

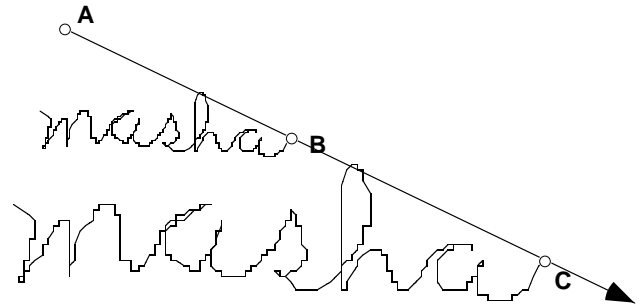
## Modeling a Pantograph

Name(s): \_\_\_\_\_

A pantograph is a simple mechanical device that uses two pens to copy and enlarge or reduce drawings or maps. Thomas Jefferson made one, hoping he could use it to write more than one letter at a time. In this activity, you'll do a very simple construction that does what a pantograph does. Then, if you're brave and if you have enough time, you'll construct a model that more closely resembles a physical pantograph.

### Sketch and Investigate

1. Construct  $\overrightarrow{AB}$ .
2. Construct point  $C$  on  $\overrightarrow{AB}$ , beyond point  $B$ .
3. Select points  $B$  and  $C$ ; then, in the **Display** menu, turn on **Trace Point**.



Select points  $A$  and  $B$ ; then, in the **Measure** menu, choose **Distance**.  
Repeat for  $AC$ . Double-click on a measurement to activate the calculator. Click once on a measurement to enter it into a calculation.

4. Drag point  $B$  to write your name.
5. Measure  $AB$  and  $AC$ .
6. Calculate  $AB/AC$ .
7. Draw something with point  $B$ . Notice that point  $C$  moves on the ray so that the ratio  $AB/AC$  stays constant.
8. Move point  $C$  to make a different ratio. Experiment drawing things with point  $B$  using different ratios.

Q1 What does the ratio have to do with the traces of points  $B$  and  $C$ ?



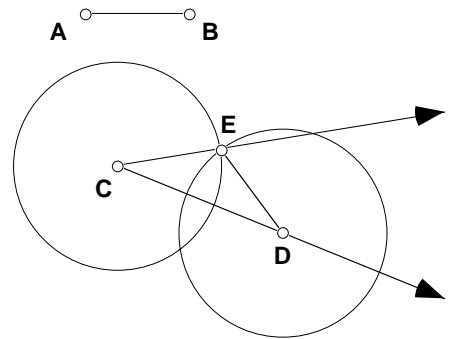
An actual, physical pantograph is constructed of rigid material, such as strips of wood. These pieces don't stretch the way a dynamic Sketchpad ray does. So an actual pantograph depends on linkages that make it flexible.

The following pages describe a construction that models a physical pantograph.

## Modeling a Pantograph (continued)

### Modeling an Actual Pantograph

9. In a new sketch, construct  $\overline{AB}$ .  
(This is not part of the pantograph, but it's a control segment that will make parts of your pantograph both rigid and adjustable.)



Steps 9–15

10. Construct  $\overrightarrow{CD}$ .

11. Construct a circle with center point  $C$  and radius  $AB$ .

12. Construct a circle with center point  $D$  and radius  $AB$ .

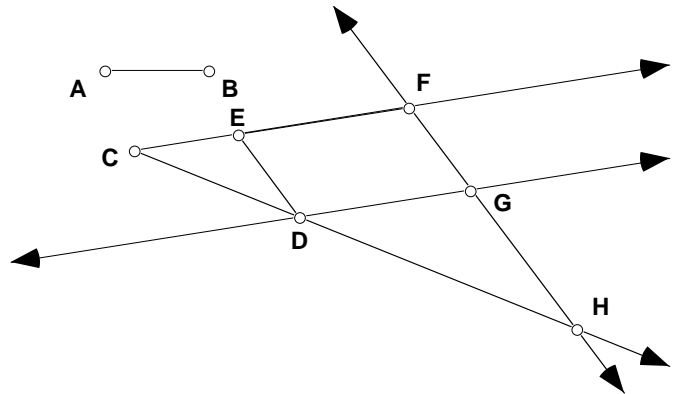
13. Construct point  $E$  at one intersection of these circles. (If the circles don't intersect, drag point  $D$  until they do.)

14. Construct  $\overrightarrow{CE}$ .

15. Construct  $\overrightarrow{DE}$ .

16. Hide the circles.

17. Construct  $\overline{EF}$  on  $\overrightarrow{CE}$ .



Steps 16–21

18. Construct a line through point  $F$  parallel to  $\overrightarrow{DE}$ .

19. Construct a line through point  $D$  parallel to  $\overrightarrow{CE}$ .

20. Construct point  $G$  where these lines intersect.

21. Construct point  $H$  at the intersection of  $\overrightarrow{FG}$  and  $\overrightarrow{CD}$ .

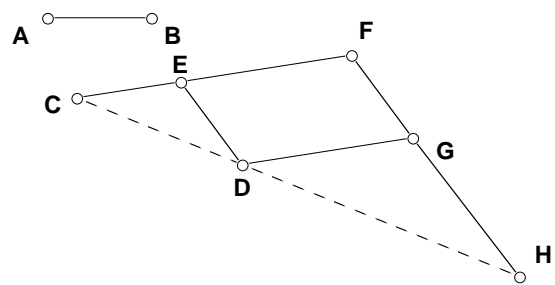
Hold the mouse button down on the Segment tool to show the Straight Objects palette.

Drag right to choose the

Ray tool. Select point  $C$  and  $\overline{AB}$ ; then, in the Construct menu, choose Circle By Center+Radius.

Select point  $F$  and  $\overrightarrow{DE}$ ; then, in the Construct menu, choose Parallel Line.

22. Hide  $\overrightarrow{CE}$ ,  $\overrightarrow{CD}$ ,  $\overrightarrow{FG}$ , and  $\overrightarrow{DG}$ .
23. Construct  $\overline{CE}$ ,  $\overline{FG}$ ,  $\overline{DG}$ , and  $\overline{GH}$ . This is something like what a real pantograph looks like.



## Modeling a Pantograph (continued)

After you draw  $\overline{CD}$ ,  
choose *Display:*  
*Line Weight:*  
*Dashed.*

24. Construct  $\overline{CD}$  and  $\overline{DH}$  and make these segments dashed. These segments wouldn't appear on a real pantograph, but they can help you see how a pantograph works.

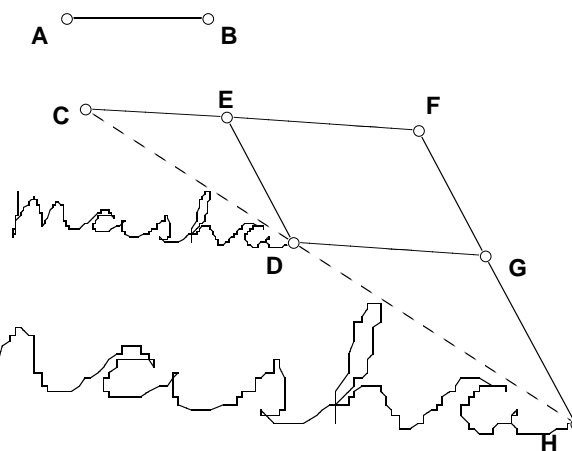
25. Drag point  $D$  to observe how the pantograph behaves. Note that it falls apart if you drag point  $D$  too far from point  $C$ . You can extend its range by lengthening  $\overline{AB}$ .

26. Turn on **Trace Points** for points  $D$  and  $H$ .

This may take  
several tries.  
Experiment with  
different starting  
places for point  $D$ . If  
necessary, make  $\overline{AB}$   
longer and move  
point  $F$  farther from  
point  $E$ .

27. Drag point  $D$  to trace out your name.

28. Move point  $F$ , then drag point  $D$  to see how the location of point  $F$  affects the trace of point  $H$ .



Q2 How would you locate point  $F$  so that the trace of point  $H$  was twice as large as the trace of point  $D$ ? Use similar triangles to explain why.



### Explore More

1. Build an actual pantograph out of old rulers, small bolts, and wing nuts.