In this problem you will illustrate the following part of Theorem 3.9 from your textbook:

> Suppose p and r are rays emanating from Q, with direction indicators U and W. Then Y is in the interior of $\angle(p, r)$ if and only if $Y = Q + aU + cW$ for $a, c > 0$.

This lab problem shouldn't take too long. It's designed to help you continue to get more accustomed to GeoGebra – especially renaming and/or hiding certain parts of your construction. You might want to keep the *Installing and Using GeoGebra* document nearby, as a reminder of how to hide the axes or other tasks. Recall that these labs are written assuming you're using a desktop version of GeoGebra. On an tablet or phone, things may be slightly different. The Input field may not be at the bottom of the window, for example!

GeoGebra Construction

(1) Open a new GeoGebra window. Hide the axes but turn on the grid.

(2) Create a new point and rename it Q. On the desktop version you can do this by typing `Q` immediately after creating the point (before typing or clicking anything else). Alternatively, you can right-click on the point to rename it. On mobile interfaces you may have to go to the `Object Properties` window to rename the point.

> Note: "polishing" steps like renaming or hiding objects might be different on tablet or web versions of GeoGebra, which have different defaults for whether the name and/or value of segments and other objects are displayed. So you might not have to change some labels, or you might have to change different labels, etc. Also, on desktop versions of GeoGebra, you can select objects from a list and edit their properties. On tablet or web versions, after opening Object Properties, you might have to tap on an object to edit it.

(3) Now create your two direction indicators with the `Vector` tool. (This is in the same dropdown menu as the `Line` tool.) After choosing the tool, click on Q and then at some other point on the grid to create a vector. GeoGebra will create a point at the end of the vector, probably named A. Create your second direction indicator. GeoGebra probably named your vectors u and v, but you should rename them U and W to match the notation in Theorem 3.9.

(4) We don't need to see the points at the ends of the vectors, probably named A and B, so you should hide them. You can do this by right clicking on each point and unchecking `Show Object`. Alternatively, you can do this in the `Object Properties` window, or by tapping the colored circle next to the name of each point in the `Algebra` pane.

(5) Create the rays for your angle by typing `Ray[Q,U]` and `Ray[Q,W]` in the input bar. Alternatively, you can use the `Ray` tool (in the same dropdown menu as the `Line` and `Vector` tools). After choosing the tool, click on Q and then the direction indicator to create a ray. Rename the rays p and r, as appropriate, to match the notation from Theorem 3.9. (Here "appropriate" means that U is the direction indicator for p, and W is the indicator for r.)

(6) Type `Y = Q + a*U + c*W` in the input field. You can replace `*` with a space, but if you type `aU` with nothing between the letters, your construction will not be correct, because GeoGebra will think you're referring to a new object `aU` instead of multiplying `U` by a number `a`. (Same for `c` and `W`.)

(7) Because the numbers a and c do not exist yet, GeoGebra will offer to "create sliders" for them. You should let GeoGebra do so, by clicking the `Create Sliders` button.

(8) Now Y will appear. Move the sliders for a and c and notice how Y changes. Verify that Y is in the interior of the angle if and only if both a and c are positive. What happens when they're 0, or both negative? Notice that this fact about Y is true even if you click and drag Q, U, or W to change your angle. You don't need to send me any answers to these questions. The point is to experiment with your construction until you understand the statement from Theorem 3.9 and see why it's true.

(9) Before you submit your lab, make sure to clean things up as necessary. As noted above, you shouldn't display the axes. (They're irrelevant in Theorem 3.9, so including them in a demonstration of the Theorem is unnecessary and distracting.) Make sure you've renamed and hidden objects as described above. If you want, you can adjust the colors or styles of the vectors, rays, or points to spruce up your presentation, but that's not necessary for full credit.

To receive credit for this assignment, save your file as `lastname-5335-lab1.ggb` and email it to me as an attachment by the beginning of class on Wednesday, 9/25/19. For full credit, make sure you've done the "polishing" work: e.g. the labels match the notation in Theorem 3.9, you've hidden the axes and any points not mentioned in the theorem.

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