

# FREE STRING ANALYSIS SPREADSHEET

## WORD OF THANKS

This free string analysis spreadsheet is available only because of the tireless work of a retired chemical engineer by the name of Walter Cowart, from North Carolina. He spent over six months poring over the technical articles in back issues of the Folk Harp Journal, placing the calculations into a Microsoft Excel spreadsheet, and trying to make it user friendly. He's likely to make more improvements/updates as time goes on, but we think it is already very helpful to anyone designing or refining a lever harp. You may even find it useful for analyzing the string tension on a guitar, psaltery, or other stringed instrument.



Walter Cowart

## INSTRUCTIONS FOR USING HARP STRING ANALYSIS SPREADSHEET

1. You will need a "string chart" to work from. This can be supplied by your harp-maker, or it can be created by taking measurements off your harp, or it can be invented by you as a possibility to check on the computer as you go through the design phase of harp-making. All you need is a hand-written sheet of data – nothing fancy. Here is the data you should have on your chart or list:
  - a) The note of each string\*
  - b) The vibrating length of each string, in inches\*\*
  - c) The diameter of each string\*\*\*
  - d) The composition of each wound string (Nylon, Steel, Bronze, Gut, Carbon, etc)
2. Enter your information into the proper column of the Excel Spreadsheet, as follows:
  - a) **Columns A & B (Rows 2 & 3)** is for the name of your instrument, and short description. Only the first 30 characters per line will show on your printout.
  - b) **Column C** (first blank column) is for the vibrating length. Be sure to match your data with the proper note shown in Column A. For example, if the highest note on your harp is G6, leave the rows above that note blank and enter your shortest vibrating length in the G6 row.
  - c) **Column D** is for the string diameter in inches. If you have wound strings on your harp, use this column for the core diameter only - you'll find other columns for the bedding and wrap. If your wound strings have a fiber core, however, leave this column blank for those strings and enter the number of fibers in Column G.
  - d) **Column E** is only used for strings measured in millimeters.
  - e) **Column F** is for naming the string material. This is case sensitive, so please type in the name from the list at the top, just as it is shown.
  - f) **Column G** is only used if your core material is multi-stranded, such as a fiber-core string.
  - g) **Column H** is only used for wound strings where there is fiber bedding between the core and wrap.
  - h) **Column I** is only used for wrapped strings. Enter the name of the wrap material from the list at the top of the column.
  - i) **Column J** is only used for wrapped strings. Enter the diameter of the wrap material, in inches.

3. As you enter all the information about each string, you should see some calculations appear in Columns K, L, M & N. Some of this data will be transferred to charts so you can see graphically how your strings compare with one another through the range of the harp. You'll want to pay particular attention to Columns M and N and Row #43 for analyzing your string set.

- a) **Column M** shows how close to the breaking point each string is. This is a mathematical calculation based on pitch, mass, and string length, and it is displayed as a percentage of the theoretical breaking point. You'll want to be careful not to exceed about 70 or 75 percent for any string in this column. We've included information in the Troubleshooting Addendum on how to correct the situation if you have strings that exceed this ceiling.
- b) **Column N** is a ratio of the tension and the string length. This calculation helps you tell how stiff or limp each string will be. Again, you can consult the Troubleshooting Addendum for assistance on interpreting and manipulating this aspect of your string set.
- c) Finally, **Row #43** displays the total tension of the entire set of strings on your harp. This figure will impress your friends. It can also serve to awaken your appreciation of how strong the harp frame needs to be to withstand so much tension! Consult the Addendum to learn how to raise or lower this number by manipulating the string diameters and pitches.
  - This program uses standard mathematical designations for string notes: C4 is Middle C, so C5 is an octave above, and C3 is an octave below Middle C. Look at Column A for the full range of notes available on this spreadsheet. The frequency is also listed (Column B) for further clarification.

**SHARPS & FLATS:** If you need a sharp or flat note, type in the frequency of the natural note into the bottom box of Column A and hit "enter". The flat and sharp frequencies of that note will appear to the right. You can type one of those new frequencies in place of the natural note in Column B where you want it.

\*\* The vibrating length is the span between the soundboard and the first stop pin (guide pin or bridge pin) on the harp. In other words, it is the length of the portion of string that vibrates when you pluck it.

\*\*\* You'll need to use a micrometer to measure the thickness of each string. Micrometers measure thousandths of an inch (three decimal points), so .025" is twenty-five thousandths of an inch. Most hardware stores now offer micrometers for around \$20.00.

## QUESTIONS?

Please direct your questions to Jerry Brown (treehouse@musik.it.com). He will do his best to help you. He may also contact the programmer, Walter Cowart, for additional help if necessary.

## TROUBLESHOOTING ADDENDUM

### COLUMN M: Tensile Strength

If you have strings that exceed the 70-75 percent threshold of Tensile Strength, you will encounter string breakage problems. A common misconception is that you can use thicker strings to relieve the situation because they are stronger, but thicker strings require more tension to tune up to the same pitch, and they will have the same TS Ratio – no help. Going to a thinner string will give you the same results because, even though it takes less tension to get them up to pitch, they are inherently weaker, so they break at the same point.

The only ways to solve the Tensile Strength problem is to either tune the strings to lower pitches, or to re-design the harp to shorten the vibrating lengths in the affected area (usually by deepening the curve of the neck). If the harp is already built, the first option is your only possibility. This will give the entire harp a lower range of notes, and it will prevent string breakage problems.

### COLUMN N: Tension/Length Ratio

Most harp makers only worry about strings that go below the value of 1 on the T/L scale. They are “longer” in inches than they are “tight” in pounds. Seems like a funny thing to worry about, but what happens is that strings with a very low T/L will be too flabby to sound good. Harpists will object to the low tension of those strings. There are several ways to raise the T/L of a string:

- a) Tune the harp higher. Be careful though. Tuning all the strings higher will affect the Tensile Strength Ratio (Column M) too. You dare not exceed 70 -75 percent of the mathematical breaking point of any string on your harp.
- b) Use a thicker string. This will increase the tension of the one string without risking string breakage elsewhere on the harp. You might try using gut in place of nylon in the baritone or bass ranges. Gut strings are often thicker than nylon strings, and they add a rich mellow sound to the lower notes.
- c) Change from a monofilament string to a wound string. You can experiment on the spreadsheet with different compositions (core and wrap material) to see how they affect the string tension and the T/L ratio. We find that we get “the most bang for the buck” using steel for the core material. Steel-core strings add significant stiffness and dramatic volume to the bass range of a harp. The challenge is to add enough bedding between the core and wrap to diminish the metallic quality of the sound.

### ROW #43: Overall String Tension

The overall tension will give you an idea of whether you have a harp with low, medium, or high string tension. Pedal harpists are accustomed to high-tension harps, but most lever harpists enjoy the medium or low tension harps because they are easier to play and more responsive to the touch.

There is no official definition of high, medium, or low tension harps in the industry, but it might help you see these comparisons:

Harps considered to be High Tension	
Lyon & Healy Troubadour Harp	approx 2,000 pounds
Harps considered to be Medium Tension	
Dusty Strings 36	approx 1,200 pounds
Musicmakers Gothic -36	approx 1,300 pounds
Harps considered to be Low Tension	
Musicmakers Gothic-31 with standard nylon strings	approx 600 pounds