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Theorem Basic Proportionality Theorem: (Thale's theorem)

If a line is drawn parallel to any one side of the triangle that intersects the other two sides in two distinct points, then the line divides those two sides in the same ratio.

To prove: $\frac{AD}{BD} = \frac{AE}{EC}$

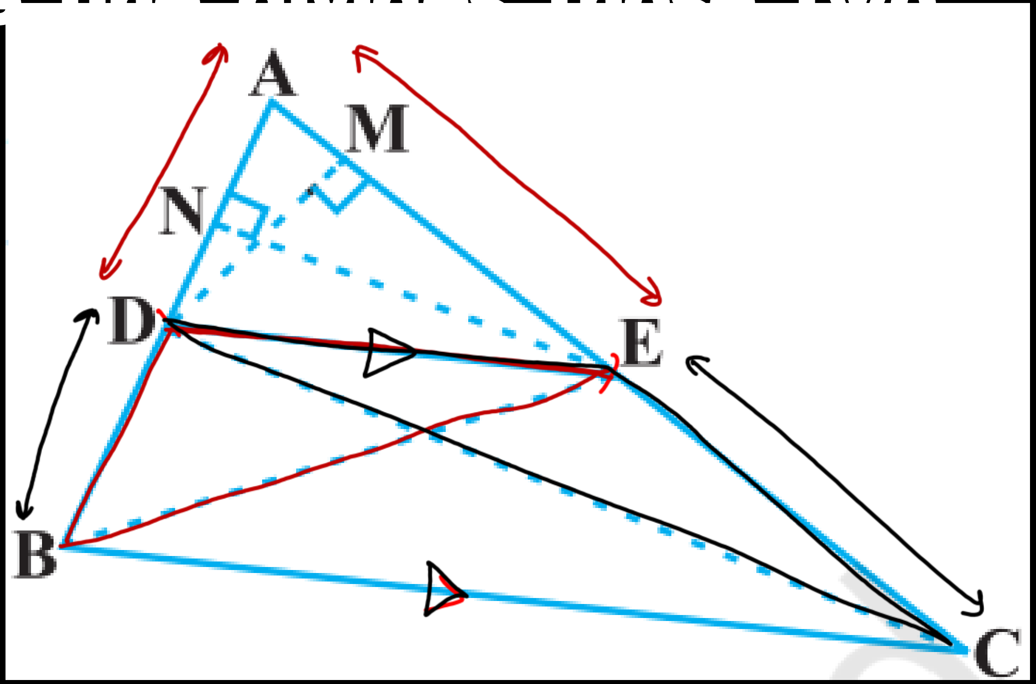
Const: → (i) $EN \perp AD$

(ii) $DM \perp AE$

proof: $ar(\triangle ADE)$

$= \frac{1}{2}(AD)(EN)$ ①

also, $= \frac{1}{2}(AE)(DM)$ → ②



$$ar(\Delta BDE) = \frac{1}{2}(DB)(EN) \longrightarrow (3)$$

$$ar(\Delta DEC) = \frac{1}{2}(EC)(DM) \text{ — } (4)$$

$(1) \div (3)$

$$\left(\frac{ar(\Delta ADE)}{ar(\Delta BDE)}\right) = \frac{\cancel{\frac{1}{2}}(AD)\cancel{(EN)}}{\cancel{\frac{1}{2}}(DB)\cancel{(EN)}} = \left(\frac{AD}{DB}\right) \text{ — } (5)$$

$(2) \div (4)$

$$\frac{ar(\Delta ADE)}{ar(\Delta DEC)} = \frac{\cancel{\frac{1}{2}}(AE)\cancel{(DM)}}{\cancel{\frac{1}{2}}(EC)\cancel{(DM)}} = \left(\frac{AE}{EC}\right) \text{ — } (6)$$

$$ar(\Delta BDE) = ar(\Delta DEC) \text{ — } (7)$$

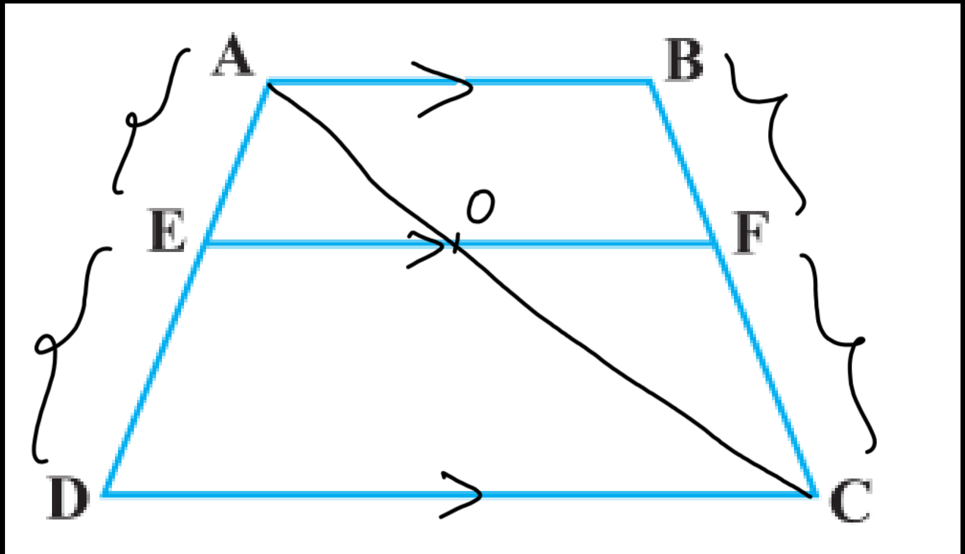
using (7) in (5) & (6) $\Rightarrow \dfrac{ar(\Delta ADE)}{ar(\Delta BDE)} = \dfrac{ar(\Delta ADE)}{ar(\Delta DEC)} \Rightarrow \boxed{\dfrac{AD}{DB} = \dfrac{AE}{EC}}$

Hence proved

$\rightarrow$ Δles with Same base & b/w Same $\parallel$ lines have equal area.

Q. ABCD is a trapezium with AB || DC. E and F are points on non-parallel sides AD and BC respectively such that EF is parallel to AB.

Show that $\frac{AE}{ED} = \frac{B\cancel{E}F}{FC}$.



Const: → Join AC, cutting line EF at 'O'.

proof: $\triangle ADE$, $OE \parallel CD$

from BPT,

$$\frac{AE}{ED} = \frac{AO}{OC} \quad \text{—— (1)}$$

In, $\triangle ABC$, $OF \parallel AB$,

from, BPT.

$$\frac{CF}{BF} = \frac{OC}{OA}$$

$$\frac{BF}{CF} = \frac{AO}{CO} \quad (2)$$ [taking reciprocal]

from (1) & (2),

$$\boxed{\frac{AE}{ED} = \frac{BF}{CF}}$$

Q. In fig. DE || AC and DF || AE. Prove that

$$\frac{BF}{FE} = \frac{BE}{EC}.$$

In $\triangle ABC$, DE || AC,

from BPT

$$\frac{BE}{EC} = \left(\frac{BD}{AD}\right) \quad —— (1)$$

In $\triangle AEB$, DF || AE,

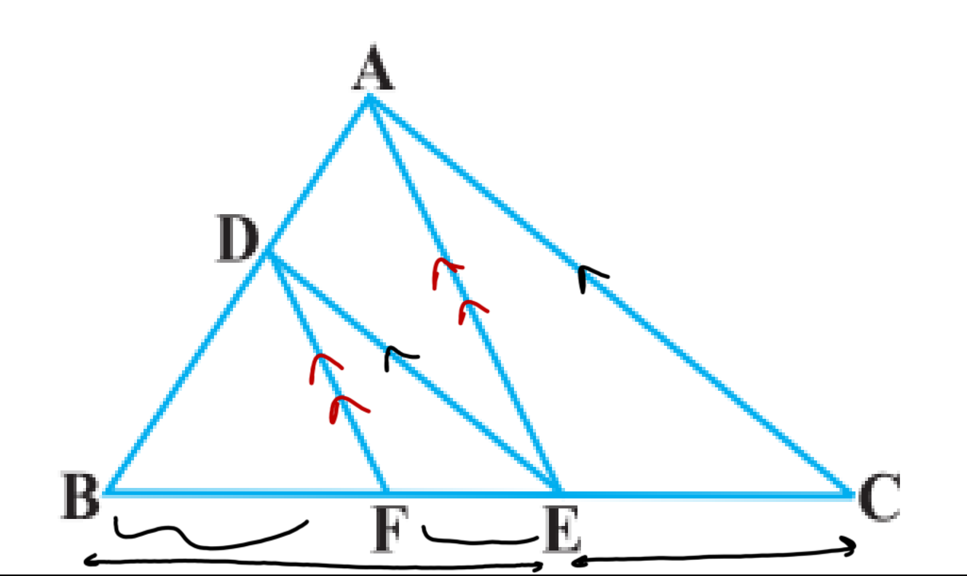
from BPT,

$$\frac{BF}{FE} = \left(\frac{BD}{AD}\right) \quad —— (2)$$

from (1) & (2),

$$\boxed{\frac{BE}{EC} = \frac{BF}{FE}}$$

proved



Theorem **Converse BPT:** If a line divides any two sides of a triangle in the same ratio, then the line must be parallel to the third side.

Given:

$$\frac{AD}{DB} = \frac{AE}{EC} \quad \text{— (1)}$$

To prove: $DE \parallel BC$

Const: $DE' \parallel BC$.

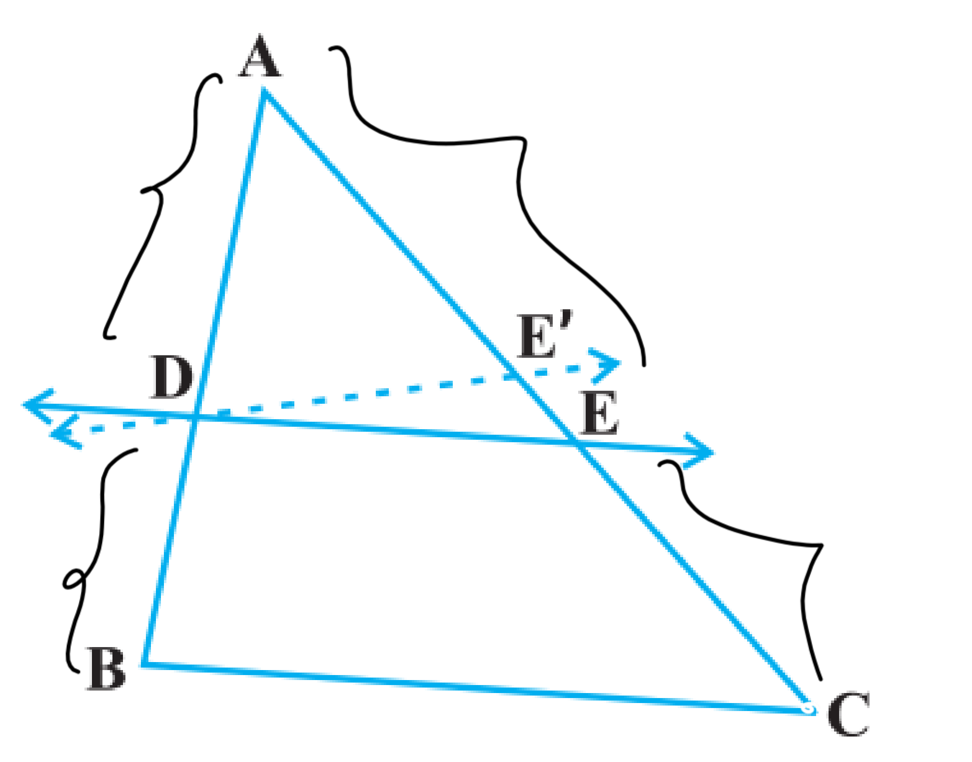
Proof: In $\triangle ABC$, $DE' \parallel BC$

from BPT,

$$\frac{AD}{BD} = \frac{AE'}{E'C} \quad \text{— (2)}$$

from (1) & (2)

$$\frac{AE}{EC} = \frac{AE'}{E'C}$$



$$\frac{AE}{EC} = \frac{AE'}{E'C}$$

(add '1' on both sides)

$$\Rightarrow \frac{AE}{EC} + 1 = \frac{AE'}{E'C} + 1$$

$$\Rightarrow \frac{AE + EC}{EC} = \frac{AE' + E'C}{E'C}$$

$$\Rightarrow \frac{\cancel{AC}^{\,1}}{EC} = \frac{\cancel{AC}^{\,1}}{E'C} \Leftrightarrow \boxed{E'C = EC}$$

E' & E coincide

$\therefore DE \parallel BC$.

Q. In fig $\boxed{\frac{PS}{SQ} = \frac{PT}{TR}}$ *and* angle PST = angle PRQ. Prove that PQR is an isosceles triangle.

$\Rightarrow$ we have

$$\frac{PS}{SQ} = \frac{PT}{TR}$$

by converse BPT $\Rightarrow ST \parallel QR$

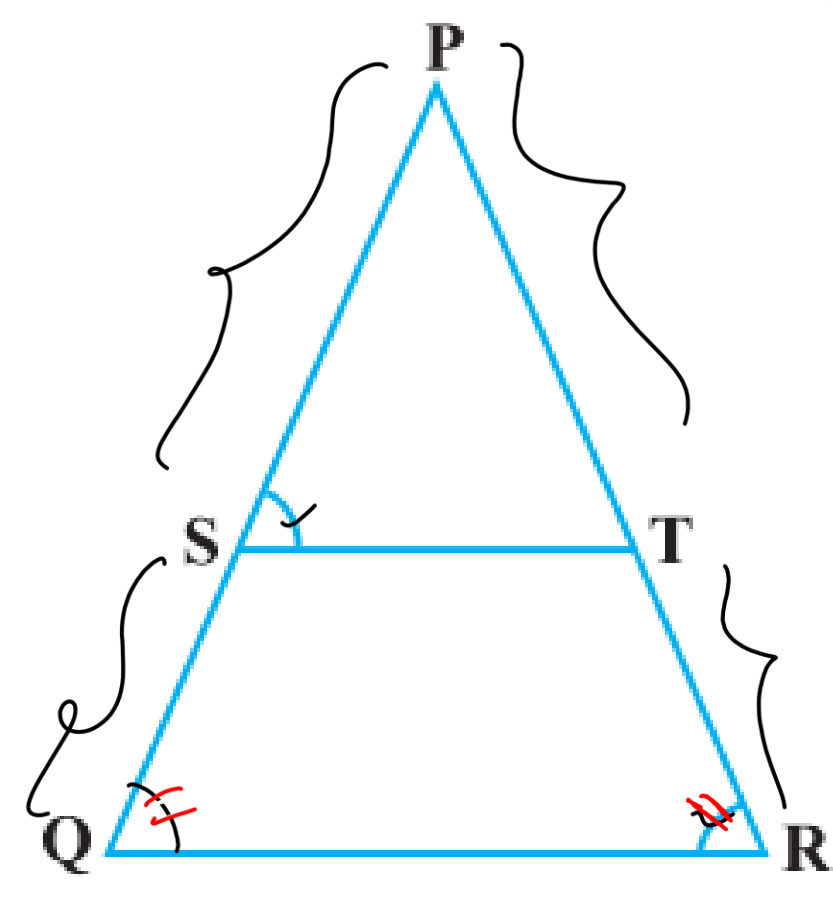
$\Rightarrow ST \parallel QR$ & SR is a transversal.

$\therefore \angle S = \angle Q$ — (1) [corresponding $\angle$les]

$\angle S = \angle R$ (2) (given)

from (1) & (2), $\boxed{\angle Q = \angle R}$

$\therefore \triangle PQR$ is isosceles



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Q. In Fig., DE || OQ and DF || OR. Show that EF || QR.

In $\triangle POQ$, $DE \parallel OQ$

by BPT

$\left(\frac{PE}{QE}\right) = \left(\frac{PD}{OD}\right)$ — (1)

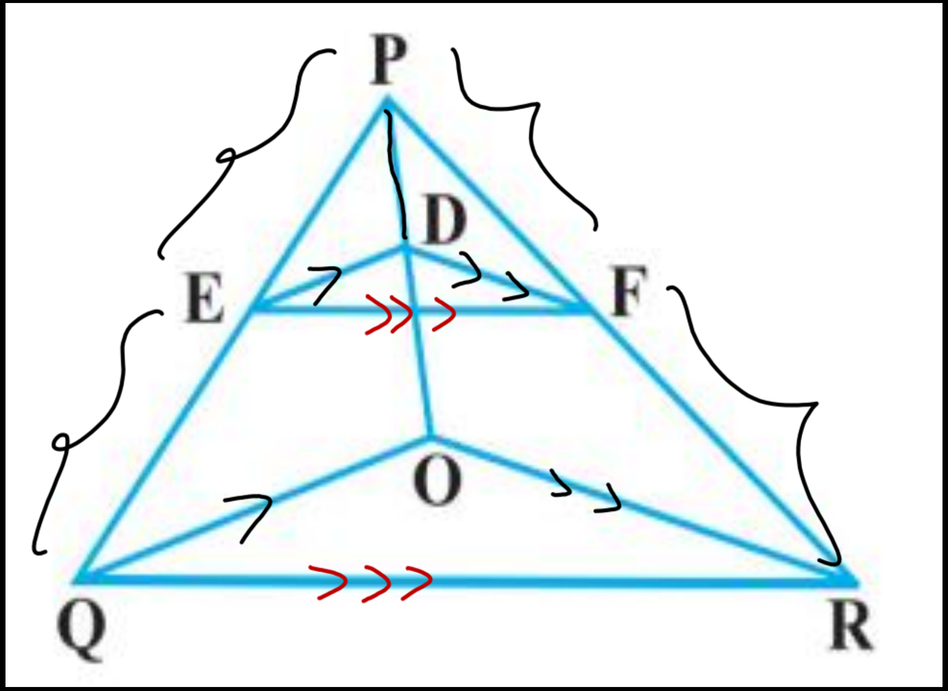
In $\triangle POR$, $DF \parallel OR$

by BPT,

$\left(\frac{PF}{FR}\right) = \left(\frac{PD}{OD}\right)$ — (2)

from (1) & (2),

$\frac{PE}{QE} = \frac{PF}{FR}$



$$\frac{PE}{QE} = \frac{PF}{FR}$$

In $\triangle PQR$, Converse of BPT,

$$\boxed{EF \parallel QR}$$

proved

Q. The diagonals of a quadrilateral ABCD intersect each other at the point O such that $\frac{AO}{BO} = \frac{CO}{DO}$. Show that ABCD is a trapezium.

Const: $\boxed{OF \parallel CD}$

In $\triangle BDC$, by BPT

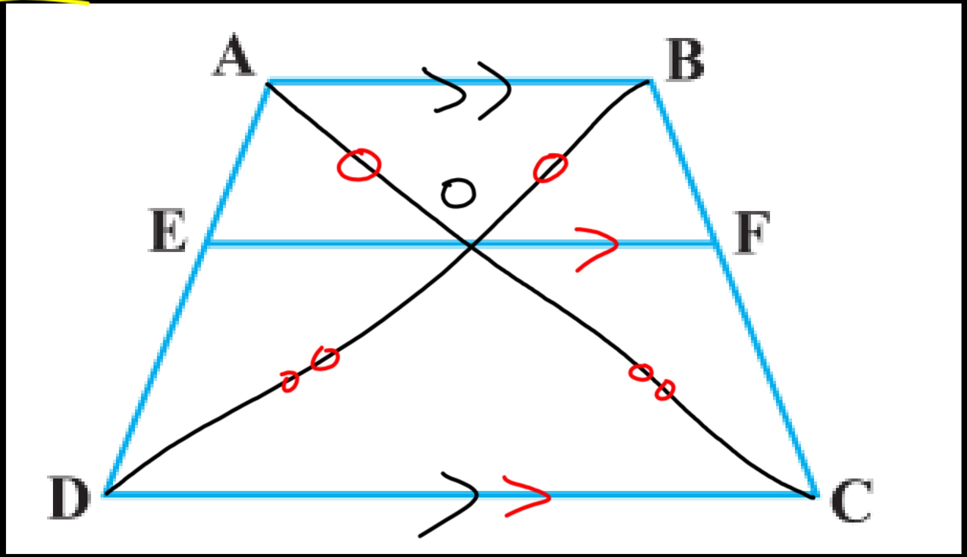
$$\frac{OB}{OD} = \frac{BF}{CF} \quad \text{--- (1)}$$

$$\frac{AO}{BO} = \frac{CO}{DO}$$

$$\frac{AO}{OC} = \frac{OB}{OD} \quad \text{--- (2)}$$

from (1) & (2)

$$\frac{AO}{OC} = \frac{BF}{CF}$$



$$\frac{AO}{OC} = \frac{BF}{CF}$$

$$\frac{OC}{AO} = \frac{CF}{BF} \quad \text{— (3)} \quad [\text{taking reciprocal}]$$

In $\triangle ABC$, by converse BPT.

using (3)

$OF \parallel AB$

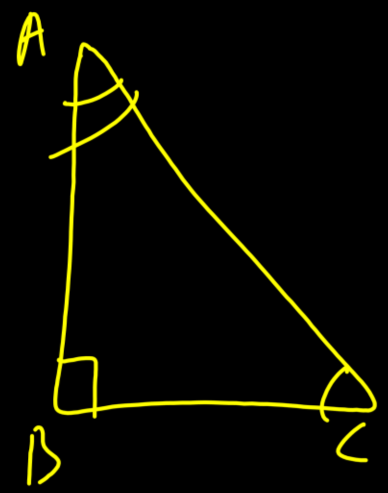
also, $OF \parallel CD$ [by Constr.]

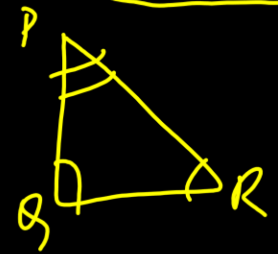
$\therefore AB \parallel OF \parallel CD$

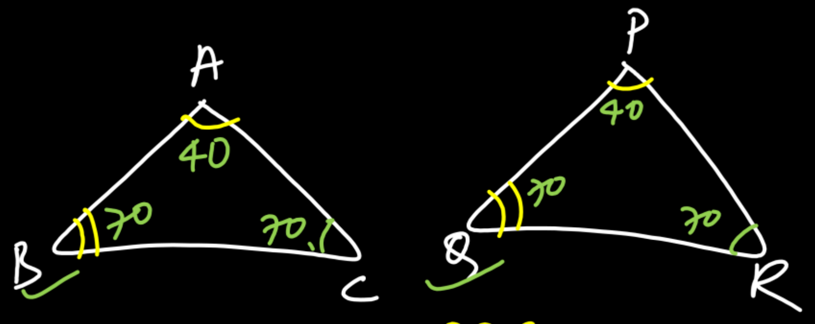
$\Rightarrow AB \parallel CD \Rightarrow ABCD$ is a trapezium.

Criteria for Similarity of Triangles

(~)







$\triangle ABC \sim \triangle PQR$

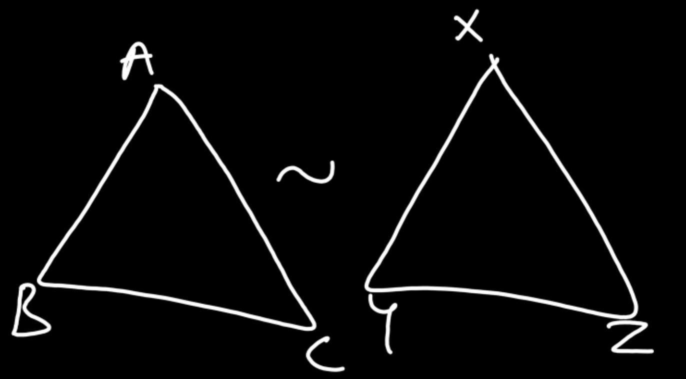
(1) (AAA)

↓

→ (AA) →

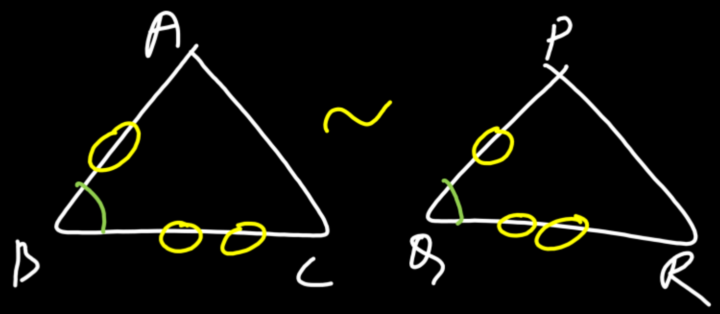
(2) (SSS) → (proportional)

$$\left(\frac{AB}{XY} = \frac{BC}{YZ} = \frac{AC}{XZ}\right)$$



③ (SAS) $\rightarrow$ included

$$\frac{AB}{PQ} = \frac{BC}{QR}$$

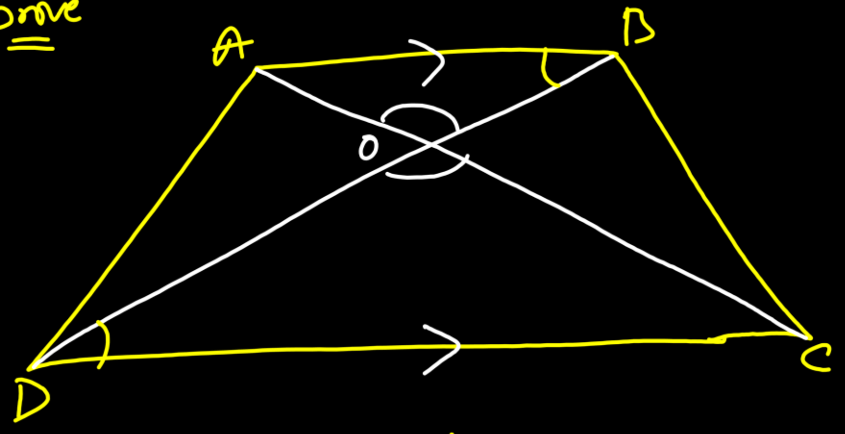


(1) AA

(2) SSS

(3) SAS

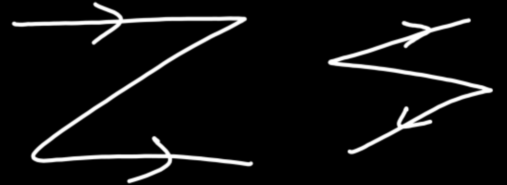
Q. Diagonals AC and BD of a trapezium ABCD with AB || DC intersect each other at the point O. Using a similarity criterion for two triangles, show that $\frac{OA}{OC} = \frac{OB}{OD}$ → To prove



⇒ In ΔAOB & ΔCOD,

$\angle AOB = \angle COD$ [V.O.A]

$\angle ABO = \angle CDO$ [AB || CD & BD is a transversal A.I.A]



$\therefore \Delta AOB \sim \Delta COD$ [AA Criteria]

$\boxed{\frac{AO}{CO} = \frac{OB}{OD}} = \frac{AB}{CD}$

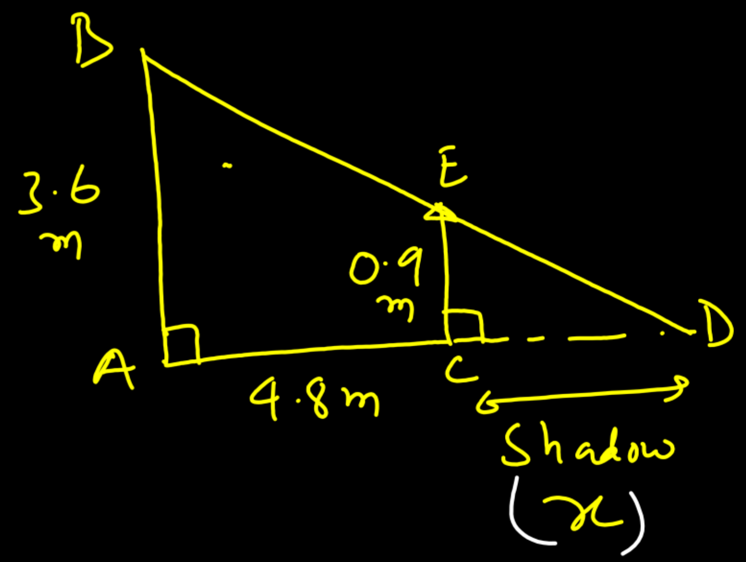
Proved

Q. A girl of height 90 cm is walking away from the base of a lamp-post at a speed of 1.2 m/s. If the lamp is 3.6 m above the ground, find the length of her shadow after 4 seconds

$D = s \times t$
$= 1.2 \times 4$
$= 4.8$ m

In $\triangle DEC$ & $\triangle DBA$,
$\angle D \rightarrow$ is common
$\angle A = \angle C = 90^\circ$
$\triangle DEC \sim \triangle DBA$ (AA Criteria)

$$\frac{EC}{AB} = \frac{CD}{AD} \Rightarrow \frac{0.9}{3.6} = \frac{x}{4.8+x}$$



$$0.9(4.8+x) = 3.6x$$

$$0.9 \times 4.8 + 0.9x = 3.6x$$

$$0.9 \times 4.8 = 3.6x - 0.9x$$

$$0.9 \times 4.8 = 2.7x$$

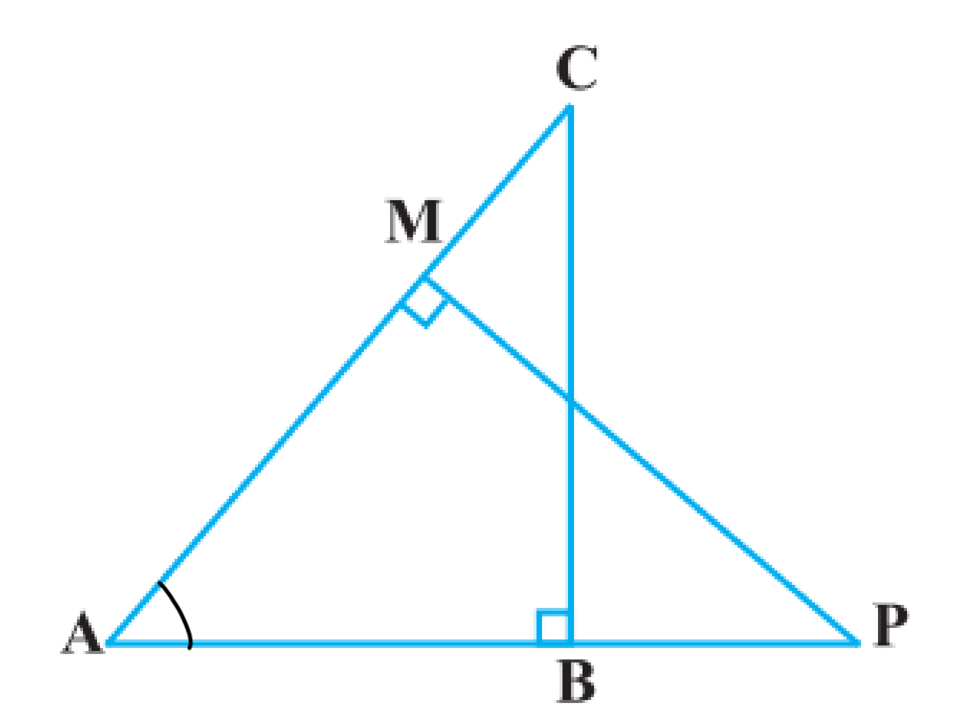
$$x = \frac{0.\cancel{9} \times \cancel{48}^{16} \times \cancel{10}}{\underset{\cancel{3}}{\cancel{27}} \times 10 \times \cancel{10}}$$

$$= \frac{16}{10} = \underline{1.6\,m}$$

Q. In Fig., ABC and AMP are two right triangles, right angled at B and M respectively. Prove that:

(i) ΔABC ~ ΔAMP

(ii) $\frac{CA}{PA} = \frac{BC}{MP}$



→ In ΔABC & ΔAMP,

∠A is common

∠B = ∠M = 90°

ΔABC ~ ΔAMP (AA ...)

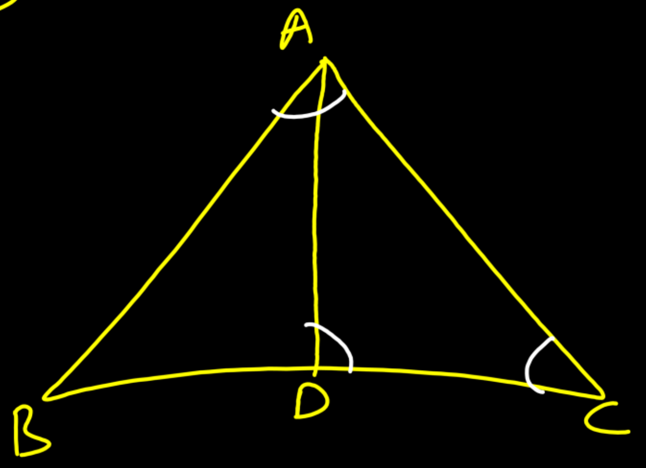
$\frac{CA}{PA} = \frac{AB}{AM} = \frac{BC}{MP}$

Hence proved

Q. D is a point on the side BC of a triangle ABC such that angle ADC = angle BAC. Show that $CA^2 = CB.CD$

$\Rightarrow CA \cdot CA = CB \cdot CD$

$\frac{CA}{CB} = \frac{CD}{CA}$



In $\triangle ADC$ & $\triangle BAC$,

$\angle ADC = \angle BAC$ (given)

$\angle C$ is common

$\triangle ADC \sim \triangle BAC$ [AA criteria]

$\frac{CA}{CB} = \frac{CD}{CA}$

$\boxed{CA^2 = CB \cdot CD}$

Hence proved

Q. Sides AB and AC and median AD of a triangle ABC are respectively proportional to sides PQ and PR and median PM of another triangle PQR. Show that Δ ABC ~ Δ PQR.

Given:

$$\left(\frac{AB}{PQ}\right) = \left(\frac{AC}{PR}\right) = \frac{AD}{PM}$$

Not part of Solution:-

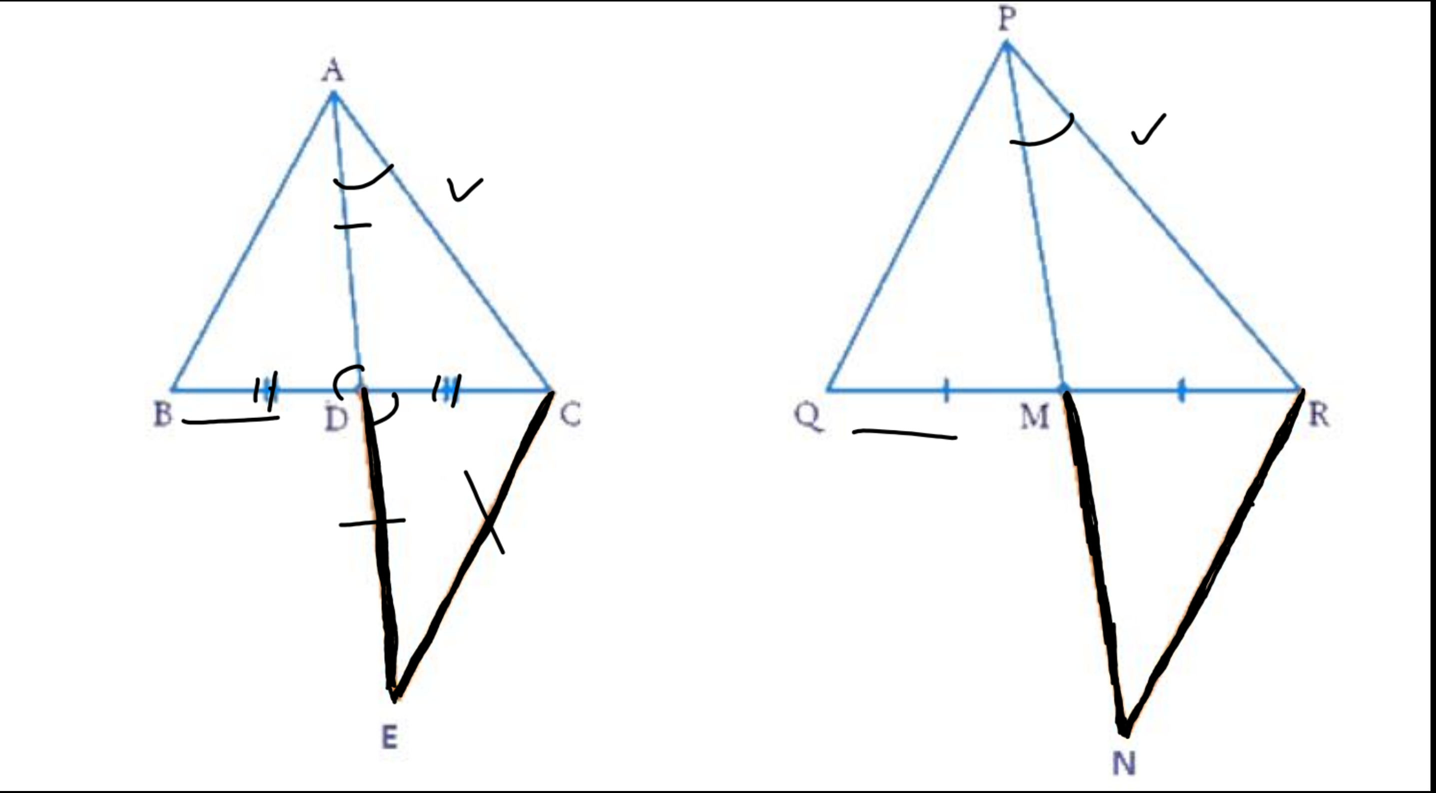
(1) $\triangle ABD \cong \triangle CED$

(2) $\triangle ACE \sim \triangle PRN$

(3) $\triangle ABC \sim \triangle PQR$

Const: $AD = DE$

$PM = MN$



In $\triangle ABD$ & $\triangle CED$,

$BD = CD$ → AD is median

$AD = DE$ → by const.

$\angle ADB = \angle EDC$ [V.O.A]

$\triangle ABD \cong \triangle CED$ [SAS Congruency]

$\boxed{AB = CE}$ (C.P.C.T)

Similarly $\boxed{PQ = RN}$

$$\frac{AB}{PQ} = \frac{AC}{PR} = \frac{AD}{PM}$$ [from given]

$$\frac{CE}{RN} = \frac{AC}{PR} = \left(\frac{AD \times 2}{PM \times 2}\right)$$

$$= \frac{2AD}{2PM} = \frac{AE}{PN}$$

$$\frac{CE}{RN} = \frac{AC}{PR} = \frac{AE}{PN}$$

$\triangle ACE \sim \triangle PRN$ (SSS Criteria)

$\angle CAD = \angle RPM$ ($\triangle$s are similar)

$\angle CAD = \angle RPM$ — ①

Similarly,

$\angle BAD = \angle QPM$ — ②

Adding ① & ②

$\angle CAD + \angle BAD = \angle RPM + \angle QPM$

$$\boxed{\angle BAC = \angle QPR}$$

also $\dfrac{AB}{PQ} = \dfrac{AC}{PR}$

$\therefore \triangle ABC \sim \triangle PQR$ (SAS Criteria)

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Life processes		

Homework Questions

1. A vertical pole of length 6 m casts a shadow 4 m long on the ground and at the same time a tower casts a shadow 28 m long. Find the height of the tower.
2. If AD and PM are medians of triangles ABC and PQR, respectively where $\Delta ABC \sim \Delta PQR$, prove that

$$\frac{AB}{PQ} = \frac{AD}{PM}$$

3. Using Theorem, prove that the line joining the mid-points of any two sides of a triangle is parallel to the third side.

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