# PointLine: A proposal for a bi-directional dependency DGS

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# Self introduction

- I'm Kazushi AHARA, Meiji University, Tokyo.

- I will introduce a system named PointLine, that is a production of my laboratory at Meiji University.

- The platform of implementation is Unity.
- Latest version is 0.811 by Mr. Yuto Saito.
- Released for Win, Mac, and WebGL.

# Definition of DGS

- DGS(Dynamic Geometry System)
- IGS(Interactive Geometry Software)
- DGE(Dynamic Geometry Environments)

- DGS is a system that allows users to create geometric constructions and to manipulate the figure after constructing

# KidsCindy : DGS for kids (2007)
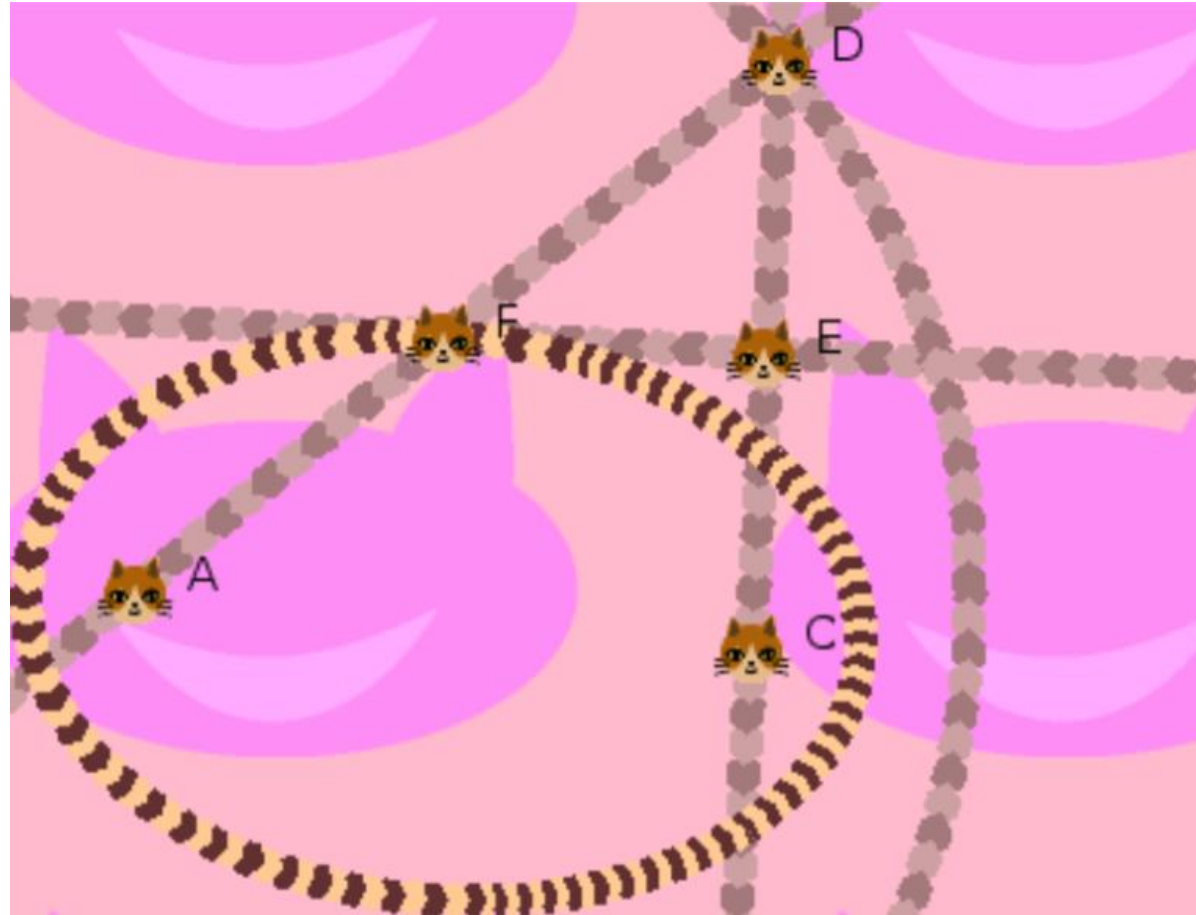
# My work on GeoGebra

- Creating many teaching materials of mathematics for Japanese high school pupils (in Japanese.)
- https://aharalab.sakura.ne.jp/geogebra/

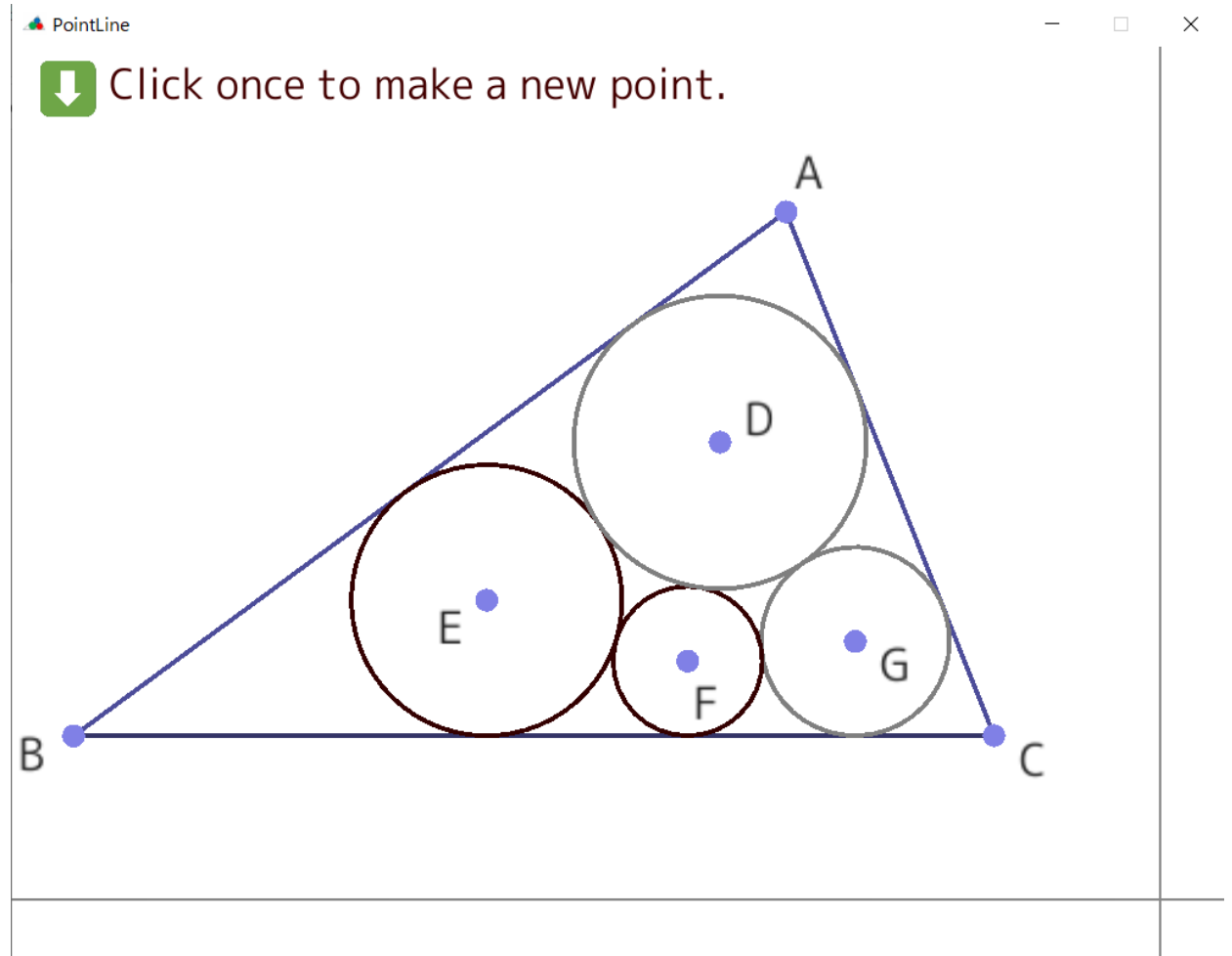# PointLine: a bi-directional dependency DGS
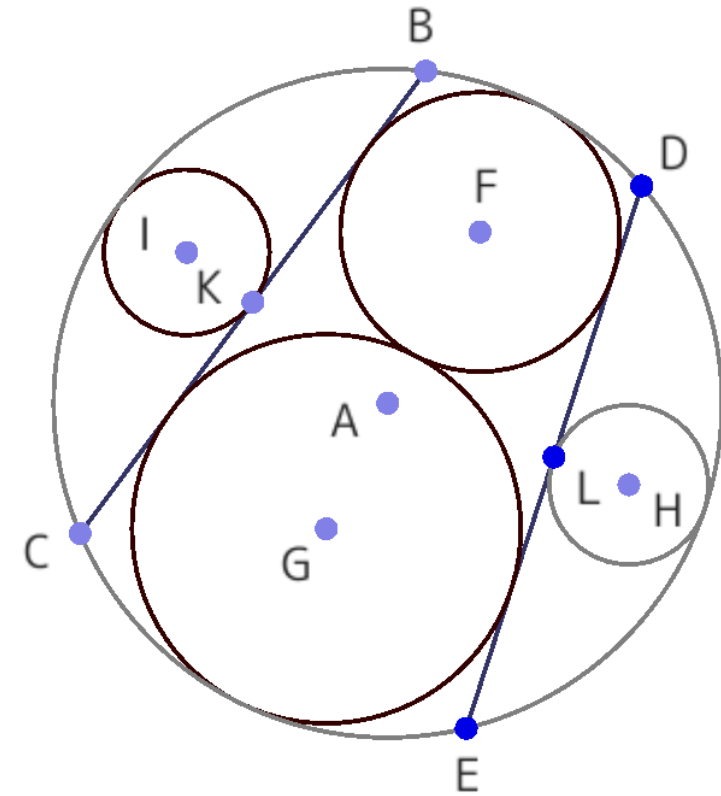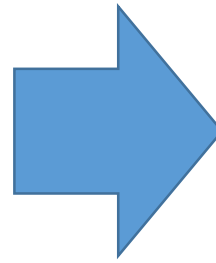
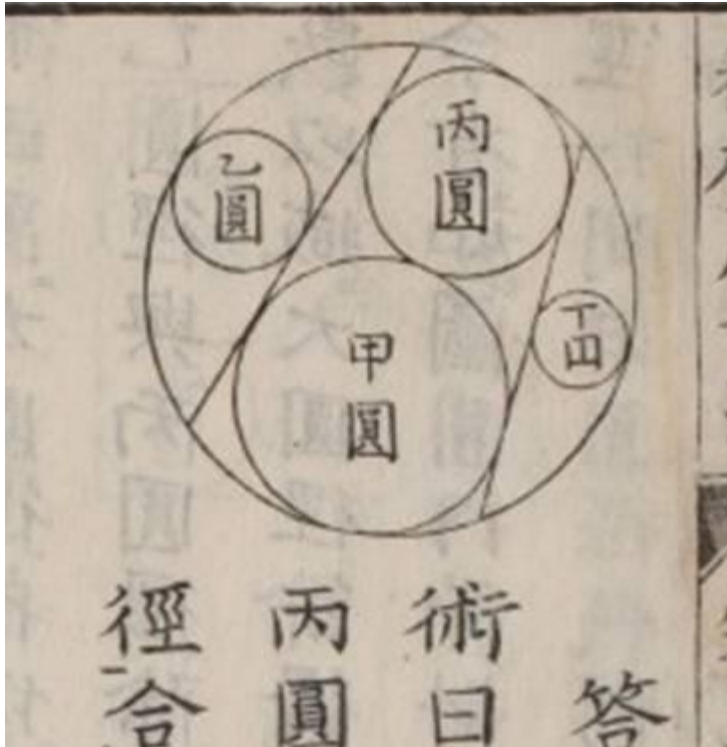- [https://aharalab.sakura.ne.jp/PointLine/](https://aharalab.sakura.ne.jp/PointLine/)
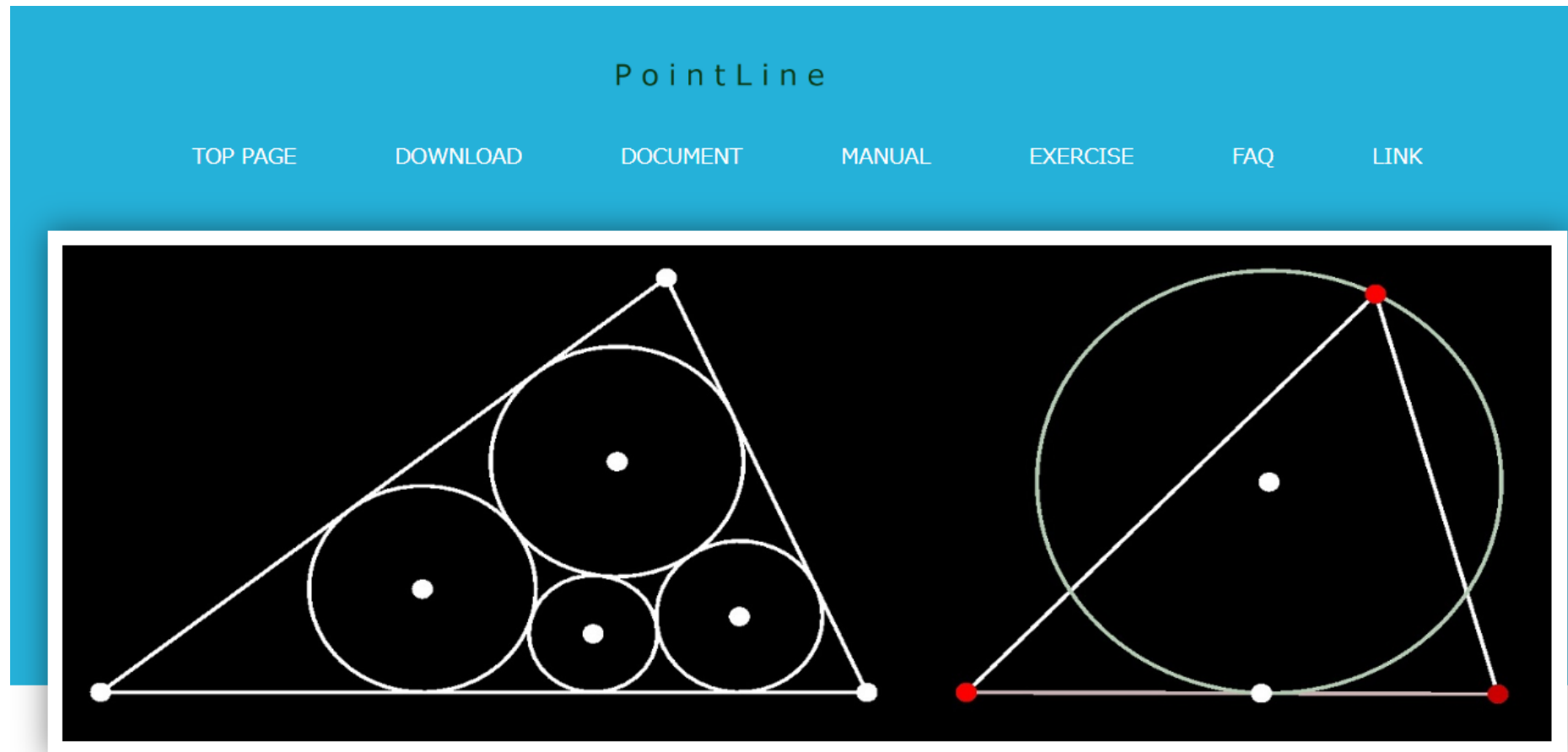
# I couldn't see how to construct this.

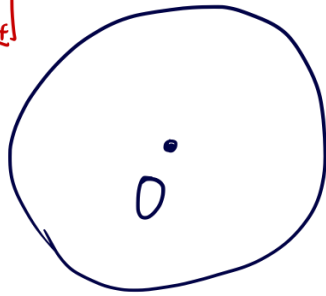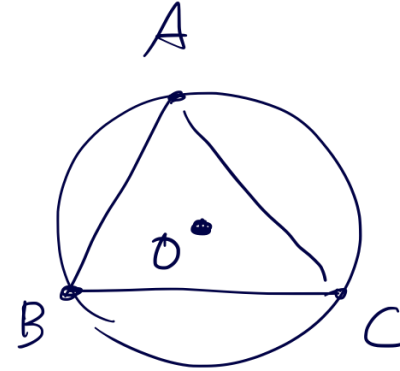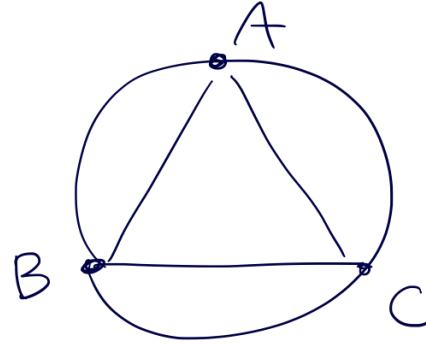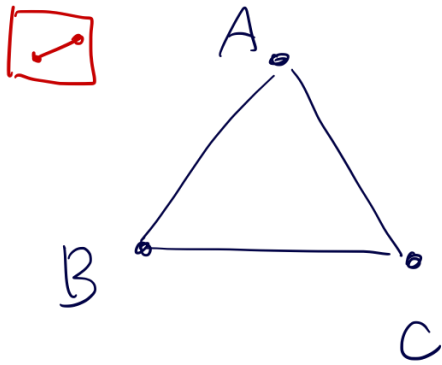- My friend, a researcher of wasan, old Japanese mathematics, asked me how to construct this figure by GeoGebra.
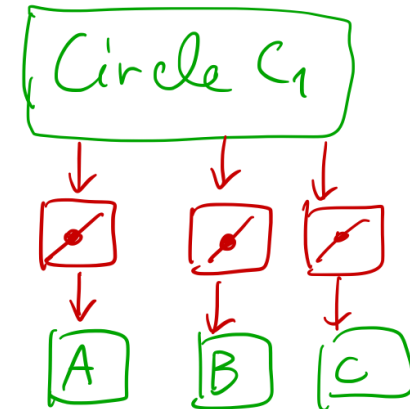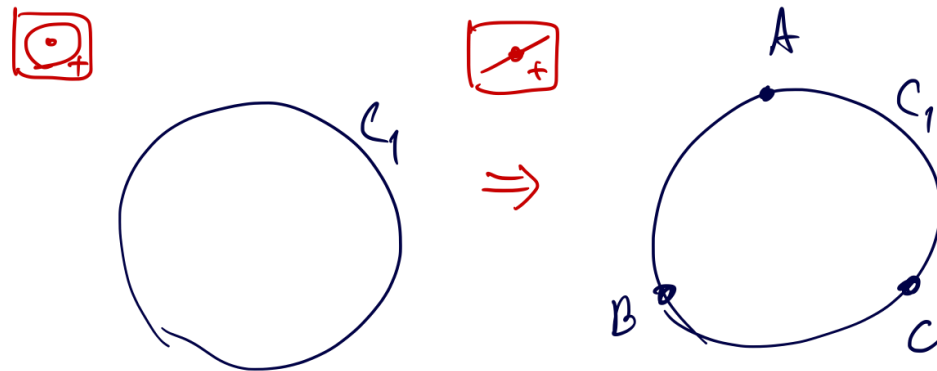
- I couldn't find how to.

 (until now.)

# Converting a screenshot to GeoGebra.

# Two ways to construct the circumcenter.
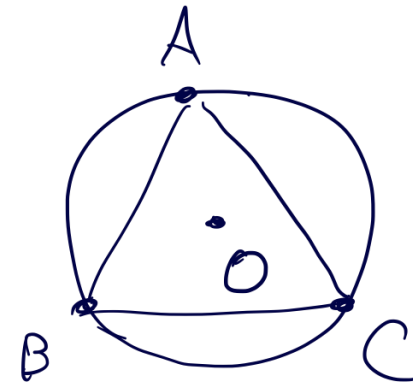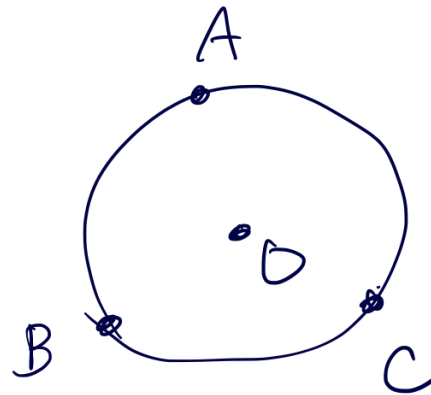
# Dependency in GDS
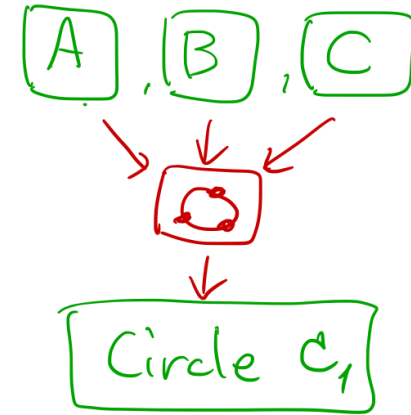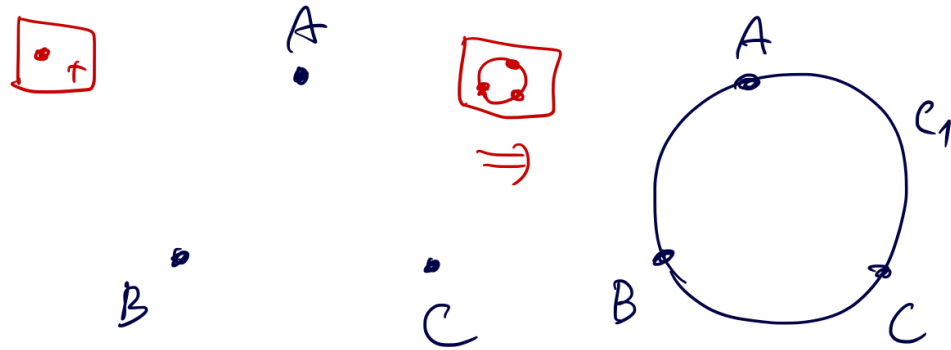
# Bi-directional dependency = relationship



If dependency is BI-directional,

then the construction will be

much FREER !

# Representation of four circles in a triangle

# Demonstration 1

- [https://www.youtube.com/watch?v=IsCWIhSa74I](https://www.youtube.com/watch?v=IsCWIhSa74I)

# Demonstration 2

- https://www.youtube.com/watch?v=YOiKmLRWrfE
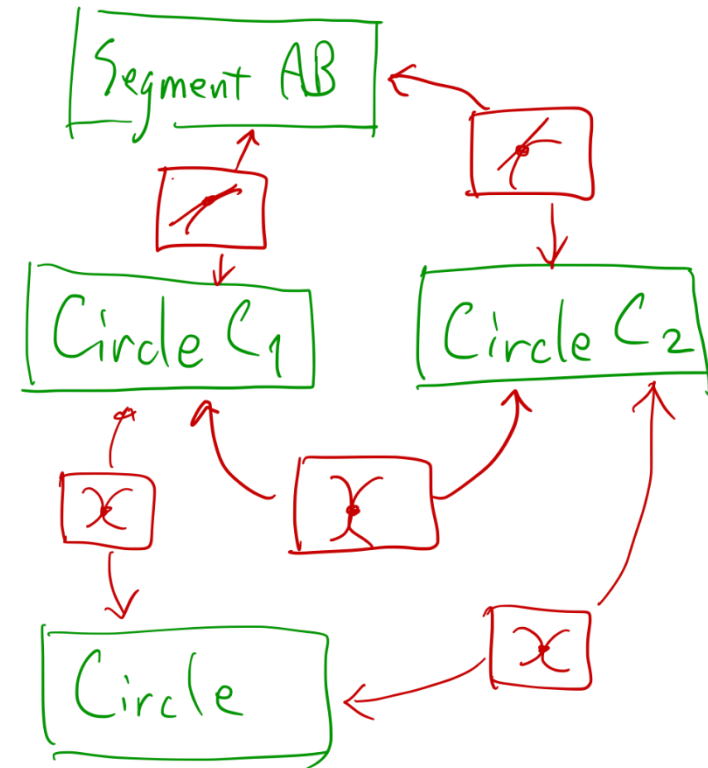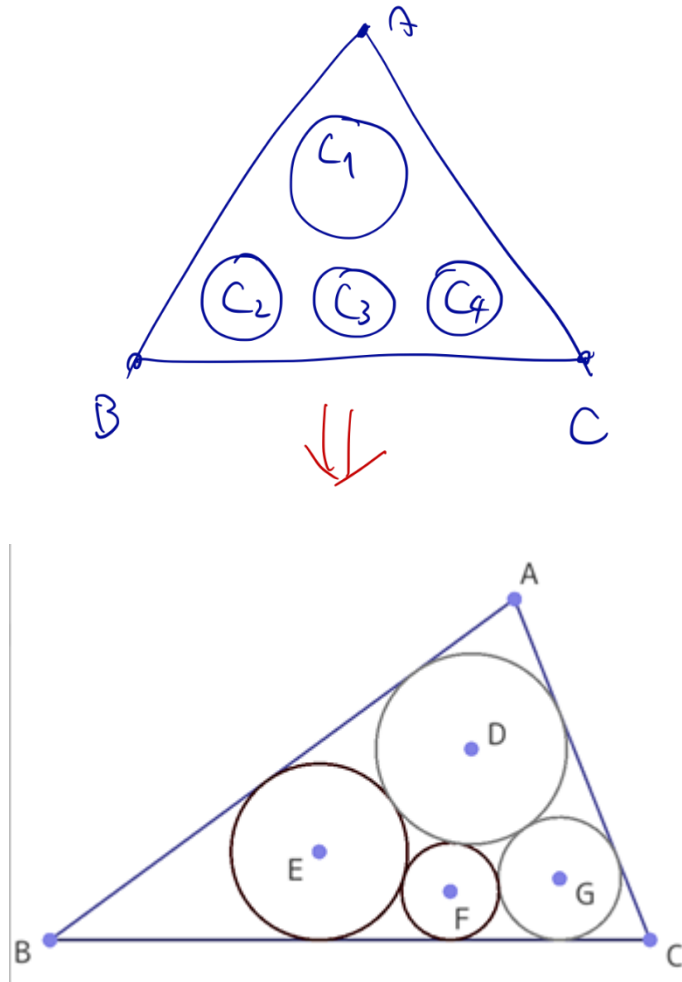
# Mathematician needn't PointLine.

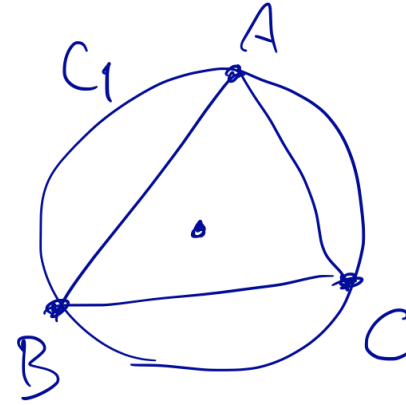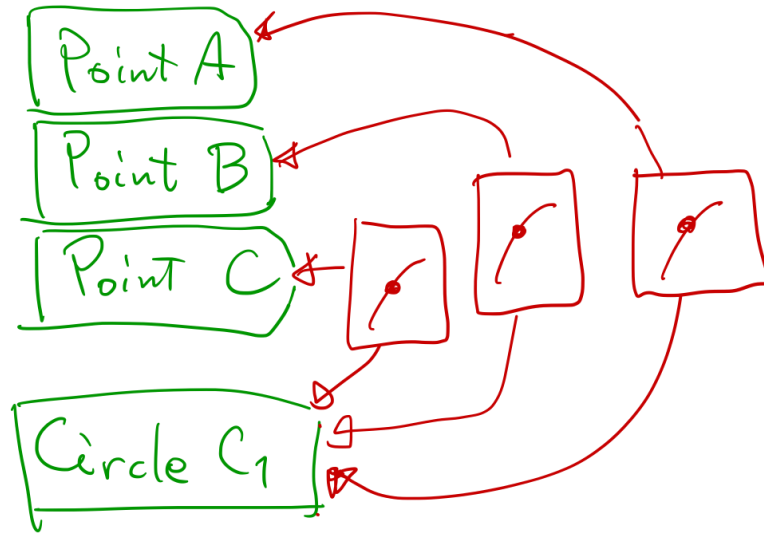- Mathematician friends of mine said that PointLine is not only useless but also harm.

- Non-mathematician friends of mine said that PointLine was fun and it was an exploratory tool of geometry.

# Newton method

- Coincidency, tangency, colinearity are polynomial equations with a low degree.
- Newton method gives solutions of systems of these relationships approximately.

- PointLine uses Newton method.
- (a system of difference equations)
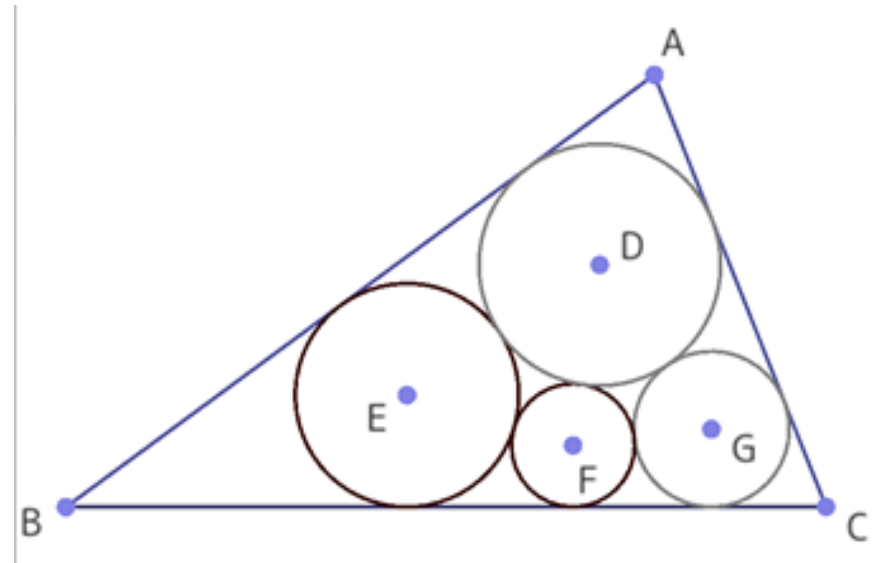
# Applications: stabilities

- $X$={configurations on PointLine}
- $G$={similarity transformation on $R^3$}
- $G$ acts on $X$ in a natural way.

- If $x \in X$ is stable, then $x':= g(x)$ $(g \in G)$ is also stable.
- -> Stable configuration set is not discrete.
- -> We want assurance for stationary, but we don't have.

- Stable configuration set may not be connected.

# Application: detecting the degree of freedom

If we fix the triangle, we cannot move four circles locally.
-> visualization of the degree of freedom

Demonstration 3

# Application: Impossible figure

## Demonstration 4

https://www.youtube.com/watch?v=SK9TqGkozz0

# Thank you for your watching

# Github URL:
https://github.com/PointLineAharaLab/PointLine