Concise 300 Circular Slide Rule

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This document looks at the Concise 300 circular slide rule, one of the few slide rules that is still in production. At the time of writing, they could be purchased from Concise in Japan for roughly $40.

Update 29 Dec 2014: I've added a short section about a Frederick Post Midget Slide rule I got in 2010.

Why bother writing such a thing?

I can't think of anyone who would voluntarily give up their electronic calculator or computer and go back to the old methods of slide rules, tables, and hand calculations. So I'm not writing this to convince you to do so. Rather, the intent is to alert you to a tool that you might occasionally find useful.

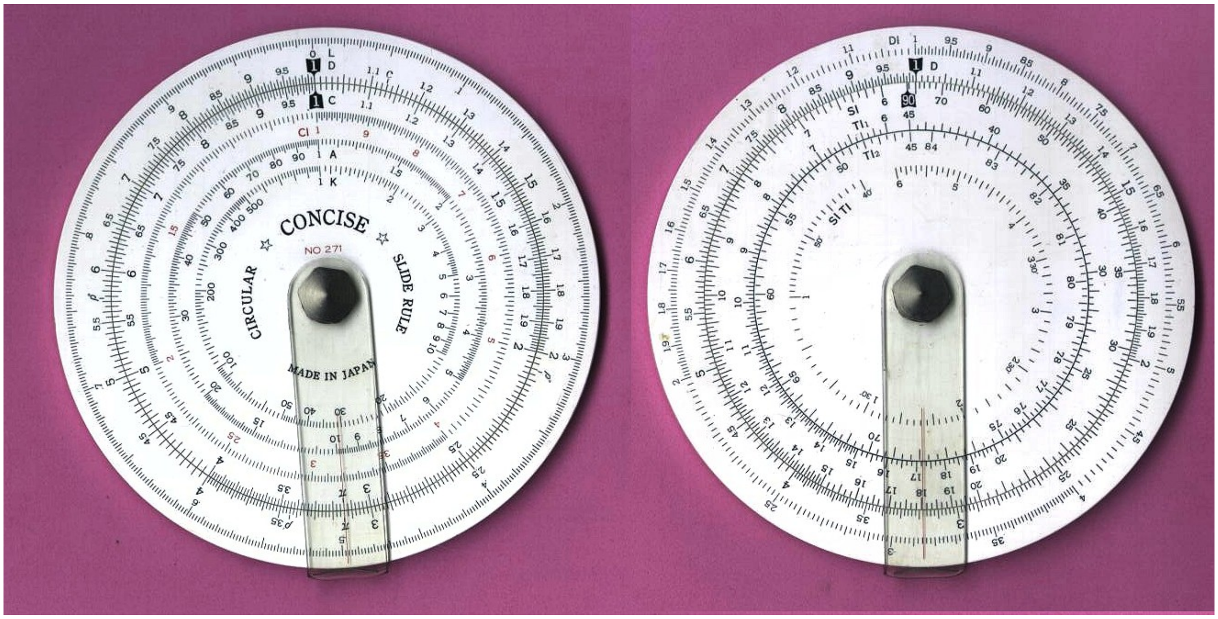
When I went to college, the hand-held electronic calculator didn't exist, so we had to use the old techniques (slide rules, log tables, etc.) to get answers. I was happy to say good riddance to these labor-intensive methods when hand-held electronic calculators became available in the 1970's. However, after spending a career doing technical stuff, I've amended my opinions a little bit: there are occasions where hand calculations and slide rule calculations are appropriate -- mainly because you don't have a calculator or computer handy. I've covered the mechanics of such stuff in [*dinosaur*].

My reason for writing this is that the Concise 300 is one of a very few slide rules that are still being manufactured -- and you may find that having a slide rule can prove useful. If my Concise 300 is representative of how the current ones are manufactured, then it's a slide rule that will outlast you if you take care of it. I still have a K&E Mannheim slide rule that belonged to my grandfather -- and it was made around 1910 (I can date it rather accurately because of the cursor style and because my grandfather was born around 1890). It does everything it always has -- and, more than 100 years later, the batteries still haven't gone dead.

What is it?

The Concise 300 is a circular slide rule 110 mm in diameter. It has a mass of 48 g. The body of the rule is 3.6 mm thick and the maximum thickness of the rule is over the rivet, which is 9 mm at the thickest part. The thickness over the transparent cursor is 5.2 mm.

Here's a picture of the rule:



The diameter of the C and D scales are 80 mm, meaning their linear length is 80π mm or 251 mm or 9.9 inches. This means the resolution of the slide rule is the same as the typical 10 inch linear slide rule. But it's more compact than a 10 inch linear slide rule and can slip into a typical shirt pocket. This is the reason I prefer a circular slide rule for general calculations over a linear slide rule.

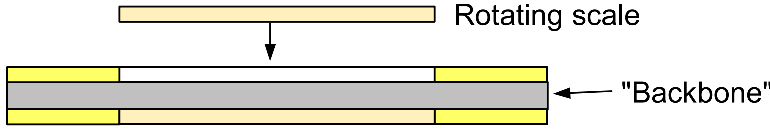
Each side of the rule consists of a fixed portion; the two fixed portions contain the D, A, and K scales on the front and D, LL2, and LL3 scales on the back. Each side has a rotating disk; both rotating disks have a C scale at their OD that meshes with the D scale to provide for multiplication and division. It requires good manufacturing to get a close and concentric fit between the rotating scale and the fixed scale.

The two sides of the rule are independent and not typically used together. If you put the cursor on the 1 of the D scale on one side, it will be lined up with the 1 on the D scale of the other side. Because the D scale has its numbers increase clockwise on each side, you can theoretically set a number on one D scale, then flip the rule over and read the reciprocal on the other scale. I say theoretically because in practice, this doesn't work as well as using the C and CI scales for reciprocals. For example, on my 300, setting the cursor over 2.5 and flipping the rule gives 3.99 on the other scale (it should be 4.00).

Construction

The rule appears to be made from a sheet plastic like PVC. I've seen slide rules made by Concise hold up well, as I have some that I bought in the late 1970's and they still work well. The construction is good and, with care, these slide rules should work indefinitely as long as the plastic doesn't degrade. The graduations and lettering appear to be chemically etched and the indentations are filled with black or red coloring. Thus, moving your fingers over the rule should never wear the markings off like can happen with cheaper rules that just print the markings on the surface.

If I had to guess how they're made, there are two thicknesses of PVC sheet: 0.8 mm and 1.5 mm. The main body would be constructed by gluing two annuli and a disk together; the side view would be



The yellow annuli are 0.8 mm thick and provide the relief for the inner rotating scales (light orange) on each side. The gray disk is 1.5 mm thick and provides the slide rule's rigidity.

The two rotating disks are 80 mm in diameter and are 0.8 mm thick.

The slide rule is held together by a metal assembly (I'll call it a rivet) that is probably pressed together and permanently assembles itself through some metal deformation. Each rotating disk has a wavy washer to provide friction along with what appears to be a thin (perhaps 0.1 mm thick) PVC washer to insulate the rotating disk from the wavy washer. The metal rivet also holds the clear plastic cursor, which is a piece that is bent over 180° and has hairlines scribed and filled on them (with red paint or ink). I suspect the primary purpose of the wavy washers is to provide suitable friction for the cursor.

The plastic cursor is made from a transparent plastic about 0.8 mm thick. The edges have been milled and the cursor was probably bent while warm into the final position. It's likely either polycarbonate or acrylic. Because of the way a small section of it scratched with a small screwdriver, I would guess it's acrylic.

One of the beauties of such a tool is that once it's assembled correctly, there's basically nothing that can go wrong with it after that (excluding a design flaw). Concise has been making slide rules since 1949, so I'll assume they've got the process down pat. The only things that I can envision that would damage these slide rules would be:

1. Excessive heat. The manual says to not expose them to temperatures greater than 60 °C (140 °F).
2. Some organic solvents.
3. Strong acids or bases or acidic/basic vapors.
4. Being left out in the sun which can cause UV discoloration and embrittlement if the plastic isn't UV-stabilized.
5. Mechanical damage (being run over by a car, chewed on by a dog, abrasion, etc.).
6. Strong nuclear radiations.
7. Being put into a microwave oven.

I would imagine that the rule could be resistant to having things like coffee or a soft drink spilled on it. It would probably clean up well in hot (no more than 60 °C), clean tap water by rinsing a number of times (a mild detergent wouldn't hurt anything, but I'd use the plain water first to see if it did the job).

Inspection of the marks and lettering with 4X and 10X loupes show that the marks are very clean and well-made. I would assume that the method involves an etching process, as etching technology has been well-developed for the semiconductor industry. At 10X magnification, the lettering appears to have been made by a computer image.

The finish of the rule's surface is predominantly matte, but there's a small amount of specular reflection. It's not annoying enough to interfere with the use of the rule.

How it's made

Update 2 Jun 2016: a person emailed me that his Concise 300 appears to be made by injection molding, as there were mold numbers on the rule. I bought mine used about two decades ago, so I'd guess it's at least 25 years old.

It's fun to speculate on how the slide rule itself is made. Here's how I would do it, although I've not worked in a place that made things like this, so it's a guess on my part. I'd have the raw sheet punched to size and deburred if necessary (mainly the ID of the annular pieces and the ODs of the "backbone" and the rotating slides). The backbone would have some mechanism for indexing the rule during subsequent construction; I'd pick two tooling holes unequally spaced in the azimuthal direction and with different radii. This would then let the piece fit on subsequent tooling in only one way. The central hole for the rivet could also be made at this time; it would be accurately drilled and reamed.

The two annuli and the backbone would then be solvent welded together. This is easy to do with PVC; the typical solvent is a mixture of tetrahydrofuran, acetone, and MEK.

Then the body assembly would have the scales chemically etched on them; the three tooling holes would provide registration. The lines of the D scale would be a bit longer than they need to be, as the excess will get machined off. The lines and lettering would be filled with appropriate colors at this point; this is probably done with the aid of suitable masks and the paint/ink is sprayed onto the plastic. The cleaning step is probably a careful wipe-off on a flat rag moistened with a suitable solvent for the ink or paint.

Then the body assembly would be put on a lathe and the two recesses for the moving slides would be accurately machined, as would the OD. A small chamfer would be put on the OD. This operation could also be done on a machine like a pin router, which would be cheaper than a lathe. I'd want to do the final machining after the etching to make sure the inner edges were nice and sharp (lightly remove any burr).

The inserts would be chemically etched, filled with paint/ink, and have their ODs machined to match the diameter of the machined recesses in the backbone.

The cursor is made from a transparent plastic. I would assume the material could be punched to rough size and the two holes put into the piece (the holes need to be accurately located and have tight restrictions on size so that the cursor doesn't wobble). Then many pieces could be ganged together and have their outside machined to finished size. The next step would be to scribe or machine the hairlines accurately with respect to the two holes and fill them with red paint/ink. The last step would be to heat and bend the cursor to final shape.

The wavy washers would be purchased and the rivet is probably farmed out to a screw machine house.

At this point the rule could be assembled. I'd assume this is a quick step, as all an operator would have to do would be to assemble the correct parts together and press the rivet halves together; then the rule is permanently assembled.

The inner rotating disks have a gap of less than 0.0015 inches (measured with a 50X microscope) from the outer disks, with no sensible runout. This leads me to believe that they were machined in a fixture.

Slide rule scales

Here I describe the scales on each side of the rule, starting at the outermost scale and working in towards the center.

Side 1

Outermost scales on fixed part of rule and their use (x is the setting on the C or D scale):

K	x^3
A	x^2
D	General multiplication, division, ratios

Innermost scales on rotating part of rule and their use (x is the setting on the C or D scale):

C	General multiplication, division, ratios
CI	Reciprocals
B	x^2
L	log(x)

Side 2

Outermost scales on fixed part of rule and their use (x is the setting on the C or D scale):

LL3	e^x
LL2	$e^{0.1x}$
D	General multiplication, division, ratios

Innermost scales on rotating part of rule and their use (x is the setting on the C or D scale):

C	General multiplication, division, ratios
S	$\sin^{-1}(x)$, for x from 0.1 to 1
T1	$\tan^{-1}(x)$, for x from 0.1 to 1
T2	$\tan^{-1}(x)$, for x from 1 to 10
ST	$\sin^{-1}(x)$ and $\tan^{-1}(x)$, for x from 0.01 to 0.1

Intended users

This is a slide rule that is aimed mostly at technical workers. The reason is because of the addition of the LL2 and LL3 scales; these scales are used to raise numbers to a power and get natural logarithms. This is a common task for engineers and scientists.

The other feature that is used by technical workers is the ability to calculate trigonometric functions. These are commonly used in the solution of triangles. If you don't need the LL scales but need the trig functions, the Concise model 270 may be a better choice, as it has some extra scales for trigonometry calculations.

Opinions

Likes

The construction of this rule is first rate. I cannot see any reasonable way of improving the existing mechanical design. Unless the cursor yellows badly over time, I would assume the rule will last indefinitely. The secret would be to store the rule out of the light; its cheap vinyl case is suitable for this.

An engineering refinement would be to design a central rivet that could be squeezed with the two fingers. When squeezed, the rivet would clamp the rotating disks so they couldn't move. The one danger when using a slide rule is that there's a slight movement of the scales while you're turning it to get a look at a needed graduation, leading to a numerical error. This improvement could reduce the chances of that happening.

Another refinement would be a small adjusting screw on each side that could be used to adjust the turning friction of the rotating scales. It appears that the wavy washer is used to provide the friction, but this is non-adjustable. This of course would add to the cost, but that would get amortized out easily over a long period of time. One reason I'd like this feature is that one side of my rule turns a bit too freely and the other side is just perfect -- and everyone has different tastes.

The rotating disks are easy to turn with your thumb while the rule is held in one hand. This leaves your other hand free for e.g. writing with a pencil. You can easily read off squares, square roots, trig values, etc. It's also not difficult to multiply and divide with one hand, although it's easier with two hands.

For older eyes, I'd like the rule scaled up by roughly 20-25% and the font size of the numbers to be increased. This would make it easier to use without a magnifier.

Dislikes

My biggest dislike of the Concise 300 slide rule is that on the trig scales, the small angles and fractions of larger angles are graduated in minutes instead of decimal degrees. For example, in Figure 1, you can see that the graduations between 7° and 8° are in 5 minute intervals. I never met anyone during my career who liked working with sexagesimal measure and I cannot understand why someone would design a slide rule this way. However, my whining about it won't change the markings, so one has to live with them. My concern is that it's easy to forget that the scales are marked this way because I just assume they're decimal like all the other scales, then make a mistake when making a calculation. In my opinion, it's a serious design flaw.

A minor nit is that the ρ'', ρ', and ρ° marks should be on all the C and D scales, not the one C scale on one side of the rule. The *C* mark is used to get the area of circles from the diameter, so it really only needs to be on the side of the rule with the A and B scales. But since there's an A outer scale and an inner B scale, the *C* mark should be on both the C and D scales. This would let you use what's closest, not have to go looking for it.

Things you can do with it

If you've never used a slide rule before, you may be surprised to learn that they are good tools for 1% type calculations. For such 1%-type calculations, an experienced slide rule user sometimes can get the answers faster than a calculator user as long as no addition or subtraction is involved.

Some of the capabilities are of the Concise 300 are[1]:

1. Multiply and divide; general operations like $\frac{a \times b \times c \times ..}{u \times v \times w \times ..}$ are done quickly with minimum movements.
2. Ratio calculations of the form $\frac{x}{a}=\frac{c}{d}$ and $\frac{a}{x}=\frac{c}{d}$ can be quickly solved. In combination with the S scale, this means triangles can be solved using the sine law. With conversion factors like 25.4 mm = 1 inch, unit conversions can be done.
3. Sines, cosines, and tangents and their inverse functions can be gotten.
4. log(x) (common logarithm) and 10^x can be calculated.
5. ln(x) (natural logarithm) and e^x can be calculated.
6. Profit and markup percentages in business can be calculated.
7. Inverse proportional relationships can be calculated.
8. Squares and square roots can be taken.
9. Cubes and cube roots can be taken.
10. Powers like x^y can be calculated.
11. Calculate the area of a circle of known diameter and the diameter of a circle with known area.

Note: the Concise 270 slide rule doesn't have the log log (LL) scales; instead, it has auxiliary scales to help with trig calculations. These ancillary trig scales give the rule more power for solving trig problems.

1 The typical linear log-log slide rule does these things too.

The Concise 300 isn't quite as powerful as a linear slide rule, as the log-log slide rules usually have the LL1 to LL3 and LL1- to LL3- scales and some have the LL0/LL0- scales.

In the following material, I'll give some examples of things done with slide rules. The list is certainly not exhaustive; there are many slide rule resources on the web should you want to learn more.

Chained calculations

The C, D, and CI scales make it easy to do calculations of the form

$$\frac{a \times b \times c \times \ldots}{u \times v \times w \times \ldots}$$

Suppose we have the problem

$$\frac{47.8\,(0.22)\,740}{19}$$

The first rule of using any tool to solve problems (slide rule, calculator, computer) is to approximate the answer; this gives you a check against the actual computation. If the check number and the computation's result differ too much, one or both are wrong.

The basic method of approximating the answer is to change things to one significant figure and/or round to a convenient number (see [*dinosaur*] for more details). This problem gets changed to

$$\frac{50\,(0.2)\,750}{20} = \frac{750}{2} = 375$$

which you should be able to do in your head (practice with paper and pencil if you can't; with practice you'll get better). You mentally say to yourself, "50 times 0.2 is 10; then cross out the ending zeros on the 10 and 20 to get 750/2. Since 0.75 is 3/4 (you know your basic fractions' decimal equivalents), half is 3/8, which is 0.375." It takes much longer to write about it and read the explanation than doing it.

Here's the method of doing this chained calculation on the Concise 300 slide rule. Move the cursor to 4.78 on the D scale. Then, you always think of adding logarithms for multiplying and subtracting them for division. To add the logarithm of 0.22, you put 2.2 on the CI scale underneath the cursor. Because the CI scale is backwards, moving off to the right to the 1 index on the CI (which is also the index for the C scale) points to the product on the D scale. Since there's another multiplication to do, we don't use the index, but move the cursor to 7.4, which gives the product on the C scale: 7.79. For the division, we move the rotating scale to put 1.9 on the C scale under the cursor and read the quotient on the D scale opposite the index mark on the C scale. This gives the answer 4.10. Thus, our answer is 410. A calculator gives 409.6. This method of using the CI scales is efficient.

For division, I personally don't think of subtracting logarithms in this case -- instead, for *a/b*, I put *a* on the D scale and *b* on the C scale underneath it and look at the index mark to see what number has the same ratio with 1 as the ratio *a/b*. Of course, it's the quotient.

There's a certain elegance to doing the problem with the slide rule, as it comes faster with practice -- and you acknowledge that it can be faster than punching numbers into a calculator. While I wouldn't want to have to depend solely on slide rule calculations, they are useful when the answer is only needed to about one-half to one percent or so.

Filling out tables

The slide rule is an analog computer. It lets you see many solutions to similar problems at once. For example, suppose you wanted to sketch a pie chart for the following sales figures:

Jan	$120
Feb	$230
Mar	$190
Apr	$170
May	$150
Jun	$200

You can use the slide rule to calculate the percentage of the total that each month's sales represents. The only calculation you'd need to do would be to sum the numbers to get $1060. You'd put 1060 on the D scale over the 1 on the C scale, then read off the percentages on the C scale. You'd quickly fill out the following table:

		% of total
Jan	$120	11.3%
Feb	$230	21.7%
Mar	$190	17.9%
Apr	$170	16.0%
May	$150	14.2%
Jun	$200	18.9%
Total	$1,060	

Next, you'd set 360 on C under 1 on C and read off the angles for the pie chart on C opposite the percentage on D:

		% of total	Angle, °
Jan	$120	11.3%	41
Feb	$230	21.7%	78
Mar	$190	17.9%	65
Apr	$170	16.0%	58
May	$150	14.2%	51
Jun	$200	18.9%	68
Total	$1,060		

You'd then construct the pie chart with a straightedge and a protractor. Of course, virtually everyone would use a spreadsheet program to do such things today, but when a computer isn't handy, it isn't hard to make hand-drawn graphs. In fact, it was a common task for engineers to hand-sketch graphs before computers became common and it wasn't a horribly onerous task, as long as the calculation for the points being plotted weren't too demanding. In fact, when you're "thinking" in your lab notebook, it's common to make quickly-drawn graphs without resorting to the computer; the slide rule can be a good tool to help with the needed calculations. Of course, if I'm at my desk with my electronic calculator, I'll use it, especially if I need to write a simple program to help with the calculations.

Proportional allotment

A similar task easy to solve with a slide rule is proportional allotment. Suppose Uncle Scrooge left Huey, Dewey, and Louis 1.37 billion dollars[2] with the stipulation that the nephews get the following shares:

2 There's been a bit of inflation since I read those comics when I was a kid...

	Share
Huey	8
Dewey	11
Louis	12

How much should each nephew get? This is solved by summing the number of shares to get 31. Then 1.37 on D is put opposite 31 on C and the money amounts are read off the D scale opposite the share value on C. This lets us quickly fill out the following table:

	Share	$ amount, billion
Huey	8	0.354
Dewey	11	0.486
Louis	12	0.530

I'd imagine that Huey will probably feel he got stiffed -- poor boy, he'll have to squeak by on 354 million dollars.

Inverse proportions

Inverse proportions are easy too. Suppose a construction project can be done in 30 days with 60 men. The boss just changed the schedule so that the work can be done in 45 days. How many men will be needed? Set 30 on D over 60 on CI. Then opposite 45 on D, read 40.1 men on CI. You'd round it to 40 men.

Here's the logic of this solution. Suppose you have M men that do the work in time t. The job thus takes $M \cdot t$ man-days of effort. In this problem, the men's work rate is such that the job takes 1800 man-days. If the amount of time for the project is changed to T, the job will still take 1800 man-days. Instead of using a product, we can express this problem with the ratio

$$MT = \frac{T}{1/M} = 1800$$

By setting T = 30 on D and M = 60 on CI, we've set the slide rule up in this ratio (the CI scale gives the reciprocal 1/M). Then we solve for other number pairs that are in the same relationship. It's fast and efficient -- and we can see many different solutions at once if the 45 days number isn't cast in concrete.

Profit and markup

In business, profit and markup are often dealt with. If p is profit and m is markup, both decimal fractions, it's not hard to derive the equations (see [*markup*])

$$p = \frac{m}{1+m}, \qquad m = \frac{p}{1-p}, \qquad \frac{1}{p} = 1 + \frac{1}{m}$$

The slide rule lets you solve for one given the other.

Example: Scrooge McDuck decides he wants to make 73% profit on some spats. How much should he mark them up over his cost? The relevant ratio given by the second equation is $\frac{73}{100-73} = \frac{73}{27}$ (multiply both sides by 100 work with percentages). You set 73 on D opposite 27 on C. Opposite the 1 on C, you read the markup 2.705, which means the markup must be 270%. Thus, to get the selling price, you multiply the cost by $1+m=3.70$ to get $85.2. In other words, we just solved the arithmetic problem

$$23\left(1 + \frac{73}{27}\right)$$

To use the last equation to find p, set the cursor over m on CI and read the number on C under the cursor. Subtract 1 from this number, set the cursor over this on C, and read the profit *p* on CI under the cursor.

Example: To do the previous method using the CI scale, set the cursor over 72 on CI, read 1.37 on C. Subtract 1 to get 0.37, set this under the cursor on C, and read 2.7.

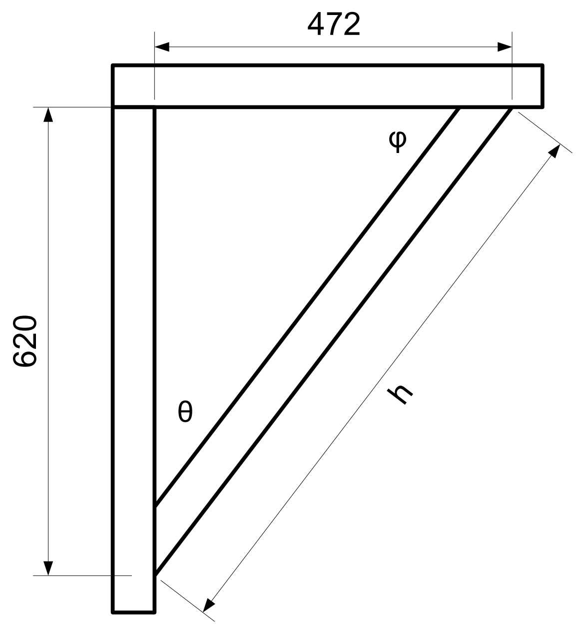
If you want to calculate the multiplier *M* from the profit, the equation is

$$M = \frac{1}{1-p}$$

To use the slide rule for this, subtract p from 1, set the cursor to the result on the CI scale and read the multiplier on the C scale. Example: for 73% profit, set the cursor on $1 - 0.73 = 0.27$ on the CI scale and read the multiplier $m = 3.70$, just as we found above.

Shop trigonometry

I'm building a brace in a carpentry project and I need to know how to set my miter saw to cut the angles given in the following picture. I also need to know how long the brace should be.



I need to calculate the length of the hypotenuse h and the two angles θ and φ (the triangle is a right triangle). h can be gotten using the Pythagorean Theorem: $h = \sqrt{620^2 + 472^2}$. Setting 6.2 on the D scale, we read the square opposite this on the A scale as 38.5; similar, the square of 4.72 is 22.3. These two sum to 60.8; we set this on the A scale and read the square root 7.8 opposite on the D scale. Thus, h = 780. Note the shifting of the decimal points to make things easier (this is how you would do the calculation using scientific notation). Here are two ways of getting θ. First, use the tangent: $\tan\theta = \frac{472}{620}$. The division yields the number 0.761. We set 0.762 on the C scale and read 37.3° on the T1 scale (we use the T1 scale because the angle is less than 45°). However, this takes two slide movements. A better way is to set the ratio $\frac{620}{472}$ so that the 620 is on the D scale. Then D's index points to the ratio 0.761 on the C scale and you can use the cursor to translate that position to the T1 scale, giving 37.3° as the angle with that tangent.

The second way is using the sine: $\sin(\theta) = \frac{472}{780}$. The ratio is 0.605. Setting that value on the C scale lets us read the angle 37.2°. I'd have to set my miter saw to cut this angle appropriately.

A calculator gives the correct value for h as 779.22. Assuming the dimensions were in mm, an error of 0.8 mm may or may not be important for this project; the allowed error would determine whether or not it was appropriate to do this problem with a slide rule or not.

Other slide rules

I chose to write about the Concise 300 since I have one and like it. If you want a reliable, well-made tool that will outlast any electronic calculator you can buy, consider getting one of these slide rules. It doesn't have to be a Concise circular slide rule -- there are hundreds of different types of slide rules to choose from.

I use slide rules to help me with quick calculations, especially when I'm not at my desk where my calculator is. For such a task, the handiest slide rule is a little one I can slip into my pocket. If I knew I was going to be doing a fair bit of numerical work and wanted to use a slide rule, I'd probably take the Concise 300 with me.

However, for general purpose stuff, it's hard to beat the small Sama & Etani slide rules that were made by Concise in the 1960's to the 1980's. They were conceived and marketed by Sama & Etani and were quite popular (search the web for pictures). Many were used for marketing promotional materials. They were small plastic cards 75x110 mm and about 2 mm thick. A 60 mm diameter circular slide rule comprised the front. A reference card could be pulled out of the middle of the device and the back of the device was printed with material relevant to the type of device (e.g., there was one for electronics, one for chemistry and chemical engineering, one for science, and one for metric conversions). The pull-out card typically had unit conversion factors and domain-specific information. These things are about 2 cm larger than a credit card in each dimension and, thus, are small and quite handy. The scales on the slide are: D, C, CI (reciprocals), L (base 10 logs), A (squares), S (sines), T (tangents), and K (cubes); i.e., basically what you would find on a Mannheim slide rule.

> I used these little slide rules in the early 1980's because they were easy to keep in a pocket and I was often away from the calculator at my desk. Even though I worked with engineers and scientists who were my age or older (and thus used slide rules in college), I never saw any other technical person use one at work.

There are many slide rules available on the web. While certain models have been scooped up by collectors, there are many other good choices -- and you can still buy new-in-the box slide rules manufactured decades ago. They're handy for doing basic approximate calculations and, for these, you don't need anything fancy.

I have a few log-log duplex pocket slide rules and these are my favorite for normal tasks. My two favorites are an Aristo 870 and a K&E 4181-1. I like the design of the Aristo, but the K&E is easier for my older eyes to read.

Years ago two companies in the UK made specialty calculators that solved specialized engineering tasks (see [*fearns*] for some examples). The two companies were Fearns and Mear (see [*hist*] for some history). I believe Fearns went out of business, but Mear is still in business (see [*mear*]). While their calculators can cost significantly more than a cheap electronic calculator, they are built for long life and hard usage. I have three different models and because they've been taken care of, they look new -- even though I bought them nearly 40 years ago. They are typically used to solve a specific engineering problem such as water flow in pipes, spring design, metal weights, etc. Check out Mear's web pages to see the types of things they offer. For an engineer or scientist who needs to solve these specialized problems a lot in their job, these calculators are easily worth their cost.

References

dinosaur	DinosaurArithmetic.pdf at http://code.google.com/p/hobbyutil/.
fearns	http://www.tinajuliecordon.webspace.virginmedia.com/Slide

%20Rules/FearnsMearSlideRules.html

hist http://www.mathsinstruments.me.uk/page61.html

markup Markup.pdf at http://code.google.com/p/hobbyutil/

mear http://www.mhmear.com/

post Frederick Post Company, *The Versalog Slide Rule*, 1951. This is a good instruction manual for using a slide rule. It's aimed primarily at the 10 inch slide rule like the Versalog, but the basic principles will be usable on virtually any slide rule, straight or circular.