MB 858.1

STUDY GUIDE

FOR

THE SLIDE RULE

(To be used with USAFI Course MB 858 or CB 858)

A TECHNICAL COURSE

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THE SLIDE RULE

YOU are enrolled either in Self-Teaching Course MB 858, *The Slide Rule*, or in Correspondence Course CB 858, *The Slide Rule*. This booklet is your Study Guide, prepared to direct your work in this course.

Except for the material inclosed in blocks, the directions given below are intended for both correspondence and self-teaching students. The directions inclosed in blocks are necessary only for correspondence course students.

PURPOSES AND OBJECTIVES

This course is intended to assist you in developing proficiency in the many time saving manipulations which can be carried out on the slide rule. Since the major use of a slide rule is in solving problems in mathematics which arise in any business or profession, a wide range of practice problems have been given. Unless the slide rule is used at every opportunity in your daily work, however, you can never develop faith in your ability to use it correctly.

MATERIALS FOR THE COURSE

Your textbook is MB 858, SLIDE RULE SIMPLIFIED, by C. O. Harris. The textbook, this Study Guide, a 10-inch Mannheim slide rule, the lesson sheets, and the envelopes for mailing the Written Assignments are all furnished by USAFI. You will have to provide your own pencils or pen, scratch paper, and erasers.

SCOPE OF THE COURSE

This course is divided into ten units with Unit 11 optional. All students are required to do Units 1–10. Unit 11 is not requred, but may be done by those who have a previous knowledge of logarithms and wish to know why the slide rule works the way it does.

The eleven units are:

UNIT NO.	UNIT TITLE
1.	The Scales on the Slide Rule
2.	Multiplication
3.	Division
4.	Combinations of Multiplication and Division
5.	Squares and Square Roots
6.	Cubes and Cube Roots
7.	Sines and Cosines
8.	Tangents
9.	The Reciprocal Scale
10.	Review of Important Rules
11.	Logarithms, Basis of the Slide Rule

Each unit should require about 5 to 6 hours of study. Do not worry if you take longer; many students have better results if they study more slowly. The important point is to secure a complete understanding of each unit before you proceed to the next one.

HOW TO DO THE WORK OF THE COURSE

To help you study this course, each unit has been organized so that it follows the same general pattern. At the beginning of each unit you will find an introduction, which has been prepared to give you an overall view of that particular unit and also its relationship to the other units.

Text Assignment

This section will tell you exactly what pages or paragraphs to study in your text. Be sure to read the explanations carefully, studying all illustrative examples given in the text, until you understand them.

Study Notes

The Study Notes are prepared to supplement your reading and to point out in more detail the method and purpose behind certain principles and procedures.

In studying your text, it is advisable first to read the textbook assignment from the beginning to the end to get a general picture of what it contains, then to go back and reread each paragraph more carefully. A textbook cannot be studied in the same manner as a popular novel. Try to set up the problems on your slide rule as they are illustrated in the text.

Self-Examination

The Self-Examination questions serve as an excellent review. Always work these exercises and check your answers with the Key in the back of this Study Guide. You may wish to discuss the questions with some member of your organization who is familiar with this field. Do NOT send this work to USAFI, it is for your own use only.

Written Assignment

This work is to be submitted by students enrolled in Correspondence course CB 858. Students enrolled in Self-Teaching course MB 858 need not submit these assignments.

The Written Assignments are to be prepared on separate sheets of paper, preferably, but not necessarily, on the lesson sheets provided by USAFI. If drawings are required, they may be made in pencil. In the solution of problems, include the details of each step. When you are required to answer a question, make the answer a complete statement, and include the reason for this statement. Be sure you have labeled each sheet you send in with your rank or rating, name, service number, address, course number, and unit number. When you have completed a Written Assignment, mail it in the envelopes provided to the United States Armed Forces Institute, Madison 3, Wisconsin, or to the oversea USAFI with which you are enrolled. A teacher will grade your work and return it to you with any comments he thinks will be helpful. When you have mailed your Written Assignment, *do not wait* for the response from USAFI to reach you, but start immediately on the work of the next unit.

QUESTIONS

If you find you have difficulty with any part of this course, find someone in your organization who can help you or write to the United States Armed Forces Institute, Madison 3, Wisconsin, or to the oversea USAFI with which you are enrolled. Your questions should be definite. Be sure to specify course number, title, number of the unit, and the exact line or question in which your difficulty occurs.

CERTIFICATE

To qualify for the United States Armed Forces Institute Certificate of Completion for the course you should:

1. Complete successfully the end-of-course test. When you have completed Unit 6, you should request the end-of-course test from the United States Armed Forces Institute, Madison 3, Wisconsin, or from the oversea USAFI with which you are enrolled. Use the application blank which is inclosed, fill it out carefully and be sure it is properly certified by an officer who will administer the test. The end-of-course test is to be taken after you have completed Unit 10.

NOTE

2. In addition, students enrolled in Correspondence Course CB 858 should complete the written assignments for all ten (10) units with an average grade of 70 or better.

UNIT 1

READING THE SCALES ON THE SLIDE RULE

THIS first unit describes the slide rule and its various parts. It also illustrates the method of holding the rule to permit moving the various parts quickly and accurately with a minimum of effort. The major part of the unit, however, deals with reading the numbers on the various scales of the slide rule. When this has been mastered, the operations can be performed without the distraction and delay of having to interpret each number.

Text Assignment

Preface, pages iii-v. How To Use This Book, pages vi-vii. Chapters 1, 2, and 3; pages 1–38, 42–43. Omit the Log Scale.

Study Notes

Before starting this first unit be sure to read carefully the preface and the following section on how to use the text. If the suggestions set forth here and throughout the text are followed, step by step, the use of the slide rule should not be hard to learn, even with a minimum of background in mathematics.

Page 2. It is pointed out that the saving in time and energy is very great as compared to doing the calculations by longhand. However, it should be noted that the slide rule does not give an exact answer except for the first three or four digits in the answer. For example, if the multiplication of 348 by 69 is carried out longhand, it gives 24,012. These same numbers multiplied on the slide rule give 24,000. There are very few calculations, except in dealing with money, where accuracy beyond the first three digits is necessary; so this is not a serious disadvantage of the slide rule.

Page 8. Fig. 3 shows how the thumbs are used to move the runner along the stock. If your slide rule has a spring on one side between the runner and the stock it is best to place this spring on the side away from the thumbs. In this way the pressure from the thumbs will not tend to tilt the runner.

Page 12. Fig. 5 shows the back of the slide with the sine scale, log scale, and tangent scale. The information on the log scale can be omitted for now. If you are interested in logarithms and want to do optional assignment 11 you can study the log scale at that time.

Page 14. Since the scales on a slide rule are concerned only with the order of the digits in a number, the left index could be thought of as 10 just as well as 1. One section to the right of the left index another number 1 appears, but this should be thought of as 1.1 or 11, the first 1 not being inscribed on the rule. The next section to the right would be 1.2 or 12, etc. It is very easy to confuse the "2" two sections to the right of the left index with the correct 2 which is a whole division to the right.

It is important that you understand the discussion on the decimal point as given on the bottom of this page. Remember that the removal or transfer of a decimal point will not change the location of a number on the C and D scales. In Fig. 6 you will notice that the location of the number 16.7 is pointed out on the C scale. In like manner, the numbers 0.167, 1.67, 167, 1670, would be located at the very same place on the C scale of your slide rule.

Page 15. Be sure to follow the procedure given in the illustrative examples very closely. This may seem to take a lot of time, but after a little practice the steps in the procedure will become automatic.

Page 16, Example 10. Be sure you can tell the difference in the location of 108 and 1008. In the case of the 108 you are in the first division, the first section and 8 spaces to the right of the left index. In the case of the 1008 you are in the first division, the first section, and the first space, only eight-tenths of a space to the right of the left index.

Page 18. Pay particular attention to the last paragraph of this page. It is not practical to divide the divisions into 10 spaces after the first section, so it becomes necessary to estimate parts of spaces. This is essential if extreme accuracy is desired.

Page 24. For best results, follow the suggestion made earlier by the author of your textbook and always have your slide rule in hand when reading the text.

Page 28. The third paragraph mentions the term "arc sine." This term means *"the angle whose sine is."* For example arc sine 0.30 means the angle whose sine is 0.30.

The usual method of subdividing angles is into minutes the same way an hour is divided into minutes. This means that one minute is simply 1/60 of a degree. Your slide rule is marked off in these units, although some slide rules divide the degrees into 10 parts as in decimals.

The reason the sine scale does not start at zero degrees is that the sine of zero degrees is zero. However, there is no zero on the A, B, C, or D scales. The left index of any of these scales may be considered as 1.00 or 0.100 or even 0.000100, but never zero.

Page 42. Try to answer the review questions on this chapter before doing the Self-Examination problems. These questions are not answered directly, but the answers can be found in the chapter itself.

Self-Examination

Answer the following questions for Unit 1. The answers will be found in the Key at the back of this Study Guide. Do *NOT* send these answers to USAFI.

1. Which of the following parts of the slide rule has no scale on it?

   (a) slide
   (b) runner
   (c) stock
   (d) none of these
   (e) all of these

2. Since the number 36.973 has too many digits to be located exactly, it would be represented on the D scale as:

   (a) 36.9
   (b) 36.1
   (c) 37.0
   (d) 37.1
   (e) none of these

3. Which of the following numbers would be located on the D scale the same as 3.1416?

   (a) 0.0003142
   (b) 314
   (c) 31,415,760
   (d) none of these
   (e) all of these

4. On the A scale, which digit of a number determines the section in which that number lies?

   (a) 1
   (b) 2
   (c) 3
   (d) 4
   (e) 5

5. On the D scale, which digit of a number determines the space in which that number lies?

(a) 1
(b) 2
(c) 3
(d) 4
(e) 5

6. If the hairline on the runner is placed over 473 on the D scale, which of the following numbers is found under it on the A scale?

(a) 278
(b) 122
(c) 1223
(d) 223
(e) none of these

7. If the hairline is placed over the number 370 on the left side of the A scale, which of the following numbers is found under it on the D scale?

(a) 1923
(b) 1830
(c) 175
(d) 608
(e) none of these

8. If the right index of the A scale is lined up with the number 116 on the right half of the B scale, which of the following angles is found under the marker on the sine scale?

(a) 5°50′
(b) 6°40′
(c) 9°13′
(d) 0°40′
(e) none of these

9. If the number 517 on the C scale is lined up with the right index of the D scale, which of the following angles is found under the marker on the tangent scale?

(a) 29°40′
(b) 26°55′
(c) 27°20′
(d) 31°40′
(e) none of these

10. If the center index of the B scale is lined up with the number 420 on the right half of the A scale, which of the following numbers on the D scale is in line with the number 1190 on the C scale?

(a) 244
(b) 390
(c) 408
(d) 238
(e) none of these

Written Assignment

NOTE: The following work is to be submitted by students enrolled in Correspondence Course CB 858. Students enrolled in Self-Teaching Course MB 858 need not complete this written work. Full instructions for sending in Written Assignments are given on page 3 of this Study Guide.

1. In each of the following cases tell which numeral is the first digit, which is the second, etc.:

(a) 1.687
(b) 0.00639
(c) 21,460
(d) 300.13
(e) 0.010039

2. In the manner of the illustrative examples of your text, explain how to locate the following numbers on the D scale:

(a) 1042
(b) 12.30
(c) 398.0
(d) 945
(e) 0.508

3. In the manner of the illustrative examples of your text, explain how to locate the following angles on the sine scale:

(a) 1°43′
(b) 8°5′
(c) 30°30′
(d) 76°
(e) 80°

4. Make a sketch about 5″ long of the first division of the D scale. In this sketch locate the following numbers by means of small arrowheads. This is illustrated on page 14, figure 6, in your text.

   (a) 101.3
   (b) 0.0137
   (c) 15.7
   (d) 1.89
   (e) 1046

5. Make a sketch about 5″ long of the three divisions at the left end of the CI scale. Locate the following numbers on this sketch:

   (a) 8.67
   (b) 70.6
   (c) 0.998
   (d) 802
   (e) 93.5

6. Line up the number 765 on the C scale with the right index of the D scale. Now locate the following numbers on the D scale and then indicate which numbers on the C scale line up with them:

   (a) 1.53
   (b) 17.4
   (c) 204
   (d) 0.00332
   (e) 685
   (f) 0.710
   (g) 8.00
   (h) 84,500
   (i) 93.0
   (j) 980

7. List the following numbers and after each one write the angle which is found on the tangent scale, when that number is located on the C scale opposite the right index of the D scale:

   (a) 126
   (b) 172
   (c) 243
   (d) 314
   (e) 810

8. List the following numbers and after each one write the angle which is found on the sine scale, when that number is located on the right half of the B scale opposite the right index of the A scale:

   (a) 126
   (b) 197
   (c) 201
   (d) 304
   (e) 910

UNIT 2

MULTIPLICATION

OTHER than addition and subtraction, multiplication is the most widely used process in mathematics. This unit describes and illustrates the steps in the process of multiplication. One section of the unit is devoted to the *digit count* method of locating the decimal point in the answer. Pay careful attention to this section since the decimal point is just as much a part of the answer as the digits.

Text Assignment

Chapter 4; pages 45–66. Omit the material on the basis of the process of multiplication on pages 61–63.

Study Notes

This chapter contains a large number of illustrative examples, as do the following chapters. Be sure to check all of the examples on your slide rule. You may disagree with the third or fourth digit in the answer, but this depends upon the accuracy of your rule and your ability to set and read it carefully. The hairlines on most of the less expensive slide rules are rather thick and this makes extreme accuracy difficult.

There are some answers given in the text which are not as accurate as it is possible to achieve with the slide rule. This Study Guide will attempt to call your attention to the more serious errors.

Page 48. Example five gives an answer of 1,005 for the product of 49.9 and 20.2. This answer should be 1,008. Practice Problem number seven mentions the term percent. Remember that when writing a percent as a decimal, the decimal point must be moved two places to the left.

Page 49. Pay particular attention to the last paragraph of this page. Accidentally moving the slide while adjusting the runner causes a large percentage of the errors in slide rule manipulation. This can be reduced to a minimum by keeping the slide as much within the stock as possible.

Page 52. The second paragraph on this page gives the digit count rules for locating the decimal point. To this explanation should be added the following: When multiplying by 1, 10, 100, etc., the slide rule need not be used, but for purposes of locating the decimal point the operation must

be considered as having moved the slide to the right. In other words, the digit count must be reduced by 1. As an example, consider the multiplication 5 x 10: Since the sum of the digit counts for 5 and 10 is 3, you subtract 1 to get a digit count of 2 and the answer is therefore 50.

Page 53. The answer to Practice Problem 11 is given in the back of the text as 790.16. This is the exact answer; but on the slide rule you would probably obtain an answer of 790. If you have any difficulty following the digit count in the examples on this page, turn to page 240 and study the rules for addition and subtraction of negative numbers.

Page 57. In Practice Problem 4, when speeds in miles per hour are converted to feet per second, the correct answer for 30 miles per hour should be 44 feet per second, not 0.44 feet per second. This type of problem, where one number is to be the multiplicand for several operations, is very common in engineering work. Care must be taken, though, to keep from moving the slide between operations.

Three or more numbers can be multiplied without writing down any intermediate results. However, you must be sure that the runner, which marks the answer from the previous steps in the multiplication, is not moved while the index of the C scale is lined up with the hairline on the runner.

Page 60. The digits in the answer to Practice Problem 2 are incorrectly given as 7,820. This answer should be 8,000. In a problem such as Practice Problem 7 some of the numbers are not indicated but are necessary to solve the problem correctly. In this case it is necessary to know that there are 60 seconds in a minute and that 60 must be multiplied by 6 x 8.3.

When working the Review Problems on page 66 watch for the problems where all of the numbers are not given. Problem 35 is an example where the numbers given in the problem are not the numbers to be multiplied. In this case 29 rivets are used, but there would be only 28 spaces, each 3.21 inches long.

Self-Examination

Answer the following questions for Unit 2. The answers will be found in the Key at the back of this Study Guide. Do *NOT* send these answers to USAFI.

For each of the following problems indicate which of the given answers is the correct one.

1. 1.375 x 26.3 =
   (a) 46.1
   (b) 36.8

(c) 36.2
(d) 28.4
(e) none of these

2. 10.05 x 790 =
(a) 793.0
(b) 79.30
(c) 8290
(d) 7130
(e) none of these

3. 0.000253 x 387 =
(a) 9.91
(b) 0.0979
(c) 0.956
(d) 0.0853
(e) none of these

4. 0.635 x 0.0422 =
(a) 2.68
(b) 0.289
(c) 0.0261
(d) 0.0268
(e) none of these

5. 197.0 x 71.5 =
(a) 14,100
(b) 12,800
(c) 13,950
(d) 1.41
(e) none of these

6. 0.0326 x 473 x 2,950 x 4.10 =
(a) 75,800
(b) 186,500
(c) 183,800
(d) 182.5
(e) none of these

7. A farmer's field is rectangular in shape and measures 18.75 yards by 38.9 yards. How many square feet of land does this field contain?
(a) 729
(b) 72.9
(c) 6560
(d) 656
(e) none of these

8. A steel bar will expand 0.0000065 inches for every inch of its length when the temperature rises one degree Fahrenheit. How many inches will an 8 foot steel bar expand when the temperature rises 29 degrees Fahrenheit?
(a) 0.001509
(b) 0.0181
(c) 0.01509
(d) 1.81
(e) none of these

9. A container 3 feet high, 2.65 feet wide and 7.48 feet long is full of water which weighs 62.4 pounds per cubic foot. How many pounds of water are there in the container?
(a) 3710
(b) 56.0
(c) 59.5
(d) 371
(e) none of these

10. A certain machined part weighs 0.182 pounds. What would be the weight in pounds of a crate containing 27 dozen of these parts?
(a) 487
(b) 584
(c) 45.2
(d) 59
(e) none of these

Written Assignment

NOTE: The following work is to be submitted by students enrolled in Correspondence Course CB 858. Students enrolled in Self-Teaching Course MB 858 need not complete this written work. Full instructions for sending in Written Assignments are given on page 3 of this Study Guide.

1. Using example 18 on page 58 of your text as a guide, explain how you multiply 26.7 x 347 x 0.00693. This explanation should include locating the decimal point by the digit count method.

2. Multiply the following numbers, writing both the original numbers and their product on your lesson sheet:
(a) 1.135 x 0.00647 = ?
(b) 1038 x .936 = ?
(c) 3.14 x 16.74 = ?

(d) 208 x 89.2 = ?
(e) 0.0764 x 0.00321 = ?
(f) 497 x .0376 = ?
(g) 0.00034 x 0.00047 = ?
(h) 0.01003 x 0.0103 = ?
(i) 97.2 x 1077 = ?
(j) 21.3 x 294 = ?

3. A truck with a capacity of 4.7 yards of gravel makes 16 trips to fill a low spot in a highway. How many yards of gravel did the hole require? If gravel weighs 2,900 pounds per yard, how many pounds were dumped into the hole?

4. Multiply the following numbers, writing both the original numbers and their product on your lesson sheet:

(a) 296 x 0.00347 x 637 = ?
(b) 0.621 x 0.0321 x 0.0097 = ?
(c) 34,900,000 x 2,468 x 0.00290 = ?
(d) 113.7 x 1.66 x 3.27 x 0.0052 = ?
(e) 1728 x 1728 x 0.26 x 3.14 = ?

5. A board foot of lumber is equivalent to a piece 1 foot long, 1 foot wide, and 1 inch thick. Thus, a piece of timber 24 feet long, 1 foot wide, and 2 inches thick would contain 24 x 1 x 2 = 48 board feet of lumber. After listing the following dimensions, indicate how many board feet each piece of lumber contains.

(a) 15 ft. x 0.66 ft. x 3 in. = ?
(b) 20 ft. x 2 ft. x 6 in. = ?
(c) 8 ft. x 1.5 ft. x 4 in. = ?
(d) 16 ft. x 0.25 ft. x 6 in. = ?
(e) 12 ft. x 0.333 ft. x 2 in. = ?

6. A piece of steel cable is tested and found to stretch 0.00032 inches over every foot of its length when every additional 1,000 lbs. of pull is applied. Thus, a piece of this cable 25 ft. long and having a pull of 8,000 lbs. would stretch a total amount equal to: 0.00032 x 25 x 8 = 0.064 inches. How much would each of the following pieces of this cable stretch when the indicated load is applied?

(a) a 13.5 foot piece with a load of 28,000 lbs.
(b) a 450 foot piece with a load of 125,000 lbs.
(c) a 64.6 foot piece with a load of 37,000 lbs.
(d) a 29 foot piece with a load of 11,000 lbs.
(e) a 42.9 foot piece with a load of 240,000 lbs.

7. A square piece of stone 1 foot on a side and 2 inches thick is found to weigh 75 lb. Each of the following pieces of this stone is 2 inches thick. Indicate how much each one would weigh.

(a) a piece 3.5 feet by 1.8 feet
(b) a piece 6.7 feet by 0.88 feet
(c) a piece 4.6 feet by 4.6 feet
(d) a piece 1.24 feet by 3.72 feet
(e) a piece 2.17 feet by 9.32 feet

8. Multiply each of the following numbers by the number 3.14:

(a) 287
(b) 0.0307
(c) 0.1573
(d) 46,700
(e) 17.2
(f) 1.006
(g) 9.62
(h) 643
(i) 18.29
(j) 832,000

UNIT 3

DIVISION

EACH remaining unit will be devoted to one chapter in your text and will cover one process or a combination of processes which can be performed on the slide rule. This unit covers the process of division. Many of the rules which apply to the process of division seem to be similar to those for multiplication. This is true, but the fact that they are similar can cause trouble if you are not careful to apply the proper rules to the operation you are performing.

Keep in mind that while studying a unit on division this one process receives your entire attention. But in the daily use of the slide rule you will be performing many operations and the process for each is different and must become automatic. It can not be emphasized too much that practice is important in developing skill with the slide rule.

Text Assignment

Chapter 5; pages 67–87. Omit the material on the basis of the process of division on pages 82–84.

Study Notes

Page 67. You will remember that in the process of multiplication it did not make any difference as to which one of the original members was chosen as the multiplicand. In division, however, it is important that the hairline on the runner be set to the dividend on the D scale.

In the word problems on page 69 and 70 it is necessary to decide which number is the dividend and which is the divisor. Problem 12 on page 70 asks for the answer in pounds per square inch. This can be considered as a problem where pounds are to be divided by square inches. This means that the dividend would be in pounds and the divisor in square inches.

Page 70. The footnote at the bottom of the page calls your attention to an exception to the rule for locating the decimal point in division. There is one more rule which should be added to this. When the divisor is 1, 10, or 100, etc., the slide rule would probably not be used, but to locate the decimal point the slide should be considered as moving to the right. In other words, the digit count for the answer would be one more than the digit count for the dividend minus the digit count for the divisor.

Page 71. Before checking illustrative example 5, turn to the back of the text on page 240 and review the material on addition and subtraction of negative numbers. Remember that when subtracting a negative number you are in effect adding a positive number. For example, $4 - (-6) = 4 + 6 = 10$.

Page 74. Pay strict attention to the section on dividing many numbers by a single number. In recording data from engineering experiments this procedure is used many times and is a great time saver. As the text points out in the examples which follow, when dividing 1 by the divisor, either end of the D scale can be used as the number 1. It is best to use the end of the D scale which will leave most of the slide within the stock. This will give you a better chance of finding most of the various dividends on the C scale within the stock. If any of these dividends do lie outside the stock the slide can be moved to make use of the other end of the D scale as the number 1.

Page 80. The answer to Practice Problem 4 should be 363 instead of the given value of 0.0216.

Be sure to work the Review Problems on page 86. No answers are given in the text but you can check your own answers in most cases. For instance, in problem 3, after finding the average speed of the motorist, multiply this speed by the time and see if the distance comes out the same as is given in the original problem.

Self-Examination

Answer the following questions for Unit 3. The answers will be found in the Key at the back of this Study Guide. Do *NOT* send these answers to USAFI. For each of the following problems indicate which of the given answers is the correct one.

1. $93{,}700 \div 27 =$

   (a) 3,660
   (b) 47.60
   (c) 4,530
   (d) 3,470
   (e) none of these

2. $821 \div 9.2 =$

   (a) 94.8
   (b) 8.92
   (c) 948
   (d) 892
   (e) none of these

3. $0.00064 \div 0.000968 =$

(a) 0.661
(b) 0.624
(c) 6.53
(d) 0.0653
(e) none of these

4. $0.0327 \div 329 =$

(a) 0.00001005
(b) 0.0000984
(c) 0.0001005
(d) 0.0000105
(e) none of these

5. $\dfrac{4.67}{36 \times 276} =$

(a) 0.1298
(b) 0.000358
(c) 0.00358
(d) 0.00047
(e) none of these

6. $\dfrac{126{,}900}{0.0029 \times 4.7} =$

(a) 2,050,000
(b) 9,300,000
(c) 930
(d) 93,000
(e) none of these

7. It is possible to pack 77 peaches in a crate without bruising them. How many crates would be required to handle a crop of 115,083 peaches?

(a) 14,940
(b) 1,630
(c) 1,494
(d) 1,955
(e) none of these

8. A coil of no. 4 insulated wire weighs 29.7 lb. A one foot length of this wire is cut off and found to weigh 0.193 lb. How many feet of wire are in the coil?

(a) 15.6
(b) 156
(c) 272
(d) 154
(e) none of these

9. A small electric hair dryer draws 2.70 amperes of current. How many of these dryers could be connected to a line fused for 40 amperes?

(a) 4
(b) 5
(c) 14
(d) 15
(e) none of these

10. One quart of gloss enamel will cover 150 square feet of surface area. How many gallons of enamel are necessary to cover 10,150 square feet?

(a) 169
(b) 19.2
(c) 192
(d) 67.7
(e) none of these

Written Assignment

NOTE: The following work is to be submitted by students enrolled in Correspondence Course CB 858. Students enrolled in Self-Teaching Course MB 858 need not complete this written work. Full instructions for sending in Written Assignments are given on page 3 of this Study Guide.

1. Using example 17 on page 79 of your text as a guide, explain how to find the result of $\dfrac{0.643}{744 \times 0.00429}$. This explanation must include locating the decimal point by the digit count method.

2. Divide the following numbers, writing both the original numbers and their quotient on your lesson sheet.

(a) $865 \div 0.0843 = ?$
(b) $224 \div 6{,}820 = ?$
(c) $1{,}040 \div 392 = ?$
(d) $0.00043 \div 1004 = ?$
(e) $0.0023 \div 0.0097 = ?$
(f) $103{,}400 \div 2{,}004 = ?$
(g) $3.975 \div 0.0236 = ?$
(h) $46.77 \div 0.4660 = ?$
(i) $29{,}680 \div 1{,}728 = ?$
(j) $47{,}400 \div 3600 = ?$

3. A round brass bar is to be cut into a series of disks 0.125 inches thick. The cutter used to separate the disks is 0.101 inches thick. How many of these disks could be cut from a bar 97.4 inches long?

4. Divide the following numbers, writing both the original numbers and their quotient on your lesson sheet.

(a) $\frac{0.0023}{0.01024 \times 0.0463} = ?$ (d) $\frac{1}{513 \times 0.6013} = ?$

(b) $\frac{10{,}750{,}000}{296 \times 1728} = ?$ (e) $\frac{100}{1049 \times 228} = ?$

(c) $\frac{144{,}000}{27 \times 0.0372} = ?$

5. A concrete highway is to be 16 feet wide and 9 inches thick. How many feet of this highway can be constructed from 875,000 cubic feet of concrete? How many miles of highway would this be?

6. A circular saw of a special design cuts best when run so the teeth are traveling at a speed of 9420 ft. min. How fast should each of the following saws rotate to achieve this speed?

(a) a 6 inch diameter saw
(b) a 7 inch diameter saw
(c) a 10 inch diameter saw
(d) a 14 inch diameter saw
(e) a 16 inch diameter saw

7. The number 754 is what percentage of the following numbers:

(a) 376
(b) 973
(c) 10,421
(d) 2,004
(e) 193

8. Divide each of the following numbers by 3.14 x 647.

(a) 4,460
(b) 623,000
(c) 0.0247
(d) 3.92
(e) 767

UNIT 4

COMBINATIONS OF MULTIPLICATION AND DIVISION

BY NOW the processes of multiplication and division should be well enough in mind and have been practiced sufficiently so the operations are becoming automatic. You have probably noticed that upon completing a multiplication of two numbers the slide rule is all set to divide the product by a third number. Also upon completing a division the slide rule is all set to perform a multiplication. This unit deals with the solutions of problems where many consecutive multiplications and divisions are carried out without regards to the intermediate answers. This is where the slide rule can best save the greatest amount of time.

Text Assignment

Chapter 6; pages 89–107.

Study Notes

Page 91. The last paragraph on this page indicates that the answer can be checked by performing the whole operation over again, but reversing the sequence of the numbers. This is a very good suggestion and it is necessary to reverse the numbers because a mistake made the first time is very apt to be repeated if the procedure is the same both times.

Page 93. The answer to example 6 is given as 0.1152 but the decimal point is incorrect and it should be 0.01152.

Page 98. In the third paragraph the text states that if you attempt to multiply and find that the multiplier on the C scale is outside the D scale you can just reverse the slide and then proceed. You can sometimes save time by using some other number of the numerator which does lie within the D scale for this multiplication. This of course adds the risk of forgetting one number or using one twice, but your own preference will enable you to decide which method to use.

Page 103. Pay close attention to example 13 on this page. Notice that if the first dividend is 1, 10, or 100 it must be set on the left index of the D scale. This is necessary in order that the digit count method will locate the decimal point correctly. The digit count method is excellent but you will have trouble with it if you aren't careful when using the numbers 1, 10, etc.

Page 105. If there are several more numbers in the denominator than in the numerator you can, as the text illustrates, simply put a one in the numerator for every extra number in the denominator. You can see though, that this will not affect the procedure for finding the sequence of digits in the answer because multiplying by one involves no use of the slide rule. In locating the decimal point, however, if you write down the ones and count them in the digit count, you will see that you must also subtract one unit for every one you have used. Thus, the result is the same as if they had never been considered.

After working the review problems on page 107, rearrange the numbers and work the problems again to check your answers.

Self-Examination

Answer the following questions for Unit 4. The answers will be found in the Key at the back of this Study Guide. Do *NOT* send these answers to USAFI. For each of the following problems indicate which of the given answers is the correct one.

1. $$\frac{2{,}150{,}000 \times 1.004}{3{,}470 \times 4{,}960} =$$

(a) 0.1206
(b) 0.130
(c) 0.1255
(d) 0.1244
(e) none of these

2. $$\frac{14.6 \times 16.9 \times 27.3}{221} =$$

(a) 304
(b) 40.9
(c) 30.9
(d) 30.5
(e) none of these

3. $$\frac{547}{982 \times 0.0321 \times 3.77} =$$

(a) 46
(b) 4.44
(c) 65.4
(d) 4.74
(e) none of these

4. $$\frac{10{,}000 \times 24 \times 24 \times 24}{384 \times 30{,}000{,}000 \times 27.4} =$$

(a) 438
(b) 0.0001825
(c) 0.000438
(d) 182.5
(e) none of these

5. $$\frac{1 \times 10 \times 100}{25 \times 476 \times 0.0328} =$$

(a) 2.56
(b) 2.76
(c) 5.8
(d) 1.602
(e) none of these

6. $$\frac{658 \times 0.000621 \times 47}{1 \times 1 \times 1.007} =$$

(a) 17.96
(b) 19.1
(c) 49.5
(d) 86.3
(e) none of these

7. To reline a certain type of brake takes 32 inches of lining. A fleet of 14 trucks using 6 of these brakes per truck is to be serviced at a garage. The brakes are to be relined every 25,000 miles and each truck travels an average of 120,000 miles per year. How many feet of lining should the garage order for one year?

(a) 12,900
(b) 1,075
(c) 179.1
(d) 10.75
(e) none of these

8. An electric lawn mower moves at the rate of 240 feet per minute cutting a 20-inch swath. How many minutes would it take to cut a rectangular lawn 25 feet by 158 feet if the cuts never overlap?

(a) 8.23
(b) 82.3
(c) 98.8
(d) 9.88
(e) none of these

9. It takes one BTU (British Thermal Unit) of heat to raise the temperature of one pound of water one degree Fahrenheit. If one kilowatt hour of electrical energy is equal to 3,413 BTUs, how many kilowatt hours are required to raise 30 gallons of water 95 degrees Fahrenheit? A gallon of water weighs 8 lb.
   (a) 6.68
   (b) 0.1496
   (c) 6.65
   (d) 5.52
   (e) none of these

10. A small house has four rooms of the following sizes: 10 x 11 ft., 10 x 13 ft., 8 x 10 ft., and 9 x 11 ft. All of these rooms have ceilings 7 ft. 10 in. high. It is desired to circulate the air in this house by means of a blower fan. What capacity (in cubic feet per minute) should this fan have to circulate all the air once every 5 minutes?
   (a) 595
   (b) 5,950
   (c) 656
   (d) 65.6
   (e) none of these

Written Assignment

NOTE: The following work is to be submitted by students enrolled in Correspondence Course CB 858. Students enrolled in Self-Teaching Course MB 858 need not complete this written work. Full instructions for sending in Written Assignments are given on page 3 of this Study Guide.

1. Using example 7 on page 96 of your text as a guide, explain how you would find the result of $\frac{4560 \times 1728}{48 \times 12{,}000{,}000 \times 236}$. This explanation must include locating the decimal point by the digit count method.

2. Calculate the results of the following numbers, writing both the original numbers and the answers on your lesson sheet.
   (a) $\frac{5 \times 1467 \times 2047}{384 \times 3{,}000{,}000 \times 72} = ?$
   (b) $\frac{0.0037 \times 100 \times 275}{30{,}300 \times 0.000462} = ?$
   (c) $\frac{297 \times 356 \times 0.00031}{144} = ?$
   (d) $\frac{0.0000065 \times 120 \times 462}{29{,}800{,}000} = ?$
   (e) $\frac{3{,}476 \times .0137}{0.021 \times 374 \times 2{,}475} = ?$

3. To calculate the amount of heat lost through the wall of a room, engineers make use of a number called a heat transfer coefficient. This number is in BTU/hr./sq. ft./deg. Fahrenheit. This means the amount of heat lost in an hour for every square foot of wall area, for every degree difference in temperature between the inside and outside of the wall. Heat transfer coefficient $= \frac{\text{BTUs}}{\text{Time in hrs. x sq. ft. x deg. F.}^\circ}$

   A certain wall material is tested and it is found that 975 BTUs are lost through a rectangular section of wall 7.5 ft. x 3.67 ft. This loss took place in 145 minutes time while the temperature on one side was 95° F. and on the other side was 32° F. What is the heat transfer coefficient for this material?

4. Calculate the results of the following numbers, writing both the original numbers and the answers on your lesson sheet.
   (a) $\frac{100}{2{,}320 \times 0.00493 \times 327} = ?$
   (b) $\frac{227 \times 10{,}040 \times 0.001069}{102 \times 936} = ?$
   (c) $\frac{188.8 \times 1{,}088}{211 \times 12{,}110} = ?$
   (d) $\frac{267 \times 0.179}{662 \times 0.00046} = ?$
   (e) $\frac{979 \times 856}{1{,}034 \times 21.74} = ?$

UNIT 5

SQUARES AND SQUARE ROOTS

IF YOU have mastered the art of multiplication and division, this unit on squares and square roots will be very simple. However, it is an important unit since many formulas contain squares and square roots. The square of a number is simply the product of the number times itself. The square root of a number is the result, which, if it were multiplied by itself would give you the original number. For example, 5 is the square root of 25 since 5 x 5 is equal to 25.

Text Assignment

Chapter 7; pages 109–123. Omit the material on the basis of the process on pages 118–120.

Study Notes

Since the square of a number is simply the number multiplied by itself, it is apparent that the square could be found on the D scale just twice as far from the left index as the number itself. This is not necessary since the divisions on the A scale are just half as long as the divisions on the D scale and so the square of a number set on the D scale appears directly above it on the A scale. The method for finding the decimal point is explained on page 110 and is consistent with the procedure for multiplication. Note that the center index of the A scale and any number to the right will always have an even number for a digit count.

Page 109. The text states that since the scales on the slide are not used, the slide can be in any position when squaring numbers. This is true but there is less chance of mistakes if you line up the numbers on the slide with those on the stock while you are finding squares or taking square roots. In this way you won't accidentally read the number on the C or B scales.

Page 113. Since every second number must be even and the ones in between odd, then the number zero must be considered even. An odd number (one) is found on one side of zero and an odd number (minus one) is found on the other side. Therefore, the square root of a number which has a digit count of zero is located on the right half of the A scale.

Page 117. In Practice Problem 4 you are asked to solve for X where $X^2 = 0.067$. The small 2 means that X squared or multiplied by itself must equal 0.067. Therefore, X is the square root of 0.067.

Page 118. You are cautioned on this page not to use the A and B scales for multiplication or division after finding the square of a number on the A scale. This temptation might occur in a problem such as: $6 \times 4^2 = ?$ The four should be squared by locating 4 on the D scale and reading its square, 16, on the right half of the A scale. The number 16 would then be set on the D scale and multiplied by 6. Another method of solution should be considered here. Since, when squaring a number you are simply multiplying it by itself, it may be quicker when the square is part of a large solution simply to multiply by the number twice using the C and D scales. This way it is not necessary to read an answer on the A scale and then set it on the D scale.

Page 121. The answer to Practice Problem 6 should be 27,800,000 instead of 28,800,000.

It is necessary, when solving problems 21 through 25 in the practice problems, to write down some of the intermediate solutions. For instance in problem 21, you must find the square of 24.5 and the square of 33.1 and then add these results. The symbol surrounding these numbers means that you are to take the square root of whatever appears beneath the line. In this case you would extract the square root of the sum of 24.5^2 and 33.1^2.

Page 122. In the review problems the expression "hypotenuse of a right triangle" is used in several places. A right triangle is a triangle containing one 90° angle and the hypotenuse is the longest side of this triangle or the side opposite the 90° angle.

Self-Examination

Answer the following questions for Unit 5. The answers will be found in the Key at the back of this Study Guide. Do *NOT* send these answers to USAFI. For each of the following problems indicate which of the given answers is the correct one.

1. $27.9^2 + 34.3^2 =$

   (a) 896
   (b) 1255
   (c) 1955
   (d) 1896
   (e) none of these

2. $(4.68^2)^2 =$
   (a) 148
   (b) 480
   (c) 102.5
   (d) 557
   (e) none of these

3. $9.47^2 + 11.12^2 =$
   (a) 192
   (b) 1019
   (c) 101.9
   (d) 213
   (e) none of these

4. $\sqrt{234^2 + 97.8^2} =$
   (a) 254
   (b) 388
   (c) 122.7
   (d) 802
   (e) none of these

5. $\sqrt{47.1^2 + 25.4^2} =$
   (a) 535
   (b) 93.2
   (c) 16.93
   (d) 53.5
   (e) none of these

6. $\sqrt{10.07^2 + 10.7^2} =$
   (a) 46.4
   (b) 4.64
   (c) 147
   (d) 215.6
   (e) none of these

7. How many small boxes 2 inches square and $1\frac{1}{2}$ inches deep can be packed in a cardboard box 28 inches square and 6 inches deep?
   (a) 676
   (b) 784
   (c) 438
   (d) 44
   (e) none of these

8. A large trunk is 49 inches long, 36 inches high, and 36 inches wide. How many square inches of exterior surface does this trunk have?
   (a) 9,648
   (b) 7,056
   (c) 2,592
   (d) 8,712
   (e) none of these

9. How long would the sides of a square be if the square is painted with 1.47 quarts of paint known to cover 187 square feet per quart?
   (a) 12.63 ft.
   (b) 52.5 ft.
   (c) 16.6 ft.
   (d) 14 ft.
   (e) none of these

10. The area of a circle is equal to 3.14 times the square of the radius. A circle of what radius would have an area of 10 square inches?
    (a) 1.787 in.
    (b) 1.77 in.
    (c) 17.87 in.
    (d) 5.60 in.
    (e) none of these

Written Assignment

NOTE: The following work is to be submitted by students enrolled in Correspondence Course CB 858. Students enrolled in Self-Teaching Course MB 858 need not complete this written work. Full instructions for sending in Written Assignments are given on page 3 of this Study Guide.

1. Using example 1 on page 110 of your text as a guide, explain how you would find the square of 31.80. This explanation must include the method of locating the decimal point.
2. Using example 8 on page 116 of your text as a guide, explain how you would find the square root of 177. This explanation must include the method of locating the decimal point.

3. The rate at which heat is given off from an electric element can be calculated by the formula Heat in watts $= \frac{E^2}{R}$ (where E is the voltage across the element and R is the resistance of the element in ohms). What wattage would be given off from the following heating elements?

   (a) a 14.7 ohm element across 110 volts.
   (b) a 2.64 ohm element across 32 volts.
   (c) an 8.4 ohm element across 220 volts.
   (d) a 16.8 ohm element across 440 volts.
   (e) a 33.6 ohm element across 440 volts.

4. Calculate the results of the following expressions, writing both the original numbers and the answers on your lesson sheet.

   (a) $\sqrt{84.9^2 + 26.5^2} = ?$
   (b) $\sqrt{3.97^2 + 14.32} = ?$
   (c) $\sqrt{0.0024^2 + 0.0079^2} = ?$
   (d) $\sqrt{5.14 \times (28.9)^2} = ?$
   (e) $\sqrt{10.47^2 \times 0.0294^2} = ?$

5. The kinetic energy of a moving body is given by the formula: Energy in foot pounds $= \frac{Wv^2}{64.4}$, where W is the weight of the body in pounds and v is the velocity in ft./sec. Calculate the energy of the following objects:

   (a) a 2,995 lb. automobile moving 104 ft./sec.
   (b) a 3 ounce bullet moving 3700 ft./sec.
   (c) a 17.4 ton truck moving 50 miles per hour.
   (d) a 185 lb. man running 9.7 yards/sec

6. Calculate the results of the following expressions writing both the original numbers and the answers on your lesson sheet.

   (a) $0.0746^2 \times 349 = ?$
   (b) $237\sqrt{0.0446} = ?$
   (c) $\sqrt{4.61} \times \sqrt{6 \times (421)^2} = ?$
   (d) $\sqrt{4.61 \times 6 (421)^2} = ?$
   (e) $13.17 \times 0.111^2 = ?$

UNIT 6

CUBES AND CUBE ROOTS

CUBES and cube roots are handled in much the same way as squares and square roots. The cube of a number is just another way of saying that the number is to be multiplied by itself twice. For example, the cube of 4 is equal to 4 x 4 x 4. The cube root of 8 is 2 since 2 x 2 x 2 is equal to 8. Your text divides the work on cubes and cube roots into two parts. Part A is for slide rules which do not have a K scale. Since your slide rule has a K scale, the assignments will cover only part B.

Text Assignment

Chapter 8; pages 144–156. Omit the material on the basis of the processes on pages 151–154.

Study Notes

Page 147. Practice Problem 13 asks for the material required for a hollow sphere. This requires two computations. First find the volume of a solid sphere of the given outside radius and from this volume subtract the volume of a solid sphere of the given inside radius.

In Practice Problem 14 you are asked to solve $X = (9.4)^3 + 0.0341\ (17.2)^3$. In solving a problem such as this it is important for you to note that only the portion in the parentheses is to be cubed. For example in the term $0.0341\ (17.2)^3$, only the 17.2 is to be cubed. The cube of 17.2 is found on the K scale as 5100. When 5100 is multiplied by 0.0341 the result is 174. The cube of 9.4 is found on the K scale to be 830. Therefore the answer should be $X = 830 + 174 = 1004$. The answer is given incorrectly as 990.

In Practice Problem 15 the entire term is to be cubed so the indicated multiplications and divisions should be carried out and then find the cube of the result. The answer is given incorrectly as 106. The correct answer is 110.

In determining in which of the 3 parts of the K scale a number must be located in order to obtain its cube root, you divide the digit count of the number by 3. Note that any remainder must be expressed as a positive remainder. The text gives you an illustration of this in the first paragraph of page 148. Be sure to study it carefully. Also note that the numbers 1, 10, 100, etc., can be handled by this same method but they must be located at the left end of the indicated section.

Page 151. Problem 15 of the practice problems asks for the inside diameter of a hollow sphere. Since the outside diameter is given, the volume of a solid sphere of this diameter can be found. If you then subtract the volume of material in the hollow sphere you will have left the volume of the hollow itself. From this the diameter of the inside can be found. The formula for the volume of a sphere is given on page 147 in Practice Problem 12.

Page 155. The answer to Practice Problem 20 should be 25 instead of 26.

Page 156. The review problems on finding cubes can be checked by multiplying the numbers by themselves twice using the C and D scales. The cube roots can be checked by taking the answer and multiplying it by itself twice to see if it gives the original number.

Although your text does not use it, the symbol $\sqrt[3]{\ }$ is sometimes used to indicate that the cube root is to be taken. All operations appearing under this symbol must be performed first and then the cube root taken of the result. For instance $\sqrt[3]{4^2 + 20}$ means that the cube root of 16 + 20 or 36 must be found. This would give 3.3 for the answer.

Self-Examination

Answer the following questions for Unit 6. The answers will be found in the Key at the back of this Study Guide. Do *NOT* send these answers to USAFI. For each of the following problems indicate which of the given answers is the correct one.

1. $45.9^3 =$

   (a) 67,000
   (b) 97,000
   (c) 6,700
   (d) 9,700
   (e) none of these

2. $\sqrt[3]{.037} =$

   (a) 0.0333
   (b) 0.1546
   (c) 0.718
   (d) 0.333
   (e) none of these

3. $\sqrt[3]{6.37^2 + 3.03^3} =$

   (a) 6.6
   (b) 8.7
   (c) 4.09
   (d) 8.8
   (e) none of these

4. $0.046^3 + 0.124^3 =$

   (a) 0.00201
   (b) 0.01166
   (c) 0.00193
   (d) 0.201
   (e) none of these

5. $(1.16^3)^3 =$

   (a) 1.56
   (b) 3.8
   (c) 1.18
   (d) 1.76
   (e) none of these

6. $(1.96^3)^2 =$

   (a) 3.83
   (b) 7.54
   (c) 5.63
   (d) 75.4
   (e) none of these

7. The volume of a sphere is given by the formula $\frac{4}{3}\pi R^3$ where π is the number 3.14 and R is the radius of the sphere. How many cubic inches of water could be poured into a hollow sphere if the inside radius is 4.75 inches?

   (a) 44.8
   (b) 472
   (c) 448
   (d) 409
   (e) none of these

8. If 4 solid spheres, each 0.762 inches in radius, were placed in the hollow sphere of problem 7, how much water could be poured in?

   (a) 7.43
   (b) 440.6
   (c) 6.78
   (d) 441.2
   (e) none of these

9. A cube of steel weighing 69.3 lb. measures 6.25 inches on each edge. How many pounds does the steel weigh per cubic ft.?

   (a) 0.283
   (b) 488
   (c) 0.00205
   (d) 244
   (e) none of these

10. If the cube of steel in problem 9 were melted and recast into a sphere, what would the radius of the sphere be in inches?

    (a) 58.5
    (b) 1.8
    (c) 8.36
    (d) 3.88
    (e) none of these

Written Assignment

NOTE: The following work is to be submitted by students enrolled in Correspondence Course CB 858. Students enrolled in Self-Teaching Course MB 858 need not complete this written work. Full instructions for sending in Written Assignments are given on page 3 of this Study Guide.

1. Using example 25 on page 145 of your text as a guide, explain how you would find the cube of .0247. This explanation should include the method of locating the decimal point.

2. Using example 30 on page 149 of your text as a guide, explain how you would find the cube root of 10.37. This explanation should include the method of locating the decimal point.

3. The center deflection or sag of a wooden beam 4 x 6 inches in cross-section is given by the formula deflection $= \frac{Pl^3}{5{,}520{,}000{,}000}$, where P is the load in pounds placed at the center of the beam, and l is the length of the beam between supports. The length must be in inches. What center deflection would this 4″ x 6″ beam have with the following lengths and loads?

   (a) a 14 ft. beam with 300 lb. center load
   (b) an 8 ft. beam with a 600 lb. center load
   (c) an 11.2 ft. beam with a 350 lb. center load

4. Find the cube of the following numbers:

   (a) 0.0126
   (b) 139.5
   (c) 47.4
   (d) 9.98
   (e) 2.007

5. Find the cube root of the following numbers:

   (a) 4,675,000
   (b) 0.0000373
   (c) 0.1007
   (d) 9,475
   (e) 37.4

6. Calculate the results of the following expressions, writing both the original numbers and the answers on your answer sheet.

   (a) $(3.14^3 + 10.74)^3 = ?$
   (b) $(27.4^2 \times 4)^3 = ?$
   (c) $\sqrt[3]{(16.4)^2 + (6.1)^3} = ?$
   (d) $(0.344^3)^3 = ?$
   (e) $\sqrt[3]{(0.036)^2 + (0.476)^3} = ?$

After you have completed this unit, you should request the end-of-course test from the United States Armed Forces Institute, Madison 3, Wisconsin, or from the overseas USAFI with which you are enrolled. Use the application blank which is supplied; fill it out carefully and make sure that it is properly certified by the officer who will administer the test. The end-of-course test is to be taken after you have completed Unit 10.

UNIT 7

SINES AND COSINES

IT IS not necessary to know what is meant by the sine or cosine of an angle in order to obtain the correct value of that sine or cosine from the slide rule. However, a simple explanation of these functions of an angle will be helpful if you are ever called upon to solve a problem where it is not stated whether you are to use the sine or the cosine of the angle.

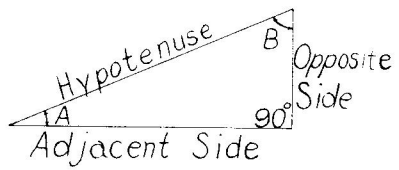

Figure 1

The drawing above is of a right triangle. This is a triangle which contains a 90° angle or right angle. One of the angles has been labeled A. The sine of angle A is the quotient of the length of the opposite side divided by the length of the hypotenuse. Notice that the hypotenuse is always opposite the 90° angle and is the longest side. As the angle A becomes very small, the opposite side also becomes small and therefore the sine of the angle becomes closer and closer to zero. If, on the other hand, the angle A becomes close to 90° then the opposite side becomes nearly as long as the hypotenuse and the sine of A is nearly 1. Thus, the sine of an angle is always between zero and 1. You can illustrate these statements by sketching several angles of different sizes.

The cosine is the quotient of the length of the adjacent side divided by the length of the hypotenuse. In the same manner as explained above the cosine becomes nearly zero as the angle gets close to 90° and nearly 1 as the angle gets close to zero degrees. You can easily prove that the sines and cosines depend only on the angle and not on the actual size of the triangle. This is apparent because if one side is doubled the other sides will also be doubled if the angle remains the same.

Text Assignment

Chapter 9; pages 157–175.

Study Notes

Before studying this chapter, go back to the material on pages 28–35 on reading the angles on the sine scale. After working as long as you have with the A, B, C, and D scales, it is a little difficult to get used to the sine scale where the degrees are divided into minutes.

Page 160. Practice Problem 16 shows the sine of 40° with a small 2 above the n in sin. This means that the sine of 40° is to be squared by the procedure used in Unit 5. The term sin is an abbreviation of the word sine just as cosine will later be abbreviated cos.

Page 161. An angle of 0°34′ is a very small angle and the opposite side of a triangle with this small angle is also very small. In fact, it is only 0.01 times as long as the hypotenuse, as your slide rule indicates. Since the sine scale does not go below 0°34′ there is a special way to calculate sines of angles less than this value.

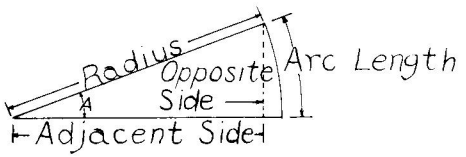

Figure 2

There is another way to measure angles and this is to express the angles in radians. This is a very simple unit in that an angle of 1 radian has an arc length equal to the radius of the arc. To find the size of an angle in radians then, you simply measure the length of the arc and divide it by the radius. With a ruler and a protractor you can show that an angle of 57.3 degrees has an arc length equal to its radius and therefore is equal to one radian.

As the angle A becomes very small the arc length and the opposite side, shown dotted in the figure above, become very nearly the same length. In this case, the sine of the angle A (opposite side divided by hypotenuse) is almost the same as the angle in radians (arc length divided by radius). Therefore, to get the sine of an angle less than 0°34′ you divide the angle in minutes by 3440, which is the number of minutes in 1 radian or 57.3 degrees.

Page 163. It is stated in the second paragraph on this page that the cosine of an angle is equal to the sine of 90° minus the angle. You can see from Fig. 1 that the opposite side of the triangle for angle A would be the adjacent side if you were considering angle B. Thus cos A is equal to sin B and you can readily prove that A plus B is equal to 90 degrees.

When subtracting an angle given in degrees and minutes from 90° it is best to write 90° as 89°60′. In this way you can subtract minutes from minutes and degrees from degrees without any danger of mixing them.

Page 164. As your text points out, finding the sine of an angle between 70° and 90° is not very precise. The formula given for finding the sine of such an angle is exact and the derivation is shown on page 165. However, the formula involves taking the square root of a number only a little less than 1. It is questionable whether the accuracy of obtaining this square root is any better than the accuracy of estimating the angle on the sine scale.

You can get a lot of good practice, however, by solving the practice problems on page 165 by both methods and comparing your results.

Page 166. In example 14, the sine of 145° should be 0.573 not 0.570.

Page 167. The answer to Practice Problem 3 is given incorrectly as 0.1765 The sine of 170° is 0.1738.

Page 168. The answer to Practice Problem 10 is given incorrectly as 0.924. This should be −0.924 since the cosine of any angle between 90° and 270° is negative.

Page 171. To find an angle whose sine is between 0.95 and 1, the text has proposed using another formula. This formula is exact but it is misleading in that the value of X^2 cannot be obtained with sufficient accuracy on the slide rule. Since X^2 is not exact, then the answer you finally arrive at is no more accurate than the one obtained directly from the sine scale if the scale is read carefully.

Page 173. The answer to Practice Problem 1 is given incorrectly as 50°40. The arc cosine of 0.622 is 51°30′.

The answer to Practice Problem 28 is given incorrectly as 0.375. The cosine of 292°52′ is 0.389.

Page 174. When working the review problems for this chapter it is a good idea to make a drawing for those involving triangles. In this manner you can tell easily which functions of the angle you are to deal with.

Self-Examination

Answer the following questions for Unit 7. The answers will be found in the Key at the back of this Study Guide. Do *NOT* send these answers to USAFI. For each of the following problems indicate which of the given answers is the correct one.

1. sin 17°47′ =
   (a) 0.321
   (b) 0.305
   (c) 0.136
   (d) 0.300
   (e) none of these

2. cos 88°35′ =
   (a) 0.247
   (b) 0.998
   (c) 0.0247
   (d) 0.0182
   (e) none of these

3. sin 84°30′ =
   (a) 0.995
   (b) 0.990
   (c) 0.985
   (d) 0.0995
   (e) none of these

4. sin 174°8′ =
   (a) 0.995
   (b) 0.1195
   (c) 0.0995
   (d) 0.1022
   (e) none of these

5. cos 247°16′ =
   (a) 0.923
   (b) 0.541
   (c) 0.387
   (d) 0.880
   (e) none of these

6. sin 24′30″ =
   (a) 0.0706
   (b) 0.00712
   (c) 0.00706
   (d) 0.0712
   (e) none of these

7. cos 90°15′ =
   (a) 1.001
   (b) 0.00436
   (c) −0.00436
   (d) 0.999
   (e) none of these

8. arc sine 0.0077 =
   (a) 0.265′
   (b) 4°25′
   (c) 26′30″
   (d) 26°30′
   (e) none of these

9. arc cosine 0.962 =
   (a) 74°
   (b) 5°32′
   (c) 84°28′
   (d) 16°
   (e) none of these

10. arc sine 0.0456 =
    (a) 27°10′
    (b) 2°57′
    (c) 15′42″
    (d) 2°37′
    (e) none of these

Written Assignment

NOTE: The following work is to be submitted by students enrolled in Correspondence Course CB 858. Students enrolled in Self-Teaching Course MB 858 need not complete this written work. Full instructions for sending in Written Assignments are given on page 3 of this Study Guide.

1. Using examples in your text as a guide, explain, step by step, how you would determine the sine of 27′34″ using the slide rule.

2. Using examples in your text as a guide, explain, step by step, how you would determine the angle which has a cosine equal to 0.0163.

3. Find the sine of each of the following angles:
   (a) 68°30′
   (b) 5°48′
   (c) 1°11′
   (d) 31′10″
   (e) 4′47″

4. Find the cosines of each of the following angles:
   (a) 89°32′
   (b) 136°15′
   (c) 330°
   (d) 73°30′
   (e) 87°

5. Find the arc cosine for each of the following numbers:
   (a) 0.0501
   (b) 0.823
   (c) 0.0010
   (d) 0.0199
   (e) 0.0000736

6. Find the arc sine for each of the following numbers:
   (a) 0.967
   (b) 0.00063
   (c) 0.0474
   (d) 0.0109
   (e) 0.757

7. It is possible to find the lengths of the two remaining sides of any triangle if the length of one side and any two angles of the triangle are known. To do this you use the formula $\frac{a}{\sin A} = \frac{b}{\sin B}$. In this formula "a" is the length of the side opposite angle A and "b" is the length of the side opposite angle B. Also remember that the sum of the three angles in a triangle is 180°. In each of the following triangles find the two remaining sides and the third angle.
   (a) One side is 11.8 feet long and the opposite angle is 58°34′. A second angle is 43°14′.
   (b) One side is 2.43 miles long and the opposite angle is 147°. A second angle is 15°19′.
   (c) One side is 9.7 inches long and the opposite angle is 5°22′. A second angle is 126°.

8. Another formula for solving triangles is $c^2 = a^2 + b^2 - 2ab \cos C$, where "C" is the angle opposite the unknown side "c" and a and b are the other sides. Find the length side "c" in each of the following triangles:
   (a) Side a is 1.7 miles long, side b is 2.97 miles long, and angle C is 13°10′.
   (b) Side a is 14.7 feet long, side b is 13.6 feet long, and angle C is 45°.
   (c) Side a is 5280 feet long, side b is 8970 feet long, and angle C is 147°.

UNIT 8

TANGENTS

YOU will remember that the sine of an angle was defined as the ratio of the length of the opposite side divided by the length of the hypotenuse when the angle was part of a right triangle. The tangent is defined as the ratio of the opposite side divided by the adjacent side. One way of finding the tangent of an angle would be to look up the sine of the angle and the cosine of the angle. Then the tangent is equal to the sine divided by the cosine. However, your slide rule contains a tangent scale where tangents of angles from 5°43′ to 45° can be read directly.

Text Assignment

Chapter 10; pages 177–192.

Study Notes

Page 180. The second paragraph on this page explains how to obtain the tangent of an angle between 1° and 5°43′. As the text states on page 182 under the heading "Basis of the Process," the tangent of a small angle is very nearly equal to the angle in radians. This same statement was made for the sine of an angle in Unit 7 and you can see that it is valid by examining Fig. 2 of this Study Guide and imagining that the angle is very small. If angle A is very small (less than 5°43′) then the arc length and the opposite side are very nearly the same length. Also the adjacent side and the hypotenuse or radius are very nearly equal in length. In this case it is sufficiently accurate to say that the sine equals the tangent and both are equal to the angle in radians.

In view of this, find the tangent of the angle the same as you found the sine for angles less than 5°34′. Use the sine scale for angles down to 0°34′ and divide the angle in minutes by 3440 to obtain the tangent of smaller angles.

Page 182. For angles between 45° and 90° the tangent can be found by one simple procedure. Find the tangent of 90° minus the angle and then use the relationship, $\tan \theta = \frac{1}{\tan (90-\theta)}$. You can prove this to your own satisfaction by turning back to Fig. 1 of this Study Guide. The tangent of Angle A could be expressed as a ratio of one length divided by another. The tangent

of angle B, which is (90° −A) would be a ratio of those same lengths but the ratio would be inverted.

Page 187. Since the arc tangent of 1 is 45° (the opposite side is equal to the adjacent side), the arc tangent of any number greater than 1 is going to be an angle between 45° and 90°. Again, one simple rule is sufficient. If a tangent is greater than 1, divide 1 by this tangent and then look up the arc tangent of the quotient. Since this quotient will always be less than 1 the arc tangent will be less than 45° and previous rules will apply. Then your answer will be 90° minus this calculated angle.

Self-Examination

Answer the following questions for Unit 8. The answers will be found in the Key at the back of this Study Guide. Do *NOT* send these answers to USAFI. For each of the following problems indicate which of the given answers is the correct one.

1. tan 43°39′ =
   (a) 0.944
   (b) 0.690
   (c) 0.954
   (d) 0.848
   (e) none of these

2. tan 5°53′ =
   (a) 1.03
   (b) 0.104
   (c) 0.971
   (d) 0.103
   (e) none of these

3. tan 1°8′ =
   (a) 1.98
   (b) 0.198
   (c) 0.179
   (d) 0.139
   (e) none of these

4. tan 16′55″ =
   (a) 0.0048
   (b) 0.00492
   (c) 0.048
   (d) 0.304
   (e) none of these

5. tan 74°13′ =
   (a) 0.283
   (b) 0.302
   (c) 3.54
   (d) 3.31
   (e) none of these

6. arc tan 0.0831. =
   (a) 39°40′
   (b) 56°20′
   (c) 4°46′
   (d) 46°23′
   (e) none of these

7. arc tan 34.7 =
   (a) 19°8′
   (b) 73°56′
   (c) 88°21′
   (d) 89°50′5″
   (e) none of these

8. arc tan 0.00317 =
   (a) 17°35′
   (b) 1°49′
   (c) 10°54′
   (d) 10′54″
   (e) none of these

9. A man standing on level ground 475 feet from a vertical wall looks at an object 367 feet up the wall. What angle does his line of sight make with the ground?
   (a) 4°26′
   (b) 37°40′
   (c) 52°20′
   (d) 7°21′
   (e) none of these

10. A man is riding in a car and coming to a right angle intersection. When he is 597 feet from the corner he sees another car on the cross road while looking 15° to the left. How far from the corner is the second car?
   (a) 16 ft.
   (b) 15.48 ft.
   (c) 160 ft.
   (d) 223 ft.
   (e) none of these

Written Assignment

NOTE: The following work is to be submitted by students enrolled in Correspondence Course CB 858. Students enrolled in Self-Teaching Course MB 858 need not complete this written work. Full instructions for sending in Written Assignments are given on page 3 of this Study Guide.

1. Using examples in your text as a guide, explain, step by step, how you would determine the tangent of 59°39′ using the slide rule.

2. Using examples in your text as a guide, explain, step by step, how you would determine the angle which has a tangent equal to 0.00329.

3. Find the tangent of each of the following angles:
   (a) 45°32′
   (b) 34°16′
   (c) 79°49′
   (d) 1°13′
   (e) 14′16″

4. Find the arc tangent for each of the following numbers:
   (a) 0.00121
   (b) 73.9
   (c) 0.987
   (d) 0.037
   (e) 0.491

5. A vertical telephone pole is 34 feet 8 inches high and stands in the center of a flat field. What angles do the sun's rays make with the earth's surface when the lengths of the shadow of the pole are as follows:
   (a) 3 ft. 4 in.
   (b) 9 ft. 1 in.
   (c) 29 ft. 11 in.
   (d) 78 ft. 3 in.
   (e) 175 ft.

6. For each of the following rectangles find the length of a line connecting opposite corners. (Hint: first find the angle between the diagonal line and one side. Then find the length of the diagonal line.)
   (a) 3 ft. by 4 ft.
   (b) 6.73 ft. by 16.95 ft.
   (c) 237 in. by 16 ft.
   (d) 99 ft. by 3 ft.
   (e) 19.7 ft. by 19.7 ft.

UNIT 9
THE RECIPROCAL SCALE

THE reciprocal scale may appear at first to be a rather useless addition to the slide rule. This scale will do nothing that cannot be done on the C and D scales but in some instances it will save several movements of the slide. The advantage of the CI scale is the time saved in computing problems in multiplication and division. Considerable practice is necessary, however, to become fully acquainted with the operation of this scale.

Text Assignment

Chapter 12; pages 207–230. Omit the material on the basis of the process on pages 211–213 and 217–220.

Study Notes

Page 208. Notice that when multiplying with the CI scale you are performing an operation similar to that of division. To explain the reason for this take as an example 8 x 6. You can see immediately that this is the same as 8 ÷ 1/6. The fraction 1/6 or as a decimal 0.1667 is found on the C scale directly below the number 6 on the CI scale. Therefore, to multiply 8 x 6 you can set the hairline to 8 on the D scale and slide 6 on the CI scale under the hairline. The answer, 48, is now found on the D scale under the left index of the C scale. This obviously is no easier than multiplying 8 x 6 in the usual manner and for multiplying two numbers together it has no value. However, on page 220 the multiplication of three numbers is discussed. Here the CI scale has an advantage. Take the multiplication of 17 x 23 x 4.07 for example. By the ordinary method of multiplication, the following steps are necessary:

1. Set the left index of the C scale to 17 on the D scale.
2. Move the hairline on the runner to 23 on the C scale.
3. Move the right index of the slide under the hairline.
4. Move the hairline to 4.07 on the C scale and read the answer under the hairline on the D scale.

If the CI scale is used for the second multiplication, the steps are then reduced to:

1. Set the left index of the C scale to 17 on the D scale.
2. Move the hairline on the runner to 23 on the C scale.
3. Move the number 4.07 on the CI scale under the hairline of the slide and then read the answer on the D scale under the left index of the C scale.

As you can see, one step is saved and the answer is apt to be a little more accurate. One disadvantage of the CI scale appears when locating the decimal point. Before, when multiplying and the slide extended to the right, the digit count was reduced by one. Using the CI scale it remains the same.

Page 213. Division with the CI scale turns out to be nothing more than a multiplication process with the reciprocal of the divisor. When the divisor is placed on the CI scale the reciprocal of the divisor will be on the C scale. As explained on page 224, this is especially valuable when dividing where there are more numbers in the denominator than in the numerator. Again the rules for the digit count method of obtaining the decimal point have been changed from the regular method of division using the C and D scales.

Page 229. Practice Problem 14 should have an answer of 9.21 instead of the given answer of 9.53. The review problems on page 230 can be worked by both methods and the answers compared.

Self-Examination

Answer the following questions for Unit 9. The answers will be found in the Key at the back of this Study Guide. Do *NOT* send these answers to USAFI. For each of the following problems indicate which of the given answers is the correct one.

1. 468 x 1.039 x 0.00321 x 269 =
   (a) 420
   (b) 365
   (c) 407
   (d) 562
   (e) none of these

2. $\dfrac{1}{333 \times 0.00497 \times 0.0741} =$
   (a) 13.39
   (b) 4.48
   (c) 8.16
   (d) 10.05
   (e) none of these

3. $\dfrac{817}{0.0307 \times 1003} =$
   (a) 25.9
   (b) 26.5
   (c) 27.4
   (d) 26.7
   (e) none of these

4. $\frac{1109 \times 2.314 \times 0.0034}{3.142} =$

(a) 4.5
(b) 2.98
(c) 4.43
(d) 2.77
(e) none of these

5. $4009 \times 0.00107 \times 27 =$

(a) 11.59
(b) 118.1
(c) 159
(d) 86.2
(e) none of these

6. $8.01 \times 8.00 \times 7.99 =$

(a) 518
(b) 80.2
(c) 512
(d) 8.02
(e) none of these

7. Which answer gives all the reciprocals correctly for the following numbers: 29, 375, 0.0027, 0.179?

(a) 3.45, 0.000333, 37, 6.41
(b) 0.0345, 0.00267, 370, 5.59
(c) 0.455, 0.00333, 3700, 0.0641
(d) 0.0455, 0.000267, 370, 0.641
(e) none of these

8. What is the smallest volume in which you could pack 180 boxes having outside dimensions equal to 10 inches by 3.7 ft. by 1.3 yds.?

(a) 2170 cu. ft.
(b) 2600 cu. ft.
(c) 86.5 cu. ft.
(d) 26,000 cu. ft.
(e) none of these

9. A steel plate one-fourth of an inch thick weighs 10.2 pounds per square foot. How much does a piece one-half inch thick and 7.4 ft. x 9.6 ft. weigh?

(a) 1428 lb.
(b) 1450 lb.
(c) 1575 lb.
(d) 145 lb.
(e) none of these

10. A mason can lay 947 bricks in an 8 hour day. What is the average number of bricks laid per minute?

(a) 1.263
(b) 2.02
(c) 0.507
(d) 1.97
(e) none of these

Written Assignment

NOTE: The following work is to be submitted by students enrolled in Correspondence Course CB 858. Students enrolled in Self-Teaching Course MB 858 need not complete this written work. Full instructions for sending in Written Assignments are given on Page 3 of this Study Guide.

1. Using the examples in your text as a guide, explain how you would find the product of 1.797 x 353 x 0.00648. This should be done by using the CI scale to its best advantage, and the explanation should include the location of the decimal point.

2. Using the examples in your text as a guide, explain how you would find the answer to $\frac{27}{436 \times 0.00327 \times 795}$. This should be done by using the CI scale to its best advantage and the explanation should include the location of the decimal point.

3. Calculate the results of the following expressions using the CI scale where practicable. Write both the original numbers and the answers on your lesson sheet.

(a) $37.95 \times 0.0317 \times 807 = ?$
(b) $10{,}006 \times 275 \times 96.4 = ?$
(c) $439 \times 0.000791 \times 38 = ?$
(d) $18.86 \times 0.595 \times 17 = ?$
(e) $1.93 \times 0.495 \times 0.0033 = ?$

4. The cake recipe which follows is supposed to fill one 8 x 8 inch square pan to a depth of 2 inches. How would you alter the recipe in order that it would fill two 10 inch round cake pans to a depth of 1½ inches?

1 cup sugar	1 egg
¼ cup butter	¾ cup milk
2 cups flour	2 teaspoons baking powder
1 teaspoon vanilla	

5. Calculate the results of the following expressions using the CI scale where practicable. Write both the original numbers and the answers on your lesson sheet.

(a) $\frac{1.81}{0.62 \times 2.19} = ?$

(b) $\frac{939}{0.00814 \times 49.1} = ?$

(c) $\frac{1}{29 \times 4.75} = ?$

(d) $\frac{61.4}{3.71 \times 41.8 \times 0.0034} = ?$

(e) $\frac{748}{9500 \times 0.036 \times 21} = ?$

6. How many cubic yards of concrete would be required to pour the following floor slabs?

(a) a 4 inch slab covering a rectangular floor 8 ft. 9 in. by 27 ft. 3 in.

(b) a 6 inch slab covering a round floor 9 ft. 5 in. in diameter

(c) a 3 inch slab covering a rectangular floor 18 ft. by 16 ft. 8 in.

UNIT 10

REVIEW OF IMPORTANT RULES

YOU have now studied all of the scales on the Mannheim slide rule except the log scale. If you have some knowledge of logarithms or wish to study them carefully at this time, you may choose to study Unit 11 (Optional). This unit will be primarily review with emphasis on common mistakes which should be avoided.

Text Assignment

Chapters 13, 14; pages 231–239.

Study Notes

Page 231. Since you already have a slide rule this chapter may seem to be unnecessary. However, check your own slide rule as suggested in this chapter and see if it is accurate and easy to operate. If you do a lot of work with the slide rule you will probably buy a better constructed and more accurate rule in the future. There is little use spending money for an inaccurate rule. Most of the more expensive rules are adjustable and this chapter will serve as a guide for adjusting those rules.

Page 235. The section on good judgment should be studied carefully. No matter how skilled you become with the slide rule, you should learn to check each answer to see if the results are logical. A mistake such as setting 901 as 910 is hard to detect in the final answer so extra care should be taken when setting such a number. Another very common error occurs when reading the K scale between numbers 6 and 10. There are only 5 spaces in each section and a number such as 6.3 is very often read as 6.15.

Page 236. It is pointed out on this page that the slide rule can be read more accurately than the smallest unit space by estimating to one tenth of one space. This is true, but in order that this accuracy is not misleading, the slide rule should be checked to make sure the spaces are marked this accurately. It does no good to estimate that you are three tenths of the way between two lines when the lines are not the correct distance apart.

A summary of rules for locating the decimal point is given on page 237. If you have not used a slide rule for some time, these rules may be forgotten and not be available. However, you can easily figure them out for yourself by solving a few very simple problems. Let us say that you want the rules

for locating the decimal point when multiplying with the C and D scales. Try the problem 2 x 4 = 8. The slide extends to the right and you must subtract one from the sum of the digit counts for the multiplicand and the multiplier to get the digit count for the answer.

Self-Examination

Answer the following questions for Unit 10. The answers will be found in the Key at the back of this Study Guide. Do *NOT* send these answers to USAFI. For each of the following problems indicate which of the given answers is the correct one.

1. Which of the answers gives the first digit correctly for the following 4 numbers? 0.00357, 286.7, 1.0037, 0.001006.

   (a) 3, 2, 3, 1
   (b) 0, 2, 1, 0
   (c) 0, 7, 0, 0
   (d) 3, 7, 3, 1
   (e) none of these

2. What value does each space have between divisions 2 and 3 on the K scale?

   (a) five in the third digit
   (b) one in the second digit
   (c) five in the second digit
   (d) two in the third digit
   (e) none of these

3. Which of the following answers gives the digit count correctly for the following 4 numbers? 0.00357, 286.7, 1.0037, 0.1006

   (a) −2, 3, 1, −1
   (b) −2, 3, −2, 0
   (c) 2, 3, 1, 0
   (d) −2, 3, 1, 0
   (e) none of these

4. One mile per hour is equal to 1.467 feet per second. The following speeds in miles per hour are given correctly in feet per second by which of the answers? 60 mph., 29.7 mph., 647 mph., 1,250 mph.

   (a) 88, 435, 949, 1833
   (b) 88, 43.5, 886, 1833
   (c) 40 9, 20.25, 441, 853
   (d) 88, 43.5, 949, 1833
   (e) none of these

5. The digit count for the answer to $\frac{5{,}105}{35.7 \times 41.9 \times 0.175}$ would be?

   (a) 1
   (b) 3
   (c) −1
   (d) −3
   (e) none of these

6. Which of the following statements is correct?

   (a) To find the square root of 357 you set 357 on the right half of the A scale and read the answer on the D scale.
   (b) To find the cube root of 35.7 you set 35.7 on the center section of the K scale and read the answer on the B scale.
   (c) The square of 1.007 is found on the A scale to be 1.143.
   (d) The cube of 42 is found on the K scale to be 72,000.
   (e) none of these

7. The cosine of 76°45′ is:

   (a) 0 973
   (b) 0.027
   (c) 0.229
   (d) 0.246
   (e) none of these

8. The sine of 25′13″ is:

   (a) 0.00733
   (b) 0.426
   (c) 0.0426
   (d) 0.0730
   (e) none of these

9. A boat drops anchor in 28 ft. of water using 49 ft. of anchor rope. If the rope is tied onto the boat at the water line, how far can this point on the boat drift from a position directly above the anchor?

   (a) 40.2 ft.
   (b) 23 ft.
   (c) 42.5 ft.
   (d) 16 ft.
   (e) none of these

10. $27.5\ (\cos 26°18' - \cos 49°)^2 = ?$
    (a) 2.68
    (b) 1.678
    (c) 1.572
    (d) 6.57
    (e) none of these

Written Assignment

NOTE: The following work is to be submitted by students enrolled in Correspondence Course CB 858. Students enrolled in Self-Teaching Course MB 858 need not complete this written work. Full instructions for sending in Written Assignments are given on page 3 of this Study Guide.

1. Find the results of the following expressions, writing both the original numbers and the results on your lesson sheet.
   (a) $\dfrac{3.14 \times (6.27)^2}{4} = ?$
   (b) $\dfrac{4 \times 3.14 \times (4.6)^3}{3} = ?$
   (c) $14{,}470 \cos 43°14' = ?$
   (d) $\dfrac{24{,}500 \times .032^2 \times \sin 14°18'}{4 \times 97} = ?$
   (e) $61.9 \times \tan^2 39°57' = ?$
2. A piece of steel is to be tested for fatigue failure in a rotating testing frame.
   (a) How many hours would it take to test this piece to 5,000,000 cycles if the frame rotates at 1750 revolutions per minute?
   $$\text{Time (minutes)} = \frac{\text{no. of cycles}}{\text{rev. per min.}}$$
   (b) If the part broke after 14 hours 35 minutes, how many cycles had it received?
3. Find the results of the following expressions, writing both the original numbers and the answers on your lesson sheet.
   (a) $86.7 \left(\dfrac{14.2 + 31.7^2}{291}\right)^2 = ?$
   (b) $\dfrac{0.01247 \times 0.00397 \times 424}{0.0000916} = ?$
   (c) $\sqrt{16.7^3 + 20.04^2} = ?$
   (d) $\sqrt[3]{1247 + 9.71^3} = ?$
   (e) $\sqrt{10.07 \times (21.9)^3} = ?$

4. A rectangular swimming pool is 135 feet long and 78 feet wide. A swimmer starts at one corner and swims directly to the diagonally opposite corner at the rate of 2.7 feet per second. Starting at the same time a man walks around the edge at the rate of 4 feet per second. Which person arrives at the opposite corner first? How long does it take each one to get there?
5. Find the results of the following expressions, writing both the original numbers and the answers on your lesson sheet.
   (a) $\sin 14' 16'' = ?$
   (b) $\cos 85°38' = ?$
   (c) $\sqrt{1 + \tan^2 18°26'} = ?$
   (d) $\dfrac{1}{\cos 18°26'} = ?$
   (e) $\tan 89°29' = ?$

REVIEW

Before taking the end-of-course test, it is important that you review the entire course. The best way to do this is to go back and do the Self-Examination at the end of each unit and check your answers against the Key at the back of this Study Guide. If you have answered any incorrectly, refer to the pages of the text or to the Study Notes concerning the material you missed. Be sure you understand the material covered.

When you feel satisfied that you understand this material, take the end-of-course test for which you applied at the time you completed Unit 6.

UNIT 11 (OPTIONAL)

LOGARITHMS, THE BASIS OF THE SLIDE RULE

THIS unit will be devoted to explaining logarithms and how they are used in laying out the scales of a slide rule. The reading assignment goes back and picks up the sections on logarithms which were omitted previously. Although you are not required to complete this unit, it is recommended that you at least read it over since it contains much interesting and valuable material.

Text Assignment

Chapter 11; pages 193–206. Also study the material previously omitted on pages 38–42, 61–63, 82–84, 118–120, 151–154, 211–213, 217–220.

Study Notes

Logarithms are very useful because of one simple mathematical truth, $a^m \times a^n = a^{(m+n)}$. The equation $2^3 \times 2^2 = (2 \times 2 \times 2)\ (2 \times 2) = 2^5$ illustrates this. The logarithm of a number is defined as the power to which a base must be raised to equal the number. Illustrated, this means: if the log $_aX = m$ then $a^m = X$. From this relationship we find an easy way to multiply two numbers. To multiply X times Y it is necessary to look up the log of X and the log of Y. These logarithms can be to any base, as long as both are to the same base. From the equations above you can see that if m is the log of X to base a then $X = a^m$. Similarly $Y = a^n$ if n is log of Y to base a. The product of X times Y is then the number which has a logarithm equal to $(m + n)$. As pointed out above, any base can be used but if the number 10 is used the work can be further simplified. The text states that when using 10 as a base the mantissa of the logarithm depends only on the sequence of digits in the number. This is the only base where that is true. If you study the material on pages 61–63 very carefully you will see how the C and D scales add logarithms to give you the product of two numbers. The digit count method of obtaining the decimal point is also explained clearly.

Pages 82–84 explain how the slide rule subtracts logarithms to find the quotient of two numbers. The explanation of division is very similar to that of multiplication but involves subtracting logarithms as illustrated here: $\frac{a^m}{a^n} = a^{(m-n)}$. Using an example, $\frac{2^5}{2^2} = \frac{2x2x2x2x2}{2x2} = 2x2x2 = 2^3$.

The material on pages 211–213 explains how the CI scale used in conjunction with the D scale actually adds logarithms to multiply. The material on pages 217–220 explains division with the CI and D scales.

The explanation of finding squares and square roots is given on pages 118–120 and should need no further discussion. A similar explanation for cubes and cube roots is carried out on pages 151–154. All of these explanations should be studied carefully if you want to understand all the rules you have previously memorized.

Page 193. In both using the slide rule and understanding its operation it was never actually necessary to find the logarithm of a number. However, many engineering calculations require that the logarithms as such be used in a formula. Logarithms to the base 10 can be obtained from the log scale on your slide rule. Pay particular attention to the second paragraph on page 196 where the method of writing logarithms for numbers less then one is explained. It has been stated before that the mantissa of a logarithm to the base 10 depends only upon the sequence of the digits. This is true, but only if the mantissa is written as a positive number.

Page 202. To find the logarithm of a number to a base other than 10 it is necessary to multiply the logarithm to the base 10 by a constant. This constant depends upon the new base and actually is equal to log 10 to the new base. The other widely used base is e or 2.7183. Logarithms to this base are explained on page 202.

Self-Examination

Answer the following questions for Unit 11 (Optional). The answers will be found in the Key at the back of this Study Guide. Do *NOT* send these answers to USAFI. For each of the following problems indicate which of the given answers is the correct one.

1. The logarithm to the base 10 of 597 is:

   (a) 0.776
   (b) 2.776
   (c) 0.396
   (d) 3.396
   (e) none of these

2. The logarithm to the base 10 of 4,043 is:

   (a) 4.606
   (b) 3.646
   (c) 3.254
   (d) 3.606
   (e) none of these

3. The logarithm to the base 10 of 0.000295 is:
   (a) –3.469
   (b) –4.469
   (c) 6.469–10
   (d) –6.469
   (e) none of these

4. The logarithm to the base 10 of 0.996 is:
   (a) 0.998
   (b) –1.998
   (c) –9.998
   (d) 9.998–10
   (e) none of these

5. The logarithm to the base e of 45.14 is:
   (a) 1.654
   (b) 1.1508
   (c) 3.81
   (d) 2.508
   (e) none of these

6. The logarithm to the base e of 0.00141 is:
   (a) –6.57
   (b) 6.57
   (c) –2.851
   (d) 7.149–10
   (e) none of these

7. The number which has 4.571 for its logarithm to the base 10 is?
   (a) 28,700
   (b) 3,730
   (c) 75,600
   (d) 0.660
   (e) none of these

8. The number which has 7.714 for its logarithm to the base e is:
   (a) 51,800,000
   (b) 2,240
   (c) 20,400,000
   (d) 2,160
   (e) none of these

9. The number which has –4.93 for its logarithm to the base e is:
   (a) 0.00725
   (b) 0.00138
   (c) 0.000725
   (d) 0.000852
   (e) none of these

10. What is the antilog of (log 15 + log 20) all to base 10?
   (a) 30
   (b) 35
   (c) 1150
   (d) 300
   (e) none of these

Written Assignment

NOTE: Students are not required to submit the following written work, but may do so if they desire. Full instructions for sending in Written Assignments are given on Page 3 of this Study Guide.

1. Using examples in your text as a guide, explain how you would find the logarithm of 10,970 to the base 10.

2. Using examples in your text as a guide, explain how you would find the logarithm of .00419 to the base e.

3. Solve the following problem by means of logarithms. In other words, do not multiply and divide on the slide rule, but look up the logarithm and then add and subtract as necessary and finally find the antilog.
$$\frac{356 \times 297}{0.0037} = ?$$

4. Find the logarithm of each of the following numbers to the base 10.
   (a) 27,450
   (b) 3.131
   (c) 0.417
   (d) 0.0000321
   (e) 947,000,000

5. Find the numbers which have the following logarithms to the base e.
   (a) 3.715
   (b) 0.0142
   (c) –0.0142
   (d) 2.3026
   (e) –6.138

6. Solve the following problem by means of logarithms. Determine the logarithms and add or subtract as necessary. $(1075 \times 1.517)^2 = ?$

KEY TO THE SELF-EXAMINATION QUESTIONS

THE following are answers to the Self-Examination questions appearing near the end of each unit in this Study Guide. Compare your answers with those given in this Key. If there are any questions which you have missed, review the material covering them in the text and the Study Guide.

Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
1. b	1. c	1. d	1. c	1. c	1. b
2. c	2. e	2. e	2. d	2. b	2. d
3. e	3. b	3. a	3. e	3. d	3. c
4. b	4. d	4. b	4. c	4. a	4. a
5. c	5. a	5. d	5. a	5. d	5. b
6. d	6. b	6. b	6. b	6. e	6. e
7. a	7. c	7. c	7. b	7. b	7. c
8. b	8. b	8. d	8. d	8. a	8. b
9. c	9. a	9. c	9. a	9. c	9. b
10. a	10. d	10. e	10. c	10. a	10. d

Unit 7	Unit 8	Unit 9	Unit 10	Unit 11 (Optional)
1. b	1. c	1. a	1. e	1. b
2. c	2. d	2. c	2. a	2. d
3. a	3. e	3. b	3. d	3. c
4. d	4. b	4. d	4. d	4. d
5. e	5. c	5. e	5. b	5. c
6. b	6. a	6. c	6. e	6. a
7. c	7. d	7. b	7. c	7. e
8. b	8. d	8. a	8. a	8. b
9. d	9. b	9. b	9. a	9. a
10. d	10. c	10. d	10. c	10. d