Graphing Vectors, Lines, and Planes with *Mathematica*

Don't forget to press **Shift-Enter** to execute each part. Watch out for upper- and lower-case.

Creating and Graphing Vectors
Define vector **v =** <0, 2, 1> by typing and executing **`v={0,2,1}`**
Define vector **u** = <1, 2, -1> the same way.

To graph vector **v**, we are going to graph it as a short line. Let's use P(1, 1, 1) as our initial point.
The line though P in the direction of **v** in parametric form is: $x = 1$, $y = 2t + 1$, $z = t + 1$

To graph this, type and execute: **`ParametricPlot3D[{1,2t+1,t+1},{t,0,1}]`**
Since we will want to look at this graph later, go back and name it by typing **`vGraph=`** in front of it and re-execute. Do the same thing for vector **u** and call it **`uGraph`**.

To find the normal vector type and execute: **`Cross[u,v]`**. Graph this vector and call it **`nGraph`**.
To see all of the vectors together use **`Show[vGraph,uGraph,nGraph]`**.

If you want to be able to rotate the graph, type and execute **``<<RealTime3D` ``** (note the backwards apostrophe). Nothing will seem to happen. Re-execute the **`Show`** command. Click and drag over the image to rotate it. Use **Ctrl** while dragging to zoom.

Creating and Graphing a Plane
The easiest way to create the graph of a 3D surface is to use the command
`Plot3D[`*f*(*x*,*y*)**`,{x,`** *xmin*, *xmax***`},{y,`***ymin***`,`** *ymax***`}]`** where *f*(*x*,*y*) is the stuff that *z* equals.
For example, to graph the circular paraboloid $z = x^2 + y^2$, type and execute:
`Plot3D[x^2+y^2,{x,-4,4},{y,-4,4}]` (Why doesn't it look round?)

Therefore, sometimes we have to solve for *z* before graphing. We can use *Mathematica* for the algebra:
Type and execute **`Solve[3x+5y==0,y]`** and observe what happens. (Note the double =)

Back to our vectors **u** and **v**. Type out the equation of the plane containing these two vectors and point P.
Use the **`Solve`** command to solve for *z*. (Don't forget to use two = signs.)

Now, rather than re-typing this result, highlight and copy the expression *following the arrow*. Type the **`Plot3D`** command **`Plot3D[`***f*(*x*,*y*)**`,{x,0,2},{y,0,2},PlotPoints->2]`**and paste the expression for *z* in for *f*(*x*,*y*). **`PlotPoints`** helps it look better—we only need two points in each direction for a plane. (Note: The domain for *x* and *y* places our point P(1,1,1) is at the center.)

Name this graph by typing **`plane=`** in front of the **`Plot3D`** command and re-execute it.
Show all of the graphs together using **`Show[vGraph,uGraph,nGraph,plane]`**.

Graph this in default mode by typing and executing **``<<Default3D` ``** (note the backwards apostrophe).
Nothing seems to happen. Re-execute the **`Show`** command. Notice now that you have a frame and axes.
To change the view point, go inside the last **`]`** of the **`Show`** command and insert a **`,`** (comma). Now select "3D ViewPoint Selector . . ." from the "Input" menu. Rotate the box to the angle you want to view your graph. Select "Paste" and then re-execute the code. (Triple-click **`ViewPoint`** to select for changing.)

Exercise: Find the plane that contains the point (1, 2, 11) and the vector <2, 6, -1> and is orthogonal to the plane $3x - 4y + z = 6$. Graph all three objects to verify your result. (Hint: Graph in RealTime.)

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