Verify the following:

1. $(0.9938)^{100} \approx 0.536$
2. $(0.9965)^{80} \approx 0.755$
3. $(0.9986)^{240} \approx 0.714$
4. $(0.99935)^{10,000} \approx .00145$

Example 7: $(20)^{.00007} = ?$

We may write: $(20)^{.00007} = (20^k)^{.00007/k}$

Now set the index of C opposite 20 on LL3 and experiment with the hairline to discover the value of k that will just put 20^k within scale range (on to the left end of LL1).

Verify that $k = .0035$ will do this, and that $20^{.0035} = 1.01055$.

Thus, the original power may be written:

$$(20)^{.00007} = (1.01055)^{.00007/.0035} = (1.01055)^{.02}$$

Now use relation (1):

$$(20)^{.00007} = (1 + .01055)^{.02} \approx 1 + (.02)(.01055) = \boldsymbol{1.000211} \text{ (approx.)}$$

Exercise B-2

Approximate the following:

1. $(1.0006)^{3.5} =$
2. $(0.9996)^{5} =$
3. $(1.0037)^{40} =$
4. $(1.0011)^{80} =$
5. $(1.00062)^{1000} =$
6. $(1.0048)^{70} =$
7. $(1.00022)^{600} =$
8. $(1.00008)^{2000} =$
9. $(0.9962)^{40} =$
10. $(0.9925)^{120} =$
11. $(0.99940)^{500} =$
12. $(0.99926)^{1200} =$
13. $(0.9981)^{250} =$
14. $(1.7)^{.0008} =$
15. $(150)^{.00004} =$
16. $(0.25)^{.0003} =$
17. $(0.65)^{.0005} =$
18. $(4.4)^{-.00025} =$
19. $(1.075)^{-.0042} =$
20. $(0.85)^{-.0034} =$

B.3 Numbers very near 1 (rules with 8 LL scales)

As mentioned before, some slide rules have two additional lower scales in the neighborhood of 1. One of these ranges from 1.001 to 1.01, and we have referred to this as the LL0 scale (on the Deci-Lon rule it is labeled Ln0). The other scale ranges from 0.990 to 0.999 and we have referred to this as the LLo0 scale (on the Versalog rule it is labeled LL/0; on the Deci-Lon rule it is labeled Ln-0).

Example 1: $(1.00236)^{240} = ?$

1. Move HL over 1.00236 on LL0. Slide left index of C under HL.
2. Move HL over 24 on C. Answer is located 2 scales higher on LL2.
3. Under HL read ***1.761*** on LL2.

Example 2: $(250)^{.00065} = ?$

1. Move HL over 250 on LL3. Slide right index of C under HL.
2. Move HL over 65 on C. Answer is located 3 scales lower on LL0.
3. Under HL read ***1.00360*** on LL0.

Example 3: $(0.99805)^{1500} = ?$

1. Move HL over 0.99805 on LLo0. Slide left index of C under HL.
2. Move HL over 15 on C. Answer is located 3 scales higher on LLo3.
3. Under HL read ***.0536*** on LLo3.

We see that these lower scales enable us to make direct readings quite close to 1. However, they do more than that: actually, we can use them to make readings *as close to 1 as we wish.*

Suppose we imagine scales even lower than LL0, and let us use "$LL0_{-1}$" to describe *one* scale *lower* than LL0, "$LL0_{-2}$" to describe *two* scales *lower* than LL0, and so on. Now it happens that the LL0 scale range is so close to 1 that these lower scales may be mentally pictured very easily, even though they are not physically present. For example, the "$LL0_{-1}$" scale would look exactly the same as the LL0 scale except that the numbers would have an *extra zero* inserted to the right of the decimal point. The "$LL0_{-2}$" scale would look the same except that *two extra zeros* would be inserted. Thus, if you are reading 1.003 on LL0, this same location corresponds to 1.0003 on "$LL0_{-1}$," 1.00003 on "$LL0_{-2}$," and so forth. It follows that any reading on LL0 may be converted to a corresponding reading on a lower scale by simply inserting the proper number of zeros.

Example 4: $(1.03)^{.02} = ?$

1. Move HL over 1.03 on LL1. Slide left index of C under HL.
2. Move HL over 2 on C. Answer is located 2 scales lower on "$LL0_{-1}$."
3. Under HL read 1.00594 on LL0; therefore, the corresponding reading on "$LL0_{-1}$" is ***1.000594***.

Example 5: $(1.000054)^{4500} = ?$

1. Move HL over 1.0054 on LL0. If we now think of this as the "$LL0_{-2}$" scale, the hairline is over 1.000054.
2. Slide right index of C under HL.
3. Move HL over 45 on C. HL is to the left of 1.000054; hence, if exponent were 4.5, answer would be located one scale higher on "$LL0_{-1}$." Decimal point in exponent is actually 3 places to the right of this: hence, answer is on LL2 (3 scales higher than "$LL0_{-1}$").
4. Under HL read ***1.274*** on LL2.

Example 6: $(1.75)^{.0006} = ?$

1. Move HL over 1.75 on LL2. Slide right index of C under HL.
2. Move HL over 6 on C. Verify that result is 3 scales lower than LL2 on "$LL0_{-1}$."
3. Under HL read 1.00337 on LL0. To obtain corresponding reading on "$LL0_{-1}$," insert one zero. Answer is ***1.000337.***

In a similar way, we may refer to scales lower than LLo0 using the labels "$LLo0_{-1}$," "$LLo0_{-2}$," and so on. In this case, we simply insert *extra nines* instead of extra zeros. Thus, if we set at 0.9975 on LLo0, this same location corresponds to 0.99975 on "$LLo0_{-1}$," 0.999975 on "$LLo0_{-2}$," and so forth.

Example 7: $(0.978)^{.0023} = ?$

1. Move HL over 0.978 on LLo1. Slide left index of C under HL.
2. Move HL over 23 on C. Answer will be 3 scales lower on "$LLo0_{-2}$."
3. Under HL read 0.9949 on LLo0; therefore, inserting 2 nines, the corresponding reading on "$LLo0_{-2}$" is ***0.999949.***

Exercise B-3

1. $(1.00545)^{75} =$
2. $(6.5)^{.0031} =$
3. $(1.00077)^{840} =$
4. $10^{.000027} =$
5. $(1.000024)^{-1200} =$
6. $(0.99465)^{65} =$
7. $(0.265)^{.0036} =$
8. $(0.947)^{.00075} =$
9. $(0.99974)^{2600} =$
10. $(0.999905)^{-7500} =$

Exercise B-2 (at the end of the previous section) may be used for further drill.

Appendix C

THE "A-RELATED" LL0 AND LL00 SCALES

C.1 Description of the scales

The LL0 and LL00 scales form a continuous scale starting at 0.999 at the left end of LL0, and decreasing down to about .000045 at the right end of LL00. It is convenient to break these scales up into four parts—the left and right halves of LL0, and the left and right halves of LL00. The range of each half-scale is associated with negative powers of e as follows:

LL0 (left half) extends from $e^{-.001}$ to $e^{-.01}$ (.999 to .990)
LL0 (right half) extends from $e^{-.01}$ to $e^{-.10}$ (.990 to .905)
LL00 (left half) extends from $e^{-.10}$ to $e^{-1.0}$ (.905 to .368)
LL00 (right half) extends from $e^{-1.0}$ to e^{-10} (.368 to .000045)

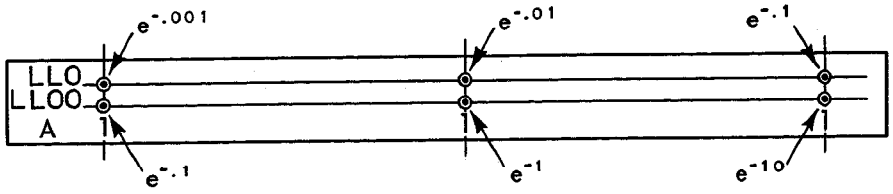

Figure C.1

It is easy to remember these ranges if you identify −10 with the right end of LL00 and then work back, shifting the decimal point one place to the left for each half-scale.

C.2 Finding e^x (x negative)

The left and right halves of LL0 and LL00 are related respectively to the left and right

sections of the A scale in the same manner as the LL1, LL2, and LL3 scales are related to the D scale. Hence, we may raise e to negative powers by reading directly from A to the appropriate scale (LL0 or LL00), bearing in mind the range associated with each scale.

Example 1: $e^{-.056} = ?$

Inasmuch as $-.056$ is in the range of LL0 (right half), we set hairline on A-right.

1. Move HL over 56 on A-right.
2. Under HL read ***0.9455*** on LL0.

(Also note that $e^{-5.6}$ is under HL on LL00. Its value is .0037.)

Example 2: $e^{-0.35} = ?$

Note that -0.35 is in the range of LL00 (left half); hence, set hairline on A-left.

1. Move HL over 35 on A-left.
2. Under HL read ***0.705*** on LL00.

(Note that $e^{-.0035}$ is under HL on LL0. Its value is 0.9965.)

Example 3: $e^{-4.51} = ?$

Note that -4.51 is in the range of LL00 (right half); hence, set hairline on A-right.

1. Move HL over 451 on A-right.
2. Under HL read ***0.0110*** on LL00.

C.3 Finding ln N (N less than 1)

Here, we have the inverse problem: knowing e^x we must find x.

Example 1: ln 0.945 = ?

1. Move HL over 0.945 on LL0 (right half).
2. Under HL read "565" on A-right. Because of the range associated with LL0 (right half), we know that answer must be ***−.0565.***

Example 2: ln .065 = ?

1. Move HL over .065 on LL00 (right half).
2. Under HL read "274" on A-right. Noting the range associated with LL00 (right half), we see that answer must be ***−2.74.***

Verify the following:

1. $e^{-2.65} = .070$
2. $e^{-.064} = 0.938$
3. $e^{-.0147} = 0.9854$
4. $e^{-0.33} = 0.719$
5. $e^{-.0074} = 0.9926$
6. $e^{-100/22} = .0106$
7. $\ln 0.724 = -0.323$
8. $\ln .0225 = -3.79$

C.4 Finding b^x (x positive)

Inasmuch as the LL0 and LL00 scales are related to A-B, the hairline is set over the exponent on the B scale.

Example 1: Evaluate the following:
a. $(0.80)^2$; **b.** $(0.80)^{10}$; **c.** $(0.80)^{20}$.

1. Move HL over 0.80 on LL00. Slide left index of B under HL.
2. Move HL over 2 on B-left (we will refer to this as the "near half" of the B scale since it is the section nearest (0.80).
   Under HL read ***0.64***. This is $(0.80)^2$.
3. Move HL over middle index of B. Under HL read ***0.108***. This is $(0.80)^{10}$.
4. Move HL over 2 on the "far half" of B. Under HL read ***.0115***. This is $(0.80)^{20}$.
   The settings are illustrated in Figure C.2.

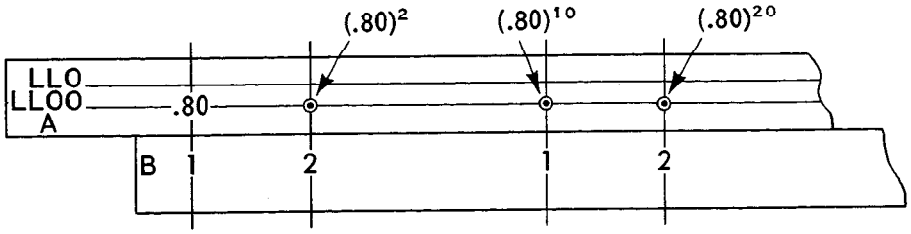

Figure C.2

Example 2: Evaluate: **a.** $(0.96)^{0.5}$; **b.** $(0.96)^{.05}$.

1. Move HL over 0.96 on LL0. Slide right index of B under HL.
2. Move HL over 5 on the near half of the B scale. Under HL read ***0.9798*** on LL0. This is $(0.96)^{0.5}$.
3. Move HL over 5 on the far half of B. Under HL read ***0.99796*** on LL0. This is $(0.96)^{.05}$. (See Figure C.3.)

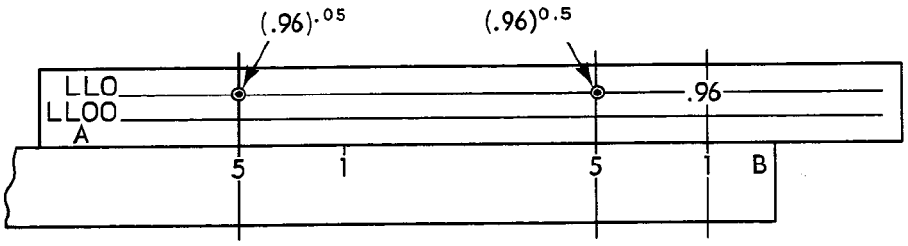

Figure C.3

From the foregoing examples we generalize as follows:

1. When evaluating b^x suppose the answer is to the *right* of b and on the *same scale*. Then:
   a. If HL is positioned on the *near half* of B, the exponent must be *between 1 and 10* (X.XX).
   b. If HL is on the *far half* of B, the exponent is *between 10 and 100* (XX.X).

2. Suppose the answer is the *left* of b and on the *same* scale. Then:
   a. If HL is positioned on the *near half* of B, the exponent must be *between 0.1 and 1* (0.XXX).
   b. If HL is positioned on the *far half* of B, the exponent is *between .01 and 0.1* (.0XXX).

Example 3: $(.05)^{.08} = ?$

1. Move HL over .05 on LL00. Slide right index of B under HL.
2. Move HL over 8 on the *far half* of B. Under HL read ***0.786*** on LL00.

Example 4: $(0.9954)^{4.5} = ?$

1. Move HL over 0.9954 on LL0. Slide left (or middle) index of B under HL.
2. Move HL over 45 on *near half* of B. Under HL read ***0.9795*** on LL0.

Verify the following:

1. $(0.75)^{15} = .0135$
2. $(0.97)^{0.35} = 0.9894$
3. $(.989)^{5.2} = 0.944$
4. $(.035)^{.075} = 0.778$

C.5 The "scale-shift" principle

The LL0 and LL00 scales are related to each other in the following way:

1. If the HL is over b^x on LL0, then b^{100x} is under the HL on LL00.
2. Conversely, if the HL is over b^x on LL00, then $b^{x/100}$ is under the HL on LL0.

In other words, moving from LL0 to LL00 shifts the decimal point in the exponent *two* places to the *right*; moving from LL00 to LL0 shifts the decimal point *two* places to the *left*.

Example 1: $(0.564)^{.04} = ?$

1. Move HL over 0.564 on LL00. Slide left index of B under HL.
2. Move HL over 4 on near half of B. The HL is now over $(0.564)^4$ on LL00; therefore, $(0.564)^{.04}$ must be under HL on LL0.
3. Under HL read ***0.9773*** on LL0. See Figure C.4.

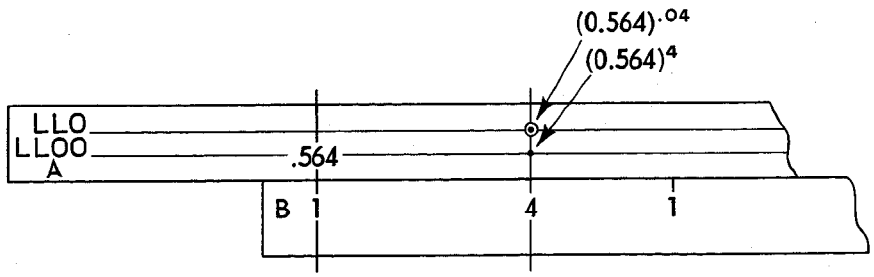

Figure C.4

Example 2: $(0.96)^5 = ?$

1. Move HL over 0.96 on LL0. Slide right index of B under HL.
2. Move HL over 5 on far half of B. The HL is now over $(0.96)^{.05}$ on LL0; therefore, $(0.96)^5$ is under HL on LL00.
3. Under HL read ***0.815*** on LL00.

Example 3: $(.064)^{.021} = ?$

1. Move HL over .064 on LL00. Slide middle index of B under HL.
2. Move HL to the right over 21 on the near half of B. HL is now over $(.064)^{2.1}$ on LL00; therefore, $(.064)^{.021}$ must be under HL on LL0.
3. Under HL read ***0.9439*** on LL0.

Example 4: $(.9971)^{250} = ?$

1. Move HL over .9971 on LL0. Slide left index of B under HL.
2. Move HL over 25 on near half of B. This puts HL over $(.9971)^{2.5}$ on LL0; therefore, HL must be over $(.9971)^{250}$ on LL00.
3. Under HL read ***0.484*** on LL00.

Verify the following:

1. $(0.48)^{0.67} = 0.612$
2. $(.0145)^{.0029} = 0.9878$
3. $(0.223)^{.083} = 0.883$
4. $(0.997)^{380} = 0.319$

C.6 Finding b^x (x negative)

Here, we may use either of the two relations:

1. $b^{-x} = \dfrac{1}{b^x}$
2. $b^{-x} = \left(\dfrac{1}{b}\right)^x$

Example 1: $(.985)^{-12} = ?$

Using relation (1), we may write: $(.985)^{-12} = \dfrac{1}{(.985)^{12}}$

1. Verify that $(.985)^{12} = 0.834$.
2. Find reciprocal of this in the conventional manner using C and CI scales (or D and DI). Verify that result is ***1.20***.

Example 2: $(0.55)^{-3.5} = ?$

Suppose we use relation (2): $(.055)^{-3.5} = \left(\dfrac{1}{0.55}\right)^{3.5}$

1. Verify that reciprocal of 0.55 is 1.82. Hence, we must evaluate $(1.82)^{3.5}$.
2. Verify that result is ***8.15***.

Example 3: $5^{-4.3} = ?$

Using relation (2): $5^{-4.3} = \left(\dfrac{1}{5}\right)^{4.3} = (0.2)^{4.3}$

Verify that result is ***.0010.***

Verify the following:

1. $8^{-3.5} = .00069$
2. $(0.94)^{-20} = 3.44$
3. $(0.75)^{-7.5} = 8.65$
4. $(65)^{-0.36} = 0.222$

Exercises in Chapters 19 and 20 may be used for further drill.

Appendix D

THE LL SCALES (BASE 10); THE FOLDED SCALES (CF/M, DF/M)

D.1 The LL scales (base 10)

Certain Pickett models have scales labeled N or LL which are associated with powers of 10 as follows:

LL1+ (or N_1) extends from $10^{.001}$ to $10^{.01}$
LL2+ (or N_2) extends from $10^{.01}$ to $10^{0.1}$
LL3+ (or N_3) extends from $10^{0.1}$ to $10^{1.0}$
LL4+ (or N_4) extends from $10^{1.0}$ to 10^{10}

Back-to-back with these are scales (increasing from right to left) which are associated with negative powers of 10 as follows:

LL1– (or $1/N_1$) extends from $10^{-.001}$ to $10^{-.01}$
LL2– (or $1/N_2$) extends from $10^{-.01}$ to $10^{-0.1}$
LL3– (or $1/N_3$) extends from $10^{-0.1}$ to $10^{-1.0}$
LL4– (or $1/N_4$) extends from $10^{-1.0}$ to 10^{-10}

In the following discussion, we shall use the "LL" rather than the "N" designation. The LL (base 10) scales are related to the D scale in the following manner:

> If the hairline is moved over a number x on **D**, then 10^x is located under the HL on the appropriate **LL** scale.
>
> Conversely, if the hairline is moved over a number N on **LL**, then $\log_{10}N$ is located under the HL on **D**.

Example 1: $10^{2.4} = ?$

Exponent is between 1 and 10; hence, answer will be on LL4+.

1. Move HL over 24 on D.
2. Under HL read ***250*** on LL4+.

Observe that $10^{-2.4}$ is located on LL4–, and is equal to .004.

Example 2: $10^{-.063} = ?$

Exponent is between −.01 and −0.10; hence, answer will be on LL2–.

1. Move HL over 63 on D.
2. Under HL read ***0.865*** on LL2–.

Observe that $10^{-.063} = 1.156$ is on LL2+.

Example 3: $\log_{10}1.1145 = ?$

1. Move HL over 1.1145 on LL2+.
2. Under HL read "471" on D. We are set on LL2+; hence, result must be between .01 and 0.10. Answer is ***.0471***.

D.2 The reciprocal property

Examples 1 and 2 of the preceding section illustrate the reciprocal property of the LL (base 10) scales:

> If the hairline is set over a number on LL4+, its reciprocal will be under the hairline on LL4–, and vice versa.
>
> A similar relation holds between LL3+ and LL3–, LL2+ and LL2–, and between LL1+ and LL1–.

Example: $1/1.73 = ?$

1. Move HL over 1.73 on LL3+.
2. Under HL read $1/1.73 =$ ***0.578*** on LL3–.

D.3 The "scale-shift" principle

Another useful property of the LL scales may be stated:

If the hairline is over b^x on one of the LL scales, then:
1. b^{10x} is under HL on the *next higher* scale.
2. $b^{x/10}$ is under HL on the *next lower* scale.

In other words, the decimal point in the exponent shifts *one place* to the *right* each time we move *one scale higher;* it shifts *one place* to the *left* each time we move *one scale lower.* (By a higher scale we mean one with a higher number designation; LL3+ is higher than LL2+, LL4– is higher than LL3–, and so on.)

Example: Evaluate 10^x for $x = .022$, $.0022$, and 2.2.

1. Move HL over 22 on D.
2. Under HL read:
   a. $10^{.022} = \boldsymbol{1.01519}$ on LL2+.
   b. $10^{.0022} = \boldsymbol{1.00507}$ on LL1+ (one scale lower than LL2+).
   c. $10^{2.2} = \boldsymbol{159}$ on LL4+ (two scales higher than LL2+).

Verify the following:

1. $1/6500 = .000154$
2. $1/0.99225 = 1.00781$
3. $\log_{10}1.00845 = 0.00366$
4. $\log_{10}0.9672 = -.01450$
5. $10^{5.81} = 650{,}000$; $10^{.0581} = 1.143$
6. $10^{-0.44} = 0.363$; $10^{-4.4} = .00004$

D.4 The CF/M and DF/M scales

These are C and D scales folded at $\log_e 10 = 2.30$. The DF/M scale is related to the base-10 LL scales as follows:

If the hairline is moved over a number x on **DF/M**, then e^x is under HL on the appropriate **LL** scale.

Conversely, if the hairline is over a number N on **LL**, then $\log_e N$ is under HL on **DF/M.**

Also, if the hairline is over $\log_{10} N$ on **D**, then $\log_e N$ is under HL on **DF/M**; thus, conversion of logs from base e to base 10, and vice versa, may be accomplished directly.

Example 1: Evaluate e^x for $x = 1, 2, 3,$ and 6.

1. Move HL over 1 on DF/M (we refer to this as the DF/M index). Under HL read $e = \boldsymbol{2.72}$ on LL3+.
2. Move HL over 2 on DF/M. Under HL read $e^2 = \boldsymbol{7.40}$ on LL3+.
3. Move HL over 3 on DF/M. Under HL read $e^3 = \boldsymbol{20.1}$ on LL4+.
4. Move HL over 6 on DF/M. Under HL read $e^6 = \boldsymbol{405}$ on LL4+.

The results of the foregoing example may be summarized:

When evaluating e^x (x between 1 and 10):
1. Answer is on ***LL3+*** when HL is to the *right* of DF/M index.
2. Answer is on ***LL4+*** when HL is to the *left* of DF/M index.

Using the scale-shift principle and the reciprocal property, more general powers of e may be obtaincd.

Example 2: $e^{.043} = ?$

1. Move HL over 43 on DF/M. HL is to the left of the DF/M index; hence, if exponent were 4.3, answer would be on LL4+. Decimal point is two places to the left of this position; therefore, answer is two scales lower on LL2+.
2. Under HL read ***1.044*** on LL2+.

Example 3: $e^{-14.5} = ?$

1. Move HL over 145 on DF/M. HL is to the right of DF/M index; hence, if exponent were 1.45, answer would be on LL3+, and if exponent were 14.5, answer would be on LL4+. Exponent is −14.5; therefore, answer is on the reciprocal scale, LL4−.
2. Under HL read approximately $\boldsymbol{5 \times 10^{-7}}$ on LL4−.

Example 4: **a.** $\log_{10}1.76 = ?$ **b.** $\log_e 1.76 = ?$

It is helpful to remember that $\log_e N$ is a little more than twice $\log_{10} N$.

1. Move HL over 1.76 on LL3+.
2. Under HL read:
   a. $\log_{10}1.76 = \boldsymbol{0.246}$ on D.
   b. $\log_e 1.76 = \boldsymbol{0.565}$ on DF/M.

Verify the following:

1. $e^{1.46} = 4.31$
2. $e^{7.45} = 1720$
3. $e^{0.65} = 1.916$
4. $e^{.015} = 1.0151$
5. $e^{.0037} = 1.00371$
6. $e^{-2.12} = 0.120$
7. $e^{-.0075} = 0.99253$
8. $e^{-16.6} = 6 \times 10^{-8}$
9. $\log_{10}20 = 1.300$; $\log_e 20 = 3.00$
10. $\log_{10}0.466 = -0.332$; $\log_e 0.466 = -0.763$

Observe that CF/M and DF/M are *operational* scales, and may be used as another pair of folded scales in the same way that you use CF and DF. Also, you may use both scales in conjunction with the LL scales.

Example 5: $e^{(6.4\times.076)/3.3} = ?$

Estimate the combined exponent to be about 0.15. We may now evaluate the exponent on the CF/M-DF/M scales and read the result on the appropriate LL scale.

1. Move HL over 64 on DF/M.
2. Slide 33 on CF/M under HL.
3. Move HL over 76 on CF/M. HL is to the right of the DF/M index; hence, if exponent were about 1.5, answer would be on LL3+. Exponent is about 0.15; therefore, result is one scale lower on LL2+.
4. Under HL read ***1.1587*** on LL2+.

Example 6: 5.6 ln 6.8 = ? (ln 6.8 means $\log_e 6.8$)

1. Move HL over 6.8 on LL3+. HL is now over ln 6.8 on DF/M. Now multiply by 5.6 using the CF/M-DF/M scales.
2. Slide CF/M index under HL. Move HL over 56 on CF/M.
3. Under HL read "1072" on DF/M. Answer is ***10.72.***

Example 7: $e^{-5/12} = ?$

Estimate exponent to be about −0.4.

1. Move HL over 5 on DF/M.
2. Slide 12 on CF/M under HL.
3. Move HL over CF/M index. Note that HL is to the left of DF/M index; hence, if exponent were about 0.4, answer would be on LL3+. Exponent is negative; therefore, answer is on the reciprocal scale, LL3−.
4. Under HL read ***0.659*** on LL3−.

Verify the following:

1. $e^{12/7} = 5.55$
2. $e^{7/60} = 1.1239$
3. $e^{-1/15} = 0.9355$
4. $e^{5\pi/4.6} = 30.2$
5. $e^{-30/(76 \times 3.75)} = 0.900$
6. $3.7 \ln 45 = 14.10$
7. $\dfrac{6.25 \ln .077}{2.44} = -6.57$

The exercises in Chapter 19 may be used for further practice.

D.5 Finding b^x

You should now refer to Chapter 20. The rules and techniques described in that chapter also apply to the base-10 scales. In following the illustrative examples in Chapter 20 with the base-10 scales, you will note certain differences in the scale designation. Thus, the number 36 is located on LL3 (base e), whereas on the base-10 scale it is found on LL4+. Also, when the left index is called for in Chapter 20, you may sometimes have to use the right index, and vice versa. You may also find it necessary to interchange indexes at a different point in the described procedure. However, the basic scale relationships and procedures outlined in Chapter 20—the reciprocal property of the scales, the "scale-shift" principle, the rule for locating b^x on the proper LL scale—all these apply equally well to the base-10 scales.

The following examples assume familiarity with the material in Chapter 20.

Example 1: $(2.46)^{.052} = ?$

1. Move HL over 2.46 on LL3+. Slide right index of C under HL.
2. Move HL over 52 on C. Note that HL is to the left of 2.46; hence, if exponent were 5.2, answer would be one scale higher on LL4+. However, decimal point in exponent is actually 2 places to the left of this position; hence, result is two scales lower on LL2+.
3. Under HL read ***1.0479*** on LL2+.

Example 2: $(0.9265)^{-170} = ?$

1. Move HL over 0.9265 on LL2−. Slide left index of C under HL.
2. Move HL over 170 on C. HL is to the right of 0.9265; hence, if exponent were 1.70, answer would be on the same scale, LL2−. Decimal point in exponent is actually two places to the right of this position; hence, if exponent were 170, answer would be on LL4−. Exponent is negative; therefore, answer is on the reciprocal scale, LL4+.
3. Under HL read approximately ***440,000*** on LL4+.

Verify the following:

1. $(2.06)^{27.6} = 4.5 \times 10^{8}$

2. $(1.00442)^{260} = 3.15$

3. $(75{,}000)^{.00535} = 1.0618$

4. $(1.545)^{-22} = 0.00007$

5. $(0.99346)^{1800} = 7.4 \times 10^{-6}$

6. $(35{,}000)^{-.0044} = 0.9551$

The exercises in Chapter 20 will provide more drill. Methods for handling numbers outside the range of the scales are discussed in Appendix B.

Appendix E

THE HYPERBOLIC SCALES (SH, TH); THE PYTHAGOREAN SCALE (P)

E.1 The Sh and Th scales

For convenience, we repeat the definitions of the hyperbolic functions given in Chapter 19:

$$\sinh x = \frac{1}{2}(e^x - e^{-x})$$

$$\cosh x = \frac{1}{2}(e^x + e^{-x})$$

$$\tanh x = \frac{\sinh x}{\cosh x} = \frac{e^{2x} - 1}{e^{2x} + 1}$$

From these definitions, the following relations may also be obtained:

$$\sinh(-x) = -\sinh x$$
$$\cosh(-x) = \cosh x$$
$$\tanh(-x) = -\tanh x$$
$$\cosh^2 x - \sinh^2 x = 1$$

The Sh scale consists of two full-length scales labeled Sh1 and Sh2 (on the Pickett models, these are back-to-back; the upper scale corresponds to Sh1, the lower scale corresponds to Sh2). The two Sh scales taken together form one continuous scale ranging from about 0.10 to 3.0.

The Th scale is a single full-length scale which also ranges from about 0.10 to 3.0.

If the Sh and Th scales are on the slide, they are related to the C scale; if they are on the body of the rule, they are related to the D scale. Hyperbolic sines and tangents may be read directly as follows:

To find sinh x:
1. Move HL over x on **Sh1** or **Sh2.**
2. Under HL read *sinh x* on **C(D).**
3. To place the decimal point:
   a. When reading from **Sh1,** sinh x is *between 0.1 and 1.0.*
   b. When reading from **Sh2,** sinh x is *between 1.0 and 10.*

To find tanh x:
1. Move HL over x on **Th.**
2. Under HL read *tanh x* on **C(D).**
3. To place the decimal point:
   For all settings on **Th,** tanh x is *between 0.1 and 1.0.*

To find cosh x:

Use the relationship: $\cosh x = \dfrac{\sinh x}{\tanh x}$

Example 1: sinh 1.85 = ? tanh 0.545 = ?

1. Move HL over 1.85 on Sh2.
2. Under HL read sinh 1.85 = ***3.10*** on C(D).
3. Move HL over 0.545 on Th.
4. Under HL read tanh 0.545 = ***0.497*** on C(D).

Example 2: cosh 0.68 = ?

We use the relation: $\cosh 0.68 = \dfrac{\sinh 0.68}{\tanh 0.68}$

Verify that cosh 0.68 = ***1.24.***

Example 3: sinh x = 0.51; x = ?

1. Move HL over 51 on C(D).
2. Under HL read x = ***0.49*** on Sh1.

Result may also be written: $\sinh^{-1}0.51 = \mathbf{0.49}$.

Example 4: $\cosh^{-1}2.04$ = ?

This problem may also be stated: cosh x = 2.04; x = ?

1. Verify that $\sinh x = \sqrt{\cosh^2 x - 1} = \sqrt{(2.04)^2 - 1} = 1.778$.
2. Move HL over 1778 on C(D).

3. Under HL read $x = \boldsymbol{1.34}$ on Sh2.

Hence, $\cosh^{-1}2.04 = \boldsymbol{1.34}$.

Verify the following:

1. $\sinh 0.55 = 0.578$

2. $\tanh(-1.26) = -0.851$

3. $\sinh 2.37 = 5.30$

4. $\cosh(-1.45) = 2.25$

5. $\sinh(-1.06) = -1.27$

6. $\cosh 0.89 = 1.423$

7. $\sinh^{-1}4.19 = 2.14$

8. $\tanh^{-1}0.493 = 0.54$

9. $\cosh^{-1}1.32 = 0.78$

10. $\cosh^{-1}2.70 = 1.65$

For values of x outside the range of the Sh and Th scales, the following approximations may be used:

1. For *large* values of x ($x > 3$):
$$\sinh x \approx \frac{1}{2}e^x \qquad \cosh x \approx \frac{1}{2}e^x \qquad \tanh x \approx 1$$

2. For *small* values of x ($0 < x < 0.1$):
$$\sinh x \approx x \qquad \cosh x \approx 1 \qquad \tanh x \approx x$$

E.2 The P scale

The P scale is often present on British and European slide rules. The scale is based on the Pythagorean relation, and ranges from 0 to 0.995 (increasing from right to left). It is usually on the body of the rule, and is related to the D scale as follows:

If the hairline is over a number x on the **D** scale ($0.1 \leq x \leq 1$), then $\sqrt{1 - x^2}$ is under the hairline on the **P** scale.

Example 1: $\sqrt{1 - (0.46)^2} = ?$

1. Move HL over 46 on D.
2. Under HL read $\boldsymbol{0.888}$ on P.

Example 2: $\sin 40° = ?$ $\cos 40° = ?$

Recall that $\cos 40° = \sqrt{1 - \sin^2 40°}$

1. Close rule and move HL over 40° on S scale.
2. Under HL read:

$\sin 40° = \mathbf{0.643}$ on D,
$\cos 40° = \mathbf{0.766}$ on P.

Example 3: Given a right triangle with $c = 26$, $a = 17$. Find side b.

Write: $b = \sqrt{c^2 - a^2} = c\sqrt{1 - (a/c)^2}$.

Substituting: $b = 26\sqrt{1 - (17/26)^2}$.

1. Using P scale, verify that $\sqrt{1 - (17/26)^2} = 0.757$.
2. Multiplying 26 by 0.757 on C-D, verify that $b = \mathbf{19.65}$.

Appendix F

SOME REPRESENTATIVE LOG LOG SLIDE RULES

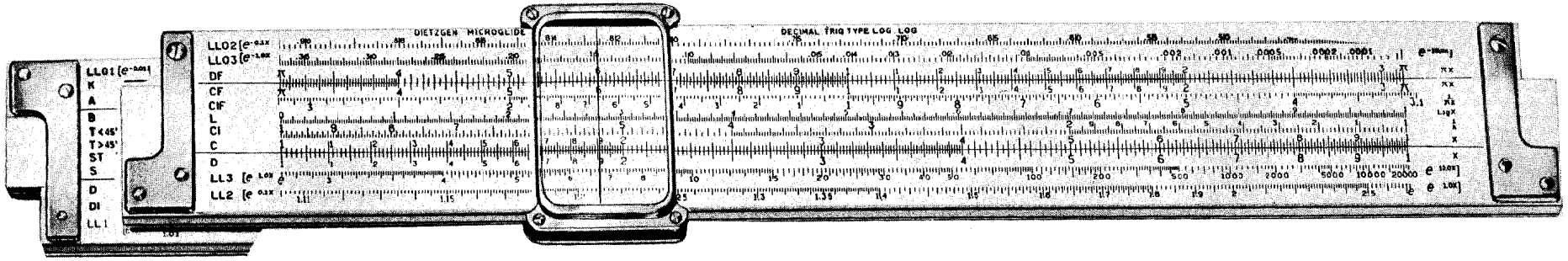

Figure F.1 DECIMAL TRIG LOG LOG TYPE (Courtesy Eugene Dietzgen Co.)

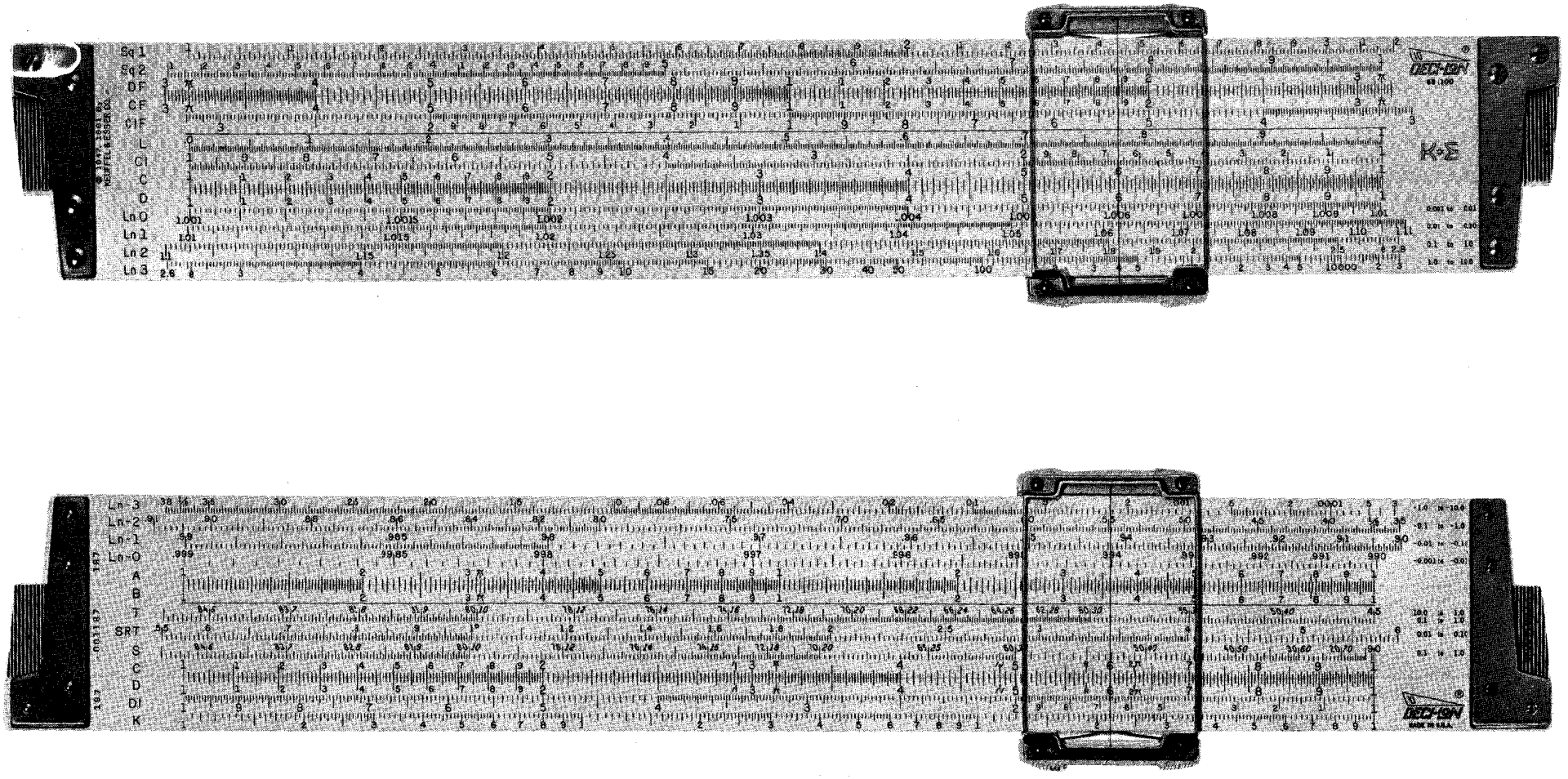

Figure F.2 DECI-LON (Courtesy Keuffel & Esser Co.)

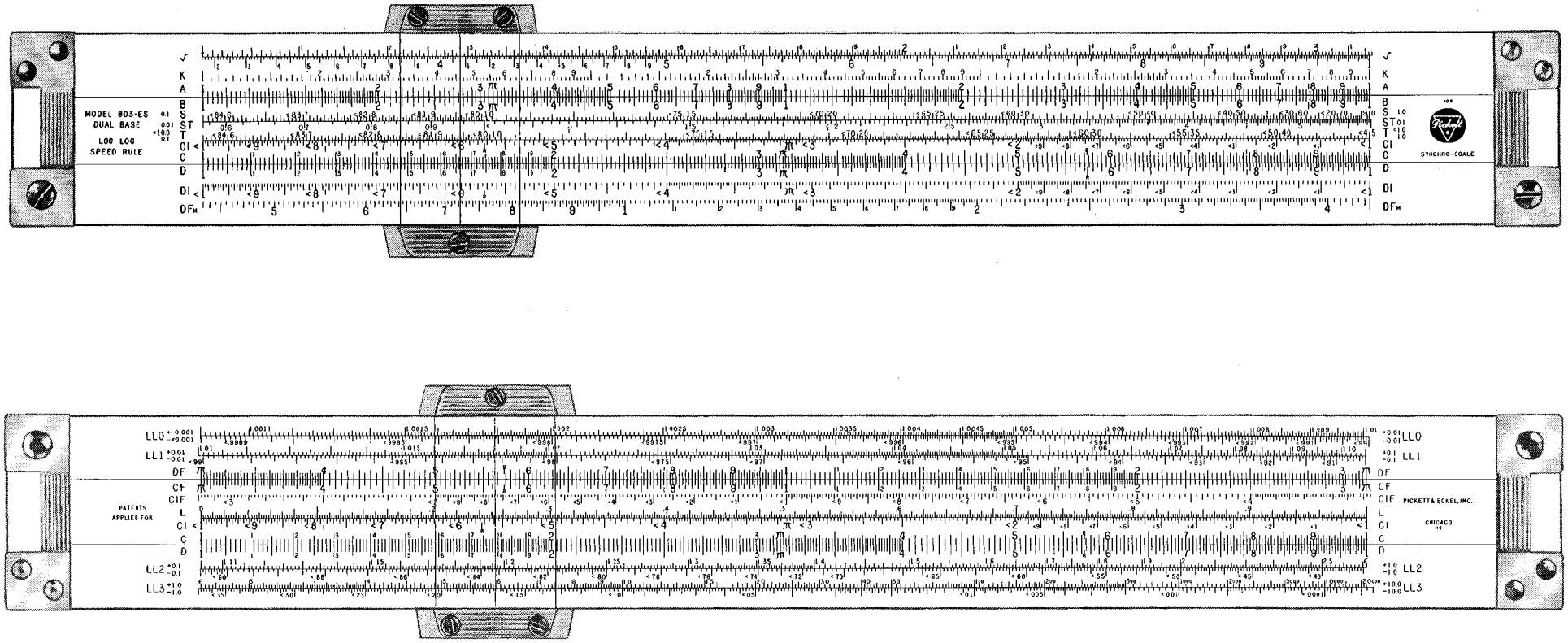

Figure F.3 DUAL BASE LOG LOG SPEED RULE, Model 803-ES (Courtesy Pickett, Inc.)

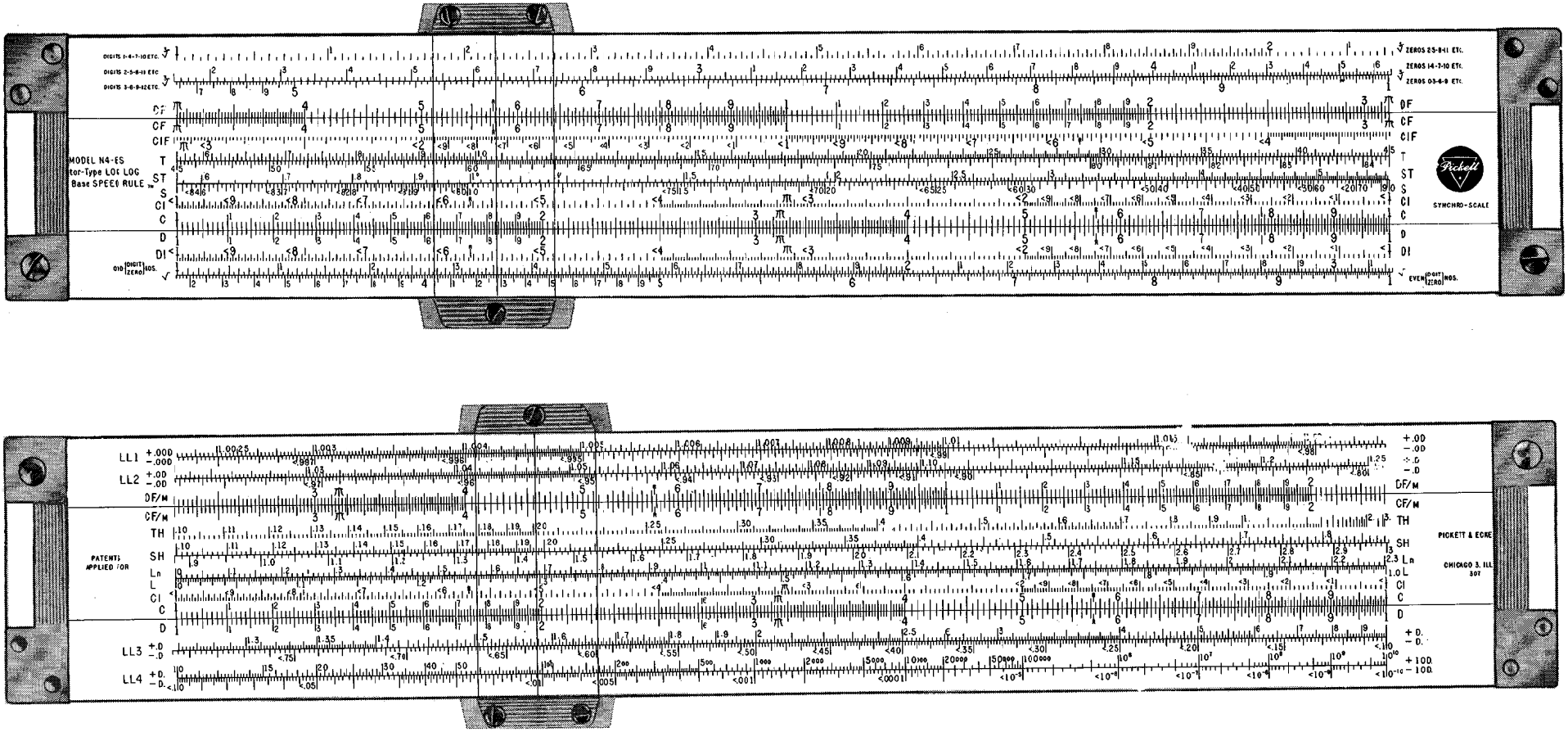

Figure F.4 VECTOR LOG LOG DUAL BASE SPEED RULE, Model N4-ES
(Courtesy Pickett, Inc.)

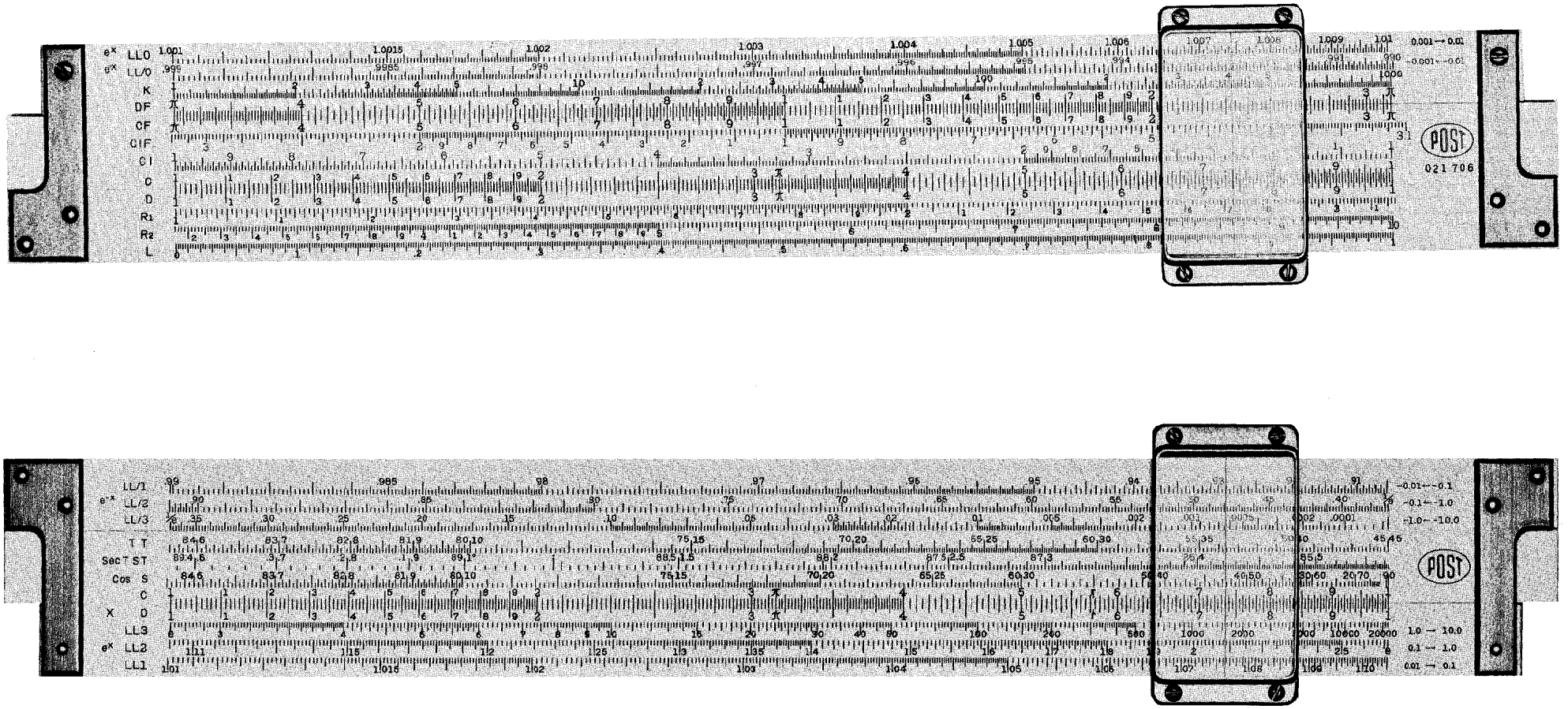

Figure F.5 VERSALOG (Courtesy Frederick Post Co.)

ANSWERS TO EXERCISES

Exercise 1-1

1. 11.76	**11.** 7.42	**21.** 13.81	**31.** 797
2. 34.7	**12.** 50.5	**22.** 116.6	**32.** 0.265
3. 96.2	**13.** 12.70	**23.** 2.38	**33.** 0.464
4. 17.68	**14.** 45.7	**24.** 351	**34.** .000524
5. 7.14	**15.** 96.6	**25.** 0.702	**35.** 71.6
6. 122.1	**16.** 19.70	**26.** 1400	**36.** 4.61
7. 5.38	**17.** 17.85	**27.** 158.1	**37.** 0.311
8. 6.32	**18.** .0292	**28.** 9350	**38.** 161.5
9. 2.78	**19.** 36.6	**29.** .0902	**39.** 946
10. 47.2	**20.** 44.7	**30.** 114.0	**40.** .000468

Exercise 1-2

1. 0.437	**8.** .000230	**15.** .0001118	**22.** 7630
2. 66,400	**9.** 8620	**16.** 137.0	**23.** 262
3. .00207	**10.** 39.0	**17.** .000267	**24.** 190,800
4. 0.1570	**11.** .000260	**18.** 230,000	**25.** .00000598
5. 42.6	**12.** 105.9	**19.** .00001538	**26.** 1980
6. 4860	**13.** .000733	**20.** 239	**27.** .000270
7. .0279	**14.** 1382	**21.** .0573	**28.** 44,700

29. 343 **30.** 0.273

Exercise 1-3

1. 43.6	**11.** 46.3	**21.** 13.15	**31.** 67.4
2. 108.7	**12.** 27.7	**22.** 485	**32.** 21.2
3. 483	**13.** 14.65	**23.** 173.5	**33.** 16.08
4. 6.08	**14.** 49.8	**24.** 940	**34.** 22.0
5. 10.00	**15.** 1078	**25.** 25.5	**35.** .0505
6. .0404	**16.** 291	**26.** 8210	**36.** 6.79
7. 4.60	**17.** 1.245	**27.** 0.753	**37.** 7.67
8. 22.8	**18.** .00795	**28.** 112.4	**38.** 4.47
9. 9.97	**19.** 3710	**29.** 0.339	**39.** .00334
10. 4.33	**20.** 1113	**30.** 5.61	**40.** 22.7

Exercises 1-4

1. 2.95×10^{-8}	**8.** 8.46×10^{5}	**15.** 7.49	**23.** 0.747
2. 5.06×10^{8}	**9.** 5.78×10^{-8}	**16.** 39.1	**24.** 3.94×10^{10}
3. 4.00×10^{-8}	**10.** 90.7	**17.** 5.09×10^{-5}	**25.** 15,980
4. 7.44×10^{6}	**11.** 2.24×10^{-4}	**18.** .0648	**26.** 4.16
5. 5.96×10^{-9}	**12.** 4.00×10^{-3}	**19.** 1.824	**27.** 6.27×10^{-5}
6. 6.07×10^{5}	**13.** 7.67×10^{-4}	**20.** 2260	**28.** 4.75×10^{7}
7. 6.56×10^{9}	**14.** 8.15	**21.** 8.03	**29.** 46,700
		22. 9.07×10^{13}	**30.** 3.54×10^{-6}

Exercise 2-1

1. A–"1003" B–"1031" C–"1060" D–"1095" E–"1143" F–"1197" G–"1260" H–"1303" I–"1372" J–"1428" K–"1425" L–"1502" M–"1590" N–"1714" O–"1763" P–"1867" Q–"1923" R–"1995"

2. A–"201" B–"214" C–"233" D–"247" E–"266" F–"280" G–"298" H–"313" I–"335" J–"381" K–"401" M–"453" N–"488" O–"514" P–"543" Q–"585" R–"627"

Exercise 2-2

(C or D)

"1259"	"501"	"205"	"646"
"1585"	"631"	"1047"	"1014"
"1995"	"794"	"1005"	"708"
"251"	"302"	"254"	"1072"
"316"	"1355"	"975"	"329"
"398"	"891"	"1845"	"995"

(L)

.389	.176	.027	.342
.542	.941	.957	.041
.031	.872	.706	.984
.328	.636	.004	.039
.600	.003	.804	.777
.840	.568	.613	.247

Exercise 3-1

1. 6.48	**6.** 77.0	**11.** 41.4	**16.** 18.30
2. 5.28	**7.** 7.28	**12.** 6.75	**17.** 527,000
3. 8.12	**8.** 19.25	**13.** 69.0	**18.** .00406
4. 70.5	**9.** 92.4	**14.** 6.15	**19.** 0.734
5. 103.6	**10.** 36.4	**15.** 91.2	**20.** 0.0662

Exercise 3-2

1. 27.3	**6.** 175.8	**11.** 272	**16.** 457
2. 31.9	**7.** 14.95	**12.** 154.6	**17.** 1450
3. 63.8	**8.** 1393	**13.** 1226	**18.** 0.478
4. 158.1	**9.** 21.2	**14.** 25.6	**19.** 0.1779
5. 14.72	**10.** 2280	**15.** 172.1	**20.** 29,000

Exercise 3-3

1. 36.8
2. 44.4
3. 52.5
4. 439
5. 61.6
6. 81.9
7. 736
8. 285
9. 864
10. 18.14
11. 33.3
12. 459
13. 1323
14. 136.9
15. 66.6
16. 77.1
17. 1678
18. 351
19. 7.72
20. 204
21. 79.4
22. 89.0
23. 522
24. 313
25. 7.57
26. 109.5
27. 347
28. 176.3
29. 102.7
30. 229
31. 161.0
32. 8510
33. 86.9
34. 230
35. 23.4
36. 124.4
37. 77.3
38. 33.3
39. 475
40. .00778
41. 10.58
42. 7.37
43. .00784
44. 88,000
45. 11,100
46. 15.96
47. 16.65
48. 1070
49. .0000890
50. 942,000
51. 12.98
52. .0000586
53. 115,200
54. 104.6
55. 0.227
56. 1809
57. .000211
58. 6.92
59. .00576
60. 38,000
61. .0347
62. 20.2
63. 498
64. .0681
65. 3.32
66. 10.76
67. 515
68. 0.1036
69. 714
70. 5.18

Exercise 3-4

1. 2.21
2. 2.47
3. 3.36
4. 2.56
5. 0.619
6. 0.455
7. 4.48
8. 11.55
9. 4.19
10. 2.62
11. 2.66
12. 3.82
13. 23.5
14. 8.78
15. 3.70
16. 3.60
17. 3.17
18. 39.0
19. 3.01
20. 5.90
21. 19.89
22. 1.346
23. 2780
24. 9.38

25. 1.283
26. 24.7
27. 5.34
28. 2.55
29. 2.62
30. 1.980
31. .00572
32. .0001305
33. 0.1573
34. .0927
35. 8.19
36. 211
37. 0.1915
38. .0819
39. 1125
40. .0306
41. 0.641
42. .0000573
43. .001940
44. 323,000
45. 299
46. 13.05
47. .01928
48. .00671
49. 184.7
50. 164.1
51. .00001738
52. .000502
53. 52.4
54. .0267
55. 60,500
56. .0863
57. .0868
58. .0203
59. .0000301
60. 3,080,000
61. .000867
62. 2170
63. 227
64. 1533
65. 0.343
66. 236,000
67. 2960
68. 3.96
69. .01733
70. 3420
71. 6130
72. 3560
73. 65.9
74. 103,400
75. .00223
76. 13.34
77. 48.3
78. 69.4
79. 81.5
80. 190.2
81. 10.61
82. 138.0
83. 8660
84. 143,500,000
85. .01649

Exercise 4-1

1. 3.50
2. 15.35
3. 15.73
4. 60.5
5. 125.1
6. 34.7
7. 87.9
8. 8.58
9. 3.96
10. 11.13
11. 57.6
12. 0.764
13. 22.2
14. 0.587
15. 2.27
16. 8.07
17. 14.18
18. 25.3
19. 12.40
20. 5.69
21. 15.33
22. 49.6
23. 96.5
24. 23.9
25. 7.80
26. 6.89
27. 1.671
28. 7.82
29. 2.07
30. 1.691
31. 15.83
32. 143.2

33. 2890
34. 8.07
35. 1.604
36. 7.71
37. 0.318
38. 3.95
39. 0.502
40. 14.25
41. 88.4
42. 8.06
43. 5.77
44. 1029
45. 157.9
46. 644
47. 0.398
48. 0.874
49. 24.9
50. 0.879

Exercise 4-2

1. 1.363
2. 0.1890
3. 3.23
4. 1.495
5. 1.950
6. 4.49
7. 2.32
8. 74.2
9. 42.5
10. 76.0
11. 69.4
12. 9.62
13. 14.67
14. 28.8
15. 171.0
16. 7.45
17. 21.0
18. 2.81
19. 0.222
20. 0.215
21. 7.40
22. 3.58
23. 35.5
24. 0.710
25. 12.88
26. 24.3
27. 362
28. 325
29. 4.88
30. 2.14
31. 6.36
32. 121.7

Exercise 5-1

1. 0.311
2. 0.211
3. 0.1972
4. 0.380
5. 0.1232
6. 0.1070
7. 0.881
8. .0307
9. .001383
10. 3.51
11. 2.42
12. .001575
13. 58.0
14. 289
15. .0216
16. 4030
17. .001203
18. 165.6
19. .01597
20. .00000353
21. 23.1
22. .001190
23. 1.406
24. .000426

Exercise 6-1

1. 0.813
2. 2.04
3. 1.565
4. 0.1979
5. 0.260
6. 1.284
7. 0.296
8. 3.43

9. 8.14
10. 0.555
11. 13.37
12. 2.46
13. 0.267
14. 1.713
15. 0.402
16. 2.23
17. 0.455
18. 0.1394
19. 1.517
20. 62.7
21. 0.557
22. 1.615
23. 11.75
24. 3.87
25. 20.5
26. 404
27. .00435
28. 0.1916
29. 3500
30. 0.772
31. 0.346
32. 121.0
33. .00214
34. 0.536
35. 0.209

Exercise 6-2

1. 50.8
2. 12.96
3. 33.3
4. 26.3
5. 48.4
6. 5.97
7. 3480
8. 25.8
9. 14.69
10. 28.7
11. 56.4
12. 79.5
13. 60.0
14. 48.1
15. 34.9
16. 4.88
17. 1.662
18. 13.88
19. 527
20. 296
21. 0.253
22. 71.5
23. 16.11
24. 159.9
25. 539
26. 24.1
27. 0.639
28. 7330
29. 493
30. 21.3
31. 16.26
32. 104.2
33. 4.52
34. 79.9
35. 2310
36. 66.9
37. .0410
38. 1.998
39. 4.53
40. 29,400

Exercise 6-3

1. 7.89
2. 1.102
3. 15.30
4. 0.950
5. 0.838
6. 0.665
7. 0.766
8. 1.162
9. 0.924
10. 0.888
11. 1.082
12. 93.4
13. 83.1
14. 8.78
15. 16.05
16. 70.6
17. 1.483
18. 67.7
19. 0.638
20. 120.0
21. 8.04
22. 1.323
23. 15.91
24. 2.97
25. 8.03

Exercise 7-1

1. 5.63, 8.48, 17.60, 25.2
2. 1.142, 3.00, 5.93, 9.34, 17.14
3. 1.675, 3.69, 4.69, 6.36, 9.72
4. 0.794, 1.746, 3.46, 9.36, 14.35
5. 3.79, 7.19, 9.49, 14.26, 22.2, 32.0 (meters)
6. 4.55, 14.20, 8.15, 67.3, 76.8, 279
7. 40.4, 86.1, 144.0, 221, 309, 549, 1089 (ohms)
8. 70.4, 159.9, 319, 464, 732, 1188 (lbs)
9. $2.51, $4.51, $18.81, $6.33, $112.20, $58.90
10. 32.5, 63.8, 129.9, 168.2, 260, 710 (lbs)
11. 0.370, 0.629, 0.903, 1.154, 1.702, 3.85 (inches)
12. $0.50, $2.39, $1.13, $7.45, $0.13, $0.36, $4.46
13. $6.07, $86.70, $25.10, $4.31, $9.54, $196.50
14. 222, 542, 711, 1630, 3700 (ft per sec)

Exercise 7-2

1. 6.40, 3.56, 2.13, 1.523, 1.103
2. 34.1, 22.7, 11.36, 9.74, 8.52
3. 196.0, 146.7, 99.5, 56.7, 25.8
4. 34.7, 20.8, 15.29, 8.89, 6.98, 5.47, 3.59, 2.31
5. 5.00, 0.357, .0833, .0287, .00757
6. 63.3, 17.92, 10.92, 3.49, 0.872
7. $90,000, $50,000, $30,000, $18,000, $15,000
8. 1662, 1271, 831, 617, 514 (rpm)
9. 34.4°, 26.54°, 22.88°, 21.108°, 20.24°
10. 21.7, 13.92, 11.12, 4.72, 3.17

Exercise 7-3

1. 17.47	**16.** 4.02	**31.** 1.551	**46.** 16.87
2. 0.659	**17.** 17.86	**32.** 6.34	**47.** 105.5
3. 15.47	**18.** 110.9	**33.** 0.707	**48.** 1355
4. 0.640	**19.** 2.08	**34.** 114.0	**49.** 1.487
5. 14.04	**20.** 175.7	**35.** 9.07	**50.** 29.0
6. 1.785	**21.** 10.23	**36.** 3.08	**51.** 0.731
7. 7.09	**22.** 1054	**37.** .000828	**52.** 138.2
8. 11.58	**23.** 7.95	**38.** .01227	**53.** 0.772
9. 1.650	**24.** 0.888	**39.** .0001442	**54.** .0387
10. 20.2	**25.** 0.351	**40.** .00804	**55.** 0.360
11. 4.42	**26.** 55.7	**41.** 194.2	**56.** 54.6
12. 7.05	**27.** 5.02	**42.** 11.03	**57.** 19.29
13. 10.32	**28.** 3.69	**43.** 11.11	**58.** 3.74
14. 9.76	**29.** 165.8	**44.** 0.898	**59.** 1.641×10^8
15. 5.78	**30.** 9.20	**45.** .00769	**60.** 0.428

Exercise 7-4

1. 8.42, 5.56, 22.1, 1.322, 0.1706, 55.3, 157.7, 3.63

2. 6.50, 4.52, 26.6, 56.9, 0.1329, 774, .00655, 0.347

3. 23.9	**7.** 26.1	**10.** 52.8	**13.** 10.35
4. 11.34	**8.** 37.7	**11.** 6.18	**14.** 7.65
5. 0.615	**9.** 11.34	**12.** 2.28	**15.** 1.304
6. 2.23			

Exercise 7-5

1. 6.37	**3.** 132.5	**5.** 0.0686	**7.** 9190
2. 429	**4.** 60.0	**6.** 50.8	**8.** 1420

9. 11.89

10. 104.6

11. 9.06

12. 545

13. 11.60

14. 107.1

15. 271

16. 556

17. 5.35×10^{-6}

18. 2.74

19. 2.15

20. **a.** 18,000
b. 240

21. **a.** 4685
b. 5020

22. **a.** 7.27
b. 5.20

23. **a.** 5.33
b. 6.08

24. **a.** 151.3
b. 1747

Exercise 8-1

1. $X = 25.5$

2. $X = 5.07$

3. $X = 26.0$

4. $X = 95.8$

5. $X = 0.738$

6. $X = 11.99$

7. $T = 59.6$

8. $T = 81.1$

9. $R = 4.74$

10. $R = 44.0$

11. $I = 337$

12. $I = 3.46$

13. $V = 157.2$

14. $V = 132.3$

15. $P = 0.861$

16. $P = 32{,}500$

17. $X = .0001493$

18. $X = 25.2$

19. $L = 10.00$

20. $L = 8.93$

21. $W = .00583$

22. $W = 106.2$

23. $F = 18.45$

24. $F = 7.84$

25. $X = 1.755$
$Y = 30.8$

26. $X = 89.4$
$Y = 2.59$

27. $X = 3.71$
$Y = 227$

28. $X = 45.8$
$Y = 94.0$

29. $V_1 = 4.22$
$V_2 = 18.89$

30. $x = 0.269$
$y = 13.74$

31. $V_1 = 90.9$
$V_2 = 3.40$

32. $V_1 = 87.0$
$V_2 = 324$

33. $X = 1.139$
$Y = 1.917$
$Z = 23.0$

34. $X = 10.67$
$Y = 9.24$
$Z = 3.31$

35. $X = 284$
$Y = 1.218$
$Z = 204$

36. $R_1 = .01103$
$R_2 = 0.467$
$R_3 = 1.490$

37. $I_1 = 5.74$
$I_2 = 41.3$
$I_3 = 157.7$

38. $T_1 = 42.7$
$T_2 = 178.2$
$T_3 = 9.01$

Exercise 8-2

1. **a.** 3.79, 18.17, 47.4 (liters)
b. 0.264, 5.55, 224 (gals)

2. **a.** 148, 46.5, 6.82 (mph)
b. 70.7, 31.8, 125.6 (ft/sec)

3. **a.** 7.70, 165.8, 275 (lbs)
b. 15.72, 74.5, 2.16 (kg)

4. **a.** 43.0, 12.81, 274 (in.merc.)
b. 0.356, 8.59 (lbs/sq in.)

5. **a.** 153.5, 24.0, 304 (miles)
b. 2.34, 4.30 (inches)

6. **a.** 92.6, 2000, 1360 (km)
b. 281, 8.32 (miles)

7. **a.** 8.34, 145.1, 934 (lbs)
b. 233, 2.71 (gals)

8. **a.** 0.1663, 48.9, 1.340 (hp)
b. 23,600, 390 (watts)

9. a. 54.2, 9.69, 117.1 (sq in.)
b. 955, 60.6 (sq cm)

10. 2.00, 8.01, 1.057 (amps)

11. 61.4, 384, 875 (miles)

12. 5.43, 16.55, 90.5 (gals)

Exercise 9-1

(D scale accuracy)

1. 2.89
2. 31.4
3. 77.4
4. 116.6
5. 54.8
6. 11.56
7. 18.23
8. 6.10
9. 807
10. 27.2
11. 4190
12. 0.1640
13. 175.5
14. .0207
15. 1037
16. 3.76×10^{4}
17. 7.67×10^{8}
18. 2.28×10^{5}
19. 6.15×10^{7}
20. 3.14×10^{9}
21. 2.64×10^{10}
22. 1.640×10^{-5}
23. .00318
24. .00001901
25. 5.11×10^{-8}
26. 1.310×10^{-9}
27. 348
28. 3.18×10^{9}
29. 42,800
30. 2.08×10^{13}

Exercise 9-2

(R scale accuracy)

1. 6.97
2. 2.330
3. 3.557
4. 1.030
5. 7.73
6. 3.286
7. 2.186
8. 19.08
9. 60.3
10. 86.4
11. 31.50
12. 4.433
13. 1.772
14. 165.5
15. 9.21
16. 5.60
17. 0.874
18. 0.644
19. 0.2057
20. .04207
21. .02678
22. 810
23. .00585
24. 0.2832
25. 16.15
26. .03028
27. 2088
28. .01559
29. .00751
30. 1.655×10^{-4}
31. 1435
32. .02450
33. 0.963
34. .0837
35. .0560
36. .01387
37. 6080
38. .0004658
39. 4.101
40. .01453

41. 1649

42. .001476

43. 2.907

44. 0.2697

45. .02857

46. 4.550×10^5

47. 7510

48. 169.4

49. 0.788

50. 763

Exercise 9-3

1. 2.42

2. 3.86

3. 0.604

4. 2950

5. 0.261

6. 0.932

7. .0330

8. 0.791

9. 6.20

10. 0.474

11. 89.0

12. 10.84

13. 764

14. 3.49

15. 0.01071

16. 1.97

17. −0.243

18. 7.48

19. 1.93

20. 17.97

21. **a.** 1.502
b. 1.637
c. 1.483

22. **a.** 95.0
b. 664
c. 411

23. **a.** 1.220
b. 0.422
c. 2.32

24. **a.** 0.319
b. 0.0513
c. 35.4

25. **a.** 6.32
b. 16.37

Exercise 9-4

1. 0.280, −1.78

2. 3, 0.4

3. 2.18, −0.327

4. 0.1090, −0.1715

5. 11.3, − 0.40

6. −0.279, −2.29

7. −0.1069, −0.652

8. 1.65, −23.4

Exercise 10-1

1. 4.10

2. 13.8

3. 275

4. 373

5. 1.86

6. 197

7. 34.0

8. 21.0

9. 520

10. 0.446

11. 0.134

12. 1210

13. 2050

14. 5.47×10^{11}

15. 2.59×10^{13}

16. 4.82×10^{7}

17. 2.46×10^{6}

18. 0.745

19. 2.02×10^{9}

20. 1.01×10^{14}

21. 0.488
22. .00995
23. 6.20×10^{-8}
24. .0660
25. .000266
26. 2.29×10^{-8}
27. 6.08×10^{-7}
28. 5.40×10^{12}
29. 317,000
30. 1.62×10^{-10}

Exercise 10-2

1. 1.951
2. 2.02
3. 2.22
4. 4.58
5. 2.60
6. 4.99
7. 9.05
8. 1.433
9. 6.65
10. 3.86
11. 1.035
12. 2.23
13. 4.81
14. 0.397
15. 0.807
16. 0.970
17. 0.274
18. 0.394
19. 0.436
20. 0.1441
21. 0.1955
22. 15.77
23. 16.73
24. 21.3
25. 12.60
26. 19.70
27. 22.0
28. 28.7
29. 40.1
30. 83.1
31. 59.2
32. 44.4
33. 0.1936
34. .0651
35. .0350
36. 287
37. .01928
38. 565
39. .00888
40. 424
41. .01403
42. .0360
43. 0.384
44. 0.1051
45. 58.0
46. 1080
47. 1608
48. .000752
49. 91,300
50. .000323

Exercise 10-3

1. 9.60
2. 226
3. 66.0
4. 0.735
5. .0152
6. .000641
7. 7250
8. .0000117
9. 122,000
10. 12.9
11. 49.0
12. 1.40
13. 176
14. 0.157
15. .00313
16. 0.297
17. 1.83×10^{-13}
18. 820,000
19. .000341
20. 4.35×10^{14}

Exercise 11-1

(A scale accuracy)

1. 58.5
2. 12.7
3. 300
4. 323
5. 1220
6. 13.8
7. 33.7
8. 6.70
9. 37.1
10. 10.5
11. 8.09
12. 1.67
13. 5.27
14. 1.72
15. 2.73
16. 64.2
17. 12,300
18. 9300
19. 170
20. 385

21. 5.68×10^{5}

22. 5.73

23. 1.20×10^{-12}

24. **a.** 1980 sq in.
b. 106 sq in.
c. 0.446 sq ft
d. 8850 sq ft
e. .000340 sq cm

25. **a.** 5.64 sq in.
b. 2.46 sq in.
c. 17.0 sq ft
d. 39.0 sq ft
e. 169 sq ft

26. 11.4, 25.6, 71.0, 139, 230

27. 36.3, 101, 198, 487

28. 0.296, 1.85, 10.6, 46.3, 266

29. 1.27, 0.486, 0.261, .0925

30. 3.10, 1.67, 1.04, 0.60

31. 37.2, 8.51, 3.20, 1.36

Exercise 11-2

(A scale accuracy)

1. 4.22
2. 7.42
3. 252
4. 23.4
5. 0.115
6. 1.28
7. 101
8. 1.74
9. 3.43
10. 30.5
11. 8.12
12. 67.2
13. 47.0
14. 1.69
15. 2160
16. 125
17. 188
18. 398
19. 76.8
20. 15.3
21. 478
22. 9,460
23. 4.78
24. 318
25. 7.83
26. 24.1
27. 128
28. 0.455
29. 1.58×10^{-4}
30. 66.1
31. 1.61
32. 8.69

33. 68.0

34. 25.1

35. 4.20×10^{5}

36. 2.40×10^{10}

37. 0.475

38. .0311

39. 8.95×10^{-5}

40. 0.430

41. 0.139

42. 4.81×10^{-4}

43. 4590

44. 6.28×10^{7}

Exercise 11-3

1. 920

2. 8370

3. 0.677

4. 14.23

5. 0.698

6. 1.263

7. −43.7

8. 3.10

9. 6.68

10. 2.14

11. 1.13

12. 39.0

13. 171

14. **a.** 293.3
b. 1498.5

15. **a.** 3.44
b. 39.2

16. **a.** .001674
b. .01866

17. **a.** 0.224
b. 0.0475

18. **a.** 0.270
b. 0.315

19. **a.** 0.1427
b. 0.0723

20. **a.** 0.1595
b. 0.253

Exercise 12-1

1. 11.40

2. 2.06

3. 100.2

4. 78.0

5. 1.286

6. 1.492

7. 1.755

8. 2.05

9. 10.15

10. 7.42

11. 6.50

12. 4.50

13. 257

14. 7.00

15. 7.36

16. 3.17

17. 22.1

18. 2.23

19. 10.18

20. 1.220

21. .0912

22. .0456

23. 0.516

24. 3.60

25. 155.0

26. 10.60

27. 2.86

28. 2.33

29. 3.52

30. 368

31. 2.41

32. 31.2

33. 30.2

34. 29.8

35. 11.78

36. 3.38

37. 24.3

38. 2.83

39. 3.93

40. 9.40

41. 0.487

42. 38.7

43. 5.19

44. 12.56

45. 0.726

46. 12.18

47. 0.1342

48. 29.4

49. 13.12

50. 892

51. 0.606

52. .000550

53. 283 **55.** 26.0 **57.** 15.24 **59.** 14.09

54. .0639 **56.** 23.7 **58.** 0.1203

Exercise 12-2

1. 5.11 **20.** 1.376 **39.** 1.640 **57.** 10.89

2. 2.88 **21.** 90.3 **40.** 4.82 **58.** 31.8

3. 3.82 **22.** 75.2 **41.** 84.5 **59.** 12.70

4. 4.59 **23.** 4.97 **42.** 10.48 **60.** 8.63

5. 11.23 **24.** 2.08 **43.** 30.8 **61.** 0.1530

6. 3.15 **25.** 16.91 **44.** 6.86 **62.** 5440

7. 1.838 **26.** 41.9 **45.** 20.9 **63.** 4.40×10^{-6}

8. 2.86 **27.** 45.6 **46.** 0.594 **64.** 8.65

9. 4.56 **28.** 25.4 **47.** 6.47 **65.** 0.1835

10. 0.615 **29.** 7.17 **48.** 282 **66.** 0.1280

11. 6.85 **30.** 45.6 **49.** .0200 **67.** 1.458

12. 11.45 **31.** 2720 **50.** 94.1 **68.** 77.0

13. 35.9 **32.** 89.3 **51.** 13.23 **69.** 0.507

14. 1.775 **33.** 2.15 **52.** 10.87 **70.** 45.4

15. 37.7 **34.** .0942 **53.** 0.496 **71.** 1.810

16. 5.24 **35.** 16.94 **54.** 1265 **72.** 32.5

17. 1.781 **36.** 0.496 **55.** 100.8 **73.** 3.83

18. 14.75 **37.** 131.0 **56.** 0.794 **74.** 1105

19. 28.5 **38.** 1.680

75. 4.41, 6.84, 16.77, 28.0

76. 2.87, 6.40, 11.70, 28.2

77. 0.666, 1.019, 1.276, 2.58

78. 90.6, 22.0, 9.38, 4.84

79. 31.5, 19.41, 9.70, 7.16

80. 19.90, 13.45, 6.30, 3.29

Exercise 12-3

1. 14.60
2. 47.6
3. 1.318
4. 1.005
5. 41.9
6. 24.7
7. 2.59
8. 5.45
9. 1.302
10. 0.765
11. 9.25
12. 2.04
13. 8.11
14. 82.4
15. 1.933
16. 98.5
17. 0.748
18. 40.4
19. 49.3
20. 0.561
21. 29,400
22. 3.39
23. 9.00×10^{-11}
24. 59.1
25. 8.55
26. 0.545
27. 1.153×10^{8}
28. 1.252×10^{-7}
29. 2.53
30. 9.80
31. 3.52
32. 0.898
33. 11.11
34. 20.8
35. 113.5
36. 7.05
37. 22.7
38. 13.20
39. 0.701
40. 5.72

Exercise 12-4

1. 1.93
2. 0.484
3. 8.93
4. 1440
5. 1.126
6. 78.3
7. 12.59
8. 322
9. 31.3
10. 1.458×10^{-7}
11. a. .0480
b. 0.0539
12. a. 0.302
b. 0.546
13. a. 2.30
b. 3.14
14. a. 1.69
b. 2.66
15. a. 143.5
b. 2710
16. a. 1420
b. 256
17. a. 0.380
b. 1.830
18. a. 75.5
b. 2670
19. a. 3.26
b. 17.7
20. a. 675
b. 12,320
21. a. 0.0834
b. 0.0226
22. a. 2.16
b. 6.80
23. a. 12.59
b. 21.6
24. a. 1.798
b. 2.96
25. a. 1.118
b. 1.101

Exercise 13-1

1. .0124 **2.** 1.780 **3.** 0.248 **4.** 2.03 **5.** 97.3 **6.** 2.16

Exercise 13-2

1. 322 **2.** 0.0346 **3.** 0.0604 **4.** 9.70 **5.** 9.95 **6. a.** 7.67, 47.8, 146.0
b. 4.68, 181.5, 1698

Exercise 13-3

1. 376 **2.** 34.8 **3.** 2.07 **4.** 4.62×10^5 **5.** 8.44 **6.** 7.11

Exercise 13-4

1. 57.4 **2.** 25.0 **3.** 14.10 **4.** 46.3 **5.** 0.456 **6.** 24.4

Exercise 13-5

1. $R_1 = 0.01069$ **2.** 5.14 **3.** 2744 **4.** 210 **5.** 0.835 **6.** 4.83, 9.32, 23.0, 38.8
$R_2 = 0.480$

Exercise 13-6

1. 23.6, 62.8, 121.5, 150.8

2. 3.92×10^{-14}

3. 406

4. 1.772×10^{-4}

5. a. 0.881, 2.74, 6.99 (in.)
b. 4.93, 13.81, 35.5 (lbs)

6. 48.6

Exercise 13-7

1. 16.05 **2.** 8.12 **3.** 627 **4.** 3.79×10^{11} **5.** 0.121 **6.** 19.00

Exercise 13-8

1. 45.0 **2.** 128.8 **3.** 2.01×10^{23} **4.** .00363 **5.** 72.2 **6.** 6.95

Exercise 14-1

1. 0.630
2. 0.242
3. 0.930
4. 0.1770
5. 0.715
6. .0401
7. .01990
8. 0.302
9. 0.842
10. 0.990
11. 0.508
12. .0130
13. 0.1333
14. 0.443
15. 0.264
16. .0325
17. .0125
18. 0.576
19. 0.970
20. .0776
21. .0935
22. 0.248
23. 0.1054
24. 0.886
25. 0.213
26. .0206
27. 0.996
28. 0.352
29. .0102
30. 0.665

Exercise 14-2

1. 0.731
2. 0.391
3. 0.927
4. 0.255
5. 0.524
6. 0.791
7. 0.1193
8. 0.961
9. .01745
10. .0454
11. .01326
12. 0.347
13. 0.1485
14. 0.870
15. 0.996
16. 0.675
17. .0436
18. 0.652
19. 0.282
20. 0.853
21. 0.565
22. .01367
23. 0.880
24. 0.734, 0.679
25. 0.297, 0.955
26. 0.948, 0.319
27. 0.611, 0.791
28. 0.826, 0.564

Exercise 14-3

1. 0.650
2. 0.306
3. 1.428
4. 4.70
5. .0349
6. 19.10
7. 0.238
8. 0.770
9. 1.235
10. 2.40
11. .0645
12. .0286
13. 0.255
14. 3.40
15. 1.167
16. 15.49

17. .01483
18. .0741
19. .01454
20. 0.206
21. 5.91
22. 0.762
23. 0.389
24. 1.285
25. .0900
26. 13.50
27. .0464
28. 0.955
29. 9.60
30. 0.1375

Exercise 14-4

1. 0.532
2. 2.25
3. 1.481
4. 1.206
5. 2.56
6. 1.466
7. 0.296
8. 0.670
9. .0454
10. 13.33
11. 0.947
12. 3.36
13. 0.410
14. 0.474
15. 0.1642
16. 1.717
17. 1.564
18. 3.19
19. 3.01
20. 0.1680
21. 1.048
22. .0583
23. 6.77
24. .0305
25. 0.836
26. 0.724
27. 1.163
28. 0.966
29. 0.1485
30. 32.2
31. .0640
32. 0.524
33. 0.499
34. 0.1123
35. .01520
36. 22.9
37. 3.94
38. .0706
39. 4.22
40. 0.875
41. 0.837
42. 1.905
43. 0.982
44. .0733
45. 24.6
46. .01483
47. 1.315
48. 3.33

Exercise 15-1

1. 0.530
2. 0.940
3. −0.407
4. −0.545
5. −0.407
6. −0.445
7. −5.67
8. 2.90
9. −0.695
10. −0.743
11. −0.738
12. 0.844
13. −17.34
14. 0.0611
15. −0.903
16. 2.48
17. 0.891
18. 0.237

Exercise 15-2

1. 18.66°
2. 35.1°
3. 56.5°
4. 17.85°
5. 33.5°
6. 39.2°
7. 25.9°
8. 53.1°
9. 71.4°
10. 2.99°
11. 2.17°
12. 87.42°
13. 27°
14. 2.10°
15. 3.5°
16. 72°
17. 52.5°
18. 75.96°
19. 5.17°
20. 10.6°
21. 48.5°
22. 40.2°
23. 87.5°
24. 85.66°
25. 74.4°
26. 4.20°
27. 202.4°
28. 101.82°
29. 118.3°
30. 137.3°
31. 0.80°
32. 6.29°
33. 163.6°
34. 161.5°
35. 87.93°
36. 88.91°
37. 71.3°
38. 1.11°
39. 4.21°
40. 61.6°
41. 174.78°
42. 84.29°
43. 33.7°
44. 1.58°
45. 88.4°
46. 89.12°
47. 194.2°
48. 47.4°
49. 70.6°
50. 86.29°
51. 48.6°
52. 19.45°

Exercise 15-3

1. 9.20
2. 35.2
3. 3.74
4. 73.5
5. 56.9
6. 4.48
7. 2.55
8. 558
293
9. 4.82
11.70
10. 1617
7320
11. 208
274
12. 91.9
−69.2
13. −4.24
−8.61
14. 150.1
454
15. 52.1
16. 315
17. 77.9
18. 69.8
19. 544
20. 92.0
21. 4560
22. 4.90
23. 213
24. 19.74
25. 3310
26. 29.1
27. 1442
28. 5.54
29. 129.0
30. 313
31. 1.918
32. 1.198
33. 1.356
34. 44.9
35. 13.54
36. 42.1

37. −38.5 **38.** 6.53 **39.** 421 **40.** 13.75

Exercise 15-4

1. a. 0.559 **b.** 1.193 **c.** 0.1190 **d.** 2.54 **e.** 3.89

2. a. 0.0636 **b.** 0.0785 **c.** 0.0321 **d.** .0131 **e.** 0.0482

3. a. 133.5° **b.** 43.5° **c.** 61.8° **d.** 300° **e.** 12.3°

4. a. 3.55° **b.** 1.97° **c.** 1.002° **d.** 3.15° **e.** 4.38°

5. 0.868

6. 0.745

7. 0.977

8. 0.430

9. 0.783

10. 0.377

11. −0.276

12. 0.952

13. 0.1770

14. −0.755

15. −0.660

16. −0.972

Exercise 15-5

1. 17.7

2. 1.565

3. 8.02

4. 29.1

5. 2.50

6. 1.844

7. 0.481

8. 7.59

9. 13.64

10. 43.3

11. 11.35°

12. 81.05°

13. 47.4°

14. a. 392
b. 5540

15. a. 19,500
b. 8860

16. a. 16°
b. 21.7°

17. a. 1.375
b. 1.535

18. a. 693
b. 177.8

19. a. 213
b. 1480

20. a. 4.22
b. 25.5

21. a. 413
b. 3390

22. a. 70.8°
b. 65.0°

23. a. 0.651
b. 0.650

24. a. 39.64°
b. 40.58°

25. a. 4.53
b. 27.2

26. a. 8.68
b. 23.0

27. a. 176
b. 49.6

28. a. 76.9
b. 17.5

29. a. 630
b. 2610

30. a. 67.4°
b. 91.4°

31. a. 0.788
b. 0.898

Exercise 16-1

1. $B = 64°$, $a = 32.0$, $b = 65.6$

2. $B = 33.8°$, $a = 262$, $b = 175$

3. $A = 42.3°$, $B = 47.7°$, $b = 38.5$

4. $A = 48.8°$, $B = 41.2°$, $a = 165.5$

5. $A = 31.4°$, $B = 58.6°$, $c = 69.1$

6. $A = 61.05°$, $B = 28.95°$, $c = 1715$

7. $A = 41.6°$, $a = 282$, $b = 318$

8. $A = 42.3°$, $B = 47.7°$, $b = 6.95$

Exercise 16-2

1. $B = 65°$, $b = 68.7$, $c = 75.8$

2. $B = 37°$, $a = 35.2$, $b = 26.5$

3. $A = 55°$, $b = 4.41$, $c = 7.69$

4. $A = 29°$, $a = 8.65$, $c = 17.83$

5. $B = 42.7°$, $a = 347$, $c = 472$

6. $A = 38.4°$, $B = 51.6°$, $b = 29.0$

7. $A = 37.9°$, $B = 52.1°$, $b = 65.5$

8. $A = 72.55°$, $B = 17.45°$, $a = 2670$

9. $A = 72.5°$, $a = 4.04$, $b = 1.275$

10. $A = 3.61°$, $B = 86.39°$, $b = 57.9$

11. $B = 85.8°$, $b = 75.5$, $c = 75.8$

12. $A = 76.4°$, $a = 3890$, $b = 940$

13. $A = 27.8°$, $B = 62.2°$, $b = 3230$

14. $A = 3.8°$, $b = 52.0$, $c = 52.1$

15. $A = 58.6°$, $a = 11.09$, $c = 12.99$

16. $A = 4.38°$, $B = 85.62°$, $b = 159.5$

17. $A = 84.9°$, $a = 20.7$, $c = 20.8$

18. $A = 47.3°$, $B = 42.7°$, $a = 6060$

19. $B = 74.7°$, $a = 96.6$, $b = 353$

20. $B = 19°$, $a = 62.7$, $c = 66.3$

Exercise 16-3

1. $A = 35.2°$, $B = 54.8°$, $c = 20.8$

2. $A = 59.3°$, $B = 30.7°$, $c = 31.4$

3. $A = 21.3°$, $B = 68.7°$, $c = 44.1$

4. $A = 31.0°$, $B = 59.0°$, $c = 1455$

5. $A = 58.6°$, $B = 31.4°$, $c = 11.13$

6. $A = 85.08°$, $B = 4.92°$, $c = 35.1$

7. $A = 57.1°$, $B = 32.9°$, $c = 7.74$

8. $A = 33.9°$, $B = 56.1°$, $c = 22.4$

9. $A = 52.7°$, $B = 37.3°$, $c = 289$

10. $A = 5.04°$, $B = 84.96°$, $c = 41.1$

11. $A = 41.0°$, $B = 49.0°$, $c = 16.37$

12. $A = 3.28°$, $B = 86.72°$, $c = 5.07$

13. $A = 47.6°$, $B = 42.4°$, $c = 861$

14. $A = 25.1°$, $B = 64.9°$, $c = 3420$

15. $A = 3.44°$, $B = 86.56°$, $c = 421$

16. $A = 70.5°$, $B = 19.5°$, $c = .0796$

17. $A = 22°$, $B = 68°$, $c = 121.5$

18. $A = 47.1°$, $B = 42.9°$, $c = 38{,}900$

Exercise 16-4

1. a. $45 + 28.1j$
b. $19.01 + 28.2j$
c. $172.1 + 52.6j$
d. $178 + 440j$
e. $9.41 + 4.88j$
f. $669 + 42.1j$
g. $-2.99 + 3.09j$
h. $-82.9 + 43.1j$
i. $-858 - 623j$
j. $25.8 - 28.2j$

2. a. $7.61\angle 66.8°$
b. $56\angle 68°$
c. $16.75\angle 17.35°$
d. $6.06\angle 22.3°$
e. $779\angle 74.35°$
f. $366\angle 3.61°$
g. $27.3\angle 171.57°$
h. $7.75\angle 234°$
i. $0.85\angle 195°$
j. $3480\angle 348.04°$

3. a. $4.51 + 6.21j$
b. $8.55 + 16.09j$
c. $14.81 + 24.0j$
d. $34.7 + 14.5j$
e. $-51.1 + 70.3j$
f. $-259 - 711j$

4. a. $4.54 + 3.81j$
b. $1.575 + 3.23j$
c. $0.1535 + 0.329j$
d. $-0.655 + 0.305j$
e. $-4.95 - 6.34j$
f. $5.49 - 4.74j$

Exercise 17-1

1. $C = 66°$, $b = 34.2$, $c = 42.0$

2. $A = 80°$, $a = 42.5$, $c = 38.5$

3. $B = 43.0°$, $C = 70.0°$, $c = 6.33$

4. $B = 112.9°$, $C = 26.1°$, $b = 119.4$

5. $A = 44.68°$, $C = 10.32°$, $a = 13.75$

6. $B = 39°$, $a = 21.8$, $c = 6.99$

7. $C = 43°$, $a = 14.71$, $b = 13.46$

8. $A = 112°$, $b = 6.20$, $c = 0.581$

9. $A = 31.5°$, $B = 76.5°$, $b = 32.0$

10. $A = 104.7°$, $c = 29.3°$, $a = 10.3$

11. $C = 43°15'$, $a = 8.36$, $c = 5.81$

12. $B = 127°10'$, $b = 476$, $c = 372$

13. $A = 19.8°$, $B = 6.2°$, $b = 6.75$

14. $B = 118°20'$, $a = 8.26$, $b = 119$

15. $B = 14.88°$, $C = 123.12°$, $c = 91.4$

16. $A = 153.37°$, $B = 4.23°$, $a = 16.10$

17. $C = 65.4°$, $b = 15.08$, $c = 20.6$

18. $B = 72.65°$, $C = 7.35°$, $b = 12.30$

19. No solution

20. $A = 17°15'$, $b = 545$, $c = 693$

Exercise 17-2

1. $B = 30.4°$, $C = 123.6°$, $c = 8.55$
$B' = 149.6°$, $C' = 4.4°$, $c' = 0.788$

2. $B = 47.8°$, $C = 95.2°$, $c = 21.5$
$B' = 132.2°$, $C' = 10.8°$, $c' = 4.05$

3. $B = 53.6°$, $C = 85.4°$, $c = 33.4$
$B' = 126.4°$, $C' = 12.6°$, $c' = 7.31$

4. $A = 151.6°$, $C = 20°$, $a = 8.66$
$A' = 11.6°$, $C' = 160°$, $a' = 3.66$

5. $B = 84.6°, C = 52.4°, b = 70.4$
$B' = 9.4°, C' = 127.6°, b' = 11.54$

6. $A = 25.5°, B = 149.2°, b = 14.62$
$A' = 154.5°, B' = 20.2°, b' = 9.87$

7. $A = 142.7°, C = 22.7°, a = 20.8$
$A' = 8.1°, C' = 157.3°, a' = 4.84$

8. $A = 80.4°, C = 77.0°, a = 1.670$
$A' = 54.4°, C' = 103°, a' = 1.376$

Exercise 17-3

1. $A = 45°, B = 97°, c = 4.35$

2. $B = 44.7°, C = 86.3°, a = 12.86$

3. $A = 32.1°, B = 45.1°, C = 102.8°$

4. $A = 55.0°, B = 62.5°, C = 62.5°$

5. $A = 21°, C = 41°, b = 14.8$

6. $A = 26.1°, B = 41.4°, c = 21.0$

7. $A = 34.8°, B = 14.7°, C = 130.5°$

8. $A = 40.1°, B = 44.6°, C = 95.3°$

9. $A = 22.1°, C = 140.7°, b = 17.0$

10. $A = 16.8°, C = 38.6°, b = 18.67$

11. $A = 39.8°, B = 32°, C = 108.2°$

12. $A = 15.6°, B = 62°, C = 102.4°$

13. $A = 52.6°, C = 22.8°, b = 9.07$

14. $B = 160.6°, C = 14.4°, a = 21.0$

15. $A = 48.5°, B = 58.9°, C = 72.6°$

16. $A = 19.2°, B = 21.1°, C = 139.7°$

Exercise 18-1

1. 2.538

2. 2.033

3. 1.064

4. $8.799 - 10$

5. $7.736 - 10$

6. 5.628

7. 3.316

8. $9.505 - 10$

9. $6.267 - 10$

10. 7.626

11. 12.307

12. $1.248 - 10$

13. $9.802 - 30$

14. 1.439

15. -2.757

16. 1.199

17. -1.370

18. 292

19. 0.1014

20. .0545

21. 0.840

22. 1052

23. 2.07

24. .0541

25. .00197

26. 1.19×10^{15}

27. 1.92×10^{-13}

28. .0366

29. 6.68×10^{9}

30. 4.93×10^{-12}

Exercise 18-2

1. 7.61

2. 4.87

3. 2.33

4. -12.7

5. -39.9

6. 0.920

7. -0.1017

8. 7.93

9. 0.1102

10. 684

11. 1.830×10^{-9}

12. 3.963

13. 9.247

14. 8.969

15. 9.46×10^{-8}

16. 5.19×10^{-13}

17. 2.36×10^{-9}

18. **a.** 12.37
b. 16.87

19. **a.** 0.523
b. 0.239

20. **a.** 1620
b. 1738

21. **a.** 1.88×10^{-7}
b. 4.59×10^{-8}

22. **a.** 1.77×10^{6}
b. 1.97×10^{-8}

23. **a.** 200
b. 71.9

24. **a.** 0.570
b. 0.737

25. **a.** 2.49
b. 1.13

26. **a.** 63.8°
b. 135.8°

Exercise 19-1

1. 4.71

2. 1.1678

3. 1.01562

4. 18.2

5. 1.0294

6. 270

7. 2.293

8. 1.323

9. 1.0434

10. 1.0920

11. 2.930

12. 1.878

13. 7.77

14. 1.122

15. 1.0264

16. 1370

17. 1.448

18. 12,000

19. 1.0129

20. 3.47

21. 106

22. 168

23. 4380

24. 4.10

25. 47.3

26. 0.656

27. 1.151

28. 6.05

29. 31.4

30. 3.08

Exercise 19-2

1. .0706

2. 0.767

3. 0.9380

4. .00166

5. .0247

6. 0.357

7. 0.9656

8. .00315

9. 0.9296

10. 0.9008

11. 0.9853

12. .000083

13. .0078

14. 0.468

15. 0.9361

16. 0.9048

17. .040

18. 0.756

19. 0.889

20. 0.257

21. 3.74

22. 8.11

23. 1.418

24. 536

25. 14.8

26. .00377

27. 0.483

28. 0.186

29. 0.254

30. 0.495

Exercise 19-3

1. 1.0034 (approx.)

2. 0.99939 (approx.)

3. 1.0072 (approx.)

4. 0.9986 (approx.)

5. 0.99963 (approx.)

6. 1.000021 (approx.)

7. 440,000 (approx.)

8. 2.65×10^{10} (approx.)

9. .0038 (approx.)

10. 2.9 (approx.)

Exercise 19-4

1. 168

2. 1.1175

3. 27.9

4. 0.9603

5. 0.651

6. 1.0253

7. 1.0378

8. 1.0699

9. 1.284

10. 0.8465

11. 0.9552

12. 1.0144

13. 1.741

14. .0535

15. 1.802

16. 2.195

17. .0090

18. 0.9277

19. 1.063

20. .0135

21. 3.32

22. 39.4

23. 0.370

24. 1.185

25. .0727

26. 0.9661, 0.9333, .0563

27. 2.99, 55, 3100

28. 181, 3.26, 1.0557

29. 93.1, 2.12, 0.171

30. 281,000, 1810, 1285

Exercise 19-5

1. 0.499

2. 1.89

3. 1.295

4. 0.892

5. −0.263

6. 1.0041

7. −0.572

8. 0.868

9. 1.140

10. 0.202

11. 1.75

12. 0.667

13. 8.75, 10.2, 15.1, 43.4

14. **a.** 0 ft/sec, 636 ft/sec
b. 735 ft/sec

Exercise 19-6

1. 5.93
2. 0.207
3. −1.743
4. 1.047
5. −.0971
6. 2.13
7. −7.32
8. 5.10
9. .0163
10. 7.82
11. −5.68
12. 3.60
13. .01237
14. 9.71
15. −0.962
16. 1.019
17. −8.65
18. .01025
19. −0.975
20. 9.03
21. 2.71
22. −2.72
23. 5.35
24. 6.30
25. 1.878
26. .0087
27. 0.9213
28. 1340
29. 1.0278
30. 0.631

Exercise 19-7

1. 2.06
2. 0.372
3. 0.237
4. −.0631
5. −1.201
6. 3.21
7. −0.170
8. 2.46
9. .0980
10. 0.306
11. −0.920
12. −72.9
13. .0343
14. 0.331
15. −.0500
16. −1.441

Exercise 20-1

1. 42.3
2. 16.6
3. 3500
4. 1.494
5. 26.9
6. 1.240
7. .00195
8. .0309
9. 0.9374
10. 0.757
11. 410
12. 389
13. 1.482
14. 0.422
15. .0955
16. 1.628
17. 1.980
4.04
9.63
18. 1.0844
1.181
1.568
19. 0.34
0.151
.091
20. 0.9213
0.870
0.726
21. 1.477
22. 2.00
23. 3100
24. 1.1045
25. .000263
26. 11.7
27. 18,200
28. 1.0736
29. 0.347
30. .000079
31. 0.844
32. 6.75

33. .00094
34. 2.89
35. 7.10
36. .000094
37. 0.393
38. 0.647
39. 340
40. 0.9539
41. .0728
42. .00225
43. 1340
44. 1.352
45. 0.9005
46. 1.1078
47. 0.448
48. 10.03
49. .0164
50. 198

Exercise 20-2

1. 330
2. 2.213
3. 1.368
4. 1.754
5. 0.875
6. 0.97395
7. 235
8. 1.600
9. 0.9514
10. 0.832
11. 1.332
12. 1.429
13. 1.0923
14. 238
15. 97
16. 0.9769
17. .0066
18. 10.7
19. 0.98872
20. 1.0458
21. 3.06
22. 1.0299
23. 1.018
24. 0.266
25. 1.0215
26. .00465
27. 1.0991
28. .00045
29. 0.579
30. .0174
31. 1420
32. .0392
33. 1.437
34. 0.98528
35. 310
36. 1.01814
37. .0365
38. 1.0328
39. 9000
40. 1.303
41. .00009
42. 0.640
43. 9400
44. 964
45. 1309
46. 170,400
47. 0.9597
48. 63
49. 0.504
50. 1.608

Exercise 20-3

1. .00077
2. .0041
3. .0585
4. 0.661
5. 2.37
6. 12.85
7. 2.138
8. 0.619
9. 1.431
10. 1.0565
11. 0.159
12. 2.41
13. 0.8142
14. 1.1218
15. 0.363
16. 0.588

17. 1.837
18. 0.9414
19. 10.25
20. 1.01236
21. 1.462
22. 73
23. 2.76
24. 3250
25. 840
26. 12,150
27. 7550
28. 0.787
29. 435
30. 1.32

Exercise 20-4

1. 3.17
2.00
1.47
1.26
2. 6.50
3. 1.777
4. 0.333
5. 1.264
6. 6.85
7. 0.680
8. 2.23
9. 1.1001
10. 0.8989
11. 0.9273
12. 1.047
13. 3.30
14. 1.0269
15. .0177
16. 3.60
17. 1.394
18. 2.915
19. 0.0315
20. 0.9734
21. 1.373
22. 0.335
23. 1.414
24. 1.273
25. 214
26. 0.98358
27. 0.729
28. 1.696
29. 4.15
30. 0.836
31. 0.828
32. 1.0945
33. 1.262
34. 128
35. 0.7585
36. 1.025
37. 18.45
38. 451

Exercise 20-5

1. 24.5
2. 4.42
3. 1.480
4. 0.359
5. 0.8534
6. 1.113
7. 1.0223
8. 1.914
9. 6900
10. 0.1142
11. 0.9652
12. 700
13. 3.68
14. 0.5415
15. 0.8376
16. 0.787
17. 1.655
18. .0152
19. 0.9665
20. 1.597
21. 3.95
22. 0.0297
23. 81
24. 1.1081
25. 1.678
26. 0.163
27. 1.159
28. 0.8021
29. .02179
30. 1.375
31. 0.1835
32. .000125

33. 1.838
34. 804
35. 415
36. 177
37. 1.87
38. 9.51
39. 1.0116
1.1485
5.65
5750

Exercise 21-1

1. 2.73
2. 2.40
3. 1.92
4. 2.45
5. 0.605
6. 25.3
7. 179.2
8. 3.40
9. 6.31
10. 0.236
11. −.0286
12. −7.07
13. 0.1270
14. 2.41
15. −1.70
16. −0.278
17. 0.322
18. 2.67
19. −0.159
20. 7.40
21. 0.241
22. −0.437
23. 0.216
24. −.0283
25. 7.18
26. .01660
27. 0.576
28. 2.24
29. −0.244
30. 0.265
31. 256
32. .0698
33. 7.41
34. 13.48
35. .0286
36. 3.13
37. −36.8
38. 2.60
39. −0.348
40. .00192

Exercise 21-2

1. 2.81
2. 2.09
3. 1.710
4. 0.368
5. 5.04
6. 0.348
7. .0625
8. −.00700
9. −.01220
10. .00712
11. .00961
12. −0.413
13. 1.379
14. 2.36
15. −0.1298
16. .0797
17. .01886
18. 2.35
19. 3.46
20. −.0648
21. 4.04
22. −0.306
23. −.0632
24. −2.91

Exercise 21-3

1. 0.612
2. 9.90
3. .0983
4. 245
5. 4.88
6. −0.735
7. 2.91
8. 44.6

9. 0.401

10. 1.705

11. 57.6

12. 302

13. 0.1268

14. 0.462

15. 131

16. 105.5

17. 8.94

18. 28.1

19. 1.130

20. 21.3

21. 14.81

22. −8.92

23. −26.4

24. 0.1277

25. 0.291

26. 0.440

27. 0.219

28. .01705

29. 8.20

30. 6.64

31. 0.271

32. .00545

33. 343

34. 112

35. 371

36. 0.749

37. .00275

38. 6.81

39. 1.17

40. −6.25

41. 1.714
−0.799

42. 0.795
−0.794

43. 0.863
0.259

44. 1.386
0.405

Exercise 21-4

Some deviation in these answers is to be expected—especially when intermediate steps involve readings on the less accurate portions of the LL scale.

1. 5.80

2. .0728

3. 0.264

4. 3250

5. 9.42×10^{-6}

6. -1.46×10^{7}

7. 1.047×10^{-6}

8. 0.692

9. 0.377

10. 3040

11. 375

12. 0.286

13. 0.140

14. 55.3

15. 10,660

16. 5.19×10^{6}

17. 87,100

18. 1.54

19. 1.054×10^{-16}

20. 50.7

21. **a.** 36
b. 63.6

22. **a.** 675
b. 26

23. **a.** 1.53
b. −0.1755

24. **a.** 0.387
b. 0.352
c. 0.242
d. .01755

25. **a.** .0387
b. .00205
c. 4.52×10^{-7}

26. **a.** 3.10
b. 10.50

27. **a.** 11,540
b. 2710

28. **a.** 65.0
b. 131.7

29. **a.** 2.18×10^{-6}
b. .090

30. **a.** 4500
b. 3270

31. **a.** 9,110
b. 886

32. **a.** 41
b. 119

33. **a.** 152
b. 3.0
c. 8.8
d. 6.2

34. **a.** 1.25
b. 1.52

35. **a.** .0352
b. 1,225,000

36. **a.** 0.11
b. 7.1

37. **a.** 0.121
b. 0.188
c. 0.221
d. .0985

38. **a.** .0394
b. .0478
c. 57
d. 62

39. **a.** 1060
b. 3350
c. 27
d. 20

40. **a.** 28
b. 44

41. **a.** 2113
b. 11,060

42. **a.** 339
b. 384
c. 1.25
d. 1.465

43. **a.** 2.77
b. 4.16

44. **a.** 1334
b. 7070

45. **a.** 13,890
b. 20,000

46. **a.** 1.199
b. 1.299

Exercise 22-1

1. 0.602

2. .0611

3. 1.091

4. 1.582

5. 1.1435

6. 0.9277

7. 7.05

8. 0.169

Exercise 22-2

1. $B = 43.8°$
$a = 386$
$c = 535$

2. 3.27

3. 72

4. 3.84

5. 2720

6. 2530

7. 14.10

8. 0.673

Exercise 22-3

1. 150

2. .0136

3. .038

4. .0602

5. 0.493

6. 40.1°

7. 0.231

8. $B = 109.8°$
$C = 27.?°$
$b = 113$

Exercise 22-4

1. 1.02205

2. 0.954

3. 51.3°

4. 0.696

5. 4.752

6. −1.181

7. $13.41 + 19.90j$

8. 1.890

Exercise 22-5

1. 1.367

2. 0.1373

3. 0.516

4. 4.31

5. 561

6. 0.628
1.331
3.73

7. .01327

8. 66.6

Exercise 22-6

1. 4.33

2. .0090

3. $17.5\angle 23.6°$

4. −1.545

5. 0.8207

6. 1.430

7. 2.04°

8. .0388

Exercise 22-7

1. .0286

2. 4.44

3. $B = 43°$
$a = 25.5$
$c = 6.93$

4. 1.037

5. 2.31

6. 80.0

7. 0.298

8. −0.594

Exercise 22-8

1. $A = 65.2°$
$B = 24.8°$
$c = 159.7$

2. 0.778

3. 1.01073

4. 336

5. 436

6. 0.198

7. 16.38

8. 73.6

Exercise A-1

1. .00454

2. .001345

3. .000253

4. .001485

5. 191

6. 212

7. .00802

8. 441

9. 11.17

10. 0.168

11. .00611
.00124
.00323
.0000393

12. .001687

13. .00356

14. .0001698

15. .000710

16. .0000655

17. 153

18. 306

19. 6250

20. 232

21. 6060

22. .0125
.0001260
.00252
.0000557

23. 133.7

24. 110.7

Exercise B-1

The following answers were obtained on a slide rule having 8 LL scales. They are more accurate than the approximate results obtained with 6 LL scales.

1. 1.497×10^{6}
2. 1.627×10^{5}
3. 3.060×10^{-7}
4. 6.918×10^{6}
5. 9.539×10^{26}
6. 1.941×10^{-26}
7. 8.040×10^{6}
8. 1.269×10^{5}
9. 1.327×10^{34}
10. 7.696×10^{23}
11. 6.617×10^{-7}
12. 1.688×10^{43}
13. 8.560×10^{-17}
14. 1.001×10^{5}
15. 9.027×10^{24}
16. 1.845×10^{-15}
17. 6.369×10^{-20}
18. 6.964×10^{25}
19. 8.858×10^{21}
20. 1.033×10^{21}

Exercise B-2

The following answers were obtained on a slide rule having 8 LL scales. They are more accurate than the approximate results obtained with 6 LL scales.

1. 1.0021
2. 0.9980
3. 1.1593
4. 1.0920
5. 1.855
6. 1.398
7. 1.1410
8. 1.1730
9. 0.8590
10. 0.406
11. 0.740
12. 0.411
13. 0.622
14. 1.000425
15. 1.000201
16. 0.999585
17. 0.999785
18. 0.999630
19. 0.999697
20. 1.000555

Exercise B-3

1. 1.504
2. 1.00582
3. 1.904
4. 1.0000624
5. 0.9717
6. 0.706
7. 0.99523
8. 0.9999592
9. 0.508
10. 2.045

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