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Applied Mathematical Models

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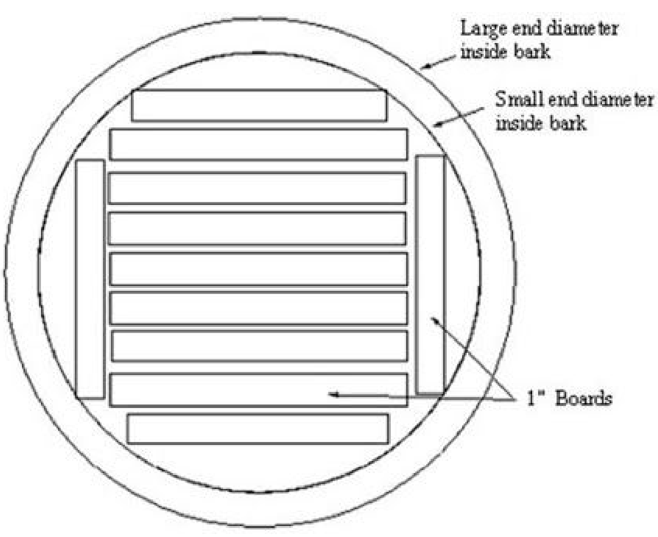
Dave's Stick

Who knew that such a simple object could be turned into an investigation and solved using mathematical models. When presented with 'Dave's Stick' I was initially confused. Obviously, like most I went straight to the numbers on the different faces. We noticed that the numbers were different scales based upon which scale you would get a different value. On the widest faces, or front and back, they had tick marks representing each inch from 1 all the way up to 30. Each inch and half inch were accompanied by two other non equal values. These values seemed to have been worn away as the years progressed and sowed the true use and age of the stick. Now the non-equal values that accompanied each inch were used to different scales. So on the 'front' side of the stick we would have scales of 10 and 12 and on the other side, 'back', we would have 8 and 14. These had different sets of values that corresponded directly with each inch.

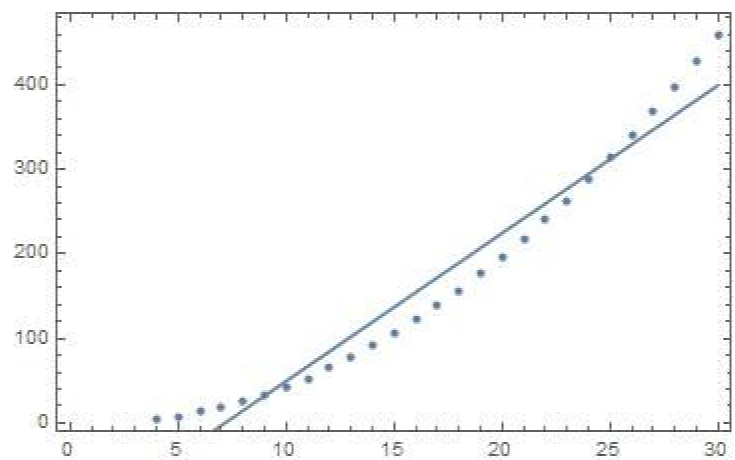
Now when looking at the physical structure of the stick. The 'bottom' of the stick had a metal fitting with a small plate attached to the fitting. Almost seemed to be a guard between the wooden stick and the ground. The top of the stick flared out and bowed slightly. This was a structural design and not simply caused by old age. There was also a company name that was faintly apparent on the flared out section of the stick with the company location as well.

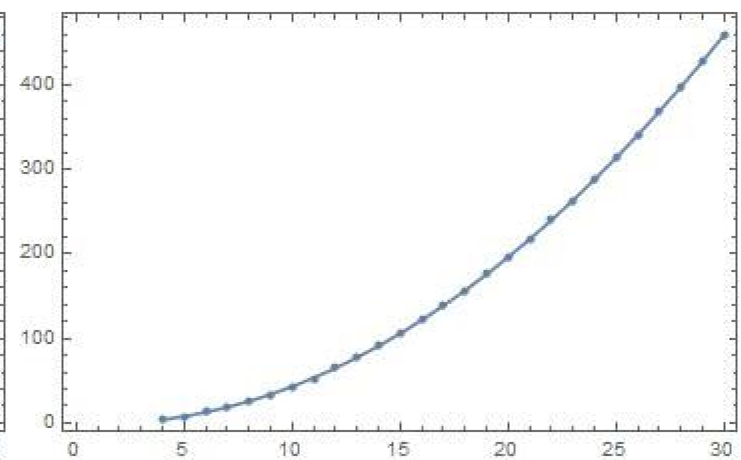
After doing some preliminary research we found that the company was located in Ontario, Canada. This company seemed to be in the logging and lumber business. At first we were confused how a stick shaped similar to that of a meter stick would be beneficial to a lumber company who deal with much more than a few meters of wood daily if not hourly. Since the company was in the logging company we furthered our search into that field hoping to find a lead. Luckily we did. We saw that years ago and still in some businesses today, this stick is used in the logging process. We watched several youtube videos of old woodsmen with beards down to their waist explain how to use the stick if you were in the logging business. Basically the procedure to correctly use the stick is to put the metal fitting side of the stick on the ground and measure roughly anywhere from four and a half feet to eye level up the trunk of the tree. Once you find that point will turn the stick perpendicular to



the tree and align the metal fitting with the left hand side of the trunk. Now obviously the stick is flat and the trunk of the tree is round so the only place in which the stick can touch the trunk is in the center of the trunk. When you have the left sides lined up you then move your focus to the right side of the stick. Gazing at
the trunk and the increments on the stick it will present you with a value. Now, backtracking to earlier where we mentioned that apart from the inch markings there were corresponding scales of 8, 10, 12, 14. We believe this to be the length of the board (in feet) you are expecting to cut from the tree. Now that you have a value that is the amount of board feet you can 'harvest' from the tree. This tool essentially allows logging companies to estimate the amount of wood they can produce from a tree before they cut it.

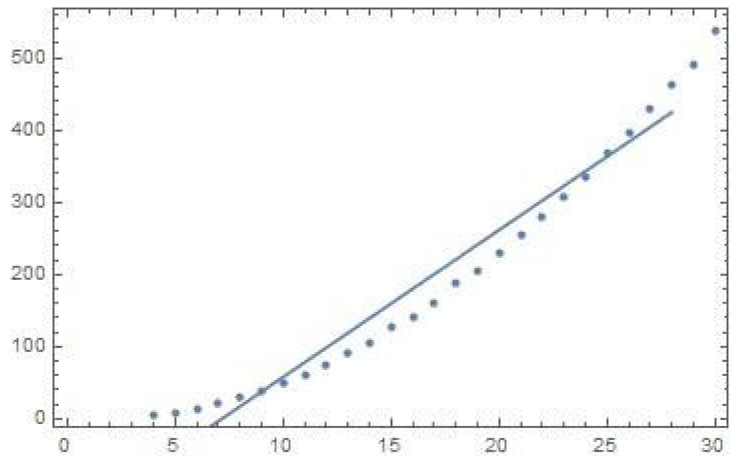
After initial observation and a brief internet search we moved onto the actual values on the stick. Many values were unreadable because they wore away over time and use. However, the '14' and '12' scales were 100% distinguishable. After recording those values in excel I inputted the values in mathematica in order to plot the data points. Staring with the '12' scale we were able to plot the points and fit a linear line to the data. Noticing that the residuals had a pattern and the best fit line did not follow the points well and the data points seemed less linear we transformed the best fit line. Instead we chose to use the x^2 transformation or the quadratic transformation.

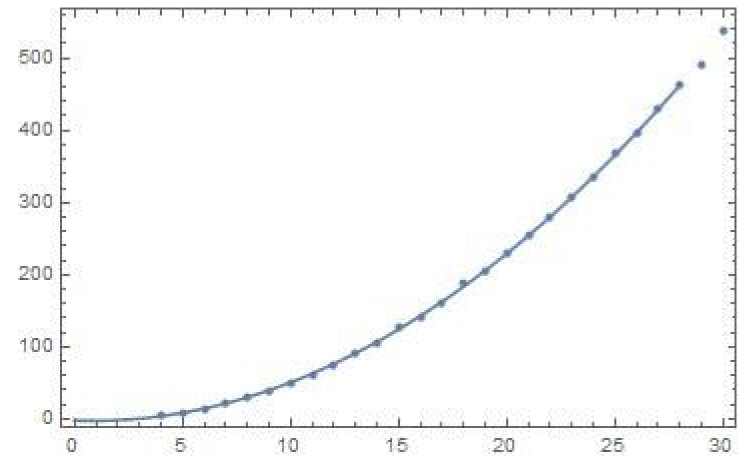




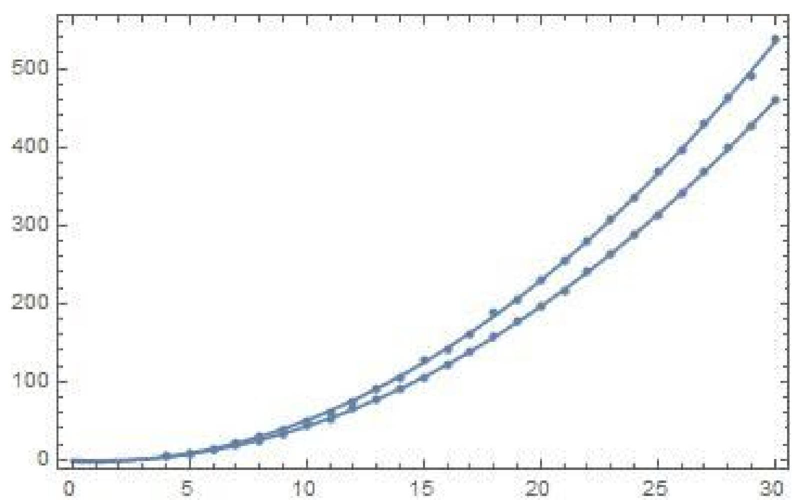
From the second graph that has a quadratic fitted line we notice it follows the data points almost exactly. This line has the equation 0.07700703-1.18074x+0.549505x^2. Using this equation for any 12 foot board you could accurately find the value of how many board feet the tree will produce.

The next problem we ran into was that the other scales had different values. For example, at the 17 inch mark, the 12 foot scale said that there would be 139 board feet but the 14 foot scale said there would be 162 board feet. Because there are two different values we noticed that there must be more than one graph and equation for each scale. So we had to record another scale's data values. The only other scale was the 14 foot scale so we recorded these. Once again we plotted the points with having the value from the scale on the y-axis, so in this case 162 and then the x-axis would have the equivalent inch value, in this case 17 etc.





After plotting the points and fitting the linear best fit line we again noticed that it seemed to portray a quadratic function so we needed to transform the graph using x^2 values now. This, as you can see is much more accurate and follows the points much more precisely. This equation for the quadratic was -2.02071-0.996657+0.628538x^2. The values are close in proximity but nonetheless different. We then decided to graph the plots on the same window to notice the difference. From the figure below we can see that the 14 foot scale creates a steeper slope as x becomes larger. I am positive that if we had access to the 10 and 8 foot scale that these too would be quadratically transformed and the 10 foot scale would be less steep than the 12 foot scale and the 8 foot scale would not be as steep as the 10 foot scale. All in all it is apparent that the values increase non linearly, and when transformed quadratically it seemed to fit the line almost perfectly.



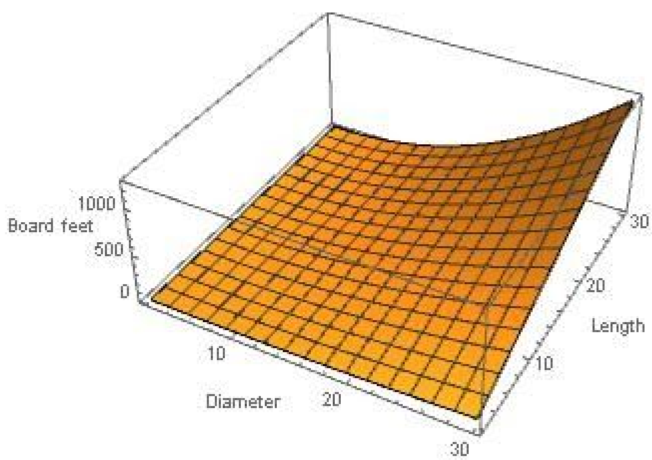
After these conclusions were drawn we did some more research on this ‘logging lumber stick’ aka Dave’s stick. We wanted to see if, like our Thomas and Thad problem, this dilemma had been solved previously. We found many youtube videos again on how to use the stick. At this point it is fair to say I have seen enough woodsmen with this stick and how to use it that minus the long beard and calloused hands I could be a logger. Nonetheless, we continued to search. We eventually came across Doyle’s Rule. It is the most widely used logging scale in the east and southern logging companies. Below is a picture of the Doyle’s Formula

$$\text{Board feet} = \left(\frac{D - 4}{4}\right)^2 \times L$$

Where D = diameter measured inside bark small end

L = length of log

From this equation we can see that this encampuses all of the four scales whether it be the 8, 10, 12, 14 foot board they are trying to cut. We were curious to see how the Doyle's formula compared to our findings of the graphs and also the values on the stick. Afterall if they matched we could attribute the values on the stick as a simple field instrument behind Doyle's equation. Don't want to reinvent the wheel if it is already working right?



So in order to check this we used the quadratic transformations and graph them against Doyle's equation. When doing a 3D plot in order to accurately look at the values we see that Doyle's equation came very close to the numbers on the stick. To the left is a plot of Doyle's equation. The Doyle rule gets us very close, but doesn't exactly match up with the markings. It looks like the lumber rule we have may be "underestimating" the amount board feet we could produce, maybe as a "safety measure." For example, the stick had a marking of 459 at the 30 inch place on the 12-foot side, where 12*((30-4)/4)^2=507

In conclusion, I believe we learned alot from this investigation. First off, sharpen and further our understanding of linear regression and transformations to best fit the data points we have in order to be able to recreate any value given the x value. Secondly, we learned that the internet is a very powerful tool. The quote goes, "work smarter not harder." This is a useful tip, especially when trying to do such a task as identify a stick presented to you for the first time. Do your research, and do not reinvent the wheel. Draw conclusions and prove why it works but make sure you use every tool available to solve the problem.

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