1 Math Circle WARM UP

Questions to consider: Please rank the following events.
Make your best guess as to what happened when.

- Moon Landing
- Apollo 13
- Invention of the pocket calculator
- Invention of the slide rule
- Invention of the first central processing unit (CPU)/ Computer.
- Graphing Calculators.
- iPhone
- Invention of Calculus
- John Napier
- First Manned Shuttle in Space
- First Woman in Space

2 Building the Scale of Multiplication Lines

2.1 Building the Addition Table

Starting with a given column and adding the given row value, build an addition table.

10											
9											
8											
7											
6											
5											
4											
3											
2											
1											
0											
+	0	1	2	3	4	5	6	7	8	9	10

What patterns do you see?

-
-
-

2.2 Building the Multiplication Table

Starting with a given column and multiplying the given row value, build a multiplication table.

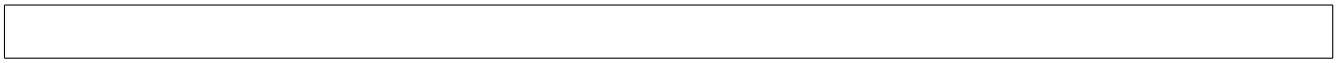
10	10	20	30	40	50	60	70	80	90	100
9	9	18	27	36	45	54	63	72	81	90
8	8	16	24	32	40	48	56	64	72	80
7	7	14	21	28	35	42	49	56	63	70
6										
5										
4										
3										
2										
1										
x	1	2	3	4	5	6	7	8	9	10

What patterns do you see?

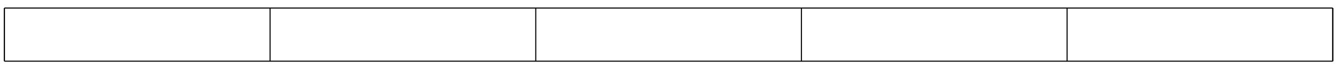
-
-
-

3 Making Our Own Sliding Scale

1. Start with a ruler:



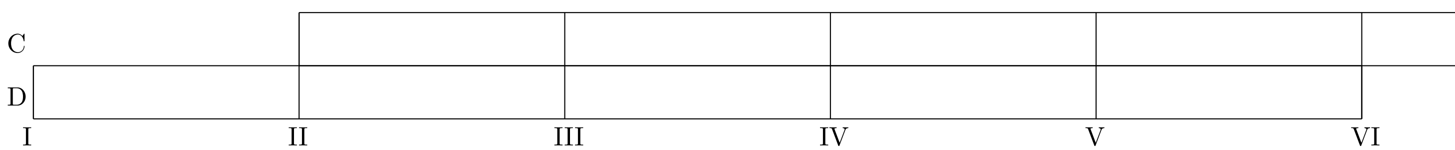
2. Let's create a multiplication scale, a gradation of the ruler at regular intervals that we can use to multiply. Given this ruler add numbers to create a scale.



   Questions to consider:

   - What number do you start with?
     hint: where does the multiplication chart start with?
   - How far between different integers?
   - If you've placed 2 and 4, where does 3 go? Is it closer to 2, closer to 4, or equal?
   - Where is 10? Where is 100?
   - How do you read numbers that are off the scale?

3. Let's stack 2 scales on top of each other and shift the top so that the first gradation on top is on top of the 2nd gradation of the bottom scale.



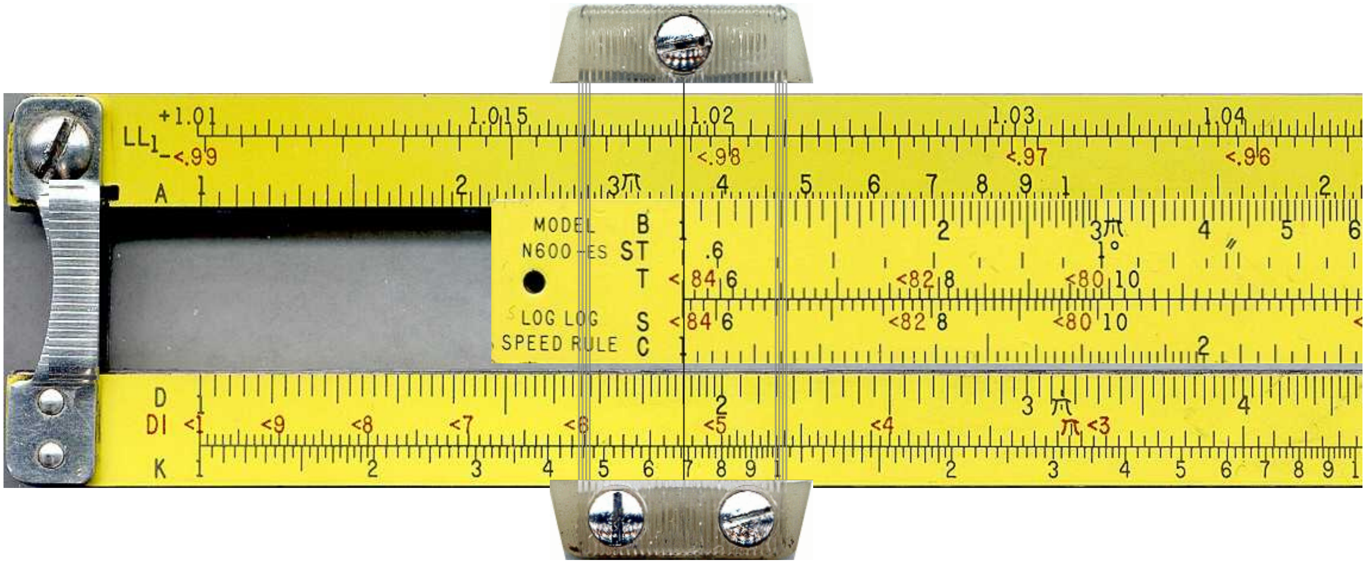
   Question: How does the top scale compare to the bottom scale for a given gradation?

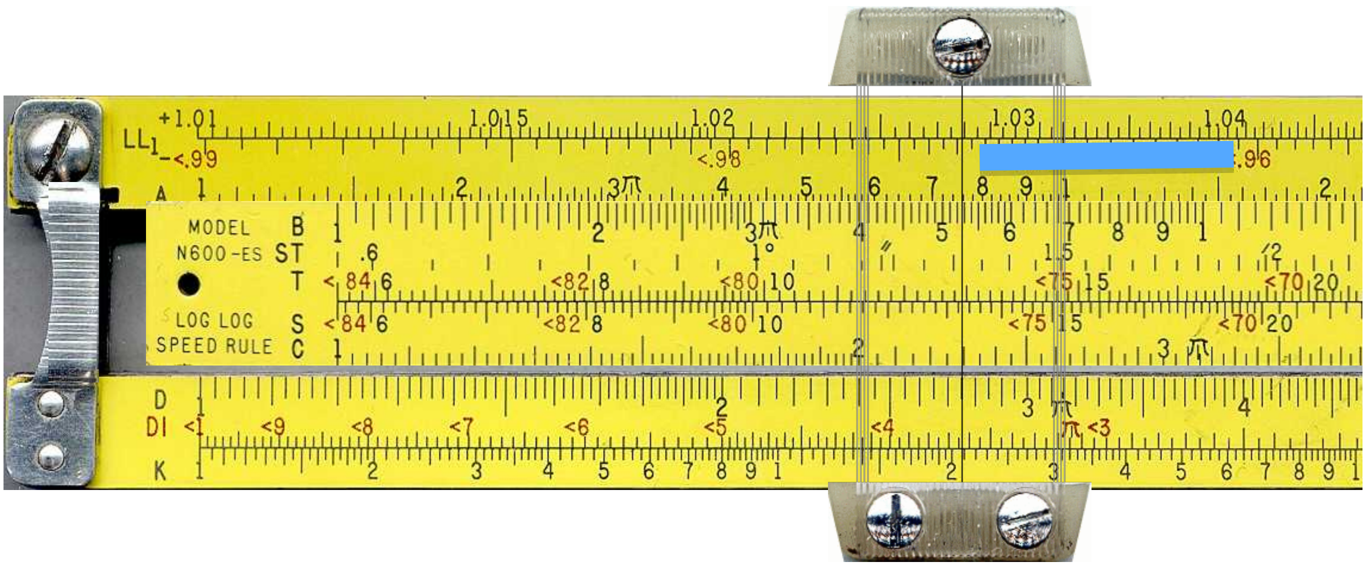
4. Let's stack 2 scales on top of each other and shift the top so that the first gradation on top is on top of the 3nd gradation of the bottom scale.

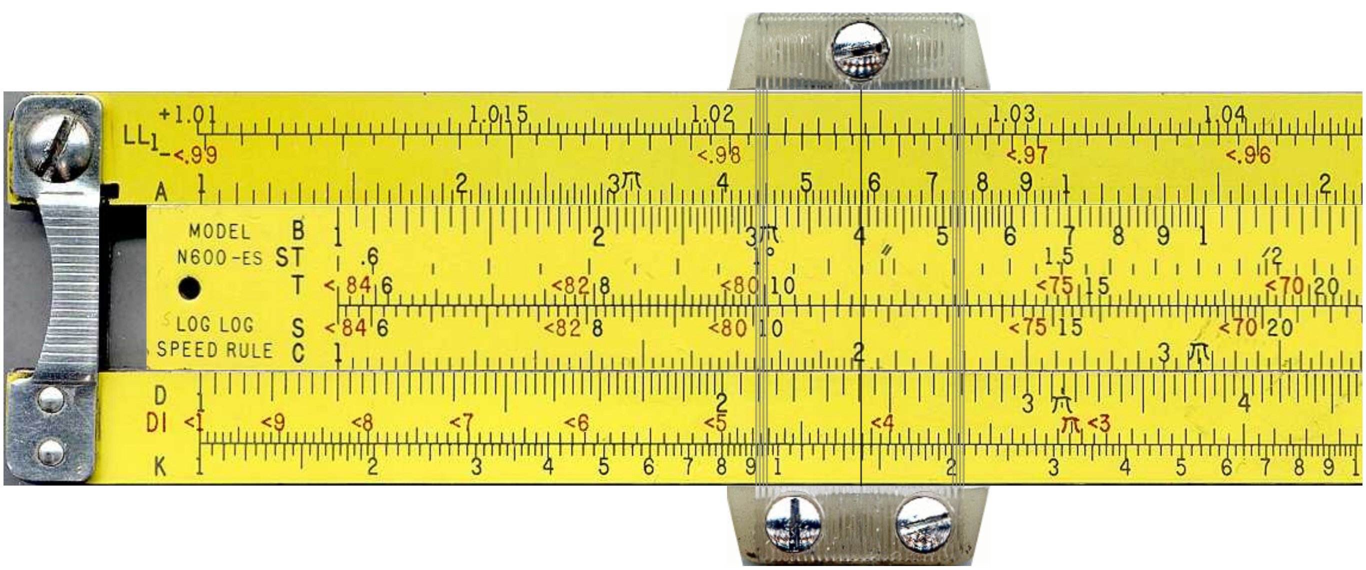
   Question: How does the top scale compare to the bottom scale for a given gradation?

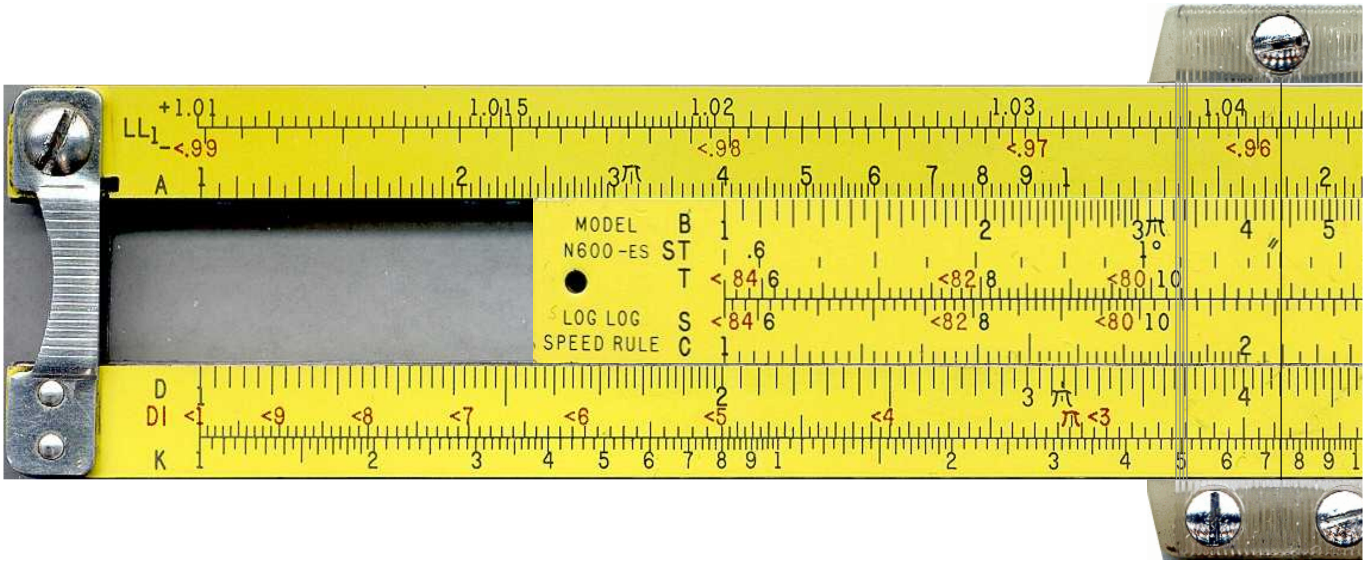
4 Reading the Slide Rule

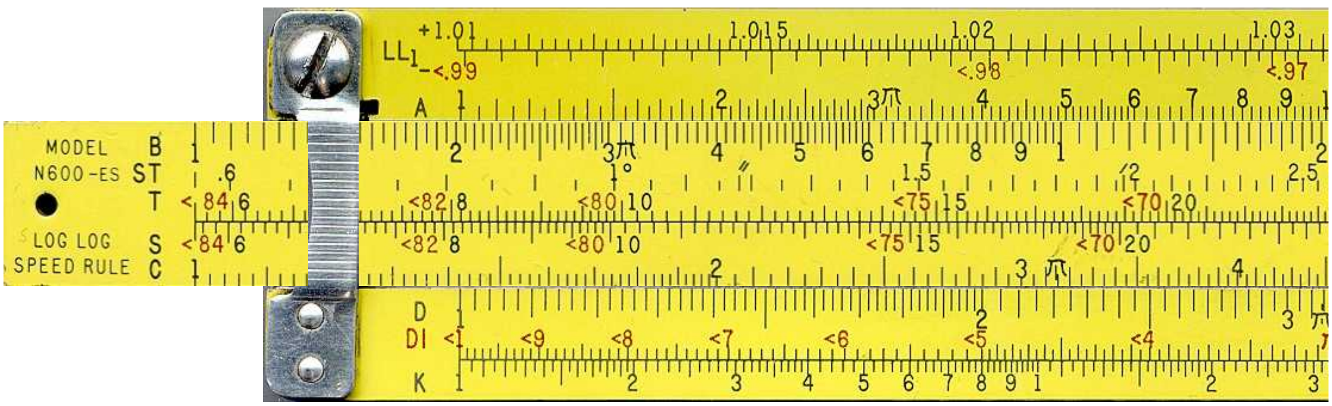
Images from `http://www.antiquark.com/sliderule/sim/virtual-slide-rule.html`











5 Somethings to Consider with Slide Rule Calculations

1. What is the largest multiplication you can calculate?

2. What is the most accuracy that you can obtain with slide rules?

3. How much accuracy do you need with a slide rule?

4. How are A/B related to C/D?

5. How is K related to D?

6. How is C_1 related to C?

6 Slide Rule Calculations

1. 1.2 x 3.6 =
2. 2 x 3.6 =
3. 1.7 x 3.6 =
4. Draw 2 slides and show how you line them us to calculate xy (x multiplied by y):
5. 3 / 1.5 =
6. 3.6 / 4.2 =
7. Draw 2 slides and show how you line them us to calculate x/y (x divided by y):
8. 4.2 x 6.7 =
9. Question: What do you do when you run out of slide? Draw the slides for another process:
10. 1^2
11. 3^2
12. 6.2^2 =
13. 3.6^2 x 4.3^2 =
14. Draw 2 slides and show how you line them us to calculate x^2 (x squared)
15. $\sqrt{2}4$
16. $\sqrt{6}7$
17. Draw 2 slides and show how you line them us to calculate $\sqrt{x}$ (square root of x)
18. $\sqrt{4}5$ $\sqrt{3}6$=
19. Log(1)
20. Log(6)

7 Additional Resources

- `http://www.sliderulemuseum.com/` International Slide Rule Museum:
  - `http://www.sliderulemuseum.com/` Slide Rule Course
  - `http://sliderulemuseum.com/SR_Loaner.htm` Slide Rule Loaner Program
- `http://www.youtube.com/watch?v=Zmv_R2hOnNI&feature=related` - Building the multiplication Table
- `http://www.hpmuseum.org/sliderul.htm` - HP Museum Slide Rule Article
- `http://jamiecolliemathematics.blogspot.com/2010/12/test-955.html` Logarithms: Much More Than Just a Button on the Calculator!
- `http://www.antiquark.com/sliderule/sim/n909es/virtual-n909-es.html` Virtual Pickett Slide Rule
- `http://www.tcf.ua.edu/AZ/ITHistoryOutline.htm` History of Calculations

USING THE A OR B SCALE:

The A and B scales are made up of 2 half size or half length logarithmic scales, therefore they are the SQUARE of the C and D scales. For practice, remove the slide. You now can clearly read the A against the D scale. Slide the cursor along, until the hairline is over 3 on D—you will read 9 on the **left** half of the scale.

The square of 5 on D is 25 on the **right** scale of A. **(SEE BELOW)**

The square of 26 is 676 on the **left** scale of A.
The square of 19 is 361 on the **left** scale of A.
The square of 55 is 3025 on the **right** scale of A.

Note that the products have **even** and **odd** numbers of digits. When square root is learned, this factor is most important in determining which scale to use.

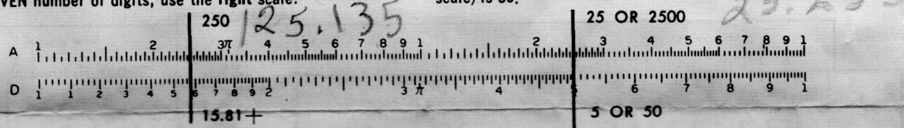
SQUARE ROOT:

Since the A scale is the square of the numbers on D, in turn, the numbers on D are the square roots of the numbers on scale A. Of prime importance here is which half of the A scale to use when putting the number to be divided into its square root "into the rule." The rule for this is simple. If ODD number of digits, use the **left** scale. If EVEN number of digits, use the **right** scale:

The square root of 25 (even number of digits—**right** scale) is 5 on D

The square root of 250 (odd number of digits—**left** scale) is 15.81+ on D scale.

The square root of 2500 (even number of digits—**right** scale) is 50.



USING THE K SCALE:

The K scale, you will note, consists of 3 log scales instead of 2 as in A. The result is that these figures are the CUBE of the D scale figures. 3 X 3 X 3 = 27, or the cube of 3 can be read directly on K by placing the cursor over 3 on D and reading 27 on the MIDDLE part of K scale. Also, the CUBE ROOT of 64 read on K on MIDDLE scale, is 4 (4 X 4 X 4). Since there are 3 scales, **left, middle,** and **right,** the rule for use of them in determining the number to put "into the rule," the **left** scale is for numbers of 1 digit, the middle scale for **2 digit numbers,** the **right** scale for **3** digit numbers.

The rule to be learned is as follows: FROM THE DECIMAL POINT, divide the number into groups of 3 digits. Now, skip over the groups of 3 next to the decimal, and determine the number of digits in the "outside" numbers. If it is only 1 digit—use the **left** part of the K scale in your computation. If 2 digits, the center part of K, if 3 digits, the **right** side of K. For instance:

1—125. has three digits **left** of decimal—use **right** K — 5 = CUBE ROOT

2—1.25 has 1 digit **left**—2 digits **right** of decimal. Since the number is more than 1 (by .25) the answer will be found in conjunction with the **left** scale (main number from 1 to 10) 12.5 would be read in the **middle** scale, since it has 2 digits in the whole number .1250 has 1 digit **right** of the first set of 3 numbers, so answer would be found in **right** scale.

THE L SCALE:

This scale is actually a graduated scale exactly 125 millimeters long. It is graduated into 500ths of this length since this length is the same as the log scale. Therefore, by reading a number on this scale we can find the **logarithm** of any number on the D scale. Note that the numbers are preceded by a decimal point, reading therefore from 1. to 0.

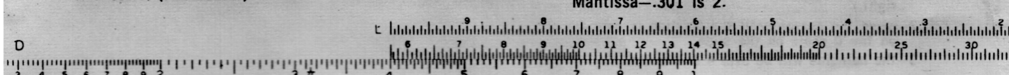
Place one index of the "L" scale against the log. number on D. Read the answer against the other factor at end of D scale. **(SEE BELOW)**

Be sure to include all decimal points, including the one on the scale in your answer. The mantissa of the logarithm is read directly on the L scale, above the index of D.

EXAMPLE: log. 4 (D scale) is .6021 (L scale)
log. 2 (D scale) is .301 (L scale)

Inversely, set the mantissa over the index of D, and read the answer or base number on D below the index of L.

Mantissa—.6021 is 4.
Mantissa—.301 is 2.



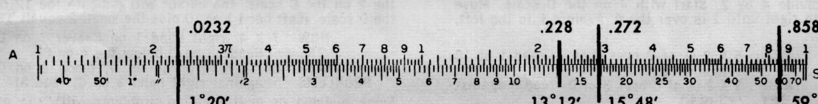
THE S SCALE:

This scale is for direct reading of the sines of angles. The scale is divided in degrees, minutes and seconds. The scale is used in conjunction with the A scale to read the answer directly. It must be noted that sines above 60° must be carefully judged, since the scale decreases rapidly. The scale divisions are in minutes (60' EQUAL 1°) with degree numbers in 10s.

To determine the Sine of an angle, follow this example:
Sin 15°48'—Set hairline over 15°48' on S scale—read .272 on A. **(SEE BELOW)**

(Remember that the **left** scale on A is .1 of **right** scale, therefore an additional decimal is required.)

Sin 4°20' is .0756



THE T SCALE:

The tangent scale starts at 5.7° and increases up to 45° on the **right.** To find the tangent of 6°45' or 6.75° place the hairline over 6°45' on T and read .1184 on the D scale. **(SEE BELOW)**

It can be seen here also that multiplication of the sine or tangent is only a matter of finding the sine or tangent of the required angle, then transferring this to the D scale, by reversing the slide, and, putting the 1 of the C scale against the hair line, multiply as required, reading your answer on D.

EXAMPLE: With slide even with scale A, Sin 13.2° or 13°12' reads 228 on A **(SEE ABOVE).** Remove slide and turn over. Now transfer .228 to D and place left 1 of C on .228. To multiply this by, say 14.6, place cursor over 14.6 on C and read 3.33 on D at hair line.

In quick review, here is a problem in each of the scales: check your answers with these, and if any question, refer to the proper instruction:

24.5 X 13.7 (C & D scales) **Answer:** 335.65 (last 2 numbers approximated)

924 ÷ 16 (C & D scales) **Answer:** 57.75

42 X 42 (42^2) (D & A scales) **Answer:** 1764 (end 2 of each number multiplied together gives last 4)

Square root of 2450. **Answer:** 49.5 (A scale—right half—answer on D)

9 X 9 X 9 (9^3) D and K scale. **Answer:** 729 (approx. 730 on scale)

Cube root of 125 (D & K scales—right side of K because of 3 digits)

Answer is 5 on D scale.

Log 6—(REVERSE SLIDE—Use L and D scale)—.778

Sin 13.4° or 13°24'—S and A scale. **Answer:** .232

Tangent 6.75° or 6°45'—T and D scale—.1185

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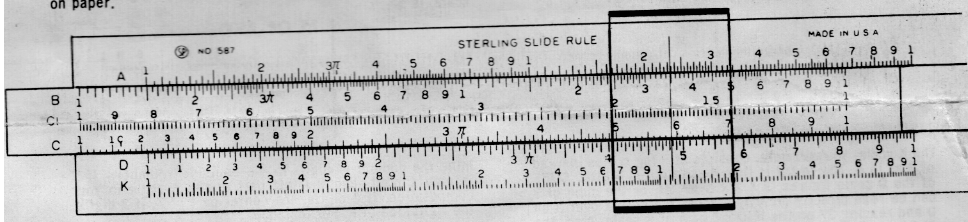
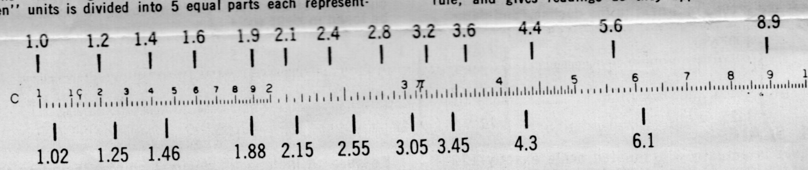
The Sterling Slide Rule has standard A, B, C, C_I, D, and K scales. The A, D, and K scales are on the body, the B, C_I and C scales on the **slide.** The **cursor** travels the full length of the body, and the hairline crosses these scales for direct comparison. On the reverse side of the slide, the S, L, and T scales appear, and the slide may be removed and reversed for use in calculating these **factors** for trigonometry problems.



MULTIPLICATION AND DIVISION

For this work, use only the C and D scales, and in some cases the C_I scale. The C and D scale start with the unit 1 at the left, thru the unit 10 (or 1) at the right. The space between 1 and 2 has small numbers indicating the "teens" following the left hand 1 or 10. Each of these "teen" units is divided into 5 equal parts each representing 1/5 or .2 of the unit. The numbers from 2 thru 5 have the units divided into 1/2 or .5—and the numbers from 5 to 1 (or 10) are in full units only. When reading the rule, these variables must be kept in mind for accuracy. The diagram below shows these as they appear on the rule, and gives readings as they appear:



MULTIPLICATION:

On a logarithmic scale, the progression of numbers is constant, therefore, the multiple of any unit or number of units can be read only if we place the factor 1 on the line of one of the factors in the problem. **The problem of 2 X 2 is therefore solved as follows:**

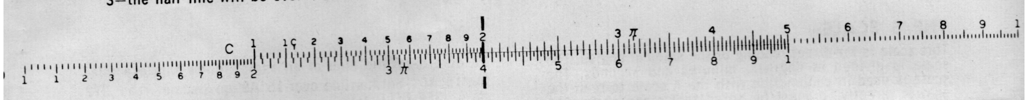
1—move the slide until the figure 1 at the **left** is over the 2 on the D scale. (Move the slide to the **right.**)

2—move the cursor until the hairline is over the 2 on the C scale on the slide.

3—the hair line will be over 4 on the D scale.

Similarly you will note 3 X 2 = 6, 4 X 2 = 8, 5 X 2 = 1 or 10 as you read across the scale.

Bear in mind that this 2 or the 2 on the C scale can represent, 2, 20 or 200. Also remember that the answer to the problem **always** appears on the same scale from which you **started**, usually the D scale.



DIVISION:

Since division is the reverse of multiplication, we reverse the procedure shown in multiplication, as follows: **Problem:** divide 4 by 2. Start with 4 on the D scale. Move slide to **right** until 2 is over the 4. Against 1 to the **left,** read 2.

NOW TRY THESE PROBLEMS

- 5 X 2 (1 of C over 5 of D—read 1 or 10 against 2 of C)
- 3 X 3 (1 of C over 3 of D—read 9 against 3 of C)
- 8 ÷ 2 (2 of C over 8 of D—read 4 against 1 of C)
- 5 ÷ 4 (4 of C over 5 of D—read 1.25 against 1 of C) **(SEE BELOW)**

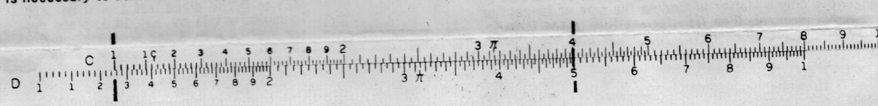
For numbers which when multiplied are more than 10, it is necessary to achieve the same effect by using the **right** hand 1 (or ten) as the factor. For instance, 2 X 6 = 12. By placing the **right** hand 1 over 6 and reading against the 2 on the C scale, the cursor will indicate the 12 on the D scale. (**Left** hand 1 or 10 plus the small 2 equals 12)

NOW TRY THESE PROBLEMS

- 7 X 4 (**right** hand 1 on C over 7 on D. Read 28 on D below the 4 on C)
- 64 ÷ 8 (over 64 on D, place 8 on C. Against **right** hand 1 on C, read 8)

Some division or multiplication problems will "run off the rule." In this case, reverse the slide, using the **right** hand or **left** hand 1, and read the answer as shown.

EXAMPLE: 4 X 4—put **left** hand 1 on C against 4 on D. The 4 on C is "off the rule." Slide the slide to the **left** until the **right** hand 1 is over 4 on D. Against 4 on C, read 16 on D.



USING THE C_I SCALE:

The C_I scale is the same as the C scale, it reads from **right to left.** This scale is the RECIPROCAL of the C scale, and can be used to avoid the necessity of moving the slide **left** or **right.**

EXAMPLE: 4 X 4—Reading from the RIGHT on C_I, place the 4 above the 4 on D—against the **left** hand 1 on C_I, read 16 on D. **(SEE BELOW)**

24 ÷ 4—place **left** hand 1 on C_I above 24 on D—Against 4 on C_I read 6 on D.

The C scale represents the fraction (decimal) of the C_I scale.

EXAMPLE: 1/8 = .125—Against 8 on C_I read .125 on C. **(SEE BELOW)**