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Logarithms and Slide Rules
DIY (Do-It-Yourself) Math Workshop

Dr. Ralph deLaubenfels

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DIY (Do-It YOURSELF)

LOGARITHMS and SLIDE RULES

WORKSHOP

As with all DIY Workshops,

Writing / drawings in red ______
are written on a chalkboard
& possibly spoken;

Writing in quotes in black
"______" is said out loud to
students, not written;

Writing not in quotes in black
______ is suggested, not
spoken or written

TABLE OF CONTENTS

I. PREREQUISITES

Knowledge of exponents is desirable, although some review will be provided.

Students should know how to use rulers with marks 1/8 inch apart.

Students should know how to add fractions & mixed numbers.

II. MATERIALS NEEDED

Two or more chalkboards, that we will call Board 1, Board 2, etc.

For each participant, including yourself, need

(1) pen + pencil

(2) two rulers

(3) many (at least 5) cardstock blank rectangles, 1½ inches wide, 11 inches long

(4) from the end of this exposition, copy of log tables & log data sheets (both filled-out & not filled-out:

'2 THROUGH 10', '0.5's', 'TENTHS,' & 'DOUBLE LOG DATA'.

III. INTRODUCTION

"A slide rule, in its simplest form is a pair of sticks you can use to multiply. The sticks are constructed with logarithms."

Board 1

SLIDE RULE:

Two log sticks that multoply.

LOG is short for LOGARITHM

("log-uh-rithum")

HISTORICAL IMAGINATION:

before calculators, multiplication was difficult.

"To understand logs, we need to understand exponents, in particular, powers of 10."

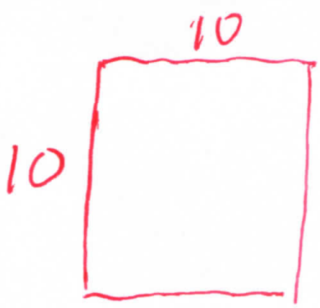
IV. EXPONENTS

Board 2

Exponent Terminology:

$100 = 10 \times 10 = 10^2$ "ten squared"

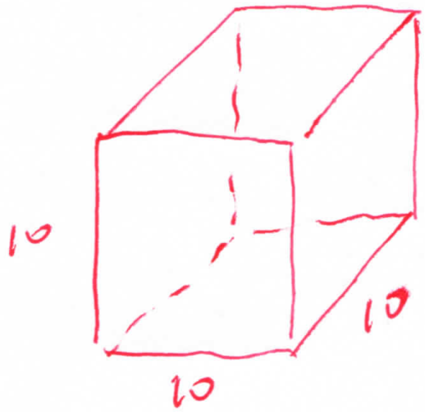
or "ten to the second power"



The "2" is an exponent

$1{,}000 = 10 \times 10 \times 10 = 10^3$ ← exponent of 3,

"ten cubed" or "ten to the third power"



new Board 1

$10{,}000 = 10 \times 10 \times \ldots ??$ "How many tens?"

$= 10^{??}$ "What is the exponent?"

"Exponent measures how many times you multiply by 10" new Board 1 continued:

For $n = 1, 2, 3, \ldots$

10^n ("ten to the n")

$$= \underbrace{10 \times 10 \times 10 \times \cdots 10}_{n \text{ times}}$$

e.g.,

10^{13} ("ten to the thirteen")

$$= 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$$

count number of 10s

out loud

"We won't get into the definition of 10^x for arbitrary x, e.g., 10^{π}."

new Board 2

"Can show" $10^0 = 1$

$10^{-1} = \frac{1}{10}$, $10^{1/2} = \sqrt{10}$, the <u>square</u> <u>root</u> of 10

$$\left((\sqrt{10})^2 = \sqrt{10} \times \sqrt{10} = 10 \right)$$

V LOGS, short for LOGARITHMS

"For powers of ten, log is a sort of shorthand."

new Board 1

$\log(10) = \log(10^1) = 1$

$\log(100) = \log(10^2) = 2$

$\log(1{,}000) = \log(10^3) = 3, \ldots$

$\log(\text{a billion}) = \log(1{,}000{,}000{,}000) = 9$

$\log(1)$? (ask students) $= 0$, since $1 = 10^0$

$\log(\sqrt{10})$? (ask students) $= \frac{1}{2}$, since $\sqrt{10} = 10^{1/2}$

p. 11

"Logs are opposites of exponents, telling you what power of 10 a number is"

new Board 2

"e.g." $\log(10{,}000) = 4$

since $10{,}000 = 10^4$

$\log(1{,}000{,}000) = 6$

since $1{,}000{,}000 = 10^6$

"In general" $\log x = y$

MEANS $x = 10^y$

"NOTE"

new Board 1

If $10{,}000 \mapsto 100{,}000$ $\left(\begin{array}{c}\text{multiply}\\ \text{by } 10\end{array}\right)$

then

$4 = \log(10{,}000) \mapsto \log(100{,}000) = 5$ $\left(\begin{array}{c}\text{add}\\ 1\end{array}\right)$

Increasing the log of a number by 1

is THE SAME as

multiplying the number by 10.

Examples 1. The <u>Richter scale</u>, which measures the intensity of an earthquake, is a log.

Thus a Richter scale measurement of 7 describes an earthquake ten times as intense as a measurement of 6.

2. Another log: pH,
which measures the strength of an acid or base. For example, a pH of 5 is ten times as acidic as a pH of 6.

HAND OUT log tables

DEMONSTRATE:

new Board 2

What is (~) log(1.73)?

number	logarithm
1.73	0.238

→ log(1.73) = (~) 0.238

(MEANS $1.73 \simeq 10^{0.238}$)

Have students practice getting logs; e.g., log(8.0), log(1.87), more?!.

DIFFERENT TYPE of question:

What number has (~) a log of 0.562?

number	logarithm
3.65	0.562

→ 3.65 has a log (~) of 0.562

(we've "unlogged" 0.562)

(MEANS $3.65 \cong 10^{0.562}$)

new Board 2

What number has a log of 0.2?

number	logarithm
1.58	0.199 ←
1.59	0.201 ←

1.58 or 1.59 has a log of (~) 0.2

Have students practice getting a number whose log is:

0.301; 0.8; more??

VI. MULTIPLICATION with LOG TABLES and ADDITION

"Look up logs of 2, 3, + 6"

new Board 1

$$\log 2 \simeq 0.301$$

$$\log 3 \simeq 0.477$$

$$\log 6 \simeq 0.778$$

"What is relationship between 2, 3, + 6?"

(Students should answer)

"What is relation-ship between the logs 0.301, 0.477, & 0.778?"

p. 19

(Students should answer)

$\log 2 \simeq 0.301$

$\log 3 \simeq 0.477$

$\log 6 \simeq 0.778$

new Board 2

$$\begin{array}{r} \log 2 \simeq 0.301 \\ + \log 3 \simeq 0.477 \\ \hline \log(2 \times 3) \simeq 0.778 \end{array}$$

log of product   sum of logs

new Board 1

IMPORTANT FACT!

$\boxed{\text{log of product is sum of logs}}$

$\left(\log(a \times b) = \log a + \log b \right)$

Log changes multiplication to addition

HARD

EASY

This page is OPTIONAL

"We can see the IMPORTANT FACT with powers of 10;

e.g.,

new Board 2

log. of product $= \log(10^4 \times 10^2) =$

$\log((10 \times 10 \times 10 \times 10) \times (10 \times 10))$ "count number of tens"

$= \log(10^6) = 6 = 4 + 2 =$

$\log(10^4) + \log(10^2) =$ sum of logs

new Board 1

IMPORTANT FACT

$$\boxed{(\text{log of product}) = (\text{sum of logs})}$$

USE THIS, with log tables, to multiply

("This was Napier's goal in inventing logs")

new Board 2

USE log tables to get

2×1.5

$$\begin{array}{r} \log 2 \simeq 0.301 \\ + \log 1.5 \simeq 0.176 \\ \hline \log(2 \times 1.5) \simeq 0.477 \end{array}$$

log of product — sum of logs

"Unlog": get number whose

log is $\simeq 0.477$

new Board 1

Number	Log
???	0.477

From log table:

$$\log 3 \simeq 0.477$$

$\rightarrow \log(2 \times 1.5) = \log 3$

$\rightarrow 2 \times 1.5 = 3$

Students should use,

with your guidance & hints,

log tables &

new Board 2

IMPORTANT FACT

$$\boxed{(\text{log of product}) = (\text{sum of logs})}$$

to approximate the following

products.

1. 1.18×2.25

2. 1.56×3.95

After students work on Product 1 put on board:

$$\begin{array}{r} \log 1.18 \simeq 0.072 \\ + \log 2.25 \simeq 0.352 \\ \hline \log(1.18 \times 2.25) \simeq 0.424 \end{array}$$

log of product

sum of logs

$= \log(??)$

(see next page)

Number	Log
2.65	0.423 ← closest to 0.424
2.70	0.431

$$\rightarrow \log(1.18 \times 2.25) \simeq \log(2.65)$$

$$\rightarrow (1.18 \times 2.25) \simeq 2.65$$

After students work on Product 2, put the next page on board:

$$\log 1.56 \simeq 0.193$$
$$+\log 3.95 \simeq 0.597$$

$$\log(1.56 \times 3.95) \simeq 0.790 \simeq \log 6.2$$

$$\rightarrow (1.56 \times 3.95) \simeq 6.2$$

REST of this page, & next page, is OPTIONAL

"We may use the IMPORTANT FACT of logs to greatly expand the set of numbers we may take logs of."

For example,

$$\log(1{,}120) = \log(1.12 \times 10^3)$$
$$= \log(1.12) + \log(10^3) \simeq$$
$$0.049 + 3 = 3.049$$

(1.12×10^3 is scientific notation for 1,120)

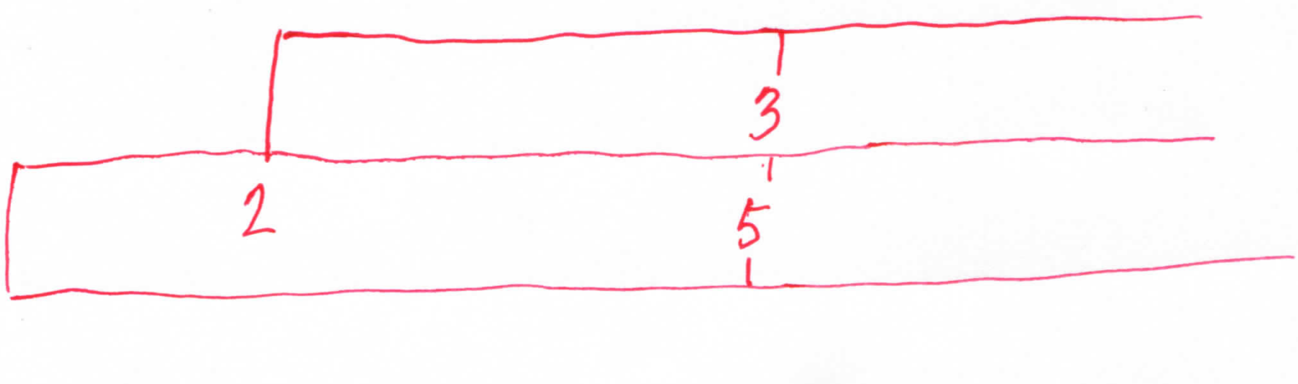
VII. LOG STICKS

Hand out two rulers to each participant (including yourself).

" Can add with a pair of rulers."

" For example, suppose you didn't know (2+3)."

Have students do, with you. (new Board 2):

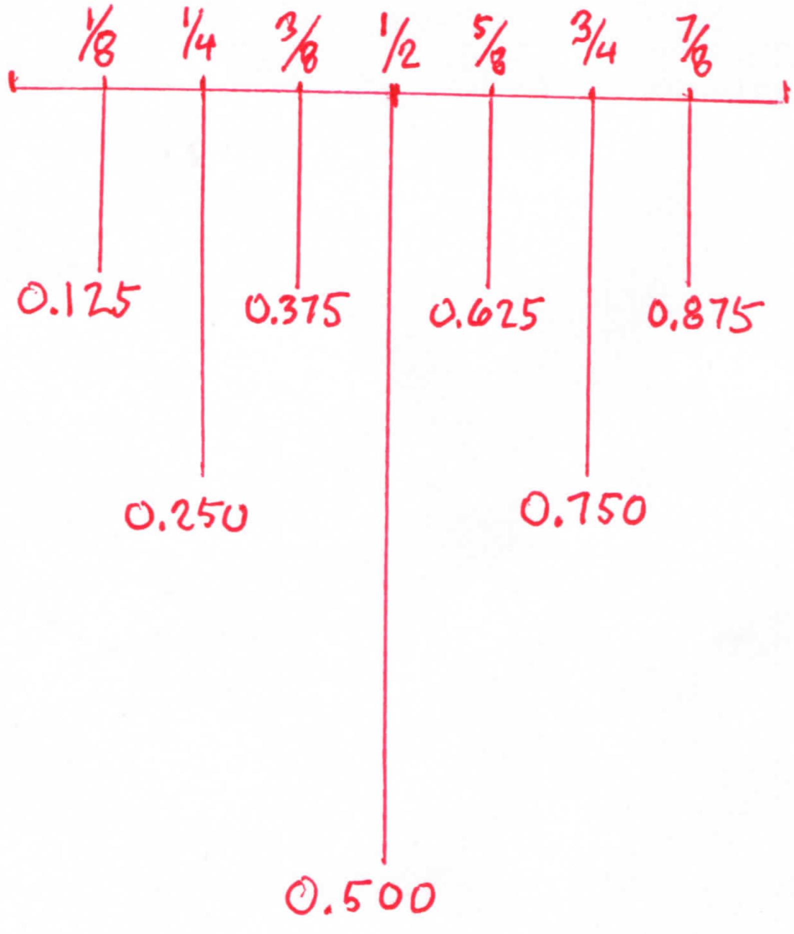


"This tells us (2+3) = 5"

Have students do this with (4+7), (1+6); more?? p. 31

"For adding numbers with decimals, need to convert to multiples of $\frac{1}{8}$, to use rulers."

Leave the picture on the next page up on Board 1 for a while (at least through the full construction of log sticks, near the end of VIII).


1/8
1/4
3/8
1/2
5/8
3/4
7/8
0.125
0.250
0.375
0.500
0.625
0.750
0.875

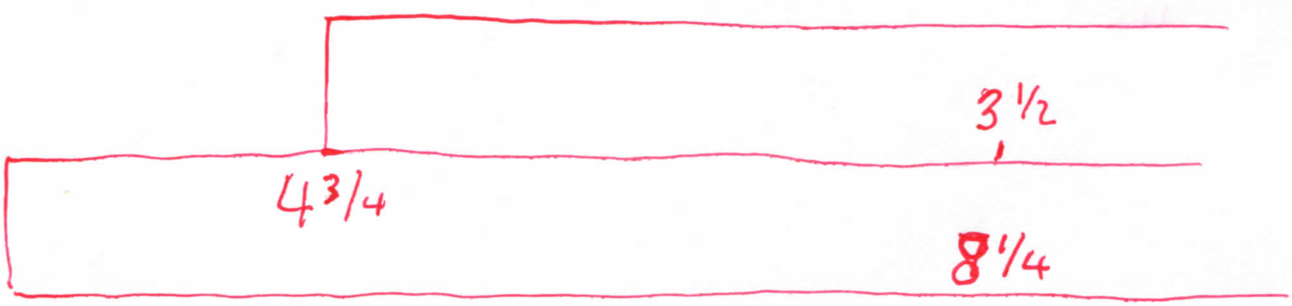
new Board 2 p. 33

"For example, to add, with rulers,

$(4.7 + 3.5)$,

"Note that 0.7 is closest, in (*), to 0.750, so add"

$4.750 + 3.500 = (4\,3/4) + (3\,1/2)$

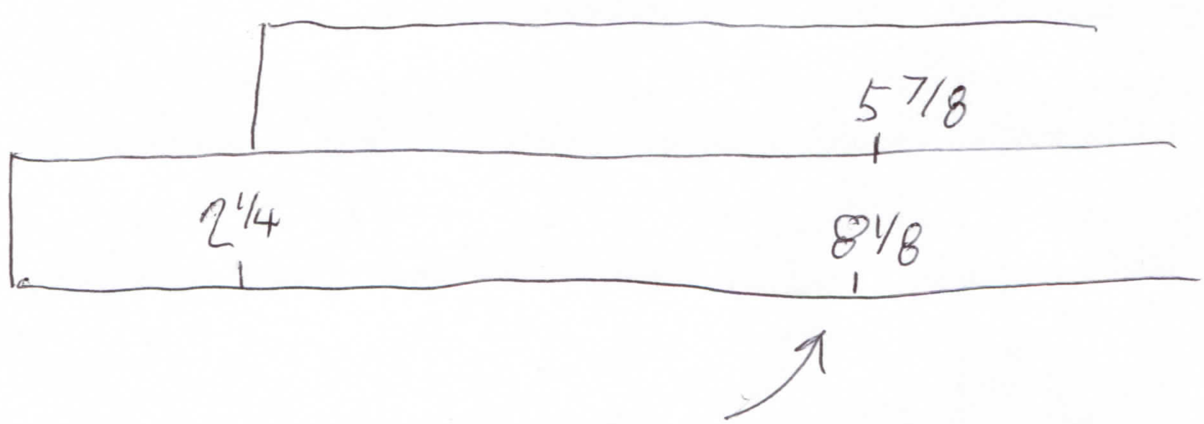


ANSWER:

$8\,1/4 = 8.25$

Have students get (2.3 + 5.9), with rulers of (*).   p. 34

They should get ($2\frac{1}{4} + 5\frac{7}{8}$), as drawn below



ANSWER:

$8\frac{1}{8} = 8.125$

"Recall that adding logs of numbers corresponds to multiplying the numbers. p. 35

We need to do addition with log sticks: like rulers, except distances are logs."

To each participant, give a pencil, a blank card stock rectangle, & the unfilled-out version of

LOG DATA: 2 THROUGH 10

"E.g., for marking 2 on your log stick, use log tables to get" p. 36

$\log 2 \simeq 0.301$

"then multiply by 10"

$10 \log 2 \simeq 3.01$

"then use (✳)" (point to (✳) still on Board 1)

"to get the best ruler approximation of $10 \log 2$."

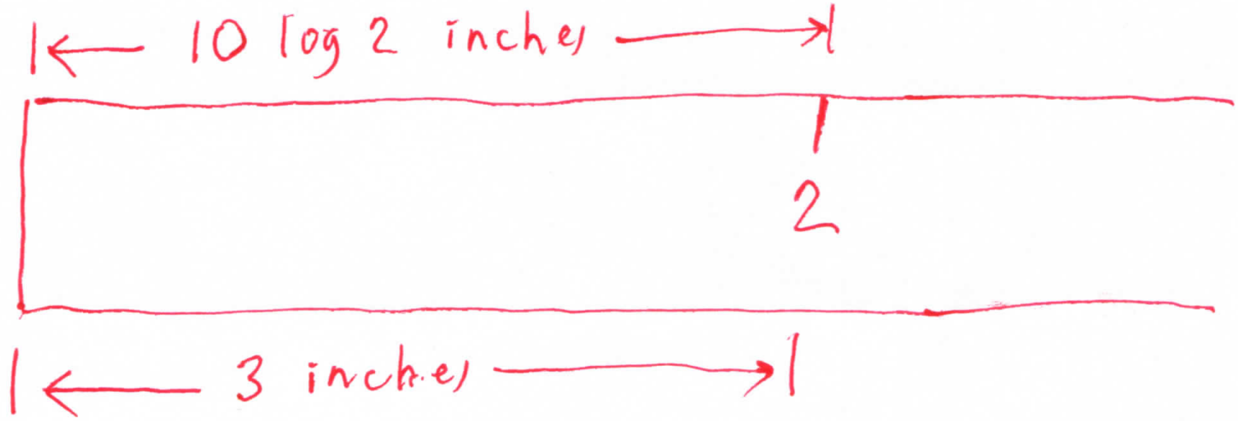
$10 \log 2 \sim 3$

"Here's how to fill in the 1st row of"

LOG DATA: 2 THROUGH 10

number	log	×10	ruler ~
2	0.301	3.01	3

"Here's how you mark 2 on your log stick:" p. 38

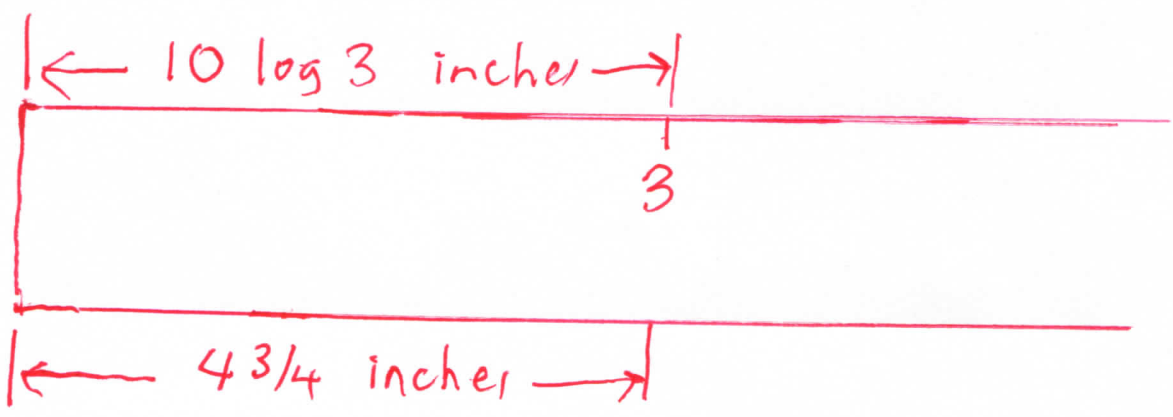


"For marking 3, fill in numbers on LOG DATA: 2 THROUGH 10 starting with 3 on the left, as we did with 2:"

p. 39

number	log	x 10	ruler ~
3	0.477	4.77	4 3/4

"This tells us to mark 3 on our log stick as follows:"



Have students (+ yourself) continue filling in rows of

LOG DATA: 2 THROUGH 10;

when finished, put filled-out version of LOG DATA above on Board 2, have students check their numbers.

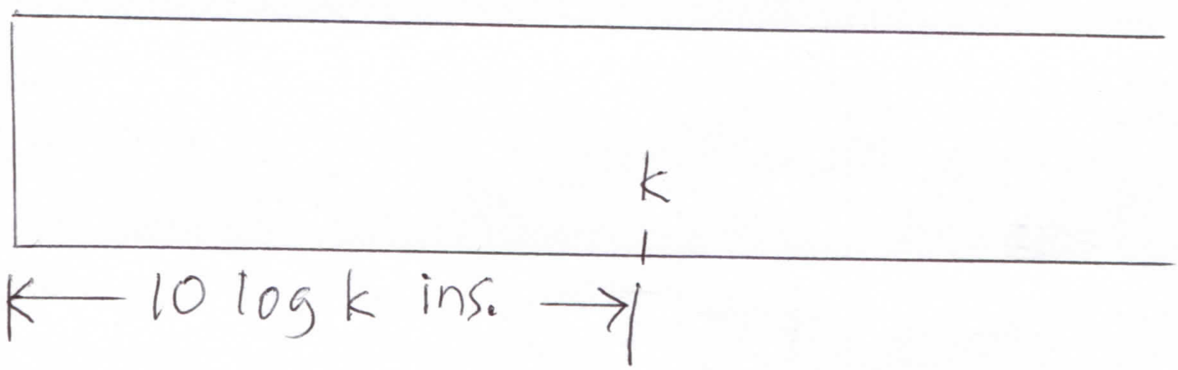
Have students (+ yourself) use the last column of filled-out

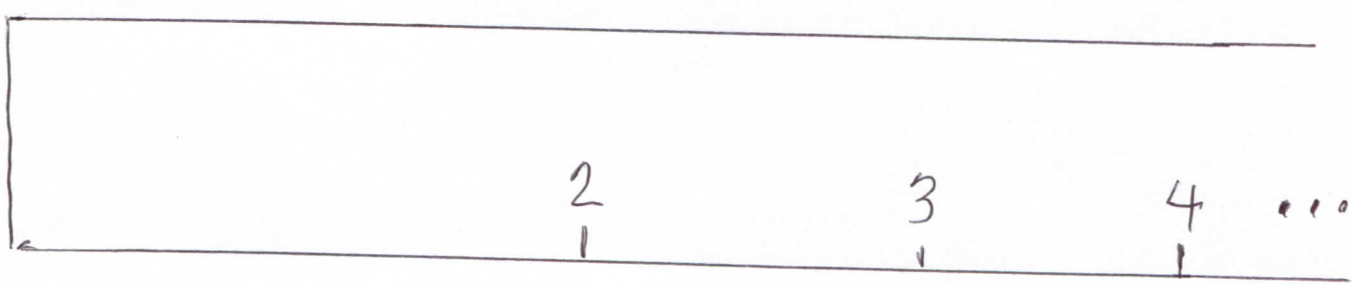
LOG DATA: 2 THROUGH 10

to make marks

$k = 2, 3, 4, \ldots, 10$

on your log sticks





Check that your log stick (see next page) matches the students! Then hand out pens, have students ink in pencil marks.

f° 42

2

3

4

5

6

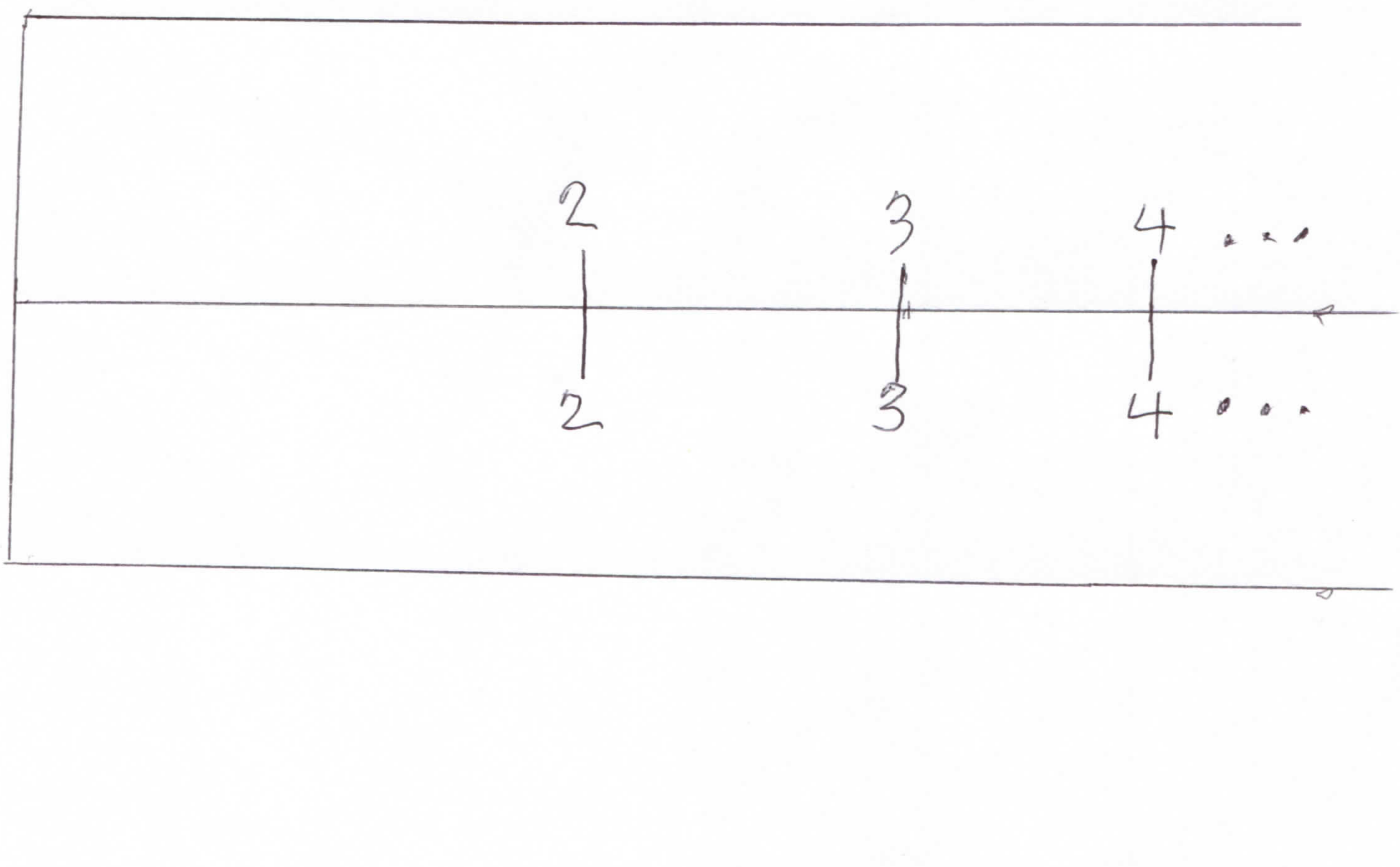
7

8

9

10

Have each student (including yourself) make a second log stick as the mirror image of the first log stick:



VIII MULTIPLICATION with LOG STICKS & ADDITION

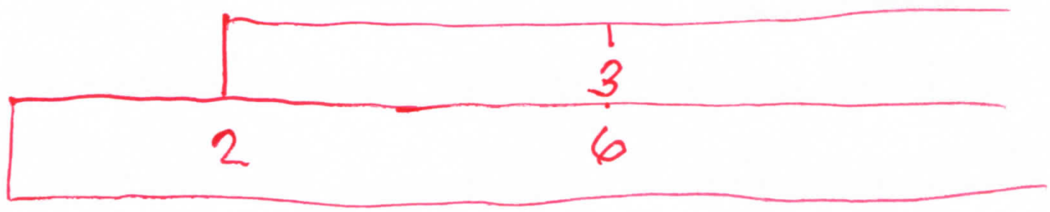
new Board 2

RULERS: add

LOG STICKS: add logs ~ multiplying

Have students multiply with their log sticks starting with (2x3)

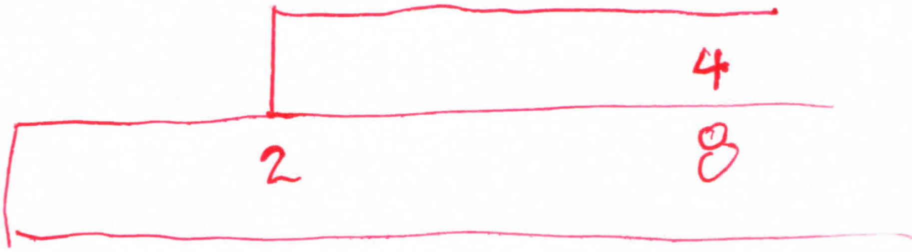
(see next page)



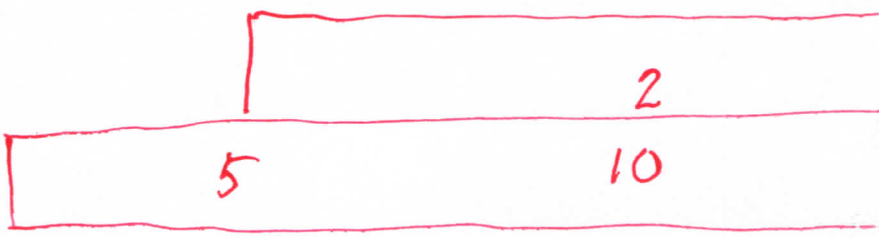
→ $(2 \times 3) = 6$

Have students work on
(with log sticks)
(2×4), (5×2), (3×3);

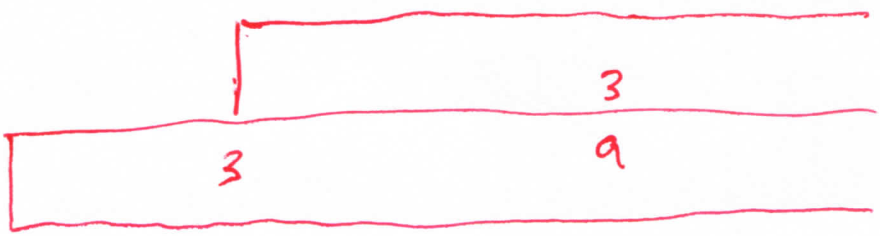
eventually put correct picture,
(see next page) on new Board 2.



→ $(2 \times 4) = 8$

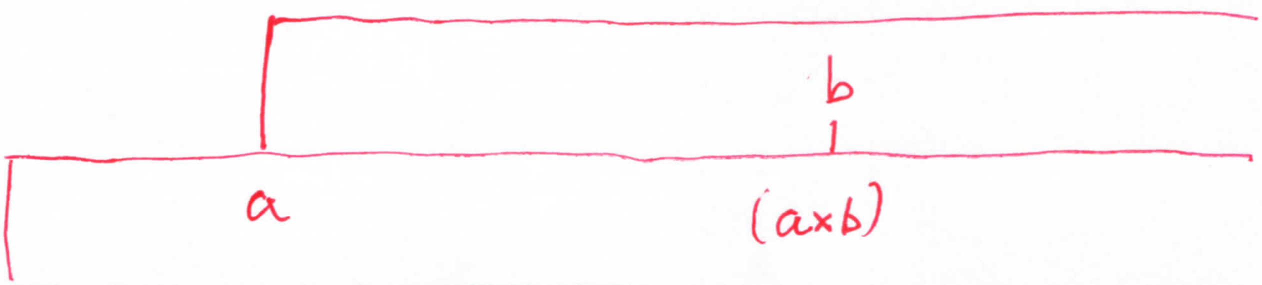


→ $(5 \times 2) = 10$



→ $(3 \times 3) = 9$

IN GENERAL



Hand out

LOG DATA: TENTHS &

LOG DATA: 0.5s,

both not filled-out, to each student (including yourself)

"Refine your log sticks by filling out the LOG DATA you just received, then marking (1st in pencil) your numbers on your log sticks, as you did with prior LOG DATA."

new Board 2

(Board 1 should still have (*), from page 33)

EXAMPLE (for LOG DATA TENTHS)

number	log	x 10	ruler ~
1.3			

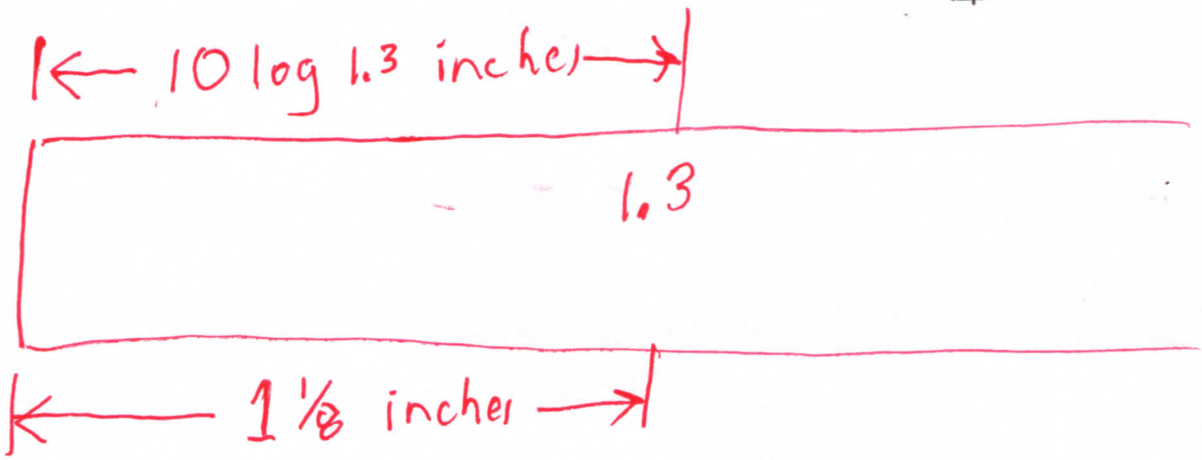
↓

number	log	x 10	ruler ~
1.3	0.114	1.14	1 1/8

↓

(see next page)

p. 49

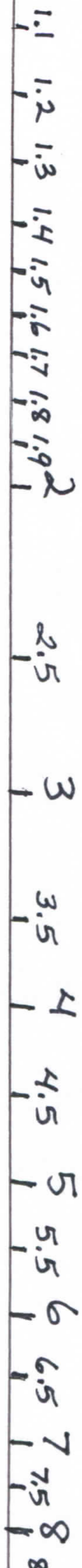


Give students time to fill out the LOG DATA they just received (they might have questions for you), then hand out the filled-in versions of our LOG DATAs; students should check that their numbers are correct.

Give students time
to fill out their log sticks;
check that all sticks are correct
(line up the stick on the next
page with the students' sticks);
then have students fill in pencil
with pen.

"Now let's approximate, with
our log sticks, products that
we don't immediately know."

p. 51



On Board 2,

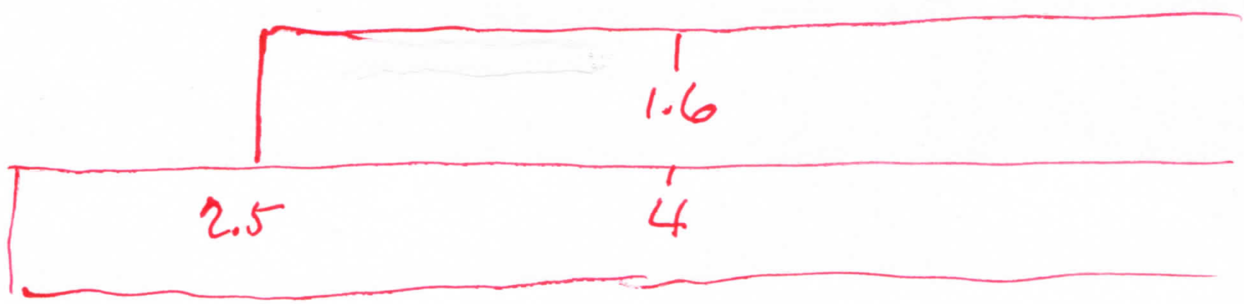
write

p. 52

Get (2.5×1.6) with log sticks

Give student time, then draw

on new Board 2



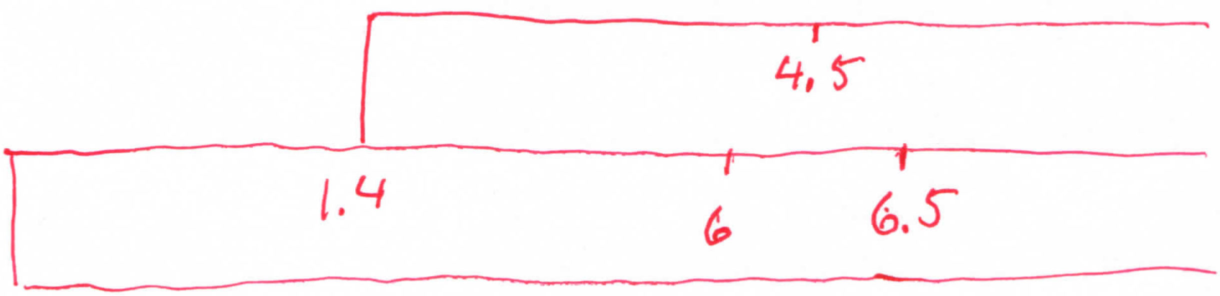
$\rightarrow$ $(2.5 \times 1.6) \simeq 4$

new Board 2 p. 53

Get (1.4×4.5) with log sticks:

Afer students work:

new Board 2



Answer ~ 6 or 6.5

COULD AVERAGE!

$$(1.4 \times 4.5) \simeq \tfrac{1}{2}(6 + 6.5) = 6.25$$

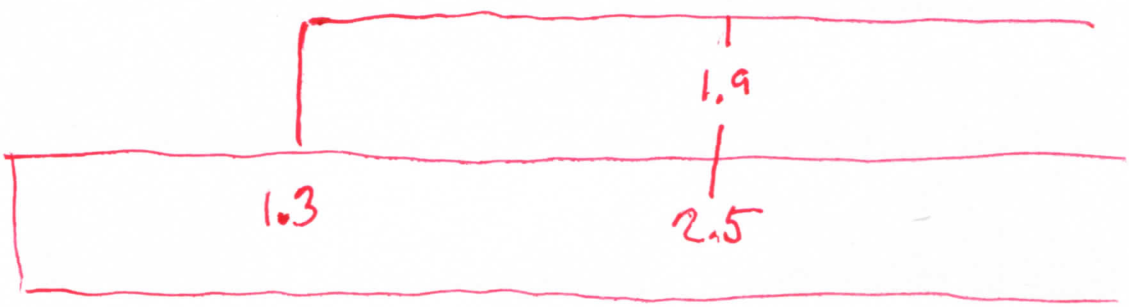
More ?? (only do products that are ≤ 10)   p. 54

new Board 2

$13 \times 19? = (1.3 \times 10^1)(1.9 \times 10^1) =$

$100 \times (1.3 \times 1.9) \simeq$ (see below)

$100 \times 2.5 = 250$



"We need a different technique for products > 10." p. 55

COULD END workshop here, with our only skill being, after factoring out powers of 10, getting $(a \times b)$ when

$1 \leq a \leq 10$, $1 \leq b \leq 10$, & $(a \times b) \leq 10$

IX. MORE LOG STICK MANIPULATION (optional)

Here are some (optional) additional slide-rule skills you could include in your workshop; we hasten to say the techniques given may not be the easiest or quickest.

Optional #1: p. 57

Get $(a \div b)$, when $1 \leq b \leq a \leq 10$.

Optional #2:

Get $(a \times b)$, when $1 \leq a \leq 10$, $1 \leq b \leq 10$.
& $(a \times b) > 10$

Optional #3:

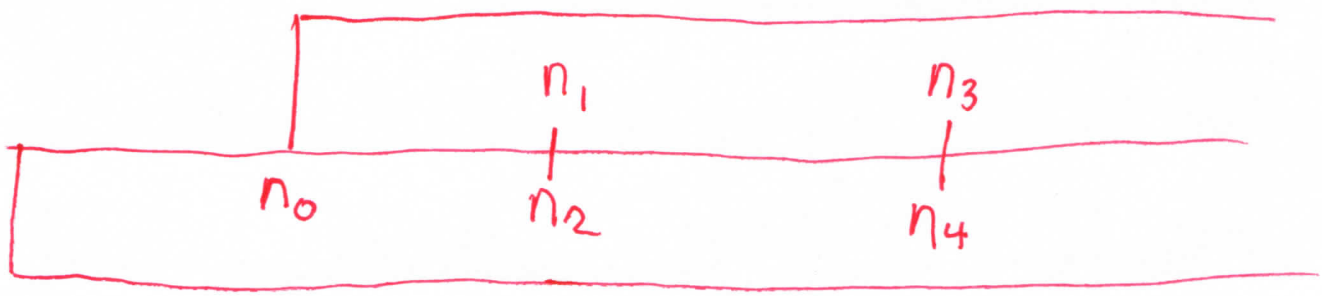
Get $(a \div b)$, when $1 \leq a \leq b \leq 10$

Optional #4:

Get square roots

(Optional)

KEY FACT, for Optional #1-3:



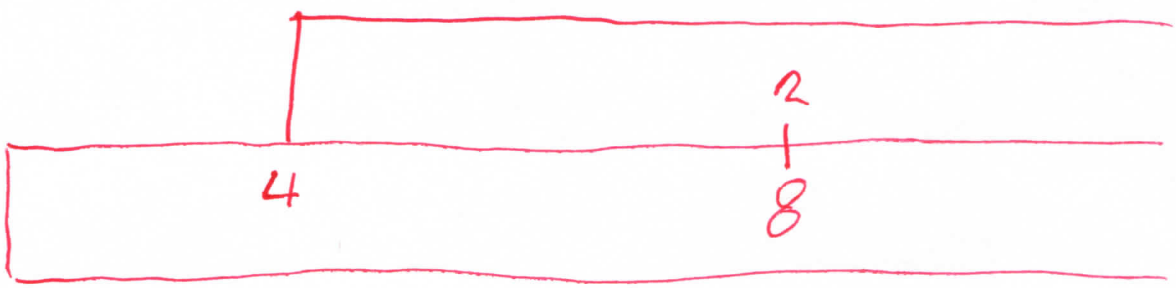
$$\rightarrow \quad n_0 = \frac{n_2}{n_1} = \frac{n_4}{n_3}$$

"n_0 is what you multiply by, in going from the upper stick above to the lower stick."

OPTIONAL #1: p. 59

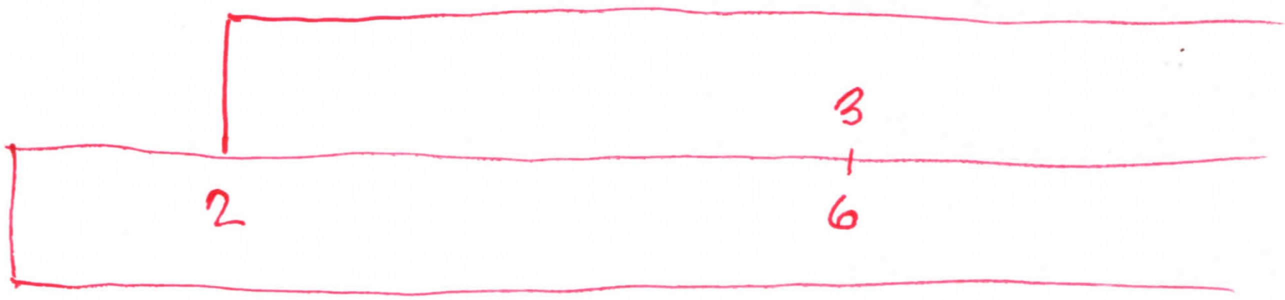
Get $(a \div b)$ when $1 \leq b \leq a \leq 10$.

Have students experiment with $(8 \div 2)$ & $(6 \div 3)$



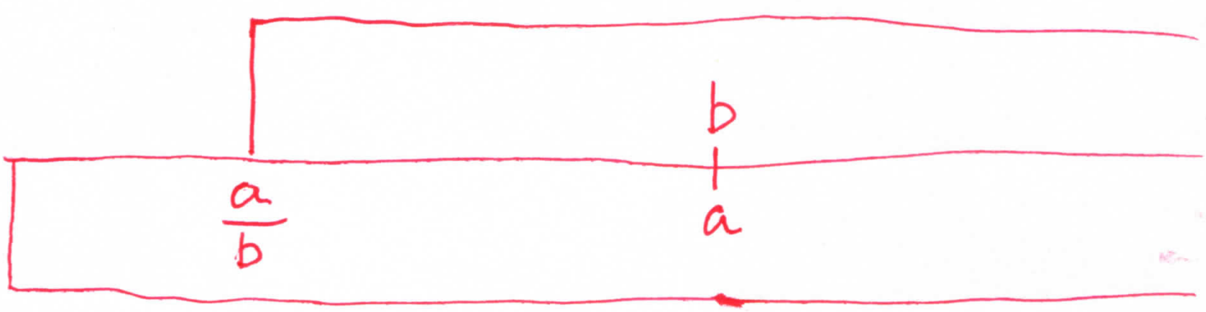
$(4 \times 2) = 8$ (from ↑) →

$4 = \frac{8}{2} = (8 \div 2)$



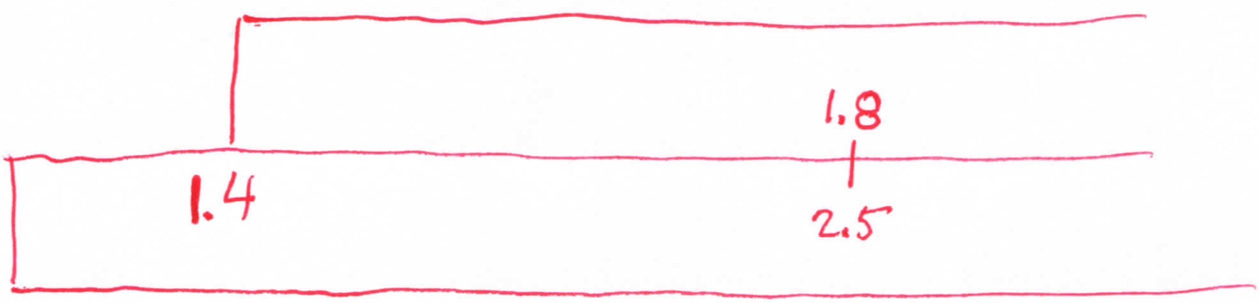
$$\frac{6}{3} = (6 \div 3) = 2$$

IN GENERAL

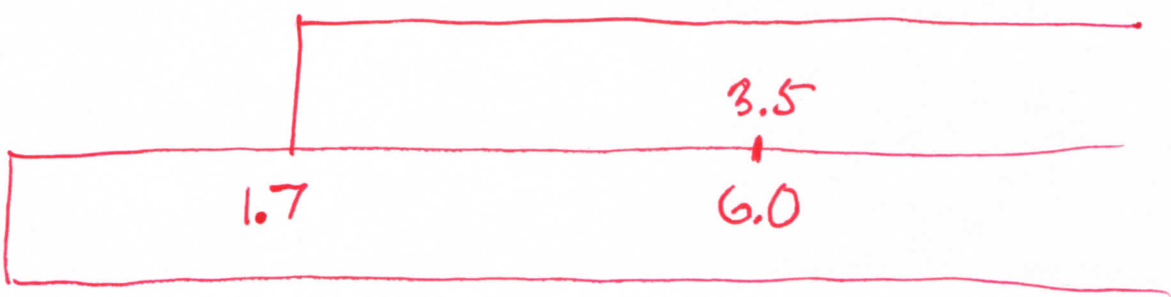


Have students practice with p. 61

$$(2.5 \div 1.8) = \frac{2.5}{1.8} \quad (\sim 1.4)$$



ALSO $\frac{60}{35} = \frac{6.0}{3.5}$ (~ 1.7)



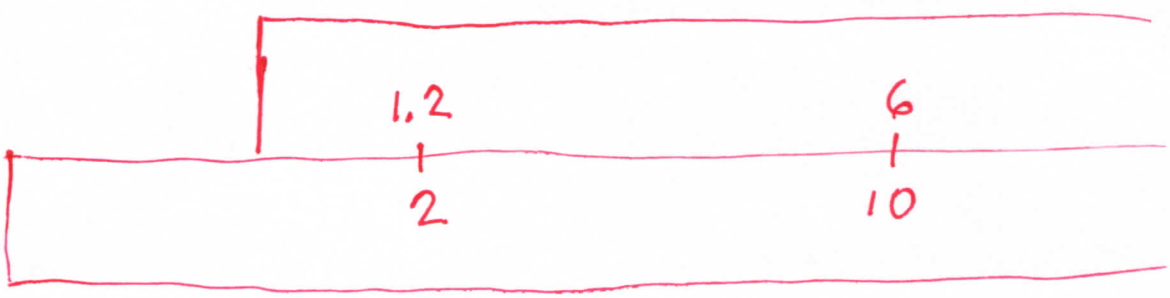
MORE??

OPTIONAL #2:   p. 62

Get $(a \times b)$, when $(a \times b) > 10$,

$1 \leq a \leq 10$, $1 \leq b \leq 10$.

Have students experiment with (2×6); eventually get

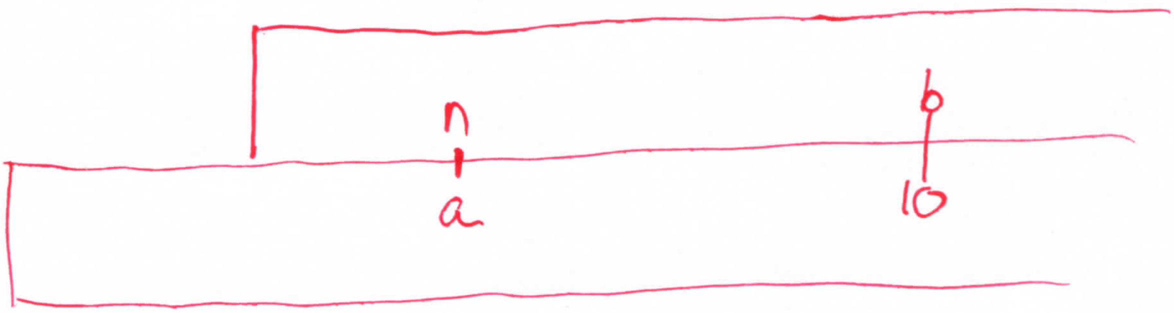


"Key Fact" → $\frac{2}{1.2} = \frac{10}{6}$ →

$6 \times 2 = 1.2 \times 10 = 12$

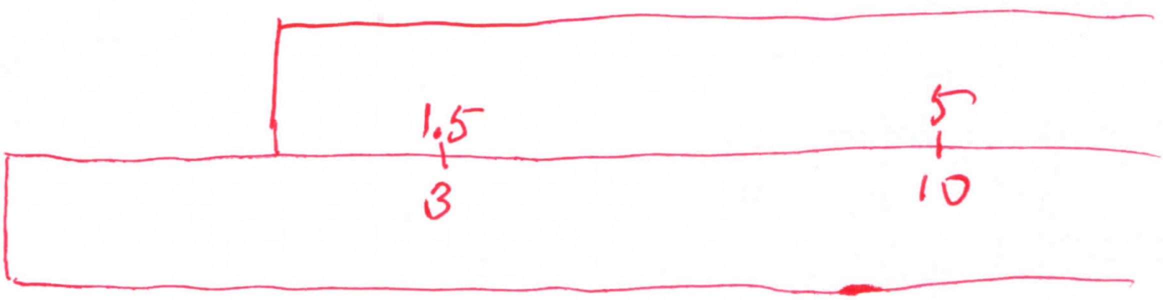
IN GENERAL

p. 63

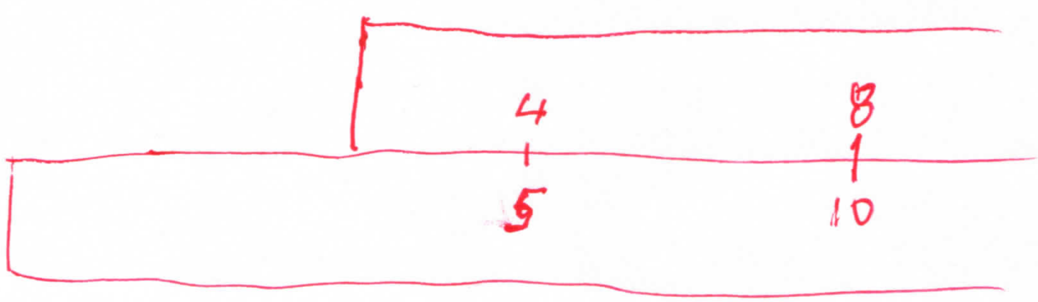


→ $n = \frac{(a \times b)}{10}$ ("Key Fact" → $\frac{a}{n} = \frac{10}{b}$)

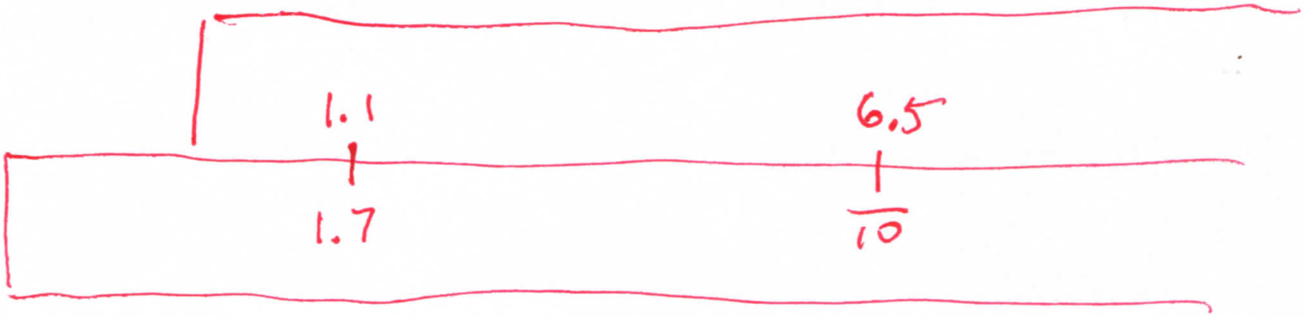
Have students work on (3x5):



& (5x8)

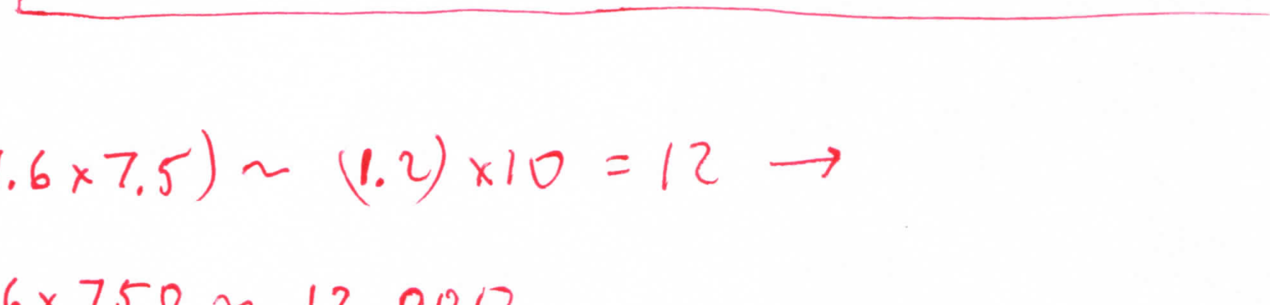


đ (1.7×6.5) p. 64



$\rightarrow (1.7 \times 6.5) \sim 1.1 \times 10 = 11$

$16 \times 750 = 10^3 \times (1.6 \times 7.5)$?



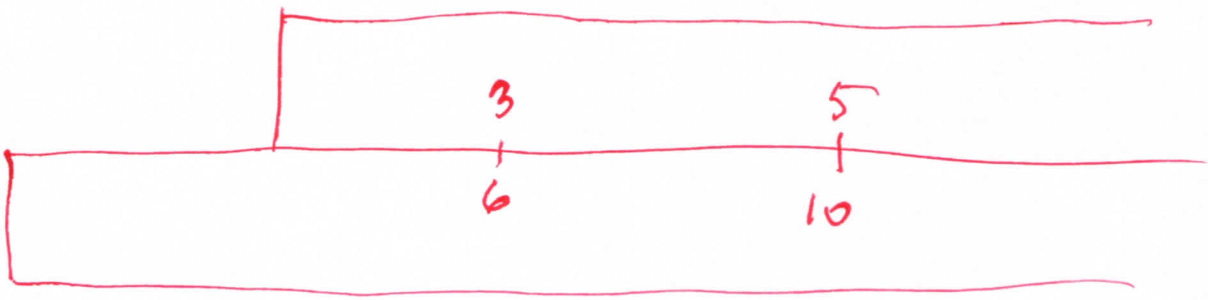
$(1.6 \times 7.5) \sim (1.2) \times 10 = 12 \rightarrow$

$16 \times 750 \sim 12{,}000$

OPTIONAL #3: p. 65

Get $(a \div b)$ when $1 \leq a \leq b \leq 10$

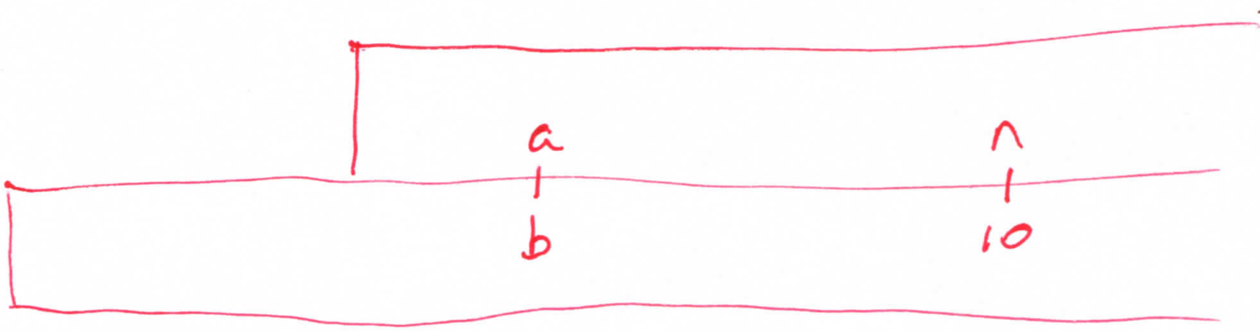
Have students work on $\frac{3}{6} = (3 \div 6)$;
should eventually get



By "Key Fact," $\frac{3}{6} = \frac{5}{10} = 0.5$

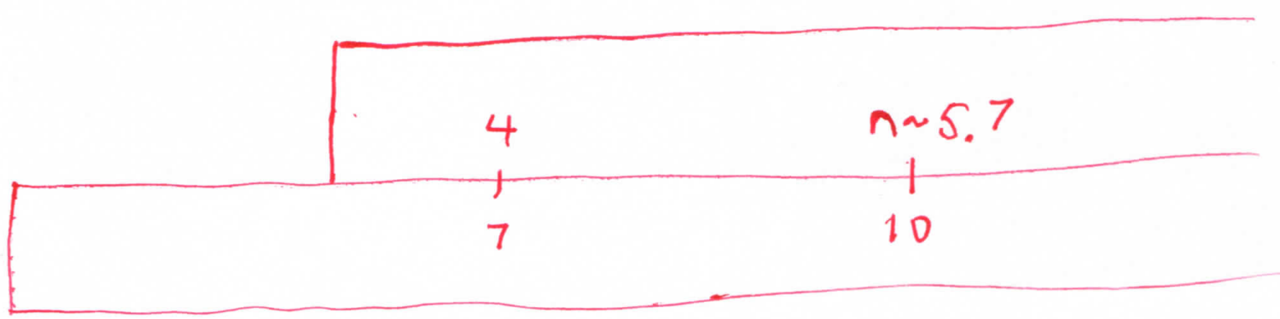
GENERAL PICTURE

p. 66



→ ("Key Fact") $\frac{a}{b} = \frac{n}{10}$

Have students work on $\frac{4}{7}$:

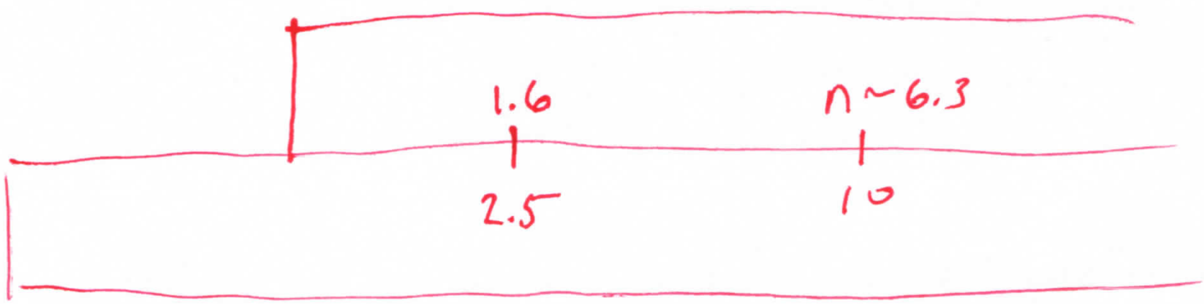


→ $\frac{4}{7} = \frac{n}{10} \simeq \frac{5.7}{10} = 0.57$

Have students work on

p. 67

$$\frac{1600}{25} = 10^2 \times \left(\frac{1.6}{2.5}\right)$$



$$\rightarrow \frac{1.6}{2.5} = \frac{n}{10} \simeq \frac{6.3}{10} = 0.63 \rightarrow$$

$$\frac{1600}{25} = 63.$$

Could mention:

$$\left(\frac{1600}{25} = \frac{1600 \times 4}{25 \times 4} = \frac{6400}{100} = 64 \right)$$

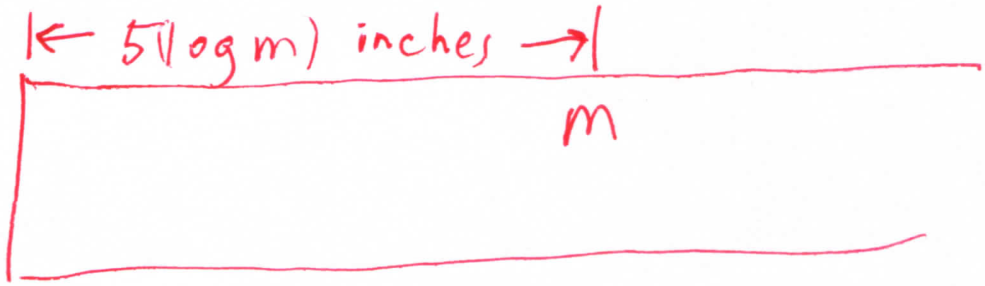
OPTIONAL #4:

p. 68

Use log sticks to get square roots.

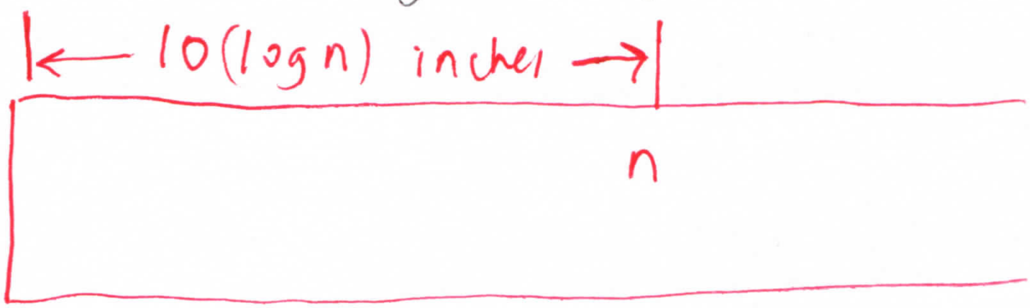
"We will need another log stick, which we will call a double log stick, marked as follows:"

Double Log Stick



$m = 2, 3, 4, \ldots, 9, 10, 16, 25, 36, \ldots, 81, 100$

"Compare to the earlier (single) log stick:" p. 69



"Here are some short cuts for constructing your double log stick:"

For m = 2, 3, 4, ..., 10, divide each number in

LOG DATA THROUGH 10

by 2.

For

$m = 16, 25, 36, \ldots, 81, 100,$

since we have perfect squares

$m = k^2;$

$5(\log m) = 5\log(k^2) = 5\log(k \times k)$

$= 5(\log k + \log k) = 10(\log k)$; that is,

$5\log 16 = 5\log(4^2) = 10\log 4$

$5\log 25 = 5\log(5^2) = 10\log 5$

$\vdots \qquad \vdots$

$5\log 100 = 5\log(10^2) = 10\log 10$

p. 71

Hand out

DOUBLE LOG DATA

(not filled out), have students

fill it out.

When they are done, hand out

filled-out DOUBLE LOG DATA;

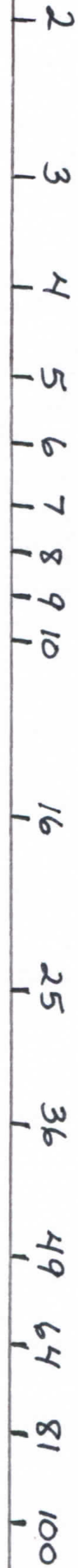
students should check that their

numbers match ours.

Have students use the numbers just calculated to make a card stock double log stick, as was done previously to make (single) log sticks.

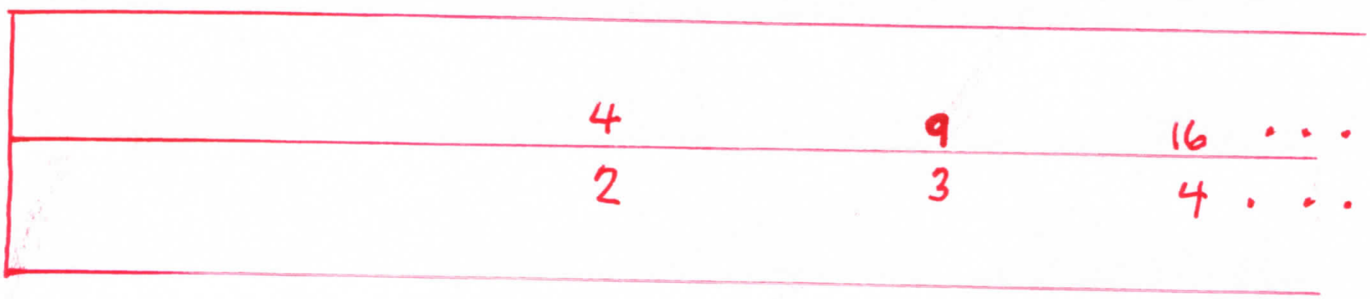
You should check that the double log stick on the next page matches the students' double log sticks.

p. 73

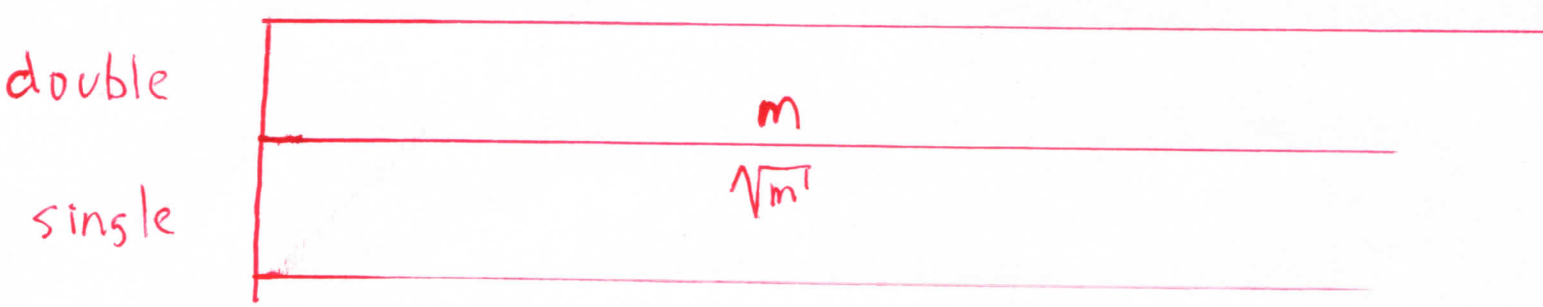


p. 74

Have students experiment with a double log stick on the top of a (single) log stick.

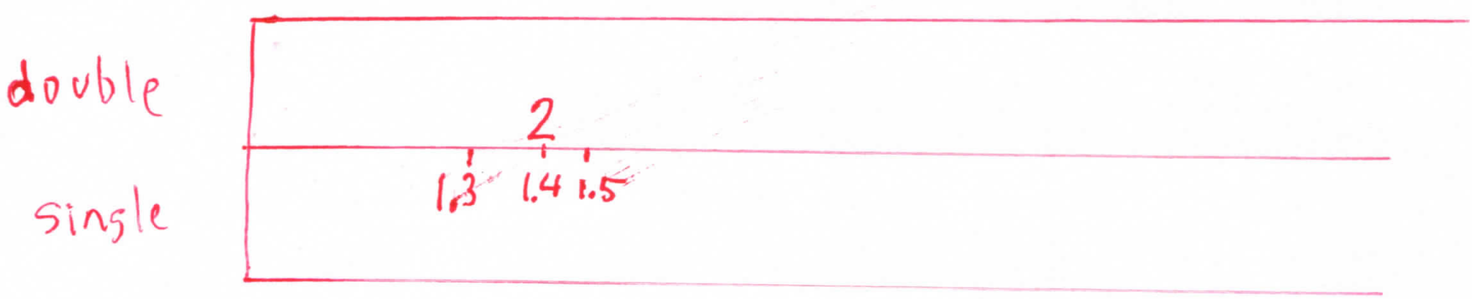


"IN GENERAL, should see"



Have students use picture just drawn to estimate $\sqrt{2}$, $\sqrt{3}$, etc.; e.g.,

p. 75



→ $\sqrt{2} \sim 1.4$

(OPTIONAL) p. 76

Proof of

m	double
$\sqrt{m}$	single

Note first that

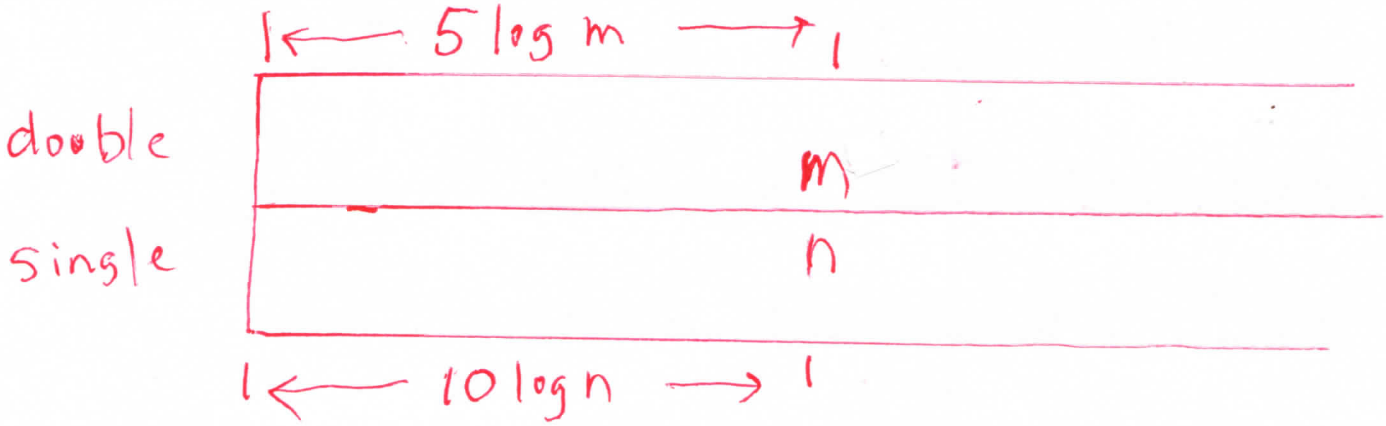
$$\log(n^2) = \log(n \times n) = \log n + \log n$$

$$= 2 \log n$$

(IN GENERAL,

$$\log(n^r) = r \log n)$$

Thus, in the picture



$$5 \log m = 10 \log n = 5 \times (2 \log n) =$$

$$5 \log(n^2) \to m = n^2 \to n = \sqrt{m}$$

Ask students how to construct a triple log stick, for getting cube roots.

"For more about logarithms, see

p. 78

MATHematics MAGnification

Logarithms 1,

on

https://teacherscholarinstitute.com"

LOG TABLE (approximate to 3 decimal places)

number	logarithm	number	logarithm	number	logarithm	number	logarithm
1.00	0.000	1.50	0.176	2.00	0.301	5.0	0.699
1.01	0.004	1.51	0.179	2.05	0.312	5.1	0.708
1.02	0.009	1.52	0.182	2.10	0.322	5.2	0.716
1.03	0.013	1.53	0.185	2.15	0.332	5.3	0.724
1.04	0.017	1.54	0.188	2.20	0.342	5.4	0.732
1.05	0.021	1.55	0.190	2.25	0.352	5.5	0.740
1.06	0.025	1.56	0.193	2.30	0.362	5.6	0.748
1.07	0.029	1.57	0.196	2.35	0.371	5.7	0.756
1.08	0.033	1.58	0.199	2.40	0.380	5.8	0.763
1.09	0.037	1.59	0.201	2.45	0.389	5.9	0.771
1.10	0.041	1.60	0.204	2.50	0.398	6.0	0.778
1.11	0.045	1.61	0.207	2.55	0.407	6.1	0.785
1.12	0.049	1.62	0.210	2.60	0.415	6.2	0.792
1.13	0.053	1.63	0.212	2.65	0.423	6.3	0.799
1.14	0.057	1.64	0.215	2.70	0.431	6.4	0.806
1.15	0.061	1.65	0.217	2.75	0.439	6.5	0.813
1.16	0.064	1.66	0.220	2.80	0.447	6.6	0.820
1.17	0.068	1.67	0.223	2.85	0.455	6.7	0.826
1.18	0.072	1.68	0.225	2.90	0.462	6.8	0.833
1.19	0.076	1.69	0.228	2.95	0.470	6.9	0.839
1.20	0.079	1.70	0.230	3.00	0.477	7.0	0.845
1.21	0.083	1.71	0.233	3.05	0.484	7.1	0.851
1.22	0.086	1.72	0.236	3.10	0.491	7.2	0.857
1.23	0.090	1.73	0.238	3.15	0.498	7.3	0.863
1.24	0.093	1.74	0.241	3.20	0.505	7.4	0.869
1.25	0.097	1.75	0.243	3.25	0.512	7.5	0.875
1.26	0.100	1.76	0.246	3.30	0.519	7.6	0.881
1.27	0.104	1.77	0.248	3.35	0.525	7.7	0.886
1.28	0.107	1.78	0.250	3.40	0.531	7.8	0.892
1.29	0.111	1.79	0.253	3.45	0.538	7.9	0.898
1.30	0.114	1.80	0.255	3.50	0.544	8.0	0.903
1.31	0.117	1.81	0.258	3.55	0.550	8.1	0.908
1.32	0.121	1.82	0.260	3.60	0.556	8.2	0.914
1.33	0.124	1.83	0.262	3.65	0.562	8.3	0.919
1.34	0.127	1.84	0.265	3.70	0.568	8.4	0.924
1.35	0.130	1.85	0.267	3.75	0.574	8.5	0.929
1.36	0.134	1.86	0.270	3.80	0.580	8.6	0.934
1.37	0.137	1.87	0.272	3.85	0.585	8.7	0.940
1.38	0.140	1.88	0.274	3.90	0.591	8.8	0.944
1.39	0.143	1.89	0.276	3.95	0.597	8.9	0.949
1.40	0.146	1.90	0.279	4.0	0.602	9.0	0.954
1.41	0.149	1.91	0.281	4.1	0.613	9.1	0.959
1.42	0.152	1.92	0.283	4.2	0.623	9.2	0.964
1.43	0.155	1.93	0.286	4.3	0.633	9.3	0.968
1.44	0.158	1.94	0.288	4.4	0.643	9.4	0.973
1.45	0.161	1.95	0.290	4.5	0.653	9.5	0.978
1.46	0.164	1.96	0.292	4.6	0.663	9.6	0.982
1.47	0.167	1.97	0.294	4.7	0.672	9.7	0.987
1.48	0.170	1.98	0.297	4.8	0.681	9.8	0.991
1.49	0.173	1.99	0.299	4.9	0.690	9.9	0.996

LOG DATA: 2 THROUGH 10

number	log	x10	ruler ~
2			
3			
4			
5			
6			
7			
8			
9			
10			

LOG DATA: 0.5s

number	log	x10	ruler ~
2.5			
3.5			
4.5			
5.5			
6.5			
7.5			
8.5			
9.5			

LOG DATA: TENTHS

number	log	x10	ruler ~
1.1			
1.2			
1.3			
1.4			
1.5			
1.6			
1.7			
1.8			
1.9			

LOG DATA: 2 THROUGH 10

number	log	x10	ruler ~
2	0.301	3.01	3
3	0.477	4.77	4 3/4
4	0.602	6.02	6
5	0.699	6.99	7
6	0.778	7.78	7 3/4
7	0.845	8.45	8 1/2
8	0.903	9.03	9
9	0.954	9.54	9 1/2
10	1	10	10

LOG DATA: 0.5s

number	log	x10	ruler ~
2.5	0.398	3.98	4
3.5	0.544	5.44	5 1/2
4.5	0.653	6.53	6 1/2
5.5	0.740	7.40	7 3/8
6.5	0.813	8.13	8 1/8
7.5	0.875	8.75	8 3/4
8.5	0.929	9.29	9 1/4
9.5	0.978	9.78	9 3/4

LOG DATA: TENTHS

number	log	x10	ruler ~
1.1	0.041	0.41	3/8
1.2	0.079	0.79	3/4
1.3	0.114	1.14	1 1/8
1.4	0.146	1.46	1 1/2
1.5	0.176	1.76	1 3/4
1.6	0.204	2.04	2
1.7	0.230	2.30	2 1/4
1.8	0.255	2.55	2 1/2
1.9	0.279	2.79	2 3/4

DOUBLE LOG DATA

number	distance from left end (in inches)
2	
3	
4	
5	
6	
7	
8	
9	
10	
16	
25	
36	
49	
64	
81	
100	

DOUBLE LOG DATA

number	distance from left end (in inches)
2	1 1/2
3	2 3/8
4	3
5	3 1/2
6	3 7/8
7	4 1/4
8	4 1/2
9	4 3/4
10	5
16	6
25	7
36	7 3/4
49	8 1/2
64	9
81	9 1/2
100	10