Neck Geometry Calculator Documentation

I intended the “Neck Geometry” Excel workbook to be used to calculate aspects of the neck geometry of archtop mandolins. Items that can be calculated are: neck angle (θ), bridge saddle height above the center of the top (*j*), the height of the neck surface (without fretboard attached) above the headblock (*d*), and the height above the top at which a line extended from the neck surface intersects the bridge (*b*). The latter is a useful indicator when fitting the neck joint to ensure the proper bridge height. Optional calculations include string break angle at the bridge, total string tension (T), and downward force on the bridge (C). Although I designed this for mandolins, it presumably would work well for other instruments. I believe the results to be quite accurate, but I cannot guarantee them and I urge you to double-check that they are reasonable if you use this as a building reference.

Length output units are the same as the input units, so calculations can be done in, for example, either mm or decimal inches, but you cannot mix units during a single calculation. Angle input and output units are always degrees.

The calculations use a horizontal line as a reference for angles and vertical heights. The top of the rim/endblock assembly works well for this.

I welcome anyone to use this, and please feel free to make improvements. I’d get some self-gratification if you send me an email telling me how you are using it, point out mistakes, or ask me questions. I started designing this for my own use, so I apologize that the workflow in the “calculations” worksheet is unorderly and perhaps unintelligible. I may try to clean it up a bit and add documentation at some point.

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Conditional input variables:

These three variables can each be calculated individually provided the other two are known. It is necessary to input exactly two of these variables.

<u>Neck angle (θ):</u> Angle in degrees from the horizontal reference. Must be between 0 and 90.
<u>Bridge height (*j*):</u> Height of the center of the bridge saddle above the top.
<u>Neck surface height at attachment fret (*d*):</u> The height of the neck surface (without fretboard) above the horizontal reference line at the fret where the neck is attached to the body (the fret number is inputted below). This value is also known as “overstand”.

Required input variables:

These variables must all be inputted in order to find the solution.

Scale length (*s*): The theoretical scale length. Compensation is not accounted for.

Top arch height above horizontal reference (*a*): Height of the center of the top above the horizontal reference line, e.g. the rim assembly. This can be measured after the instrument is assembled using a contour gauge.

Fretboard thickness (*k*): If the fretboard is radiused, I would recommend using the center (greatest) thickness. Alternately, you could run the calculation multiple times for different parts of the fretboard.

Fret height (*f*)

Fret number at action measurement: The fret number where you will measure the string action. *Note:* fret distances are calculated internally using the rule of 18ths method, with a scale factor of 17.817. This is the most common modern fret calculation method.

Fret number at neck/body joint: The fret number where the neck joins the body (typically the 15^{th} fret for F5 mandolins).

Desired Action (*v*): The action at the fret number defined above. *Note:* if you desire different actions for bass and treble strings, you can run separate calculations to get the correct saddle height for each string.

Optional input variables:

These need to be entered only if you wish to calculate total string break angle at the bridge, total string tension, and downward force on the bridge.

Horizontal distance from bridge back to the intersection of the extended string plane with the horizontal reference line (B): This is used to calculate the string angle on the tailpiece side of the bridge.

String type: Select the string type from the dropdown menu. It is assumed that you are using standard tuning for the instrument you select, and that it is a four-course instrument with two strings per course.

New In Version 3: You now have the option of entering custom string gauges for four-course instruments. If you enter a gauge for any string, you must enter ones for all four strings. You must also indicate whether the string is wound or unwound. A popup box will give you additional guidelines for the possible range of values for both wound and unwound strings. The unit weight information for custom string gauges is taken from *The Bouzouki Book*, by Graham McDonald. Graham obtained these weights by empirical measurement.

Results:

Whichever conditional input variable you left blank is calculated. The other conditional variables listed in the results are simply your inputs. The value for *b* is calculated from the other results. Error messages will be shown if you have too many or too few input variables.

Unit Calculator:

Simply converts between millimeters and inches.

Formulas:

The formulas below are those used to define the relationships between all variables. The identities of the intermediate variables (those not described above) are shown on the diagram. The fret numbers are not shown in the formulas, but are used internally to calculate () and (). I made a minor simplification in the math that introduces a very small amount of error, which I believe to be less than ~0.003 length units in the normal working range.

Most calculations are done in a hidden worksheet page called “calculations”. To unhide this sheet, go to Format > Sheet > Unhide. The “results” worksheet is locked to prevent inadvertently changing cell contents, but to be able to edit it and see formulas, go to Tools > Protection > Unprotect Sheet.

$$o = \phi + \theta$$

$$\sin\theta = \frac{b+a-d}{r}$$

$$\tan\theta = \frac{b+a-d}{e}$$

$$\sin\phi = \frac{g}{s}$$

$$\sin\phi = \frac{v}{u}$$

$$\sin\phi = \frac{w}{t}$$

$$\frac{g}{s} = \frac{v}{u} = \frac{w}{t}$$

$$\cos\theta = \frac{f}{h}$$

$$\cos o = \frac{g}{i}$$

$$\cos o = \frac{w}{x}$$

$$j = c + b$$

$$q = s - t$$

$$z = i - x$$

$$z^2 = r^2 + q^2 - 2rq(\cos\phi)$$

$$T = \frac{UW \times (2SF)^2}{386.4}$$

$$\tan \mathrm{A} = \frac{a + j}{\mathrm{B}}$$

$$C = T \times (\sin \frac{\phi + \theta}{2})$$

$F =$ frequency in Hz

$UW =$ Unit Weight of string

Neck geometry sketch

(exaggerated for clarity)