Stick Bow Design Program
User Instructions

Version 6.2

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November 30, 2006

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Introduction

I wrote this program over the last couple of years for two reasons. First, was to better understand the design and physics behind the simple stick bow. Second, was to pick up a new skill in Visual Basic programming.

Regarding design, the simple stick bow is a classic case of easy to learn but difficult to master! Like any simple machine, there are limitations that the bowyer must learn to cope with. Some of these limitations cannot be overcome, but there are techniques to minimize them to design the most efficient bow possible. There are many subtleties in bow design that can be difficult to visualize or difficult to measure with any great consistency. My goal with this program was to create a tool that can be used to quickly design and analyze, modify, and compare designs in order to speed up the development process and cut out some of the tedious trial and error.

Finally, there is no good reason to keep this program to myself. Bow building for me is something that I enjoy as a hobby and not a job, so I share it with the rest of the community in the hope that you will get some use out of it as well. I only ask a few things in return:

1) Let me know if you are aware of some design elements that are critical to bow design that this program is not taking into account.
2) Provide feedback on how the real bow behaves compared to the virtual bow. I would like to build upon comparisons to real data in order to continuously improve this tool.
3) Let me know if you find any bugs or unexplained error.
4) Let me know if there are any features that you would like to see added in the future.
5) If you come up with a cool new design, BUILD it and I would love to hear about it.

Best Regards, Alan Case

Before Starting

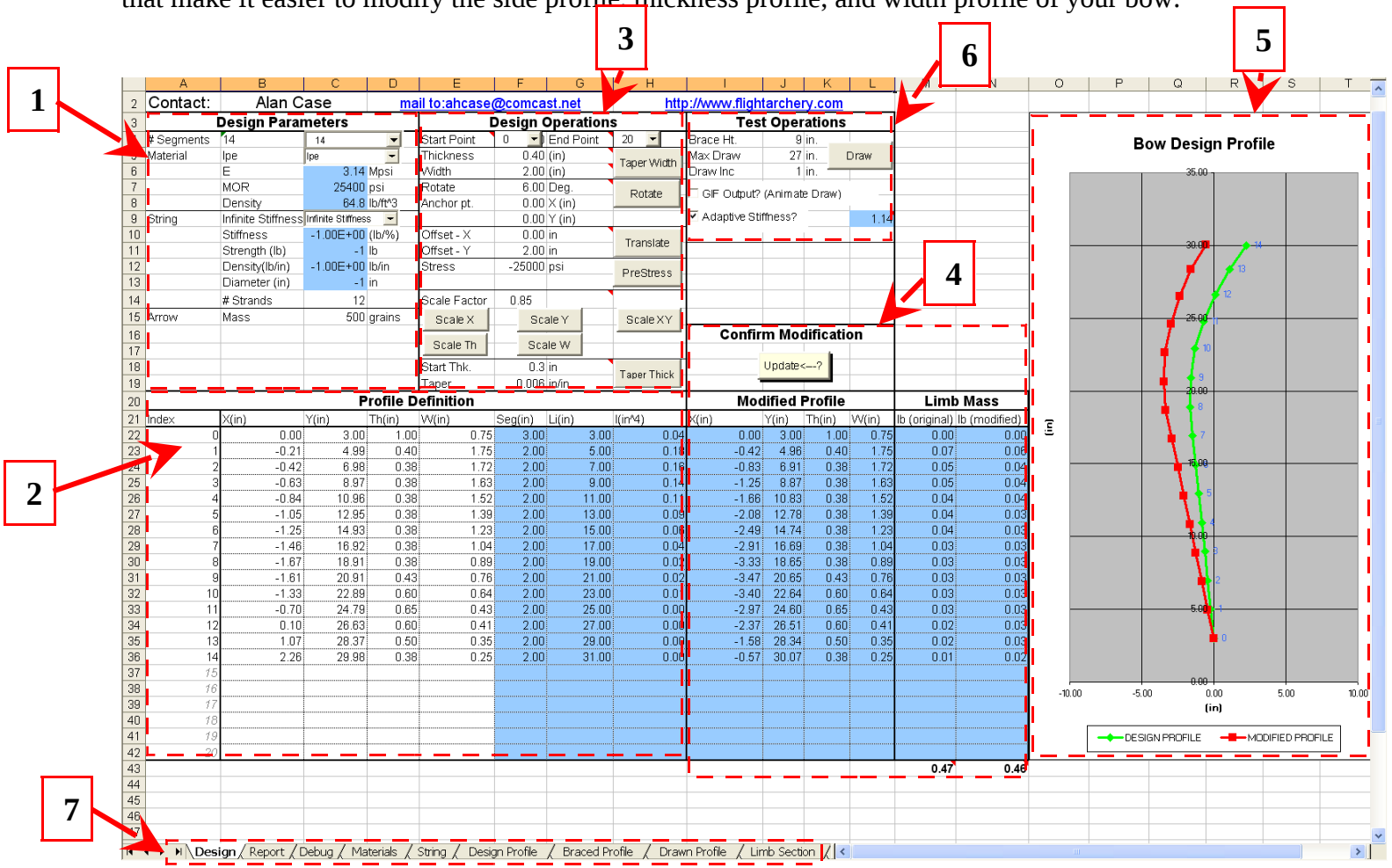
This program uses is written in Visual Basic and requires uses MicroSoft Excel as the user interface. When starting up this program, you will need to make sure to set a couple of options first to enable the program to run.

1) In Excel, go to the Tools->Macro->Security option. In the Macros Security window, you will need to make sure that the "Medium" or "Low" option is checked.
2) If you check "Medium", Excel will prompt you give you a warning that the worksheet contains macros. Be sure to click on the "Enable Macros" button. Otherwise, the program will not run.

Figure 1 Security Warning

Opening Screen (Design Tab)

The design tab is where all the input parameters are entered to describe the design of your bow. There are also a number of functions that make it easier to modify the side profile, thickness profile, and width profile of your bow.



1) Design Parameters

The Design parameters are where you describe the basic design elements of your bow.

Design Parameters			
# Segments	14	14	
Material	Ipe	Ipe	
	E	3.14	Mpsi
	MOR	25400	psi
	Density	64.8	lb/ft^3
String	Infinite Stiffness	Infinite Stiffness	
	Stiffness	-1.00E+00	(lb/%)
	Strength (lb)	-1	lb
	Density(lb/in)	-1.00E+00	lb/in
	Diameter (in)	-1	in
	# Strands	12	
Arrow	Mass	500	grains

Of Segments

The way this program works is it breaks down a complex bow design into a number of straight beam segments that are joined together. Fewer segments allow you to approximate the shape of complex curves more accurately. More segments also give better resolution on string contact and stresses along the limb. In most cases, I prefer to use no more than 12 segments. Any more, and the model gets too complicated to modify easily. Sometimes, I will start off with a very simple model with only three or four segments to rapidly compare a number of design changes then switch to a more detailed model later.

Material

Use the drop down box to select a material. This program only allows a single material for the entire bow. Often, this is more than adequate when comparing one design against another because the material choice (or composite of materials) only affects the stiffness of the bow. A bow designed in this program will never actually break. You will need to determine if it did break by looking at the stresses in the **Report Tab** after running the program.

String

This allows selection of the string material and number of strands to use. There is limited string data in this program that you can use if you are interested in how much the string length changes while the bow is drawn. Most of the time, I select the "Infinite Stiffness" string material because the string material has a very minor role in the force draw curve and limb stresses. The "Infinite Stiffness" string also simplifies the calculation that this program must undergo, so be sure to use this option if the program is having difficulty finding a solution.

Arrow

The only parameter used here is arrow mass. The program does not do much with this other than output a comparison of arrow mass Vs. limb mass as the bow is drawn. Perhaps this program will actually allow the virtual bow to be fired at a later date.

2) Profile Definition

This is where you define how your bow will look from the side profile. Be sure to supply X and Y values for each segment defined in the # Segments entry. The X values are the horizontal measurements at each point, and the Y values are the vertical measurements. You can supply the thickness and width for each point or use the Taper Width operation to generate default values for these.

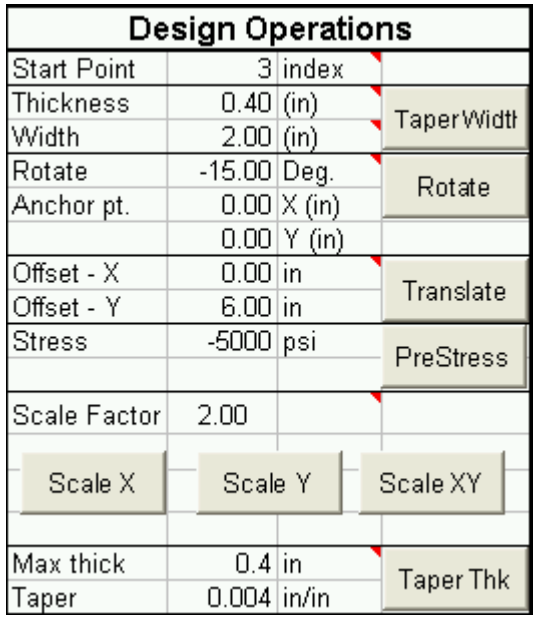
The Seg, Li, and I values are calculated automatically. Seg shows the length of each segment. Li shows the cumulative length measured along the bow limb, and I displays the area moment of inertia at each point along the limb.

Profile Definition

Index	X(in)	Y(in)	Th(in)	W(in)	Seg(in)	Li(in)	I(in^4)
0	0.00	0.00	2.00	2.00	0.00	0.00	1.33
1	0.00	2.75	2.00	2.00	2.75	2.75	1.33
2	0.00	5.50	2.00	2.00	2.75	5.50	1.33
3	0.00	8.25	0.20	2.00	2.75	8.25	0.13
4	0.00	11.00	0.20	2.00	2.75	11.00	0.13
5	0.00	13.75	0.20	2.00	2.75	13.75	0.13
6	0.00	16.50	0.20	2.00	2.75	16.50	0.13
7	0.00	19.25	0.20	2.00	2.75	19.25	0.13
8	0.00	22.00	0.20	2.00	2.75	22.00	0.13
9	0.00	24.75	0.20	2.00	2.75	24.75	0.13
10	0.00	27.50	0.20	2.00	2.75	27.50	0.13
11	0.00	30.25	0.20	2.00	2.75	30.25	0.13
12	0.00	33.00	0.20	2.00	2.75	33.00	0.13
13							
14							
15							
16							
17							
18							
19							
20							

3) Design Operations

Think of the Design Operations section as a basic computer aided design program just for designing stick bows. This section makes it easy to rapidly modify and fine tune your design. After using one of these operations, the result is displayed in the **Modified Profile** section.



Start Point

The start point tells the program where you want the modification to start at. The index number corresponds to the index number at the profile definition. Be sure to check where you have this number set before performing any of the modification operations. Also, make sure that it is not set to a higher number than your total number of segments.

Taper Width

This feature will take the definition of your profile and starting with the **Start Point**, taper the width of the bow from the width specified to a tip width that is no less than the thickness specified. It will also apply a single thickness to the bow limb. In short, this feature rapidly generates a pyramid tiller for you.

Rotate

Use this feature to rotate entire limb past the **Start Point**. I use this feature to create a sudden bend in the limb. If you supply a positive number of degrees of rotation, the limb will be bent in deflex. Positive number bends the limb in reflex.

Translate

Translate offsets all points on the limb, including the **Start Point** from it's original position.

+ Y value moves the limb upwards.
- Y value moves the limb downwards.
+ X value moves the limb forwards (in same direction as the arrow travels).
- X value moves the limb backwards.

Pre-stress

The Pre-stress option induces a stress in the limb beginning with the **Start Point**. The result is that the bow limb will curl or uncurl depending on the original profile shape and the pre-stress value supplied. A positive pre-stress value will curl the limb in deflex. A negative value will curl the limb in reflex. Remember, the amount the limb bends is dependent on the thickness at each point along the bow limb. Areas of higher thickness will bend less than areas of lower thickness.

ScaleX, ScaleY, ScaleXY

These options are used to stretch or shrink the bow limb profile. In all cases, the **Start Point** is used to determine where the stretching or shrinking is to begin. A number entered that is greater than one will stretch the limb. A number that is less than one will shrink the limb.

ScaleX – Only stretches or shrinks the limb in the horizontal direction.
ScaleY – Only stretches or shrinks the limb in the vertical direction.
ScaleXY – Stretches or shrinks the limb in both directions.

Taper Thickness

This option tapers the thickness beginning with the maximum thickness value at the **Start point**. It then uses the taper value to calculate the taper the limb along its length to the tip. This option also modifies the width along the profile to keep the stresses as close to the original design as possible.

4) Modified profile

This area displays the modified profile each time one of the **Design Operations** is used. The Limb Mass section provides a before and after snapshot of the mass of the limb before and after the modification. If you want to keep the modification, press the "Update?" button.

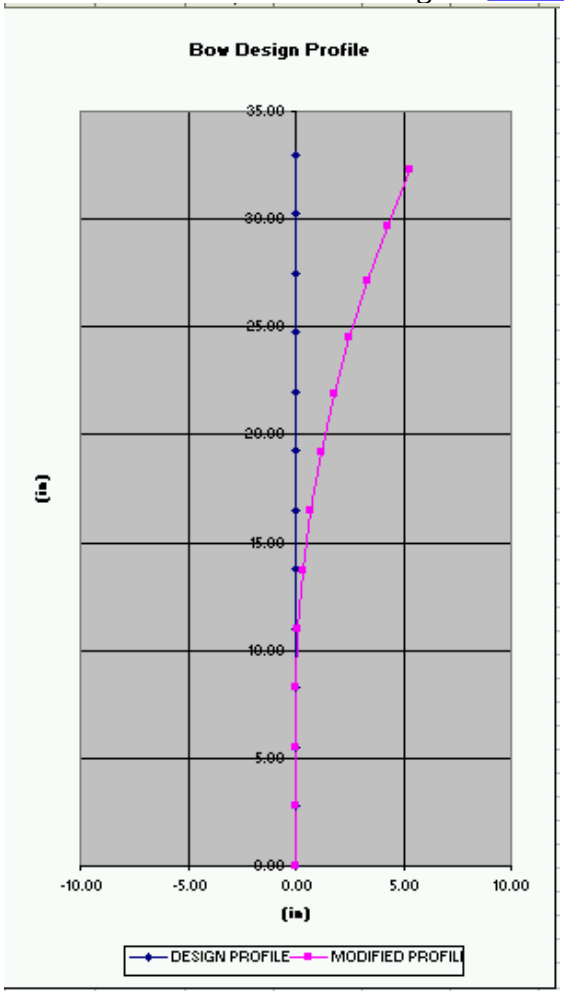
Confirm Modification

Update<---?

Modified Profile				Limb Mass	
X(in)	Y(in)	Th(in)	W(in)	lb (original)	lb (modified)
0.00	0.00	2.00	2.00	0.00	0.00
0.00	2.75	2.00	2.00	0.41	0.29
0.00	5.50	2.00	2.00	0.41	0.29
0.00	8.25	0.20	2.00	0.23	0.16
0.12	11.00	0.20	2.00	0.04	0.03
0.36	13.74	0.20	2.00	0.04	0.03
0.72	16.46	0.20	2.00	0.04	0.03
1.20	19.17	0.20	2.00	0.04	0.03
1.80	21.86	0.20	2.00	0.04	0.03
2.51	24.51	0.20	2.00	0.04	0.03
3.34	27.13	0.20	2.00	0.04	0.03
4.29	29.72	0.20	2.00	0.04	0.03
5.34	32.25	0.20	2.00	0.04	0.03
				1.42	**1.01**

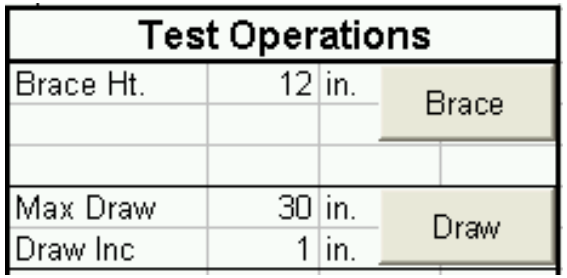
5) Profile plot

This plot shows the profile of the bow limb before and after modification using the **Prestress** operation.



6) Test Operations

Once the bow profile and design parameters have been defined, it is time to test it and see how it performs.



Brace

This option only braces the bow and displays the results on the **Report** tab. Note that the brace height value supplied here is measured from the back of the bow.

Draw

This option first braces the bow then draws the bow to the maximum draw value supplied. It uses the "Draw Inc" as the increment to output the forces and stresses on the **Report** tab as the bow is drawn.

7) Navigation

Be sure to note the tabs along the bottom of the spreadsheet. To switch your view from the Design to the Report worksheet, simply click on the appropriate tab.

Report Tab

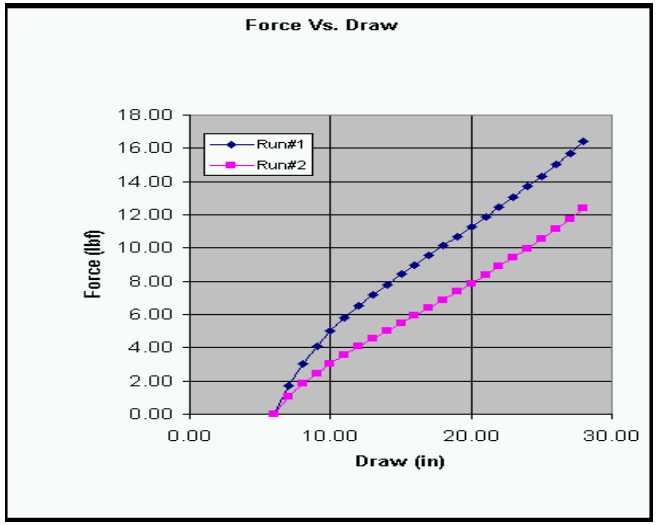
The Report Tab is where all the analysis results of your bow profile are displayed. There is a large amount of information displayed here that can provide a great deal of insight into several key characteristics of your design. The layout is broken into two major sections. The top section contains a report on the current design. The bottom section contains the saved output from a previous design. This allows you to rapidly compare the effects of making subtle design changes.

There's lots of data output on this tab. I'll take you through a few of the highlights as follows:

1) Force Draw Output

The upper left area of the report tab lists the force draw data from your virtual bow. The draw position is measured from the back of the bow and it outputs one measurement for each draw increment until it reaches the Maximum Draw supplied in the Design tab. In addition to the draw force, this table supplies the tension on the string and cumulative energy storage. The program also creates plots for this same data. If you saved a previous run, then the plot will show the current run against the previous run which makes for a quick visual comparison.

Draw Increment	Draw Position (in)	Draw Force (lb)	String Tension (lb)	Energy Stored (ft-lb)
0	6.00	0.00	68.06	0.00
1	7.00	1.70	61.88	0.07
2	8.00	3.03	56.99	0.27
3	9.00	4.11	53.10	0.57
4	10.00	5.02	49.97	0.95
5	11.00	5.82	47.44	1.40
6	12.00	6.53	45.37	1.91
7	13.00	7.19	43.67	2.49
…	…	…	…	…
…	…	…	…	…
22	28.00	16.43	37.10	17.05



2) Profile at Brace

This table lists the braced profile. In addition it displays a number of statistics from the braced bow. There are two string lengths given. The first length is for the non-stretched string. The second string length value shows what the stretched string length value is. These two values **should** be identical if the Infinite Stiffness string was chosen and the simulation ran properly. The **Bending Stress** column displays the bending stresses at each point along the profile. Use this as a guide to judge where you may want to add width or change the thickness of your limb design.

The **Copy Run** button saves all the values of the current run to a lower location on the report worksheet. This allows you to go back to the Design Worksheet, make some changes, and run again without losing the results of the first run.

Copy Run

Profile At Brace

String Length	32.17	32.17		
Draw Load	0.00			
Draw Length	6.00			
String Tension	68.06			

Index	X	Y	SX	SY	Bending Stress
0	0.00	0.00	-6.00	0.00	7912.30
1	-0.04	2.75	-6.00	2.68	8577.00
2	-0.13	5.50	-6.00	5.36	9301.18
3	-0.27	8.24	-6.00	8.04	10088.20
4	-0.48	10.99	-6.00	10.72	10941.29
5	-0.78	13.72	-6.00	13.40	11863.14
6	-1.16	16.44	-6.00	16.08	12855.11
7	-1.66	19.15	-6.00	18.76	13915.35
8	-2.27	21.83	-6.00	21.44	15033.36
9	-3.03	24.47	-6.00	24.13	16171.81
10	-3.94	27.07	-6.00	26.81	14424.41
11	-4.95	29.62	-6.00	29.49	7955.58

12	-6.00	32.17	-6.00	32.17	0.00

3) Profile at Full Draw

This table is similar to the profile at braced table except that this shows the point locations of the limb when at full draw. In addition, there are a number of new useful statistics. The **SE/PDF** value (unlabeled) is a common test measurement that takes the total stored energy and divides it by the draw weight. The **FD Shape Factor** compares the force draw curve of this run to the ideal maximum force draw curve. A value of 1.0 would require a force draw curve that is shaped like a rectangle and signifies perfect energy storage. A value of 0.5 implies a force draw curve that looks more like a triangle. Less than 0.5 indicates that your bow is stacking. A **FD Shape Factor** greater than 0.5 indicates that the bow has a very fat FD curve.

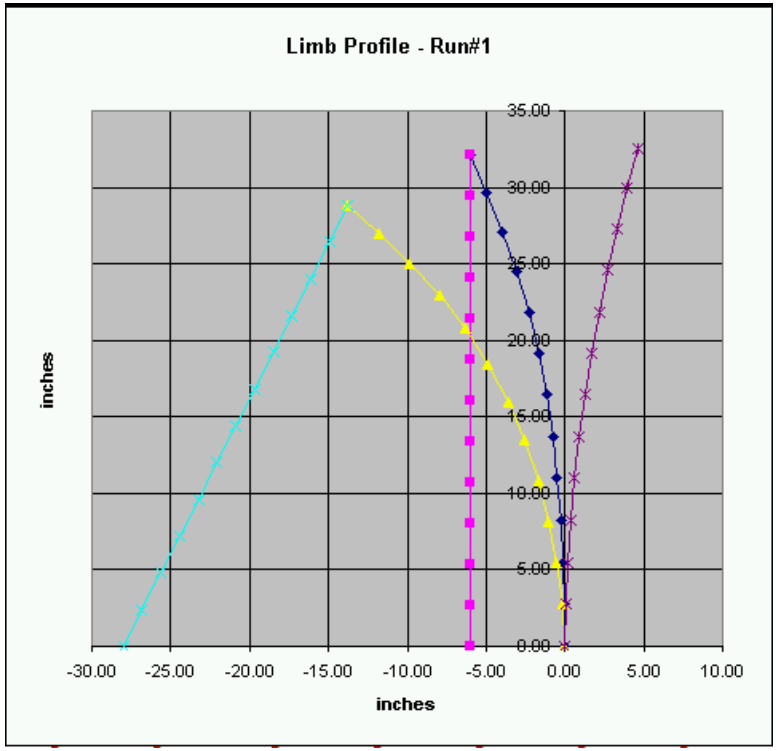
SE/PDF

Profile At Full Draw	1.04	**FD Shape Factor**	0.57	**String Length**	32.17
Draw Load	-16.4				
Draw Length	28.0				
String Tension	37.10				

Index	**X**	**Y**	**SX**	**SY**	**Bending Stress**
0	0.00	0.00	-28.00	0.00	17605.31
1	-0.16	2.75	-26.81	2.40	18173.87
2	-0.49	5.48	-25.63	4.81	18735.69
3	-0.99	8.18	-24.44	7.21	19287.67
4	-1.68	10.84	-23.25	9.61	19826.61
5	-2.55	13.45	-22.07	12.02	20349.24
6	-3.62	15.99	-20.88	14.42	20852.46
7	-4.87	18.43	-19.69	16.83	21333.61
8	-6.32	20.77	-18.51	19.23	21791.27
9	-7.97	22.97	-17.32	21.63	22227.28
10	-9.81	25.02	-16.13	24.04	18909.00
11	-11.76	26.95	-14.95	26.44	9833.14
12	-13.76	28.84	-13.76	28.84	0.00

4) Limb Profile Plot

This graph shows the unbraced, braced, and full draw profile of your bow. If the plot looks out of proportion, it might be caused when Excels resized the plot window to fit all the geometry. If this happened, simply resize the chart so that the gridlines appear as squares instead of rectangular.



5) Other Data

There is an enormous amount of additional plots and statistics generated on the Report Tab. Much of it is self explanatory, but do not hesitate to contact me if you would like to know more about this.