Derive Tutorial

Derive is a computer algebra system by Texas Instruments. You have used Derive for algebra, the purpose of this document is to help with some of the three dimensional capabilities of the program.

Vectors in Derive are entered using brackets. [x, y] or [x, y, z]. You can integrate or differentiate vectors just like other expressions.

3D Graphing - If you want a separate graph, click on the 3D graph window icon. If you would like your graph embedded in the document (which is what I would like for your project), then use the "Insert 3D plot object" (ctl-3) command. When you go insert a plot into the object, highlight the vector in the algebra window, switch to the plot window and then use the Insert Plot (F4) command. There is a plot icon, but using the insert plot command allows you to increase the number of panels (the number of steps for your parameters – default is 20 and the graph is kind of jerky, so increase it to 50 or so for a smoother curve). Unfortunately, you can't change the colors on a predictable basis for a vector plot.

To plot the curve $\mathbf{r}(t) = 3t\,\mathbf{i} - 2t^2\,\mathbf{j} - 4t\,\mathbf{k}$, enter [3t,-2t^2,-4t].
To plot the vector from (3,2,1) to (5,7,-2), enter [[3,2,1], [5,7,-2]]

You will also use the F5 - Insert Text Object - a lot. This allows you to place labels in the output so that you can identify what things are. The object will be inserted below the currently highlighted object.

There are some functions written to help you find curvature. Load the utility file "DifferentiationApplications". For help on how to use the commands, go to the help index and search for "curvature".

Example problem: Graph a vector curve $\mathbf{r}(t) = 3\cos t\,\mathbf{i} + 2\sin t\,\mathbf{j} + t\,\mathbf{k}$ and draw the unit tangent, normal, and binormal vectors when $t = 0$. The Derive output is on the following pages. You do not have to annotate as much as I have, I'm trying to show you how to accomplish the tasks.

Find T, N, and B and graph when t=0

Start with the function r(t)

#1: $[3\cdot\text{COS}(t),\ 2\cdot\text{SIN}(t),\ t]$

Find r(0) by using the subsitution command on expression #1 with t=0

#2: $[3,\ 0,\ 0]$

Find the derivative by highlighting expression 1, clicking on the partial derivative symbol and then clicking simplify

#3: $\frac{d}{dt}[3\cdot\text{COS}(t),\ 2\cdot\text{SIN}(t),\ t]$

#4: $[-\ 3\cdot\text{SIN}(t),\ 2\cdot\text{COS}(t),\ 1]$

Make it a unit vector by dividing by the norm. The norm of vector is called the absolute value in Derive, so author **#4/abs(#4)** and press control-enter for "enter and simplify"

#5: $$\frac{[-\ 3\cdot\text{SIN}(t),\ 2\cdot\text{COS}(t),\ 1]}{\left|[-\ 3\cdot\text{SIN}(t),\ 2\cdot\text{COS}(t),\ 1]\right|}$$

#6: $$\left[-\ \frac{3\cdot\sqrt{5}\cdot\text{SIN}(t)}{5\cdot\sqrt{(\text{SIN}(t)^2 + 1)}},\ \frac{2\cdot\sqrt{5}\cdot\text{COS}(t)}{5\cdot\sqrt{(\text{SIN}(t)^2 + 1)}},\ \frac{\sqrt{5}}{5\cdot\sqrt{(\text{SIN}(t)^2 + 1)}}\right]$$

Evaluate T(0) by using the subsitute command on #6 with t=0

#7: $$\left[0,\ \frac{2\cdot\sqrt{5}}{5},\ \frac{\sqrt{5}}{5}\right]$$

The problem with T(0) is that its initial point is at the origin. We need to have it start at r (0), so that the terminal point is r(0)+r'(0). To do this, author **[#2, #2+#7]** which will create a line segment. Again, hit control-enter instead of enter to go ahead and simplify it.

#8: $$\left[[3,\ 0,\ 0],\ [3,\ 0,\ 0] + \left[0,\ \frac{2\cdot\sqrt{5}}{5},\ \frac{\sqrt{5}}{5}\right]\right]$$

#9: $$\begin{bmatrix} 3 & 0 & 0 \\ 3 & \frac{2\cdot\sqrt{5}}{5} & \frac{\sqrt{5}}{5} \end{bmatrix}$$

Find the Normal vector, which is T'(t) / norm(T'(t)). T(t) is #6, so highlight #6 and then differentiate.

$$\#10: \quad \frac{d}{dt}\left[-\frac{3\cdot\sqrt{5}\cdot\mathrm{SIN}(t)}{5\cdot\sqrt{(\mathrm{SIN}(t)^2+1)}},\ \frac{2\cdot\sqrt{5}\cdot\mathrm{COS}(t)}{5\cdot\sqrt{(\mathrm{SIN}(t)^2+1)}},\ \frac{\sqrt{5}}{5\cdot\sqrt{(\mathrm{SIN}(t)^2+1)}}\right]$$

$$\#11: \quad \left[-\frac{3\cdot\sqrt{5}\cdot\mathrm{COS}(t)}{5\cdot(\mathrm{SIN}(t)^2+1)^{3/2}},\ -\frac{4\cdot\sqrt{5}\cdot\mathrm{SIN}(t)}{5\cdot(\mathrm{SIN}(t)^2+1)^{3/2}},\ -\frac{\sqrt{5}\cdot\mathrm{SIN}(t)\cdot\mathrm{COS}(t)}{5\cdot(\mathrm{SIN}(t)^2+1)^{3/2}}\right]$$

Since we don't need N(t) for further calculations, we can go ahead and evaluate it at t=0 by using the substitution command.

$$\#12: \quad \left[-\frac{3\cdot\sqrt{5}}{5},\ 0,\ 0\right]$$

Make it a unit vector by dividing by the norm. **#12/abs(#12)**

$$\#13: \quad \frac{\left[-\frac{3\cdot\sqrt{5}}{5},\ 0,\ 0\right]}{\left\|\left[-\frac{3\cdot\sqrt{5}}{5},\ 0,\ 0\right]\right\|}$$

$$\#14: \quad [-1,\ 0,\ 0]$$

Now relocate it so that it starts at r(0). **[#2, #2+#14]**

$$\#15: \quad [[3,\ 0,\ 0],\ [3,\ 0,\ 0] + [-1,\ 0,\ 0]]$$

$$\#16: \quad \begin{bmatrix} 3 & 0 & 0 \\ 2 & 0 & 0 \end{bmatrix}$$

Now find the binormal vector B by using the cross product command. T is in #7 and N is in #14, so **cross(#7,#14)**

$$\#17: \quad \mathrm{CROSS}\left(\left[0,\ \frac{2\cdot\sqrt{5}}{5},\ \frac{\sqrt{5}}{5}\right],\ [-1,\ 0,\ 0]\right)$$

#18: $$\left[0,\ -\frac{\sqrt{5}}{5},\ \frac{2\cdot\sqrt{5}}{5}\right]$$

Relocate it so that it begins at r(0). **[#2, #2+#18]**

#19: $$\left[[3,\ 0,\ 0],\ [3,\ 0,\ 0] + \left[0,\ -\frac{\sqrt{5}}{5},\ \frac{2\cdot\sqrt{5}}{5}\right]\right]$$

#20: $$\begin{bmatrix} 3 & 0 & 0 \\ 3 & -\frac{\sqrt{5}}{5} & \frac{2\cdot\sqrt{5}}{5} \end{bmatrix}$$

Insert a 3D plot object and then insert plots of r [#1], T(0) [#9], N(0) [#16], and B(0) [#20]. You may wish to drag your graph bigger before you edit it. Note that annotations don't always transfer correctly from the 3D window to the embedded object and if you double-click to re-edit the object, it will default back to the regular zoom level. For that reason, you might want to set your plot range rather than just using the zoom to get a good look at the graph.