PREPARING MATHEMATICAL ANIMATIONS FOR THE WEB WITH MAPLE 6

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Abstract. Some topics in the calculus sequence are difficult for students to visualize. The concepts become clearer to the students if they can see an animated example. It is relatively straightforward and simple to create animations in two or three dimensions with Maple 6. Maple 5 also has this capability and it is possible, although more time consuming, to create animation frames with Mathematica. In this paper, I will describe the procedure that will animate the generation of the surface of a solid of revolution. I will describe the procedures necessary to:

(1) create mathematical animations with Maple 6,
(2) export the animation as a GIF file, and
(3) create movie clips with QuickTime.

1. Creating the Animations with Maple 6

The animation commands in Maple are part of the plots package. The first step is to use the command

(1.1) with(plots):

to load the plots package. The calling sequence for the animate3d command is

(1.2) animate3d(F, x, y,t);

where F is a surface (or surfaces) to be plotted, x and y are the independent variables, and t is the animation parameter[2]. I find it simplest to define the surface parametrically as [x(t), y(t), z(t)]. For the surface of a solid of revolution about a horizontal line, for this demonstration I will use the x-axis,

(1.3a) $x(t) = x$,

We want the cross section of the solid perpendicular to the yz-plane to be a disc of radius $f(x)$ centered on the x-axis. Therefore

(1.3b) $y(t) = f(x)\sin(t)$,

and

(1.3c) $z(t) = f(x)\cos(t)$.

We need to define $f(x)$ as a function in Maple. For this example I will use $f(x) = 2\cosh\left(\frac{x}{2}\right)$ which is defined with the command

(1.4) f := x -> 2*cosh(x/2);

Next we define the animation. I have two distinct versions. The first shows the rotating curve only. The syntax of this command is

(1.5) animate3d([x,f(x)*sin(t),f(x)*cos(t)],x=-1..2,y=-3..3,t=0..2*Pi,axes=normal, scaling=unconstrained,orientation=[-45,75],frames=32,labels=[x,y,z]);

The second form sweeps out the surface as the curve rotates about the x-axis. I accomplish this by replacing the reference to y ranges with a second parameter s which varies from zero to one. The syntax of this command is

(1.6) animate3d([x,f(x)*sin(s*t),f(x)*cos(s*t)],x=-1..2,s=0..1,t=0..2*Pi,axes=normal, scaling=unconstrained,orientation=[-45,75],frames=32,labels=[x,y,z]);

Notice that there are several options invoked in the command. The default for three-dimensional plotting is to have no axes. This is superseded by the option 'axes=normal'. The 'orientation=[-45,75]' sets the point of view of the observer. Probably the most useful option is the 'frames=' option. Increasing the number of frames makes the animation smoother but may take longer for the end user to download over the web.

1.1. **Extensions of the Rotation.** It is also possible to rotate the graph around any horizontal line $y = L$. The cross section is now a disc of radius $|f(x) - L|$ centered at the point $(x, L, 0)$. Thus, the parameterizations for y and z are

(1.7a) $y(t) = L + (f(x) - L)\sin(st)$

and

(1.7b) $z(t) = (f(x) - L)\cos(st)$.

The animation command is

(1.8) animate3d([x,L+(f(x)-L)*sin(s*t),(f(x)-L)*cos(s*t)],x=-1..2,s=0..1,t=0..2*Pi, axes=normal,scaling=unconstrained,orientation=[-45,75],frames=32, labels=[x,y,z]);

We may also ask Maple to create the surface of a solid of revolution about a vertical line $x = H$. The cross section parallel to the xy plane are discs of radius $|x - H|$ centered at the point $(H, 0, f(x))$. The parameterizations of the coordinates to rotate the curve are

(1.9a) $x(t) = H + (x - H)\cos t$,

(1.9b) $y(t) = (x - H)\sin t$,

and

(1.9c) $z(t) = f(x)$.

The animation command is

(1.10) animate3d([H+(x-H)*cos(t),(x-H)*sin(t),f(x)],x=-1..2,y=-2..2,t=0..2*Pi, axes=normal,scaling=unconstrained,orientation=[-45,75],frames=32,labels=[x,y,z]);

If you wish to see the surface swept out the reference to the cosine function in $x(t)$ needs to be $\cos(st)$ and the reference to the sine function in $y(t)$ needs to be $\sin(st)$. The animation command is

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animate3d([H+(x-H)*cos(s*t),(x-H)*sin(s*t),f(x)],x=-1..2,s=0..1,t=0..2*Pi,
axes=normal,scaling=unconstrained,orientation=[-45,75],frames=32,labels=[x,y,z]);
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(1.11)

1.2. **Exporting the Animation as a GIF File.** Once you have defined the animation as you wish it is easy to export it as a GIF file. simply

(1) Right click on the picture.
(2) Choose 'Export As, Graphics Interchange Format (GIF)'
(3) Choose the folder in which you want to save the animation (If you are using Microsoft FrontPage the best choice is My Documents/My Webs because this is the default for FrontPage) and give the file a name. It may take some time to export the GIF file depending on the number of frames chosen[2].

2. Creating the QuickTime Movie from the GIF File

To create movies with QuickTime (or with Real Player) it is necessary to have the enhanced version. For QuickTime, this is QuickTime Pro which can be accessed for $29.95 at http://www.apple.com. In order to import the GIF file into QuickTime

(1) Click on the File menu of the QuickTime Player.
(2) Choose Import and find the file.
(3) Click on Convert.

For this animation I want to put the two versions together in a single movie. We can accomplish this by opening each file in a separate Quicktime Player. Next, we advance one of the animations to the point that we wish to insert the other file. Next, we use the Edit menu on the player that contains the file that we wish to copy, click on 'Select All', then click on 'Copy' in the Edit menu. Return to the original player and click on 'Paste' in the Edit menu[1].

We are now ready to export the finished QuickTime Movie. This is accomplished by choosing 'Save As' from the File menu, give the movie a name, and choose Save normally.

References

1. Apple Computer Inc., *Help pages for quicktime pro version 5.0.2*, On-line linked from QuickTime player Help menu, 2001.
2. Waterloo Maple Inc., *Help page for plots,animate3d command*, packaged with Maple 6.01, June 2000.

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