Make Your Own Slide Rule

Only a Monitor and Scissors Are Needed

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Abstract

We describe several easy methods in detail how to plan and construct into final form our own slide rules for different calculating tasks, either using a monitor or printing to paper. Though there are a lot of counting devices on the net[9,11-15,27,28,36] ready to print and cut, in many cases we cannot find the specific one we need. After making your own, you can share your work on the net and with me.

0. Introduction

Many times, we quickly need some simple helping device for calculations of different problems. Slide rules basically do multiplication (adding logarithms)[22] and many other more sophisticated operations[22,26,30], so why not make one from a strip of paper and/or on our monitor? Analogue devices have many illustrative advantages versus digital ones! Some people (like me) even enjoy constructing a working device from wood or paper.

Additions occur in many everyday cases, e.g., *permanent (perpetual) calendars*[3,4,17,20,21,27], *Caesar-cipher cryptography*[1,2,36], absolute and relative pitch in Kodály's method in *solmization*[10,15,23] ("Movable-do solfège"), *timezones*[14], *photography*[31-34], addition of *fractions*[9], *multiplication* with business cards[12,13], table of *binomial coefficients* (Pascal's matrix[18,19,28]), *sunrise and sunset*, and finally my favorite everyday problem: if the sailor is at height h on the mast and observes the top of the tower of height t , then what is the distance between the mast and tower[7,26]? Furthermore, we have many other useful paper folding ideas (origami) on the net[11].

In what follows, first we discuss in detail two of our slide rules[27,28,36] as examples, and then we share our general ideas to plan and fulfill any idea for your own slide rules. Enjoy!

1. The Perpetual Calendar and the Binomial Slide Rules

Many permanent (perpetual) calendars[3,4,17,20,21] are easy to use: we need only produce remainders[35]of months and years (do not forget leap years), add them to the date of the day, divide by seven, and get the name of the day. Because adding three or more numbers (and memorizing many more) is hard for me, I prepared my slide rule displayed in Figure 1[27].

The upper scale on the stator (above the upper green line) "stores" the remainders of the years (from 1900 to 2099): each tick increments the remainder by one (corresponding to 3 space characters). Leap years are marked in bold red. "Storing remainders" means that each year is positioned to its place, after each three characters (from left to the right), one higher remainder follows. The final answer will be found on the lower part of the same stator (below the lower green line), after we move the slider (between the two green lines) according to the month ([1] through [12], corresponding to January through December). Again the position of the month stores that month's remainder (take care of leap years, marked in **bold black** -- their months behave differently). Keep in mind that you must use **`monospaced fonts`** (e.g., **`Courier New`**) only[16], because using other (proportional) fonts you cannot determine the position of the numbers and other data, which is extremely important in slide rules!

You can move the slider either (a) using the .png file[27] in a drawing program, by selecting the slider, hold down the mouse button, and moving the slider; or (b) using the .doc file[27] and inserting / deleting spaces in a word processing program. In the latter case you must synchronize the lines of the slider (because the word processing program moves one line at a time), this is why we typed a column of # to the left of the **slider.**

We ask the reader to believe that this construction stores and adds the remainders of the years, months, and dates, according to the general theory of the slide rules[26]. Moreover this construction includes leap years -- no headache anymore! If in doubt you can check references 3, 4, and 17.

Another favorite of mine is my "Binomial" slide rule.[28] The complete original is too long to fit here, but a segment is displayed in Figure 2.

The slider contains only a short segment (below the green line). For "calculating" the binomial coefficients[18,19] $\binom{n}{k}$ for any $n \in \mathrm{N}$ and for $0 \le k \le n$, first find the first n on Scale "**`n`**" in red on the stator (below the dotted line), second move the red **`0`** on the slider (Scale "**`k≤n/2`**") below this n, third find **`k`** on the slider, and now you find the values of $\binom{n}{k}$ on the stator above the dotted line (reading the numerals vertically downwards). In our example **n=9** and you can see on Figure 2 the values of $\binom{9}{k}$ for k=0,1,2, 3,4 as $\binom{9}{0}$=1, $\binom{9}{1}$=9, $\binom{9}{2}$=36, $\binom{9}{3}$=84 and $\binom{9}{4}$=126. (We can imagine the brackets of $\binom{n}{k}$ crossed by the green line as $\binom{n}{k}$.) For k=5,6,7,8,9 you must use the symmetry property $\binom{n}{k}=\binom{n}{n-k}$ for any **n** and **k**, which gives you $\binom{9}{5}$=126, $\binom{9}{6}$=84, $\binom{9}{7}$=36, $\binom{9}{8}$=9 and $\binom{9}{9}$=1. When you type similar tables with a word processing program, remember to use monospaced fonts[16].

Where did we do addition in the above process? The observant reader notes that the stator (above the dotted line) contains the rows of a static table ("two-variable discrete function") arranged in a line: the delimiters of the rows are the red numbers between the dotted and the green lines. Moving the slider just marks the desired row we are interested in, e.g., the **9**th row is between **9** and **10** and contains 1, 9, 36, 84, and 126. This trick can be done with any small table for capturing the data (and playing with the slider). Why not, because there are many one-variable functions on the regular slide rule. The interested reader might consider the realization of slide rules for the tasks listed in the previous Section.

2. Planning the Scales

Now let us start to plan and to realize our own slide rule for our own task.

First we have to plan the scales. If the stator contains the scale $f(x)$ and the slider $g(y)$ (where f and g are strictly monotonic functions), then one movement of the slider produces the distance $f(x)\pm g(y)$. We can use another scale $F(z)$ on the stator to realize the formula

$$F(z) = f(x) \pm g(y) \qquad (1)$$

or equivalently, $z = F^{-1}(f(x)\pm g(y))$ (here F^{-1} denotes the *inverse* of the function F).

Our articles[25,26] explain this formula in more detail. The choice of the functions $f(x)$ and $g(y)$ depends on the task we want the slide rule to solve. Finding $f(x)$, $g(y)$ and $F(z)$ is the most important and the hardest task, but no general rule or advice exists! There are several methods to translate other formulas into (1)[5,6,24,26,29,30]. In case of any problem (or success) please do not hesitate to email me!

Planning the layout of the scales on the slide rule is also a hard and important job. We need to determine the range (domain) of the functions $f(x)$, $g(y)$ and $F(z)$, the unit of calculation, zooming, the length of our slide rule, etc. (Some examples are shown in our article[8].) But using a computer (see next Section), we can make and try out several variants (on the monitor or on paper), in which case we advise to save all variants to choose the best one(s).

3. Realizations

Now we turn to the main topic of the present article. Having planned the scales and their layout we are ready to make our own real, physical 2D or 3D slide rule. Using a computer we have several possibilities for constructing our slide rule.

We can use a word processing program, this is the simplest method, but suits only to the simplest, integer valued functions $f(x)$, $g(y)$, and $F(z)$. We must use monospaced fonts[16] and will be able to position characters at integer distances only. Our Perpetual Calendar[27], the Binomial[28] and Cryptograhy[36] slide rules were typed in Courier New.

Next possibility is a drawing program, in which we can draw vertical and horizontal lines (by hand!) in high resolution and type letters and figures in several sizes and types. Well, manual drawing and previous calculations of the right positions of the ticks (values of $f(x)$, $g(y)$ and $F(z)$) with a pocket calculator is rather boring and results in dozens of errors. This leads programmers to make computer and mobile programs (applications) to draw slide rules[7,30].

The number and quality of slide rule making programs keep increasing each day. I still use Turbo Pascal 3.0 and Acrospin (1990); the Javascript one[30] is not complete yet. Ace Hoffman's Flash Adobe applications[7] are professional ones -- his homepage is worth a visit!

Next, how to use our slide rule? We can move the slider directly on the monitor. But in both of the following methods, do not forget to save a backup copy in advance!

In the case we used a word processing program, we just have to insert or delete spaces to move the slider. Well, in this case we can move only one row, so this method becomes a little uncomfortable for many rows; it is still satisfactory for making experiments. In this case you must synchronize the lines of slider (because the word processor moves one line at a time), e.g. by typing a column of # to the left of the slider . Please also remember that this method works for equidistant scales and monospaced fonts[16] only. For sliders containing more rows, drawing programs (like Paint or

Photoshop) offer a better solution. Consider for example the slider (between the green lines) displayed on Figure 1. Copy this picture (i.e. the original .png[27,36]) into a drawing program; then, by "selecting" the slider and holding the mouse button, we can move it directly, to any direction, between the upper and lower scales of the stator. It looks like a real slide rule! You can copy a screen to a new file using "print screen" and "paste" (Ctrl+v) in most applications.

We might want to have a hard copy. We may print Figure 1 (the .png[27,36]) and cut it into three parts along the green lines. The middle part can be moved as a slider. If we do not stick these strips into a cardboard frame like in the right bottom part of Figure 3, these three paper strips tend to “run away” on our table, so we might prefer to fold back the upper and lower part of the stator in order to firmly hold the slider, as seen in Figure 3. Surprisingly, we have to use slightly different layouts for printing and folding back the printout. In this case the scales A and C on the stator change their positions as shown on Figure 3. The original printout is in the upper left part in Figure 3. Look carefully at the result of the folding back of Scales A and C, in the middle of the Figure (**gray color** indicates the backside of the paper). In the printout, the lower scale C must be on the top and the upper scale A must be on the bottom. Please, take a little piece of a rectangular paper in your hands, put the marks "A" and "C", fold the paper, and look at the result. Or, compare carefully the original[27] .doc and .pdf files to the .png one. You also might have a look at my other slide rules[26,28,30,36]. Finally, we note that we have to print the scales A, B, and C normally, i.e., not upside down.

Of course, we need to be exact in printing and cutting out; folding is my nightmare. I advise you to run the ticks to the end of the paper for ease of use. (Evidently you will not use the scissors directly on the monitor, unless you were promised to have a new one for Christmas!)

Enjoy your own Slide Rule !!!

4. Acknowledgement

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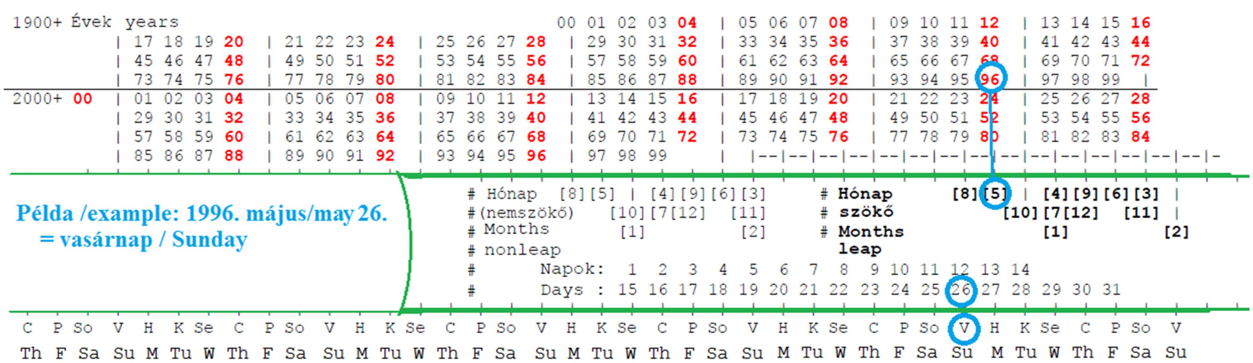

FIGURE 1. Perpetual Calendar Slide Rule

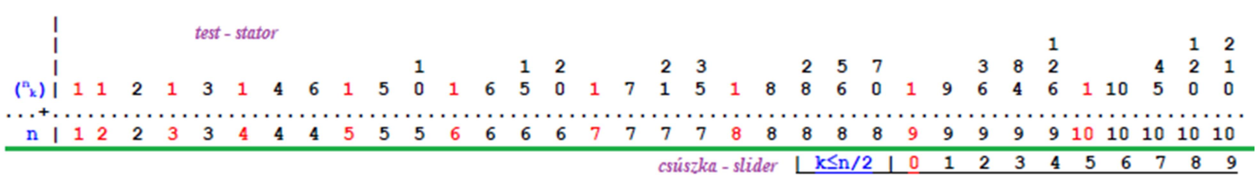

FIGURE 2.Binomial Slide Rule (fragment)

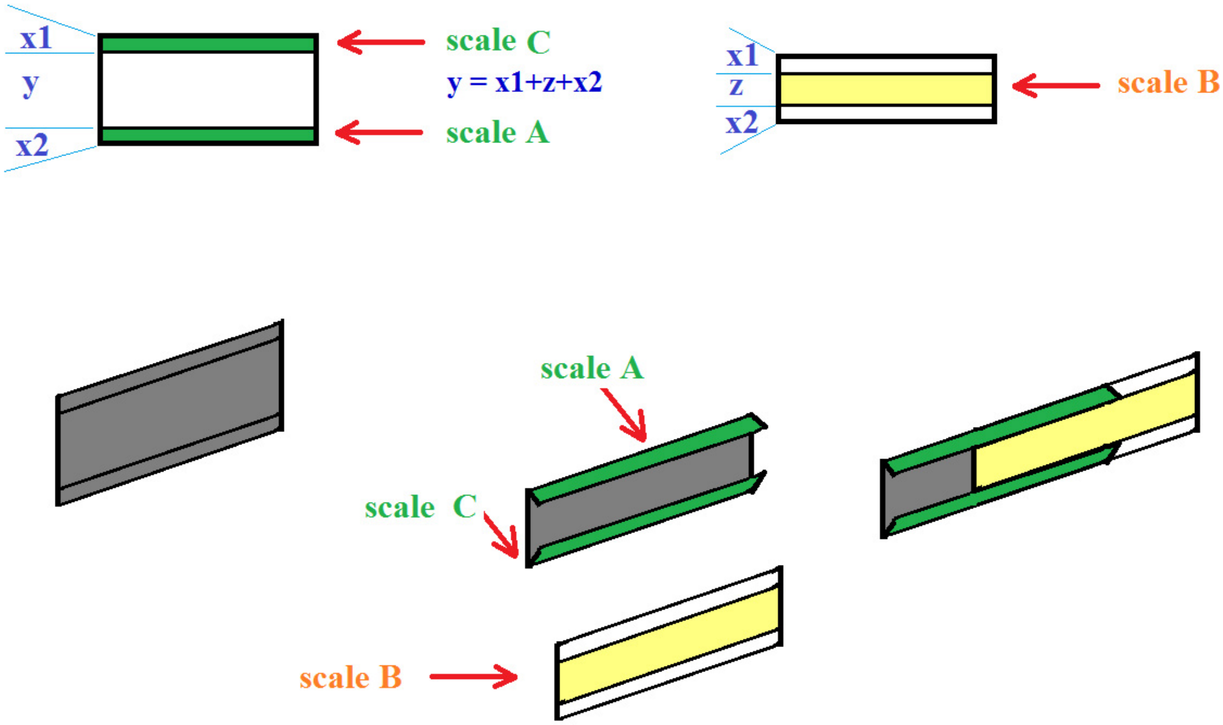

FIGURE 3. Folding Paper Scales into a Slide Rule

Notes

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