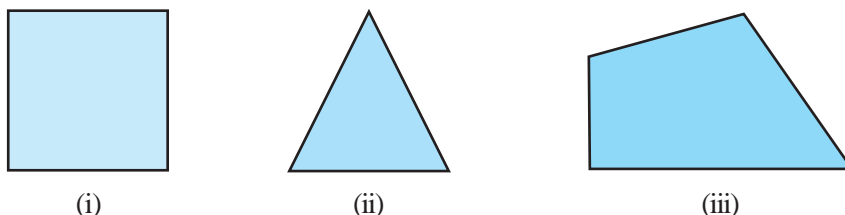


## AREAS OF PARALLELOGRAMS AND TRIANGLES

### (A) Main Concepts and Results

The area of a closed plane figure is the measure of the region inside the figure:

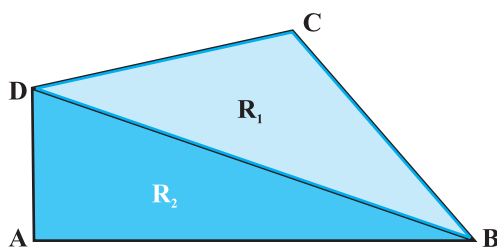


**Fig. 9.1**

The shaded parts (Fig.9.1) represent the regions whose areas may be determined by means of simple geometrical results. The square unit is the standard unit used in measuring the area of such figures.

- If  $\Delta ABC \cong \Delta PQR$ , then  $\text{ar}(\Delta ABC) = \text{ar}(\Delta PQR)$

Total area  $R$  of the plane figure  $ABCD$  is the sum of the areas of two triangular regions  $R_1$  and  $R_2$ , that is,  $\text{ar}(R) = \text{ar}(R_1) + \text{ar}(R_2)$



**Fig. 9.2**

- Two congruent figures have equal areas but the converse is not always true,
- A diagonal of a parallelogram divides the parallelogram in two triangles of equal area,
- (i) Parallelograms on the same base and between the same parallels are equal in area
- (ii) A parallelogram and a rectangle on the same base and between the same parallels are equal in area.
- Parallelograms on equal bases and between the same parallels are equal in area,
- Triangles on the same base and between the same parallels are equal in area,
- Triangles with equal bases and equal areas have equal corresponding altitudes,
- The area of a triangle is equal to one-half of the area of a rectangle/parallelogram of the same base and between same parallels,
- If a triangle and a parallelogram are on the same base and between the same parallels, the area of the triangle is equal to one-half area of the parallelogram.

### (B) Multiple Choice Questions

**Sample Question 1 :** The area of the figure formed by joining the mid-points of the adjacent sides of a rhombus with diagonals 12 cm and 16 cm is

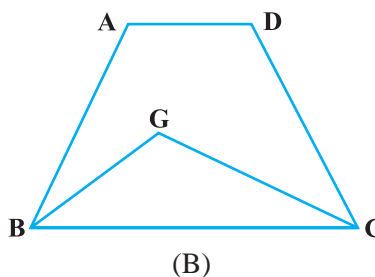
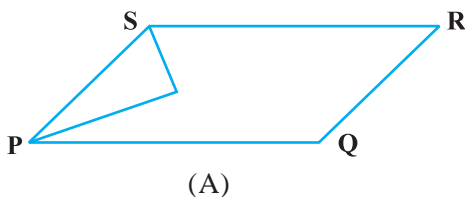
- (A)  $48 \text{ cm}^2$       (B)  $64 \text{ cm}^2$       (C)  $96 \text{ cm}^2$       (D)  $192 \text{ cm}^2$

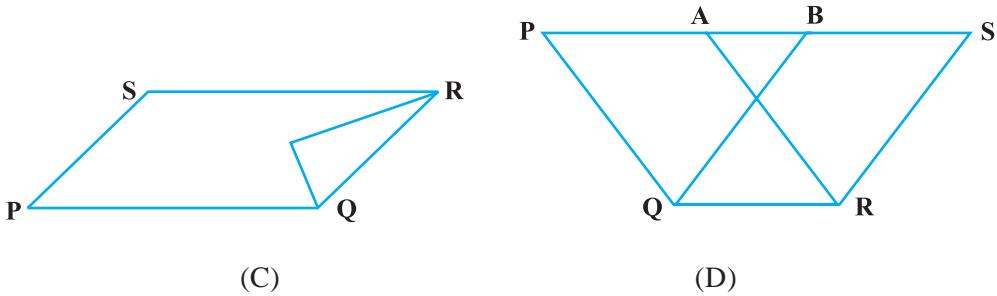
**Solution:** Answer (A)

### EXERCISE 9.1

Write the correct answer in each of the following :

- The median of a triangle divides it into two
  - triangles of equal area
  - congruent triangles
  - right triangles
  - isosceles triangles
- In which of the following figures (Fig. 9.3), you find two polygons on the same base and between the same parallels?

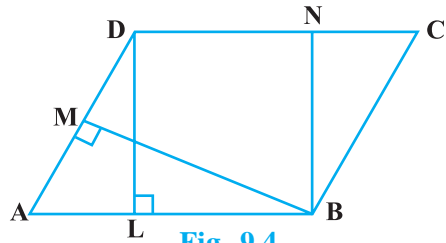


**Fig. 9.3**

3. The figure obtained by joining the mid-points of the adjacent sides of a rectangle of sides 8 cm and 6 cm is :
- (A) a rectangle of area  $24 \text{ cm}^2$       (B) a square of area  $25 \text{ cm}^2$   
 (C) a trapezium of area  $24 \text{ cm}^2$       (D) a rhombus of area  $24 \text{ cm}^2$

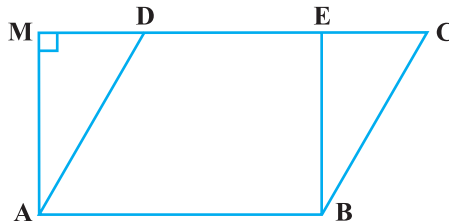
4. In Fig. 9.4, the area of parallelogram ABCD is :

- (A)  $AB \times BM$   
 (B)  $BC \times BN$   
 (C)  $DC \times DL$   
 (D)  $AD \times DL$

**Fig. 9.4**

5. In Fig. 9.5, if parallelogram ABCD and rectangle ABEM are of equal area, then :

- (A) Perimeter of ABCD = Perimeter of ABEM  
 (B) Perimeter of ABCD < Perimeter of ABEM  
 (C) Perimeter of ABCD > Perimeter of ABEM  
 (D) Perimeter of ABCD =  $\frac{1}{2}$  (Perimeter of ABEM)

**Fig. 9.5**

6. The mid-point of the sides of a triangle along with any of the vertices as the fourth point make a parallelogram of area equal to
- (A)  $\frac{1}{2}$  ar (ABC) (B)  $\frac{1}{3}$  ar (ABC)
- (C)  $\frac{1}{4}$  ar (ABC) (D) ar (ABC)
7. Two parallelograms are on equal bases and between the same parallels. The ratio of their areas is
- (A) 1 : 2 (B) 1 : 1 (C) 2 : 1 (D) 3 : 1
8. ABCD is a quadrilateral whose diagonal AC divides it into two parts, equal in area, then ABCD
- (A) is a rectangle (B) is always a rhombus
- (C) is a parallelogram (D) need not be any of (A), (B) or (C)
9. If a triangle and a parallelogram are on the same base and between same parallels, then the ratio of the area of the triangle to the area of parallelogram is
- (A) 1 : 3 (B) 1 : 2 (C) 3 : 1 (D) 1 : 4
10. ABCD is a trapezium with parallel sides  $AB = a$  cm and  $DC = b$  cm (Fig. 9.6). E and F are the mid-points of the non-parallel sides. The ratio of ar (ABFE) and ar (EFCD) is
- (A)  $a : b$
- (B)  $(3a + b) : (a + 3b)$
- (C)  $(a + 3b) : (3a + b)$
- (D)  $(2a + b) : (3a + b)$

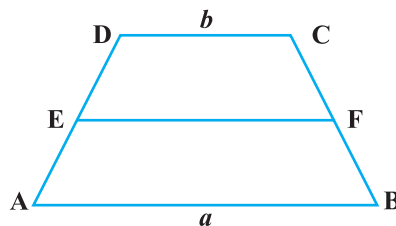


Fig. 9.6

### (C) Short Answer Questions with Reasoning

Write **True** or **False** and justify your answer.

**Sample Question 1 :** If P is any point on the median AD of a  $\Delta ABC$ , then ar (ABP)  $\neq$  ar (ACP).

**Solution :** False, because ar (ABD) = ar (ACD) and ar (PBD) = ar (PCD), therefore, ar (ABP) = ar (ACP).

**Sample Question 2 :** If in Fig. 9.7, PQRS and EFRS are two parallelograms, then

$$\text{ar (MFR)} = \frac{1}{2} \text{ ar (PQRS)}.$$

**Solution :** True, because  $\text{ar (PQRS)} = \text{ar (EFRS)} = 2 \text{ ar (MFR)}$ .

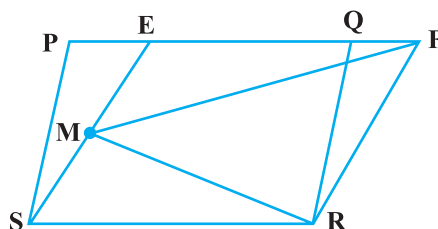


Fig. 9.7

## EXERCISE 9.2

Write True or False and justify your answer :

1. ABCD is a parallelogram and X is the mid-point of AB. If  $\text{ar (AXCD)} = 24 \text{ cm}^2$ , then  $\text{ar (ABC)} = 24 \text{ cm}^2$ .
2. PQRS is a rectangle inscribed in a quadrant of a circle of radius 13 cm. A is any point on PQ. If  $PS = 5 \text{ cm}$ , then  $\text{ar (PAS)} = 30 \text{ cm}^2$ .
3. PQRS is a parallelogram whose area is  $180 \text{ cm}^2$  and A is any point on the diagonal QS. The area of  $\triangle ASR = 90 \text{ cm}^2$ .
4. ABC and BDE are two equilateral triangles such that D is the mid-point of BC.

Then  $\text{ar (BDE)} = \frac{1}{4} \text{ ar (ABC)}$ .

5. In Fig. 9.8, ABCD and EFGD are two parallelograms and G is the mid-point of CD. Then

$$\text{ar (DPC)} = \frac{1}{2} \text{ ar (EFGD)}.$$

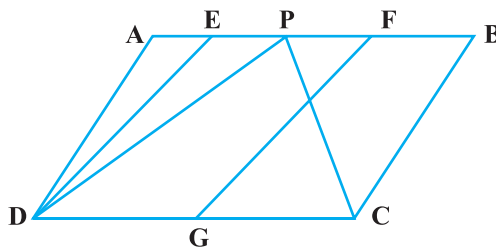


Fig. 9.8

## (D) Short Answer Questions

**Sample Question 1 :** PQRS is a square. T and U are respectively, the mid-points of PS and QR (Fig. 9.9). Find the area of  $\triangle OTS$ , if  $PQ = 8 \text{ cm}$ , where O is the point of intersection of TU and QS.

**Solution :**  $PS = PQ = 8 \text{ cm}$  and  $TU \parallel PQ$

$$ST = \frac{1}{2} PS = \frac{1}{2} \times 8 = 4 \text{ cm}$$

$$PQ = TU = 8 \text{ cm}$$

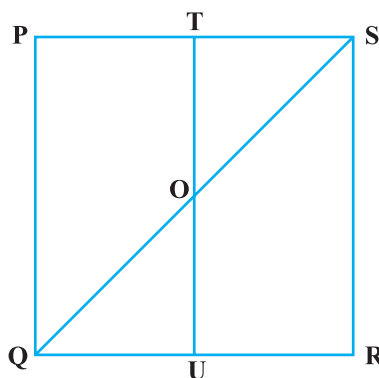


Fig. 9.9

$$OT = \frac{1}{2} TU = \frac{1}{2} \times 8 = 4 \text{ cm}$$

Area of triangle OTS

$$\begin{aligned} &= \frac{1}{2} \times ST \times OT \text{ cm}^2 \text{ [Since OTS is a right angled triangle]} \\ &= \frac{1}{2} \times 4 \times 4 \text{ cm}^2 = 8 \text{ cm}^2 \end{aligned}$$

**Sample Question 2 :** ABCD is a parallelogram and BC is produced to a point Q such that AD = CQ (Fig. 9.10). If AQ intersects DC at P, show that ar (BPC) = ar (DPQ)

**Solution:** ar (ACP) = ar (BCP) (1)

[Triangles on the same base and between same parallels]

$$\text{ar (ADQ)} = \text{ar (ADC)} \quad (2)$$

$$\text{ar (ADC)} - \text{ar (ADP)} = \text{ar (ADQ)} - \text{ar (ADP)}$$

$$\text{ar (APC)} = \text{ar (DPQ)} \quad (3)$$

From (1) and (3), we get

$$\text{ar (BCP)} = \text{ar (DPQ)}$$

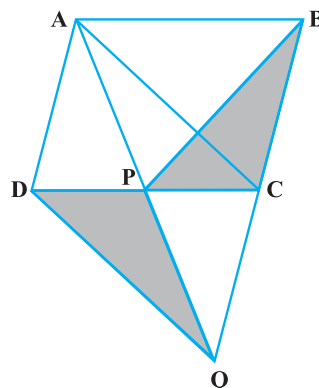


Fig. 9.10

### EXERCISE 9.3

1. In Fig.9.11, PSDA is a parallelogram. Points Q and R are taken on PS such that PQ = QR = RS and PA || QB || RC. Prove that ar (PQE) = ar (CFD).

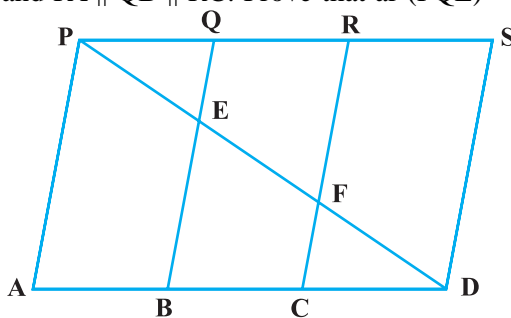


Fig. 9.11

2. X and Y are points on the side LN of the triangle LMN such that  $LX = XY = YN$ . Through X, a line is drawn parallel to LM to meet MN at Z (See Fig. 9.12). Prove that
- $$\text{ar}(\text{LZY}) = \text{ar}(\text{MZYX})$$

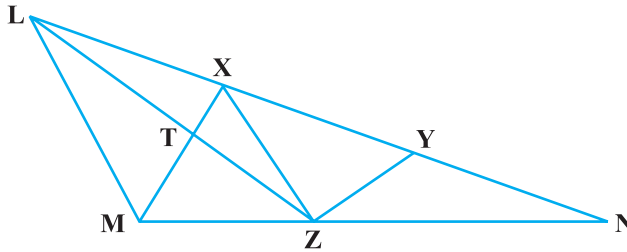


Fig. 9.12

3. The area of the parallelogram ABCD is  $90 \text{ cm}^2$  (see Fig. 9.13). Find
- $\text{ar}(\text{ABEF})$
  - $\text{ar}(\text{ABD})$
  - $\text{ar}(\text{BEF})$

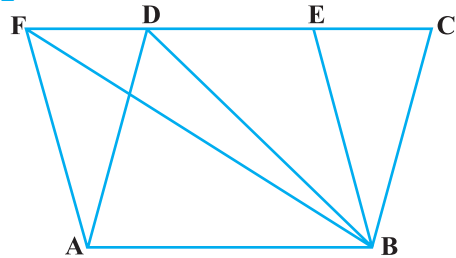


Fig. 9.13

4. In  $\triangle ABC$ , D is the mid-point of AB and P is any point on BC. If  $CQ \parallel PD$  meets AB in Q (Fig. 9.14), then prove that

$$\text{ar}(\text{BPQ}) = \frac{1}{2} \text{ar}(\text{ABC}).$$

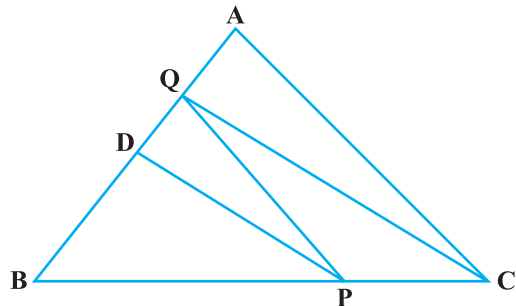


Fig. 9.14

5. ABCD is a square. E and F are respectively the mid-points of BC and CD. If R is the mid-point of EF (Fig. 9.15), prove that
- $$\text{ar}(\text{AER}) = \text{ar}(\text{AFR})$$

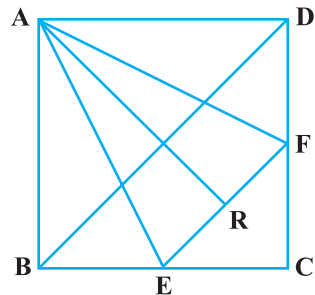


Fig. 9.15

6. O is any point on the diagonal PR of a parallelogram PQRS (Fig. 9.16). Prove that  $\text{ar}(\text{PSO}) = \text{ar}(\text{PQO})$ .

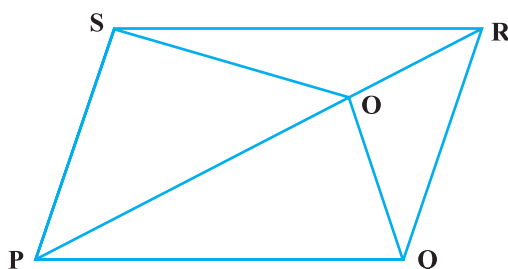


Fig. 9.16

7. ABCD is a parallelogram in which BC is produced to E such that  $CE = BC$  (Fig. 9.17). AE intersects CD at F.

If  $\text{ar}(\text{DFB}) = 3 \text{ cm}^2$ , find the area of the parallelogram ABCD.

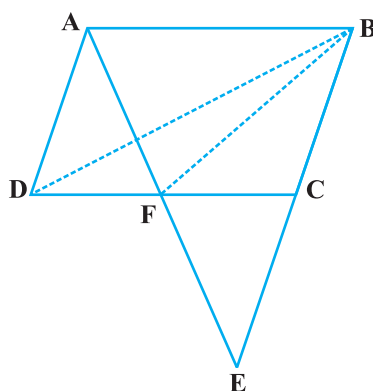


Fig. 9.17

8. In trapezium ABCD,  $AB \parallel DC$  and L is the mid-point of BC. Through L, a line PQ  $\parallel AD$  has been drawn which meets AB in P and DC produced in Q (Fig. 9.18). Prove that  $\text{ar}(\text{ABCD}) = \text{ar}(\text{APQD})$ .

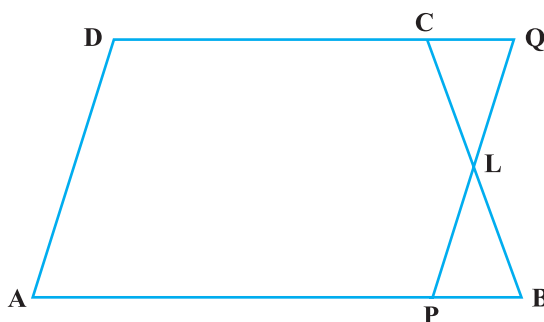
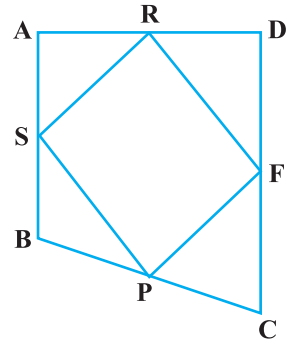


Fig. 9.18



9. If the mid-points of the sides of a quadrilateral are joined in order, prove that the area of the parallelogram so formed will be half of the area of the given quadrilateral (Fig. 9.19).

[**Hint:** Join BD and draw perpendicular from A on BD.]

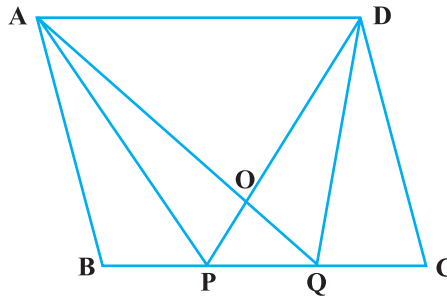


**Fig. 9.19**

### (E) Long Answer Questions

**Sample Question 1 :** In Fig. 9.20, ABCD is a parallelogram. Points P and Q on BC trisect BC in three equal parts. Prove that

$$\text{ar (APQ)} = \text{ar (DPQ)} = \frac{1}{6} \text{ar(ABCD)}$$

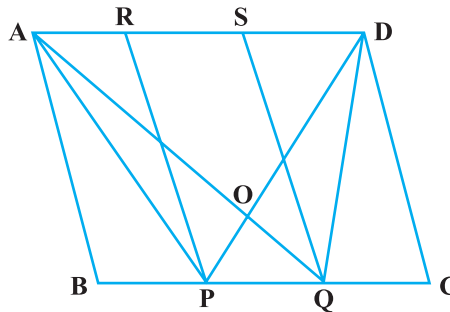


**Fig. 9.20**

**Solution :**

Through P and Q, draw PR and QS parallel to AB. Now PQRS is a parallelogram and

its base  $PQ = \frac{1}{3} BC$ .



**Fig. 9.21**

$$\text{ar (APD)} = \frac{1}{2} \text{ar (ABCD)} \text{ [Same base BC and BC } \parallel \text{ AD]} \quad (1)$$

$$\text{ar (AQD)} = \frac{1}{2} \text{ar (ABCD)} \quad (2)$$

From (1) and (2), we get

$$\text{ar (APD)} = \text{ar (AQD)} \quad (3)$$

Subtracting ar (AOD) from both sides, we get

$$\text{ar (APD)} - \text{ar (AOD)} = \text{ar (AQD)} - \text{ar (AOD)}$$

$$\text{ar (APO)} = \text{ar (OQD)},$$

Adding ar (OPQ) on both sides in (2), we get

$$\text{ar (APO)} + \text{ar (OPQ)} = \text{ar (OQD)} + \text{ar (OPQ)}$$

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

Since,  $\text{ar (APQ)} = \frac{1}{2} \text{ar (PQRS)}$ , therefore

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

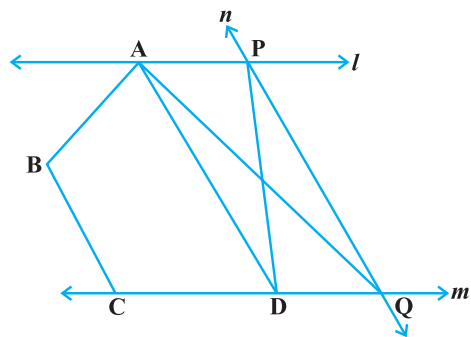
$$\text{Now, ar (PQRS)} = \frac{1}{3} \text{ar (ABCD)}$$

Therefore,  $\text{ar (APQ)} = \text{ar (DPQ)}$

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

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

**Sample Question 2 :** In Fig. 9.22,  $l, m, n$ , are straight lines such that  $l \parallel m$  and  $n$  intersects  $l$  at P and  $m$  at Q. ABCD is a quadrilateral such that its vertex A is on  $l$ . The vertices C and D are on  $m$  and  $AD \parallel n$ . Show that



**Fig. 9.22**

$$\text{ar}(\text{ABCQ}) = \text{ar}(\text{ABCDP})$$

$$\text{Solution : } \text{ar}(\text{APD}) = \text{ar}(\text{AQD}) \quad (1)$$

[Have same base AD and also between same parallels AD and n].

Adding ar (ABCD) on both sides in (1), we get

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

$$\text{or ar}(\text{ABCDP}) = \text{ar}(\text{ABCQ})$$

**Sample Questions 3 :** In Fig. 9.23,  $BD \parallel CA$ ,

E is mid-point of CA and  $BD = \frac{1}{2} CA$ . Prove

$$\text{that ar}(\text{ABC}) = 2\text{ar}(\text{DBC})$$

**Solution :** Join DE. Here BCED is a parallelogram, since

$$BD = CE \text{ and } BD \parallel CE$$

$$\text{ar}(\text{DBC}) = \text{ar}(\text{EBC}) \quad (1)$$

[Have the same base BC and between the same parallels]

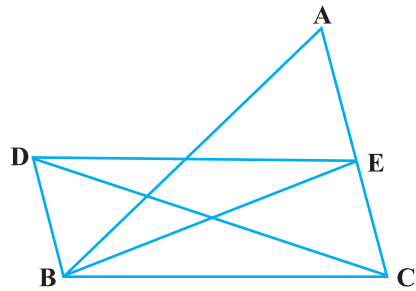
In  $\triangle ABC$ , BE is the median,

$$\text{so, } \text{ar}(\text{EBC}) = \frac{1}{2} \text{ar}(\text{ABC})$$

$$\text{Now, } \text{ar}(\text{ABC}) = \text{ar}(\text{EBC}) + \text{ar}(\text{ABE})$$

$$\text{Also, } \text{ar}(\text{ABC}) = 2 \text{ar}(\text{EBC}), \text{ therefore,}$$

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

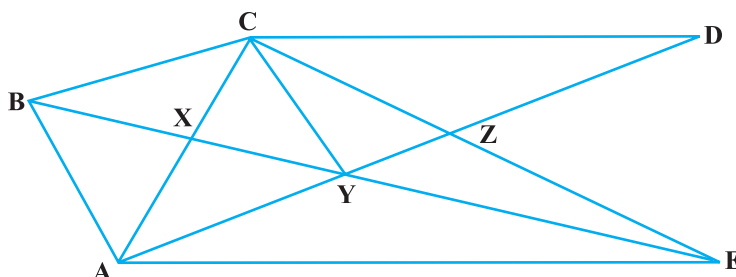


**Fig. 9.23**

### EXERCISE 9.4

1. A point E is taken on the side BC of a parallelogram ABCD. AE and DC are produced to meet at F. Prove that  
 $\text{ar}(\text{ADF}) = \text{ar}(\text{ABFC})$
2. The diagonals of a parallelogram ABCD intersect at a point O. Through O, a line is drawn to intersect AD at P and BC at Q. show that PQ divides the parallelogram into two parts of equal area.
3. The medians BE and CF of a triangle ABC intersect at G. Prove that the area of  $\triangle GBC$  = area of the quadrilateral AFGE.

4. In Fig. 9.24,  $CD \parallel AE$  and  $CY \parallel BA$ . Prove that  
 $\text{ar}(\text{CBX}) = \text{ar}(\text{AXY})$

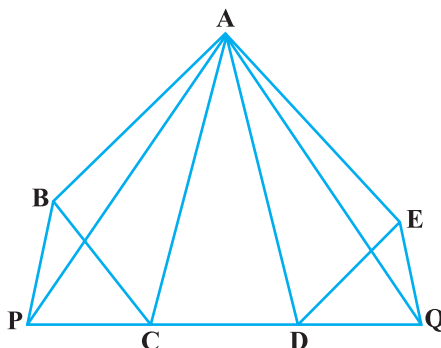


**Fig. 9.24**

5. ABCD is a trapezium in which  $AB \parallel DC$ ,  $DC = 30$  cm and  $AB = 50$  cm. If X and Y are, respectively the mid-points of AD and BC, prove that

$$\text{ar}(\text{DCYX}) = \frac{7}{9} \text{ar}(\text{XYBA})$$

6. In  $\triangle ABC$ , if L and M are the points on AB and AC, respectively such that  $LM \parallel BC$ . Prove that  $\text{ar}(\text{LOB}) = \text{ar}(\text{MOC})$
7. In Fig. 9.25, ABCDE is any pentagon. BP drawn parallel to AC meets DC produced at P and EQ drawn parallel to AD meets CD produced at Q. Prove that  
 $\text{ar}(\text{ABCDE}) = \text{ar}(\text{APQ})$

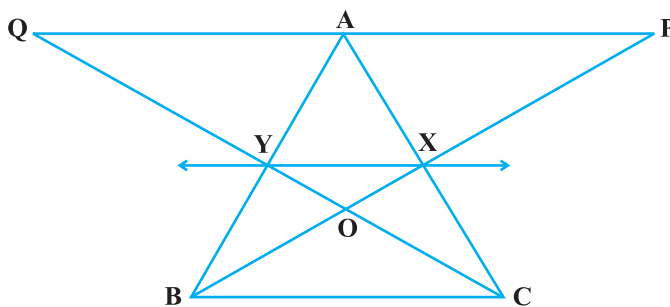


**Fig. 9.25**

8. If the medians of a  $\Delta ABC$  intersect at G, show that  
 $\text{ar}(\text{AGB}) = \text{ar}(\text{AGC}) = \text{ar}(\text{BGC})$

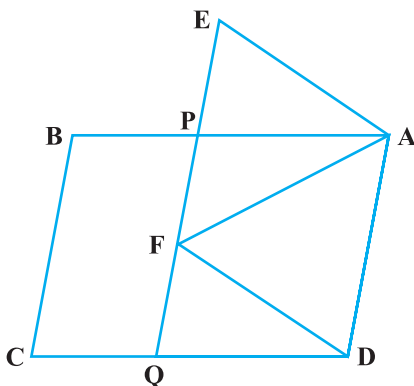
$$= \frac{1}{3} \text{ar}(\text{ABC})$$

9. In Fig. 9.26, X and Y are the mid-points of AC and AB respectively,  $QP \parallel BC$  and CYQ and BXP are straight lines. Prove that  $\text{ar}(\text{ABP}) = \text{ar}(\text{ACQ})$ .



**Fig. 9.26**

10. In Fig. 9.27, ABCD and AEFD are two parallelograms. Prove that  
 $\text{ar}(\text{PEA}) = \text{ar}(\text{QFD})$  [**Hint:** Join PD].



**Fig. 9.27**