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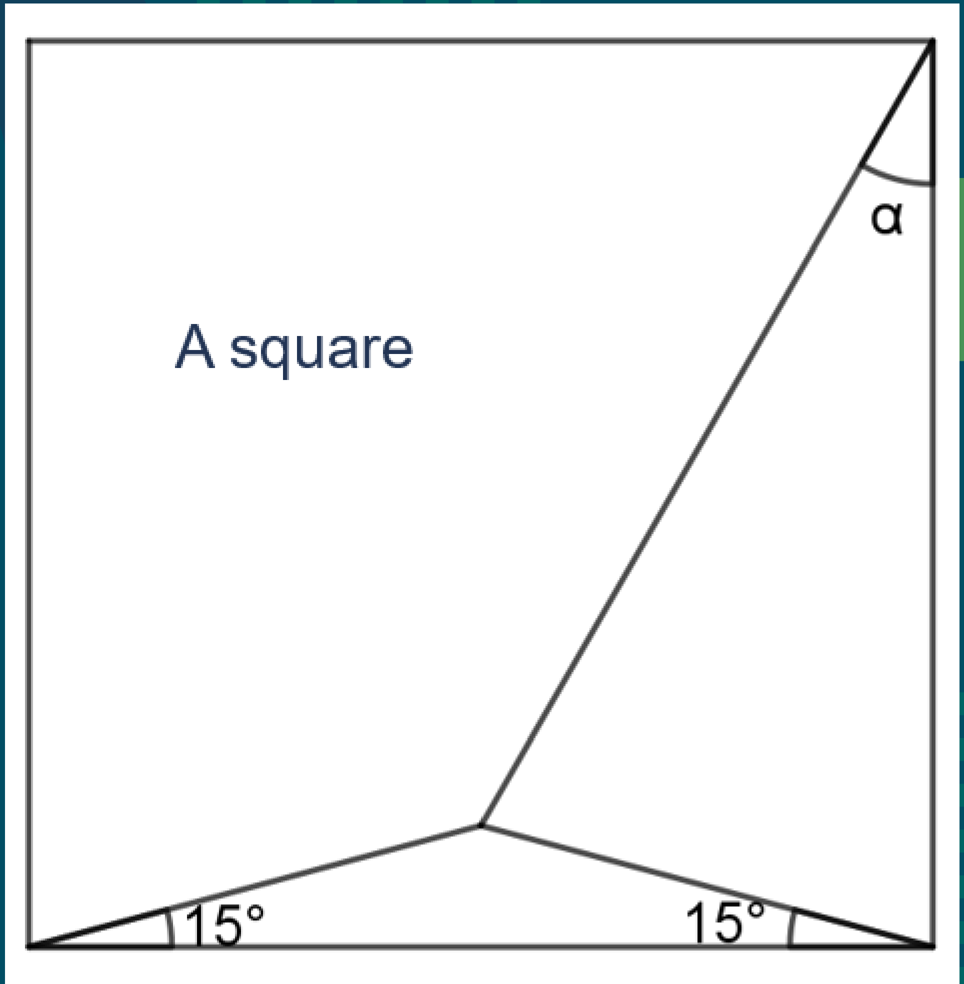
Geometric Problem Solving

Bernard Murphy



Geometric Problem Solving

Geometry offers opportunities for genuine problem solving: walk around the problem, view it from different angles and decide on a plan of attack. In this session we’ll start just beyond where GCSE stops. With Pythagoras, similar triangles and the circle theorems in our toolkit, we’ll introduce two or three new helpful ideas and then tackle a range of problems, thinking how you operate when a problem really is a problem.

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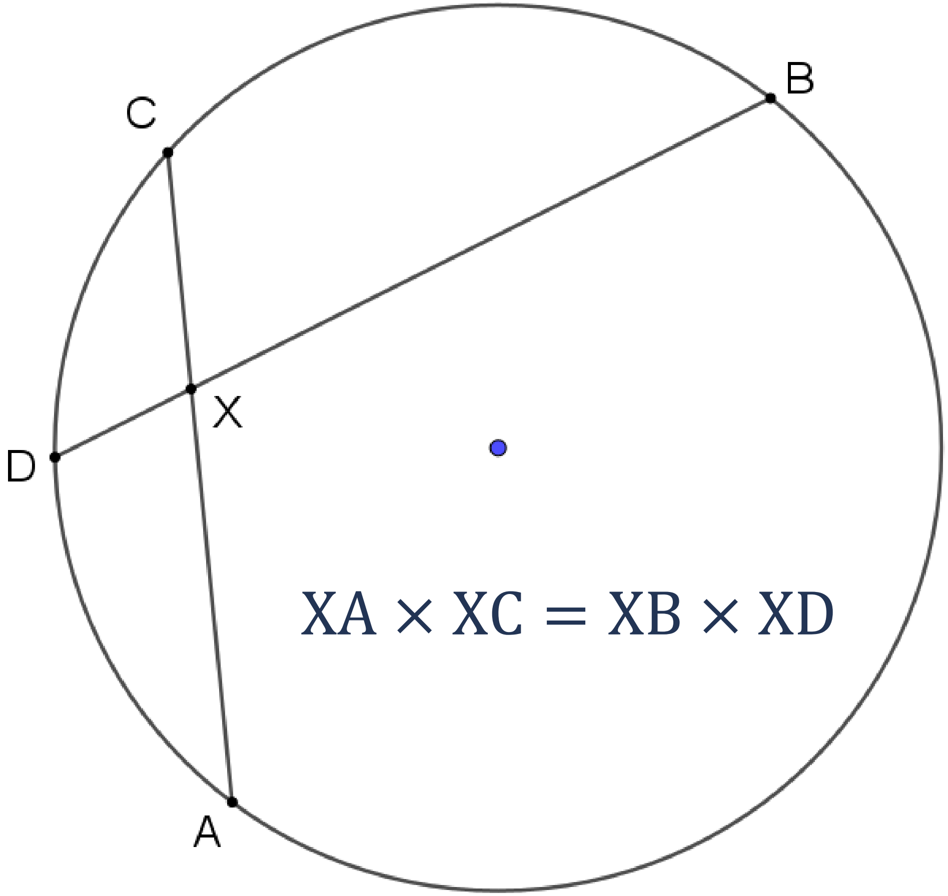
Intersecting chords theorem



$$XA \times XC = XB \times XD$$

Add lines
Similar triangles
Circle Theorems
Intersecting chords theorem

https://www.geogebra.org/m/pjcnttrg

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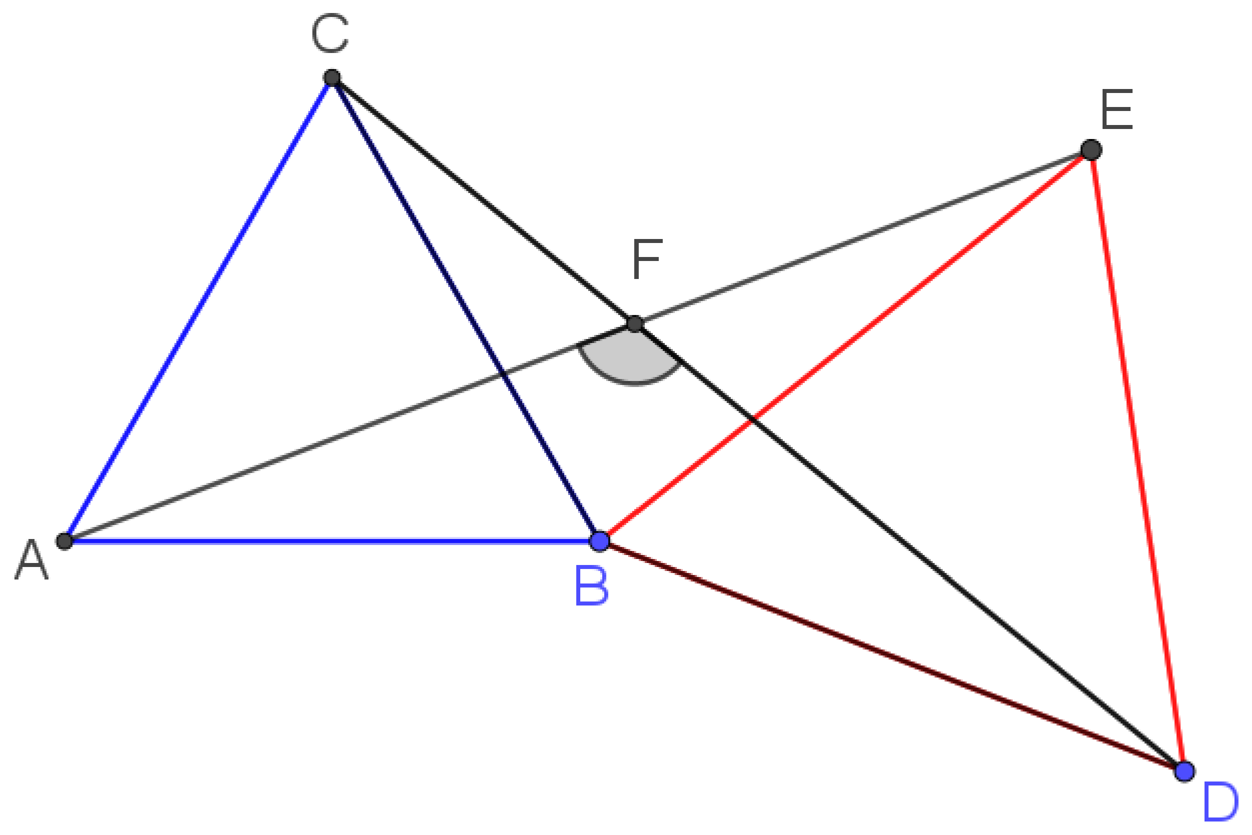
ABC and BDE are equilateral triangles.

CD and AE meet at F.

What is the angle at F?



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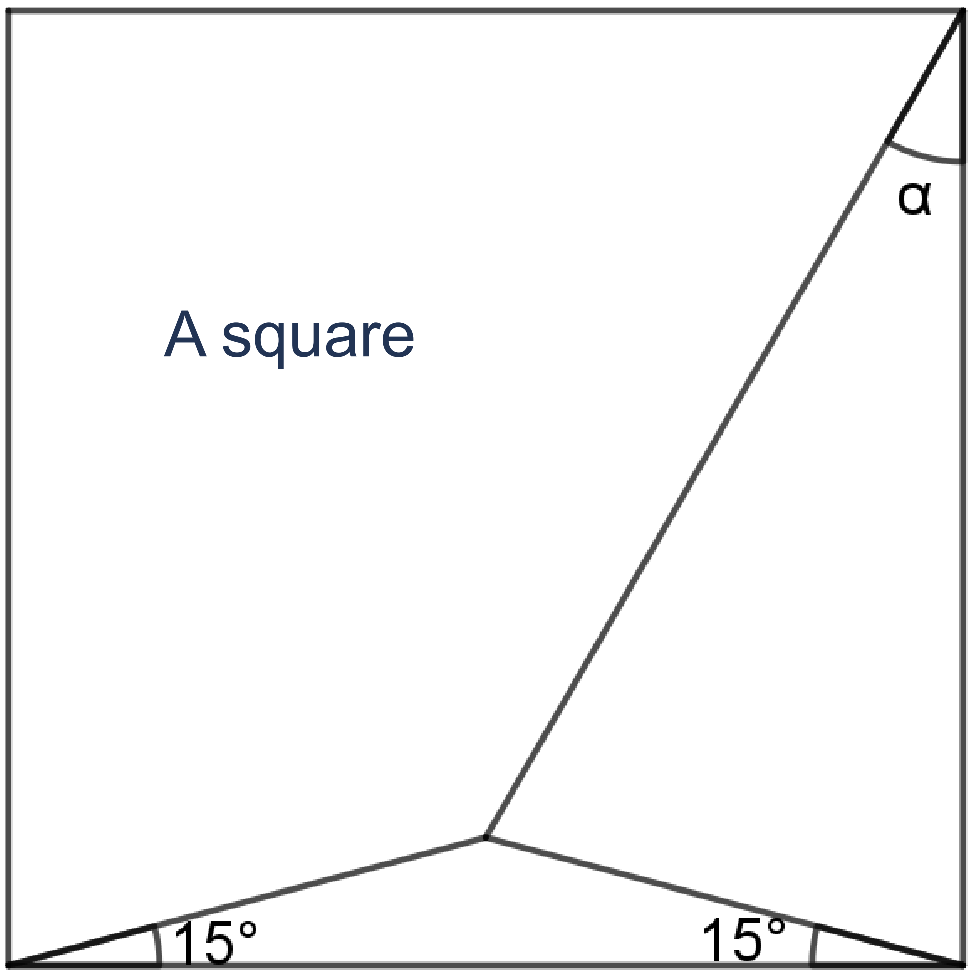
Add lines
Similar triangles
Circle Theorems
Intersecting chords theorem

Congruent triangles
Rotation



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Add lines
Similar triangles
Circle Theorems
Intersecting chords theorem

Congruent triangles
Rotation

Ignore some information
Isosceles triangles
Equilateral triangles

Pythagoras
Cyclic quadrilaterals

Over to you

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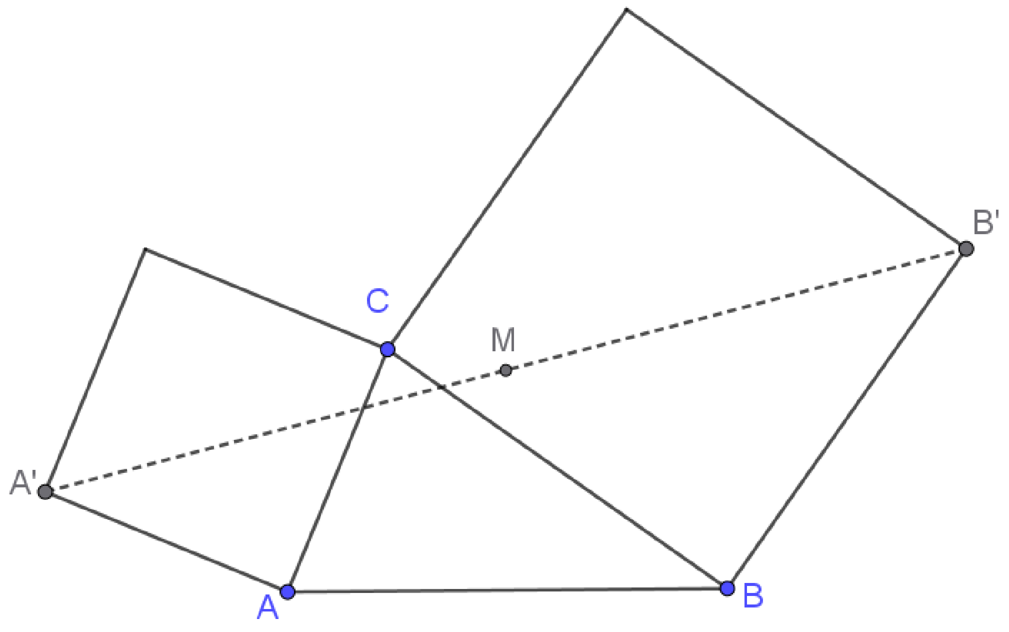


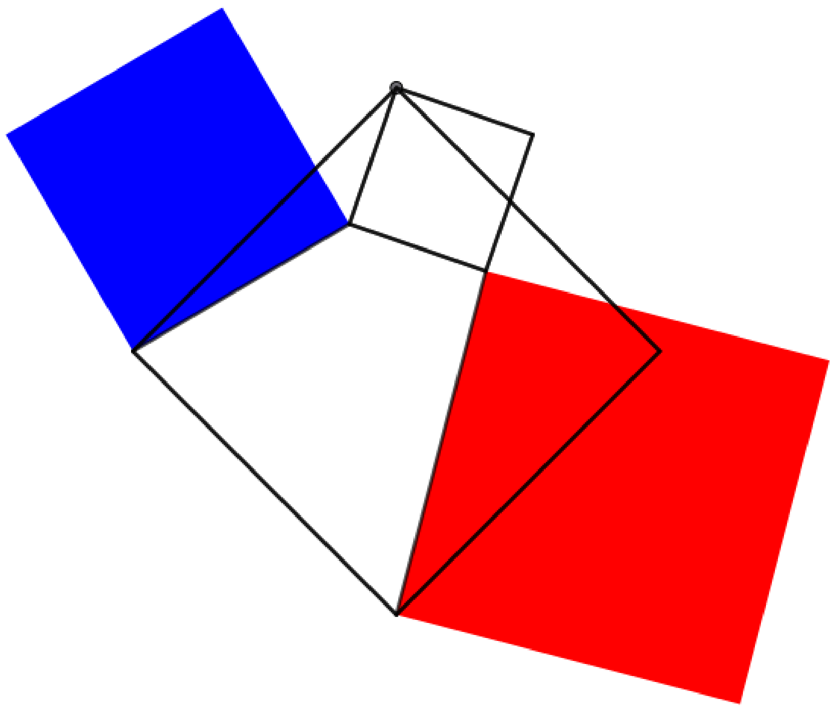
AB is fixed, C can move.

Construct squares on AC and BC.

Prove that M, the midpoint of A'B', is fixed.

https://www.geogebra.org/m/yaqsuyeb

The two unshaded squares share a vertex. Prove that the red square has double the area of the blue square.



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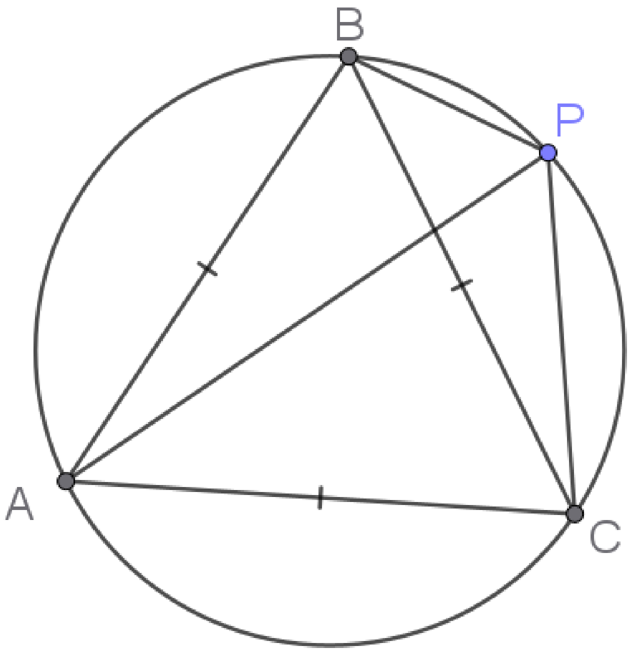
Van Schooten's Theorem.
Equilateral triangle ABC in a circle with P on minor arc BC.
Prove AP=BP+PC



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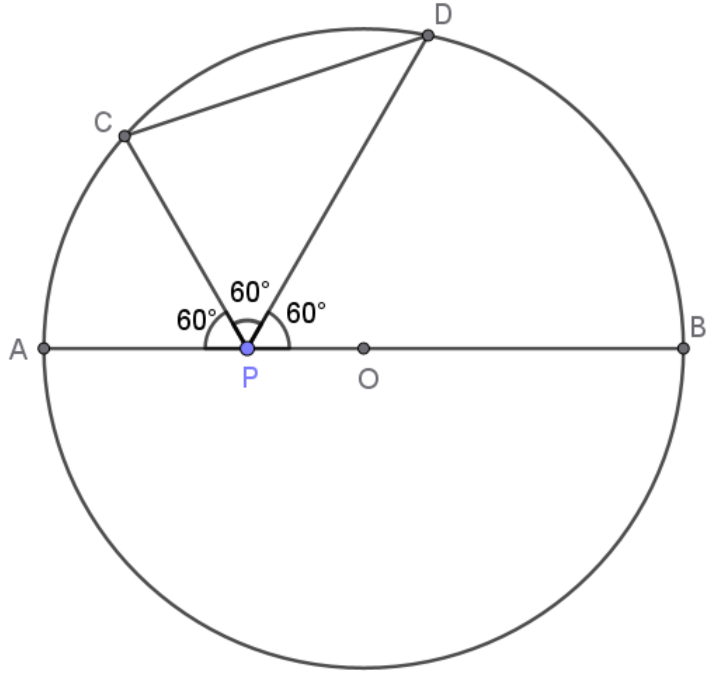
As P moves along the diameter AB, prove that the length CD is constant.



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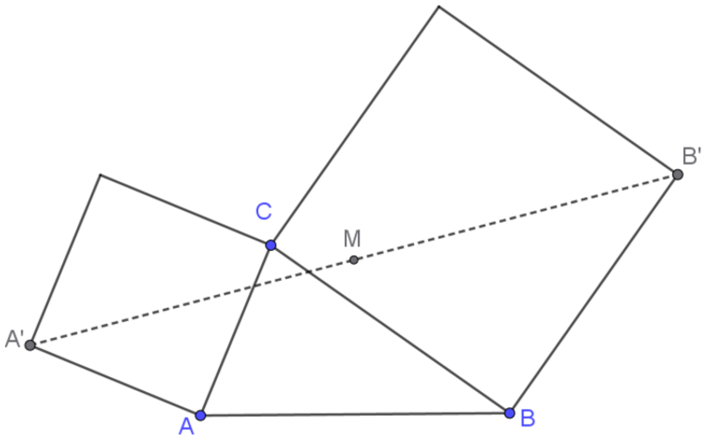
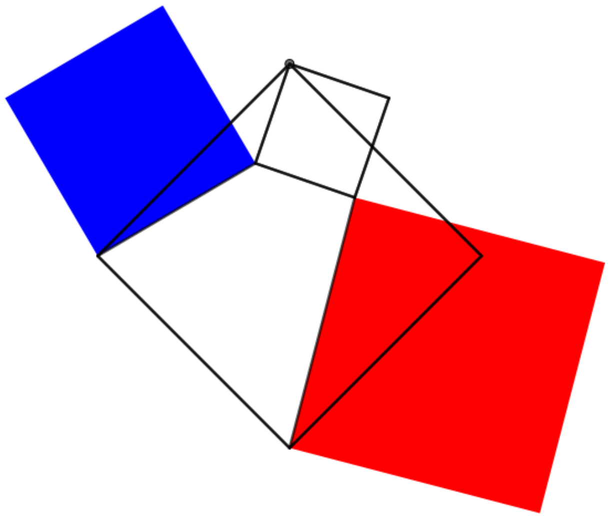
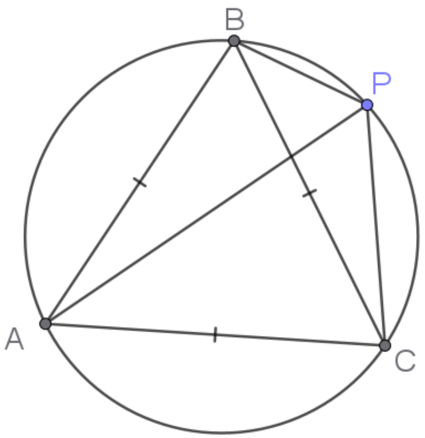
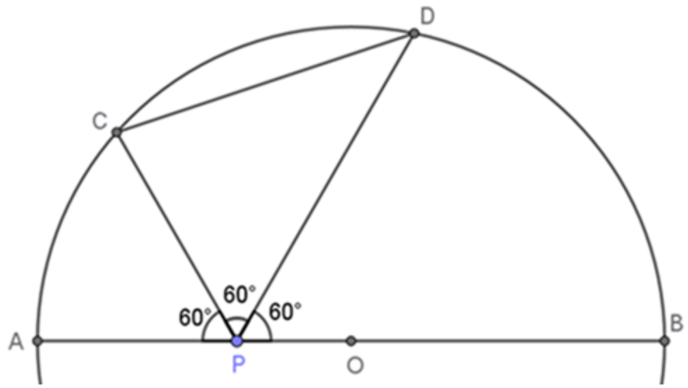
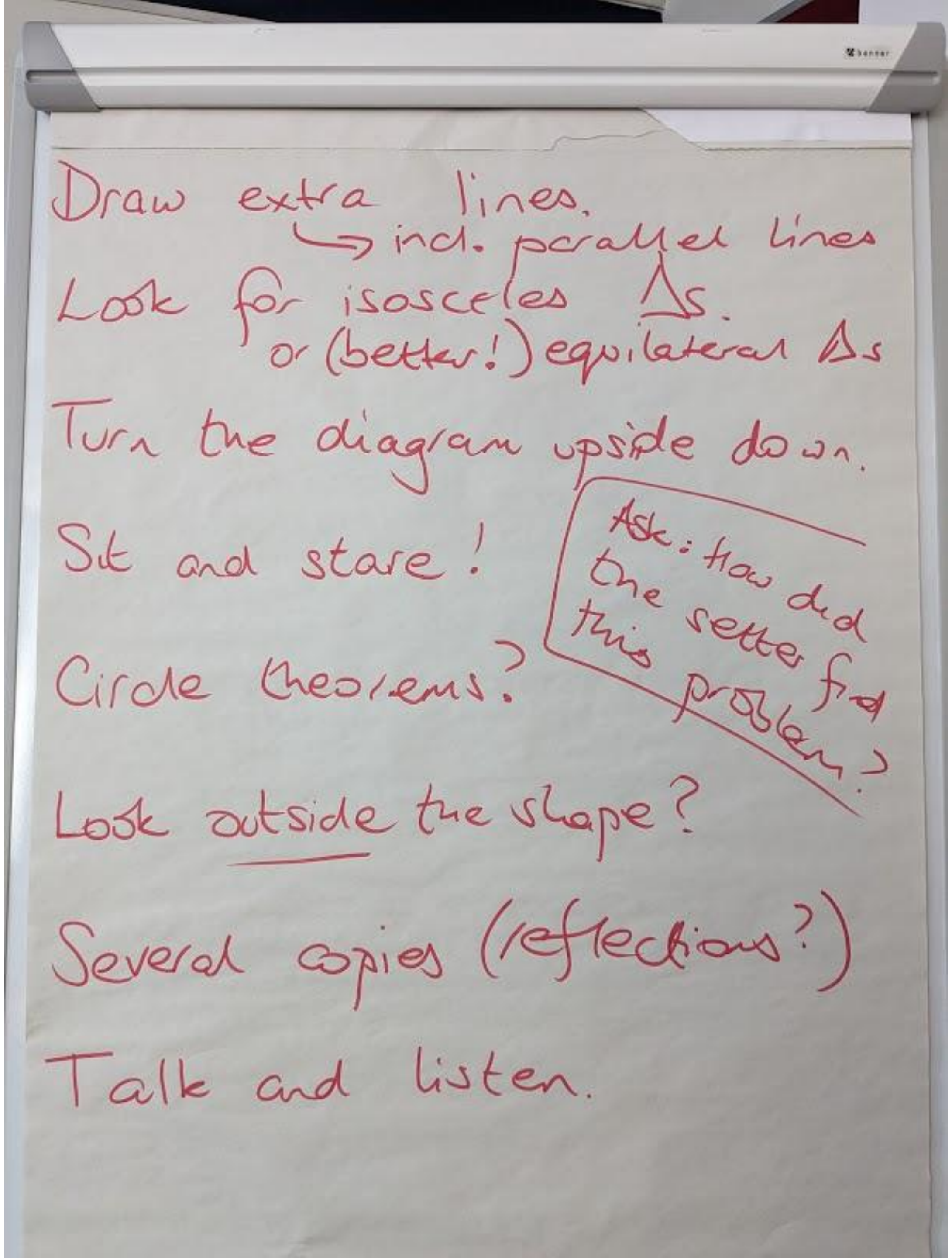
Special case of https://www.geogebra.org/m/vt3bevha


C
M
B'
A'
A
B




B
P
A
C


D
C
60°
60°
60°
A
P
O
B


Draw extra lines.
↳ incl. parallel lines
Look for isosceles △s.
or (better!) equilateral △s
Turn the diagram upside down.
Sit and stare!
Ask: how did the setter find this problem?
Circle theorems?
Look outside the shape?
Several copies (reflections?)
Talk and listen.

Others you might like to think about

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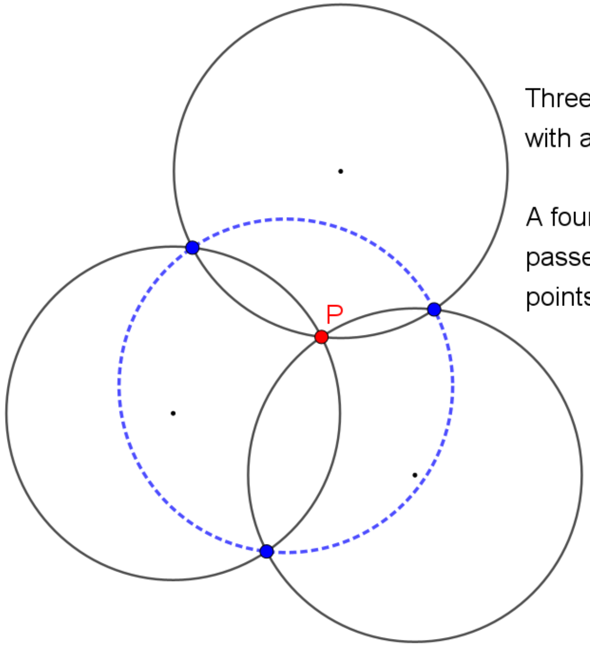
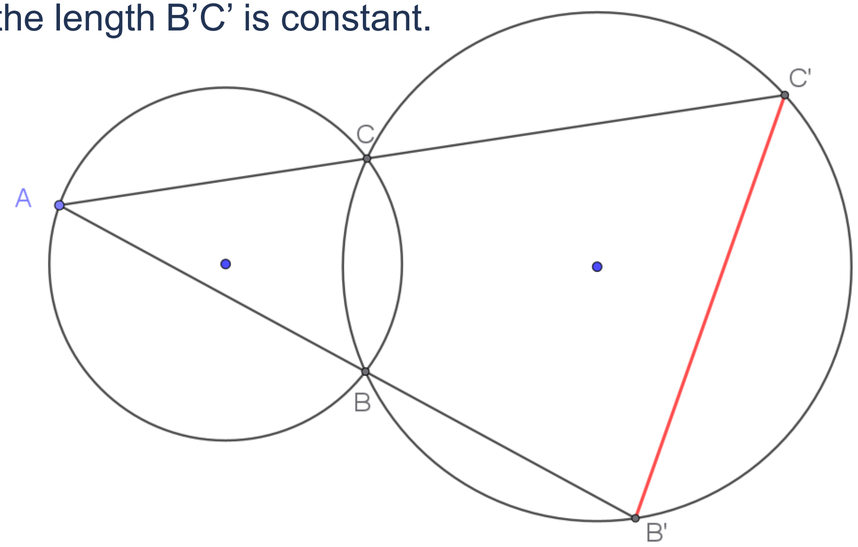


Three congruent circles with a common point.

A fourth congruent circle passes through the other points of intersection.

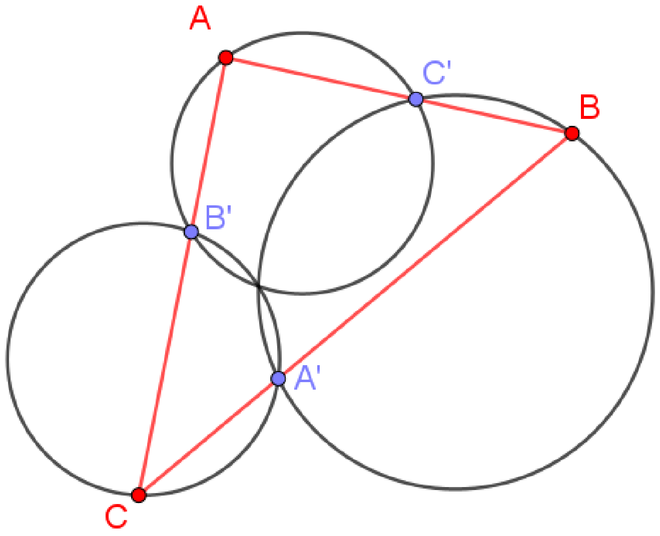
Fixed circles meet at B and C. As A moves, prove that the length B’C’ is constant.

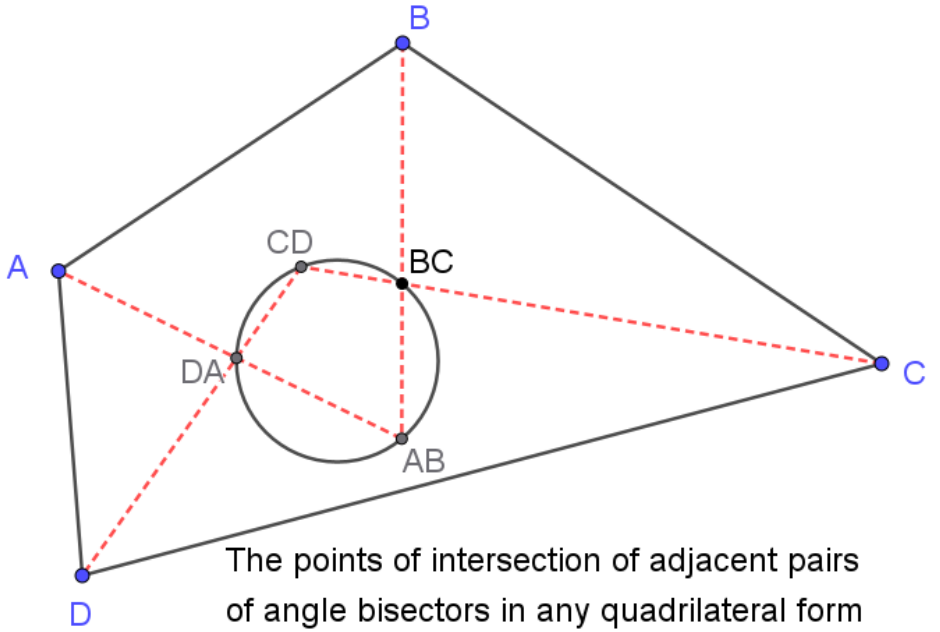


Any triangle ABC.

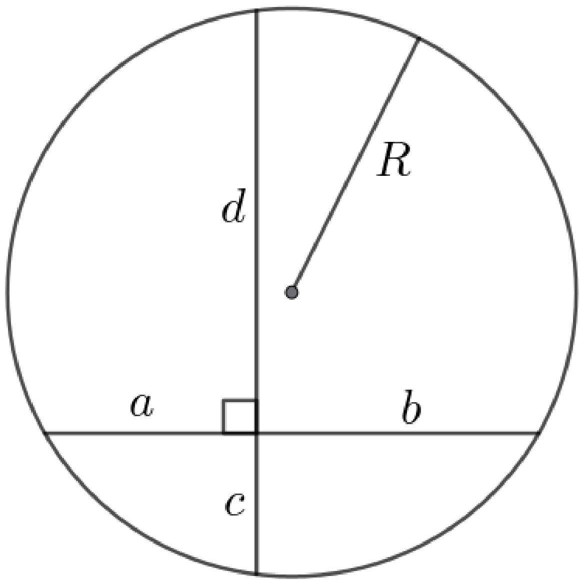
A',B',C' are any points on the opposite edges.

Circles AB'C', BC'A', CA'B' pass through common point.

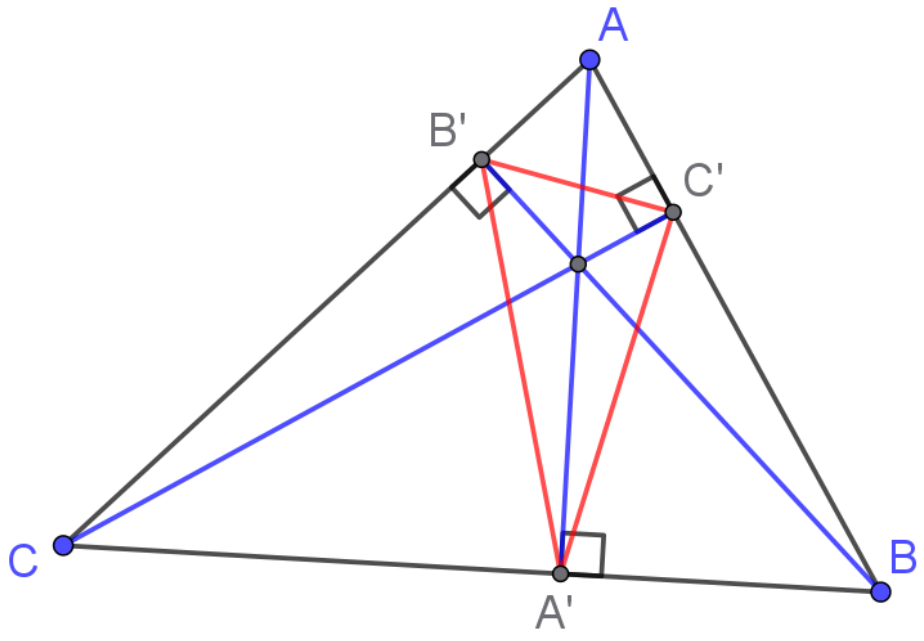




The points of intersection of adjacent pairs of angle bisectors in any quadrilateral form the corners of a cyclic quadrilateral



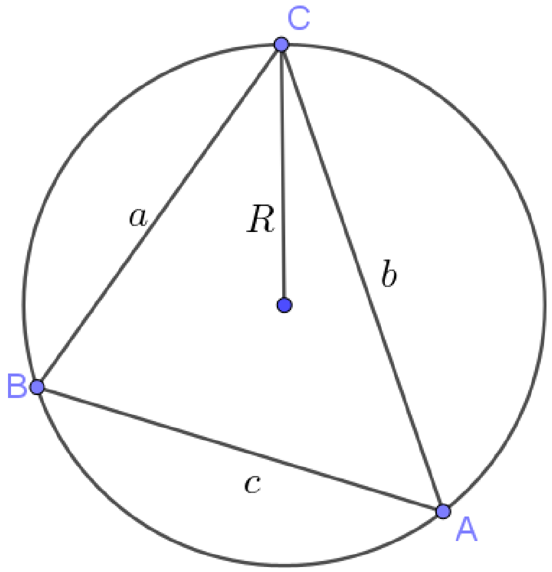
$$a^2 + b^2 + c^2 + d^2 = 4R^2$$



A',B',C' are the bases of the altitudes of triangle ABC.

A'B'C' is called the Pedal Triangle.

The angles in the pedal triangle are bisected by the altitudes.



Area of triangle: $\dfrac{abc}{4R}$

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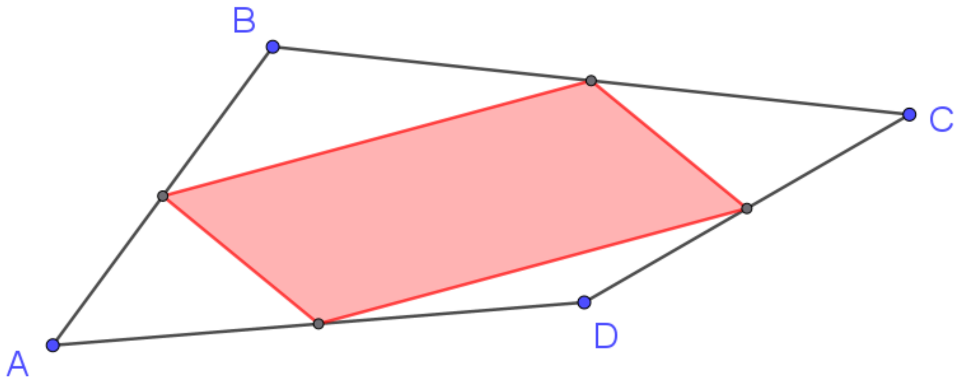
Varignon's Theorem

The midpoints of the sides of a quadrilateral form a parallelogram

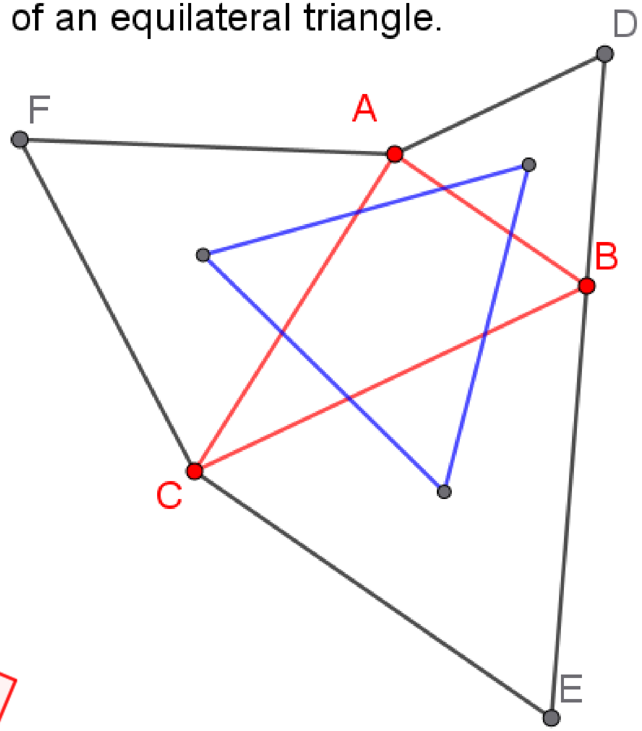


Napoleon's Theorem

Any triangle ABC.

Construct equilateral triangle on each edge.

Centres are corners of an equilateral triangle.

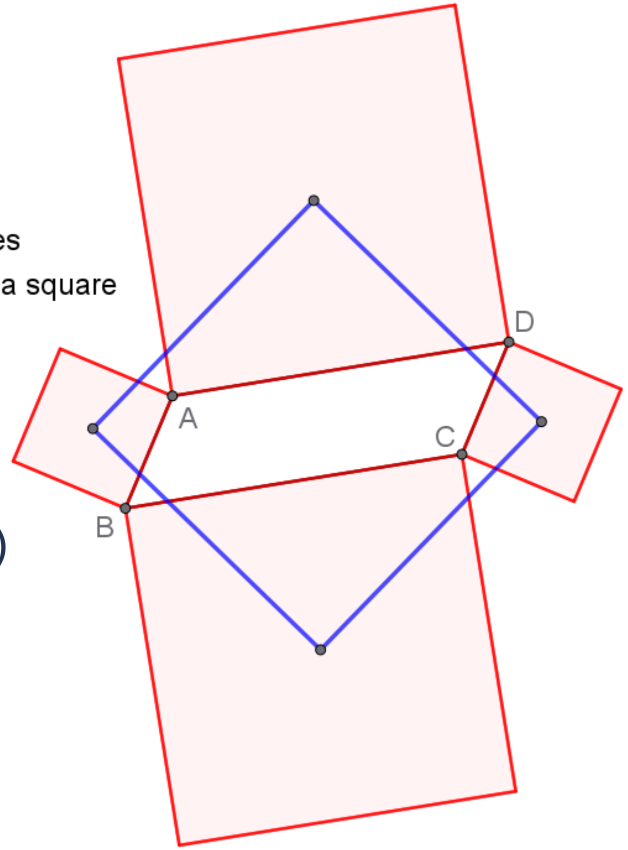


Any parallelogram ABCD

Construct squares on edges

Centres are the vertices of a square

Thebault's Theorem (1938)



And finally…

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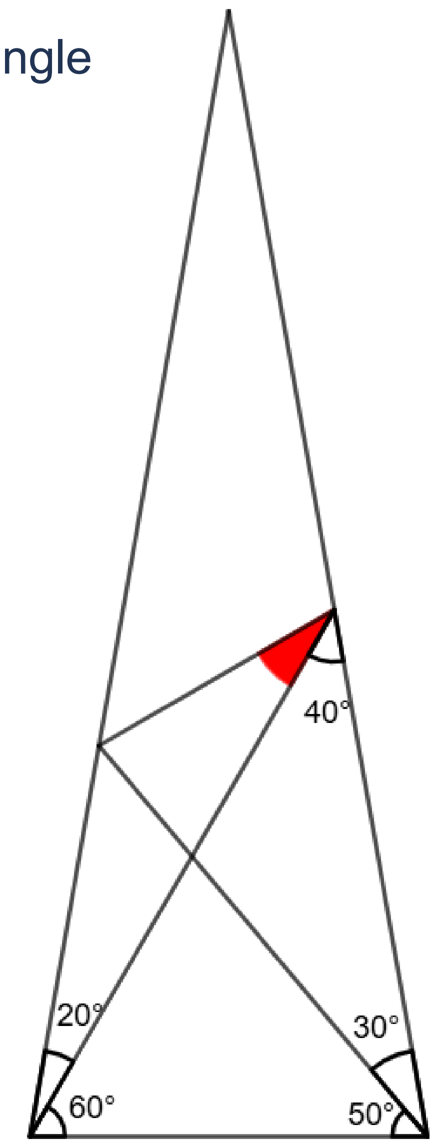
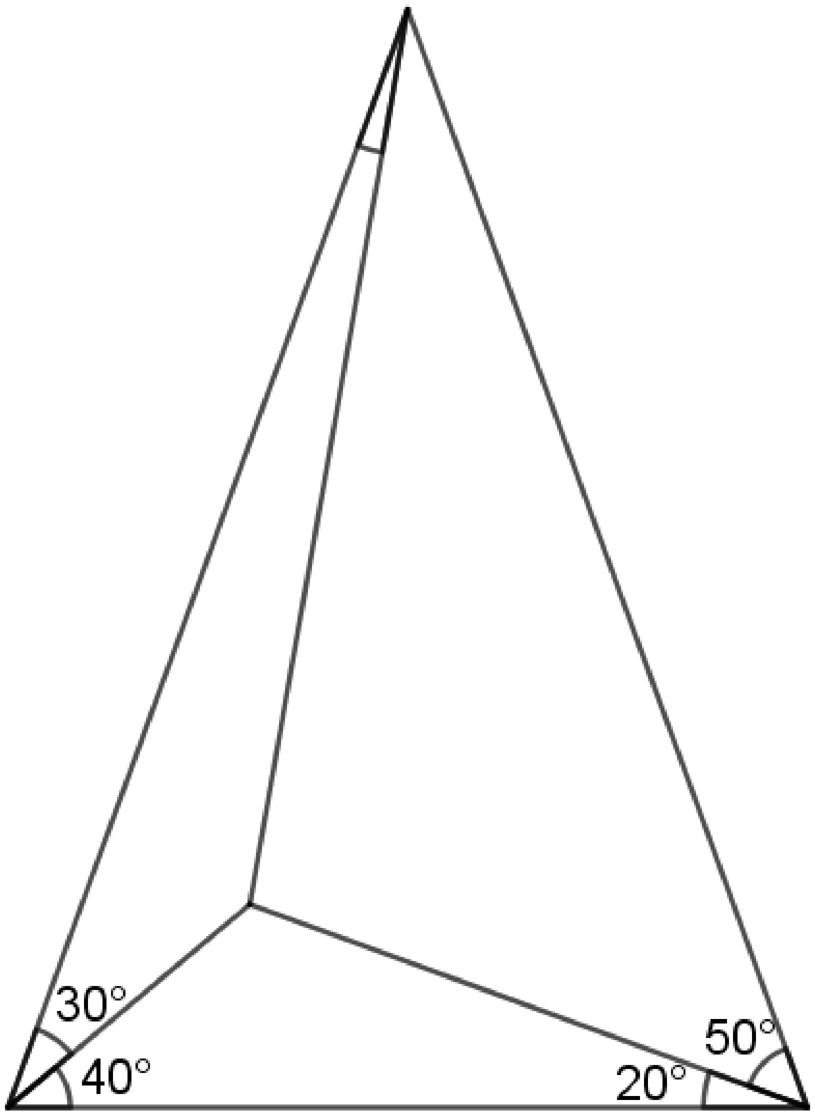
Langley's Triangle





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