Oughtred on Gauging – 1633 AD

Editorial Notes on the Oughtred Text

The following excerpts are from Oughtred's book The New Artificial Gauging Line or Rod, *printed by Aug. Mathewes, London, 1633. The book is in the Bodleian Library, University of Oxford, England, which organization has kindly permitted us to reprint certain portions of it. The shelf mark there is Ashm.1065(19). It is a very rare and interesting book. The interest arises from the name of the author and the fact it describes in fair detail one of the very first applications of the slide rule to a real world problem.*

The book has only 40 text pages. This extract contains material from pages 17 through 32, and the greater part of page 37. Generally, the typography and spelling have been modified to conform to modern usage. Oughtred writes 0.1 *as* $0|\underline{1}$. *Keeping as close to this as was practical, the extract employs* $0|1$ *for this same purpose.*

Prior to reading the original Oughtred text, it might be beneficial to read the notes before the excerpts. There is some analysis of the accuracy of Oughtred's method after the excerpts.

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Notes on Oughtred and the Text

William Oughtred, according to Cajori[1], was born either in 1573, 1574 or 1575, and died in 1660. He graduated from Cambridge University, and his career was principally that of clergyman. He became the rector of Albury in 1610, which position he held for most of his life.

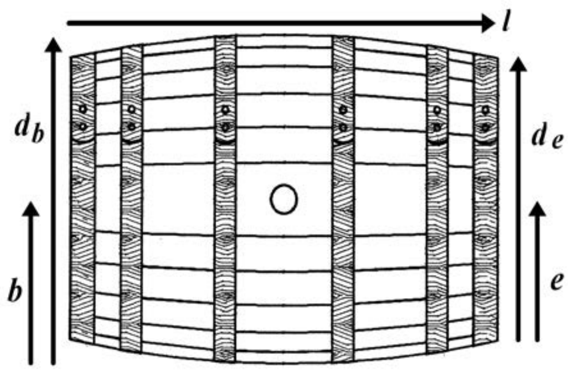
Mathematics was apparently an avocation with him, rather than being directly connected with his work. He wrote a number of books on slide rules, sun dials, and algebra. His book *Clavis mathematicae* ("The Key to Mathematics") was a standard text on algebra for many years. Recall that algebra was in a relatively primitive stage at that time, particularly in its notation. Again according to Cajori, $(A-E)^2$ would be written $Q : A-E :$, where the colons effectively take the place of parentheses, and Q means that the term that follows is a quadratic, i.e., squared. This works, but it is clumsy, and does not illuminate exponentials and logarithms.

Cajori (and others) credit Oughtred with inventing the linear and circular forms of the slide rule. Three of the circular slide rules designed by him are still in existence, and are the earliest surviving slide rules of any kind. The cover of Vol. 5, No. 1 of the *JOS* shows the one made by Elias Allen for Oughtred. It is in the Whipple Museum in Cambridge. See the article by Bruce Babcock in that same issue, and the article by Derek Slater in *JOS,* Vol. 6, No. 1.

It seems likely that the rule in the book under discussion was one of the first, if not the first, application of the principle of the slide rule to a technical problem, and was certainly one of the first made, and in quantity at that.

The Problem

The problem solved by Oughtred's rule is that of measuring the gallon content of a barrel. The barrel is lying on its side with the bung hole at the top, as shown in the adjoining figure. To solve this problem, he designed a combination linear rule and slide rule. It consists of two pieces of brass, each 32 inches long. When hooked together, they form a long rule used to take the three readings required by his process. When not hooked together, they may be placed side by side. In this configuration they form a slide rule, with one logarithmic scale on each of the two pieces of brass.



Top view of the barrel, bung in center. End diameter = d_e, end radius = e. Bung diameter = d_b, bung radius = b.

There are two quite different non-logarithmic scales used to take the barrel measurements. One is an ordinary scale of inches, and it is used to measure the *length of* the barrel. The other is a scale of "wine gallon inches" divided by three. It is used to measure the *diameters* of the barrel at the ends (assumed to be equal) and at the bung. This scale is non-linear, and reads directly in wine gallon inches. More appropriately, the scale might be called "gallons per inch". A length measurement in gallon inches is the number of gallons of liquid in a cylindrical vessel one inch deep and having the measured diameter. There are 231 cubic inches in a wine gallon[2]. For example, one wine gallon in inches corresponds to a diameter d as follows:

$$1 = \frac{\pi d^2}{4 \times 231}$$

so that $d = 17.15\ldots$ inches. Twice this diameter corresponds to four gallon inches, etc. Oughted's method employs the following formula:

$$\text{Gallons} = \frac{\text{length} \times (2 \times (\text{bung gallons}) + (\text{end gallons}))}{3}$$

That is, you measure the diameters at the end of the barrel and at the center (at the bung) in gallon inches, add them up as indicated and then multiply by the length in inches and you are done. **Note:** In order to avoid the division by three, the values on the scale designed by Oughtred are predivided by three. Thus, the formula employed in his text is:

$$\text{Gallons} = l \times ((\text{bung gallons})^* + (\text{bung gallons})^* + (\text{end gallons})^*)$$

where l is the length of the barrel in inches and the * mark indicates that the true gallon inch values have been divided by three. Thus, to get the content in gallons, three numbers are added and their total then multiplied by the length of the barrel in inches, the latter calculation made using the rod as a slide rule. Oughtred has reduced the calculation to something very easy to perform. But is it accurate? See the comments at the end of the two excerpts.

[1] Cajori, Florian, *William Oughtred – A Great Seventeenth-Century Teacher of Mathematics,* the Open Court Publishing Co., Chicago, 1916.

[2] There were a number of different gallon sizes. The *wine gallon* is 231 cubic inches (the same volume as the US gallon), Oughtred quotes an ale gallon at 278.25 cubic inches, the later *ale gallon* is 282 cubic inches and the *Imperial gallon* is 277.274 cubic inches.