Name_____   Date _____
Cross Product of Vectors that start at the origin in the Third Dimension in GeoGebra   Calculus Topic
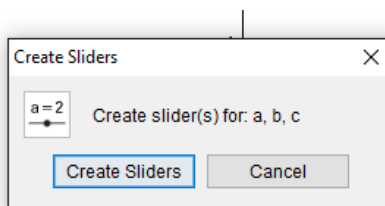
1. **Open GeoGebra.**

2. Look at the bottom of the window. See the input box? **Let's type in a vector!**

   a. In the input box type in: Vector[(a , b , c)]
      i. Make sure you typed exactly what is shown **with the spaces**.
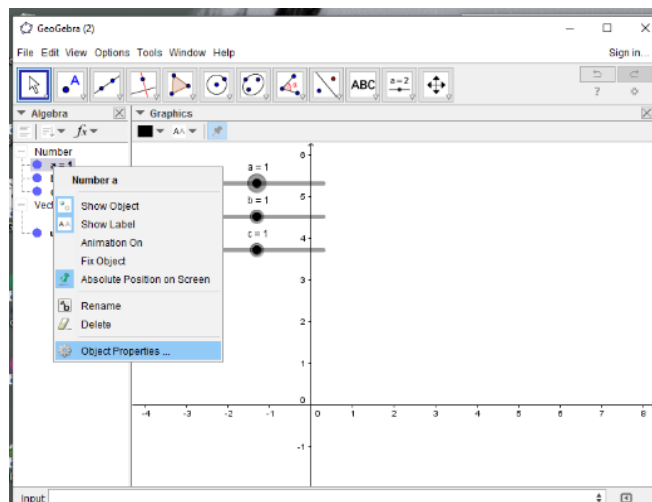

   b. A box will pop up saying "Do you want to create sliders for a, b, and c?"
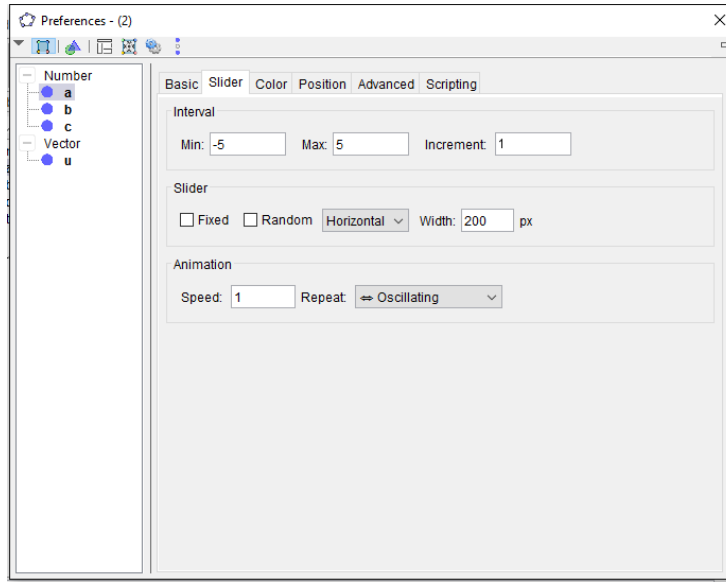   i. Click "Create Sliders".

3. **Change the increments** of the variables you just created

   a. Right click over number 'a' and unfix the object by clicking "Fix Object"

   b. Right click again and open object properties

c. In the slider tab:

    i. Minimum is -5 and maximum is 5

    ii. Increment is 1

    iii. Hit the enter key

d. Make sure the slider now ranges from -5 to 5 and goes up by ones.

e. Repeat steps 3a to3d for variables b and c

4. **When messing around with the sliders when does a vector appear in the graphics view?**

a. **What are the values of the variables when the vector appears on the xy-coordinate plane?**

b. **Using what you know about vectors, why does it appear under these conditions?**

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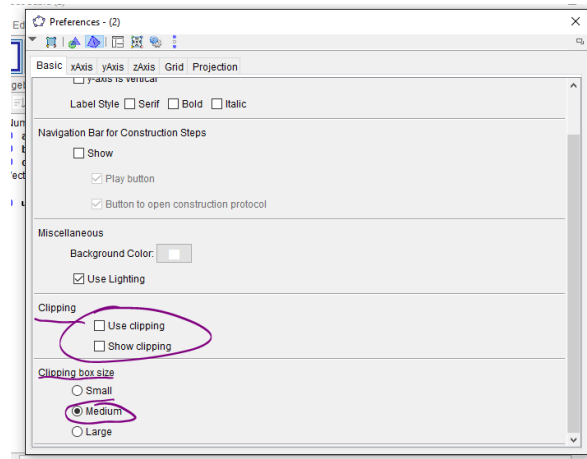
5. **Let's go to the ~Third Dimension~!**
   a. Look at the top of the window, to the right of the "File" option.
   b. Click "View" and turn on "3D graphics" by clicking on it. Stretch the 3D graphics so that it takes up most of the window but you are still able to see the sliders and graphic view.
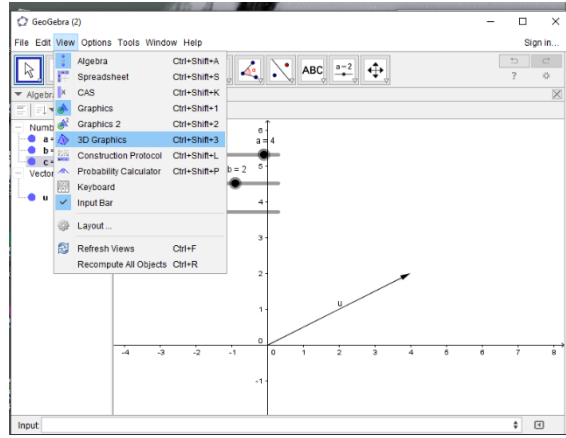
   c. Now right click in the 3D graphics window and choose the graphic settings at the bottom of the pop up menu.
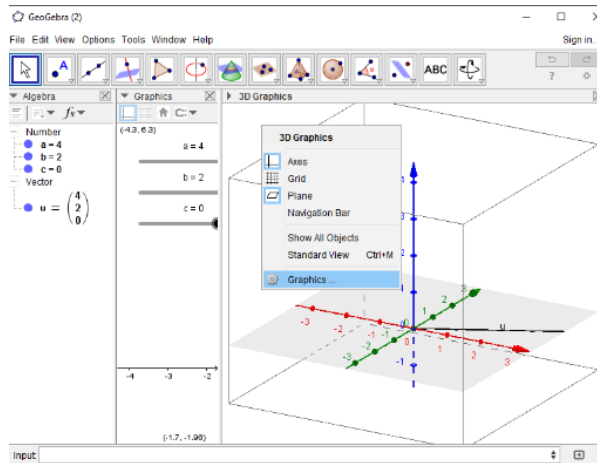
   d. Once there, under the "Basic" tab uncheck the "Show clipping" option and the "Use clipping" option under "Clipping". In the same area make sure "Clipping box" size is medium.

6. **Now move around the sliders around. Describe what happens to the vector in the third dimension for the movement of each variable.**
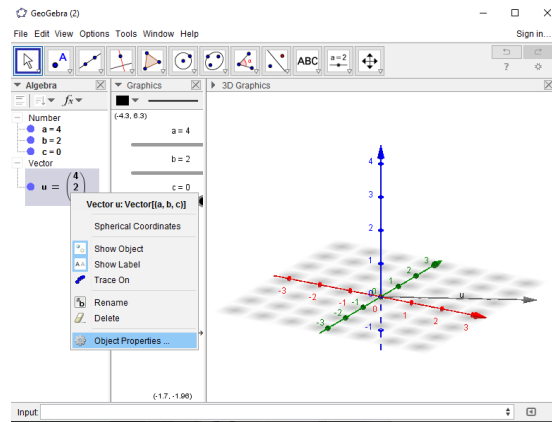   a. **Variable "a"**

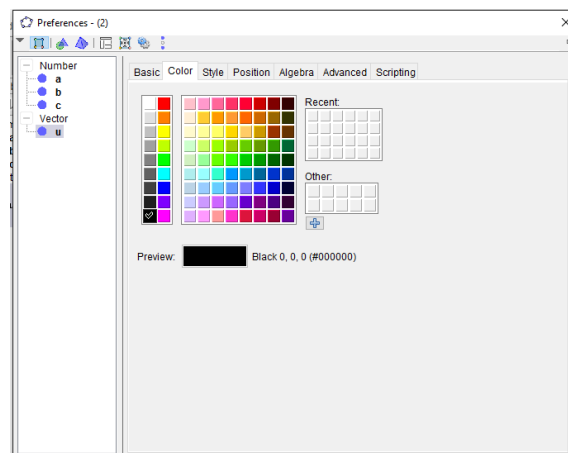   b. **Variable "b"**

   c. **Variable "c"**

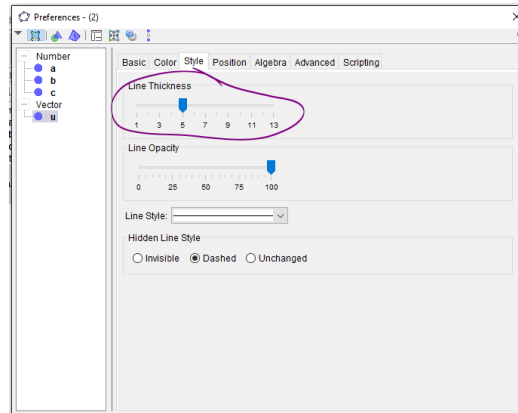7. **Make your vector colorful!** Make sure it is distinct.
   a. Right click on the vector and choose object properties

   b. Under the "color" tab change the color of the vector. Don't forget the axes are already blue, red and green!

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c. Under the "style" tab change the thickness of the vector so that it is easier to see. Between 4 and 7 is a good size.

d. Change the color of the sliders to match the new color of vector!
   i. While in the object properties of the vector to the left you'll see the objects you have inputted so far. Click on one of the variables listed.
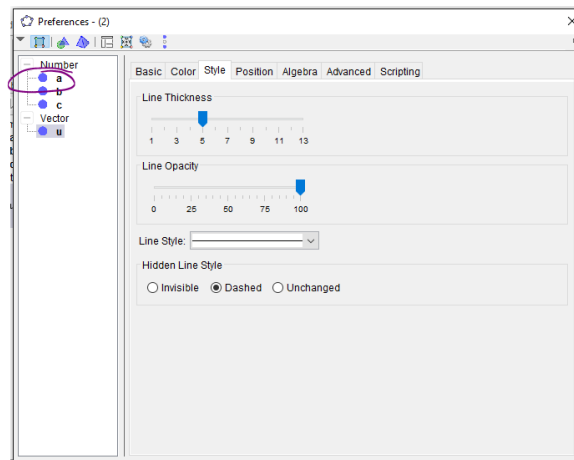
   ii. Under the "color" tab look under "recent" to see the color you just used for the vector and click it.
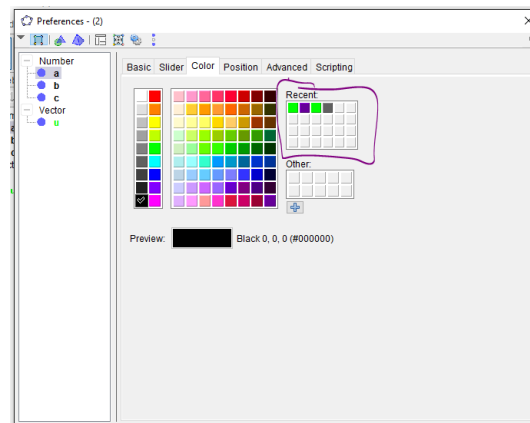
   iii. Repeat for variables a, b, and c.

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8. **Time to add in a new vector!**
   a. This time when you input a vector at the bottom of the window in the input box use the variables d, f, and g. Don't forget the spaces or GeoGebra will not recognize to create sliders!

   Input: Vector[(d , f , g)]

   b. Repeat all of step 3 for sliders of variables d, f, and g

   c. Make this vector colorful too!
      i. Repeat step 7 for vector v and sliders d, f, and g

9. **If you can't see the colors, change the background of the graph to black or dark grey.**
   a. Right click in the 3D graphics view and go into the graphics properties again (see 5c)
   b. Under the "Basic" tab there is a section called "Miscellaneous". There is a section that says "Background color" click the box next to it and choose the black color or a dark grey color.
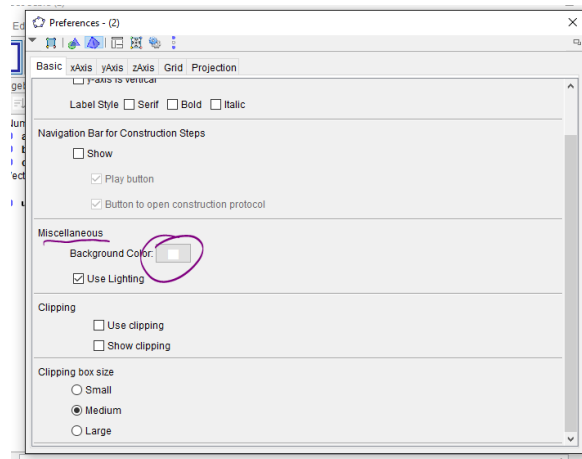
   c. Right click in the 2D graphics view and go into the graphic settings at the bottom of the pop up menu. Chang the color of the axis to white and the background color black or dark grey.
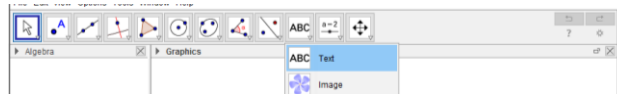

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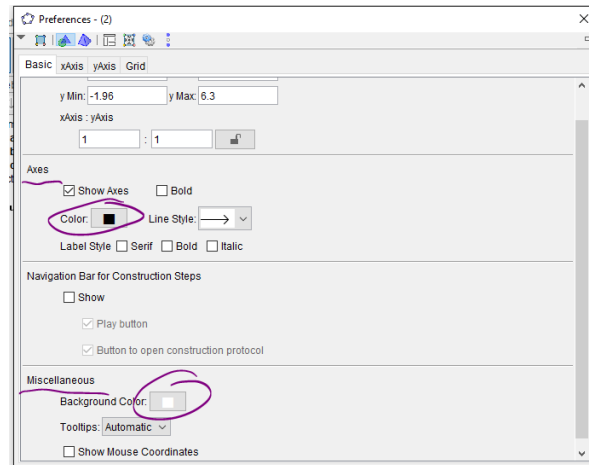
10. ~ Cross Product Time! ~

   a.   In the input box at the bottom of the window type in: Cross[u , v]

        Input: **Cross[u , v]**   α   ◁

   b.   This will give the cross product of u x v. Make the resulting vector more visible with colors like in step 7.

11. Text Boxes for labels:

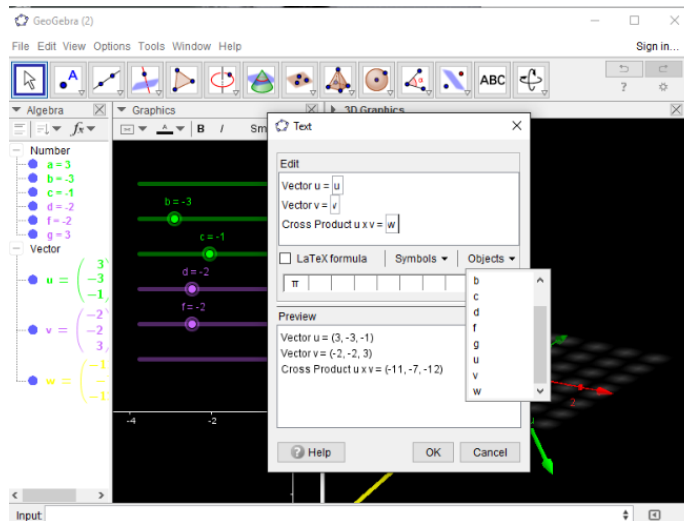   a.   Click the top square that says "ABC" and choose "text". Then click within the 3D graphics.

   b.   Type in the following. Where you see "[object __]" choose the corresponding object through the drop down called "objects":

             Vector u = [object u]
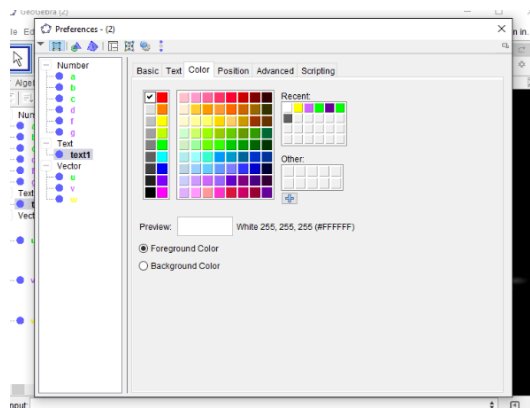
             Vector v = [object v]

             Cross Product vector u x v = [object w*]

   *or whatever your cross product vector is named as

   c.   Next change the color of the text you just made to white. Right click on text in algebra view and open object properties. Click on the 'color' tab and change the color to white.

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d. Now make labels for your sliders by using the "text" option in the 2D graphics view. Make two texts. One that says "Vector u" and one that says "Vector v". Color the text to correspond to the colors you chose for u and v.
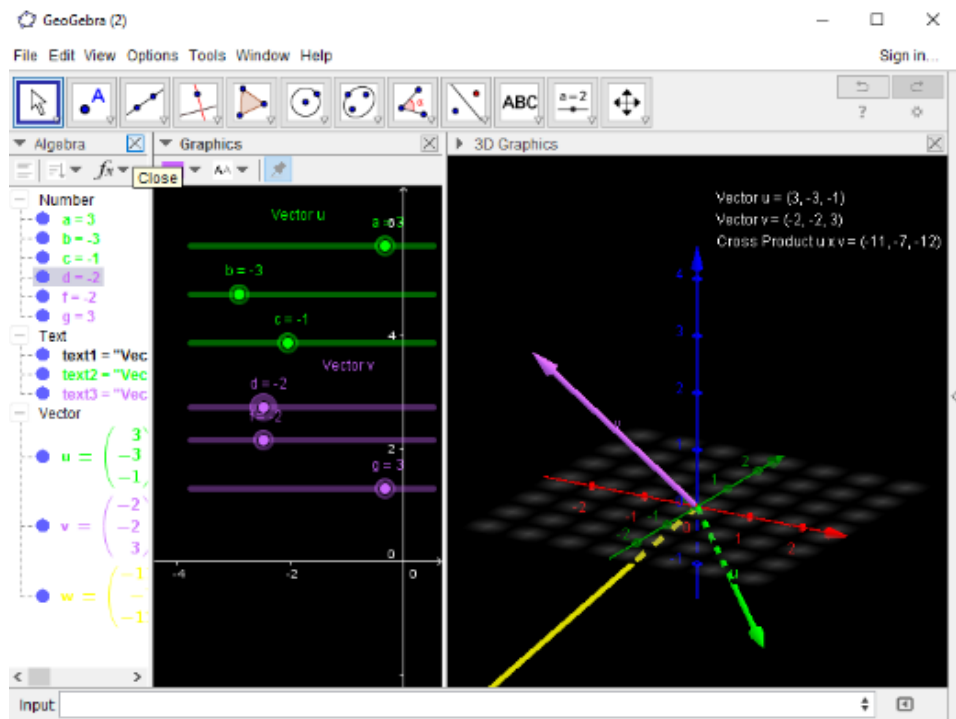
e. Once you have your labels you can close out the Algebra view to make more room for the 2D and 3D graphics. Move around your text and sliders to make the graph and sliders easier to see.

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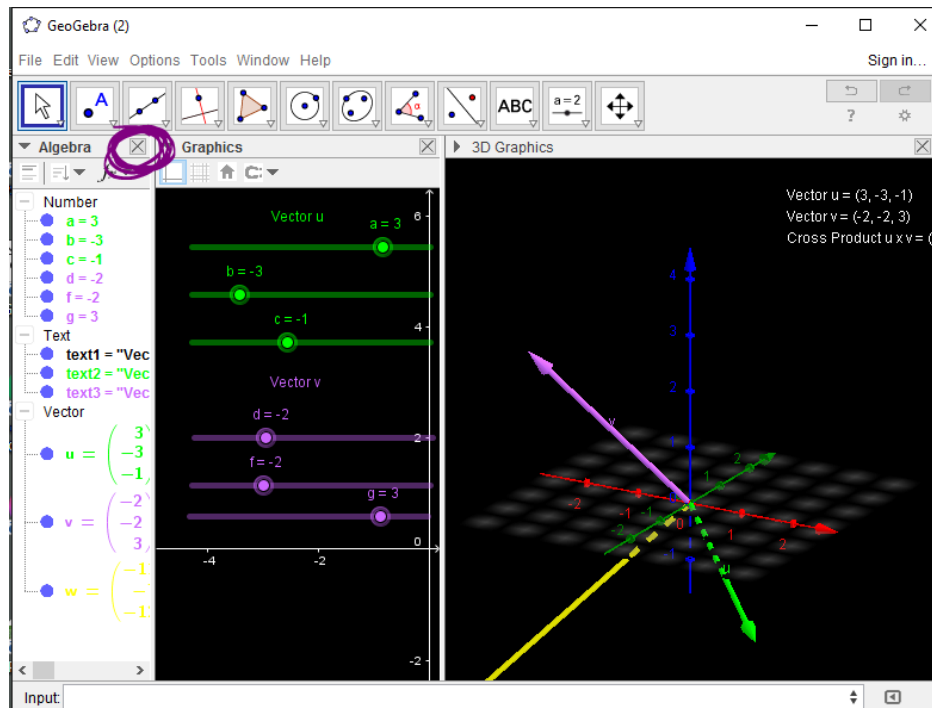
12. **How does the cross product of u x v look in comparison to the original vectors? What happens to the cross product of u x v when you move around the vectors with the sliders? If possible, use specific examples of vectors.**

    a. **If vectors u and v are on the xy plane, where is the cross product of the vectors?**

    b. **What happens when the u and v are on two of the axis? Where is the cross product?**

    c. **Any other comments or patterns you see with the relationship of the vectors u and v and the cross product of u x v?**

13. **Think back to the Dot Product. How does the Cross Product of vectors differ from the Dot Product of vectors?**

14. **Can you predict how will the cross product of v x u differ? Will it just equal the cross product of u x v?**

    a. **Test it out and give specific examples of vectors.**
       (hint: look back at number 10 for how the cross product is inputted. If you need the "algebra" view again to see the formulas, go up to "view" at the top of the window and select "Algebra".)

    b. **Will all four vectors (u, v, u x v, v x u) be able to shown on the xy plane? Explain why or why not using specific examples of vectors.**