COMPLETE, SEMI-PROGRAMMED TEACHING INSTRUCTIONS FOR THE USE OF

ELEMENTARY SIMPLEX MATH SLIDE RULE

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PICKETT

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FOREWORD

The Pickett ELEMENTARY SIMPLEX MATH Slide Rule brings to the teachers of second grades and higher, a simple and effective tool for use in the teaching of basic mathematics. Here, on this specially created rule, the student physically experiences the relationship of numbers, becomes acquainted with exponential notation, sees how addition and subtraction work, watches the interplay of negative and positive numbers, learns multiplication and division. It provides an easily acquired and fundamental understanding of mathematics.

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The text of this manual is specially written in simple, easy-to-understand, primary level terms for the lower level student. It is semi-programmed in nature, designed both for self-instruction and classroom work, and complements regular teaching methods. Teachers as well as students will almost certainly observe a greater and more facile understanding and ability with mathematics through the use of this new Pickett ELEMENTARY SIMPLEX MATH Slide Rule.

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John W. Pickett

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7. To find $2 + 6$, move the slide so that 0 on $\overline{Y}$ is under ________ on $\overline{X}$.

8. Above +6 on ________ find +8 on $\overline{X}$.

9. To find $1 + 9$, set the slide so that 0 on $\overline{Y}$ is under ________ on $\overline{X}$.

10. Above +9 on $\overline{Y}$ find ________ on $\overline{X}$.

11. To see why this works, set 0 on $\overline{Y}$ under +4 on $\overline{X}$. Think of this as a marking off of a length of 4 inches from 0 on $\overline{X}$.

Now find +3 on $\overline{Y}$. Think of this as marking off a length of ________ on $\overline{Y}$.

12. Now how far from 0 on $\overline{X}$ is the +4 on $\overline{Y}$? 3 inches

13. You have found $4 + 3$ by adding a length of 3 to a length of 4.

The total length is measured on the scale named ________.

14. To find $3 + 5$, you mark off 3 on the $\overline{X}$ scale. You do this by setting ________ of $\overline{Y}$ under it.

15. Next you find the length for 5 on the ________ scale.

16. You read the combined length above the 5 on the ________ scale.

17. You have now done some examples which show how a slide works for addition of "whole numbers" or integers. Next we will do examples like $2.7 + 4.6$. How many smaller parts are shown between 0 and +1 on the $\overline{X}$ scale?

18. How many smaller parts are shown between +1 and +2 on the $\overline{X}$ scale?

19. The shorter marks between the numerals on the $\overline{X}$ scale stand for tenths. The mark for +2.1 is the first short mark beyond the mark for ________.

20. The seventh short mark beyond +2 is the mark for ________.

21. The mark for 4.6 is between the mark for +4 and ________.

22. The mark for +4.6 is the ________ short mark beyond the mark for +4.

23. To find $2.7 + 4.6$, first set 0 of the $\overline{Y}$ scale under ________ of the $\overline{X}$ scale.

24. Next locate +4.6 on the ________ scale.

25. Above +4.6 read the sum of +7.3 on the ________ scale.

26. To find $5.2 + 3.9$, move ________ on the $\overline{Y}$ scale under 5.2 on the $\overline{X}$ scale.

27. Move the hairline of the runner over 3.9 on the $\overline{Y}$ scale. Under the hairline read the sum ________ on the $\overline{X}$ scale.

9.1
INTRODUCTION

This instruction manual has been written to accompany the Pickett Elementary Basic Math Simplex Slide Rule. It is in programmed style. The text is organized by numbered "frames." Near the end of each frame a blank space ________ is left. The student is to decide what response will correctly fill the blank.

At the bottom of each frame there is a line ruled across the page. The student is expected to keep the part of the page below this line covered with a piece of paper or cardboard until he has made his response. Then he may move the paper down and look at the correct response below the line and in the right-hand margin.

If his response is correct, he goes on to the next frame. If it is not correct, he studies the frame or his work to see where he went wrong.

Responses may be written in the space at the right of the frame if desired, and then compared with the correct response below. For some frames, scratch paper and pencil may be useful.

It will not do much if any harm if a student sees the correct response before he has given an answer. He will learn from doing so. Above all, he must want to learn about the slide rule. He needs no one but himself if he goes through the instruction guide without making the effort to really learn.

Portions of this manual may be too difficult for some students, especially if they are very young. The work gets more difficult with each section covered. If a section seems very difficult, it is probably best not to continue. It can be studied later when the student is more mature.

Needless to say, the student is expected to have a slide rule at hand as he works through the frames. In most frames, he should make the settings described and follow the procedures outlined.

When working with the slide rule, he should hold firmly near the middle with the thumb and first two fingers of one hand (usually the left). He moves the slide or the indicator with the other hand. He should not pinch the body of the rule too tightly, however, because then the slide may bend. With a little practice, the physical manipulation of the rule is easily learned.

HOW TO ADD

1. The slide rule is a tool. For example, a slide rule helps if you want to do multiplication. It also helps in many other kinds of problems. A slide rule looks something like an ordinary ruler. It has scales or "number lines" marked on it. One of these scales is named by the letter X. The mark in the middle of the X-scale is named ________

2. The part of the X scale to the right of 0 is divided into 10 smaller parts. The first of these division marks is labeled 0. This is read "positive one". The last division mark shown is named ________

3. The part of the X scale to the left of 0 is also divided into 10 smaller parts. The first of these division marks is labelled -1. This is read "negative one". The last division mark going toward the left is named ________

4. The scale named with the letter Y is on the slide. It is just like the X scale. The first mark on this scale, starting at the left end, is named ________

5. The mark in the middle of the Y scale is named ________

6. Now you are ready to do a very easy addition with the slide rule. We will find 4 + 3.
Move the slide so that 0 of the Y scale is under 4 of the X scale.
Next find 3 on the Y scale.
Above the 3 on the Y scale the mark on the X scale is named ________
28. For practice, find the sums below by using the slide rule.
   a) 0.8 + 6.7
   b) 5.4 + 3.8
c) 2.6 + 7.2
   d) 4.7 + 2.3

29. You also can find the sums of larger numbers, for example, 36 + 28. To
do this, you think of +10 when you see +1 ten. Think of +2 as standing
for +20. Now what number does +3 stand for?

30. When you read the scales this way, you will find 36 between +30 and ________.

31. The mark for 36 is the same as the mark for 3.6, but now you
    think of it as standing for the number ________.

32. Set 0 on the \(\overline{V}\) scale under 36 on the ________ scale.

33. Move the hairline over the mark for 28 on the ________ scale.

34. The mark on the \(\overline{X}\) scale under the hairline is the mark for 36.

35. Find the sum 39 + 47. The mark for 39 is between +3 and
    ________.

36. The mark for 39 is used as the mark for ________.

37. Under 39 on the \(\overline{X}\) scale set ________ on \(\overline{Y}\).

38. Move the hairline over 47 on \(\overline{Y}\). The mark on the \(\overline{X}\) scale under
    the hairline is the mark for ________.

39. For practice, find the sums below by using the slide rule.
   a) 63 + 24
   b) 46 + 54
c) 7 + 85
   d) 20 + 67

40. You can find a number close to the sum of still larger numbers, for example, 240 + 432. To do this, think of +2 as standing
    for 200. Now what number does +3 stand for?
   a) 87
   b) 100
   c) 92
   d) 87

41. When you read the scales this way, you will read 240 where you read
    24 or ________ before.

42. Set 0 of the \(\overline{V}\) scale under 240 of the \(\overline{X}\) scale. Move the hair-
    line to 430 of the \(\overline{V}\) scale. Now
    432 is between the mark for 430
    and the mark for 440. Is there
    a small space between these
    marks?

43. To set 432 move the hairline just a little farther to the right.
    Under the hairline read the sum of 240 + 432 on the \(\overline{X}\) scale.
    The sum is ________.

44. Later you will become more expert in placing the hairline
    between two marks. All you need to do now is know that this
    is possible and useful. Now you see how a slide rule works
    for addition. Notice that we did not do any examples like
    4.2 + 37.6. The numbers were always whole numbers or
    expressed to tenths, for example. Do not try to do examples
    like this one with the slide rule. However, when you study
    multiplication, examples like 4.2 x 37.6 will be easy.
45. Subtraction is the "opposite" or inverse of addition. With a slide rule, this means we work "backwards" from addition. Set your rule to find 4 + 3 = 7.

Addition
\[ 4 + 3 = 7 \]

Under 4 on \( X \) set 0 on \( Y \). Over 3 on \( Y \) read 7 on \( X \).

Subtraction
\[ 7 - 3 = 4 \]

Under 7 on \( X \) set 3 on \( Y \). Over 0 on \( Y \) read ___ on \( X \).

46. Find 9 - 3. Set the slide so +3 on \( Y \) is under +9 on \( X \). Over 0 on \( Y \) read _______ on \( X \).

47. Find 6 - 4. Set 4 on \( Y \) under +6 on \( X \). Over 0 on \( Y \) read 2 on ______.

48. The answer in addition is always read on the ______ scale.

\[ X \]

49. The answer in subtraction is always read on the ______ scale.

\[ X \]

50. For practice, find the following by using a slide rule.

\[ \begin{align*}
  a) \quad 75 - 45 & \quad b) \quad 91 - 76 \\
  c) \quad 5.9 - 2.7 & \quad d) \quad 650 - 490
\end{align*} \]

\[ \begin{align*}
  a) \quad 28 & \quad b) \quad 15 \\
  c) \quad 3.2 & \quad d) \quad 160
\end{align*} \]

51. Now you will learn to add positive and negative numbers with a slide rule. Notice the numerals for the negatives -1, -2, -3, ..., -10 on the \( X \) scale. One of the meanings sometimes given to these numbers has to do with temperatures below zero. Then -5 means 5 degrees below zero. There are many other useful meanings of the negative numbers. The mark on a thermometer for 8 degrees below zero is named _______.

52. The short mark for -0.1, or "negative one-tenth," is just to the left of 0. The next short mark to the left is the mark for ______.

53. The short mark for -1.1 is just to the left of the mark for -1. The next short mark to the left is the mark for ______.

54. Reading to the left the next three short marks stand for ______.

55. We will find the sum (+7) + (-3). Under +7 on the \( X \) scale, set 0 on \( Y \). The number named on \( X \) over -3 on \( Y \) is ______.

\[ -1.3, -1.4, -1.5 \]

56. Find (+5) + (-8). Under +5 on \( X \) set 0 on \( Y \). Over +8 on \( Y \) read ______ on \( X \).

\[ +4 \]

57. Find (-3) + (-4). Under -3 on \( X \) set 0 on \( Y \). Over -4 on \( Y \) read ______ on \( X \).

\[ -3 \]

58. Find (-5) + (+9). Under -5 on \( X \) set 0 on \( Y \). Over +9 on \( Y \) read ______ on \( X \).

\[ -7 \]

59. Find (+6.3) + (+7.8). Under +6.3 on \( X \) set 0 on \( Y \). Over +7.8 on \( Y \) find ______ on \( X \).

\[ 14 + 1.5 \]
60. Find \((-4.7) + (-3.6)\).

61. Find \((+28) + (-59)\). -8.3

62. Now you will do some subtraction of positive and negative numbers with the slide rule. Find \((+13) - (-5)\). Under \((+3)\) on \(X\) set \((-5)\) on \(Y\). Over 0 on \(Y\) read \(\quad\) on \(X\).

63. Find \(3 - 5\). This is the same as \((+3) - (+5)\). Under \((+3)\) on \(X\) set \((+5)\) on \(Y\). Over 0 on \(Y\) read \(\quad\) on \(X\).

64. Find \((-3) - (+7)\). Under \((-3)\) on \(X\) set \((+7)\) on \(Y\). Over 0 on \(Y\) read \(\quad\) on \(X\).

65. You see that with a slide rule you do addition and subtraction with negative numbers just like you did for positive numbers or ordinary "whole numbers". Do the following for more practice.

   a) \((+3.6) - (-4.8)\)
   b) \((-42) - (-37)\)
   c) \((-2.5) - (-3.8)\)
   d) \((-21) - (-45)\)

66. Here are some addition and subtraction examples for more practice.

   a) \((+4.1) + (-3.3)\)
   b) \((-56) - (25)\)
   c) \((-8.2) + (+8.2)\)
   d) \((-24)\)
   e) \((-1.6) - (-2.4)\)
   f) \((+13) + (-18)\)
   g) \((-46) - (+24)\)
   h) \((+2.9) + (+6)\)
   i) \((-250) + (+430)\)
   j) \((-250) + (+430)\)

67. The scales named C and D are used for multiplication. They are just alike. First you must learn to read them. Begin with the numeral 1 at the left end. Set the hairline over 1 of the D scale. Now move it toward the right until it is over -4 on the X scale. Then the numeral on the D scale now under the hairline is \(\quad\).

68. Now move the hairline farther to the right until it is over 3 on the D scale. Is the hairline now almost half way across the slide rule?

69. Now move it toward the right again till it passes over 4, then 5, then 6, etc. What number comes after 9 in counting?

70. If you read the numerals on the D scale as 1, 2, 3, etc., you should read the 1 at the right end as \(\quad\).

71. Now begin again at the left end of the D scale. This time read the "1" as 10. When the hairline is over "2", read the "2" as "20". How should you now read the other numerals on the scale?

72. If the "1" at the left end is read as "10", you should read the "1" at the right end as \(\quad\).

73. You see that the same mark (or numeral) may be used for different numbers. For example, the mark for 2 is also the mark for 20, for 200, for 2,000, etc. The mark for 3 is also the mark for \(\quad\).

   a) \(-8\)  b) \(-81\)  c) 0  d) \(-9\)  e) \(-4.0\)  f) \(-5\)  g) \(-70\)  h) \(+1.9\)  i) \(+180\)  j) \(-680\)
74. The mark for 2 is also the mark for .2, for .02, for .002, etc. The mark for 3 is also the mark for ________.

75. The mark at the left end of the D scale is called the left index. The mark at the right end of the D scale is called the right ________.

76. Place the hairline over the left index on the D scale. Notice the small numeral 1 under the glass on the right side. Also notice that the space between 1 and 2 is separated into ten parts. The marks have little numerals below them. The little "1" is read as 1.1. The mark for the small numeral 2 not under the glass is read as 1.2. Moving to the right, we read 1.3, 1.4, ________, ________, ________, ________.

77. Now you are near the mark that is under the larger numeral 2, which now can be read as 2.0. Notice the space between 2 and 3 is again separated into ten parts by little marks. However, these marks do not have numerals shown. They can be read as 2.1, 2.2, 2.3, ________, ________, ________, ________.

78. The space between the numerals 3 and 4 is also separated into ten parts. These marks can be read as 3.1, 3.2, 3.3, ________, ________, ________, ________, ________, ________, ________, ________, ________.

79. Notice the part of the D scale to the right of the numeral 4. The space between 4 and 5 is separated into ten parts.

80. Between 7 and 8 these marks can be read as ________, ________, ________, ________. 5.1, 5.2, 5.3, etc.

81. You see that between any two of the large numerals you can read "to tenths." Between 1 and 2 there is enough room on the D scale to show small numerals for the "tenths" marks. Between 2 and 3, and between all the other larger numerals, there is not enough room to show numerals for the "tenths". You must look at the scale and count the larger marks. This is like counting "fourths of an inch" on an ordinary foot ruler. As you become more familiar with the rule, you will learn to do this at a glance. You can now read two digits of a numeral: for example, 4.7. How many digits are in the numeral 1.11?
82. Next you will learn to read three digit numerals. Begin by setting the hairline over the mark for 1.1.

```
1.01
```

Now move the hairline over the first short mark to the right of 1.1. This is the mark for 1.11. Notice the space between 1.1 and 1.2 is separated into ten small parts. The little marks are read 1.11, 1.12, 1.13, ..., 1.19, etc.

83. Begin at 1.7, and read the next four little marks to the right. They are read ___ , ___ , ___ , ___ .

84. Between 1 and 1.1 the reading is tricky. The short mark at the right of 1 is the mark for 1.01. The next three short marks are for ___ , ___ , ___ .

85. Between the large numerals 1 and 2 on the D scale there is a little mark that can be read as 'hundredths'. The mark for 1.41 is the first short mark to the right of the longer mark for 1.4, or 1.40. The mark for 1.63 is the ___ short mark to the right of the longer mark for 1.6 or 1.60.

86. The distance between the marks for 2.0 and 2.1 is too short to have marks that separate it into ten parts. The little marks separate it into five parts. Then each part can be counted as two hundredths. Set the hairline over the mark for 2.1. The little marks are now read as 2.12, 2.14, 2.16, 2.18. Now you are at the longer mark for 2.2 or 2.20. The next four little marks are read as ___ , ___ , ___ , ___ .

```
2.02 2.04 2.06 2.08
2.12 2.14 2.16 2.18
2.20 2.22 2.24 2.26
```

87. Between 2.0 and 2.1 the reading is tricky. The little mark just to the right of the 2 is read as ___ .

88. The next four marks are read as ___ , ___ , ___ , ___ .

89. The four little marks just to the right of 3 are read as ___ , ___ , ___ , ___ .

90. The second little mark to the right of 3.4 is read as ___ .

91. The third little mark to the right of 3.7 is read as ___ .

92. The first little mark after 3.5 is ___ .

93. The fourth short mark after 3.9 is ___ .

94. The number 2.56 is set as the third short mark after 2.5. The number 2.74 is set as the ___ short mark after 2.7.
95. The number 3.88 is set as the ______ mark after 3.8.

96. There is no mark for 2.31.

The number 2.31 is half-way between 2.30 and 2.32. You can place the hairline about half-way between two marks to read to one-hundredth; for example, 2.31. Half-way between the marks for 2.30 and 2.34 is the setting for ______.

97. Half-way between the marks for 2.00 and 2.02 is the setting for ______.

98. Do not worry about the "reading between the marks" not being quite accurate. The slide rule is used as a tool by many engineers and scientists. It gives answers that are good enough for them, even if the answers are not exact. You can learn to get readings that are exact enough for many purposes. The setting for 3.55 is half-way between the marks for ______ and ______.

99. The setting for 3.99 is half-way between the setting for ______ and ______.

100. Now you can see how to read the D scale and the C scale to three digits when the number is between 2 and 4. Next you will see how to read when the number is greater than 4. Between 4 and 5 there is not enough room to show marks for hundredths that can be "counted by twos". There is only one little mark between each of the marks for "tenths". Place the hairline on the mark for 4.60. The next little mark is for 4.65. The little marks are "counted by five hundredths". The little mark between 4.30 and 4.40 is the mark for ______.

101. The little mark to the right of 4 is read as ______.

102. The little mark to the right of 5 is read as ______.

103. The next mark after 5.05 is for ______.

104. The next mark after 5.10 is for ______.

105. The setting for 7.55 is over the little mark between ______ and ______.

106. To place the hairline for a number like 6.12 you have to set it in the space between the marks for 6.10 and 6.15. It is about half-way between 6.10 and 6.15 (see figure for Frame 100). The setting for 6.11 will be just a little to the right of 6.10. The setting for 6.16 will be just a little to the right of ______.
107. The setting for 5.63 will be about half-way between _____ and _____.

108. The setting for 5.64 will be just a little to the left of _____, 5.60, 5.65

109. You see that for numbers greater than 4 you can make the reading or setting by imagining little marks between the marks that are shown on the scale. You can do this without much trouble as you become more familiar with the scales. The G scale and D scale can be read to three digits by doing this. Between 1 and 2 you can sometimes even read to four digits, but these readings are not as accurate.

Between 1 and 2 you have marks for hundredths. Between 2 and 4, how many marks must you imagine are between each mark shown when you read to hundredths?

110. Between 4 and 10, how many marks must you imagine are between each mark shown when you read to hundredths?

111. Now you will learn to read the scales when the large numerals 1, 2, 3, etc., are thought of as 10, 20, 30, etc. If 1 at the left index is read as 10, and 2 is read as 20, then 1.1 is read as 11. Now instead of 1.2 you would read _____.

112. Instead of 1.5, you would read _____.

113. Instead of 1.21, you would read _____.

114. Instead of 2.46, you would read _____.

115. You can see that the same marks or settings can be used for a number and 10 times that number. If 1 at the left index is read as 100, and 2 is read as 200, then 1.36 is read as 136. Now instead of 1.27, you would read _____.

116. Instead of 2.46, you would read _____.

117. Instead of 8.92, you would read _____.

118. The same settings are used on the D scale for a number and 100 times that number. In the same way, we can use the same setting for a number and that number multiplied by 1,000, 10,000, etc. Also, if the number is multiplied by .1, or .01, or .001, etc., exactly the same setting can be used.

This means that in using the C scale and D scale, we can pay no attention to where the decimal point stands in the numeral. The setting for 456,000 is the same as the setting for 4.56. The setting for .000456 is the same as the setting for _____.

119. The setting for 7,980 is the same as the setting for _____.

120. The setting for .0825 is the same as the setting for _____.

121. Of course, you have to pay attention to where the decimal point is sometimes. You will learn how to do this in a later section of this book.
122. In an example like $2 \times 3 = 6$, the numbers 2 and 3 are factors, and $2 \times 5$ or 6, is the product. The factors in $4 \times 5$ are ___ and ___.

123. The product of $4 \times 5$ is ___.

124. To see how multiplication is done with a slide rule, we will do $2 \times 3$. Move the slide so that the left index 1 of the C scale is over 2 of the D scale. Under 3 of the C scale, on the D scale read ___.

125. Find $17 \times 4$. Move the slide so that the left index 1 of the C scale is over 17 of the D scale. Under 4 of the C scale, on the D scale read ___.

126. To multiply, you begin by setting the index 1 of the C scale over one of the factors on the ___ scale.

127. Then find the other factor on the C scale, and use the hairline to read the product on the ___ scale.

128. Multiplication with the C and D scales is much like addition with the X and Y scales. To do addition, you add two lengths.

In multiplication you also add two "lengths," but the scales are made so the numbers are multiplied. There is one "length" for each factor. In the setting shown above, the "length" for 17 is "measured" on the ___ scale.

129. The "length" for 4 is "measured" on the ___ scale.

130. The total length is measured by the ___ scale.

131. The number corresponding to this length is ___.

132. You can also set 1 of the C scale over 4 of the D scale. Then under 17 of the ___ scale, read 68 on the D scale.

133. Find $2.4 \times 6.3$. Set the left index 1 of C over 24 on D. Now 63 on C is "outside the rule", and you cannot read the product on D. When this happens, you should use the right-hand index. Set the right-hand index 1 over 63 on D. Under 24 on C read on D the digits of the product ___.

134. The decimal point in a product can often be placed by "common sense" or estimating. 2.4 is a little more than 2 and 6.3 is a little more than 6. The product will be a little more than 12, but not as much as 100. Then the product must be ___.

135. The exact product is 15.12, so there is a slight error in this answer. It is only about one-tenth of 1 per cent. In most problems the error is a very small per cent. How many pennies would there be in $10?'

136. The error is about the same as losing one penny out of 1,000 pennies. Now we will find $237 \times 346$. Set 1 on C over 237 on D. Under 346 of C find the digits of the product ___.

137. Now we will find where to put the decimal point. 237 is near 200; and 346 is near 300. But 200 $\times$ 300 is easy. It is ___.
138. To find 200 × 300, we can multiply 2 × 3 and count the zeros in 200 and 300. The numerals of the product are 6 followed by 4 zeros. We now know the answer is "near" 60,000. It is not 6, or 60, or 600, or even 6,000. Neither is it as large as 600,000. It must be 32 followed by _______ zeros.

139. In another section you will learn a more scientific way of placing the decimal point. For now, we can say the product of 237 × 346 is _______.

140. Here are some multiplication examples for practice. 82,000
   a) 15 × 37
   b) 9.54 × 16.7
   c) 753 × 89.1
   d) 21.5 × 37.9
   e) 280 × 34
   f) 7.4 × 6.7
   g) 114 × 5.3
   h) 34.2 × 4.87
   i) 275 × 46
   j) 98 × 93

141. Division is the "opposite" or inverse of multiplication. With a slide rule, this means we work "backwards" from multiplication. Set your rule to find 2 × 3 = 6.

   Multiplication                     Division
   2 × 3 = 6                          6 ÷ 3 = 2
   Over 2 on D set 1 of C             Over 6 on D set 3 on C
   Under 3 on C read 6 on D.          Under 1 on C read _______ on D.

142. Find 8 ÷ 4. Over 8 on D set 4 on C. Under 1 of C read _______ on D.

143. Find 9 ÷ 4.5. Over 9 on D set 4.5 on C. Under 1 of C read _______ on D.

144. Notice these examples may be written in the form:

   \[
   \frac{6}{7} = \frac{2}{4.5} = \frac{9}{4.5} = \frac{2}{1}
   \]

   With only one setting of the slide you can read many proportions. For example, this same setting also gives:

   On D: \[
   \frac{30}{15} = \frac{36}{18} = \frac{48}{24} = \frac{80}{40} = \frac{72}{36} = \frac{2}{1}
   \]
   On C: \[
   \frac{15}{30} = \frac{18}{36} = \frac{24}{48} = \frac{40}{80} = \frac{36}{72} = \frac{1}{2}
   \]

   Now try to work a harder example. Find 68 ÷ 44. Over 68 on D set 44 on C. Under 1 of C read _______ on D. You can place the decimal point in the answer by noticing that 68 ÷ 44 is more than 1 and not as much as 2, because 2 × 44 = 88.

145. Find 56.7 ÷ 2.48. Over 56.7 on D set 2.48 on C. Under 1 of C read _______ on D. You can place the decimal point by noticing the example is roughly the same as 50 ÷ 2, or 25.

22.8
146. Next find $87,342 \div 38.29$. First, you set 874 on D, because you can set only 3 digits on the D scale. This is the same as "rounding off" the number to 87,400. Next, set 38.3 on the C scale over the 874 on the D scale. Under 1 of the C scale, read 228 on the D scale. Now to place the decimal point in the answer, think of the numbers in the example. 87,432 is near 88,000, and 38.29 is near 40.

But $\frac{88,000}{40} = \frac{8800}{4} = \frac{2200}{1}$. So the
answer is __________.

147. In another section you will learn a more scientific method of placing the decimal point. For now, find $28 \div 65$. Over 28 on D set 6.5 on C. Under the right-hand index 1 of C find _____ on D. To place the decimal point, think of this example as $30 \div 60$ or $1/2$ or .5.

148. Notice that you can always read the result in division under either the left-hand index or the right-hand index. You never need to move the slide because the answer is on a part of the scale "outside the rule." Here are some examples for practice.

a) $47 \div 29$  
b) $81 \div 7$

c) $75 \div 92$  
d) $69 \div 79$

e) $137 \div 51.3$  
f) $152 \div 56.7$

g) $490 \div 23$  
h) $17.3 \div 2.31$

i) $924 \div 26.3$  
j) $847 \div 31.6$

149. In Frame 144, there were some examples of proportions. You can solve proportions easily with a slide rule. For example, find the number $n$ in the proportion.

$$\frac{1}{14} = \frac{7.5}{n}$$

Over 3 on D set 14 on C. Over 7.5 on D read _____ on C.

150. The same example can be done by another setting. Set 3 of C over 14 of D. Under 7.5 of C read _____ on D.

151. Solve the proportion

$$\frac{39}{23} = \frac{n}{56}$$

Set 39 of C over 23 on D. Over 56 on D read _____ on C.

152. You can see that with this setting the numerals on the scales appear in the same position as they do in the written form:

<table>
<thead>
<tr>
<th>On C</th>
<th>39</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>On D</td>
<td>23</td>
<td>56</td>
</tr>
</tbody>
</table>

Solve the proportion:

$$\frac{26}{19} = \frac{89}{n}$$

Here the number $n$ is _____.

153. You can use proportion to find per cents. A team won 5 of the 8 games it played. What per cent is this? You need to solve:

$$\frac{5}{8} = \frac{n}{100}$$

Over 5 on D set 8 on C. Under 1 (that is, 100) on C read _____ on D.
154. A student did 42 examples and got 37 of them right. What percent was this? You need to solve:

\[
\frac{37}{42} = \frac{n}{100}
\]

Over 42 on D set 37 on C. Under 1 of C read _____ on D.

155. What is 35 percent of 54? You need to solve:

\[
\frac{35}{100} = \frac{n}{54}
\]

Over 35 on D set 1 (that is, 100), on C. Under 54 on C read _____ on D.

156. The number 62 is 25 percent of what number? You need to solve:

\[
\frac{25}{100} = \frac{62}{n}
\]

Over 25 on D set 100 on C. Over 62 on D read _____ on C.

157. Here are some proportion examples for practice.

a) \( \frac{5}{3} = \frac{2}{n} \)

b) \( \frac{14}{17} = \frac{35}{n} \)

c) \( \frac{12}{7} = \frac{23}{n} \)

d) \( \frac{18}{51} = \frac{13}{n} \)

e) \( \frac{42.5}{91} = \frac{13.2}{n} \)

f) \( \frac{90.5}{n} = \frac{3.42}{1.54} \)

g) \( \frac{0.14}{100} = \frac{n}{29} \)

h) \( \frac{24}{29} = \frac{n}{100} \)

i) \( \frac{163}{295} = \frac{350}{n} \)

j) \( \frac{488}{450} = \frac{n}{100} \)

a) 1.25

b) 42.5
c) 13.4
d) 68.7
e) 300

f) 40.7
g) 64.3

h) 82.7

i) 440

j) 108.5

158. Scientists have a special way of writing numerals. You will learn some of the advantages of this way of writing as you study more mathematics and science. Just now, you will first learn how to write numerals this way. Then you will learn how to use this way to place the decimal point in difficult examples.

The numeral system in common use is the decimal system. It uses ten basic symbols to write the numeral for any number. These symbols are 0, 1, 2, 3, etc., to _____.

159. Notice the scale named D* (read D star) on the body of the slide rule. Place the hairline over 0 on the \( \overline{X} \) scale. Then the mark on the D* scale under the hairline is named _____.

160. Move the hairline to +1 of the \( \overline{X} \) scale. Now the mark on the D* scale named \( 10^1 \) (read "10 to the first power") is under the hairline. \( 10^1 = 10 \). When the hairline is over +2 on \( \overline{X} \), it is also over \( 10^2 \) (read "10 to the second power," or (10 squared), on _____.

161. \( 10^2 \) means \( 10 \times 10 \) or 100. When the hairline is over \( 10^2 \) (read "10 to the third power") or (read "10 cube") it is also over _____ on \( \overline{X} \).

162. \( 10^3 \) means \( 10 \times 10 \times 10 \) or 1,000. When the hairline is over +3 on \( \overline{X} \), it is also over _____ on D*.

163. \( 10^4 \) means _____.

\( 10 \times 10 \times 10 \times 10 \)

or 10,000
164. $10^7$ means $10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$. This is 10 used as a factor 7 times. Then $10^5$ means 10 used as a factor 

165. When the hairline is over $10^9$ on $D^9$, it is also over 9 on $\bar{D}$. 

166. The number which tells how many times 10 is used as a factor is called an exponent. For $10^5$ the exponent is 5. 

167. What can the number 8 in $10^8$ be called? 

168. The number 10 used as a factor is called the base. The exponent number named by a base and an exponent is called the power. 10,000 or $10^4$ is the 4th power of 10. The number 1,000 or $10^3$ is called the 3rd power of 10. 

169. The number $10^6$, or 1,000,000 is called the power of 10. 

170. For the ninth power of 10 the exponent is sixth. 

171. Using the base 10 and an exponent, the number $10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$ can be written $10^9$. 

172. Using the base 10, the exponent of 10 $\times 10 \times 10 \times 10 \times 10$ is $10^5$. 

173. Using base 10 and an exponent, the number $10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$ can be written $10^7$. 

174. Notice the numerals as you read on $D^9$ from the right-hand end toward the left. Also notice the exponents just above on $\bar{D}$. 

\begin{align*} 
10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0 \\
10^1, 10^0, 10^3, 10^4, 10^5, 10^6, 10^7, 10^8, 10^9, 10^{10} \\
10^{11}, 10^{12}, 10^{13}, 10^{14}, 10^{15}, 10^{16}, 10^{17}, 10^{18}, 10^{19}, 10^{20} \\
\end{align*} 

To keep the same pattern, we agree that below 0 on $\bar{D}$ we should have $10^{-5}$ on $D^9$. But in mathematics $10^0$ is 1. When the hairline is over 0 on $\bar{D}$ it is also over 1 on $D^9$. 

175. The number 328 is equal to $3.28 \times 10^2$ or $3.28 \times 10^2$. Also, the number 463 is equal to $4.63 \times 10^2$. 

176. The number 671 is $6.71 \times 10^2$. 

177. Numbers expressed as $6.71 \times 10^2$ are in scientific notation. This notation is much used in science and mathematics. When expressed in scientific notation, the number 149 is written $1.49 \times 10^2$. 

178. The number $9,826$ in scientific notation is $9.826 \times 1,000$ or $9.826 \times 10^3$. 

179. You can use a slide rule which has a $D^9$ scale to help express numbers in scientific notation. Place the hairline over 1 on $D^9$. The next short mark to the right on this scale represents 2. Move the hairline over this mark. The next short mark represents 3. The next two marks represent 4 and 5. 

180. The marks to the right of the mark for 5 until you get to $10^1$ stand for 4, 5, 6, 7, 8, 9.
181. Notice the shorter marks between $10^1$ and $10^2$ or 100. Now you must count them by tens. The first mark to the right of $10^1$ is the mark for 20. The next mark to the right stands for the number _____.

182. Count the marks over to $10^2$ or 100 in this way. The next one is 40. The following five marks are for _____, _____, _____, _____, _____.

183. The D₄ scale is an example of a non-uniform scale. The marks between 1 and $10^1$ get closer together as you move to the right. The marks for 10 and the mark for 20 to put in all the marks for 11, 12, 13, etc. You can imagine they are there. The space between the mark for 20 and the mark for 30 represents 21, 22, 23, etc. The setting for 25, for example, is a little more than half-way between the mark for 20 and ________._

184. The number 25 in scientific notation is $2.5 \times 10^1$. In scientific notation the number is always expressed as the product of two factors. In this example, the factors are 2, 5 and ________.

185. The number 700 expressed as the product of two factors is $7 \times 10^2$. In this example, the second factor is ________.

186. In scientific notation, one of the factors is always a power of ten. For example, 160 = $3.60 \times 100$, or $3.60 \times 10^2$. In this example, the power of ten is the ________.

187. In scientific notation, the factor that is not a power of ten always is expressed so that the decimal point is at the right of the first digit. For example, we write $275 = 2.75 \times 10^2$. The first digit of 275 is the numeral ________.

188. The number 8, 3 expressed in scientific notation is $8.3 \times 10^1$ or $8.3 \times ________$.

189. The number 830 expressed in scientific notation is $8.3 \times 10^2$.

190. You can use an easy way to express a number in scientific notation. For example, try 8,520. First, write 8,52. Then count the number of digits in 8,52 between the first digit and the decimal point. There are 3 digits. Then finish by writing a times sign and $10^3$ after the 8.52. Thus $8,520 = 8.52 \times 10^3$

3 places the exponent

When 956,000 is expressed in scientific notation, the exponent of 10 is ________.

191. Expressed in scientific notation, 956,000 becomes ________.

192. In scientific notation, 1,000,000 is written ________.

193. In scientific notation, 3,784 is written ________.
194. Notice the following pattern.

\[
\begin{align*}
100,000 &= 1 \times 10^5 \\
10,000 &= 1 \times 10^4 \\
1,000 &= 1 \times 10^3 \\
100 &= 1 \times 10^2 \\
10 &= 1 \times 10^1 \\
1 &= 1 \times 10^0 \\
0.1 &= 1 \times 10^{-1} \\
0.01 &= 1 \times 10^{-2} \\
0.001 &= 1 \times 10^{-3} \\
0.0001 &= 1 \times 10^{-4} \\
\end{align*}
\]

etc.

The number \(0.0001\) written in scientific notation is \(1 \times 10^{-4}\).

195. When numbers less than 1 are written in scientific notation, the exponent of 10 is a negative number. For example, \(0.034 = 3.4 \times 10^{-2}\). You can find the exponent of 10 by counting. Begin at the right of the first digit and count the digits to the decimal point.

\[
\begin{array}{c}
\text{Begin} \\
0.034 \\
\end{array}
\]

In this example, the count is 2. You are counting toward the left. Then the exponent of 10 is \(-2\). The exponent of 10 for \(0.0056\) is \(-3\).

196. Expressed in scientific notation, \(0.0056\) becomes \(5.6 \times 10^{-3}\).

197. Notice that if you count toward the right, the exponent of 10 is a positive number. For example, in \(8,347\)

\[
\begin{array}{c}
\text{Begin here} \\
8,347 \\
\end{array}
\]

the count is 3 toward the right. In scientific notation, \(8,347\) is written \(8.347 \times 10^3\).

198. Here are some examples for practice. Write each numeral in scientific notation.

\[
\begin{align*}
a)\ 430,000 & \quad b)\ \cdot 000043 \\
c)\ 26.5 & \quad d)\ .62 \\
e)\ 723.5 & \quad f)\ \cdot 2.7 \\
g)\ 94,600 & \quad h)\ \cdot 00137 \\
i)\ \cdot 0066 & \quad j)\ 26,000,000 \\
\end{align*}
\]

\[
\begin{align*}
a)\ 4.3 \times 10^5 & \quad b)\ 4.3 \times 10^{-5} \\
c)\ 2.65 \times 10^2 & \quad d)\ 6.2 \times 10^{-1} \\
e)\ 7.235 \times 10^3 & \quad f)\ 2.7 \times 10^6 \\
g)\ 9.40 \times 10^4 & \quad h)\ 1.37 \times 10^{-3} \\
i)\ 6. \times 10^{-2} & \quad j)\ 2 \times 10^7 \\
\end{align*}
\]
PLACING THE DECIMAL POINT

199. You can use scientific notation to help place the decimal point. First, you must learn to multiply numbers written in scientific notation. Here is an easy example.

\[ 2,000 \times 300. \]

In scientific notation, this is

\[ 2 \times 10^3 \times 3 \times 10^2. \]

Changing the order of the factors, you get

\[ 2 \times 3 \times 10^3 \times 10^2 \]

This is \( 6 \times 10 \times 10 \times 10 \times 10 \).

Written in scientific notation, this becomes \( \boxed{6 \times 10^5} \) or \( \boxed{600,000} \).

200. To multiply powers of ten, like \( 10^3 \times 10^2 \), you can add the exponents and use the sum as an exponent of 10.

\[ 10^3 \times 10^2 = 10^5 \]

In \( 10^2 \times 10^3 \), the exponent of 10 in the product is \( \boxed{5} \).

201. \( 10^4 \times 10^7 = 10,000,000 \). This is the numeral 1 followed by 7 zeros. In the example \( 10^2 \times 10^6 \), the exponent of 10 is \( \boxed{8} \).

202. You can do examples like these on the slide rule. For example, place the hairline over \( 10^2 \) on the D scale. On the X scale just above you find \( 42 \). The numbers for the X scale are the exponents for the D scale. The numeral \( +5 \) on X is just above \( 10 \) on the D scale.

203. Remember, to multiply powers of ten you can add the exponents. The X and Y scales are used for addition. In an example like \( 10^2 \times 10^6 \), you want to add +2 and +6. Set 0 on the Y scale under +2 on the X scale. Over +6 on the Y scale read 98 on X. Below 8 read \( 10^9 \) on D. For the example \( 10^3 \times 10^6 \), set 0 of Y under +3 of X (\( 10^3 \) of D). Over +6 of Y read +9 on X, or read \( \boxed{10^9} \) on D.

204. Products of powers of ten are easy when both exponents are positive numbers. They are harder if one (or both) of the exponents is a negative number. However, you can use the slide rule here too. For example, find \( 10^2 \times 10^{-5} \). Set 0 of Y under +2 of X (or \( 10^2 \) of D). Under \( -5 \) of Y, read \( -3 \) on X, or \( \boxed{10^{-3}} \) on D.

205. Remember that \( 10^2 \times 10^{-5} \) is .00001, so you have multiplied 100 x .00001. You get \( 10^{-3} \) or .001 as the answer. Now find 200 x .00003. First, write the example in scientific notation.

\[ 2 \times 10^2 \times 3 \times 10^{-5} \]

Next change the order of the factors:

\[ 2 \times 3 \times 10^2 \times 10^{-5} \]

This can be written: \( 6 \times 10^{-3} \).

206. The result in ordinary notation is \( \boxed{.006} \).

207. Now try a harder example. Find \( .0024 \times .000196 \).

This is \( 2.4 \times 10^{-3} \times 1.96 \times 10^{-4} \), or \( 2.4 \times 1.96 \times 10^{-3} \times 10^{-4} \).

First multiply \( 2.4 \times 1.96 \) using the C and D scales. The product is \( \boxed{4.70} \).
208. Next, find $10^{-3} \times 10^{-4}$. Set 0 of Y under -3 on X. Over -4 on Y read _______ on D®.

209. Now you have $4.70 \times 10^{-7}$. Start at the decimal point and count $10^{-7}$ toward the left, writing 6 zeros in front of the 4.

Then you have 7 digits to the left of the original decimal point.
The answer is _______.

210. Find $0.0048 \times 73,000$. This can be written: $0.000,000,047$

$4.8 \times 10^{-3} \times 7.3 \times 10^4$, or

$4.8 \times 7.3 \times 10^{-3} \times 10^4$.

First, multiply $4.8 \times 7.3$. The product is _______.

211. Next, find $10^{-3} \times 10^4$. Set 0 of Y under -3 of X. Over +4 on Y, read _______ on D®.

Then the answer is $35 \times 10^1$, or _______.

212. There is another way to think of the answer.

Notice $35 = 3.5 \times 10$, so $35 \times 10 = 3.5 \times 10 \times 10$, or $3.5 \times 10^2$, which is _______.

213. You can use scientific notation to place the decimal point in division. Here is an easy example. $600,000 \div 300$. Written in scientific notation, this becomes $6 \times 10^5 \div 3 \times 10^2$, or

$6 \times 10^3$. First, divide 6 by 3; the result is 2. Next, you must divide $10^5$ by $10^2$.

$10^5 \times 10^{10} \times 10^{-10}$

Dividing by the two tens, you see you will then have the product of three tens, or $10^3$. The answer is $2 \times 10^3$, or written in ordinary notation _______.

214. To divide powers of ten, like $10^5 \div 10^2$, we can subtract the exponent of the division from the exponent of the dividend, and use the difference as the exponent of 10 in the answer.

For example, $10^5 \div 10^2 = 10^{5-2} = 10^3$.

In $10^9 \div 10^5$, the exponent of 10 in the quotient is _______.

215. In $\frac{10^8}{10^5}$ the exponent of 10 in the quotient is _______.

216. You can do examples like these on the slide rule. You do the subtraction with the X and Y scales. For example, find $10^7 \div 10^3$. Set the hairline over +7 on the X scale. Set the slide so that +3 on Y is under the +7 on X. Over 0 on Y read +4 on X, or _______ on D®.

217. When one (or both) of the exponents is negative, the problem is a little harder. However, if you use a slide rule the problem is easy. Find $10^5 \div 10^{-3}$. Under +3 of X set -4 of Y. Over 0 of Y read _______ on X.

218. Then $10^3 \div 10^{-4} = 10^7$, or in ordinary notation,

$1,000 \div .0001 = _______$. 

219. Now you can do a harder example. Find $0.0067 \div 0.032$.

Write the example in scientific notation.

$6.7 \times 10^{-3}$

$3.2 \times 10^{-2}$

First, divide 6.7 by 3.2 using the C and D scales. The answer is _______.

220. Next, divide $10^{-3} \div 10^{-2}$ using the X and Y scales. Under -3 on X set -2 on Y. Over 0 on X read -1 on X, or _______ on D®.

221. The answer is _______.

2,000
222. Now you have $2.09 \times 10^{-1}$. So the final answer is ___.

223. Find $4.2, 200 \div 0.088$.
   
   In scientific notation, this is
   
   \[4.2 \times 10^3\]
   \[8.8 \times 10^{-2}\]
   
   First, find the quotient of $4.2 \div 8.8$. The result is ___.

224. Next find $10^3 \div 10^{-2}$. The result is ___.
   
   .477

225. Now you have $4.77 \times 10^5$. But .477 is not in scientific notation. Changed to scientific notation, it is ___.
   
   $10^5$

226. Then you have $4.77 \times 10^{-1} \times 10^5$.
   
   But $10^{-1} \times 10^5 = 10$.
   
   $4.77 \times 10^1$

227. Then in ordinary notation the answer is ___.
   
   4

228. Here are some more examples for practice.
   
   a) $3,240 \times 0.0039$
   
   b) $0.0146 \div 32.8$
   
   c) $2,650 \times 0.0007$
   
   d) $8,570 \div 0.0219$
   
   e) $.43 \times .0027$
   
   f) $7,630 \div .0198$
   
   g) $.000478 \times .0069$
   
   h) $.00231 \div 41.3$

229. Notice the scale named CI on the slide. It is an ordinary C scale but the numbers increase from right to left, instead of left to right. Place the hairline over the right-hand index.
   
   If this is read as 1, the left-hand index is read as 10. A small arrow beside the numerals (for example, $\frac{4}{2}, \frac{4}{3}$) will remind you that the CI scale is reversed or "inverted". Place the hairline over 2 on the CI scale. Then the numeral under the hairline on the C scale is ___.

230. Two numbers whose product is 1 are **reciprocals**. For example, 2 and 1/2 are reciprocals, because $2 \times \frac{1}{2} = 1$.
   
   But 1/2 can also be written as .5. So $2 \times .5 = 1$, and 2 and .5 are reciprocals. The reciprocal of 4 is ___.

231. Each number represented on the CI scale is the reciprocal of the number represented just below it on the C scale. Place the hairline over 4 on the C scale. The corresponding reciprocal on CI is ___.

232. Find the reciprocal of 47. Set the hairline over 47 on C. On CI read the reciprocal as ___.

233. Did you have the decimal point correctly placed? Remember, the reciprocal of 47 is $\frac{1}{47}$, because $47 \times \frac{1}{47} = 1$.
   
   But $\frac{1}{47} = \frac{1 \times 2}{47 \times 2}$. This shows the reciprocal is about $\frac{2}{100}$ or .02. You can also use scientific notation to find the decimal point. The reciprocal of 60 is ___.
234. Instead of multiplying by a factor, you can divide by the reciprocal of the factor. For example, \( 7 \times \frac{1}{8} = 7 \times 0.125 \).
Suppose that you try to do \( 7 \times 8 \) on the slide rule by setting the left index of C over 7 on D. Then 8 on C is far “outside the rule”. You must move the slide so that the right-hand index of C is over 7 on D. Now, move the hairline to 8 on C. The answer on D is 56.
You can avoid moving the slide “end-for-end” in examples like this by using the CI scale. Let’s do \( 7 \times 8 \) again. This time, move 8 on CI over 7 on D. Under 1 of CI (or C) read _____ on D. You only had to move the slide once this way.

235. Find \( 53 \times 7.9 \). Notice that if you move the slide to set 1 over either of these numbers, the stick will stick far outside the rule. Place the hairline over 79 on D. Move the slide so 53 on CI is under the hairline. Then under the index of CI read _____ on D.

236. Find \( 84 \times 3.1 \). The answer is _____.

237. The CI scale has other uses. Perhaps you will learn some of them when you study slide rules that have many useful scales that are not on a simple rule.

SQUARES OF NUMBERS and SQUARE ROOTS

238. Notice the scale named A above the D scale. Place the hairline over 2 of the D scale. Then on the A scale you can read 4 or \( 2 \times 2 \). Under 3 of D you can read 9 or \( 3 \times 3 \) on A. The number 9 is the square of 3. The square of 3 can also be written \( 3^2 \).
If the left-hand 1 of A is read as 1, the numeral 1 (just to the right of 9) is read 10. The numerals on A at the right are now read as 20, 30, 40, etc. The right-hand index of A is then 100.
Place the hairline over 4 on D. The reading under the hairline on A is _____.

239. Find \( 5^2 \). Set the hairline over 5 on D. On A, read _____.

240. Find \( 16^2 \). Set the hairline over 16 on D. On A, read _____.

241. Find \( 48^2 \). Set the hairline over 48 on D. On A, read _____.

242. If you find the square of a one-digit number (like 3 or 7), the square will have either one or two digits. If it is read on the left-hand half of the A scale, it has one digit. \( 3^2 = 9 \).
If it is read on the right-hand half of A, it will have two digits. \( 7^2 \) will be read on the right half and has _____ digits.

243. If you find the square of a two-digit number (like 16 or 48), it will have either three or four digits. It will have three digits if it is read from the left-hand half of A. Example: \( 16^2 = 256 \). If it is read from the right-hand half of A it will have _____ digits.
The square of a three-digit number which is read from the left half of A will have ___ digits.

The square of 137 is ___.

The square of a three-digit number which is read from the right half of A will have ___ digits.

The square of 631 is ___.

You can find the square of any number by remembering how the left-right pattern goes. The squares read from the left half of the A scale have an odd number of digits. The squares read from the right half of the A scale have an even number of digits.

You can also think of finding squares by ordinary multiplication and using scientific notation to locate the decimal point.

\[
(1.37)^2 = 1.37 \times 1.37
\]

Then

\[
3.7 \times 10^{-1} \times 3.7 \times 10^{-1} =
\]

\[
3.7 \times 3.7 \times 10^{-1} \times 10^{-1}
\]

But

\[
3.7 \times 3.7 \text{ or } (3.7)^2
\]

Then written in scientific notation, \(13.7 = 1.37 \times 10^1\).

Therefore,

\[
(3.7)^2 = 1.37 \times 10^1 \times 10^{-1} \times 10^{-1}
\]

This is

\[
1.37 \times 10^0 \times 10^{-1}, \text{ or } 1.37 \times 10^{-1}.
\]

The answer is ___.

Here are some more examples for practice.

a) \((1.91)^2\)

b) \((19.1)^2\)

c) \((5.74)^2\)

d) \((48.2)^2\)

e) \((.32)^2\)

f) \(254^2\)

You know that \(5 \times 5 = 25\). Here 5 is one of the two equal factors of 25. The number 25 is the square root of 25. The square root of 16 is ___.

You can find square roots easily with the slide rule. The symbol for square root is \(\sqrt{}\). Find \(\sqrt{9}\).  Set the hairline over 9 on the left half of the A scale. Read ___ on the D scale.

Finding square roots is the opposite of finding squares. You begin on the A scale and end on the D scale. Find \(\sqrt{25}\). Since 25 is a 2 digit number, you use the right-hand half of the A scale. Set the hairline over 25 and on D read ___.

Find \(\sqrt{561}\). Since 361 has three digits, it is an "odd-digit number". Use the left-hand half of the A scale. Set 361 on A. Above on D read ___.

You know the decimal point comes after the 9 in 19 because it takes a two-digit number (19) to have a three digit square (361). Find \(\sqrt{5900}\). Set the hairline over 49 on the right-hand half of A. On D, read the square root as ___.

You know the answer is 70 and not 7 or 700 because it takes a two-digit number (70) to have a four-digit square (4900).

Find \(\sqrt{6.4}\). Use the left half of A. Set 6.4 on A, read ___ on D.
257. You see that you can use your knowledge about squares to help you find square roots. If you forget how the scales are related, choose a simple example. You see 3 is on D, and 9 is on A. The number is on D, the square is on ____.

258. If the number is on A, the square root is on _____.

259. In difficult examples, use scientific notation to help. For example, find \( \sqrt{.00075} \). Written in scientific notation, \(.00075 = 7.5 \times 10^{-4}\). Now you can find \( \sqrt{7.5} \) and \( \sqrt{10^{-4}} \). First, use A and D to find \( \sqrt{7.5} \), which is ______.

260. Now \( 10^{-2} \times 10^{-2} = 10^{-4} \). That is, one of the two equal factors of \( 10^{-4} \) is \( 10^{-2} \). So \( \sqrt{10^{-4}} = 10^{-2} \).

Then \( 2.74 \times 10^{-2} = _______ \).

261. The exponent of the square root of a power of ten is just half the exponent of the power. For example, if the power is \( 10^{-4} \), the exponent of the square root is \( 10^{-2} \).

To find the square root it is necessary to write the exponent as an "even" number. For example, suppose you want to find \( \sqrt{.0075} \). In scientific notation, \(.0075 = 7.5 \times 10^{-3}\). The exponent of 10 is not "even", or divisible by 2. You can change it so that exponent is even, but then you have to change the other factor too. For example, \(.0075 \times \frac{75}{10,000} = \frac{75}{10^{-2}} = 75 \times 10^{-4}\).

Now you have 75 instead of 7.5, and \( 10^{-4} \) instead of \( 10^{-3} \).

You can find \( \sqrt{75} \), which is ______.

262. Next find \( \sqrt{10^{-4}} = 10^{-2} \). So \( \sqrt{.0075} = 8.66 \times 10^{-2} \), or in ordinary notation _______.

263. Here are some more examples for practice.

\begin{align*}
a) \sqrt{7.3} & \quad b) \sqrt{73} \\
c) \sqrt{450} & \quad d) \sqrt{841} \\
e) \sqrt{3000} & \quad f) \sqrt{3.73} \\
g) \sqrt{.006} & \quad h) \sqrt{.062} \\
\end{align*}

\begin{align*}
a) \quad 2.7 & \quad b) \quad 8.54 \\
c) \quad 21.2 & \quad d) \quad 29 \\
e) \quad 54.8 & \quad f) \quad 1.93 \\
g) \quad .0775 & \quad h) \quad .249 \\
\end{align*}
264. Notice the scale named \( L \) at the bottom of the rule. It is a uniform scale, similar to the \( X \) scale and \( Y \) scale. In fact, it is like the part of the \( X \) scale between 0 and 41, except that it has been magnified or stretched 20 times. The small numeral 1 corresponds to the first little mark after the 0 on \( X \).

\[
\begin{array}{c}
\text{L} \\
\text{Y} \\
0 \quad 1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \end{array}
\]

The \( L \) scale is made to read with the \( C \) and \( D \) scale. Now you can see that the \( D \) scale corresponds to the section of \( D^2 \) between 1 and \( 10^1 \), but the \( D \) scale is 20 times as long.

You could use the \( D^2 \) to get answers with the decimal point all taken care of. But the answers will not be accurate to much more than one digit. By magnifying the \( D^2 \) scale 20 times, and only using one section between 0 and 1, as is done with the \( C \) and \( D \) scales, you can read to 3 digits, but you have to place the decimal point by some other method.

The \( L \) scale is named \( L \) because it is used to get logarithms, which are really just exponents of 10. Set the hairline over 2 of \( D \). Then the hairline is over .301 of \( L \). Now, \( 2 = 10^{0.301} \). Find the logarithm, or exponent of 10 for which the power is 3. Set the hairline over 3 of \( D \). On \( L \), read ______.

265. Now you know that \( 3 = 10^{1.477} \). Do not try to think of this as .477 factors of 10. But the rules for exponents work all right for numbers expressed this way. For example, \( 2 \times 3 = 10^{0.301} \times 10^{0.477} \). Now we add .301 and .477. The sum is ______.

266. If you place the hairline over .778 of \( L \), you can read 5 on \( D \), and \( 2 \times 3 = 5 \).

On a slide rule, we multiply by adding logarithms, or exponents.

Logarithms have many uses. You can learn more about them in high school. If you do, then the way a slide rule is made and the reason it works can be explained.
HOW TO ADJUST YOUR SLIDE RULE

Each rule is accurately adjusted before it leaves the factory. However, handling during shipment, dropping the rule, or a series of jars may loosen the adjusting screws and throw the scales out of alignment. Follow these simple directions for slide rule adjustment.

CURSOR WINDOW HAIRLINE ADJUSTMENT
Line up the hairline on one side of the rule at a time.
1. Lay rule on flat surface and loosen adjusting screws in end plates.
2. Line up C index with D index. Then align DF (or A) index with CF (or B) index.
3. Tighten screws in end plates.
4. Loosen cursor window screws. Slip a narrow strip of thin cardboard (or 3 or 4 narrow strips of paper) under center of window.
5. Align hairline with D and DF (or D and A) indices, and tighten cursor window screws. Check to see that window surfaces do not touch or rub against rule surfaces.

Note: The narrow strip of cardboard under the window will prevent possible distortion or “bowing in” of the window when screws are tightened. “Bowing in” may cause rubbing of window against rule surface with resultant wear or scratches.

Line up hairline on reverse side of rule.
1. Loosen all cursor window screws.
2. Place narrow strip of thin cardboard under window to prevent “Bowling in” when screws are tightened.

HEHOW TO KEEP YOUR SLIDE RULE IN CONDITION

OPERATION • Always hold your rule between thumb and forefinger at the ENDS of the rule. This will insure free, smooth movement of the slider. Holding your rule at the center tends to bind the slider and hinder its free movement.

CLEANING • Wash surface of the rule with a non-abrasive soap and water when cleaning the scales.

LUBRICATION • The metal edges of your slide rule will require lubrication from time to time. To lubricate, put a little white petroleum jelly (White Vaseline) on the edges and move the slider back and forth several times. Wipe off any excess lubricant. Do not use ordinary oil as it may eventually discolor rule surfaces.

LEATHER CASE CARE • Your leather Slide Rule Case is made of the finest top-grain, genuine California Saddle Leather. This leather is slow-tanned using the natural tanbark from the rare Lithocarpus Oak which grows only in California. It polishes more and more with use and age.

To clean your case and to keep the leather pliable and in perfect condition, rub in a good harness soap such as Proper’s Harness Soap.

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