The following is an excerpt from the first chapter of Jerry Brown's book, *Folk Harp Design and Construction*, available from Musicmakers (www.harpkit.com). Jerry has included it here to explain more fully the article on Home Built Harps in this issue of the Journal.

Harmonic Curve [Why are Harp Necks Curved?]

Let me begin this section with a disclaimer: I am mathematically challenged. I have read all the articles in back issues of the Folk Harp Journal on string analysis, the most notable ones written by Joseph Jourdain and the highly entertaining Mark Bolles, and I got hopelessly left behind. No offense to these scientific minds, but I decided at that point to write this book for non-mathematicians. My goal here is to help you build a harp that will safely handle the tuning range you want, without having to understand the math. Those who desire to venture into those murky waters would be well-advised to consult the back-issues of the Journal and have at it!

We will discuss harp strings a bit further in a later chapter on Stringing. For now, though, you simply need to make sure [you design your harp] to stay within the "safe" range of string lengths so that you won't have to discard your first test model due to an unworkable harmonic curve.

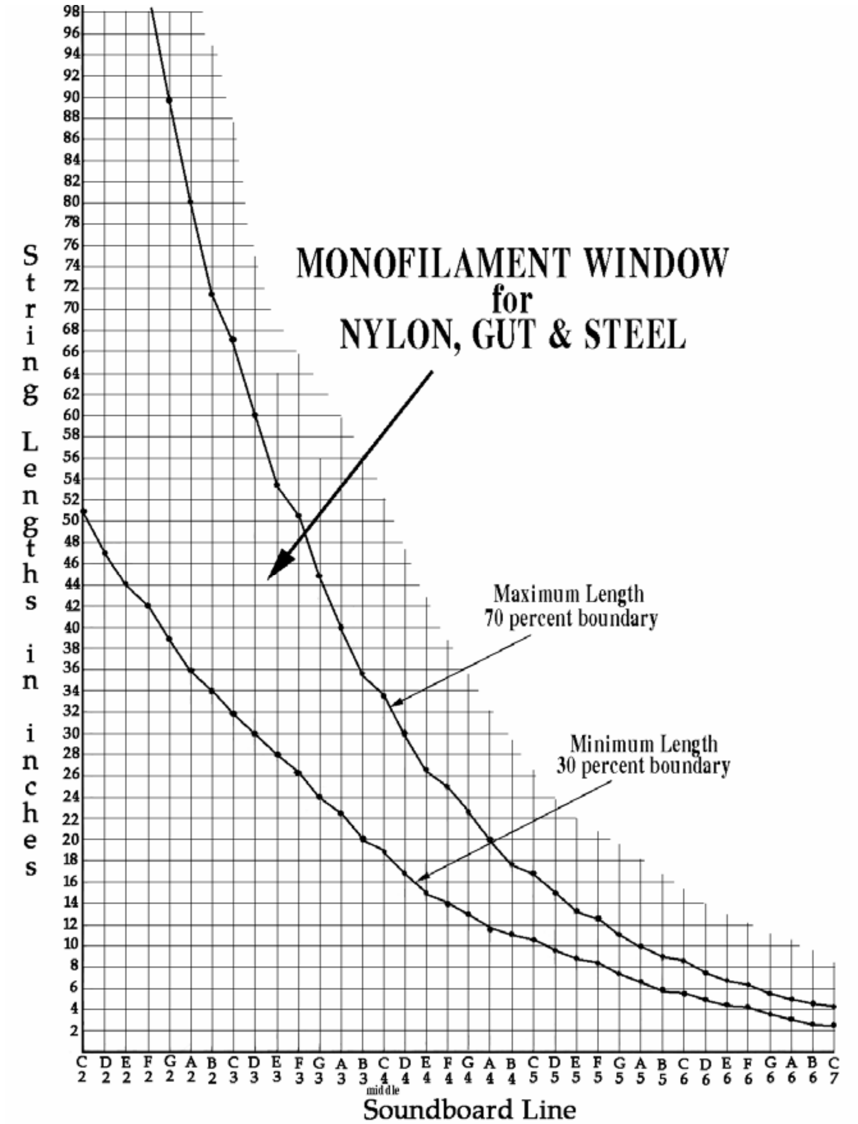
One thing that stuck with me from reading all those string analysis articles is that changing the diameter (thickness) of a monofilament string does not change its breaking point. That is to say, if a .036" diameter nylon string with a 34" vibrating length tends to break when tuned up to Middle C, so will a .040" diameter nylon string or a .025" diameter nylon string of that same length, when tuned up to the same pitch. I know, it sounds counterintuitive, but it is true. Just don't ask me to do the math.

Thankfully, this means that you can plot out your string lengths before you even know what diameters of nylon (or gut, or steel) you will end up using. The main challenge is to ensure that each string will have sufficient tension to vibrate clearly, but not so much that it will give you breakage problems.

There are computer programs designed to assist with this calculation, and I find them very helpful, but I have drawn a graph on the next page that shows the acceptable "window" of monofilament string lengths for any given pitch. That acceptable length lies between 30 percent and 70 percent of the string's theoretical breaking point, and the chart that follows applies equally to monofilament (single strand) strings made of nylon, gut, or steel. [You can see right away that the calculations result in a graph with a gentle curve].

Please note that if you wish to string your harp with brass or bronze wire, you will need to consult a different chart, as those materials are softer and have a narrower "window" of acceptable vibrating lengths. I have placed that chart in the Appendix [of the manual] so you wouldn't use it by mistake.

In lieu of purchasing the computer program for string analysis, you can either "borrow" the measurements from a successful harp that you like, or make use of this chart showing the "Monofilament Window" of acceptable string lengths for each pitch, from C2 (two octaves below Middle C) at the bottom to C7 three octaves above Middle C) at the top. I have not proceeded beyond that 36-string range, but you could fairly easily extend the chart by simple logic if you desire to make a harp with a wider range.



[I've spelled out the numbers from which the graph was drawn in the box to the right.] Notice that the highest strings have a narrower window of acceptable lengths than the lowest strings. This is quite important. If you are not careful at the top of the range [highest notes], you will end up with strings that break because they are just an inch too long, or sound dead because they are an inch too short for the assigned pitch.

Note to the Math Guys: If you do the calculations yourself, you will find that my minimum string lengths for the notes below Middle C are considerably less than the 30 percent calculations. I have done this to give a more realistic picture of common string lengths in that range. Most builders do not use monofilament strings below C3 anyway, so there is no point in adhering to the 30 percent rule in the bass range.

MONOFILAMENT WINDOW FOR NYLON, GUT & STEEL
(length in inches)

Note	Max length (70%)	Min length (30%)
C7	4.2"	2.8"
B6	4.5	2.9
A6	5.0	3.3
G6	5.6	3.7
F6	6.3	4.1
E6	6.7	4.4
D6	7.5	4.9
C6	8.4	5.5
B5	8.9	5.8
A5	10.0	6.6
G5	11.2	7.4
F5	12.6	8.3
E5	13.4	8.7
D5	15.0	9.8
C5	16.8	10.5
B4	17.8	11.0
A4	20.0	11.5
G4	22.5	13.0
F4	25.2	14.0
E4	26.7	15.0
D4	30.0	17.0
Middle C4	33.7	19.0
B3	35.7	20.0
A3	40.0	22.5
G3	44.9	24.0
F3	50.5	26.0
E3	53.5	28.0
D3	60.0	30.0
C3	67.4	32.0
B2	71.4	34.0
A2	80.1	36.0
G2	89.9	39.0
F2	100.9	42.0
E2	106.9	44.0
D2	120.0	47.0
C2	134.7	51.0

You have more flexibility in drawing your harmonic curve as you come down the scale. You can, for example, have a successful monofilament string tuned to middle C that is 33” long, or one that is only 19” in vibrating length.

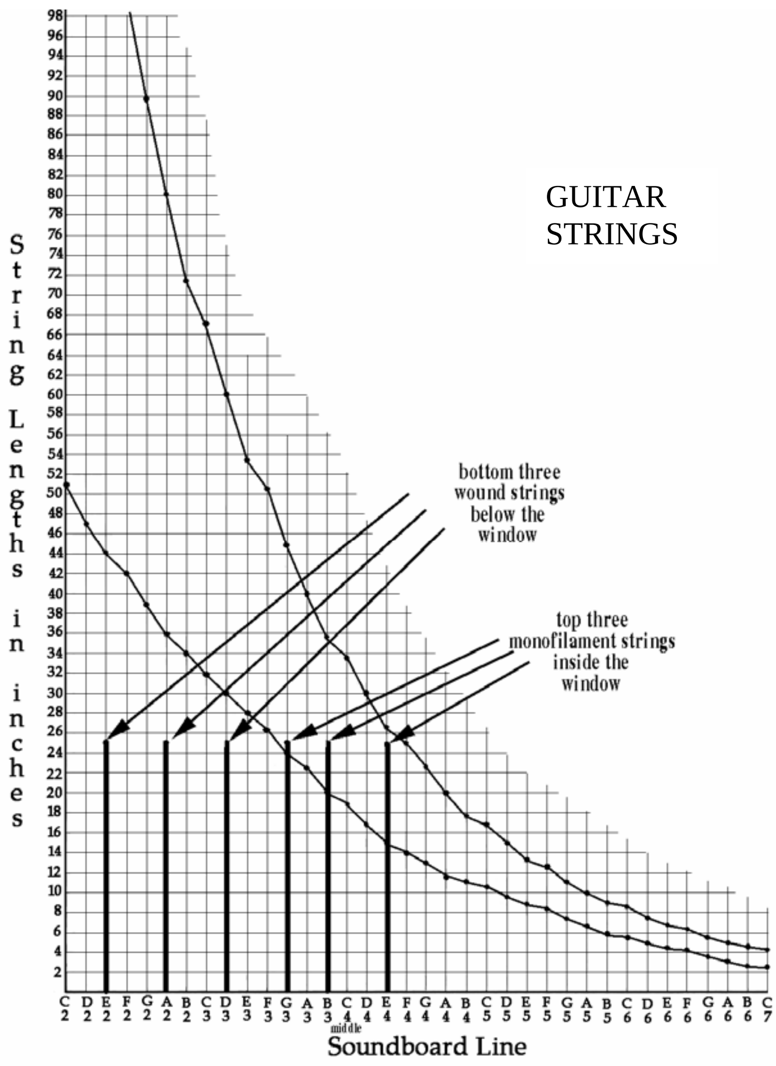
Notice, however, that the maximum lengths become ridiculously long toward the bottom of the musical scale. You will obviously not build a harp with strings having a 10 foot vibrating length! What most builders do is hug the maximum line in the upper range and shift closer to the minimum line at the bottom of the harp.

What builders do to make a relatively short string sound good at a low pitch is to switch from using a monofilament string to some sort of compound string made up of a core with some wrappings around it. This allows you to go below the minimum line.

Think of a guitar. Its 6 strings span two entire octaves of pitch (E2 to E4) even though the vibrating lengths are all the same (about 25 inches). No harmonic curve at all! This is accomplished by having monofilament strings (nylon or steel) in the high range, where they fit in the window, and wound strings in the low range where they fall below the window.

A guitarist, of course, has the added benefit of being able to shorten the vibrating length of any string by pushing it down against a fret, thus raising the pitch to allow playing higher scales. If you are interested in following how this works, look for the point where the high E string would intersect the graph if it were fretted in the middle of its length (12.5 inches) to sound an octave higher (E5).

Wa-La! It stays within the window. [Amazing, huh?]



If you are an incurable experimenter who enjoys building hybrid musical instruments, this graph alone will be worth the price of the manual. It should help you figure out the acceptable tuning range of, say, a home-made hammered dulcimer, or help you decide what kind of strings to get for an antique zither. You either have to know the vibrating lengths to see what notes they could be safely tuned to, or you need to know the tuning range you want in order to see what vibrating lengths will work for that range. But whatever you do, remember the Golden Rule: Don’t go above the 70 percent line [with your string lengths]!