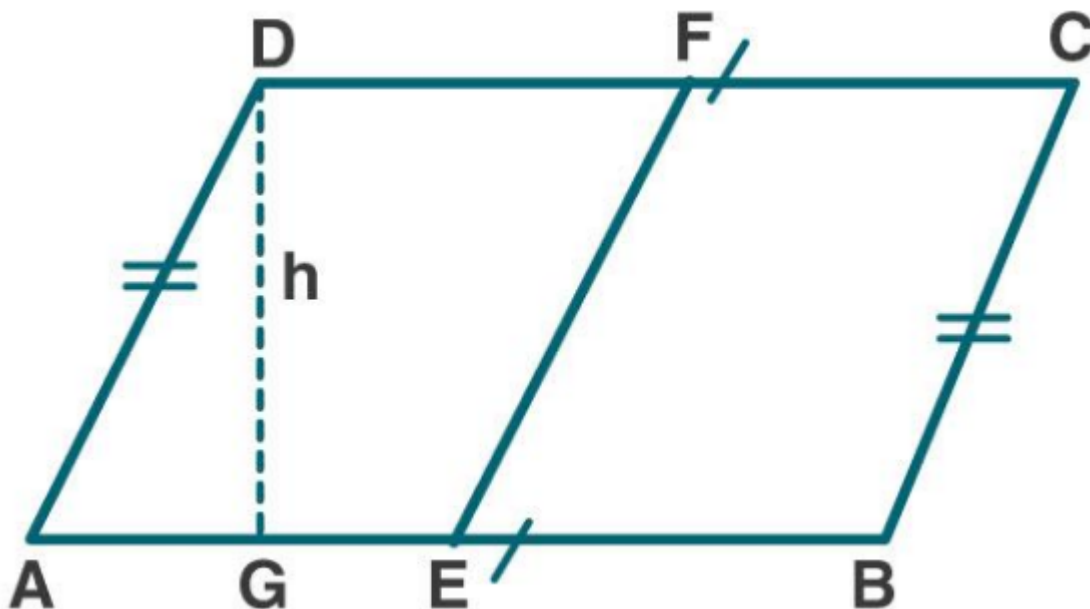
EXERCISE 14

1. Prove that the line segment joining the mid-points of a pair of opposite sides of a parallelogram divides it into two equal parallelograms.

Solution:

Let us consider ABCD be a parallelogram in which E and F are mid-points of AB and CD. Join EF.

To prove: $\text{ar}(\parallel \text{AEFD}) = \text{ar}(\parallel \text{EBCF})$



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Let us construct $DG \perp AG$ and let $DG = h$ where, h is the altitude on side AB .

Proof:

$$\text{ar} (\parallel ABCD) = AB \times h$$

$$\text{ar} (\parallel AEFD) = AE \times h$$

$$= \frac{1}{2} AB \times h \dots\dots (1) \text{ [Since, E is the mid-point of AB]}$$

$$\text{ar} (\parallel EBCF) = EF \times h$$

$$= \frac{1}{2} AB \times h \dots\dots (2) \text{ [Since, E is the mid-point of AB]}$$

From (1) and (2)

$$\text{ar} (\parallel ABFD) = \text{ar} (\parallel EBCF)$$

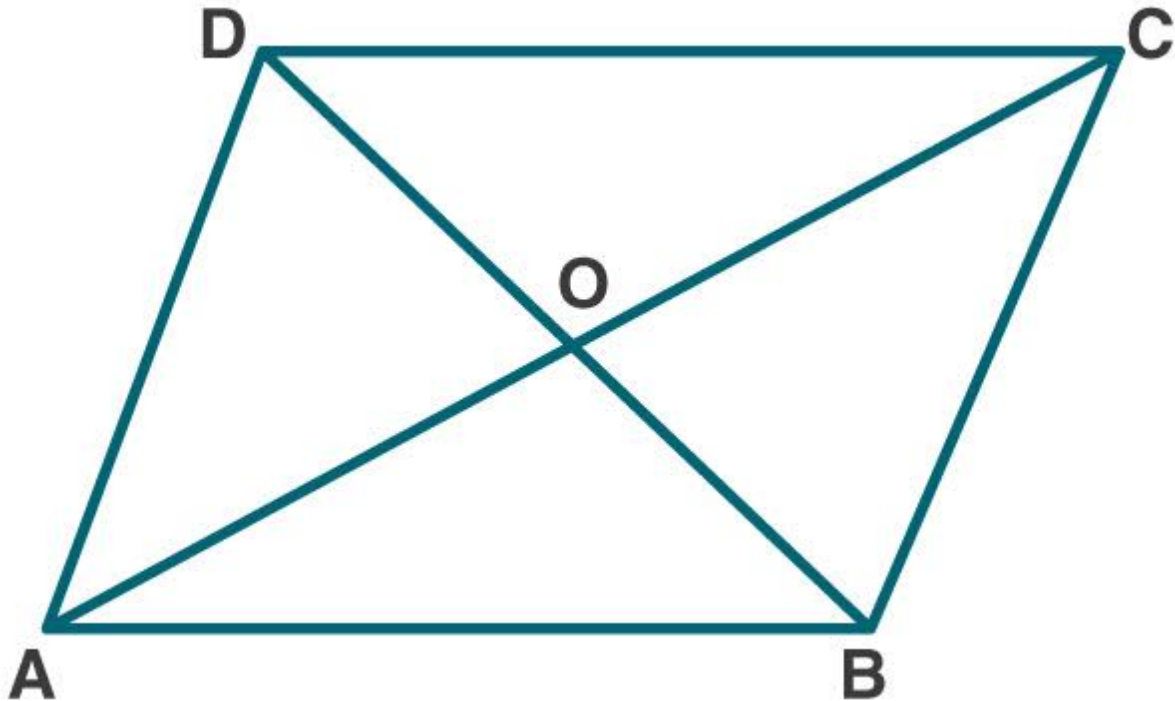
Hence proved.

2. Prove that the diagonals of a parallelogram divide it into four triangles of equal area.

Solution:

Let us consider in a parallelogram $ABCD$ the diagonals AC and BD are cut at point O .

To prove: $\text{ar} (\triangle AOB) = \text{ar} (\triangle BOC) = \text{ar} (\triangle COD) = \text{ar} (\triangle AOD)$



Proof:

In parallelogram ABCD the diagonals bisect each other.

$$AO = OC$$

In $\triangle ACD$, O is the mid-point of AC. DO is the median.

$$\text{ar}(\triangle AOD) = \text{ar}(\triangle COD) \dots\dots (1) \text{ [Median of } \triangle \text{ divides it into two triangles of equal areas]}$$

Similarly, in $\triangle ABC$

$$\text{ar}(\triangle AOB) = \text{ar}(\triangle COB) \dots\dots (2)$$

In $\triangle ADB$

$$\text{ar}(\triangle AOD) = \text{ar}(\triangle AOB) \dots\dots (3)$$

In $\triangle CDB$

$$\text{ar}(\triangle COD) = \text{ar}(\triangle COB) \dots\dots (4)$$

From (1), (2), (3) and (4)

$$\text{ar}(\triangle AOB) = \text{ar}(\triangle BOC) = \text{ar}(\triangle COD) = \text{ar}(\triangle AOD)$$

Hence proved.

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3. (a) In the figure (1) given below, AD is median of $\triangle ABC$ and P is any point on AD. Prove that

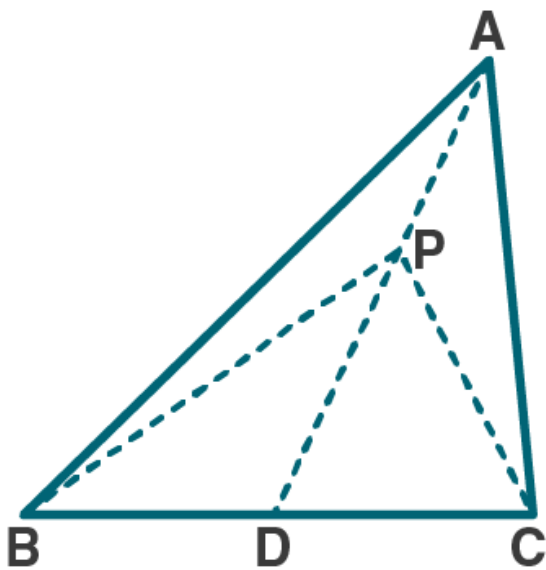
(i) Area of $\triangle PBD$ = area of $\triangle PDC$.

(ii) Area of $\triangle ABP$ = area of $\triangle ACP$.

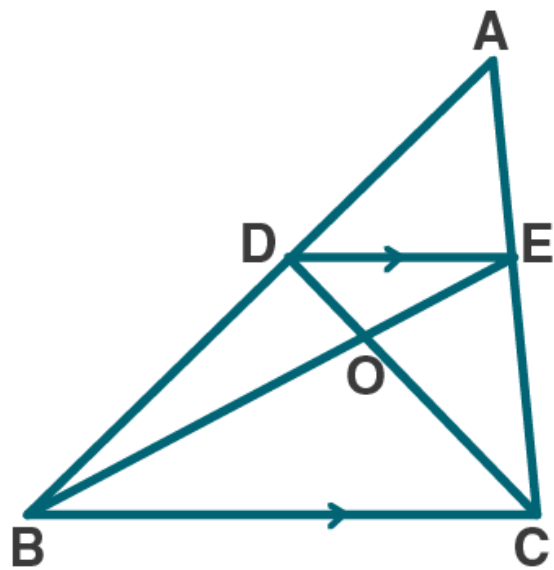
(b) In the figure (2) given below, $DE \parallel BC$. Prove that

(i) area of $\triangle ACD$ = area of $\triangle ABE$.

(ii) Area of $\triangle OBD$ = area of $\triangle OCE$.



(1)



(2)

Solution:

(a) Given:

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$\triangle ABC$ in which AD is the median. P is any point on AD. Join PB and PC.

To prove:

(i) Area of $\triangle PBD$ = area of $\triangle PDC$.

(ii) Area of $\triangle ABP$ = area of $\triangle ACP$.

Proof:

From fig (1)

AD is a median of $\triangle ABC$

So, $\text{ar}(\triangle ABD) = \text{ar}(\triangle ADC) \dots (1)$

Also, PD is the median of $\triangle BPD$

Similarly, $\text{ar}(\triangle PBD) = \text{ar}(\triangle PDC) \dots (2)$

Now, let us subtract (2) from (1), we get

$\text{ar}(\triangle ABD) - \text{ar}(\triangle PBD) = \text{ar}(\triangle ADC) - \text{ar}(\triangle PDC)$

Or $\text{ar}(\triangle ABP) = \text{ar}(\triangle ACP)$

Hence proved.

(b) Given:

$\triangle ABC$ in which $DE \parallel BC$

To prove:

(i) area of $\triangle ACD$ = area of $\triangle ABE$.

(ii) Area of $\triangle OBD$ = area of $\triangle OCE$.

Proof:

From fig (2)

$\triangle DEC$ and $\triangle BDE$ are on the same base DE and between the same $\parallel$ line DE and BE.

$\text{ar}(\triangle DEC) = \text{ar}(\triangle BDE)$

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Now add $\text{ar}(\triangle ADE)$ on both sides, we get

$$\text{ar}(\triangle DEC) + \text{ar}(\triangle ADE) = \text{ar}(\triangle BDE) + \text{ar}(\triangle ADE)$$

$$\text{ar}(\triangle ACD) = \text{ar}(\triangle ABE)$$

Hence proved.

$$\text{Similarly, } \text{ar}(\triangle DEC) = \text{ar}(\triangle BDE)$$

Subtract $\text{ar}(\triangle DOE)$ from both sides, we get

$$\text{ar}(\triangle DEC) - \text{ar}(\triangle DOE) = \text{ar}(\triangle BDE) - \text{ar}(\triangle DOE)$$

$$\text{ar}(\triangle OBD) = \text{ar}(\triangle OCE)$$

Hence proved.

4. (a) In the figure (1) given below, ABCD is a parallelogram and P is any point in BC. Prove that: Area of $\triangle ABP$ + area of $\triangle DPC$ = Area of $\triangle APD$.

(b) In the figure (2) given below, O is any point inside a parallelogram ABCD. Prove that:

$$\text{(i) area of } \triangle OAB + \text{area of } \triangle OCD = \frac{1}{2} \text{ area of } \parallel \text{ gm ABCD}$$

$$\text{(ii) area of } \triangle OBC + \text{area of } \triangle OAD = \frac{1}{2} \text{ area of } \parallel \text{ gm ABCD}$$

Solution:

(a) Given:

From fig (1)

ABCD is a parallelogram and P is any point in BC.

To prove:

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Area of $\triangle ABP$ + area of $\triangle DPC$ = Area of $\triangle APD$

Proof:

$\triangle APD$ and $\parallel$ gm ABCD are on the same base AD and between the same $\parallel$ lines AD and BC,

$$\text{ar}(\triangle APD) = \frac{1}{2} \text{ar}(\parallel \text{ gm ABCD}) \dots (1)$$

In parallelogram ABCD

$$\text{ar}(\parallel \text{ gm ABCD}) = \text{ar}(\triangle ABP) + \text{ar}(\triangle APD) + \text{ar}(\triangle DPC)$$

Now, divide both sides by 2, we get

$$\frac{1}{2} \text{ar}(\parallel \text{ gm ABCD}) = \frac{1}{2} \text{ar}(\triangle ABP) + \frac{1}{2} \text{ar}(\triangle APD) + \frac{1}{2} \text{ar}(\triangle DPC) \dots (2)$$

From (1) and (2)

$$\text{ar}(\triangle APD) = \frac{1}{2} \text{ar}(\parallel \text{ gm ABCD})$$

Substituting (2) in (1)

$$\text{ar}(\triangle APD) = \frac{1}{2} \text{ar}(\triangle ABP) + \frac{1}{2} \text{ar}(\triangle APD) + \frac{1}{2} \text{ar}(\triangle DPC)$$

$$\text{ar}(\triangle APD) - \frac{1}{2} \text{ar}(\triangle APD) = \frac{1}{2} \text{ar}(\triangle ABP) + \frac{1}{2} \text{ar}(\triangle DPC)$$

$$\frac{1}{2} \text{ar}(\triangle APD) = \frac{1}{2} [\text{ar}(\triangle ABP) + \text{ar}(\triangle DPC)]$$

$$\text{ar}(\triangle APD) = \text{ar}(\triangle ABP) + \text{ar}(\triangle DPC)$$

$$\text{Or } \text{ar}(\triangle ABP) + \text{ar}(\triangle DPC) = \text{ar}(\triangle APD)$$

Hence proved.

(b) Given:

From fig (2)

$\parallel$ gm ABCD in which O is any point inside it.

To prove:

$$(i) \text{ area of } \triangle OAB + \text{area of } \triangle OCD = \frac{1}{2} \text{ area of } \parallel \text{ gm ABCD}$$

$$(ii) \text{ area of } \triangle OBC + \text{area of } \triangle OAD = \frac{1}{2} \text{ area of } \parallel \text{ gm ABCD}$$

Draw POQ $\parallel$ AB through O. It meets AD at P and BC at Q.

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Proof:

(i) $AB \parallel PQ$ and $AP \parallel BQ$

ABQP is a $\parallel$ gm

Similarly, PQCD is a $\parallel$ gm

Now, $\triangle OAB$ and $\parallel$ gm ABQP are on same base AB and between same $\parallel$ lines AB and PQ

$$\text{ar}(\triangle OAB) = \frac{1}{2} \text{ar}(\parallel \text{gm ABQP}) \dots (1)$$

$$\text{Similarly, ar}(\triangle OCD) = \frac{1}{2} \text{ar}(\parallel \text{gm PQCD}) \dots (2)$$

Now by adding (1) and (2)

$$\text{ar}(\triangle OAB) + \text{ar}(\triangle OCD) = \frac{1}{2} \text{ar}(\parallel \text{gm ABQP}) + \frac{1}{2} \text{ar}(\parallel \text{gm PQCD})$$

$$= \frac{1}{2} [\text{ar}(\parallel \text{gm ABQP}) + \text{ar}(\parallel \text{gm PQCD})]$$

$$= \frac{1}{2} \text{ar}(\parallel \text{gm ABCD})$$

$$\text{ar}(\triangle OAB) + \text{ar}(\triangle OCD) = \frac{1}{2} \text{ar}(\parallel \text{gm ABCD})$$

Hence proved.

(ii) we know that,

$$\text{ar}(\triangle OAB) + \text{ar}(\triangle OBC) + \text{ar}(\triangle OCD) + \text{ar}(\triangle OAD) = \text{ar}(\parallel \text{gm ABCD})$$
$$[\text{ar}(\triangle OAB) + \text{ar}(\triangle OCD)] + [\text{ar}(\triangle OBC) + \text{ar}(\triangle OAD)] = \text{ar}(\parallel \text{gm ABCD})$$

$$\frac{1}{2} \text{ar}(\parallel \text{gm ABCD}) + \text{ar}(\triangle OBC) + \text{ar}(\triangle OAD) = \text{ar}(\parallel \text{gm ABCD})$$

$$\text{ar}(\triangle OBC) + \text{ar}(\triangle OAD) = \text{ar}(\parallel \text{gm ABCD}) - \frac{1}{2} \text{ar}(\parallel \text{gm ABCD})$$

$$\text{ar}(\triangle OBC) + \text{ar}(\triangle OAD) = \frac{1}{2} \text{ar}(\parallel \text{gm ABCD})$$

Hence proved.

5. If E, F, G and H are mid-points of the sides AB, BC, CD and DA respectively of a parallelogram ABCD, prove that area of quad. EFGH = $\frac{1}{2}$ area of $\parallel$ gm ABCD.

Solution:

Given:

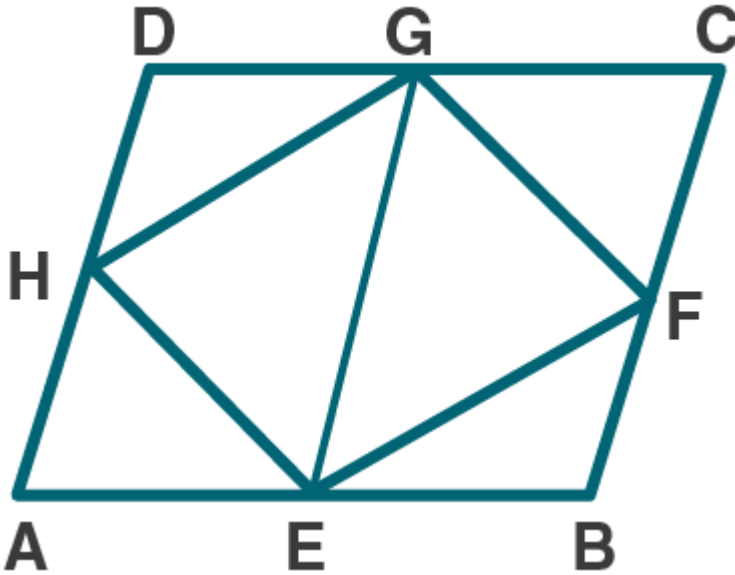
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In parallelogram ABCD, E, F, G, H are the mid-points of its sides AB, BC, CD and DA.

Join EF, FG, GH and HE.

To prove:

area of quad. EFGH = $\frac{1}{2}$ area of || gm ABCD



Proof:

Let us join EG.

We know that, E and G are mid-points of AB and CD.

$EG \parallel AD \parallel BC$

AEGD and EBCG are parallelogram

Now, || gm AEGD and $\triangle EHG$ are on the same base and between the parallel lines.

$\text{ar } \triangle EHG = \frac{1}{2} \text{ ar || gm AEGD} \dots (1)$

Similarly,

$\text{ar } \triangle EFG = \frac{1}{2} \text{ ar || gm EBCG} \dots (2)$

Now by adding (1) and (2)

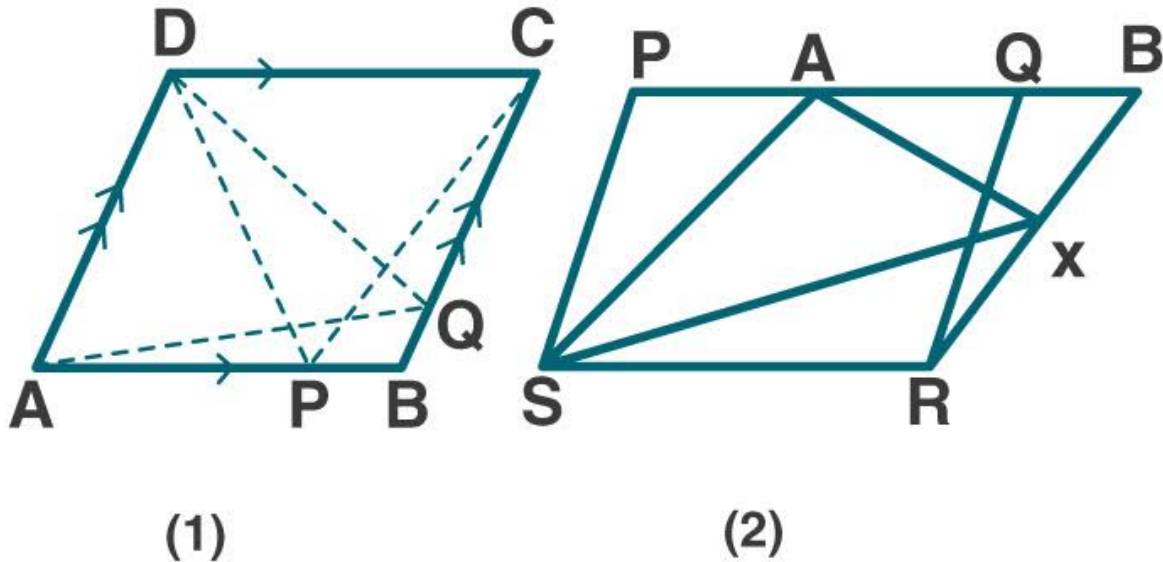
$\text{ar } \triangle EHG + \text{ar } \triangle EFG = \frac{1}{2} \text{ ar || gm AEGD} + \frac{1}{2} \text{ ar || gm EBCG}$

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area quad. EFGH = $\frac{1}{2}$ ar || gm ABCD

Hence proved.

6. (a) In the figure (1) given below, ABCD is a parallelogram. P, Q are any two points on the sides AB and BC respectively. Prove that, area of $\triangle CPD$ = area of $\triangle AQD$.



(b) In the figure (2) given below, PQRS and ABRS are parallelograms and X is any point on the side BR. Show that area of $\triangle AXS$ = $\frac{1}{2}$ area of ||gm PQRS.

Solution:

(a) Given:

From fig (1)

||gm ABCD in which P is a point on AB and Q is a point on BC.

To prove:

area of $\triangle CPD$ = area of $\triangle AQD$.

Proof:

$\triangle CPD$ and ||gm ABCD are on the same base CD and between the same parallels AB and CD.

ar ($\triangle CPD$) = $\frac{1}{2}$ ar (||gm ABCD) (1)

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$\triangle AQD$ and $\parallel gm ABCD$ are on the same base AD and between the same parallels AD and BC.

$$ar(\triangle AQD) = \frac{1}{2} ar(\parallel gm ABCD) \dots (2)$$

from (1) and (2)

$$ar(\triangle CPD) = ar(\triangle AQD)$$

Hence proved.

(b) From fig (2)

Given:

PQRS and ABRS are parallelograms on the same base SR. X is any point on the side BR.

Join AX and SX.

To prove:

$$area\ of\ \triangle AXS = \frac{1}{2} area\ of\ \parallel gm\ PQRS$$

we know that, $\parallel gm$ PQRS and ABRS are on the same base SR and between the same parallels.

$$So, ar\ \parallel gm\ PQRS = ar\ \parallel gm\ ABRS \dots (1)$$

we know that, $\triangle AXS$ and $\parallel gm$ ABRS are on the same base AS and between the same parallels.

$$So, ar\ \triangle AXS = \frac{1}{2} ar\ \parallel gm\ ABRS$$

$$= \frac{1}{2} ar\ \parallel gm\ PQRS\ [From\ (1)]$$

Hence proved.

7. D, E and F are mid-point of the sides BC, CA and AB respectively of a $\triangle ABC$. Prove that

(i) FDCE is a parallelogram

(ii) area of $\triangle DEF = \frac{1}{4}$ area of $\triangle ABC$

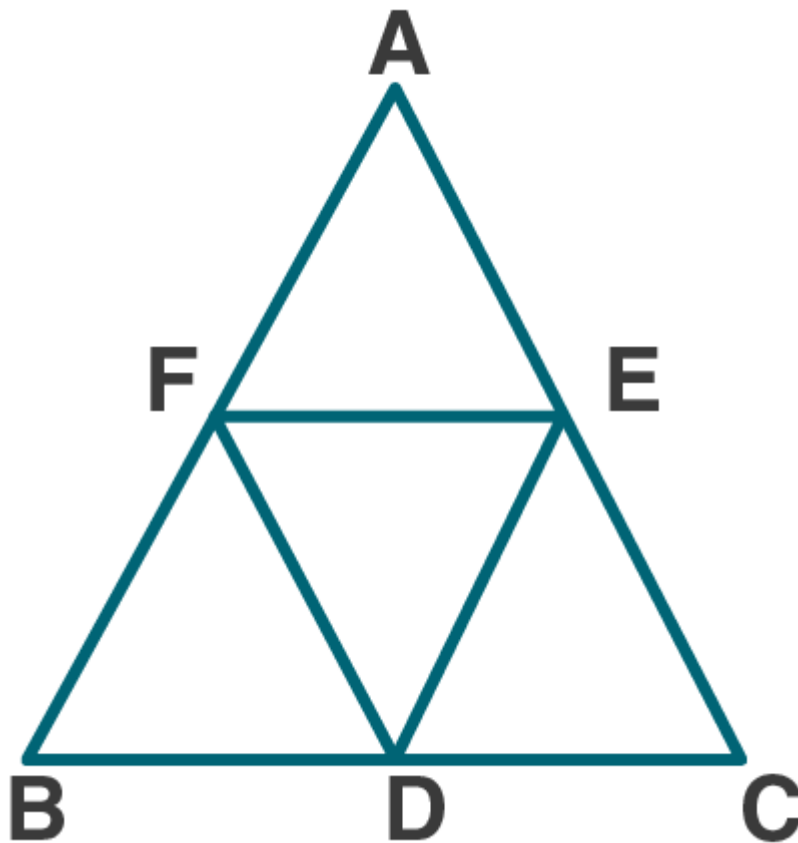
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(iii) area of || gm FDCE = $\frac{1}{2}$ area of $\triangle ABC$

Solution:

Given:

D, E and F are mid-point of the sides BC, CA and AB respectively of a $\triangle ABC$.



To prove:

(i) FDCE is a parallelogram

(ii) area of $\triangle DEF = \frac{1}{4}$ area of $\triangle ABC$

(iii) area of || gm FDCE = $\frac{1}{2}$ area of $\triangle ABC$

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Proof:

(i) F and E are mid-points of AB and AC.

So, $FE \parallel BC$ and $FE = \frac{1}{2} BC$ (1)

Also, D is mid-point of BC

$CD = \frac{1}{2} BC$ (2)

From (1) and (2)

$FE \parallel BC$ and $FE = CD$

$FE \parallel CD$ and $FE = CD$ (3)

Similarly,

D and F are mid-points of BC and AB.

So, $DF \parallel EC$ is a parallelogram.

Hence proved.

(ii) we know that, FDCE is a parallelogram.

And DE is a diagonal of ||gm FDCE

So, $\text{ar}(\triangle DEF) = \text{ar}(\triangle DEC)$ (4)

Similarly, we know BDEF and DEAF are ||gm

So, $\text{ar}(\triangle DEF) = \text{ar}(\triangle BDF) = \text{ar}(\triangle AFE)$ (5)

From (4) and (5)

$\text{ar}(\triangle DEF) = \text{ar}(\triangle DEC) = \text{ar}(\triangle BDF) = \text{ar}(\triangle AFE)$

Now, $\text{ar}(\triangle ABC) = \text{ar}(\triangle DEF) + \text{ar}(\triangle DEF) + \text{ar}(\triangle DEF) + \text{ar}(\triangle DEF)$

$= 4 \text{ ar}(\triangle DEF)$

$\text{ar}(\triangle DEF) = \frac{1}{4} \text{ ar}(\triangle ABC)$ (6)

Hence proved.

(iii) $\text{ar of || gm FDCE} = \text{ar}(\triangle DEF) + \text{ar}(\triangle DEC)$

$= \text{ar}(\triangle DEF) + \text{ar}(\triangle DEF)$

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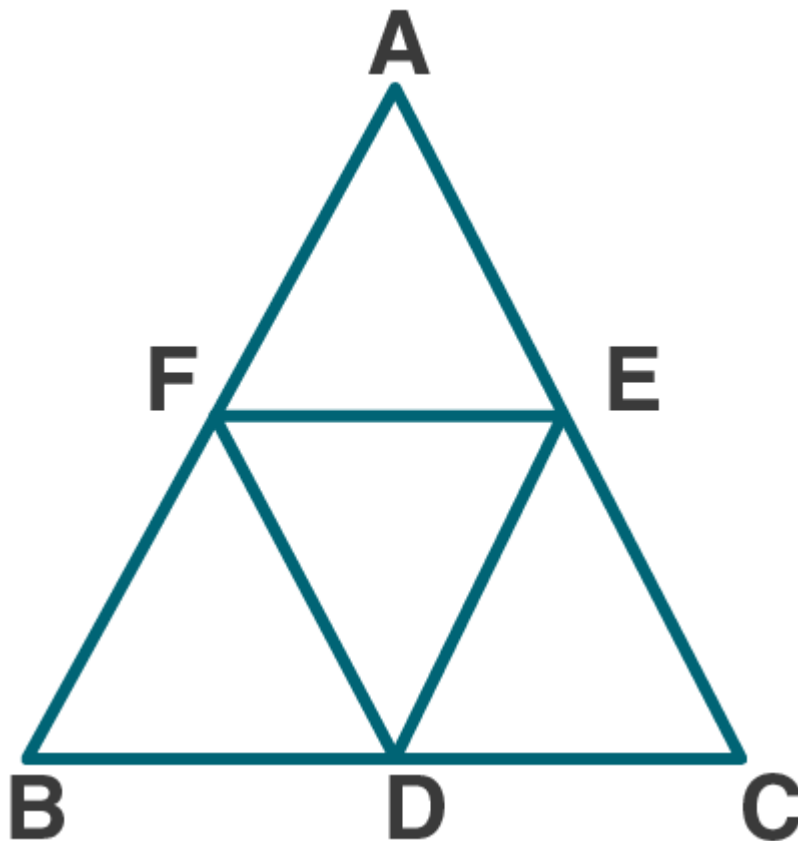
$$= 2 \text{ ar } (\triangle DEF) \text{ [From (4)]}$$

$$= 2 \left[\frac{1}{4} \text{ ar } (\triangle ABC) \right] \text{ [From (6)]}$$

$$\text{ar of } \parallel \text{ gm FDCE} = \frac{1}{2} \text{ ar of } \triangle ABC$$

Hence proved.

8. In the given figure, D, E and F are mid points of the sides BC, CA and AB respectively of $\triangle ABC$. Prove that BCEF is a trapezium and area of trap. BCEF = $\frac{3}{4}$ area of $\triangle ABC$.



Solution:

Given:

In $\triangle ABC$, D, E and F are mid points of the sides BC, CA and AB.

To prove:

$$\text{area of trap. BCEF} = \frac{3}{4} \text{ area of } \triangle ABC$$

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Proof:

We know that D and E are the mid-points of BC and CA.

So, $DE \parallel AB$ and $\frac{1}{2} AB$

Similarly,

$EF \parallel BC$ and $\frac{1}{2} BC$

And $FD \parallel AC$ and $\frac{1}{2} AC$

$\therefore$ BDEF, CDFE, AFDE are parallelograms which are equal in area.

ED, DF, EF are diagonals of these ||gm which divides the corresponding parallelogram into two triangles equal in area.

Hence, BCEF is a trapezium.

area of trap. BCEF = $\frac{3}{4}$ area of $\triangle ABC$

9. (a) In the figure (1) given below, the point D divides the side BC of $\triangle ABC$ in the ratio m: n. Prove that area of $\triangle ABD$: area of $\triangle ADC$ = m: n.

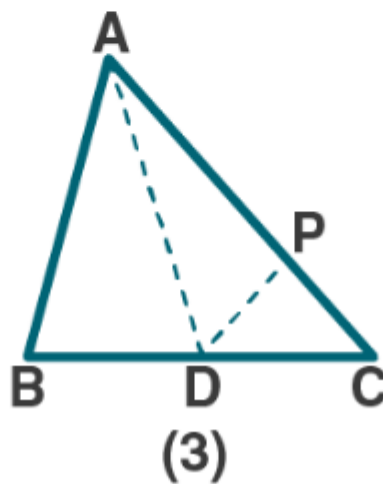
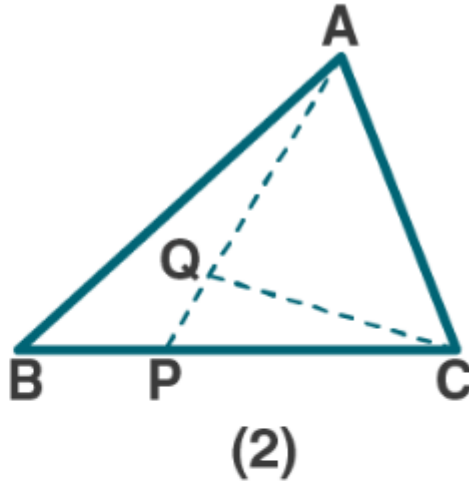
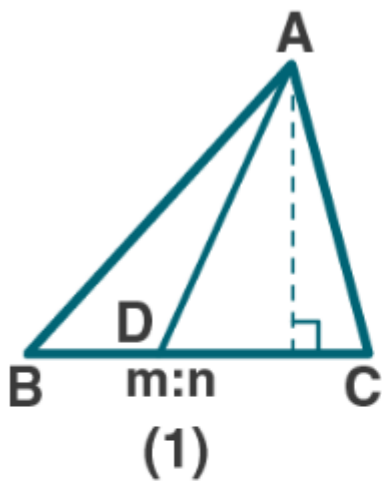
(b) In the figure (2) given below, P is a point on the side BC of $\triangle ABC$ such that $PC = 2BP$, and Q is a point on AP such that $QA = 5 PQ$, find area of $\triangle AQC$: area of $\triangle ABC$.

(c) In the figure (3) given below, AD is a median of $\triangle ABC$ and P is a point in AC such that area of $\triangle ADP$: area of $\triangle ABD$ = 2:3. Find

(i) AP: PC

(ii) area of $\triangle PDC$: area of $\triangle ABC$.

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Solution:

(a) Given:

From fig (1)

In $\triangle ABC$, the point D divides the side BC in the ratio m: n.

BD: DC = m: n

To prove:

area of $\triangle ABD$: area of $\triangle ADC$ = m: n

Proof:

area of $\triangle ABD$ = $\frac{1}{2} \times \text{base} \times \text{height}$

ar ($\triangle ABD$) = $\frac{1}{2} \times BD \times AE$ (1)

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$$\text{ar } (\triangle ACD) = \frac{1}{2} \times DC \times AE \dots\dots (2)$$

let us divide (1) by (2) $[\text{ar } (\triangle ABD) = \frac{1}{2} \times BD \times AE] / [\text{ar } (\triangle ACD) = \frac{1}{2} \times DC \times AE]$ $[\text{ar } (\triangle ABD)] / [\text{ar } (\triangle ACD)] = BD/DC$

$$= m/n \text{ [it is given that, } BD: DC = m: n]$$

Hence proved.

(b) Given:

From fig (2)

In $\triangle ABC$, P is a point on the side BC such that $PC = 2BP$, and Q is a point on AP such that $QA = 5PQ$.

To Find:

area of $\triangle AQC$: area of $\triangle ABC$

Now,

It is given that: $PC = 2BP$

$$PC/2 = BP$$

We know that, $BC = BP + PC$

Now substitute the values, we get

$$BC = BP + PC$$

$$= PC/2 + PC$$

$$= (PC + 2PC)/2$$

$$= 3PC/2$$

$$2BC/3 = PC$$

$$\text{ar } (\triangle APC) = \frac{2}{3} \text{ ar } (\triangle ABC) \dots\dots (1)$$

It is given that, $QA = 5PQ$

$$QA/5 = PQ$$

We know that, $QA = PQ + QA$

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So, $QA = \frac{5}{6} AP$

$$\text{ar}(\triangle AQC) = \frac{5}{6} \text{ar}(\triangle APC)$$

$$= \frac{5}{6} \left(\frac{2}{3} \text{ar}(\triangle ABC)\right) \text{ [From (1)]}$$

$$\text{ar}(\triangle AQC) = \frac{5}{9} \text{ar}(\triangle ABC)$$

$$\text{ar}(\triangle AQC) / \text{ar}(\triangle ABC) = \frac{5}{9}$$

Hence proved.

(c) Given:

From fig (3)

AD is a median of $\triangle ABC$ and P is a point in AC such that area of $\triangle ADP$: area of $\triangle ABD = 2:3$

To Find:

(i) AP: PC

(ii) area of $\triangle PDC$: area of $\triangle ABC$

Now,

(i) we know that AD is the median of $\triangle ABC$

$$\text{ar}(\triangle ABD) = \text{ar}(\triangle ADC) = \frac{1}{2} \text{ar}(\triangle ABC) \dots\dots (1)$$

It is given that,

$$\text{ar}(\triangle ADP) : \text{ar}(\triangle ABD) = 2 : 3$$

$$AP : AC = 2 : 3$$

$$AP/AC = 2/3$$

$$AP = \frac{2}{3} AC$$

Now,

$$PC = AC - AP$$

$$= AC - \frac{2}{3} AC$$

$$= (3AC - 2AC)/3$$

$$= AC/3 \dots\dots (2)$$

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So,

$$AP/PC = (2/3 AC) / (AC/3)$$

$$= 2/1$$

$$AP: PC = 2:1$$

(ii) we know that from (2)

$$PC = AC/3$$

$$PC/AC = 1/3$$

So,

$$\text{ar } (\triangle PDC)/\text{ar } (\triangle ADC) = PC/AC$$

$$= 1/3$$

$$\text{ar } (\triangle PDC)/1/2 \text{ ar } (\triangle ABC) = 1/3$$

$$\text{ar } (\triangle PDC)/\text{ar } (\triangle ABC) = 1/3 \times 1/2$$

$$= 1/6$$

$$\text{ar } (\triangle PDC): \text{ar } (\triangle ABC) = 1: 6$$

Hence proved.

10. (a) In the figure (1) given below, area of parallelogram ABCD is 29 cm². Calculate the height of parallelogram ABEF if AB = 5.8 cm

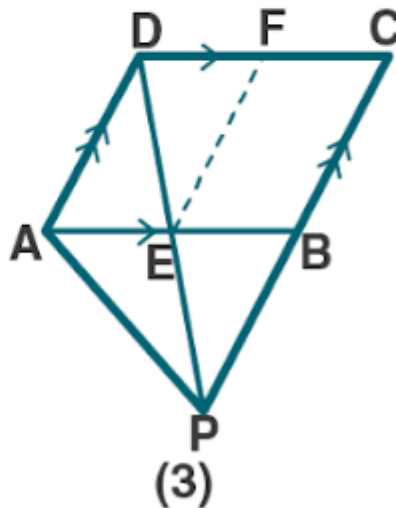
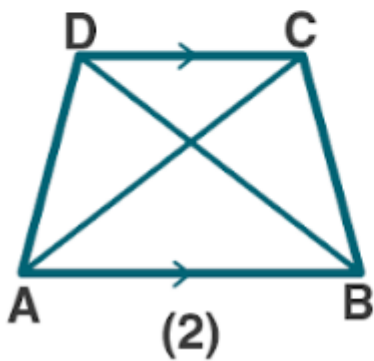
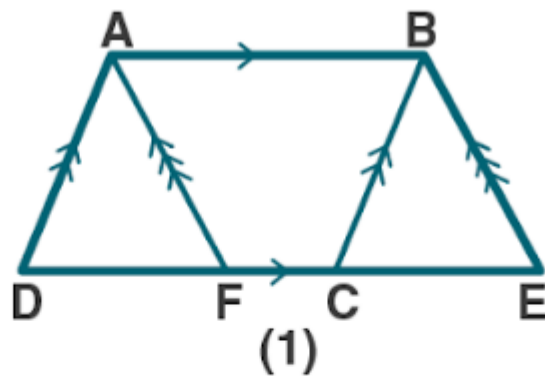
(b) In the figure (2) given below, area of $\triangle ABD$ is 24 sq. units. If AB = 8 units, find the height of ABC.

(c) In the figure (3) given below, E and F are mid points of sides AB and CD respectively of parallelogram ABCD. If the area of parallelogram ABC is 36 cm².

(i) State the area of $\triangle APD$.

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(ii) Name the parallelogram whose area is equal to the area of $\triangle APD$.



Solution:

(a) Given:

From fig (1)

ar ||gm ABCD = 29cm^2

To find:

Height of parallelogram ABEF if AB = 5.8 cm

Now, let us find

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We know that $\parallel\text{gm ABCD}$ and $\parallel\text{gm ABEF}$ with equal bases and between the same parallels so that their areas are same.

$$\text{ar}(\parallel\text{gm ABEF}) = \text{ar}(\parallel\text{gm ABCD})$$

$$\text{ar}(\parallel\text{gm ABEF}) = 29\text{cm}^2 \dots\dots (1) \text{ [Since, ar } \parallel\text{gm ABCD} = 29\text{cm}^2]$$

$$\text{also, ar}(\parallel\text{gm ABEF}) = \text{base} \times \text{height}$$

$$29 = AB \times \text{height} \text{ [From (1)]}$$

$$29 = 5.8 \times \text{height}$$

$$\text{Height} = 29/5.8$$

$$= 5$$

$\therefore$ Height of parallelogram ABEF is 5cm

(b) Given:

From fig (2)

area of $\triangle ABD$ is 24 sq. units. $AB = 8$ units

To find:

Height of ABC

Now, let us find

$$\text{We know that ar } \triangle ABD = 24 \text{ sq. units} \dots\dots (1)$$

$$\text{So, ar } \triangle ABD = \triangle ABC \dots\dots (2)$$

From (1) and (2)

$$\text{ar } \triangle ABC = 24 \text{ sq. units}$$

$$\frac{1}{2} \times AB \times \text{height} = 24$$

$$\frac{1}{2} \times 8 \times \text{height} = 24$$

$$4 \times \text{height} = 24$$

$$\text{Height} = 24/4$$

$$= 6$$

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$\therefore$ Height of $\triangle ABC = 6$ sq. units

(c) Given:

From fig (3)

In $\parallel gm ABCD$, E and F are mid points of sides AB and CD respectively.

$$ar(\parallel gm ABCD) = 36cm^2$$

To find:

(i) State the area of $\triangle APD$.

(ii) Name the parallelogram whose area is equal to the area of $\triangle APD$.

Now, let us find

(i) we know that $\triangle APD$ and $\parallel gm ABCD$ are on the same base AD and between the same parallel lines AD and BC.

$$ar(\triangle APD) = \frac{1}{2} ar(\parallel gm ABCD) \dots\dots (1)$$

$$ar(\parallel gm ABCD) = 36cm^2 \dots\dots (2)$$

From (1) and (2)

$$ar(\triangle APD) = \frac{1}{2} \times 36$$

$$= 18cm^2$$

(ii) we know that E and F are mid-points of AB and CD

In $\triangle CPD$, $EF \parallel PC$

Also, EF bisects the $\parallel gm ABCD$ in two equal parts.

So, $EF \parallel AD$ and $AE \parallel DF$

AEFD is a parallelogram.

$$ar(\parallel gm AEFD) = \frac{1}{2} ar(\parallel gm ABCD) \dots\dots\dots (3)$$

From (1) and (3)

$$ar(\triangle APD) = ar(\parallel gm AEFD)$$

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$\therefore$ AEFD is the required parallelogram which is equal to area of $\triangle APD$.

11. (a) In the figure (1) given below, ABCD is a parallelogram. Points P and Q on BC trisect BC into three equal parts. Prove that :

area of $\triangle APQ$ = area of $\triangle DPQ$ = $\frac{1}{6}$ (area of ||gm ABCD)

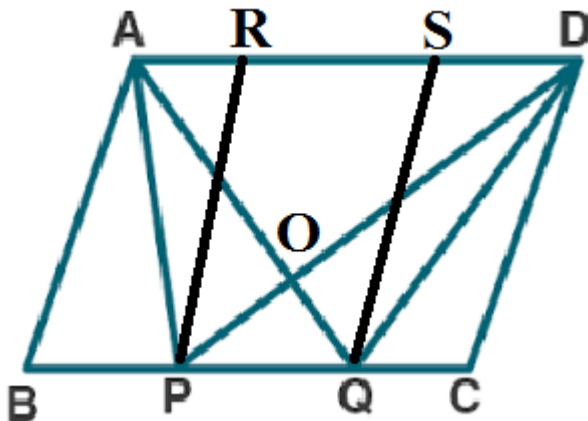
(b) In the figure (2) given below, DE is drawn parallel to the diagonal AC of the quadrilateral ABCD to meet BC produced at the point E. Prove that area of quad. ABCD = area of $\triangle ABE$.

(c) In the figure (3) given below, ABCD is a parallelogram. O is any point on the diagonal AC of the parallelogram. Show that the area of $\triangle AOB$ is equal to the area of $\triangle AOD$.

Solution:

(a) Given:

From fig (1)



In ||gm ABCD, points P and Q trisect BC into three equal parts.

To prove:

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area of $\triangle APQ$ = area of $\triangle DPQ$ = $\frac{1}{6}$ (area of $\parallel\text{gm ABCD}$)

Firstly, let us construct: through P and Q, draw PR and QS parallel to AB and CD.

Proof:

$\text{ar}(\triangle APD) = \text{ar}(\triangle AQD)$ [Since, $\triangle APD$ and $\triangle AQD$ lie on the same base AD and between the same parallel lines AD and BC]

$\text{ar}(\triangle APD) - \text{ar}(\triangle AOD) = \text{ar}(\triangle AQD) - \text{ar}(\triangle AOD)$ [On subtracting $\text{ar} \triangle AOD$ on both sides]

$\text{ar}(\triangle APO) = \text{ar}(\triangle OQD)$ (1)

$\text{ar}(\triangle APO) + \text{ar}(\triangle OPQ) = \text{ar}(\triangle OQD) + \text{ar}(\triangle OPQ)$ [On adding $\text{ar} \triangle OPQ$ on both sides]

$\text{ar}(\triangle APQ) = \text{ar}(\triangle DPQ)$ (2)

We know that, $\triangle APQ$ and $\parallel\text{gm PQSR}$ are on the same base PQ and between same parallel lines PQ and AD.

$\text{ar}(\triangle APQ) = \frac{1}{2} \text{ar}(\parallel\text{gm PQRS})$ (3)

Now, $[\text{ar}(\parallel\text{gm ABCD})/\text{ar}(\parallel\text{gm PQRS})] = [(BC \times \text{height})/(PQ \times \text{height})] = [(3PQ \times \text{height})/(1PQ \times \text{height})]$

$\text{ar}(\parallel\text{gm PQRS}) = \frac{1}{3} \text{ar}(\parallel\text{gm ABCD})$ (4)

by using (2), (3), (4), we get

$\text{ar}(\triangle APQ) = \text{ar}(\triangle DPQ)$

$= \frac{1}{2} \text{ar}(\parallel\text{gm PQRS})$

$= \frac{1}{2} \times \frac{1}{3} \text{ar}(\parallel\text{gm ABCD})$

$= \frac{1}{6} \text{ar}(\parallel\text{gm ABCD})$

Hence proved.

(b) Given:

In the figure (2) given below, $DE \parallel AC$ the diagonal of the quadrilateral ABCD to meet at point E on producing BC. Join AC, AE.

To prove:

area of quad. ABCD = area of $\triangle ABE$

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Proof:

We know that, $\triangle ACE$ and $\triangle ADE$ are on the same base AC and between the same parallelgram.

$$\text{ar}(\triangle ACE) = \text{ar}(\triangle ADC)$$

Now by adding $\text{ar}(\triangle ABC)$ on both sides, we get

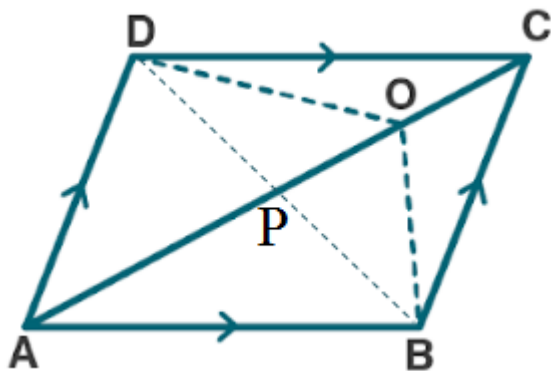
$$\text{ar}(\triangle ACE) + \text{ar}(\triangle ABC) = \text{ar}(\triangle ADC) + \text{ar}(\triangle ABC)$$

$$\text{ar}(\triangle ABE) = \text{ar quad. ABCD}$$

Hence proved.

(c) Given:

From fig (3)



In ||gm ABCD, O is any point on diagonal AC.

To prove:

area of $\triangle AOB$ is equal to the area of $\triangle AOD$

Proof:

Let us join BD which meets AC at P.

In $\triangle ABD$, AP is the median.

$$\text{ar}(\triangle ABP) = \text{ar}(\triangle ADP) \dots\dots (1)$$

$$\text{similarly, ar}(\triangle PBO) = \text{ar}(\triangle PDO) \dots\dots (2)$$

now add (1) and (2), we get

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$$\text{ar}(\triangle ABO) = \text{ar}(\triangle ADO) \dots (3)$$

so,

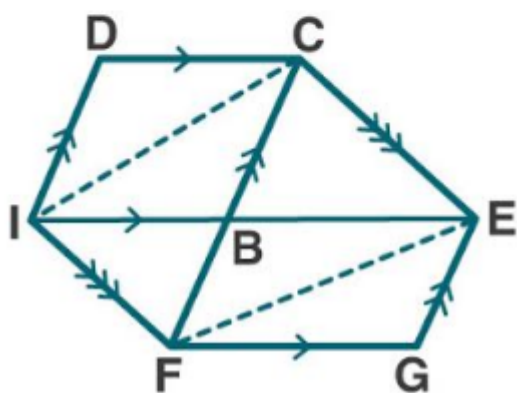
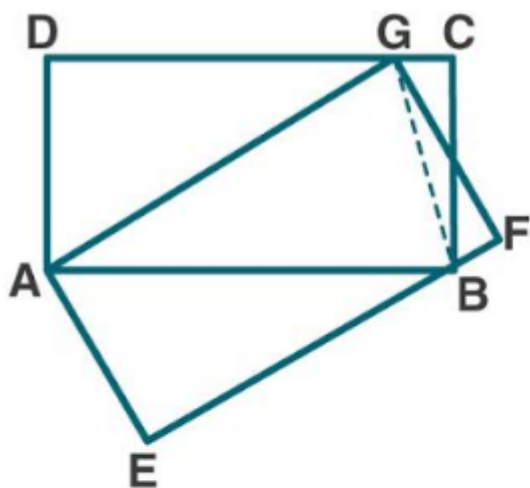
$$\triangle AOB = \triangle AOD$$

Hence proved.

12. (a) In the figure given, ABCD and AEFG are two parallelograms.

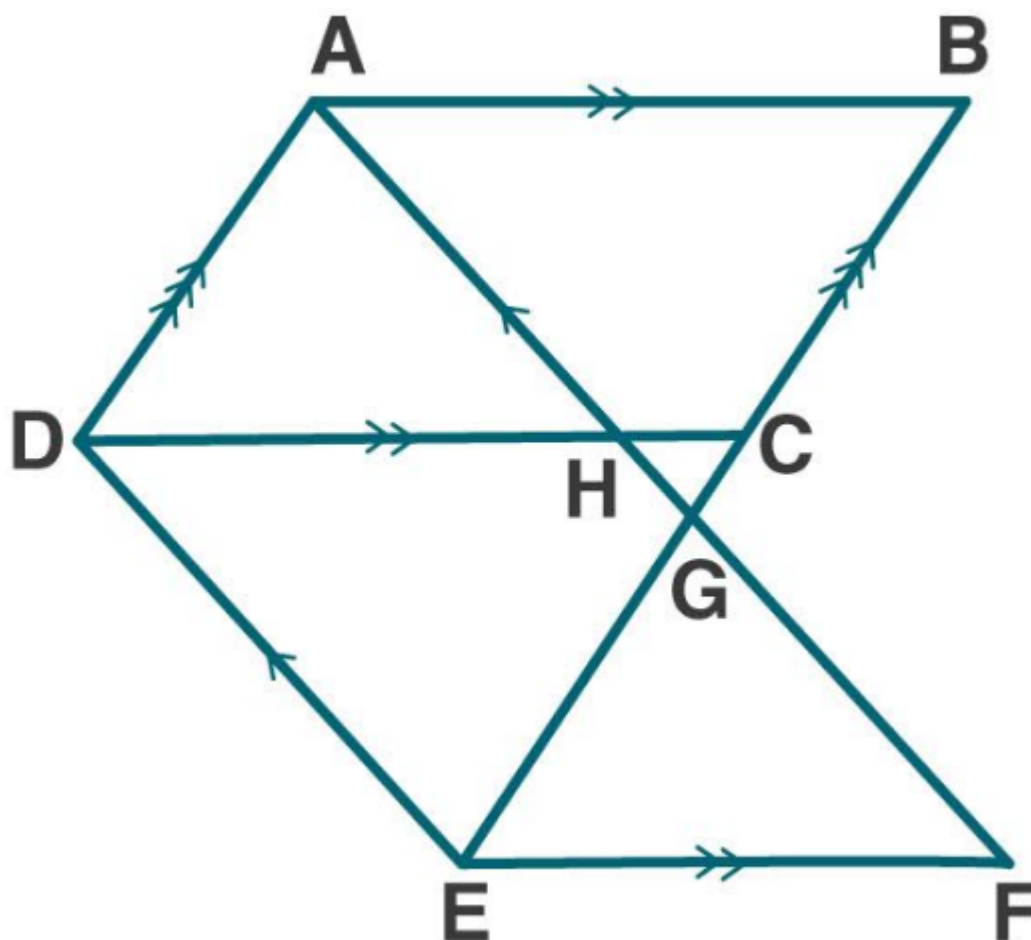
Prove that area of || gm ABCD = area of || gm AEFG.

(b) In the fig. (2) Given below, the side AB of the parallelogram ABCD is produced to E. A straight line through A is drawn parallel to CE to meet CB produced at F and parallelogram BFGE is Completed prove that area of || gm BFGE=Area of || gm ABCD.



(c) In the figure (3) given below $AB \parallel DC \parallel EF$, $AD \parallel BE$ and $DE \parallel AF$. Prove the area of $DEFH$ is equal to the area of $ABCD$.

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Solution:

(a) Given:

From fig (1)

ABCD and AEFG are two parallelograms as shown in the figure.

To prove:

area of $\parallel$ gm ABCD = area of $\parallel$ gm AEFG

Proof:

let us join BG.

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We know that,

$$\text{ar } (\triangle ABG) = \frac{1}{2} (\text{ar } \parallel\text{gm } ABCD) \dots\dots (1)$$

Similarly,

$$\text{ar } (\triangle ABG) = \frac{1}{2} (\text{ar } \parallel\text{gm } AEFG) \dots\dots (2)$$

From (1) and (2)

$$\frac{1}{2} (\text{ar } \parallel\text{gm } ABCD) = \frac{1}{2} (\text{ar } \parallel\text{gm } AEFG)$$

So,

$$\text{ar } \parallel\text{gm } ABCD = \text{ar } \parallel\text{gm } AEFG$$

Hence proved.

(b) Given:

From fig (2)

A parallelogram ABCD in which AB is produced to E. A straight line through A is drawn parallel to CE to meet CB produced at F and parallelogram BFGE is Completed.

To prove:

$$\text{area of } \parallel\text{ gm } BFGE = \text{Area of } \parallel\text{ gm } ABCD$$

Proof:

Let us join AC and EF.

We know that,

$$\text{ar } (\triangle AFC) = \text{ar } (\triangle AFE) \dots\dots (1)$$

now subtract ar $(\triangle ABF)$ on both sides, we get

$$\text{ar } (\triangle AFC) - \text{ar } (\triangle ABF) = \text{ar } (\triangle AFE) - \text{ar } (\triangle ABF)$$

$$\text{Or ar } (\triangle ABC) = \text{ar } (\triangle BEF)$$

Now multiply by 2 on both sides, we get

$$2. \text{ ar } (\triangle ABC) = 2. \text{ ar } (\triangle BEF)$$

$$\text{Or ar } (\parallel\text{gm } ABCD) = \text{ar } (\parallel\text{gm } BFGE)$$

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Hence proved.

(c) Given:

From fig (3)

$AB \parallel DC \parallel EF$, $AD \parallel BE$ and $DE \parallel AF$

To prove:

area of DEFH = area of ABCD

Proof:

We know that,

$DE \parallel AF$ and $AD \parallel BE$

It is given that ADEG is a parallelogram.

So,

$\text{ar}(\text{||gm ABCD}) = \text{ar}(\text{||gm ADEG}) \dots (1)$

Again, DEFG is a parallelogram.

$\text{ar}(\text{||gm DEFH}) = \text{ar}(\text{||gm ADEG}) \dots (2)$

From (1) and (2)

$\text{ar}(\text{||gm ABCD}) = \text{ar}(\text{||gm DEFH})$

Or $\text{ar ABCD} = \text{ar DEFH}$

Hence proved.

13. Any point D is taken on the side BC of, a $\triangle ABC$ and AD is produced to E such that $AD=DE$, prove that area of $\triangle BCE$ = area of $\triangle ABC$.

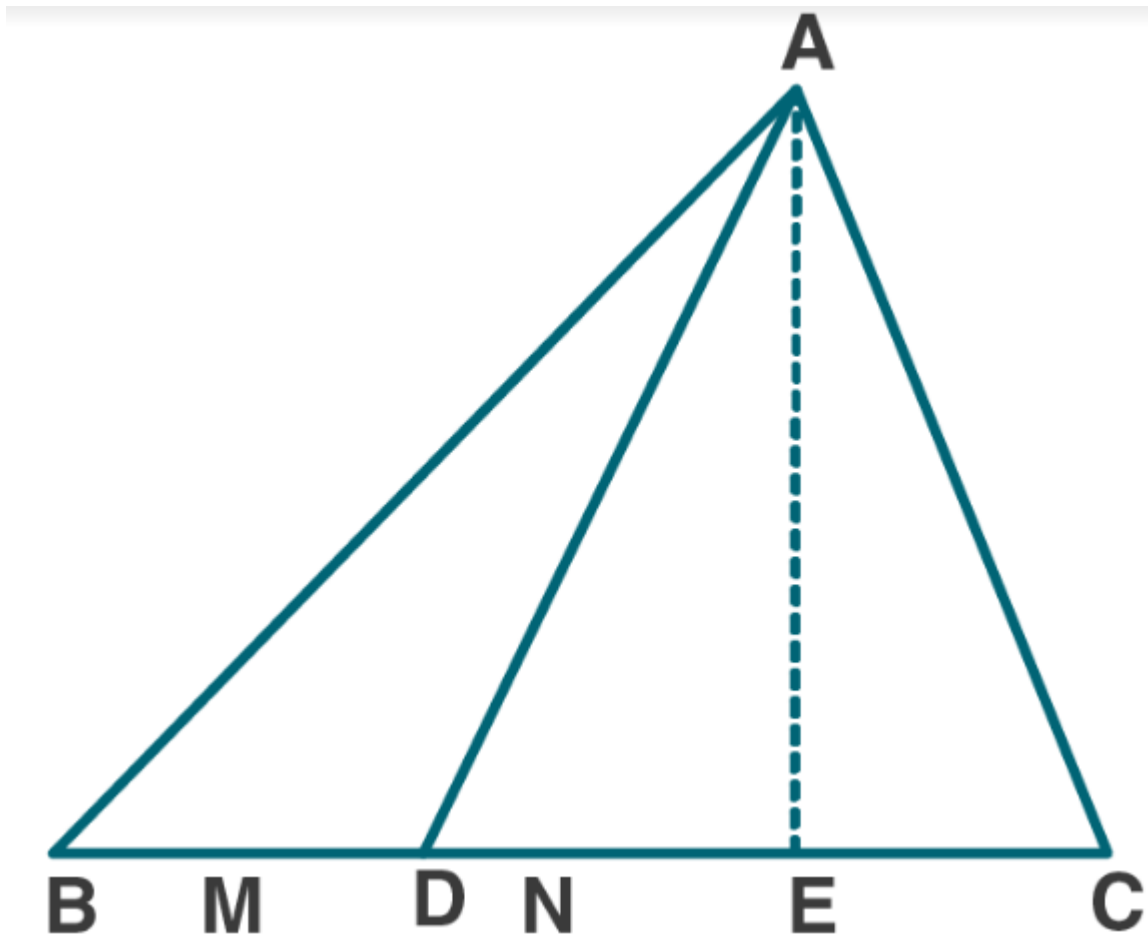
Solution:

Given:

In $\triangle ABC$, D is taken on the side BC.

AD produced to E such that $AD = DE$

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To prove:

area of $\triangle BCE$ = area of $\triangle ABC$

Proof:

In $\triangle ABE$, it is given that $AD = DE$

So, BD is the median of $\triangle ABE$

$\text{ar}(\triangle ABD) = \text{ar}(\triangle BED) \dots\dots (1)$

similarly,

In $\triangle ACE$, CD is the median of $\triangle ACE$

$\text{ar}(\triangle ACD) = \text{ar}(\triangle CED) \dots\dots (2)$

By adding (1) and (2), we get

$\text{ar}(\triangle ABD) + \text{ar}(\triangle ACD) = \text{ar}(\triangle BED) + \text{ar}(\triangle CED)$

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Or $\text{ar}(\triangle ABC) = \text{ar}(\triangle BCE)$

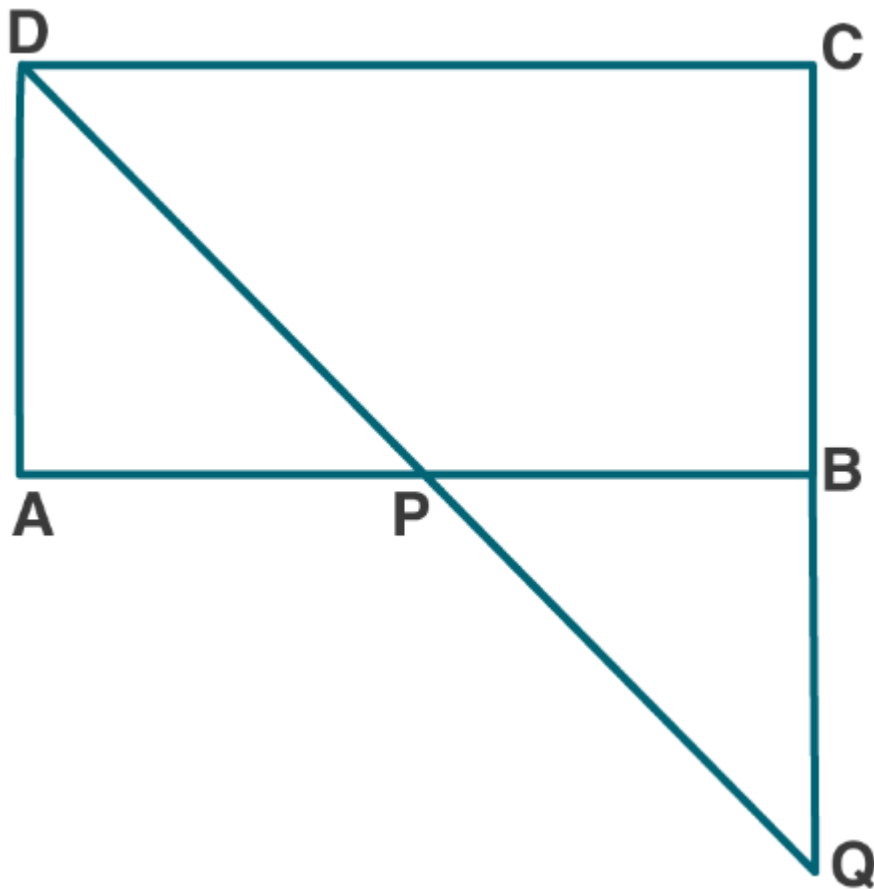
Hence proved.

14. ABCD is a rectangle and P is mid-point of AB. DP is produced to meet CB at Q. Prove that area of rectangle $\triangle BCD =$ area of $\triangle DQC$.

Solution:

Given:

ABCD is a rectangle and P is mid-point of AB. DP is produced to meet CB at Q.



To prove:

area of rectangle $\triangle BCD =$ area of $\triangle DQC$

Proof:

In $\triangle APD$ and $\triangle BQP$

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$AP = BP$ [Since, D is the mid-point of AB]

$\angle DAP = \angle QBP$ [each angle is 90°]

$\angle APD = \angle BPQ$ [vertically opposite angles]

So, $\triangle APD \cong \triangle BQP$ [By using ASA postulate]

$\text{ar}(\triangle APD) = \text{ar}(\triangle BQP)$

Now,

$\text{ar} ABCD = \text{ar}(\triangle APD) + \text{ar} PBCD$

$= \text{ar}(\triangle BQP) + \text{ar} PBCD$

$= \text{ar}(\triangle DQC)$

Hence proved.

15. (a) In the figure (1) given below, the perimeter of parallelogram is 42 cm. Calculate the lengths of the sides of the parallelogram.

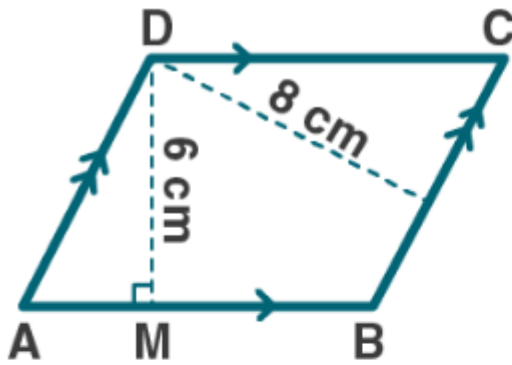
(b) In the figure (2) given below, the perimeter of $\triangle ABC$ is 37 cm. If the lengths of the altitudes AM, BN and CL are $5x$, $6x$, and $4x$ respectively, Calculate the lengths of the sides of $\triangle ABC$.

(c) In the fig. (3) Given below, ABCD is a parallelogram. P is a point on DC such that area of $\triangle DAP = 25 \text{ cm}^2$ and area of $\triangle BCP = 15 \text{ cm}^2$. Find

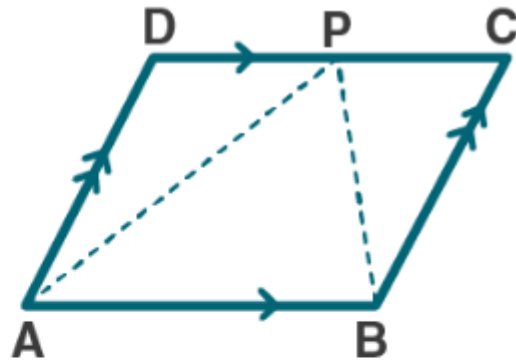
(i) area of || gm ABCD

(ii) DP: PC.

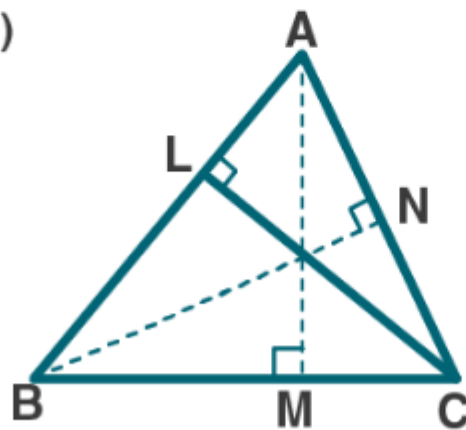
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(1)



(3)



(2)

Solution:

(a) Given:

The perimeter of parallelogram ABCD = 42 cm

To find:

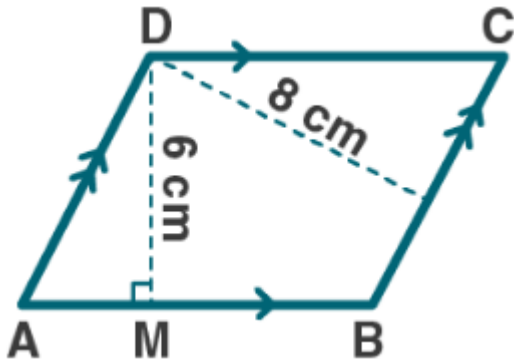
Lengths of the sides of the parallelogram ABCD.

From fig (1)

We know that,

$AB = P$

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Then, perimeter of $\parallel\text{gm ABCD} = 2 (AB + BC)$

$$42 = 2(P + BC)$$

$$42/2 = P + BC$$

$$21 = P + BC$$

$$BC = 21 - P$$

So, ar ($\parallel\text{gm ABCD}$) = $AB \times DM$

$$= P \times 6$$

$$= 6P \dots\dots\dots (1)$$

Again, ar ($\parallel\text{gm ABCD}$) = $BC \times DN$

$$= (21 - P) \times 8$$

$$= 8(21 - P) \dots\dots\dots (2)$$

From (1) and (2), we get

$$6P = 8(21 - P)$$

$$6P = 168 - 8P$$

$$6P + 8P = 168$$

$$14P = 168$$

$$P = 168/14$$

$$= 12$$

Hence, sides of $\parallel\text{gm}$ are

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$$AB = 12\text{cm and } BC = (21 - 12)\text{cm} = 9\text{cm}$$

(b) Given:

The perimeter of $\triangle ABC$ is 37 cm. The lengths of the altitudes AM, BN and CL are $5x$, $6x$, and $4x$ respectively.

To find:

Lengths of the sides of $\triangle ABC$. i.e., BC, CA and AB.

Let us consider $BC = P$ and $CA = Q$

From fig (2),

Then, perimeter of $\triangle ABC = AB + BC + CA$

$$37 = AB + P + Q$$

$$AB = 37 - P - Q$$

$$\text{Area } (\triangle ABC) = \frac{1}{2} \times \text{base} \times \text{height}$$

$$= \frac{1}{2} \times BC \times AM = \frac{1}{2} \times CA \times BN = \frac{1}{2} \times AB \times CL$$

$$= \frac{1}{2} \times P \times 5x = \frac{1}{2} \times Q \times 6x = \frac{1}{2} (37 - P - Q) \times 4x$$

$$= 5P/2 = 3Q = 2(37 - P - Q)$$

Let us consider first two parts:

$$5P/2 = 3Q$$

$$5P = 6Q$$

$$5P - 6Q = 0 \dots\dots (1)$$

$$25P - 30Q \text{ (multiplying by 5)} \dots\dots (2)$$

Let us consider second and third parts:

$$3Q = 2(37 - P - Q)$$

$$3Q = 74 - 2P - 2Q$$

$$3Q + 2Q + 2P = 74$$

$$2P + 5Q = 74 \dots\dots (3)$$

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$$12P + 30Q = 444 \text{ (multiplying by 6)..... (4)}$$

By adding (2) and (4), we get

$$37P = 444$$

$$P = 444/37$$

$$= 12$$

Now, substitute the value of P in equation (1), we get

$$5P - 6Q = 0$$

$$5(12) - 6Q = 0$$

$$60 = 6Q$$

$$Q = 60/6$$

$$= 10$$

$$\text{Hence, } BC = P = 12\text{cm}$$

$$CA = Q = 10\text{cm}$$

$$\text{And } AB = 37 - P - Q = 37 - 12 - 10 = 15\text{cm}$$

(c) Given:

ABCD is a parallelogram. P is a point on DC such that area of $\triangle DAP = 25 \text{ cm}^2$ and area of $\triangle BCP = 15 \text{ cm}^2$.

To Find:

(i) area of || gm ABCD

(ii) DP: PC

Now let us find,

From fig (3)

(i) we know that,

$$\text{ar } (\triangle APB) = \frac{1}{2} \text{ ar } (\text{||gm ABCD})$$

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Then,

$$\frac{1}{2} \text{ar} (\parallel\text{gm ABCD}) = \text{ar} (\triangle\text{DAP}) + \text{ar} (\triangle\text{BCP})$$

$$= 25 + 15$$

$$= 40\text{cm}^2$$

$$\text{So, ar} (\parallel\text{gm ABCD}) = 2 \times 40 = 80\text{cm}^2$$

(ii) we know that,

$\triangle\text{ADP}$ and $\triangle\text{BCP}$ are on the same base CD and between same parallel lines CD and AB.

$$\text{ar} (\triangle\text{DAP})/\text{ar}(\triangle\text{BCP}) = \text{DP}/\text{PC}$$

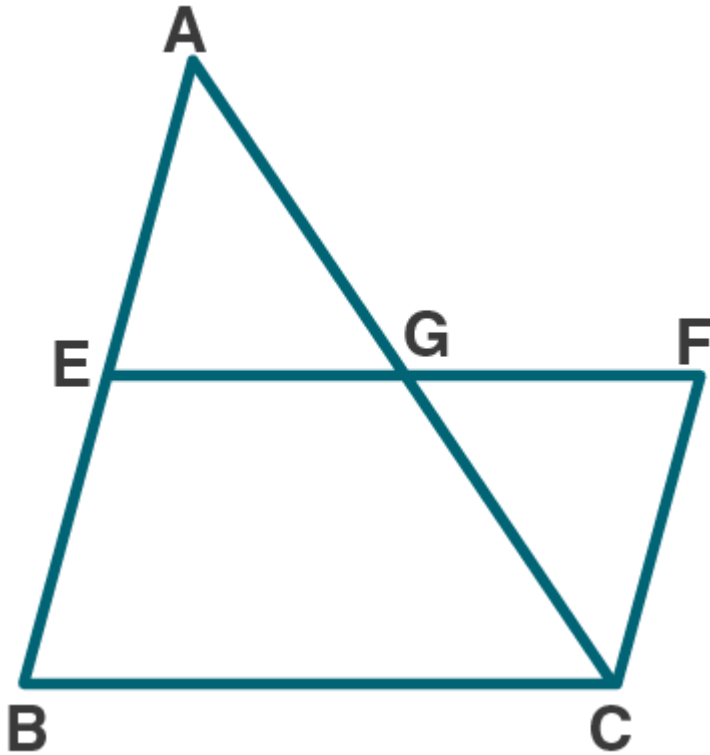
$$25/15 = \text{DP}/\text{PC}$$

$$5/3 = \text{DP}/\text{PC}$$

$$\text{So, DP: PC} = 5: 3$$

16. In the adjoining figure, E is mid-point of the side AB of a triangle ABC and EBCF is a parallelogram. If the area of $\triangle\text{ABC}$ is 25 sq. units, find the area of $\parallel\text{gm EBCF}$.

Solution:



Let us consider EF, side of ||gm BCFE meets AC at G.

We know that, E is the mid-point and $EF \parallel BC$

G is the mid-point of AC.

So,

$$AG = GC$$

Now, in $\triangle AEG$ and $\triangle CFG$,

The alternate angles are: $\angle EAG$, $\angle GCF$

Vertically opposite angles are: $\angle EGA = \angle CGF$

So, $AG = GC$

Proved.

$$\therefore \triangle AEG \cong \triangle CFG$$

$$\text{ar}(\triangle AEG) = \text{ar}(\triangle CFG)$$

Now,

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$$\text{ar} (\parallel\text{gm EBCF}) = \text{ar BCGE} + \text{ar} (\triangle CFG)$$

$$= \text{ar BCGE} + \text{ar} (\triangle AEG)$$

$$= \text{ar} (\triangle ABC)$$

We know that, $\text{ar} (\triangle ABC) = 25\text{sq. units}$

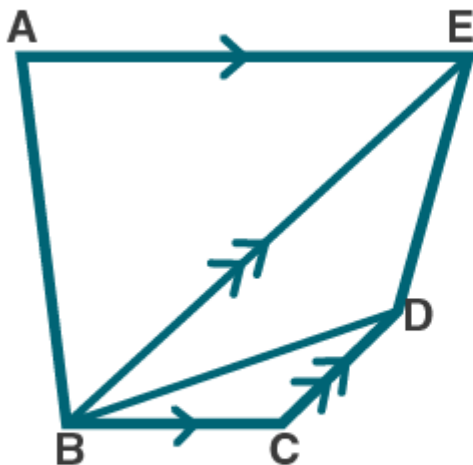
Hence, $\text{ar} (\parallel\text{gm EBCF}) = 25\text{sq. units}$

17. (a) In the figure (1) given below, $BC \parallel AE$ and $CD \parallel BE$. Prove that: area of $\triangle ABC =$ area of $\triangle EBD$.

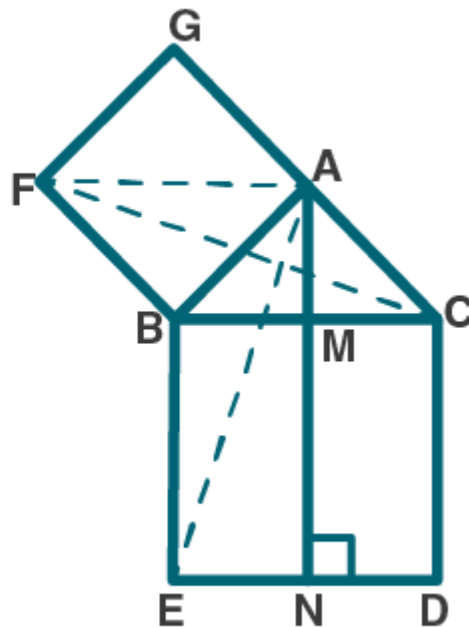
(b) In the figure (2) given below, ABC is right angled triangle at A . $AGFB$ is a square on the side AB and $BCDE$ is a square on the hypotenuse BC . If $AN \perp ED$, prove that:

(i) $\triangle BCF \cong \triangle ABE$.

(ii) area of square $ABFG =$ area of rectangle $BENM$.



(1)



(2)

<https://www.indcareer.com/schools/ml-aggarwal-solutions-for-class-9-maths-chapter-14-theorems-on-area/>

Solution:

(a) Given:

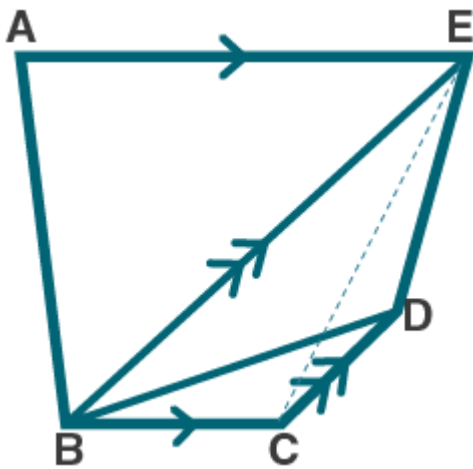
From fig (1)

$BC \parallel AE$ and $CD \parallel BE$

To prove:

area of $\triangle ABC$ = area of $\triangle EBD$

Proof:



By joining CE.

We know that, from $\triangle ABC$ and $\triangle EBC$

$\text{ar}(\triangle ABC) = \text{ar}(\triangle EBC) \dots\dots (1)$

From $\triangle EBC$ and $\triangle EBD$

$\text{ar}(\triangle EBC) = \text{ar}(\triangle EBD) \dots\dots (2)$

From (1) and (2), we get

$\text{ar}(\triangle ABC) = \text{ar}(\triangle EBD)$

Hence proved.

(b) Given:

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ABC is right angled triangle at A. Squares AGFB and BCDE are drawn on the side AB and hypotenuse BC of $\triangle ABC$. $AN \perp ED$ which meets BC at M.

To prove:

(i) $\triangle BCF \cong \triangle ABE$.

(ii) area of square ABFG = area of rectangle BENM

From the figure (2)

(i) $\angle FBC = \angle FBA + \angle ABC$

So,

$$\angle FBC = 90^\circ + \angle ABC \dots (1)$$

$$\angle ABE = \angle EAC + \angle ABC$$

So,

$$\angle ABE = 90^\circ + \angle ABC \dots (2)$$

From (1) and (2), we get

$$\angle FBC = \angle ABE \dots (3)$$

So, $BC = BE$

Now, in $\triangle BCF$ and $\triangle ABE$

$$BF = AB$$

By using SAS axiom rule of congruency,

$$\therefore \triangle BCF \cong \triangle ABE$$

Hence proved.

(ii) we know that,

$$\triangle BCF \cong \triangle ABE$$

$$\text{So, ar } (\triangle BCF) = \text{ar } (\triangle ABE) \dots (4)$$

$$\angle BAG + \angle BAC = 90^\circ + 90^\circ$$

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$$= 180^\circ$$

So, GAC is a straight line.

Now, from $\triangle BCF$ and square AGFB

$$\text{ar}(\triangle BCF) = \frac{1}{2} \text{ar}(\text{square AGFB}) \dots (5)$$

From $\triangle ABE$ and rectangle BENM

$$\text{ar}(\triangle ABE) = \frac{1}{2} \text{ar}(\text{rectangle BENM}) \dots (6)$$

From (4), (5) and (6)

$$\frac{1}{2} \text{ar}(\text{square AGFB}) = \frac{1}{2} \text{ar}(\text{rectangle BENM})$$

$$\text{ar}(\text{square AGFB}) = \text{ar}(\text{rectangle BENM})$$

Hence proved.

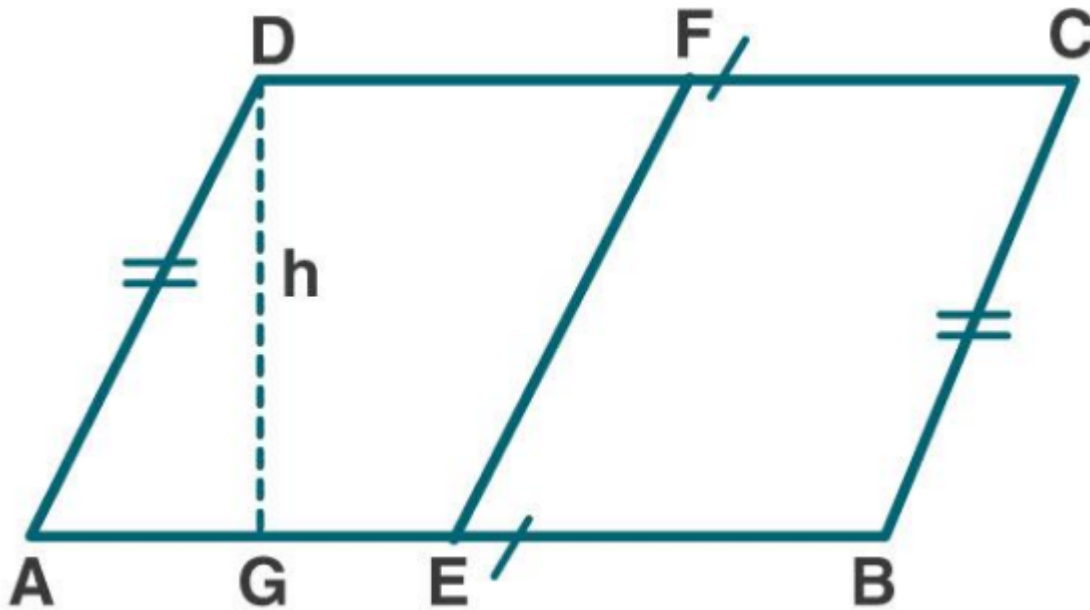
EXERCISE 14

1. Prove that the line segment joining the mid-points of a pair of opposite sides of a parallelogram divides it into two equal parallelograms.

Solution:

Let us consider ABCD be a parallelogram in which E and F are mid-points of AB and CD. Join EF.

To prove: $\text{ar}(\parallel \text{AEFD}) = \text{ar}(\parallel \text{EBCF})$



Let us construct $DG \perp AG$ and let $DG = h$ where, h is the altitude on side AB .

Proof:

$$\text{ar} (\parallel ABCD) = AB \times h$$

$$\text{ar} (\parallel AEFD) = AE \times h$$

$$= \frac{1}{2} AB \times h \dots\dots (1) \text{ [Since, E is the mid-point of AB]}$$

$$\text{ar} (\parallel EBCF) = EF \times h$$

$$= \frac{1}{2} AB \times h \dots\dots (2) \text{ [Since, E is the mid-point of AB]}$$

From (1) and (2)

$$\text{ar} (\parallel ABFD) = \text{ar} (\parallel EBCF)$$

Hence proved.

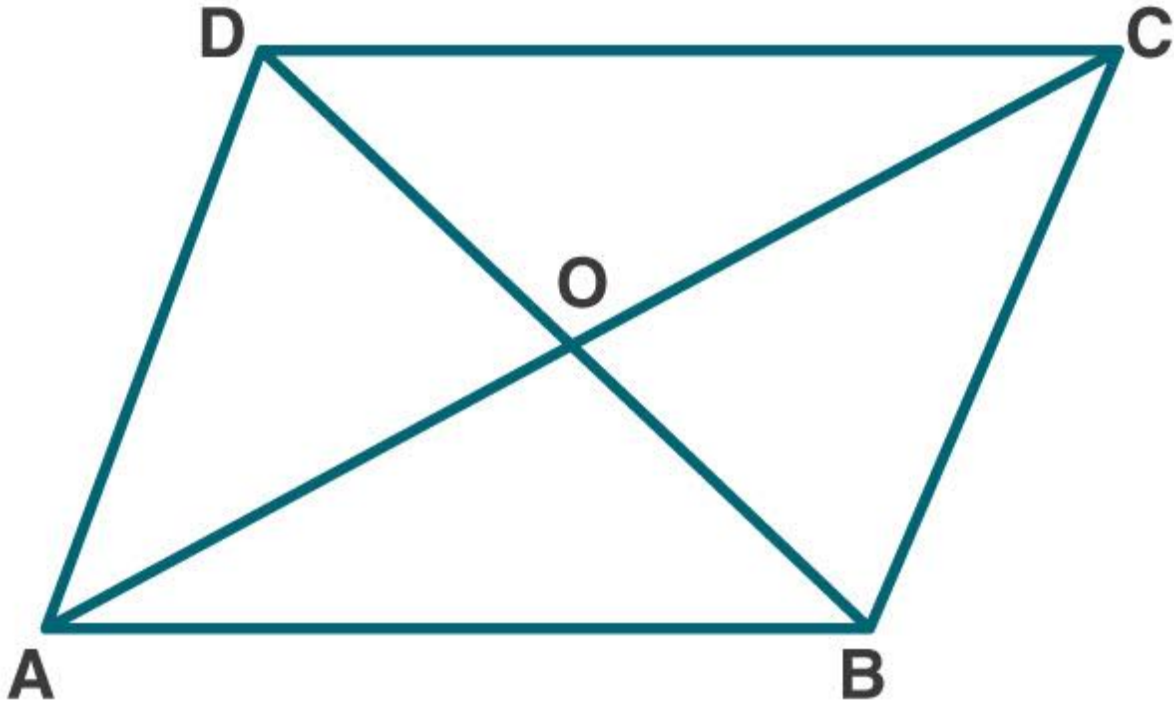
2. Prove that the diagonals of a parallelogram divide it into four triangles of equal area.

Solution:

Let us consider in a parallelogram $ABCD$ the diagonals AC and BD are cut at point O .

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To prove: $\text{ar}(\triangle AOB) = \text{ar}(\triangle BOC) = \text{ar}(\triangle COD) = \text{ar}(\triangle AOD)$



Proof:

In parallelogram ABCD the diagonals bisect each other.

$$AO = OC$$

In $\triangle ACD$, O is the mid-point of AC. DO is the median.

$$\text{ar}(\triangle AOD) = \text{ar}(\triangle COD) \dots\dots (1) \text{ [Median of } \triangle \text{ divides it into two triangles of equal areas]}$$

Similarly, in $\triangle ABC$

$$\text{ar}(\triangle AOB) = \text{ar}(\triangle COB) \dots\dots (2)$$

In $\triangle ADB$

$$\text{ar}(\triangle AOD) = \text{ar}(\triangle AOB) \dots\dots (3)$$

In $\triangle CDB$

$$\text{ar}(\triangle COD) = \text{ar}(\triangle COB) \dots\dots (4)$$

From (1), (2), (3) and (4)

$$\text{ar}(\triangle AOB) = \text{ar}(\triangle BOC) = \text{ar}(\triangle COD) = \text{ar}(\triangle AOD)$$

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Hence proved.

3. (a) In the figure (1) given below, AD is median of $\triangle ABC$ and P is any point on AD. Prove that

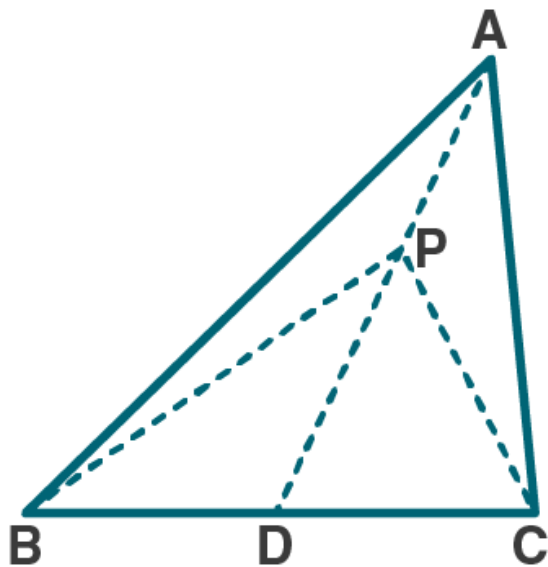
(i) Area of $\triangle PBD$ = area of $\triangle PDC$.

(ii) Area of $\triangle ABP$ = area of $\triangle ACP$.

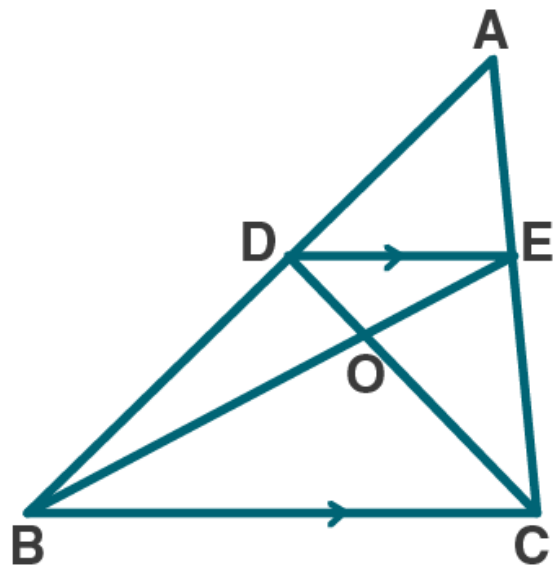
(b) In the figure (2) given below, $DE \parallel BC$. Prove that

(i) area of $\triangle ACD$ = area of $\triangle ABE$.

(ii) Area of $\triangle OBD$ = area of $\triangle OCE$.



(1)



(2)

Solution:

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(a) Given:

$\triangle ABC$ in which AD is the median. P is any point on AD. Join PB and PC.

To prove:

(i) Area of $\triangle PBD$ = area of $\triangle PDC$.

(ii) Area of $\triangle ABP$ = area of $\triangle ACP$.

Proof:

From fig (1)

AD is a median of $\triangle ABC$

So, $\text{ar}(\triangle ABD) = \text{ar}(\triangle ADC) \dots (1)$

Also, PD is the median of $\triangle BPD$

Similarly, $\text{ar}(\triangle PBD) = \text{ar}(\triangle PDC) \dots (2)$

Now, let us subtract (2) from (1), we get

$\text{ar}(\triangle ABD) - \text{ar}(\triangle PBD) = \text{ar}(\triangle ADC) - \text{ar}(\triangle PDC)$

Or $\text{ar}(\triangle ABP) = \text{ar}(\triangle ACP)$

Hence proved.

(b) Given:

$\triangle ABC$ in which $DE \parallel BC$

To prove:

(i) area of $\triangle ACD$ = area of $\triangle ABE$.

(ii) Area of $\triangle OBD$ = area of $\triangle OCE$.

Proof:

From fig (2)

$\triangle DEC$ and $\triangle BDE$ are on the same base DE and between the same $\parallel$ line DE and BE.

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$$\text{ar } (\triangle DEC) = \text{ar } (\triangle BDE)$$

Now add $\text{ar } (\triangle ADE)$ on both sides, we get

$$\text{ar } (\triangle DEC) + \text{ar } (\triangle ADE) = \text{ar } (\triangle BDE) + \text{ar } (\triangle ADE)$$

$$\text{ar } (\triangle ACD) = \text{ar } (\triangle ABE)$$

Hence proved.

$$\text{Similarly, ar } (\triangle DEC) = \text{ar } (\triangle BDE)$$

Subtract $\text{ar } (\triangle DOE)$ from both sides, we get

$$\text{ar } (\triangle DEC) - \text{ar } (\triangle DOE) = \text{ar } (\triangle BDE) - \text{ar } (\triangle DOE)$$

$$\text{ar } (\triangle OBD) = \text{ar } (\triangle OCE)$$

Hence proved.

4. (a) In the figure (1) given below, ABCD is a parallelogram and P is any point in BC. Prove that: Area of $\triangle ABP$ + area of $\triangle DPC$ = Area of $\triangle APD$.

(b) In the figure (2) given below, O is any point inside a parallelogram ABCD. Prove that:

(i) area of $\triangle OAB$ + area of $\triangle OCD$ = $\frac{1}{2}$ area of $\parallel$ gm ABCD

(ii) area of $\triangle OBC$ + area of $\triangle OAD$ = $\frac{1}{2}$ area of $\parallel$ gm ABCD

Solution:

(a) Given:

From fig (1)

ABCD is a parallelogram and P is any point in BC.

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To prove:

Area of $\triangle ABP$ + area of $\triangle DPC$ = Area of $\triangle APD$

Proof:

$\triangle APD$ and $\parallel$ gm ABCD are on the same base AD and between the same $\parallel$ lines AD and BC,

$$\text{ar}(\triangle APD) = \frac{1}{2} \text{ar}(\parallel \text{ gm ABCD}) \dots (1)$$

In parallelogram ABCD

$$\text{ar}(\parallel \text{ gm ABCD}) = \text{ar}(\triangle ABP) + \text{ar}(\triangle APD) + \text{ar}(\triangle DPC)$$

Now, divide both sides by 2, we get

$$\frac{1}{2} \text{ar}(\parallel \text{ gm ABCD}) = \frac{1}{2} \text{ar}(\triangle ABP) + \frac{1}{2} \text{ar}(\triangle APD) + \frac{1}{2} \text{ar}(\triangle DPC) \dots (2)$$

From (1) and (2)

$$\text{ar}(\triangle APD) = \frac{1}{2} \text{ar}(\parallel \text{ gm ABCD})$$

Substituting (2) in (1)

$$\text{ar}(\triangle APD) = \frac{1}{2} \text{ar}(\triangle ABP) + \frac{1}{2} \text{ar}(\triangle APD) + \frac{1}{2} \text{ar}(\triangle DPC)$$

$$\text{ar}(\triangle APD) - \frac{1}{2} \text{ar}(\triangle APD) = \frac{1}{2} \text{ar}(\triangle ABP) + \frac{1}{2} \text{ar}(\triangle DPC)$$

$$\frac{1}{2} \text{ar}(\triangle APD) = \frac{1}{2} [\text{ar}(\triangle ABP) + \text{ar}(\triangle DPC)]$$

$$\text{ar}(\triangle APD) = \text{ar}(\triangle ABP) + \text{ar}(\triangle DPC)$$

$$\text{Or } \text{ar}(\triangle ABP) + \text{ar}(\triangle DPC) = \text{ar}(\triangle APD)$$

Hence proved.

(b) Given:

From fig (2)

$\parallel$ gm ABCD in which O is any point inside it.

To prove:

(i) area of $\triangle OAB$ + area of $\triangle OCD$ = $\frac{1}{2}$ area of $\parallel$ gm ABCD

(ii) area of $\triangle OBC$ + area of $\triangle OAD$ = $\frac{1}{2}$ area of $\parallel$ gm ABCD

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Draw $POQ \parallel AB$ through O. It meets AD at P and BC at Q.

Proof:

(i) $AB \parallel PQ$ and $AP \parallel BQ$

ABQP is a $\parallel$ gm

Similarly, PQCD is a $\parallel$ gm

Now, $\triangle OAB$ and $\parallel$ gm ABQP are on same base AB and between same $\parallel$ lines AB and PQ

$$\text{ar}(\triangle OAB) = \frac{1}{2} \text{ar}(\parallel \text{gm ABQP}) \dots (1)$$

$$\text{Similarly, ar}(\triangle OCD) = \frac{1}{2} \text{ar}(\parallel \text{gm PQCD}) \dots (2)$$

Now by adding (1) and (2)

$$\text{ar}(\triangle OAB) + \text{ar}(\triangle OCD) = \frac{1}{2} \text{ar}(\parallel \text{gm ABQP}) + \frac{1}{2} \text{ar}(\parallel \text{gm PQCD})$$

$$= \frac{1}{2} [\text{ar}(\parallel \text{gm ABQP}) + \text{ar}(\parallel \text{gm PQCD})]$$

$$= \frac{1}{2} \text{ar}(\parallel \text{gm ABCD})$$

$$\text{ar}(\triangle OAB) + \text{ar}(\triangle OCD) = \frac{1}{2} \text{ar}(\parallel \text{gm ABCD})$$

Hence proved.

(ii) we know that,

$$\text{ar}(\triangle OAB) + \text{ar}(\triangle OBC) + \text{ar}(\triangle OCD) + \text{ar}(\triangle OAD) = \text{ar}(\parallel \text{gm ABCD})$$
$$[\text{ar}(\triangle OAB) + \text{ar}(\triangle OCD)] + [\text{ar}(\triangle OBC) + \text{ar}(\triangle OAD)] = \text{ar}(\parallel \text{gm ABCD})$$

$$\frac{1}{2} \text{ar}(\parallel \text{gm ABCD}) + \text{ar}(\triangle OBC) + \text{ar}(\triangle OAD) = \text{ar}(\parallel \text{gm ABCD})$$

$$\text{ar}(\triangle OBC) + \text{ar}(\triangle OAD) = \text{ar}(\parallel \text{gm ABCD}) - \frac{1}{2} \text{ar}(\parallel \text{gm ABCD})$$

$$\text{ar}(\triangle OBC) + \text{ar}(\triangle OAD) = \frac{1}{2} \text{ar}(\parallel \text{gm ABCD})$$

Hence proved.

5. If E, F, G and H are mid-points of the sides AB, BC, CD and DA respectively of a parallelogram ABCD, prove that area of quad. EFGH = $\frac{1}{2}$ area of $\parallel$ gm ABCD.

Solution:

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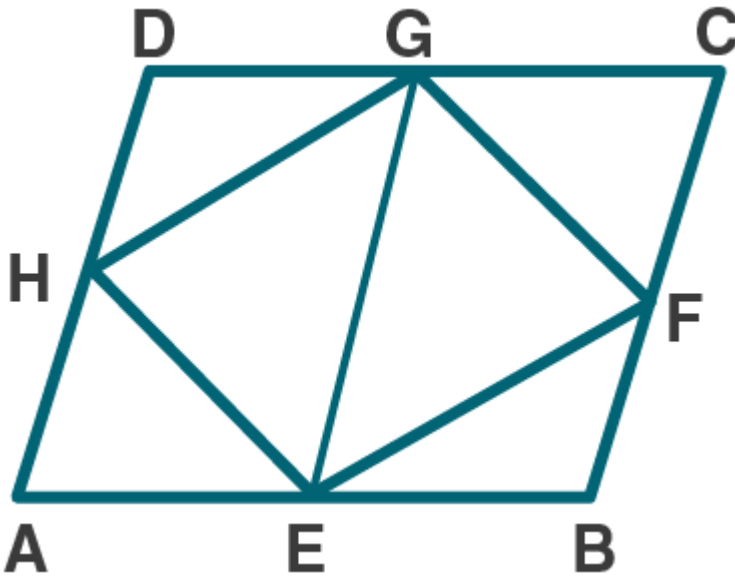
Given:

In parallelogram ABCD, E, F, G, H are the mid-points of its sides AB, BC, CD and DA.

Join EF, FG, GH and HE.

To prove:

area of quad. EFGH = $\frac{1}{2}$ area of || gm ABCD



Proof:

Let us join EG.

We know that, E and G are mid-points of AB and CD.

$EG \parallel AD \parallel BC$

AEGD and EBCG are parallelogram

Now, || gm AEGD and $\triangle EHG$ are on the same base and between the parallel lines.

ar $\triangle EHG = \frac{1}{2}$ ar || gm AEGD (1)

Similarly,

ar $\triangle EFG = \frac{1}{2}$ ar || gm EBCG (2)

Now by adding (1) and (2)

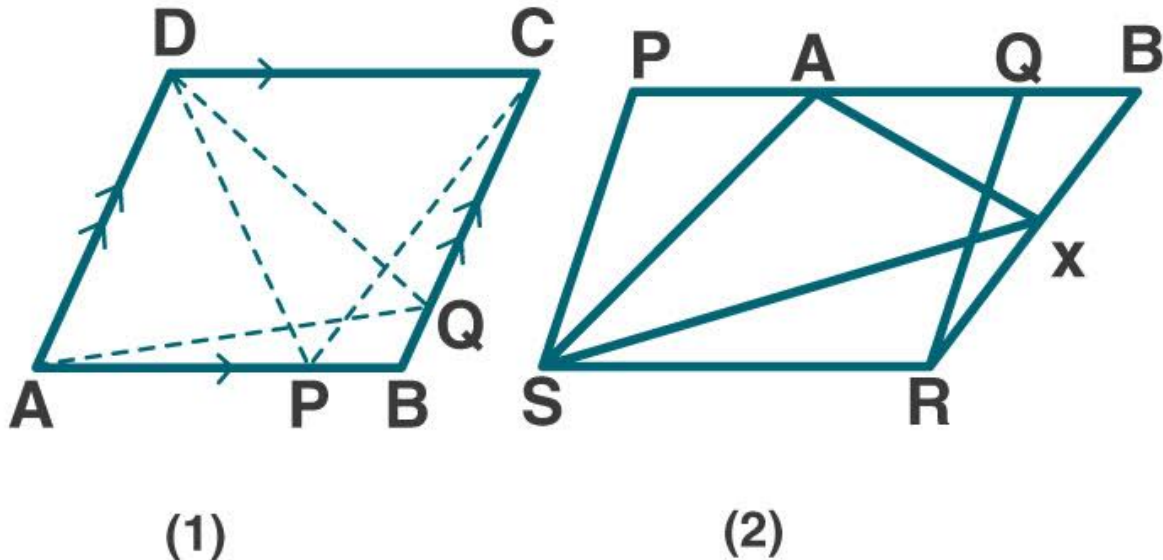
<https://www.indcareer.com/schools/ml-aggarwal-solutions-for-class-9-maths-chapter-14-theorems-on-area/>

$$\text{ar } \triangle EHG + \text{ar } \triangle EFG = \frac{1}{2} \text{ar } \parallel \text{gm AEGD} + \frac{1}{2} \text{ar } \parallel \text{gm EBCG}$$

$$\text{area quad. EFGH} = \frac{1}{2} \text{ar } \parallel \text{gm ABCD}$$

Hence proved.

6. (a) In the figure (1) given below, ABCD is a parallelogram. P, Q are any two points on the sides AB and BC respectively. Prove that, area of $\triangle CPD$ = area of $\triangle AQD$.



(b) In the figure (2) given below, PQRS and ABRS are parallelograms and X is any point on the side BR. Show that area of $\triangle AXS$ = $\frac{1}{2}$ area of $\parallel \text{gm PQRS}$.

Solution:

(a) Given:

From fig (1)

$\parallel \text{gm ABCD}$ in which P is a point on AB and Q is a point on BC.

To prove:

$$\text{area of } \triangle CPD = \text{area of } \triangle AQD.$$

Proof:

$\triangle CPD$ and $\parallel \text{gm ABCD}$ are on the same base CD and between the same parallels AB and CD.

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$$\text{ar } (\triangle CPD) = \frac{1}{2} \text{ar } (\parallel\text{gm } ABCD) \dots (1)$$

$\triangle AQD$ and $\parallel\text{gm } ABCD$ are on the same base AD and between the same parallels AD and BC .

$$\text{ar } (\triangle AQD) = \frac{1}{2} \text{ar } (\parallel\text{gm } ABCD) \dots (2)$$

from (1) and (2)

$$\text{ar } (\triangle CPD) = \text{ar } (\triangle AQD)$$

Hence proved.

(b) From fig (2)

Given:

$PQRS$ and $ABRS$ are parallelograms on the same base SR . X is any point on the side BR .

Join AX and SX .

To prove:

$$\text{area of } \triangle AXS = \frac{1}{2} \text{area of } \parallel\text{gm } PQRS$$

we know that, $\parallel\text{gm } PQRS$ and $ABRS$ are on the same base SR and between the same parallels.

$$\text{So, ar } \parallel\text{gm } PQRS = \text{ar } \parallel\text{gm } ABRS \dots (1)$$

we know that, $\triangle AXS$ and $\parallel\text{gm } ABRS$ are on the same base AS and between the same parallels.

$$\text{So, ar } \triangle AXS = \frac{1}{2} \text{ar } \parallel\text{gm } ABRS$$

$$= \frac{1}{2} \text{ar } \parallel\text{gm } PQRS \text{ [From (1)]}$$

Hence proved.

7. D, E and F are mid-point of the sides BC, CA and AB respectively of a $\triangle ABC$. Prove that

(i) FDCE is a parallelogram

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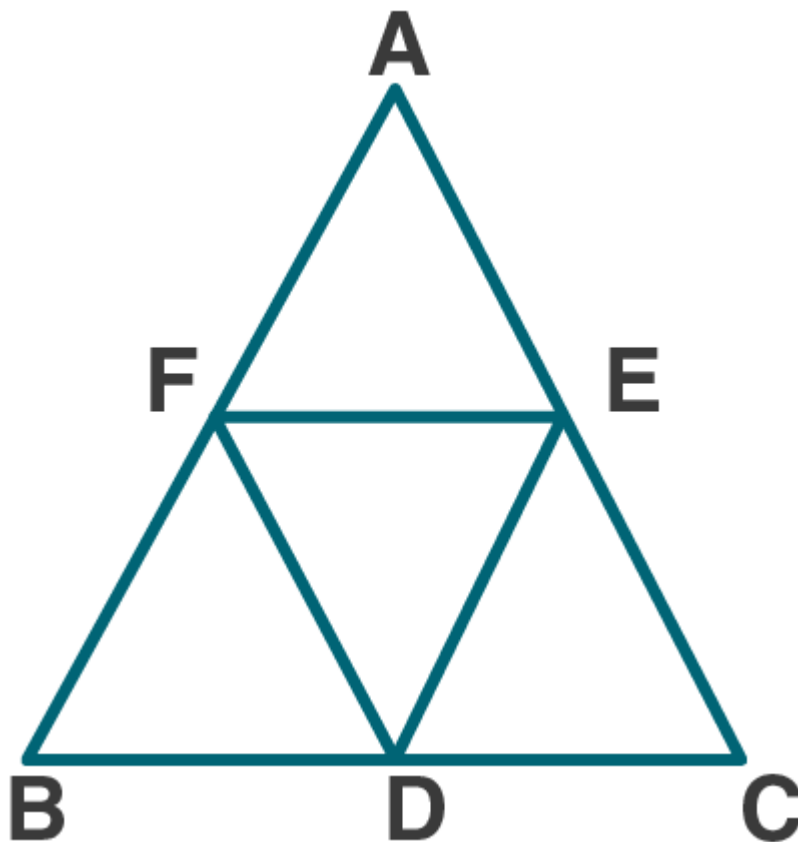
(ii) area of $\triangle DEF = \frac{1}{4}$ area of $\triangle ABC$

(iii) area of $\parallel gm FDCE = \frac{1}{2}$ area of $\triangle ABC$

Solution:

Given:

D, E and F are mid-point of the sides BC, CA and AB respectively of a $\triangle ABC$.



To prove:

(i) FDCE is a parallelogram

(ii) area of $\triangle DEF = \frac{1}{4}$ area of $\triangle ABC$

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(iii) area of $\parallel$ gm FDCE = $\frac{1}{2}$ area of $\triangle ABC$

Proof:

(i) F and E are mid-points of AB and AC.

So, FE $\parallel$ BC and FE = $\frac{1}{2}$ BC (1)

Also, D is mid-point of BC

CD = $\frac{1}{2}$ BC (2)

From (1) and (2)

FE $\parallel$ BC and FE = CD

FE $\parallel$ CD and FE = CD (3)

Similarly,

D and F are mid-points of BC and AB.

So, DF $\parallel$ EC is a parallelogram.

Hence proved.

(ii) we know that, FDCE is a parallelogram.

And DE is a diagonal of $\parallel$ gm FDCE

So, ar ($\triangle DEF$) = ar ($\triangle DEC$) (4)

Similarly, we know BDEF and DEAF are $\parallel$ gm

So, ar ($\triangle DEF$) = ar ($\triangle BDF$) = ar ($\triangle AFE$) (5)

From (4) and (5)

ar ($\triangle DEF$) = ar ($\triangle DEC$) = ar ($\triangle BDF$) = ar ($\triangle AFE$)

Now, ar ($\triangle ABC$) = ar ($\triangle DEF$) + ar ($\triangle DEF$) + ar ($\triangle DEF$) + ar ($\triangle DEF$)

= 4 ar ($\triangle DEF$)

ar ($\triangle DEF$) = $\frac{1}{4}$ ar ($\triangle ABC$) (6)

Hence proved.

(iii) ar of $\parallel$ gm FDCE = ar ($\triangle DEF$) + ar ($\triangle DEC$)

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$$= \text{ar} (\triangle DEF) + \text{ar} (\triangle DEF)$$

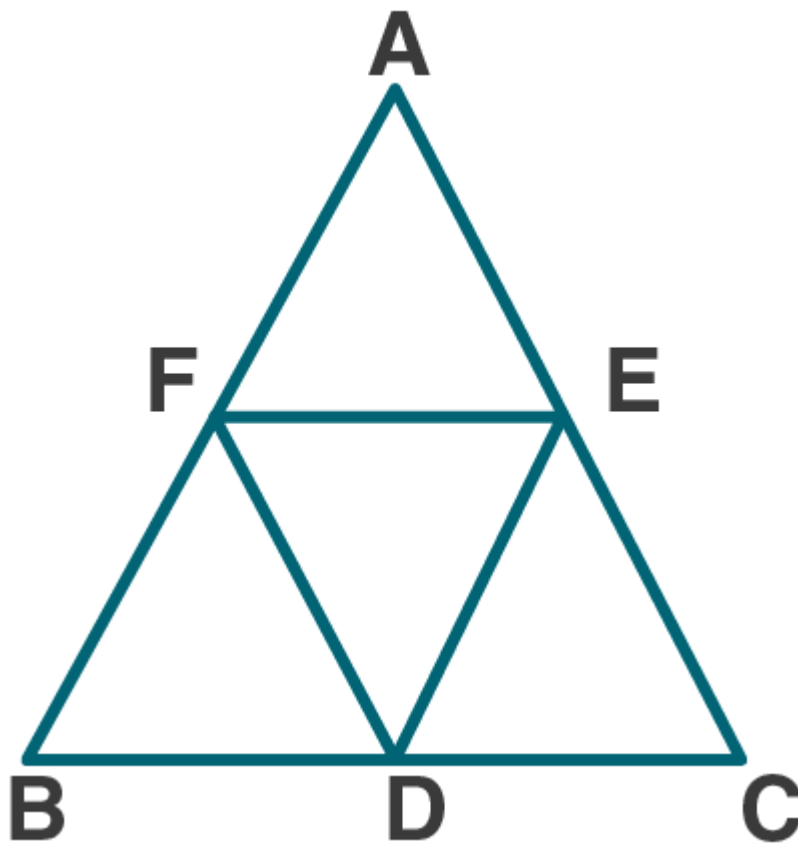
$$= 2 \text{ ar} (\triangle DEF) \text{ [From (4)]}$$

$$= 2 \left[\frac{1}{4} \text{ ar} (\triangle ABC) \right] \text{ [From (6)]}$$

$$\text{ar of } \parallel \text{ gm FDCE} = \frac{1}{2} \text{ ar of } \triangle ABC$$

Hence proved.

8. In the given figure, D, E and F are mid points of the sides BC, CA and AB respectively of $\triangle ABC$. Prove that BCEF is a trapezium and area of trap. BCEF = $\frac{3}{4}$ area of $\triangle ABC$.



Solution:

Given:

In $\triangle ABC$, D, E and F are mid points of the sides BC, CA and AB.

To prove:

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area of trap. BCEF = $\frac{3}{4}$ area of $\triangle ABC$

Proof:

We know that D and E are the mid-points of BC and CA.

So, $DE \parallel AB$ and $\frac{1}{2} AB$

Similarly,

$EF \parallel BC$ and $\frac{1}{2} BC$

And $FD \parallel AC$ and $\frac{1}{2} AC$

$\therefore$ BDEF, CDFE, AFDE are parallelograms which are equal in area.

ED, DF, EF are diagonals of these ||gm which divides the corresponding parallelogram into two triangles equal in area.

Hence, BCEF is a trapezium.

area of trap. BCEF = $\frac{3}{4}$ area of $\triangle ABC$

9. (a) In the figure (1) given below, the point D divides the side BC of $\triangle ABC$ in the ratio m: n. Prove that area of $\triangle ABD$: area of $\triangle ADC$ = m: n.

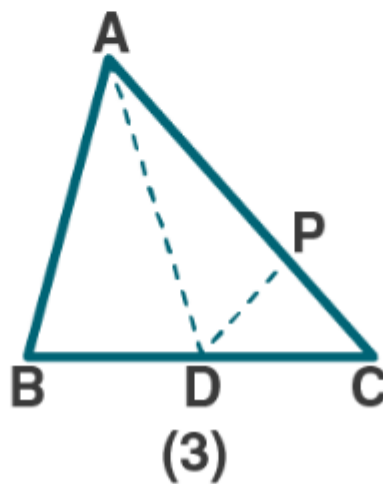
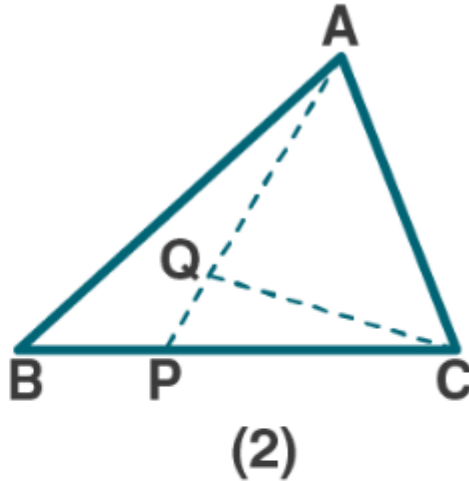
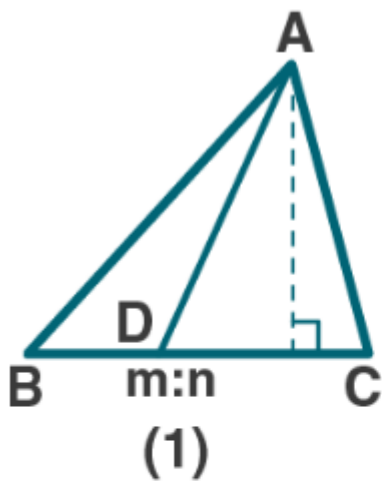
(b) In the figure (2) given below, P is a point on the side BC of $\triangle ABC$ such that $PC = 2BP$, and Q is a point on AP such that $QA = 5PQ$, find area of $\triangle AQC$: area of $\triangle ABC$.

(c) In the figure (3) given below, AD is a median of $\triangle ABC$ and P is a point in AC such that area of $\triangle ADP$: area of $\triangle ABD$ = 2:3. Find

(i) AP: PC

(ii) area of $\triangle PDC$: area of $\triangle ABC$.

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Solution:

(a) Given:

From fig (1)

In $\triangle ABC$, the point D divides the side BC in the ratio m: n.

BD: DC = m: n

To prove:

area of $\triangle ABD$: area of $\triangle ADC$ = m: n

Proof:

area of $\triangle ABD$ = $\frac{1}{2} \times \text{base} \times \text{height}$

ar ($\triangle ABD$) = $\frac{1}{2} \times BD \times AE$ (1)

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$$\text{ar } (\triangle ACD) = \frac{1}{2} \times DC \times AE \dots\dots (2)$$

let us divide (1) by (2) $[\text{ar } (\triangle ABD) = \frac{1}{2} \times BD \times AE] / [\text{ar } (\triangle ACD) = \frac{1}{2} \times DC \times AE]$ $[\text{ar } (\triangle ABD)] / [\text{ar } (\triangle ACD)] = BD/DC$

$$= m/n \text{ [it is given that, } BD: DC = m: n]$$

Hence proved.

(b) Given:

From fig (2)

In $\triangle ABC$, P is a point on the side BC such that $PC = 2BP$, and Q is a point on AP such that $QA = 5PQ$.

To Find:

area of $\triangle AQC$: area of $\triangle ABC$

Now,

It is given that: $PC = 2BP$

$$PC/2 = BP$$

We know that, $BC = BP + PC$

Now substitute the values, we get

$$BC = BP + PC$$

$$= PC/2 + PC$$

$$= (PC + 2PC)/2$$

$$= 3PC/2$$

$$2BC/3 = PC$$

$$\text{ar } (\triangle APC) = \frac{2}{3} \text{ ar } (\triangle ABC) \dots\dots (1)$$

It is given that, $QA = 5PQ$

$$QA/5 = PQ$$

We know that, $QA = PQ + QA$

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So, $QA = \frac{5}{6} AP$

$$\text{ar}(\triangle AQC) = \frac{5}{6} \text{ar}(\triangle APC)$$

$$= \frac{5}{6} \left(\frac{2}{3} \text{ar}(\triangle ABC)\right) \text{ [From (1)]}$$

$$\text{ar}(\triangle AQC) = \frac{5}{9} \text{ar}(\triangle ABC)$$

$$\text{ar}(\triangle AQC) / \text{ar}(\triangle AQC) = 5/9$$

Hence proved.

(c) Given:

From fig (3)

AD is a median of $\triangle ABC$ and P is a point in AC such that area of $\triangle ADP$: area of $\triangle ABD = 2:3$

To Find:

(i) AP: PC

(ii) area of $\triangle PDC$: area of $\triangle ABC$

Now,

(i) we know that AD is the median of $\triangle ABC$

$$\text{ar}(\triangle ABD) = \text{ar}(\triangle ADC) = \frac{1}{2} \text{ar}(\triangle ABC) \dots\dots (1)$$

It is given that,

$$\text{ar}(\triangle ADP) : \text{ar}(\triangle ABD) = 2 : 3$$

$$AP : AC = 2 : 3$$

$$AP/AC = 2/3$$

$$AP = \frac{2}{3} AC$$

Now,

$$PC = AC - AP$$

$$= AC - \frac{2}{3} AC$$

$$= (3AC - 2AC)/3$$

$$= AC/3 \dots\dots (2)$$

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So,

$$AP/PC = (2/3 AC) / (AC/3)$$

$$= 2/1$$

$$AP: PC = 2:1$$

(ii) we know that from (2)

$$PC = AC/3$$

$$PC/AC = 1/3$$

So,

$$\text{ar } (\triangle PDC)/\text{ar } (\triangle ADC) = PC/AC$$

$$= 1/3$$

$$\text{ar } (\triangle PDC)/1/2 \text{ ar } (\triangle ABC) = 1/3$$

$$\text{ar } (\triangle PDC)/\text{ar } (\triangle ABC) = 1/3 \times 1/2$$

$$= 1/6$$

$$\text{ar } (\triangle PDC): \text{ar } (\triangle ABC) = 1: 6$$

Hence proved.

10. (a) In the figure (1) given below, area of parallelogram ABCD is 29 cm^2 . Calculate the height of parallelogram ABEF if $AB = 5.8 \text{ cm}$

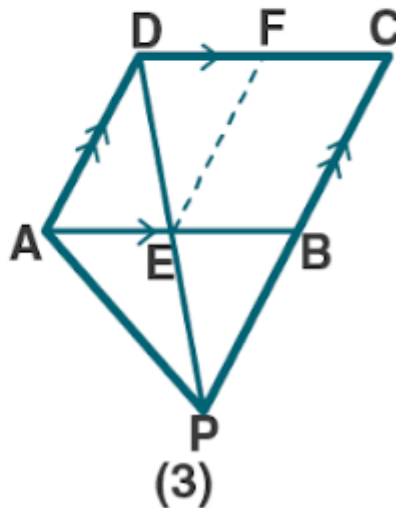
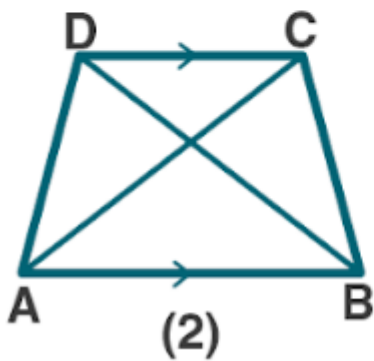
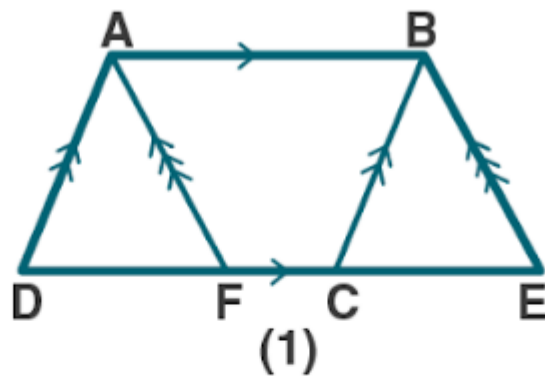
(b) In the figure (2) given below, area of $\triangle ABD$ is 24 sq. units . If $AB = 8 \text{ units}$, find the height of ABC.

(c) In the figure (3) given below, E and F are mid points of sides AB and CD respectively of parallelogram ABCD. If the area of parallelogram ABC is 36 cm^2 .

(i) State the area of $\triangle APD$.

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(ii) Name the parallelogram whose area is equal to the area of $\triangle APD$.



Solution:

(a) Given:

From fig (1)

ar ||gm ABCD = 29cm^2

To find:

Height of parallelogram ABEF if AB = 5.8 cm

Now, let us find

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We know that $\parallel\text{gm ABCD}$ and $\parallel\text{gm ABEF}$ with equal bases and between the same parallels so that their areas are same.

$$\text{ar}(\parallel\text{gm ABEF}) = \text{ar}(\parallel\text{gm ABCD})$$

$$\text{ar}(\parallel\text{gm ABEF}) = 29\text{cm}^2 \dots\dots (1) \text{ [Since, ar } \parallel\text{gm ABCD} = 29\text{cm}^2]$$

$$\text{also, ar}(\parallel\text{gm ABEF}) = \text{base} \times \text{height}$$

$$29 = \text{AB} \times \text{height} \text{ [From (1)]}$$

$$29 = 5.8 \times \text{height}$$

$$\text{Height} = 29/5.8$$

$$= 5$$

$\therefore$ Height of parallelogram ABEF is 5cm

(b) Given:

From fig (2)

area of $\triangle ABD$ is 24 sq. units. $\text{AB} = 8$ units

To find:

Height of ABC

Now, let us find

$$\text{We know that ar } \triangle ABD = 24 \text{ sq. units} \dots\dots (1)$$

$$\text{So, ar } \triangle ABD = \triangle ABC \dots\dots (2)$$

From (1) and (2)

$$\text{ar } \triangle ABC = 24 \text{ sq. units}$$

$$\frac{1}{2} \times \text{AB} \times \text{height} = 24$$

$$\frac{1}{2} \times 8 \times \text{height} = 24$$

$$4 \times \text{height} = 24$$

$$\text{Height} = 24/4$$

$$= 6$$

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$\therefore$ Height of $\triangle ABC = 6$ sq. units

(c) Given:

From fig (3)

In $\parallel gm ABCD$, E and F are mid points of sides AB and CD respectively.

$$ar(\parallel gm ABCD) = 36cm^2$$

To find:

(i) State the area of $\triangle APD$.

(ii) Name the parallelogram whose area is equal to the area of $\triangle APD$.

Now, let us find

(i) we know that $\triangle APD$ and $\parallel gm ABCD$ are on the same base AD and between the same parallel lines AD and BC.

$$ar(\triangle APD) = \frac{1}{2} ar(\parallel gm ABCD) \dots (1)$$

$$ar(\parallel gm ABCD) = 36cm^2 \dots (2)$$

From (1) and (2)

$$ar(\triangle APD) = \frac{1}{2} \times 36$$

$$= 18cm^2$$

(ii) we know that E and F are mid-points of AB and CD

In $\triangle CPD$, $EF \parallel PC$

Also, EF bisects the $\parallel gm ABCD$ in two equal parts.

So, $EF \parallel AD$ and $AE \parallel DF$

AEFD is a parallelogram.

$$ar(\parallel gm AEFD) = \frac{1}{2} ar(\parallel gm ABCD) \dots (3)$$

From (1) and (3)

$$ar(\triangle APD) = ar(\parallel gm AEFD)$$

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∴ AEFD is the required parallelogram which is equal to area of $\triangle APD$.

11. (a) In the figure (1) given below, ABCD is a parallelogram. Points P and Q on BC trisect BC into three equal parts. Prove that :

area of $\triangle APQ$ = area of $\triangle DPQ$ = $\frac{1}{6}$ (area of ||gm ABCD)

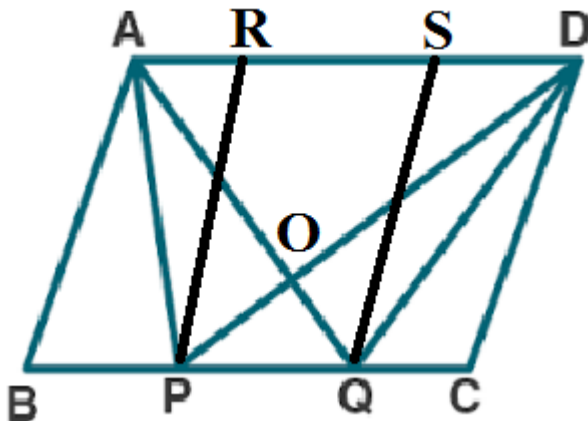
(b) In the figure (2) given below, DE is drawn parallel to the diagonal AC of the quadrilateral ABCD to meet BC produced at the point E. Prove that area of quad. ABCD = area of $\triangle ABE$.

(c) In the figure (3) given below, ABCD is a parallelogram. O is any point on the diagonal AC of the parallelogram. Show that the area of $\triangle AOB$ is equal to the area of $\triangle AOD$.

Solution:

(a) Given:

From fig (1)



In ||gm ABCD, points P and Q trisect BC into three equal parts.

To prove:

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area of $\triangle APQ$ = area of $\triangle DPQ$ = $\frac{1}{6}$ (area of $\parallel\text{gm ABCD}$)

Firstly, let us construct: through P and Q, draw PR and QS parallel to AB and CD.

Proof:

$\text{ar}(\triangle APD) = \text{ar}(\triangle AQD)$ [Since, $\triangle APD$ and $\triangle AQD$ lie on the same base AD and between the same parallel lines AD and BC]

$\text{ar}(\triangle APD) - \text{ar}(\triangle AOD) = \text{ar}(\triangle AQD) - \text{ar}(\triangle AOD)$ [On subtracting $\text{ar} \triangle AOD$ on both sides]

$\text{ar}(\triangle APO) = \text{ar}(\triangle OQD)$ (1)

$\text{ar}(\triangle APO) + \text{ar}(\triangle OPQ) = \text{ar}(\triangle OQD) + \text{ar}(\triangle OPQ)$ [On adding $\text{ar} \triangle OPQ$ on both sides]

$\text{ar}(\triangle APQ) = \text{ar}(\triangle DPQ)$ (2)

We know that, $\triangle APQ$ and $\parallel\text{gm PQSR}$ are on the same base PQ and between same parallel lines PQ and AD.

$\text{ar}(\triangle APQ) = \frac{1}{2} \text{ar}(\parallel\text{gm PQRS})$ (3)

Now, $[\text{ar}(\parallel\text{gm ABCD})/\text{ar}(\parallel\text{gm PQRS})] = [(BC \times \text{height})/(PQ \times \text{height})] = [(3PQ \times \text{height})/(1PQ \times \text{height})]$

$\text{ar}(\parallel\text{gm PQRS}) = \frac{1}{3} \text{ar}(\parallel\text{gm ABCD})$ (4)

by using (2), (3), (4), we get

$\text{ar}(\triangle APQ) = \text{ar}(\triangle DPQ)$

$= \frac{1}{2} \text{ar}(\parallel\text{gm PQRS})$

$= \frac{1}{2} \times \frac{1}{3} \text{ar}(\parallel\text{gm ABCD})$

$= \frac{1}{6} \text{ar}(\parallel\text{gm ABCD})$

Hence proved.

(b) Given:

In the figure (2) given below, $DE \parallel AC$ the diagonal of the quadrilateral ABCD to meet at point E on producing BC. Join AC, AE.

To prove:

area of quad. ABCD = area of $\triangle ABE$

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Proof:

We know that, $\triangle ACE$ and $\triangle ADE$ are on the same base AC and between the same parallelgram.

$$\text{ar}(\triangle ACE) = \text{ar}(\triangle ADC)$$

Now by adding $\text{ar}(\triangle ABC)$ on both sides, we get

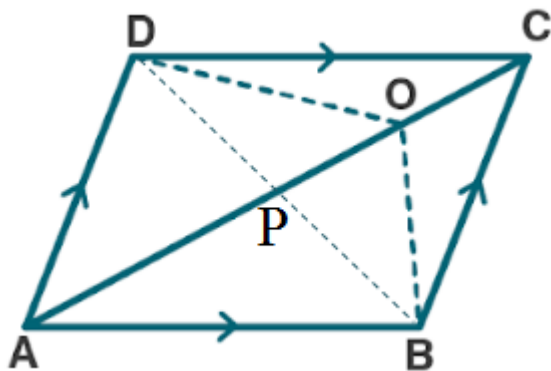
$$\text{ar}(\triangle ACE) + \text{ar}(\triangle ABC) = \text{ar}(\triangle ADC) + \text{ar}(\triangle ABC)$$

$$\text{ar}(\triangle ABE) = \text{ar quad. ABCD}$$

Hence proved.

(c) Given:

From fig (3)



In ||gm ABCD, O is any point on diagonal AC.

To prove:

area of $\triangle AOB$ is equal to the area of $\triangle AOD$

Proof:

Let us join BD which meets AC at P.

In $\triangle ABD$, AP is the median.

$$\text{ar}(\triangle ABP) = \text{ar}(\triangle ADP) \dots\dots (1)$$

$$\text{similarly, ar}(\triangle PBO) = \text{ar}(\triangle PDO) \dots\dots (2)$$

now add (1) and (2), we get

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$$\text{ar}(\triangle ABO) = \text{ar}(\triangle ADO) \dots (3)$$

so,

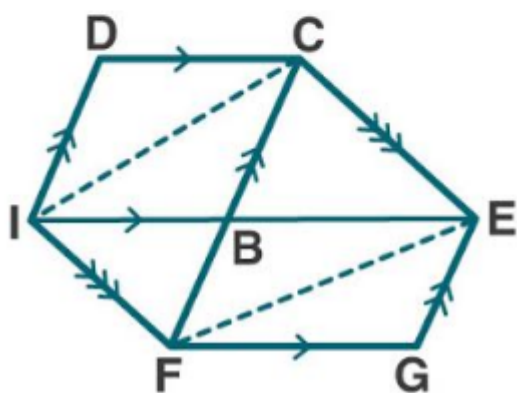
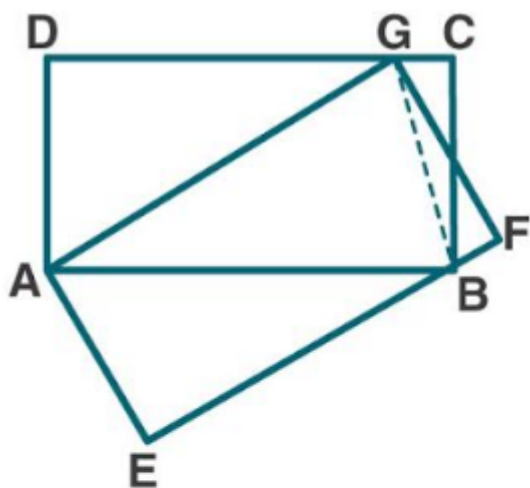
$$\triangle AOB = \triangle AOD$$

Hence proved.

12. (a) In the figure given, ABCD and AEFG are two parallelograms.

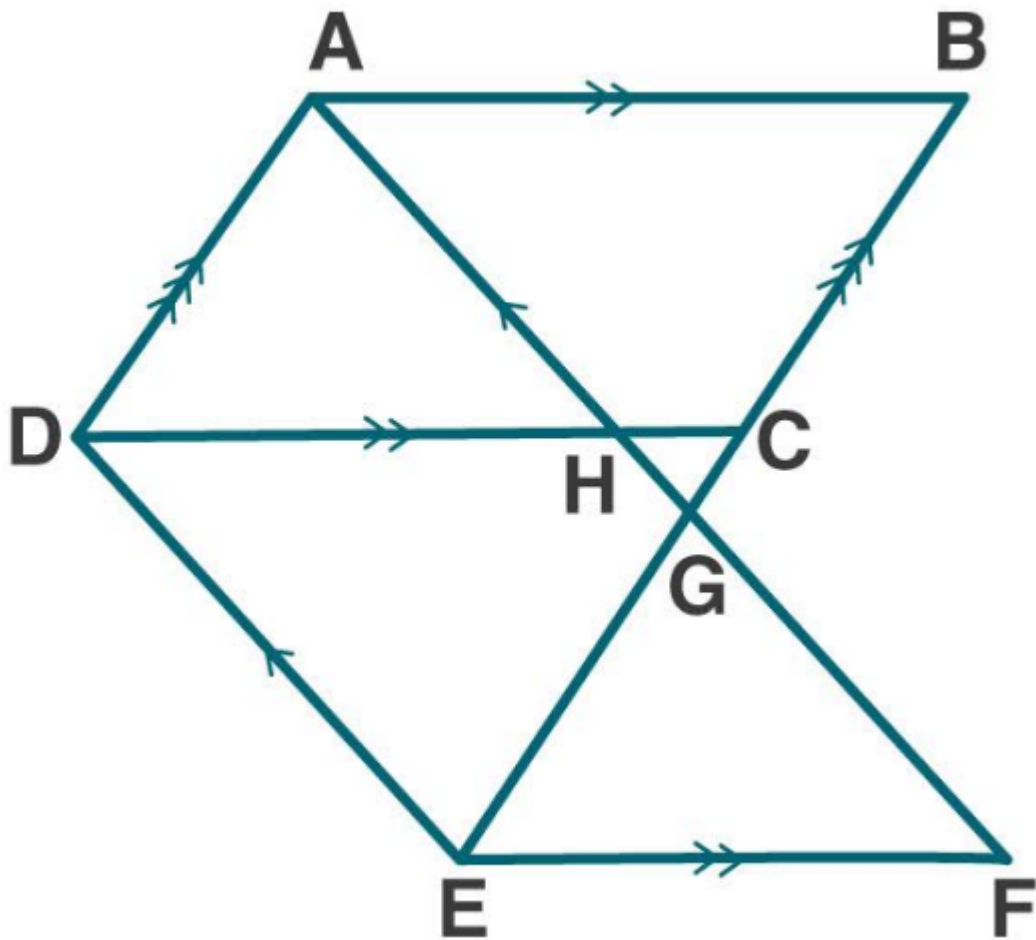
Prove that area of || gm ABCD = area of || gm AEFG.

(b) In the fig. (2) Given below, the side AB of the parallelogram ABCD is produced to E. A straight line through A is drawn parallel to CE to meet CB produced at F and parallelogram BFGE is Completed prove that area of || gm BFGE=Area of || gm ABCD.



(c) In the figure (3) given below $AB \parallel DC \parallel EF$, $AD \parallel BE$ and $DE \parallel AF$. Prove the area of DEFH is equal to the area of ABCD.

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Solution:

(a) Given:

From fig (1)

ABCD and AEFG are two parallelograms as shown in the figure.

To prove:

area of || gm ABCD = area of || gm AEFG

Proof:

let us join BG.

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We know that,

$$\text{ar } (\triangle ABG) = \frac{1}{2} (\text{ar } \parallel\text{gm } ABCD) \dots\dots (1)$$

Similarly,

$$\text{ar } (\triangle ABG) = \frac{1}{2} (\text{ar } \parallel\text{gm } AEFG) \dots\dots (2)$$

From (1) and (2)

$$\frac{1}{2} (\text{ar } \parallel\text{gm } ABCD) = \frac{1}{2} (\text{ar } \parallel\text{gm } AEFG)$$

So,

$$\text{ar } \parallel\text{gm } ABCD = \text{ar } \parallel\text{gm } AEFG$$

Hence proved.

(b) Given:

From fig (2)

A parallelogram ABCD in which AB is produced to E. A straight line through A is drawn parallel to CE to meet CB produced at F and parallelogram BFGE is Completed.

To prove:

$$\text{area of } \parallel\text{ gm } BFGE = \text{Area of } \parallel\text{ gm } ABCD$$

Proof:

Let us join AC and EF.

We know that,

$$\text{ar } (\triangle AFC) = \text{ar } (\triangle AFE) \dots\dots (1)$$

now subtract ar $(\triangle ABF)$ on both sides, we get

$$\text{ar } (\triangle AFC) - \text{ar } (\triangle ABF) = \text{ar } (\triangle AFE) - \text{ar } (\triangle ABF)$$

$$\text{Or ar } (\triangle ABC) = \text{ar } (\triangle BEF)$$

Now multiply by 2 on both sides, we get

$$2. \text{ ar } (\triangle ABC) = 2. \text{ ar } (\triangle BEF)$$

$$\text{Or ar } (\parallel\text{gm } ABCD) = \text{ar } (\parallel\text{gm } BFGE)$$

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Hence proved.

(c) Given:

From fig (3)

$AB \parallel DC \parallel EF$, $AD \parallel BE$ and $DE \parallel AF$

To prove:

area of DEFH = area of ABCD

Proof:

We know that,

$DE \parallel AF$ and $AD \parallel BE$

It is given that ADEG is a parallelogram.

So,

$\text{ar}(\text{||gm ABCD}) = \text{ar}(\text{||gm ADEG}) \dots\dots (1)$

Again, DEFG is a parallelogram.

$\text{ar}(\text{||gm DEFH}) = \text{ar}(\text{||gm ADEG}) \dots\dots (2)$

From (1) and (2)

$\text{ar}(\text{||gm ABCD}) = \text{ar}(\text{||gm DEFH})$

Or $\text{ar ABCD} = \text{ar DEFH}$

Hence proved.

13. Any point D is taken on the side BC of, a $\triangle ABC$ and AD is produced to E such that $AD=DE$, prove that area of $\triangle BCE$ = area of $\triangle ABC$.

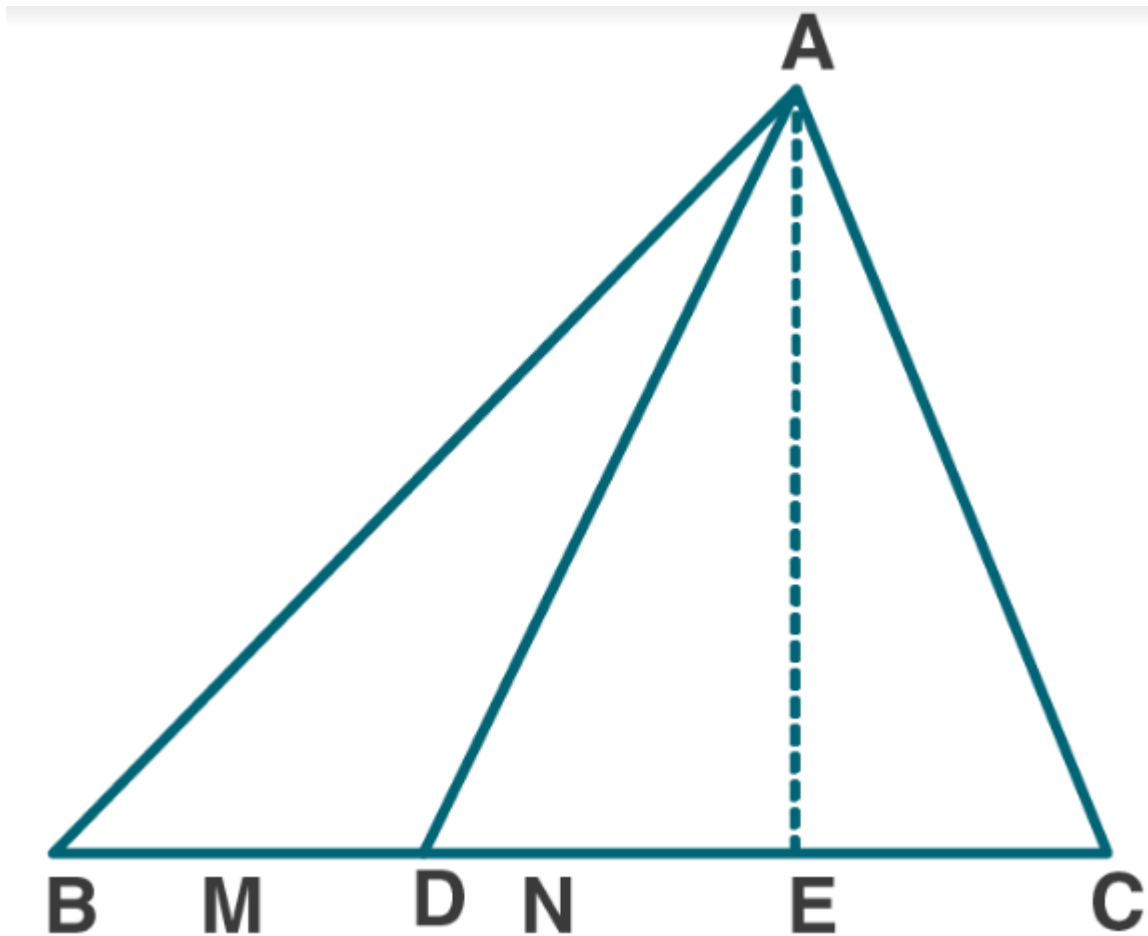
Solution:

Given:

In $\triangle ABC$, D is taken on the side BC.

AD produced to E such that $AD = DE$

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To prove:

area of $\triangle BCE$ = area of $\triangle ABC$

Proof:

In $\triangle ABE$, it is given that $AD = DE$

So, BD is the median of $\triangle ABE$

$\text{ar}(\triangle ABD) = \text{ar}(\triangle BED) \dots\dots (1)$

similarly,

In $\triangle ACE$, CD is the median of $\triangle ACE$

$\text{ar}(\triangle ACD) = \text{ar}(\triangle CED) \dots\dots (2)$

By adding (1) and (2), we get

$\text{ar}(\triangle ABD) + \text{ar}(\triangle ACD) = \text{ar}(\triangle BED) + \text{ar}(\triangle CED)$

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Or $\text{ar}(\triangle ABC) = \text{ar}(\triangle BCE)$

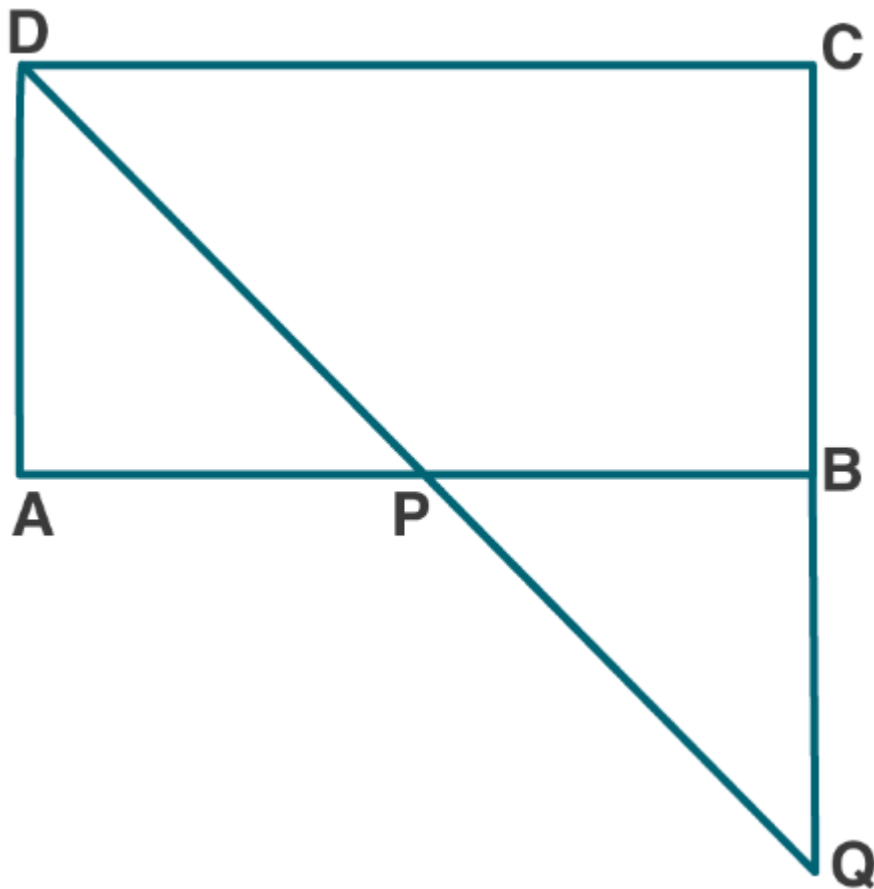
Hence proved.

14. ABCD is a rectangle and P is mid-point of AB. DP is produced to meet CB at Q. Prove that area of rectangle $\triangle BCD =$ area of $\triangle DQC$.

Solution:

Given:

ABCD is a rectangle and P is mid-point of AB. DP is produced to meet CB at Q.



To prove:

area of rectangle $\triangle BCD =$ area of $\triangle DQC$

Proof:

In $\triangle APD$ and $\triangle BQP$

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$AP = BP$ [Since, D is the mid-point of AB]

$\angle DAP = \angle QBP$ [each angle is 90°]

$\angle APD = \angle BPQ$ [vertically opposite angles]

So, $\triangle APD \cong \triangle BQP$ [By using ASA postulate]

$\text{ar}(\triangle APD) = \text{ar}(\triangle BQP)$

Now,

$\text{ar} ABCD = \text{ar}(\triangle APD) + \text{ar} PBCD$

$= \text{ar}(\triangle BQP) + \text{ar} PBCD$

$= \text{ar}(\triangle DQC)$

Hence proved.

15. (a) In the figure (1) given below, the perimeter of parallelogram is 42 cm. Calculate the lengths of the sides of the parallelogram.

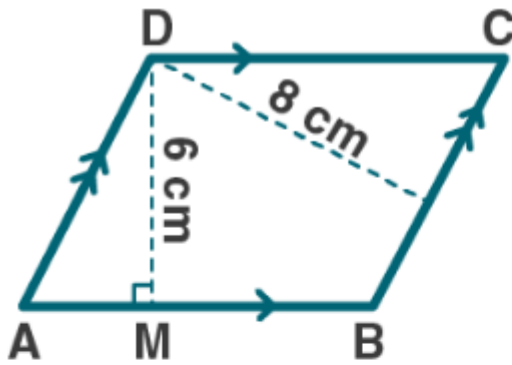
(b) In the figure (2) given below, the perimeter of $\triangle ABC$ is 37 cm. If the lengths of the altitudes AM, BN and CL are $5x$, $6x$, and $4x$ respectively, Calculate the lengths of the sides of $\triangle ABC$.

(c) In the fig. (3) Given below, ABCD is a parallelogram. P is a point on DC such that area of $\triangle DAP = 25 \text{ cm}^2$ and area of $\triangle BCP = 15 \text{ cm}^2$. Find

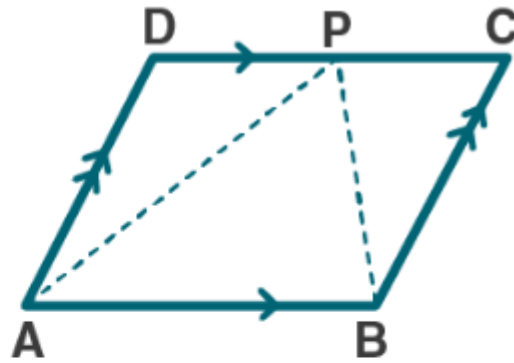
(i) area of || gm ABCD

(ii) DP: PC.

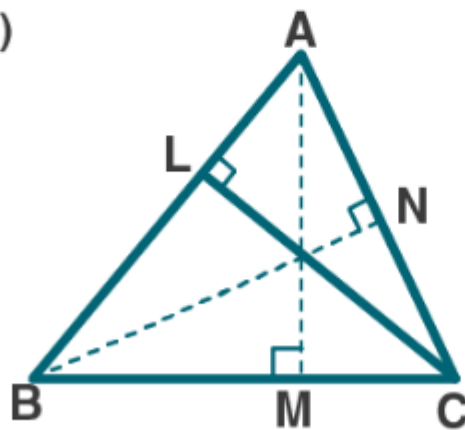
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(1)



(3)



(2)

Solution:

(a) Given:

The perimeter of parallelogram ABCD = 42 cm

To find:

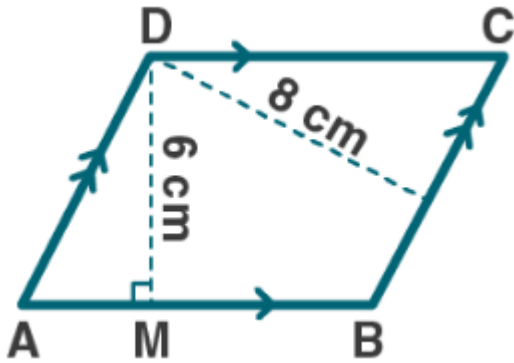
Lengths of the sides of the parallelogram ABCD.

From fig (1)

We know that,

$AB = P$

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Then, perimeter of $\parallel\text{gm ABCD} = 2 (AB + BC)$

$$42 = 2(P + BC)$$

$$42/2 = P + BC$$

$$21 = P + BC$$

$$BC = 21 - P$$

So, ar ($\parallel\text{gm ABCD}$) = $AB \times DM$

$$= P \times 6$$

$$= 6P \dots\dots\dots (1)$$

Again, ar ($\parallel\text{gm ABCD}$) = $BC \times DN$

$$= (21 - P) \times 8$$

$$= 8(21 - P) \dots\dots\dots (2)$$

From (1) and (2), we get

$$6P = 8(21 - P)$$

$$6P = 168 - 8P$$

$$6P + 8P = 168$$

$$14P = 168$$

$$P = 168/14$$

$$= 12$$

Hence, sides of $\parallel\text{gm}$ are

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$$AB = 12\text{cm and } BC = (21 - 12)\text{cm} = 9\text{cm}$$

(b) Given:

The perimeter of $\triangle ABC$ is 37 cm. The lengths of the altitudes AM, BN and CL are $5x$, $6x$, and $4x$ respectively.

To find:

Lengths of the sides of $\triangle ABC$. i.e., BC, CA and AB.

Let us consider $BC = P$ and $CA = Q$

From fig (2),

Then, perimeter of $\triangle ABC = AB + BC + CA$

$$37 = AB + P + Q$$

$$AB = 37 - P - Q$$

$$\text{Area } (\triangle ABC) = \frac{1}{2} \times \text{base} \times \text{height}$$

$$= \frac{1}{2} \times BC \times AM = \frac{1}{2} \times CA \times BN = \frac{1}{2} \times AB \times CL$$

$$= \frac{1}{2} \times P \times 5x = \frac{1}{2} \times Q \times 6x = \frac{1}{2} (37 - P - Q) \times 4x$$

$$= 5P/2 = 3Q = 2(37 - P - Q)$$

Let us consider first two parts:

$$5P/2 = 3Q$$

$$5P = 6Q$$

$$5P - 6Q = 0 \dots\dots (1)$$

$$25P - 30Q \text{ (multiplying by 5)} \dots\dots (2)$$

Let us consider second and third parts:

$$3Q = 2(37 - P - Q)$$

$$3Q = 74 - 2P - 2Q$$

$$3Q + 2Q + 2P = 74$$

$$2P + 5Q = 74 \dots\dots (3)$$

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$$12P + 30Q = 444 \text{ (multiplying by 6)..... (4)}$$

By adding (2) and (4), we get

$$37P = 444$$

$$P = 444/37$$

$$= 12$$

Now, substitute the value of P in equation (1), we get

$$5P - 6Q = 0$$

$$5(12) - 6Q = 0$$

$$60 = 6Q$$

$$Q = 60/6$$

$$= 10$$

Hence, $BC = P = 12\text{cm}$

$CA = Q = 10\text{cm}$

And $AB = 37 - P - Q = 37 - 12 - 10 = 15\text{cm}$

(c) Given:

ABCD is a parallelogram. P is a point on DC such that area of $\triangle DAP = 25 \text{ cm}^2$ and area of $\triangle BCP = 15 \text{ cm}^2$.

To Find:

(i) area of || gm ABCD

(ii) DP: PC

Now let us find,

From fig (3)

(i) we know that,

$$\text{ar}(\triangle APB) = \frac{1}{2} \text{ar}(\text{||gm ABCD})$$

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Then,

$$\frac{1}{2} \text{ar} (\parallel\text{gm ABCD}) = \text{ar} (\triangle\text{DAP}) + \text{ar} (\triangle\text{BCP})$$

$$= 25 + 15$$

$$= 40\text{cm}^2$$

$$\text{So, ar} (\parallel\text{gm ABCD}) = 2 \times 40 = 80\text{cm}^2$$

(ii) we know that,

$\triangle\text{ADP}$ and $\triangle\text{BCP}$ are on the same base CD and between same parallel lines CD and AB.

$$\text{ar} (\triangle\text{DAP})/\text{ar}(\triangle\text{BCP}) = \text{DP}/\text{PC}$$

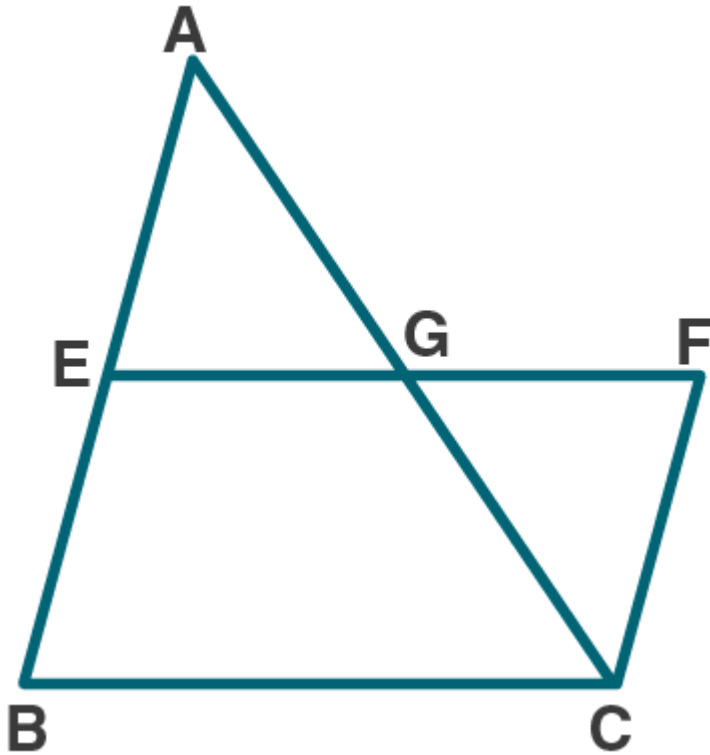
$$25/15 = \text{DP}/\text{PC}$$

$$5/3 = \text{DP}/\text{PC}$$

$$\text{So, DP: PC} = 5: 3$$

16. In the adjoining figure, E is mid-point of the side AB of a triangle ABC and EBCF is a parallelogram. If the area of $\triangle\text{ABC}$ is 25 sq. units, find the area of $\parallel\text{gm EBCF}$.

Solution:



Let us consider EF, side of ||gm BCFE meets AC at G.

We know that, E is the mid-point and $EF \parallel BC$

G is the mid-point of AC.

So,

$$AG = GC$$

Now, in $\triangle AEG$ and $\triangle CFG$,

The alternate angles are: $\angle EAG$, $\angle GCF$

Vertically opposite angles are: $\angle EGA = \angle CGF$

So, $AG = GC$

Proved.

$$\therefore \triangle AEG \cong \triangle CFG$$

$$\text{ar}(\triangle AEG) = \text{ar}(\triangle CFG)$$

Now,

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$$\text{ar} (\parallel\text{gm EBCF}) = \text{ar BCGE} + \text{ar} (\triangle CFG)$$

$$= \text{ar BCGE} + \text{ar} (\triangle AEG)$$

$$= \text{ar} (\triangle ABC)$$

We know that, $\text{ar} (\triangle ABC) = 25\text{sq. units}$

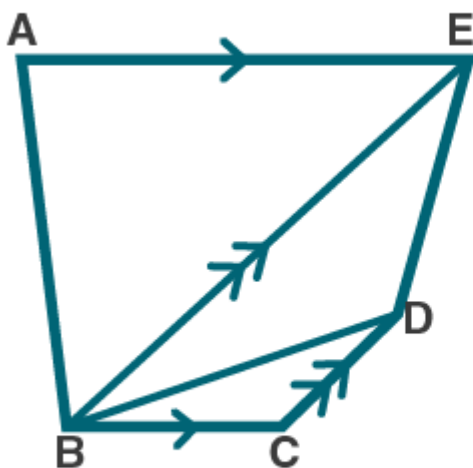
Hence, $\text{ar} (\parallel\text{gm EBCF}) = 25\text{sq. units}$

17. (a) In the figure (1) given below, $BC \parallel AE$ and $CD \parallel BE$. Prove that: area of $\triangle ABC =$ area of $\triangle EBD$.

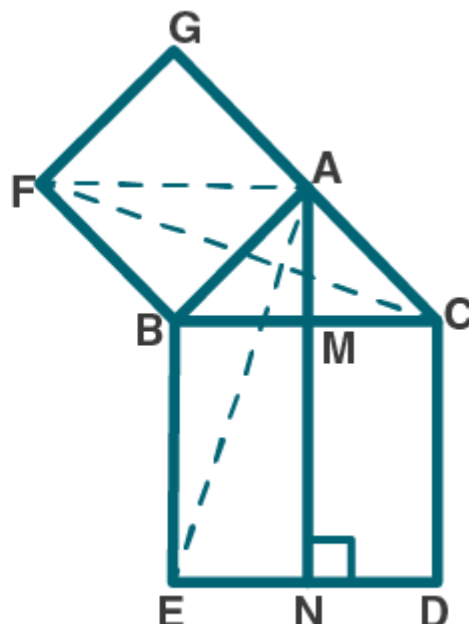
(b) In the figure (2) given below, ABC is right angled triangle at A . $AGFB$ is a square on the side AB and $BCDE$ is a square on the hypotenuse BC . If $AN \perp ED$, prove that:

(i) $\triangle BCF \cong \triangle ABE$.

(ii) area of square $ABFG =$ area of rectangle $BENM$.



(1)



(2)

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Solution:

(a) Given:

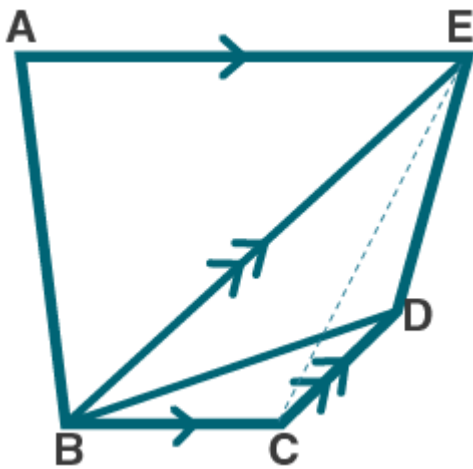
From fig (1)

$BC \parallel AE$ and $CD \parallel BE$

To prove:

area of $\triangle ABC$ = area of $\triangle EBD$

Proof:



By joining CE.

We know that, from $\triangle ABC$ and $\triangle EBC$

$$\text{ar}(\triangle ABC) = \text{ar}(\triangle EBC) \dots\dots (1)$$

From EBC and $\triangle EBD$

$$\text{ar}(\triangle EBC) = \text{ar}(\triangle EBD) \dots\dots (2)$$

From (1) and (2), we get

$$\text{ar}(\triangle ABC) = \text{ar}(\triangle EBD)$$

Hence proved.

(b) Given:

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ABC is right angled triangle at A. Squares AGFB and BCDE are drawn on the side AB and hypotenuse BC of $\triangle ABC$. $AN \perp ED$ which meets BC at M.

To prove:

(i) $\triangle BCF \cong \triangle ABE$.

(ii) area of square ABFG = area of rectangle BENM

From the figure (2)

(i) $\angle FBC = \angle FBA + \angle ABC$

So,

$$\angle FBC = 90^\circ + \angle ABC \dots (1)$$

$$\angle ABE = \angle EAC + \angle ABC$$

So,

$$\angle ABE = 90^\circ + \angle ABC \dots (2)$$

From (1) and (2), we get

$$\angle FBC = \angle ABE \dots (3)$$

So, $BC = BE$

Now, in $\triangle BCF$ and $\triangle ABE$

$$BF = AB$$

By using SAS axiom rule of congruency,

$$\therefore \triangle BCF \cong \triangle ABE$$

Hence proved.

(ii) we know that,

$$\triangle BCF \cong \triangle ABE$$

$$\text{So, ar } (\triangle BCF) = \text{ar } (\triangle ABE) \dots (4)$$

$$\angle BAG + \angle BAC = 90^\circ + 90^\circ$$

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$$= 180^\circ$$

So, GAC is a straight line.

Now, from $\triangle BCF$ and square AGFB

$$\text{ar}(\triangle BCF) = \frac{1}{2} \text{ar}(\text{square AGFB}) \dots (5)$$

From $\triangle ABE$ and rectangle BENM

$$\text{ar}(\triangle ABE) = \frac{1}{2} \text{ar}(\text{rectangle BENM}) \dots (6)$$

From (4), (5) and (6)

$$\frac{1}{2} \text{ar}(\text{square AGFB}) = \frac{1}{2} \text{ar}(\text{rectangle BENM})$$

$$\text{ar}(\text{square AGFB}) = \text{ar}(\text{rectangle BENM})$$

Hence proved.



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About ML Aggarwal

M. L. Aggarwal, is an Indian mechanical engineer, educator. His achievements include research in solutions of industrial problems related to fatigue design. Recipient Best Paper award, Manipal Institute of Technology, 2004. Member of TSTE.

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