

## Secrets of cubic splines, world-wide ac power standards, and some details on the Hacker's Mac.

By Don Lancaster

Before getting into this month's column, let me tell you that my brand-new two-volume *Applewriter/Laserwriter Utilities Package* is all ready to go. Its features totally boggle the mind. In fact, all of the artwork for this month's column was done using Applewriter on a IIe and this package.

Neat, huh?

On to this month's goodies . . .

### Read any good power supply circuit books lately?

The *Lambda* people have a free *Semiconductor Applications Handbook* available that has lots of good information on voltage regulators, switching and linear power supplies, dc motor controls and stuff like that. You can get one by asking for it over their 800 number or by requesting a copy on a business letterhead.

While there's lots of great stuff in this book, note that *Lambda* tends to be somewhat on the "Baldwin Locomotive Works" side of reality, since they are very much into high-reliability and mil-spec products.

If you happen to be into switching-mode power supplies, *Raytheon* has a data sheet on its 4191/2/3 Micro-Power Switching Regulators that might interest you. Again, there is no charge, and you will find some excellent background tutorial material here.

Finally, if you are at all interested in any "big mutha" semiconductors of any type for use in electric vehicles, robots, steppers, machine tools, giant power supplies, magnetics, super high currents, or whatever, you might want to subscribe to *Powerconversion International*. This trade journal is available free if you meet its qualifications on the bingo card.

### What are cubic splines?

Cubic splines are a major breakthrough in computer graphics that let you draw smooth and accurate "freehand" or "freeform" curves as easily as you would draw a plain old box.

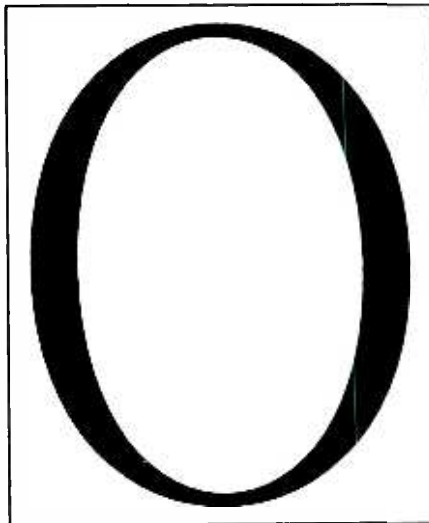


Fig. 1. Only 16 data points are needed to draw this O with cubic splines.

Cubic splines are also a superb way to handle typographic fonts, since the fonts can be stored in an extremely compact form. More importantly, the fonts can be easily scaled to any size and any shape desired, with resolution and smoothness increasing as font size increases. Compare this to scaling a bit-mapped font that gets "chunkier" as the size increases.

The *Laserwriter* uses cubic splines for many of its font characters and for its *curveto* and *rcurveto* operators. This ability places Laserwriter head and shoulders above its "one-size font in an outrageously priced cartridge" shoddy imitators.

Though easily accessible from *Applewriter* on a IIe, cubic splines are conspicuously absent from the Macintosh Quickdraw routines. I'll try to give you some fundamental background here and show you where to go for enough info that you can, with bunches of personal effort, add cubic spline ability to most any graphics program on most any microcomputer of your choice.

First, a plain old spline is a plastic-coated lead ruler that drafting, engineering, and architectural people use to draw a curve that won't "fit" the usual compass or French curve contours. First, you carefully bend the spline to the desired shape.

Then you use this shape to draw or ink your line.

Cubic splines use the same general idea. By selecting the right data points, you can force a line to go from its start to its finish by way of a smooth and controllable route. Change the data points, and the shape of the curve changes.

They are called cubic splines because the hairy math behind them involve a pair of polynomials of order three that involve a constant, a linear term, a square term, and a cubic term. Should the curve be too complicated for a single cubic spline to handle, you use as many splines as you need, end to end, to get the job done.

Figure 1 shows a good example. Only four cubic splines having a total of 16 data points are needed to draw this Roman "O," regardless of font size. By way of comparison, the Fig. 1 original measured roughly two inches by three inches. At 300 dots-to-the-inch resolution, a bit map of 540,000 pixels would be required!

The first spline covers the top half of the outside edge. The second does the bottom half, while the third does the top inside edge, and the fourth handles the bottom inside edge. A fill routine then uses an "even-odd" rule to blacken the inside of the letter.

You can approach cubic splines from two different ways. Chances are you will like the intuitive or "try it and see" route, instead of the analytical or "mess with all that hairy math" method. Cubic splines lend themselves beautifully to experimenting and playing with them.

Anyway, Fig. 2 shows what is involved in using cubic splines, once the microcomputer or printer is internally set up or programmed to handle them. The object of the game is to build a curve from a point marked START to a point named END. To get from START to END, you go by way of two influence points. The positioning of the influence points sets the shape of the curve you will get.

The direction you leave START is set by the first influence point, while the direction you enter END is set by the second influence point. The distance from START to the first influence point, or

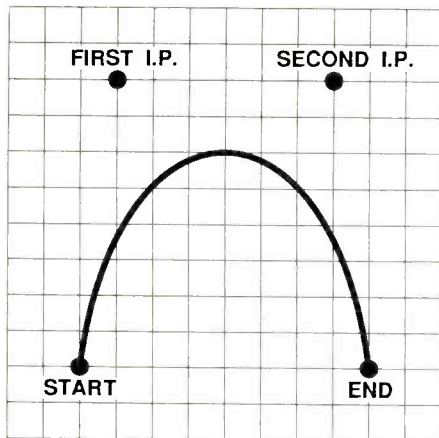


Fig. 2. A cubic spline is drawn via two "influence points" (I.P.s).

from the second influence point to END sets the "enthusiasm" at which the curve moves in the intended direction.

Once you have left START, the smoothest possible curve that can be drawn with a pair of cubic polynomials will then be drawn. One cubic polynomial handles the horizontal motion, while the second takes care of the vertical. The direction you head in is called the *bias* by the computer graphics people, while the enthusiasm is called the *tension*.

The oldest of cubic spline techniques are called *Bezier curves*. Newer and more powerful versions go by the names B-Splines and *Beta-splines*. There are also *conic splines*, available, among lots of others. Many of these fancier splines are more powerful and more flexible, but they are not easily or quickly done on a smaller microcomputer. Some are three dimensional.

One way to get different curves is to move the influence points around and see what happens. Let's see if we can't second-guess what we can or cannot do with a single cubic spline.

First, rotate this page around 360 degrees. Obviously, the same shape curve can be generated in any direction, so long as the relative position of the influence points with regard to START and END does not change.

Now, let's get back to Fig. 2 right side up. If both influence points are above START and END, the curve will be above START and END. If both influence points are below START and END, the curve will be below START and END. If both influence points are between START and END, you will get nothing but a straight line. If one or both influence points are on extensions of the straight line between START and END, you will get a straight line that "over-shoots" START, END, or both.

If one influence point is above and one is below, you will get a somewhat sine-wave-looking curve that crosses the axis between START and END. You get symmetrical curves if the influence points are related to START and END in the same or mirrored ways. You get asymmetrical

curves if one influence point has different bias or tension than the other.

Now for the neat part. If the first influence point is to the right of the second influence point, then the curve may cross, creating a sharp *cusp* or a *loop*. The size and sharpness depends on how far away the influence points are from the START and END points, as well as how far apart they are from each other. You can get an "open" loop if only one of the two influence points is far left or far right of normal. Thus, it seems that you can use one cubic spline to do a smooth symmetric or asymmetric curve, a curve with one change in its curvature direction, a curve with one cusp, or a curve with a loop in it. Anything fancier can be built up with repeated cubic splines.

Sometimes one of the influence points

Fig. 3. This is a sample page from a cubic spline catalog. The dot is the first influence point, while the square is the second influence point.



is placed directly over START or END. This can be used to either sharpen a corner or smooth out a result, depending on the need.

Reviewing, to do a cubic spline on a microcomputer or printer set up to handle them, set a START point, an END point, and two influence points. Then tell the software or firmware to have at it. Once again, the first influence point sets the direction or bias you leave START, while its distance sets up the enthusiasm or tension the curve will head in that direction. The second influence point behaves in a mirror manner with END.

Note that the curve rarely will pass through either influence point. More often that not, it will miss these points by bunches on the "inside," since the smoothest possible curve is being drawn. Many curves will stay inside a "fence" drawn between the four points.

Here's how simple it is to draw the curve of Fig. 2 on a Laserwriter:

```
2 2 moveto
3 10 9 10 10 2 curveto
stroke
```

This says to move two blocks in and two blocks up to set START. Then define the first influence point at three blocks in and ten blocks up. Then define the second influence point at nine blocks in and ten blocks up. Next, set the END point at ten blocks in and two blocks up. Finally, activate *curveto* to draw the curve.

You will also, of course, have to scale and translate the curve to where you want it, as well as set your desired line width and shade of gray.

It turns out that the Fig. 2 curve is actually easier to draw than a plain old box!

Figure 3 is a page out of a spline catalog I worked up. Not too shabby for Applewriter on a IIe is it? At any rate, these cubic spline curves may seem a little dull, because the catalog is based only on a  $9 \times 9$  integer grid. Even at this grid size, there are over 6500 splines in the 81-page catalog! Many of these are rotations or mirror images of each other.

START is always two blocks right and four blocks up. END is always six blocks right and four blocks up. The first in-

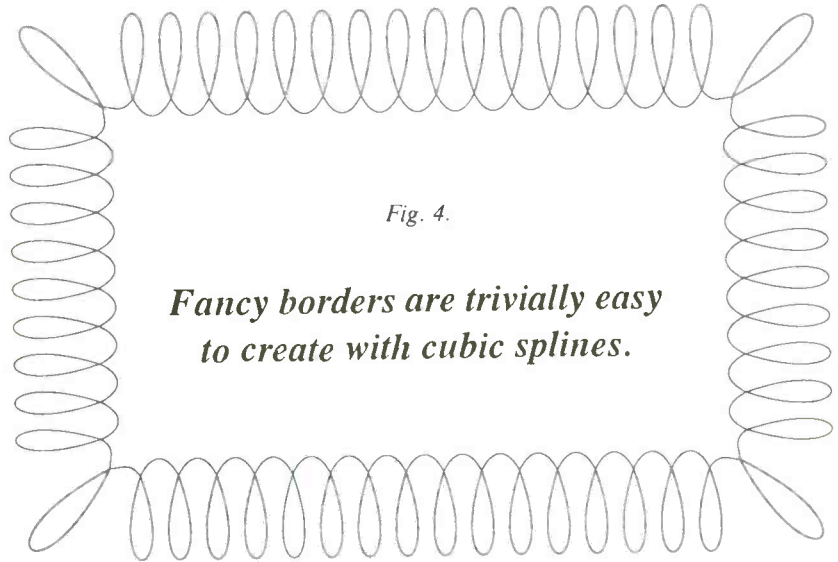


Fig. 4.

*Fancy borders are trivially easy to create with cubic splines.*

fluence point is a round dot. The second influence point is a square. In the upper left figure, the dot and square are sitting on top of each other.

Should you widen the influence points, the curves will gain in impact, grace, and all around impressiveness. As it is, the catalog does show all possible shape families you can get with a single spline. Note that even on one catalog page, you have concave and convex shapes; shapes both symmetrical and asymmetrical; shapes with cusps, loops, open loops; and shapes with or without changes in the direction of curvature.

The number of possible splines you can draw between START and END is nearly infinite. The influence points do *not* have to be integer values.

Figure 4 shows a totally different and totally mind-blowing use for splines. Fancy borders like this are utterly trivial to handle with cubic splines. Only five different splines are needed! These are the main side loop from the crossover point, the inner arc, the diagonal end loop, and the two transition arcs connecting the corner loops to the edge loops.

To really get fancy, you can use a double border like this with a slight size difference. This will make the lines fatter in some places and thinner in others, just

like "real" engraving. (I have a free *Postscript* listing of Fig. 4 available for you. Just ask for a copy.)

This particular border takes around 20 seconds to create using the Laserwriter's internal computer. All cubic splines need lots of processing time. While ideal for laser printing or creating final bitmaps of fixed visual images, they may not be well suited for real-time animation, unless you have a humongous computer available.

So, how can you tap these cubic splines for your own profit and enjoyment? You can do this with or without a Laserwriter. One route is to get yourself a copy of *Inside Laserwriter*, study it and log some hands-on time on a low-cost rental Laserwriter at your nearby quick copy center.

Otherwise, it is off to the nearest technical library. Bezier's original papers, for some strange reason, are all in French. He is translated in *Numeric Control—Mathematics and Applications*, by A.R. Forrest and A.F. Pankhurst, and published by Wiley in 1972. This seems to be out of print, so check a large technical library or a microfilm service.

The best and most consistent source I've found for information on cubic splines, along with excellent bibliographies, are the various *SIGGRAPH* proceedings, available from the *Association*

# HARDWARE HACKER...

for Computer Machinery. These usually appear in the number-three issue of each year's *ACM Computer Graphics* quarterly. The 1983 and 1984 proceedings are especially useful. I've yet to see the 1985 SIGGRAPH stuff. The advance promotion promises one paper on conic splines.

An obvious money-making idea that involves splines would be to apply them directly to Apple or other HIRES graphics routines, so that free-form curves can be handled as gracefully as ordinary boxes can. They are also sorely needed by the Mac. What would be really neat is to be able to real-time move the influence points around.

Let me know what you discover in this fascinating new area.

## ***What ac power plugs get used where in the world at what voltage and frequency?***

Did you know that the vast majority of countries in the world use 220 volts, 50 Hz

as their primary power standard? Or that some buildings in some developing countries actually may have several different power lines connected to several different and totally incompatible power systems?

Did you also know that there are at least 10 different major sizes and shapes of ac power plugs and sockets, all totally incompatible with each other?

This might affect you if you are planning to travel and take a computer or test gear with you, or if you are being assigned to a foreign office, or if you are designing products you want to sell world-wide. You might also be interested in this if you are catering to international tourists.

What is used how and where?

There's a great free book called *International Primary Power Components*. This combined reference and catalog is published by *Panel Components Corp.* It tells you all about all the voltages, frequencies and connectors as they are used everywhere in the world. As usual, you

get a copy by way of a request on a business letterhead or by telephone request.

Most electronic equipment these days have a removable cordset that plugs into a standard three-prong socket called an IEC 320 connector. Among countless other places, you'll find these on Hewlett-Packard and Tektronix test equipment and on most personal computers.

All you may have to do to use test equipment in a different country is swap the cordset for the one that fits the ac wall socket and flip a hidden or buried 110/220 switch to the proper position. But this can happen only if your piece of equipment operates either on both 110 and 220 volts or lets you switch between them.

*A 110-volt anything could instantly burn out on 220 volts!* At the very least, all primary fuses will immediately blow.

While most modern electronic equipment can run at 50 or 60 Hz equally well, many motors may not and could even be damaged. Any motors that are used for timing probably will run at the wrong speed. Certain phonograph turntables and clocks are obvious examples.

Be darn sure you read the label and check the switches before trying to run something at 220 volts or 240 volts. Conversely, most equipment rated at 220 or 240 volts will not work at all on 110 or 120 volts. The extreme "brownout" can damage motors and such if they try to run too slow under too high a load.

Even if there is no 110/220 switch, the internal power supply in your computer or whatever may let you rewire the power transformer primary for 110 or 220. Sometimes a pair of input windings is provided. Wire them in parallel aiding for 110/120 volts or series aiding for 220/240 volts. Details will appear in the tech manual for the instrument or computer in use. As a general rule, if they don't tell you about 220-volt or 50 Hz operation, then you cannot do it.

The final option is to get an external 220/240 to 110/120 step-down transformer big enough to handle the load. Plug the 220 side into the wall outlet and

## NAMES AND NUMBERS

### **Golemics**

2600 Tenth Street  
Berkeley, CA 94710  
(415) 486-8344

### **Inside Laserwriter**

467 Saratoga Avenue S621  
San Jose, CA 95129  
(408) 988-6009

### **Lambda Semiconductors**

121 International Drive  
Corpus Christi, TX 78410  
(800) 255-9606

### **Panel Components Corp.**

Box 6626  
Santa Rosa, CA 95406  
(707) 578-5478

### **Powerconversion International**

2472 Eastman Avenue U-34  
Ventura, CA 93003  
(805) 658-0933

### **Raytheon Semiconductor**

350 Ellis Street  
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### **SIGGRAPH ACM**

11 West 42nd Street  
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### **Howard W. Sams**

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### **Synergetics**

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(602) 428-4073

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New York, NY 10158  
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the test equipment or computer into the 110 side. Do this only if the equipment will run on *both* 50 or 60 Hz equally well.

Panel Components Corp. sells cordsets for just about every conceivable plug and socket in the world. Typical pricing for a single cordset is around \$5 each.

There's lots of other good stuff in the company's catalog, including a complete list of the standards people and their addresses, world maps, and lots more.

Check it out.

### What is the Hacker's Mac?

The *real* powers that be in the microcomputer world have decided that Apple can no longer be trusted with the Macintosh design. Apple had their chance and they totally blew it.

Enter the Hacker's Mac, a totally unlocked, totally open, totally expandable Macintosh-like machine, with a public-domain design, a public-domain operating system, public-domain documentation, and ready availability as low-cost kits, using easy-to-get stock parts. Lots of expansion slots, naturally. Everything socketed, naturally. Four channels or more of DMA and full multitasking and coprocessing ability. Full color in various resolutions, naturally.

At this writing, the Hackers Mac is just a dream. But Lee Felsenstein of *Golems* is rapidly making it happen. And you are invited to participate in any way you feel you are able. Contact Lee directly for information to see how you can help.

#### NEED HELP?

Phone or write your hardware hacker questions directly to:

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