Geometry Expressions: A Constraint Based Interactive Geometry System

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geometry expressions

Outline

- Project History (1987 – 2006)
- Architecture of an Interactive Symbolic Geometry System
- Examples of Use

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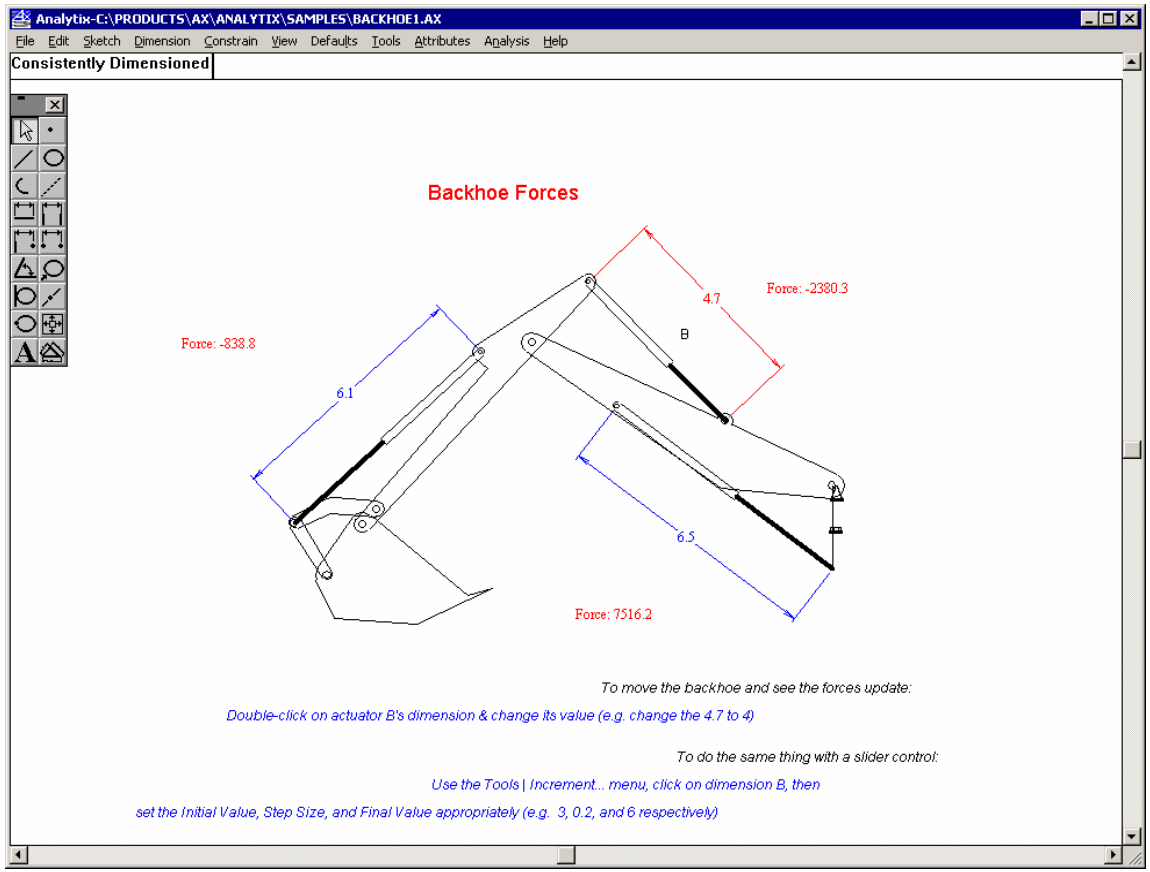
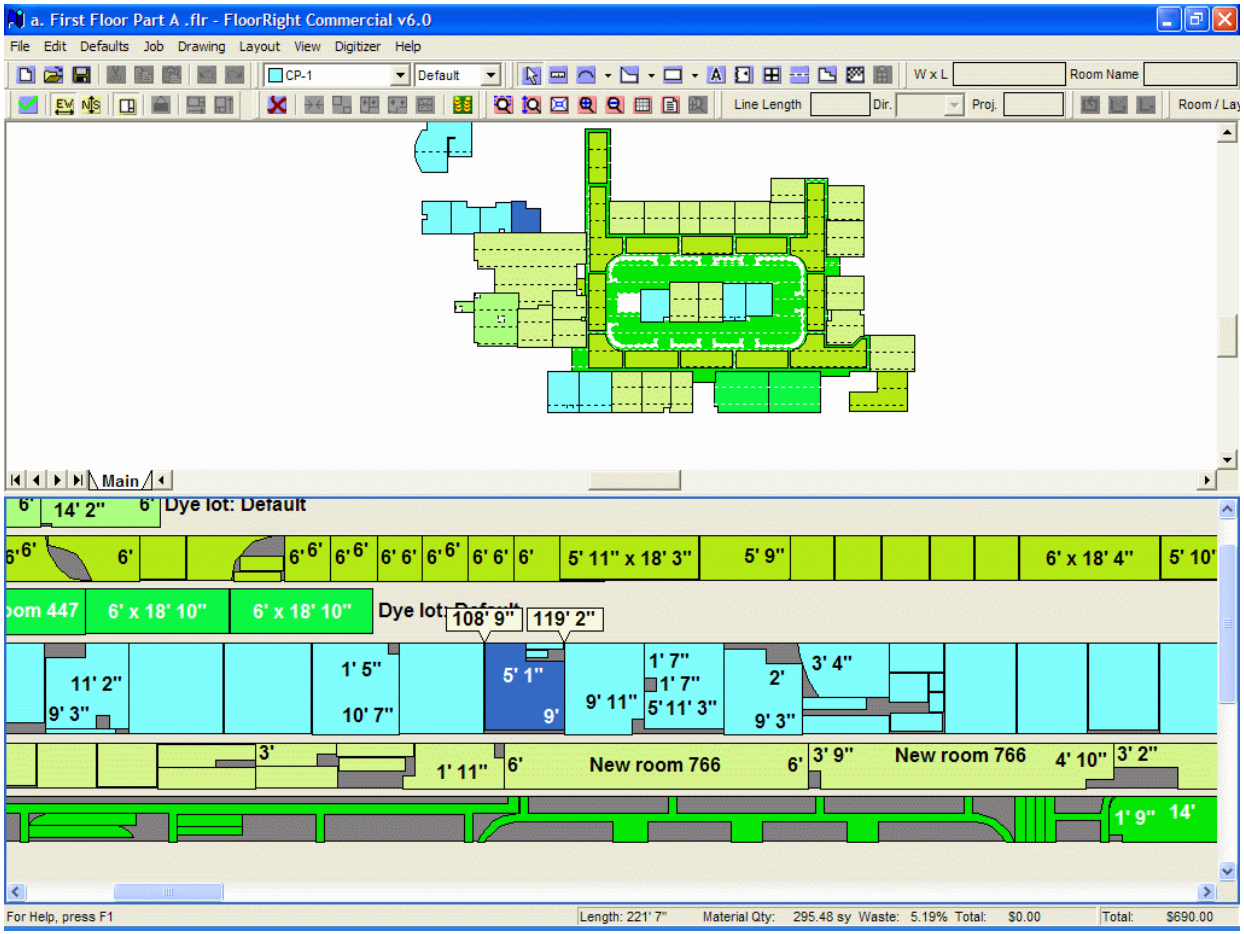
Project History

- 1987 Symbolic Geometry project at Tektronix Computer Research Lab
- 1989 Saltire Software founded
- 1992 – 1995 NSF SBIR research grant
- 2003 demo old prototype on new computer
- May 2006 Geometry Expressions released

Analytix 1989-1996



FloorRight 1996-2006



Calculators 1996-2006

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Architecture

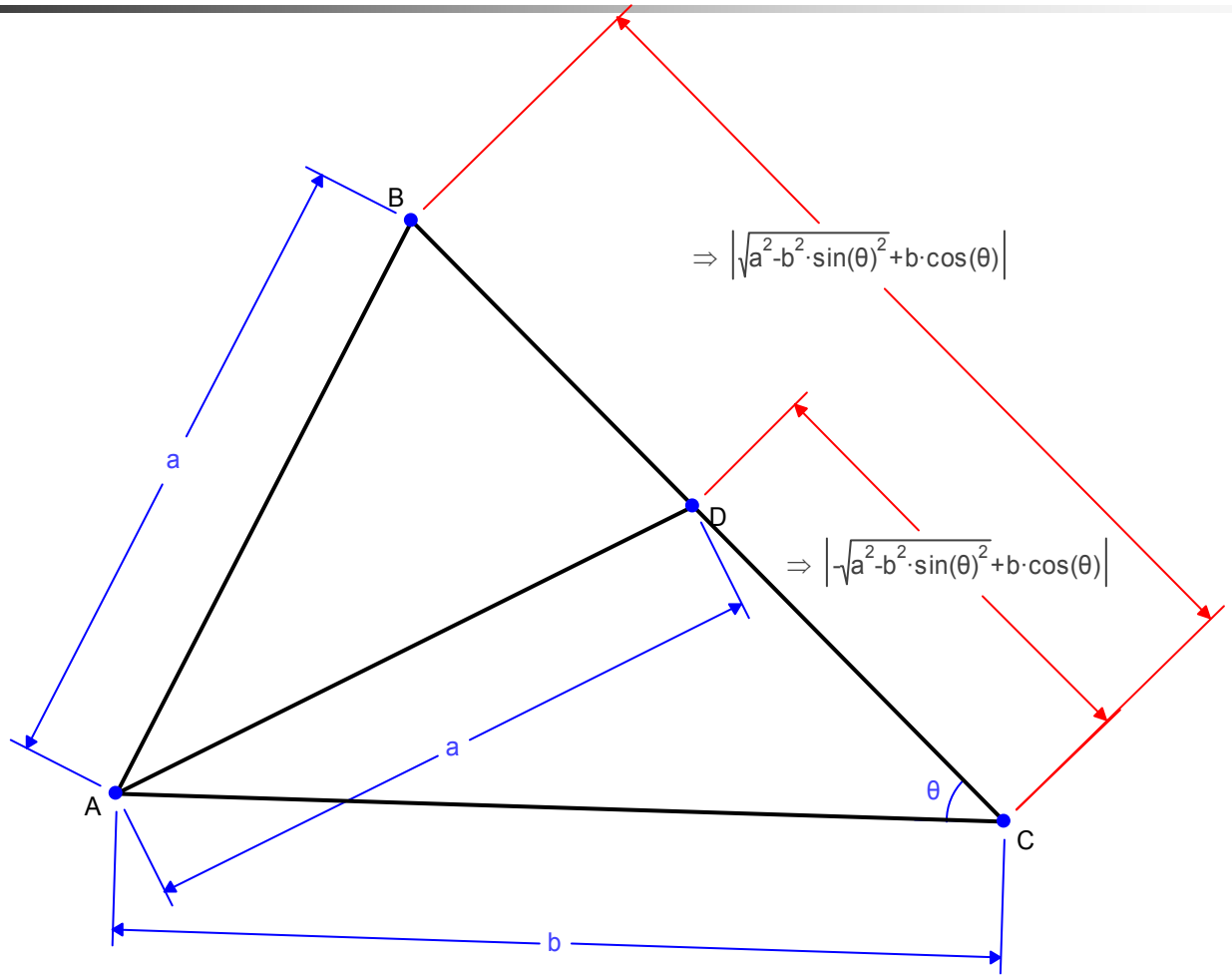
- Archetypal Variable Value Manager
- Constraint graph algorithms
- Algebra system
- MathML

Archetypal Variable Value Manager

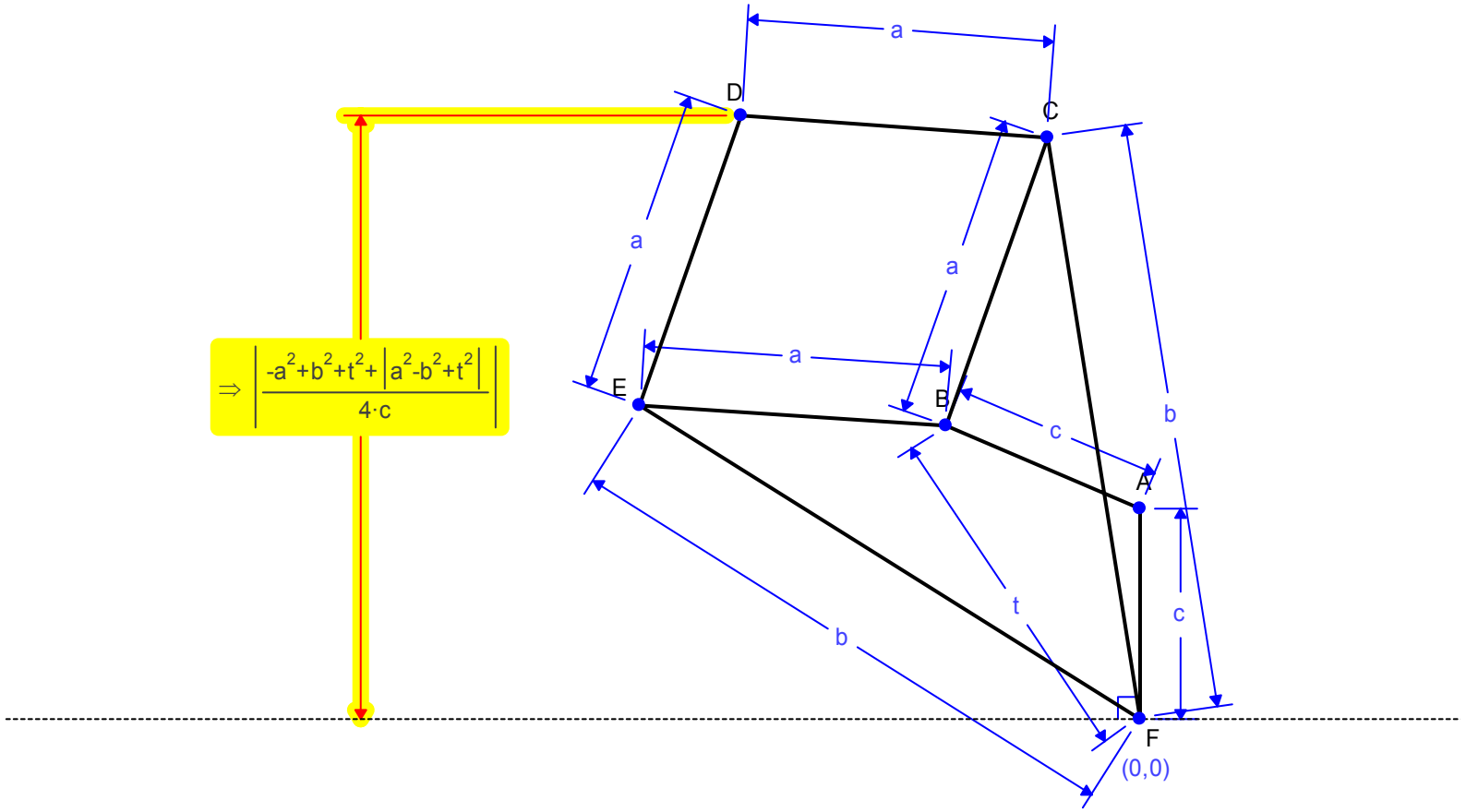
Uses for archetypal real values

- Drawing
- Construction disambiguation
- Automatic assumption mechanism

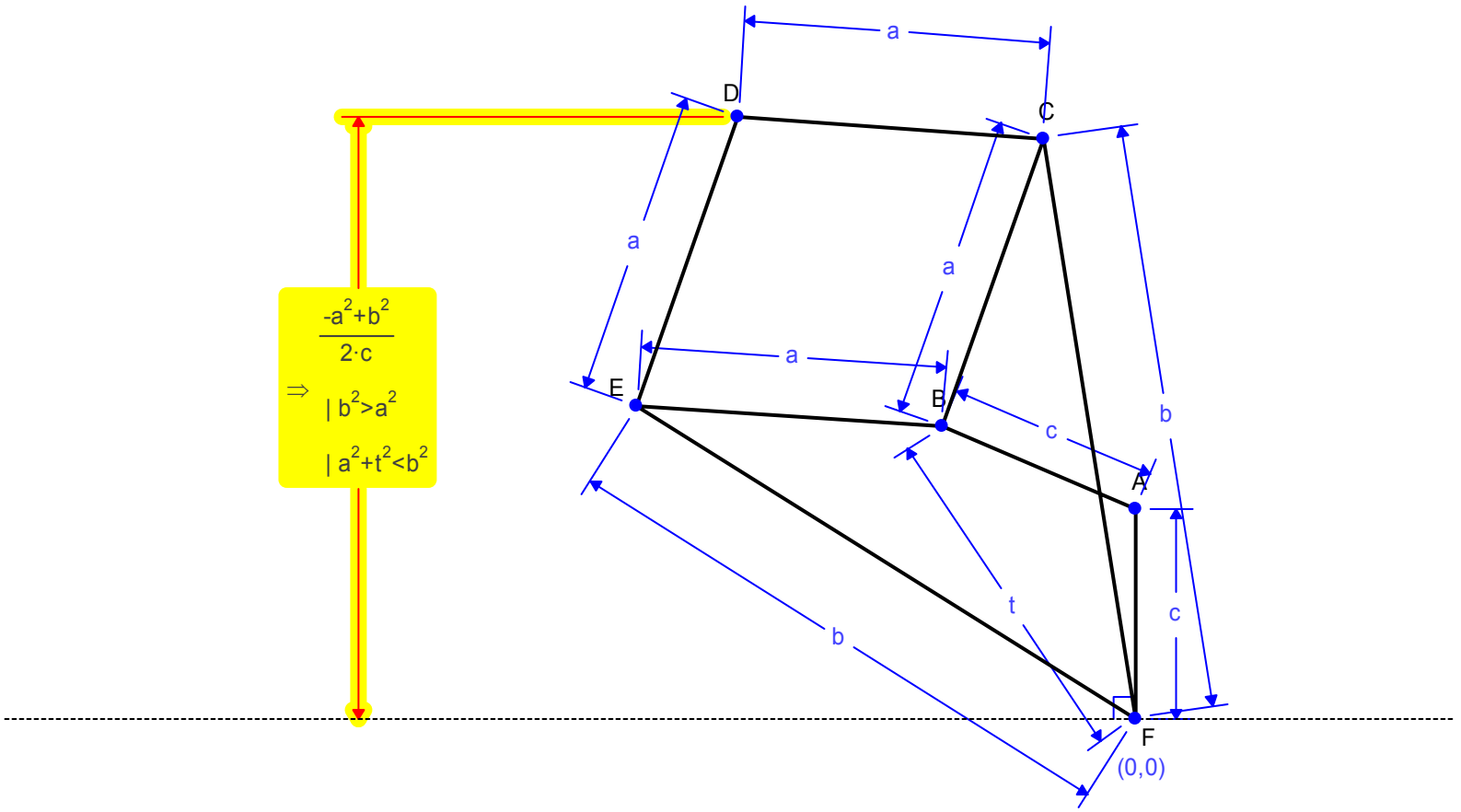
Construction Disambiguation



Automatic Assumption Mechanism



Automatic Assumption Mechanism



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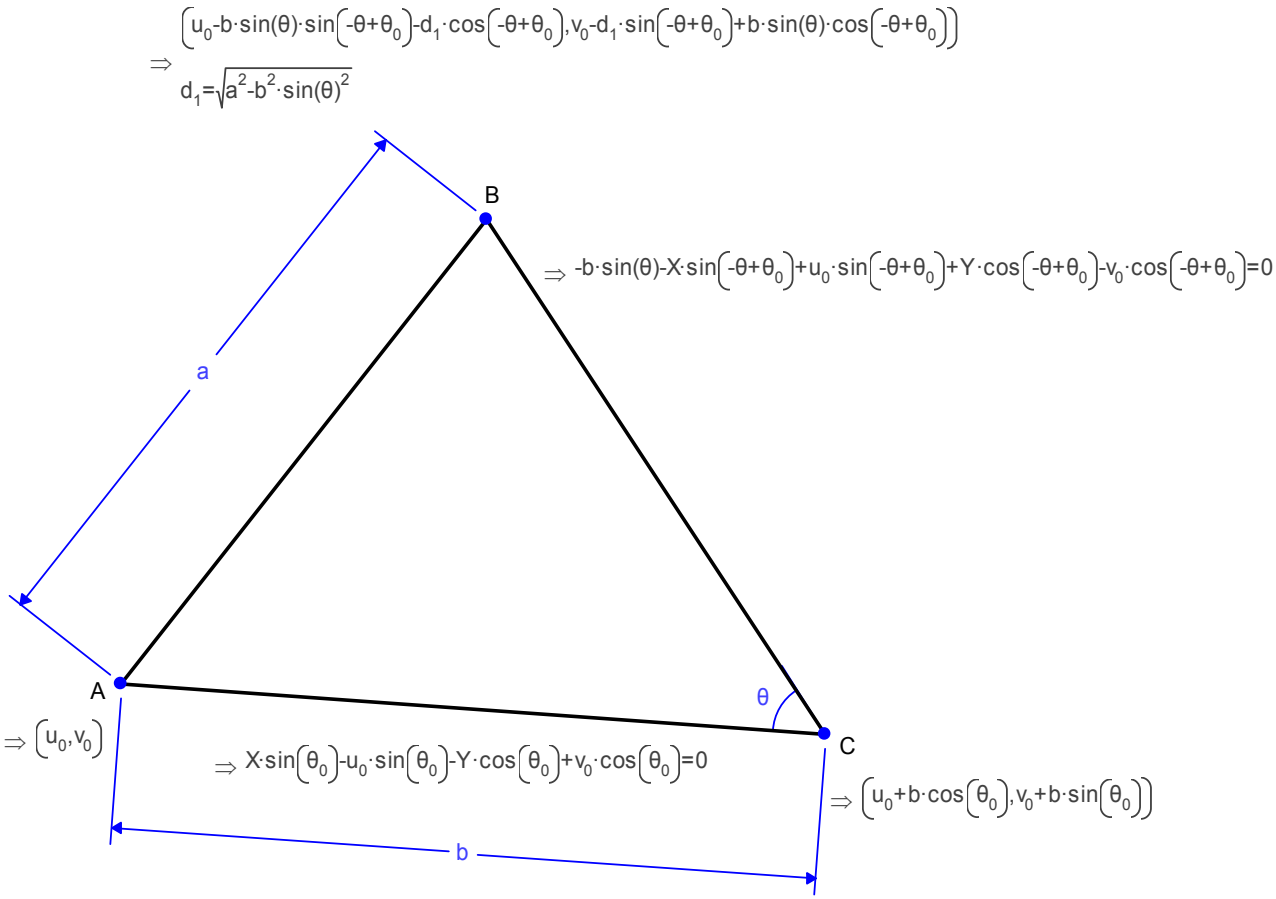
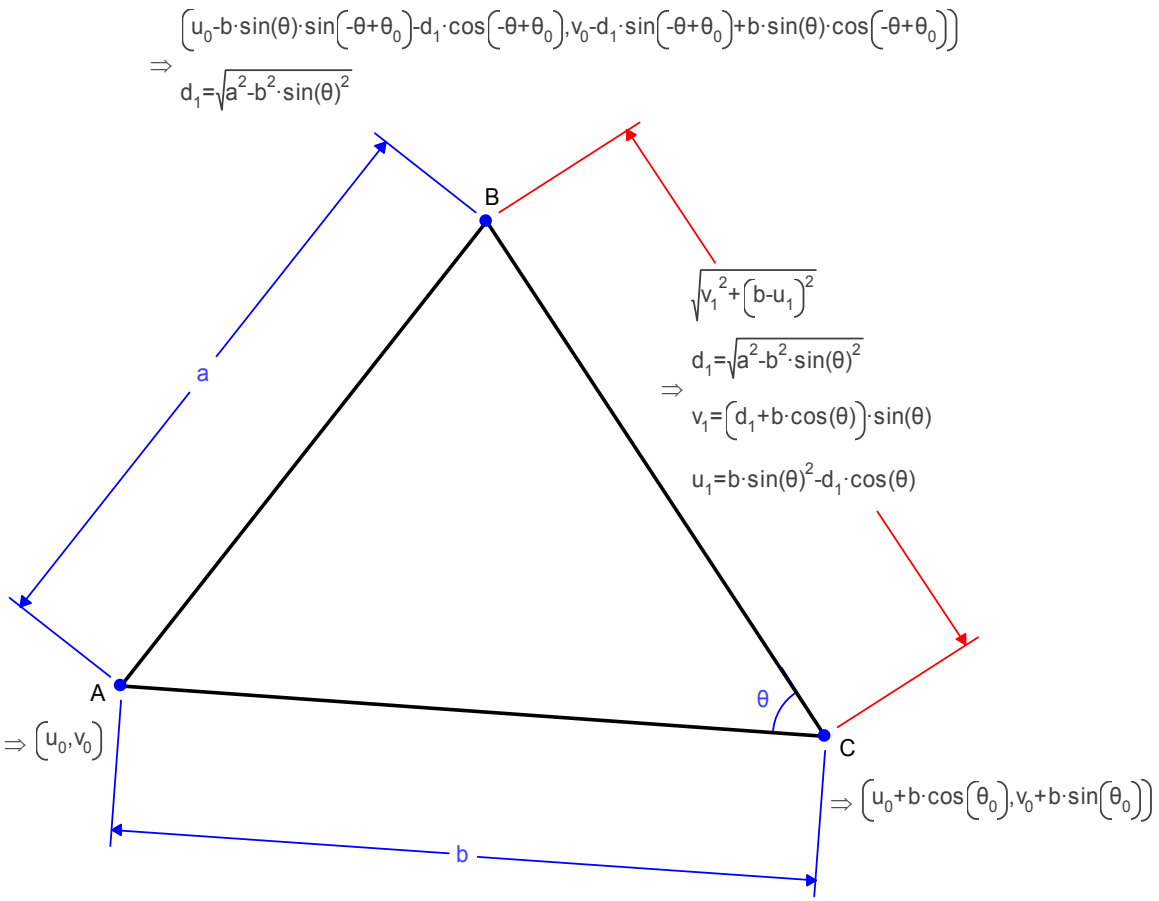
Architecture

- Archetypal Variable Value Manager
- ***Constraint graph algorithms***
- ***Algebra system***
- MathML

IV rich construction



IV rich measurement

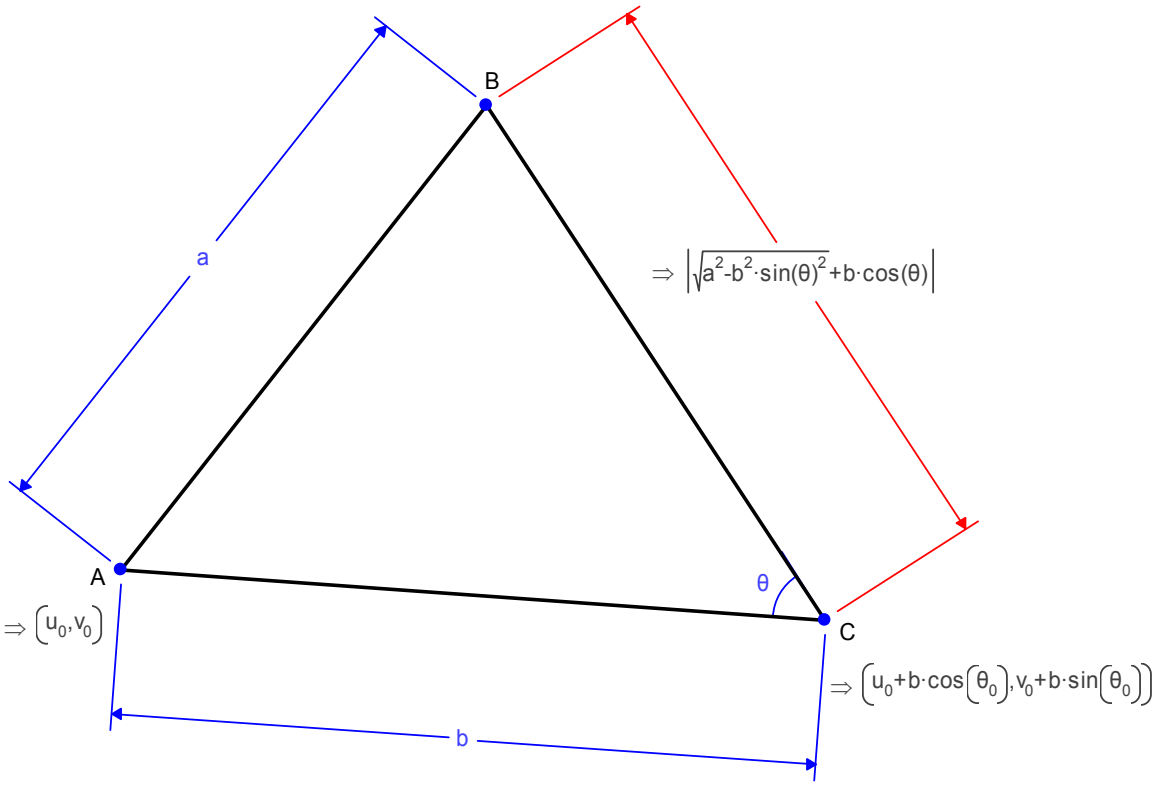


IV Removal & Simplification

$$\left(u_0-b\cdot\sin(\theta)\cdot\sin\left(-\theta+\theta_0\right)-d_1\cdot\cos\left(-\theta+\theta_0\right),v_0-d_1\cdot\sin\left(-\theta+\theta_0\right)+b\cdot\sin(\theta)\cdot\cos\left(-\theta+\theta_0\right)\right)$$

$$\Rightarrow$$

$$d_1=\sqrt{a^2-b^2\cdot\sin(\theta)^2}$$



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Architecture

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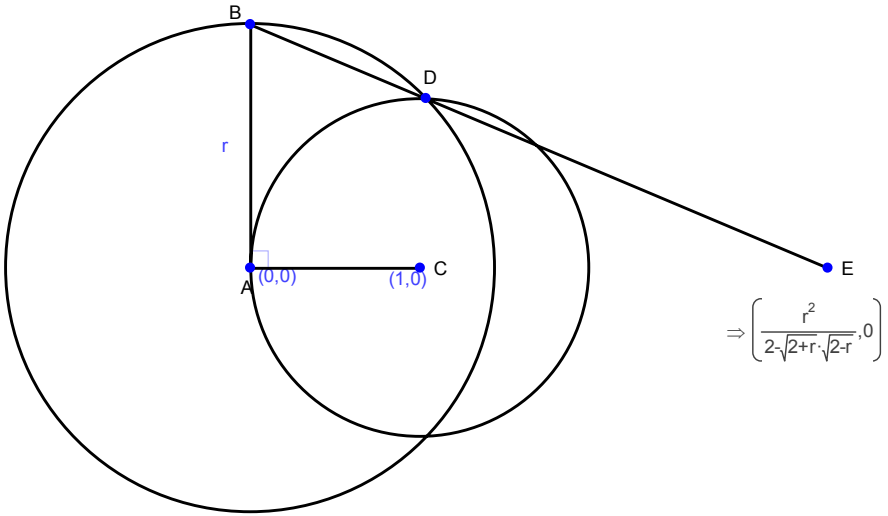
- Constraint graph algorithms
- Algebra system
- ***MathML***

MathML Export Import




```
> limit(-r^2/(sqrt(-r+2)*sqrt(r+2)-2),r=0);
```

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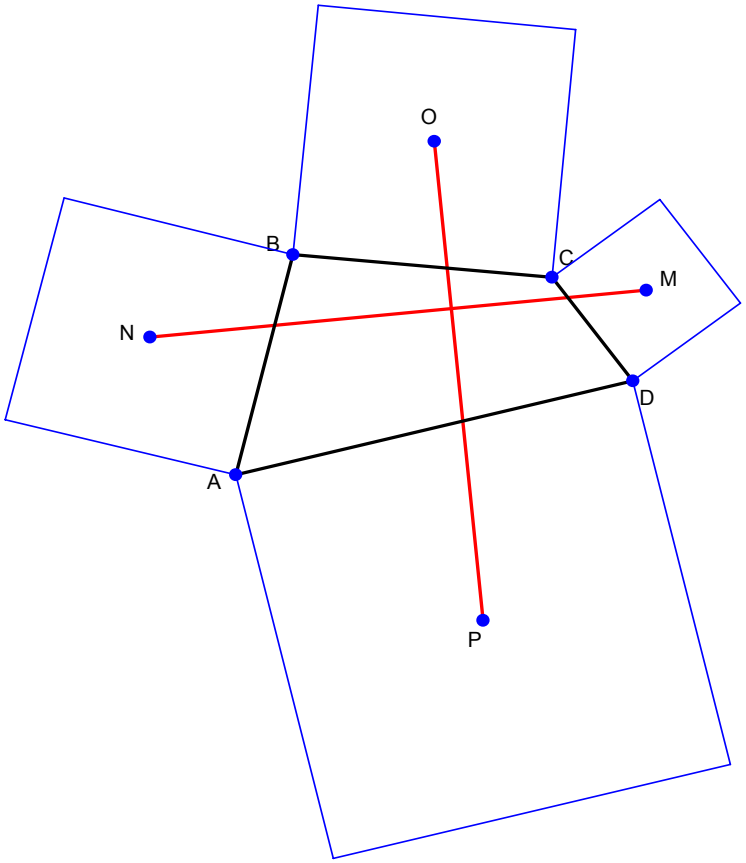
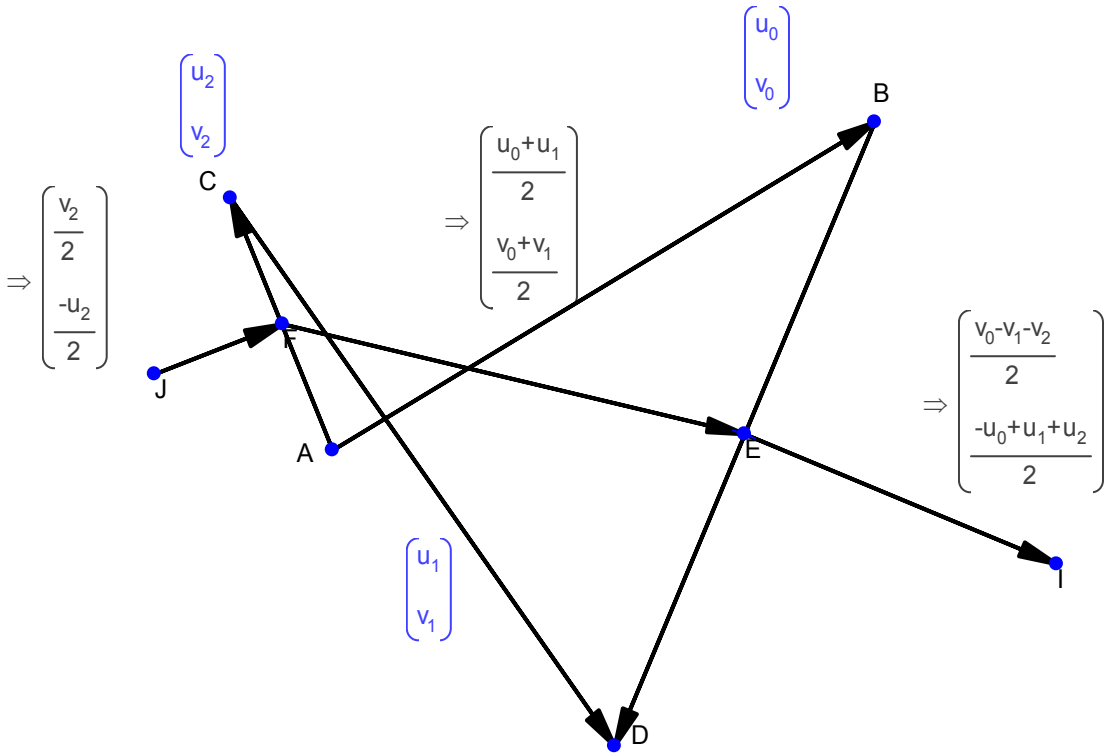
- ***Examples of Use***

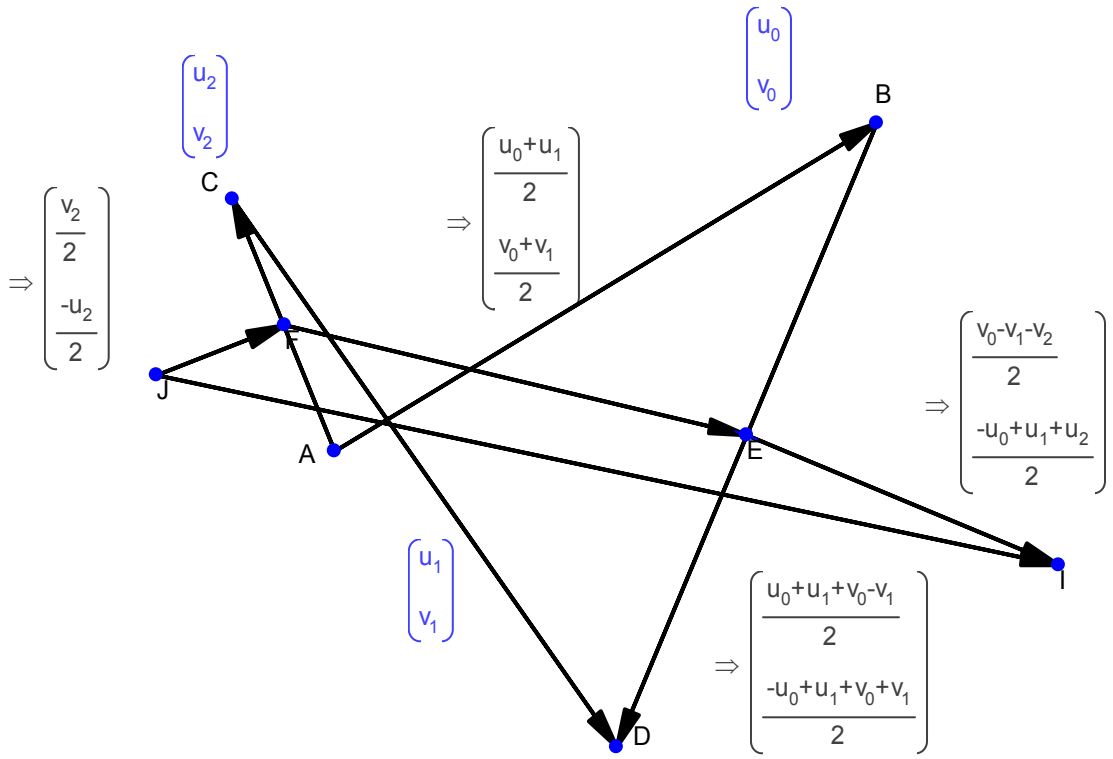
Example – von Abuel's Theorem



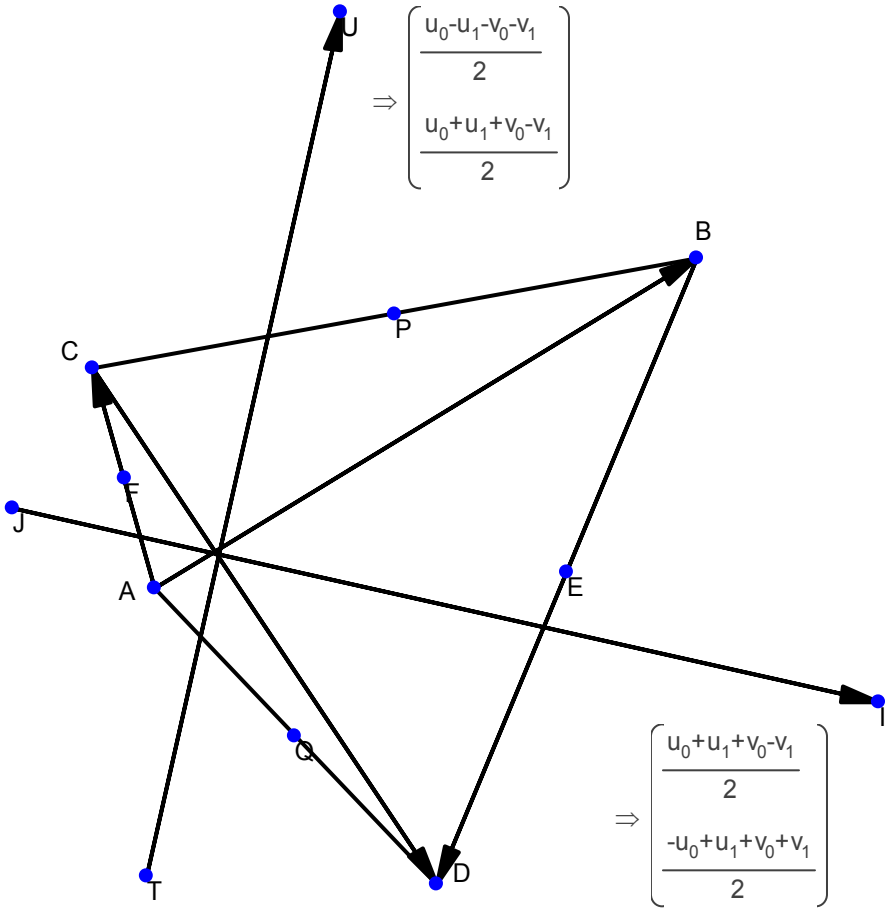
Von Abuel's Proof



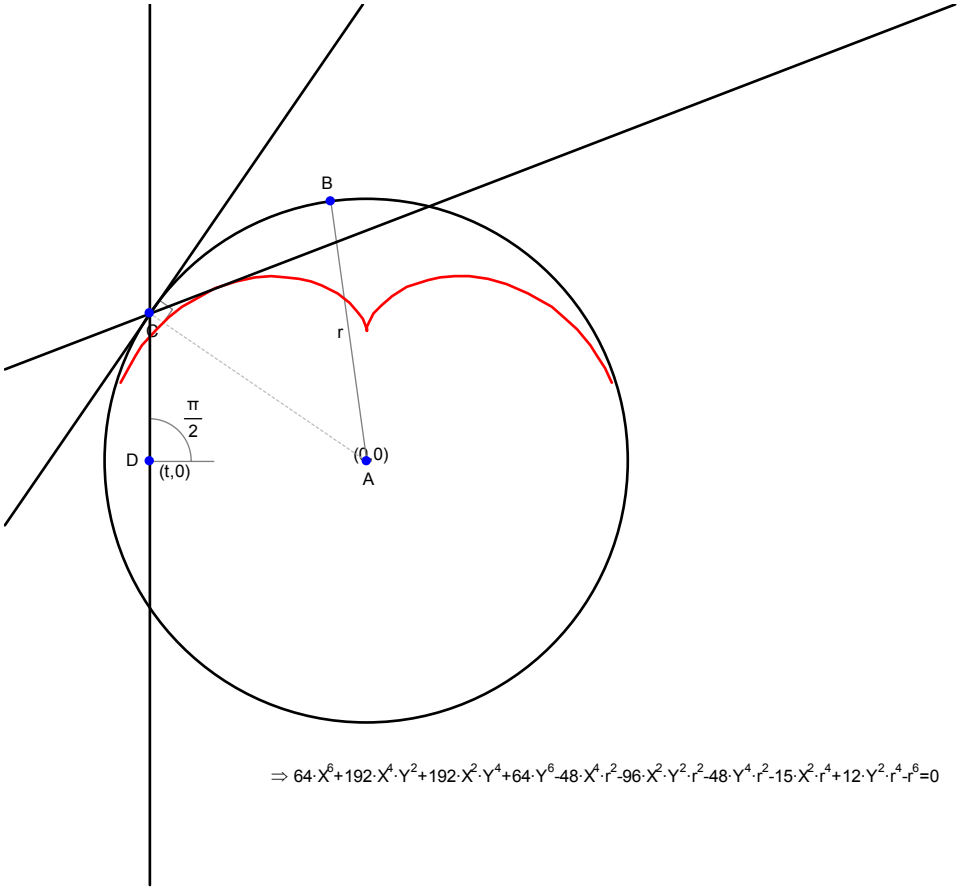
Von Abuel's Proof



Von Abuel's Proof

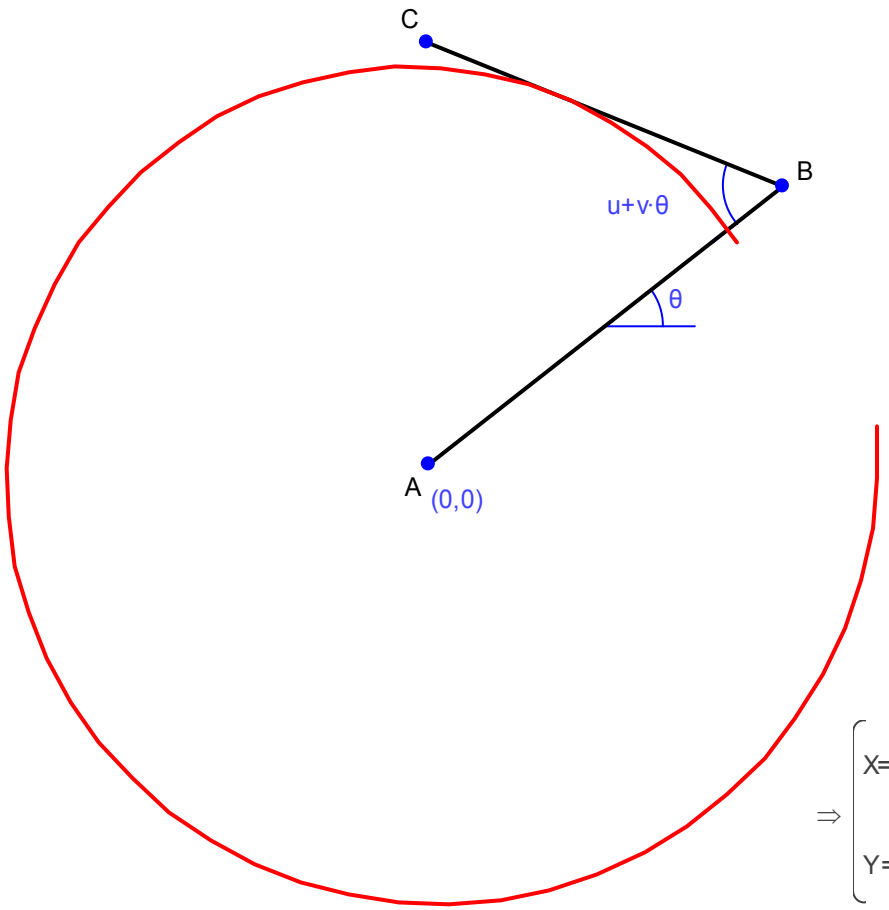


Coffee cup caustic



$$\Rightarrow 64 \cdot X^6+192 \cdot X^4 \cdot Y^2+192 \cdot X^2 \cdot Y^4+64 \cdot Y^6-48 \cdot X^4 \cdot r^2-96 \cdot X^2 \cdot Y^2 \cdot r^2-48 \cdot Y^4 \cdot r^2-15 \cdot X^2 \cdot r^4+12 \cdot Y^2 \cdot r^4-r^6=0$$

Linear rise flat face oscillating cam



$$\Rightarrow \begin{bmatrix} X=\dfrac{d_0\cdot(-\cos(\theta)+2\cdot v\cdot\cos(\theta)+\cos(2\cdot u+\theta\cdot(-1+2\cdot v)))}{2\cdot(-1+v)} \\ Y=\dfrac{d_0\cdot(-\sin(\theta)+2\cdot v\cdot\sin(\theta)-\sin(2\cdot u+\theta\cdot(-1+2\cdot v)))}{2\cdot(-1+v)} \end{bmatrix}$$

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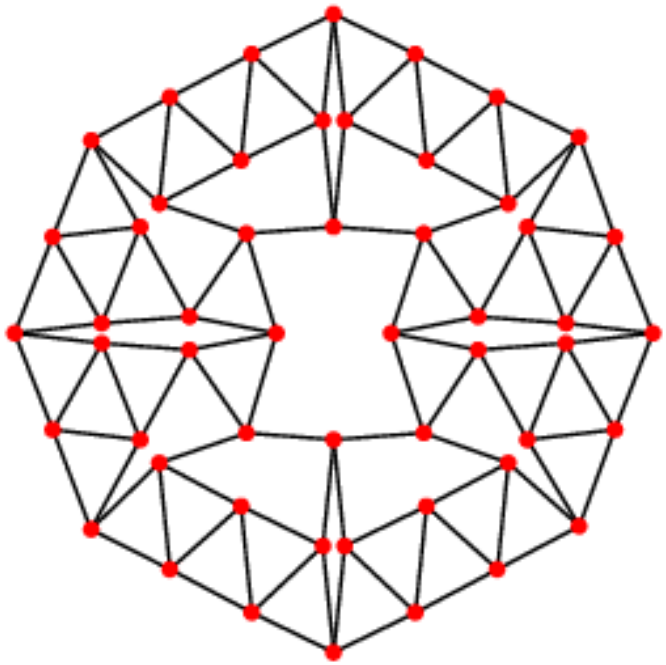
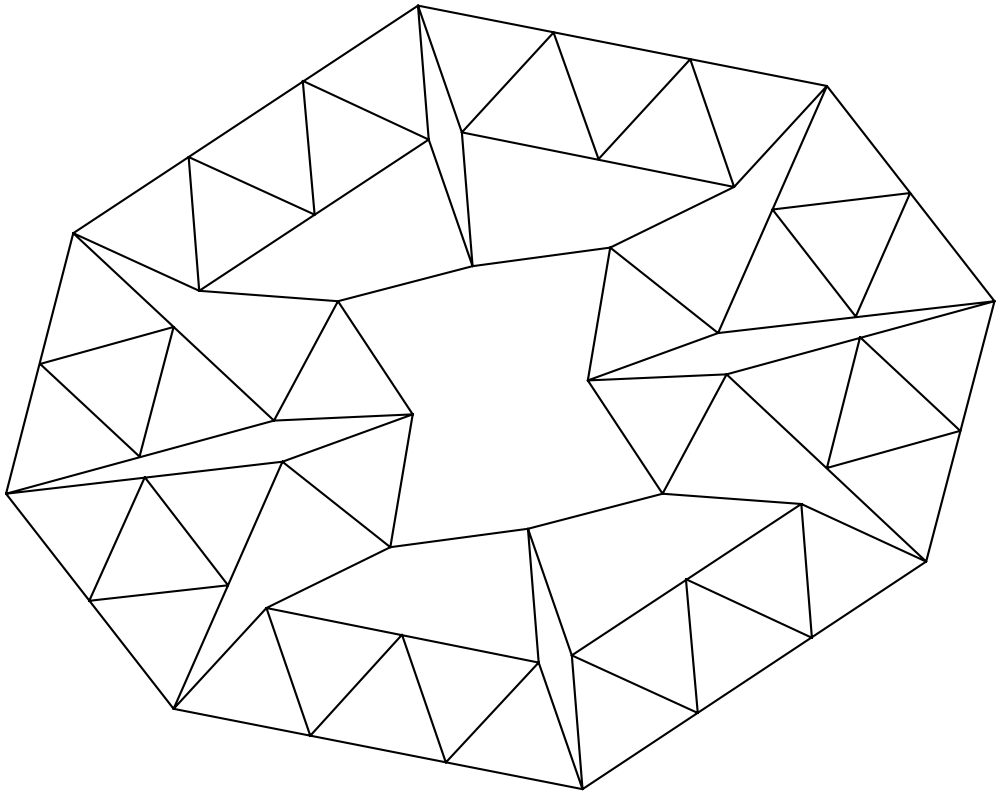
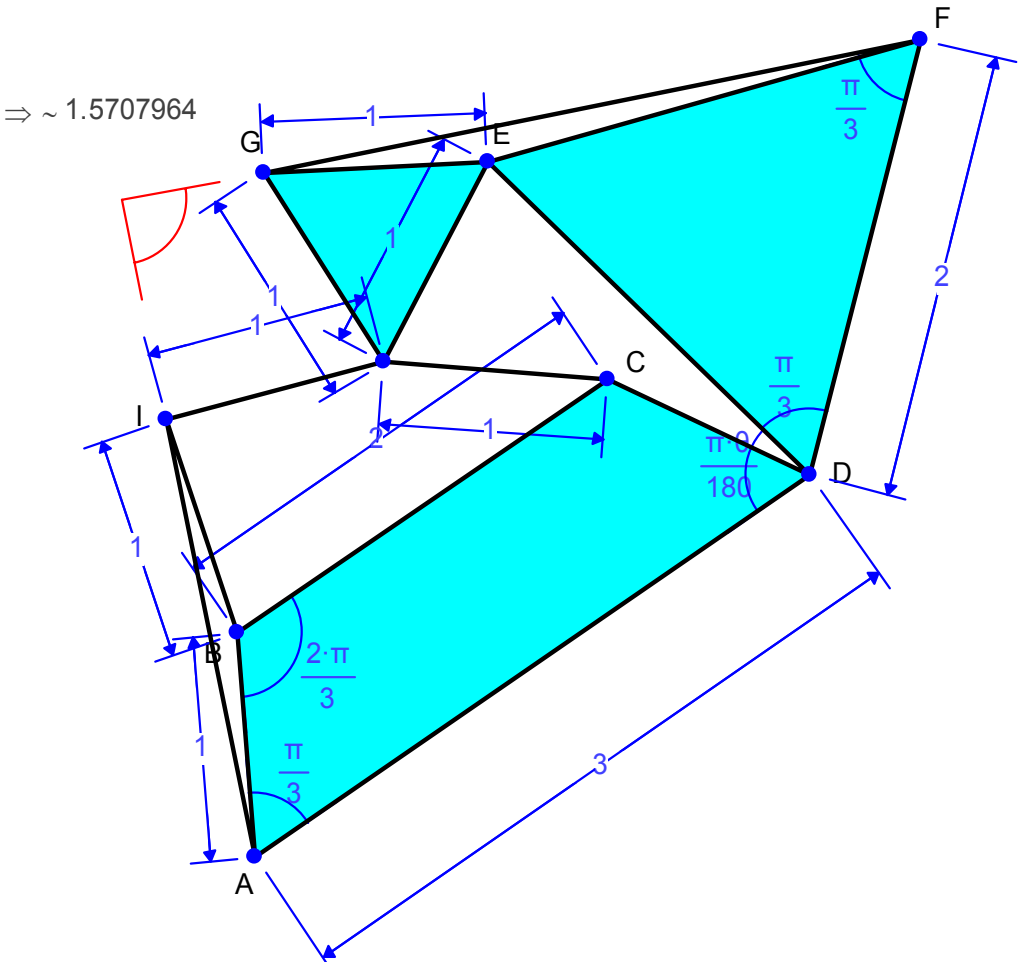
Harborth Graph

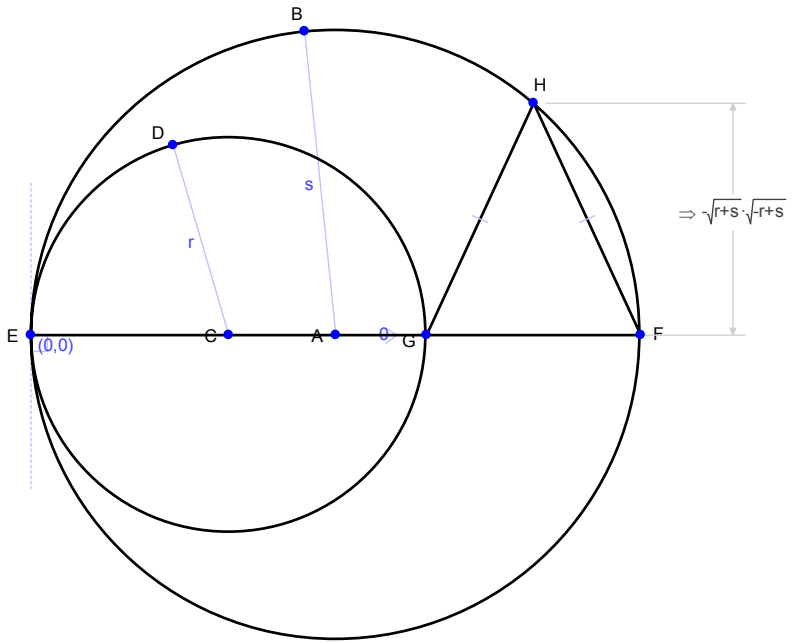


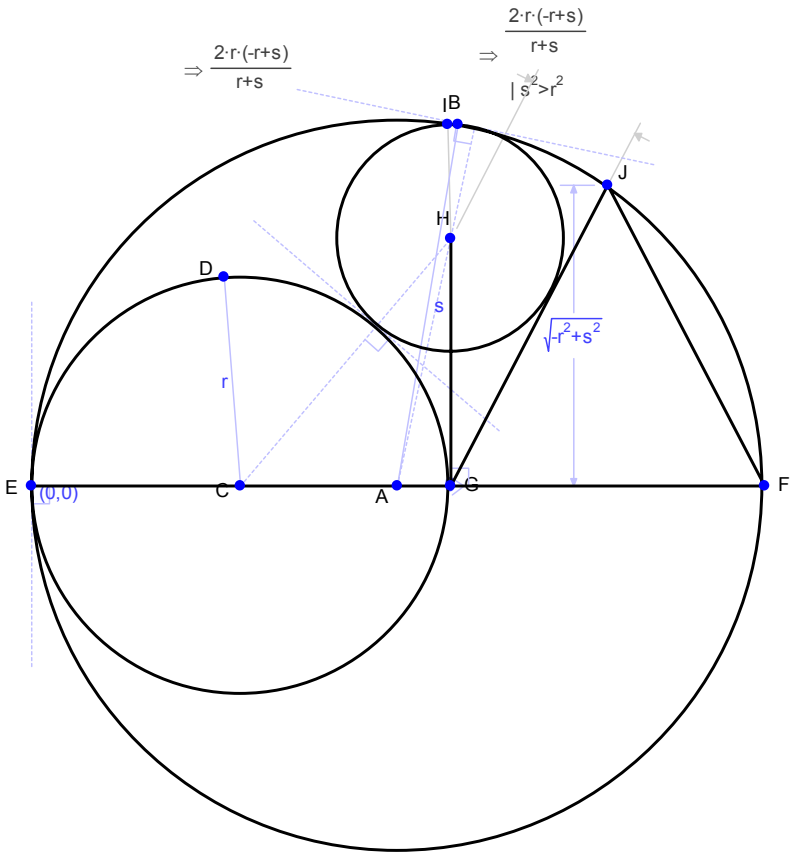


Harborth Derivation



Buehler's Circle Theorem





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