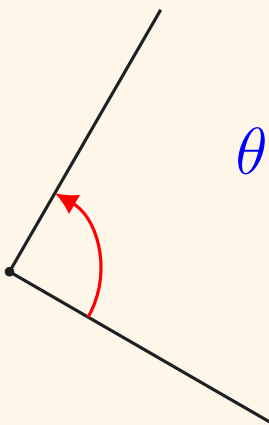
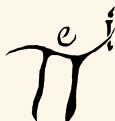


The Comprehensive List of  
**References in Geometry**

AN ILLUSTRATED MANUAL



DECEMBER 2020





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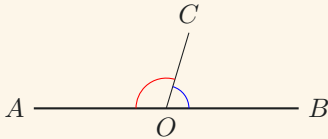
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## Appendix B

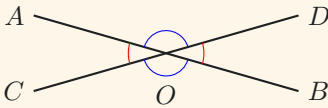
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# Lines



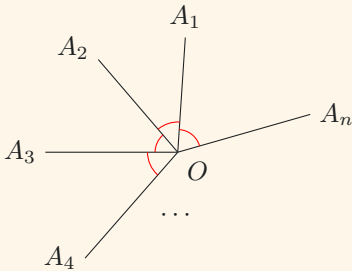
*Adj.  $\angle$ s on st. line*

$$\angle AOC + \angle COB = 180^\circ.$$



*Vert. oppo.  $\angle$ s*

$$\begin{aligned} \angle AOC &= \angle DOB, \\ \angle AOD &= \angle COB. \end{aligned}$$



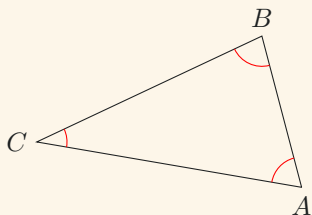
*$\angle$ s at a pt.*

$$\begin{aligned} \angle A_1OA_2 + \angle A_2OA_3 \\ + \dots + \angle A_{n-1}OA_n = 360^\circ. \end{aligned}$$

# TRIANGLES

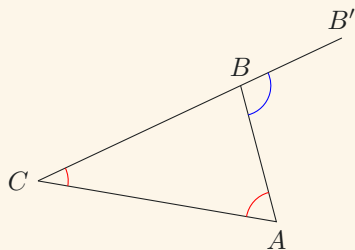
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## Triangles



$\angle$  sum of  $\triangle s$

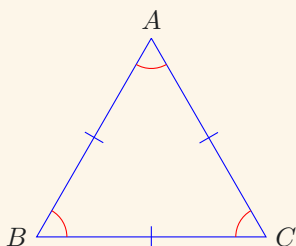
$$\begin{aligned} \angle CAB + \angle ABC \\ + \angle BCA = 180^\circ. \end{aligned}$$



*Ext.*  $\angle$  of  $\triangle s$

$$\angle CAB + \angle BCA = \angle B'BA.$$

## Equilateral Triangles

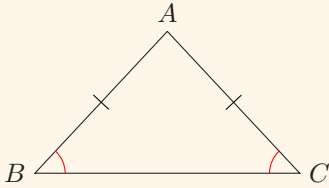


*Prop. of equil.  $\triangle s$*

$$AB = BC = CA,$$

$$\begin{aligned} \angle CAB = \angle ABC \\ = \angle BCA = 60^\circ. \end{aligned}$$

### Isosceles Triangles

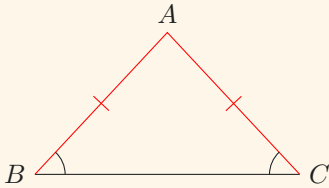


*Base  $\angle$ s, isos.  $\triangle$*

$$AB = AC$$



$$\angle ABC = \angle ACB.$$

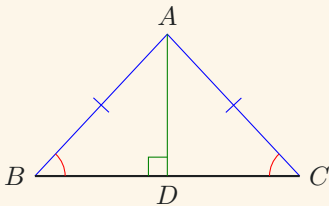


*Sides oppo. eq.  $\angle$ s*

$$\angle ABC = \angle ACB$$



$$AB = AC.$$



*Prop. of isos.  $\triangle$ s*

$$\angle ABC = \angle ACB$$



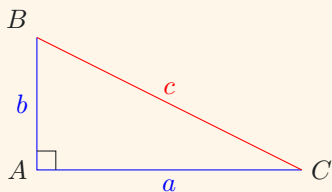
$$AB = AC$$



$$AD \perp BC.$$



### Pythagoras's Theorem

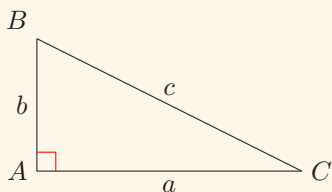


**Pyth. thrm.**

$$BA \perp AC$$



$$a^2 + b^2 = c^2.$$



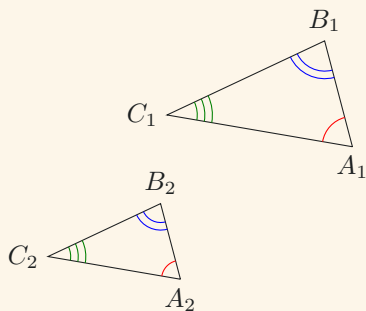
**Conv. of Pyth. thrm.**

$$a^2 + b^2 = c^2$$



$$BA \perp AC.$$

### Similar Triangles



**Corr.  $\angle s \mid \sim \Delta s$**

$$\triangle A_1B_1C_1 \sim \triangle A_2B_2C_2$$



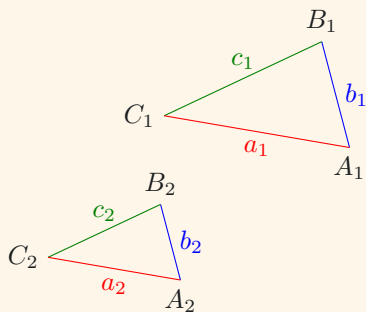
$$\angle C_1A_1B_1 = \angle C_2A_2B_2,$$

$$\angle A_1B_1C_1 = \angle A_2B_2C_2,$$

$$\angle B_1C_1A_1 = \angle B_2C_2A_2.$$

# TRIANGLES

---



**Corr. sides** |  $\sim \Delta s$

$$\Delta A_1B_1C_1 \sim \Delta A_2B_2C_2$$

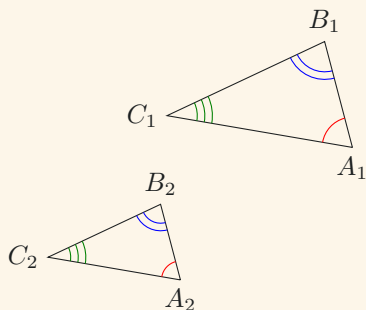
$$\Downarrow$$

$$\frac{a_1}{b_1} = \frac{a_2}{b_2},$$

$$\frac{b_1}{c_1} = \frac{b_2}{c_2},$$

$$\frac{a_1}{b_1} = \frac{a_2}{b_2}.$$

## Conditions for Proving Similar Triangles



**AAA**

$$\angle C_1A_1B_1 = \angle C_2A_2B_2,$$

$$\angle A_1B_1C_1 = \angle A_2B_2C_2,$$

$$\angle B_1C_1A_1 = \angle B_2C_2A_2$$

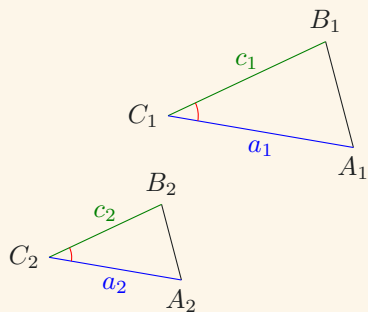
◀ Any two of the three is sufficient.

$$\Downarrow$$

$$\underline{\underline{\Delta A_1B_1C_1 \sim \Delta A_2B_2C_2}}$$

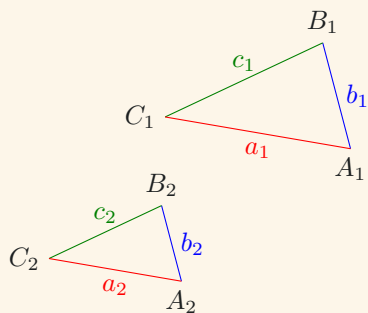
# TRIANGLES

---



*Ratio of two sides,  
incl.  $\angle$*

$$\frac{a_1}{c_1} = \frac{a_2}{c_2},$$
$$\angle B_1C_1A_1 = \angle B_2C_2A_2$$
$$\Downarrow$$
$$\underline{\underline{\triangle A_1B_1C_1 \sim \triangle A_2B_2C_2.}}$$



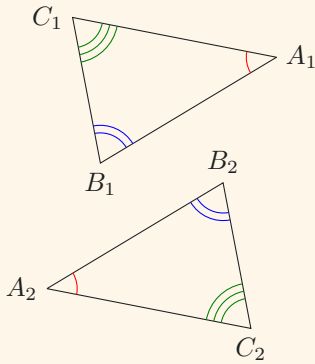
*Three sides  
proportional*

$$\frac{a_1}{b_1} = \frac{a_2}{b_2},$$
$$\frac{b_1}{c_1} = \frac{b_2}{c_2},$$
$$\frac{a_1}{b_1} = \frac{a_2}{b_2}$$
$$\Downarrow$$
$$\underline{\underline{\triangle A_1B_1C_1 \sim \triangle A_2B_2C_2.}}$$

# TRIANGLES

---

## Congruent Triangles



**Corr.  $\angle s$  |  $\cong \triangle s$**

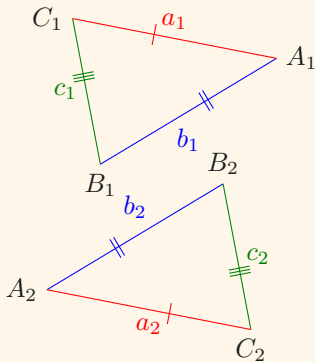
$$\triangle A_1B_1C_1 \cong \triangle A_2B_2C_2$$



$$\angle C_1A_1B_1 = \angle C_2A_2B_2,$$

$$\angle A_1B_1C_1 = \angle A_2B_2C_2,$$

$$\angle B_1C_1A_1 = \angle B_2C_2A_2.$$



**Corr. sides |  $\cong \triangle s$**

$$\triangle A_1B_1C_1 \cong \triangle A_2B_2C_2$$



$$a_1 = a_2,$$

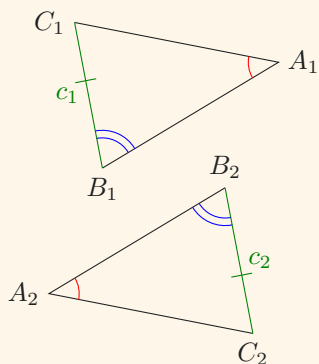
$$b_1 = a_2,$$

$$c_1 = a_2.$$

# TRIANGLES

---

## Conditions for Proving Congruent Triangles



**AAS**

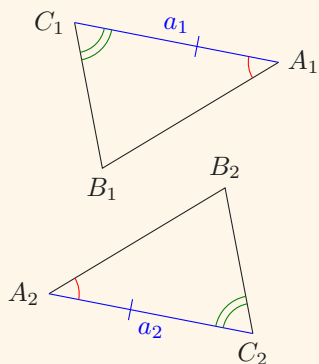
$$\angle C_1A_1B_1 = \angle C_2A_2B_2,$$

$$\angle A_1B_1C_1 = \angle A_2B_2C_2,$$

$$c_1 = c_2$$



$$\underline{\underline{\triangle A_1B_1C_1 \cong \triangle A_2B_2C_2.}}$$



**ASA**

$$\angle A_1B_1C_1 = \angle C_2A_2B_2,$$

$$a_1 = a_2,$$

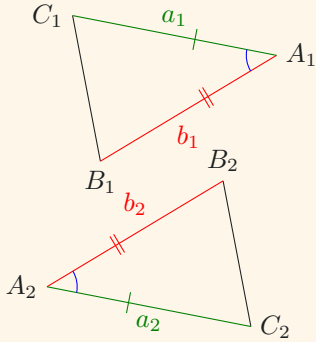
$$\angle B_1C_1A_1 = \angle B_2C_2A_2,$$



$$\underline{\underline{\triangle A_1B_1C_1 \cong \triangle A_2B_2C_2.}}$$

# TRIANGLES

---

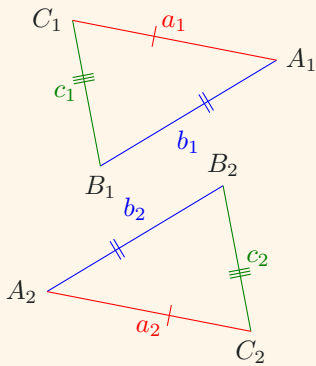


**SAS**

$$\begin{aligned} a_1 &= b_1, \\ \angle B_1A_1C_1 &= \angle B_2A_2C_2, \\ b_1 &= b_2 \end{aligned}$$



$$\underline{\underline{\triangle A_1B_1C_1 \cong \triangle A_2B_2C_2.}}$$



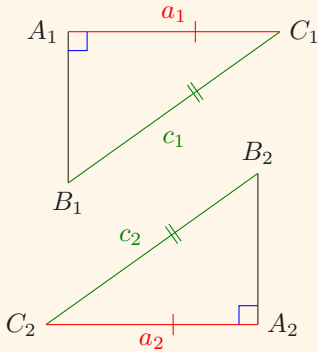
**SSS**

$$\begin{aligned} a_1 &= a_2, \\ b_1 &= a_2, \\ c_1 &= a_2 \end{aligned}$$



$$\underline{\underline{\triangle A_1B_1C_1 \cong \triangle A_2B_2C_2.}}$$

# POLYGONS



**RHS**

$$\angle B_1A_1C_1 = \angle B_2A_2C_2$$

$$= 90^\circ,$$

$$c_1 = c_2,$$

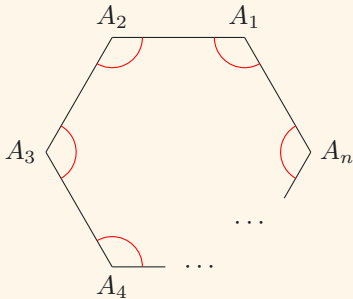
$$a_1 = a_2$$



$$\underline{\underline{\triangle A_1B_1C_1 \cong \triangle A_2B_2C_2.}}$$

◀ One of the sides must be the hypotenuse.

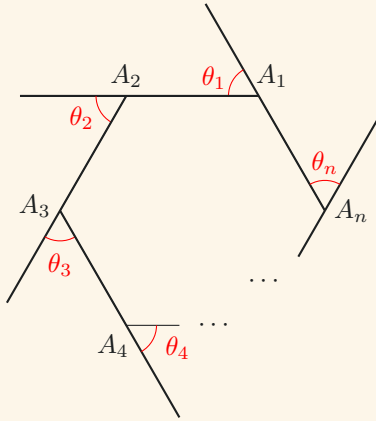
## Polygons



$\angle$  *sum of polygons*

$$\begin{aligned} & \angle A_nA_1A_2 + \angle A_1A_2A_3 + \dots \\ & + \angle A_{n-1}A_nA_1 = (n-2) \cdot 180^\circ. \end{aligned}$$

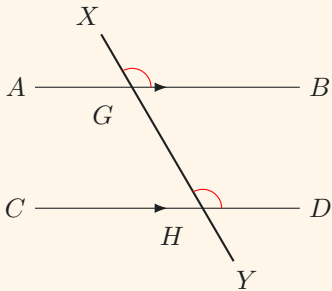
# PARALLEL LINES



*Ext.  $\angle$ s of polygons*

$$\theta_1 + \theta_2 + \dots + \theta_n = 360^\circ.$$

## Parallel Lines



*Corr.  $\angle$ s |  $AB \parallel CD$*

$$AB \parallel CD$$

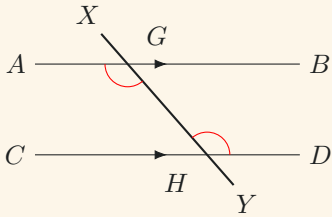


$$\angle XGB = \angle XHD.$$



# PARALLEL LINES

---

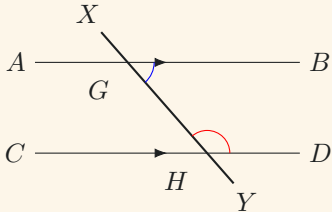


*Alt.*  $\angle s \mid AB \parallel CD$

$$AB \parallel CD$$



$$\angle YGA = \angle XHD.$$



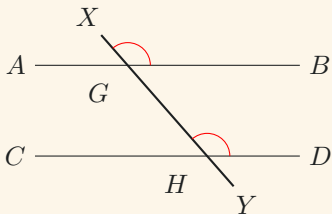
*Int.*  $\angle s \mid AB \parallel CD$

$$AB \parallel CD$$



$$\angle YGB + \angle XHD = 180^\circ.$$

## Conditions for Proving Parallelism



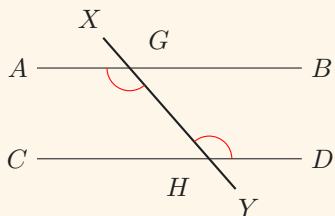
*Int.*  $\angle s \text{ eq.}$

$$\angle YGB + \angle XHD = 180^\circ$$



$$\underline{AB \parallel CD.}$$

# PARALLELOGRAMS

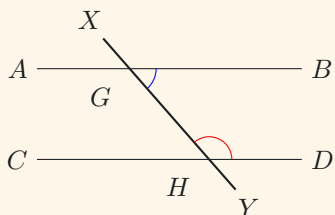


**Alt.  $\angle$ s eq.**

$$\angle YGA = \angle XHD$$



$$\underline{\underline{AB \parallel CD.}}$$



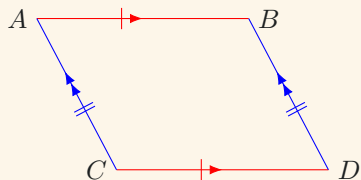
**Int.  $\angle$ s eq**

$$\angle YGB + \angle XHD = 180^\circ$$



$$\underline{\underline{AB \parallel CD.}}$$

## Parallelograms



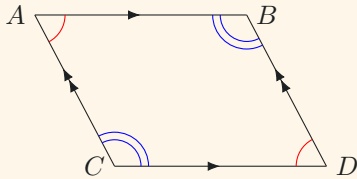
**Oppo. sides of  $\parallel$ -gram**

$$AB = CD,$$

$$AC = BD.$$

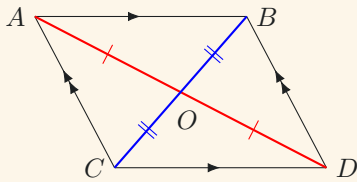
# PARALLELOGRAMS

---



*Oppo.  $\angle$ s of  $\parallel$ -gram*

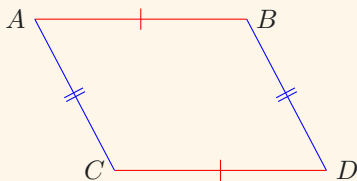
$$\begin{aligned}\angle BAC &= \angle BDC, \\ \angle ACD &= \angle ABD.\end{aligned}$$



*Diags. of  $\parallel$ -gram*

$$\begin{aligned}OA &= OD, \\ OB &= OC.\end{aligned}$$

## Conditions for Identifying Parallelograms



*Oppo. sides eq.*

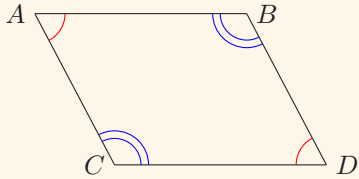
$$\begin{aligned}AB &= CD, \\ AC &= BD\end{aligned}$$



$ABCD$  is a  $\parallel$ -gram.

# PARALLELOGRAMS

---

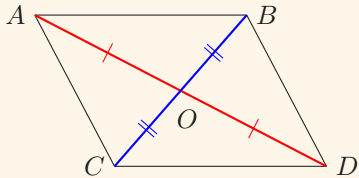


***Oppo.  $\angle$ s eq.***

$$\begin{aligned} \angle BAC &= \angle BDC, \\ \angle ACD &= \angle ABD \end{aligned}$$



ABCD is a // -gram.

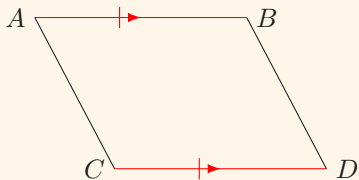


***Diags. bisect each other***

$$\begin{aligned} OA &= OD, \\ OB &= OC \end{aligned}$$



ABCD is a // -gram.



***Two sides eq. and //***

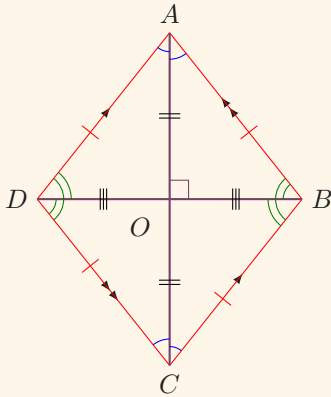
$$\begin{aligned} AB &= CD, \\ AB &\parallel CD \end{aligned}$$



ABCD is a // -gram.

## Other Quadrilaterals

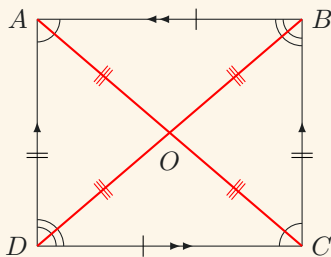
Rhombus - a quadrilateral with four equal sides



**Prop. of rhombuses**

- $AB \parallel CD \quad AD \parallel BC,$
- $OA = OC \quad OB = OD,$
- $AB = BC = CD = DA,$
- $AC \perp BD,$
- $\angle OAD = \angle OAB$
- $\quad = \angle OCD = \angle OCB,$
- $\angle ODA = \angle ODC$
- $\quad = \angle OBA = \angle OBC.$

Rectangle - a quadrilateral with four equal interior angles

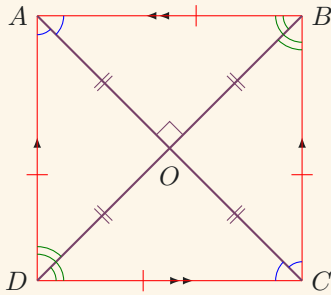


**Prop. of rectangles**

- $AB \parallel CD \quad AD \parallel BC,$
- $AB = CD \quad AD = BC,$
- $\angle BAD = \angle BCD,$
- $\angle ABC = \angle ADC,$
- $OA = OB = OC = OD.$

## QUADRILATERALS

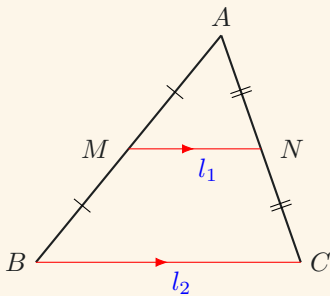
**Square** - a quadrilateral with four equal sides and interior angles



### *Prop. of squares*

$$\begin{aligned} AB \parallel CD \quad AD \parallel BC, \\ AB = BC = CD = DA, \\ OA = OB = OC = OD, \\ AC \perp BD, \\ \angle OAD = \angle OAB = 90^\circ \\ = \angle OCD = \angle OCB, \\ \angle ODA = \angle ODC = 90^\circ \\ = \angle OBA = \angle OBC. \end{aligned}$$

## Miscellaneous Results



### *Mid-pt. thrm.*

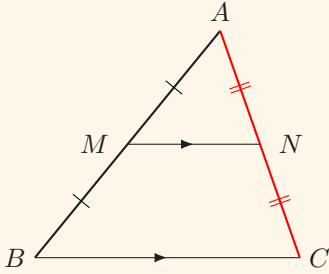
$$MA = MB \quad NA = NC$$



$$\begin{aligned} 2l_1 &= l_2, \\ MN &\parallel BC. \end{aligned}$$

# QUADRILATERALS

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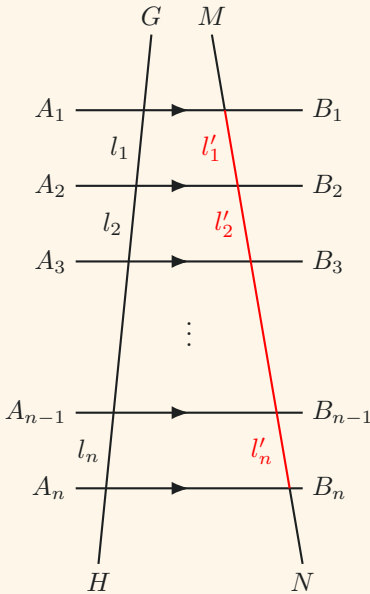


**Intercept thrm.** variant i

$$MA = NA \quad MN \parallel BC$$



$$MB = NC.$$



**Intercept thrm.** variant ii

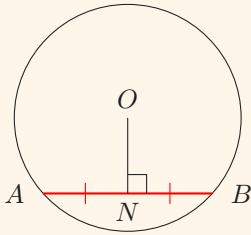
$$A_1B_1 \parallel A_2B_2 \parallel \dots \parallel A_nB_n$$

$$l_1 = l_2 = \dots = l_n.$$



$$l'_1 = l'_2 = \dots = l'_n.$$

## Circles

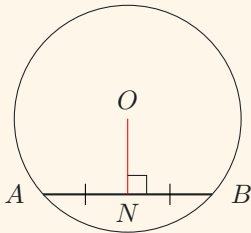


*Line from cen.  $\perp$   
chord bisects chord*

$$ON \perp AB$$



$$NA = NB.$$



*Line joining cen.  
to mid-pt. of  
chord  $\perp$  chord*

$$NA = NB$$

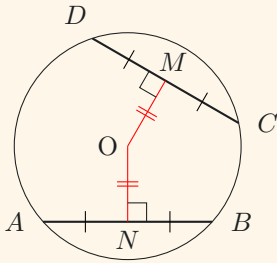


$$ON \perp AB.$$



# CIRCLES

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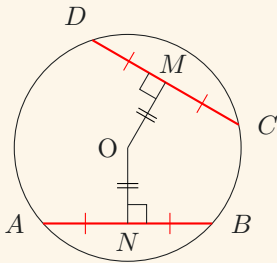
*Eq. chords  
equidis. from cen.*

$$ON \perp AB \quad OM \perp CD,$$

$$AB = CD$$



$$ON = OM.$$



*Chords equidis. from  
cen. are eq.*

$$ON \perp AB \quad OM \perp CD,$$

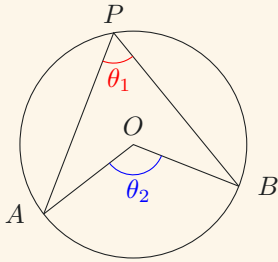
$$ON = OM$$



$$AB = CD.$$

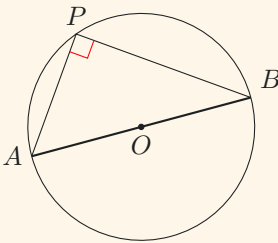
# CIRCLES

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$\angle$  at cen. twice  
 $\angle$  at  $\odot^{ce}$

$$2\theta_1 = \theta_2.$$

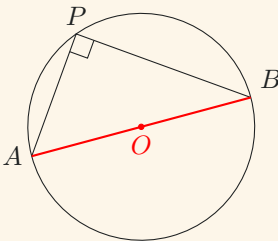


$\angle$  in semi-circ.

$AB$  is a diameter



$$\angle APB = 90^\circ.$$



Converse of  
 $\angle$  in semi-circ.

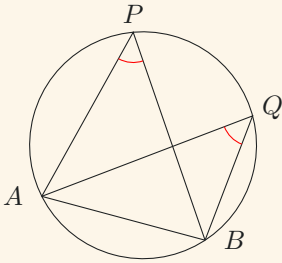
$$\angle APB = 90^\circ$$



$AB$  is a diameter.

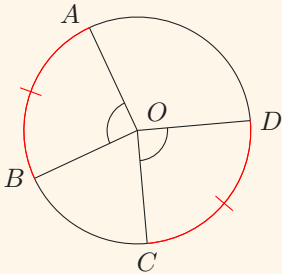
# CIRCLES

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$\angle s$  in the same segment

$$\angle APB = \angle AQB.$$

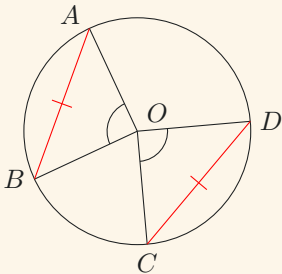


Eq.  $\angle s$ , eq. arcs

$$\angle AOB = \angle COD$$



$$\widehat{AB} = \widehat{CD}.$$



Eq.  $\angle s$ , eq. chords

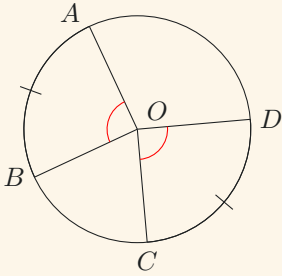
$$\angle AOB = \angle COD$$



$$AB = CD.$$

# CIRCLES

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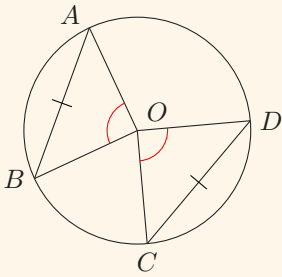


*Eq. arcs, eq.  $\angle$ s*

$$\widehat{AB} = \widehat{CD}$$



$$\angle AOB = \angle COD.$$

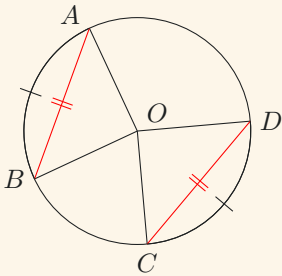


*Eq. chords, eq.  $\angle$ s*

$$AB = CD$$



$$\angle AOB = \angle COD.$$



*Eq. arcs, eq. chords*

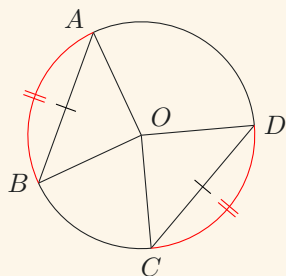
$$\widehat{AB} = \widehat{CD}$$



$$AB = CD.$$

# CIRCLES

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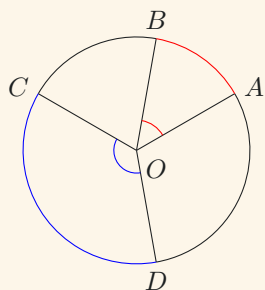


*Eq. chords, eq. arcs*

$$AB = CD$$

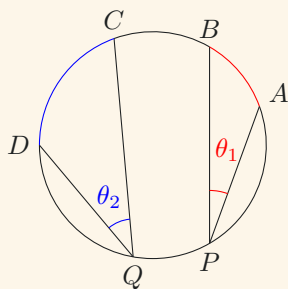


$$\widehat{AB} = \widehat{CD}.$$



*Arcs prop. to  $\angle$ s at cen.*

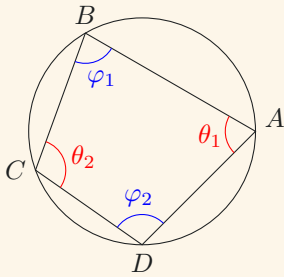
$$\frac{\widehat{AB}}{\widehat{CD}} = \frac{\theta_1}{\theta_2}.$$



*Arcs prop. to  $\angle$ s at  $\odot^{ce}$*

$$\frac{\widehat{AB}}{\widehat{CD}} = \frac{\theta_1}{\theta_2}.$$

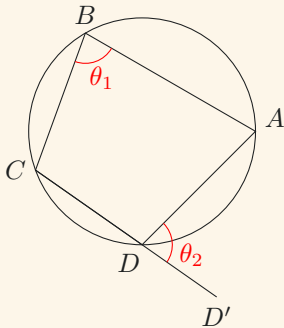
### Cyclic Quadrilaterals



*Oppo.  $\angle$ s, cyclic quad.*

$$\theta_1 + \theta_2 = 180^\circ,$$

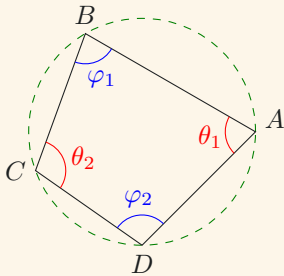
$$\phi_1 + \phi_2 = 180^\circ.$$



*Ext.  $\angle$ s, cyclic quad.*

$$\theta_1 = \theta_2.$$

Conditions for Identifying Cyclic Quadrilaterals

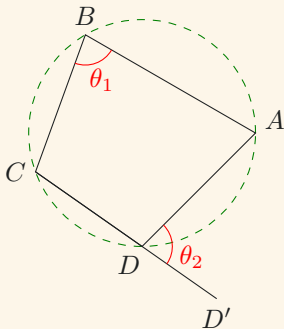


*Oppo.  $\angle$ s supp.*

$$\begin{aligned} \theta_1 + \theta_2 &= 180^\circ, \\ \varphi_1 + \varphi_2 &= 180^\circ \end{aligned}$$



$A, B, C$  and  $D$  are concyclic.



*Ext.  $\angle =$  int. oppo.  $\angle$*

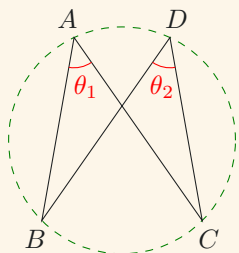
$$\theta_1 = \theta_2$$



$A, B, C$  and  $D$  are concyclic.

# CIRCLES

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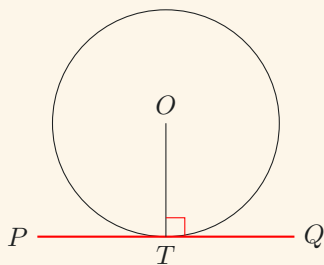
*Converse of  $\angle s$   
in the same segment*

$$\theta_1 = \theta_2$$



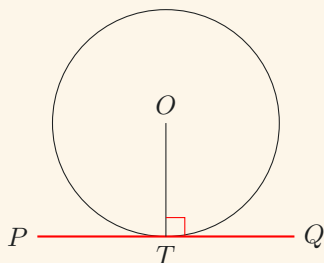
$A, B, C$  and  $D$  are concyclic.

## Tangents



*Tan.  $\perp$  radius*

$$OT \perp PQ.$$



*Converse of  
tan.  $\perp$  radius*

$$OT \perp PQ.$$

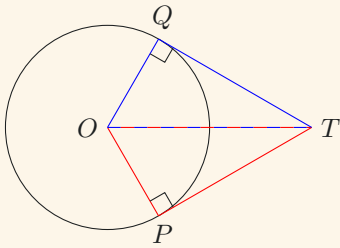


$PQ$  is tangent  
to the circle at  $T$ .



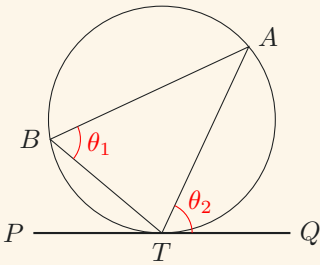
# CIRCLES

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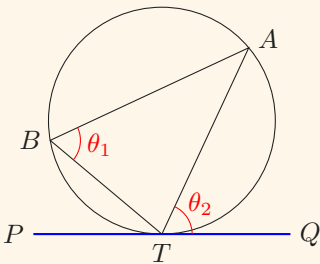
*Tan. prop.*

$$\triangle OPT \cong \triangle OQT.$$



$\angle$  in alt. segment

$$\theta_1 = \theta_2.$$



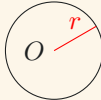
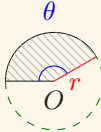
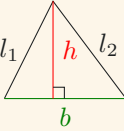
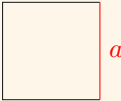
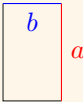
*Converse of*  
 $\angle$  in alt. segment

$$\theta_1 = \theta_2$$



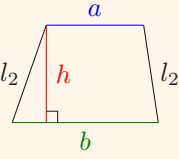
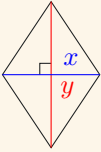
$PQ$  is tangent  
to the circle at  $T$ .

## Appendix A: Area and Perimeters of Common Plane Figures

FIGURE	AREA	PERIMETER	
	$\pi r^2$	$2\pi r$	◀ CIRCLES
	$\frac{\pi\theta r^2}{360^\circ}$	$\frac{2\pi\theta r}{360^\circ} + 2r$	◀ SECTORS
	$\frac{hb}{2}$	$b + l_1 + l_2$	◀ TRIANGLES
	$a^2$	$4a$	◀ SQUARES
	$ab$	$2(a + b)$	◀ RECTANGLES

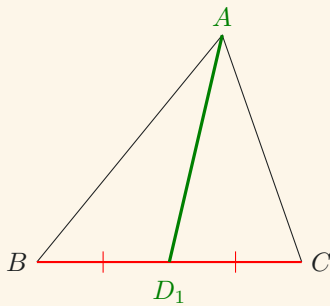
# SPECIAL POINTS AND LINES IN $\triangle$ S

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	$\frac{h(a+b)}{2}$	$a + b + l_1 + l_2$	◀ TRAPEZIUMS
	$\frac{xy}{2}$	$2\sqrt{x^2 + y^2}$	◀ RHOMBUSES

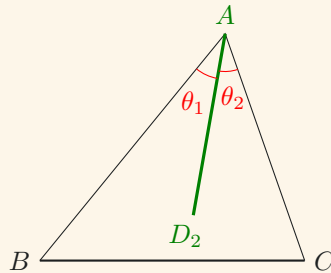
## Appendix B: Special Points and Lines in $\triangle$ s

$AD_1$  is the *median* of  $BC$



$$BD_1 = CD_1.$$

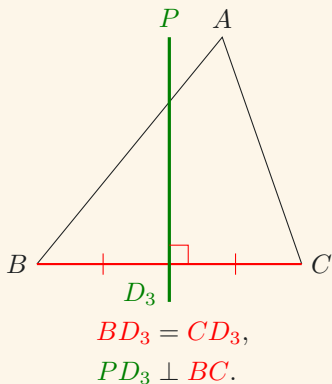
$AD_2$  is an *angle bisector* of  $\angle BAC$



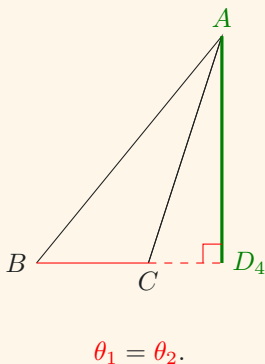
$$\theta_1 = \theta_2.$$

# SPECIAL POINTS AND LINES IN $\triangle$ S

$PD_3$  is a *perpendicular bisector* of  $BC$

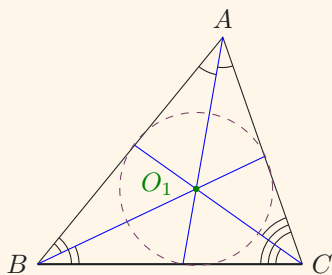


$AD_2$  is the *altitude* of  $BC$



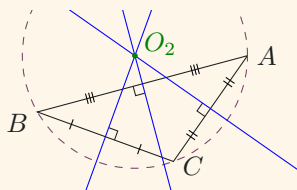
◀ May not necessarily lie in  $\triangle$ .

$O_1$  is the *in-centre* of  $\triangle ABC$



The *in-centre* is the point of intersection of the three **angle bisectors** (of a triangle). It is the center of the triangle's inscribed circle.

$O_2$  is the *circumcentre* of  $\angle BAC$



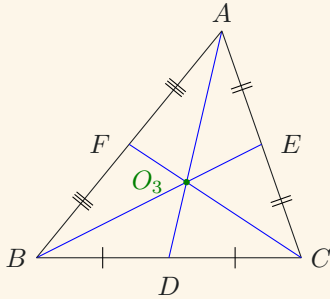
The *circumcentre* is the point of intersection of the three **perpendicular bisectors**. It is the center of the triangle's circumcircle.

◀ May not necessarily lie in  $\triangle$ .

## SPECIAL POINTS AND LINES IN $\triangle$ S

---

$O_1$  is the *centroid* of  $\triangle ABC$

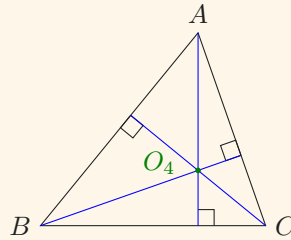


The *centroid* is the point of intersection of the three **medians** (of a triangle).

It divides each median in the ratio of 2 : 1, i.e.,

$$\frac{O_3A}{O_3D} = \frac{O_3B}{O_3E} = \frac{O_3C}{O_3F} = 2.$$

$O_4$  is the *orthocentre* of  $\triangle ABC$



The *orthocentre* is the point of intersection of the three **altitudes**.

◀ May not necessarily lie in  $\triangle$ .

These four points are generally distinct from one another.