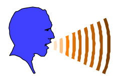
Chapter 3

LOGARITHMS
AND ANTILOGARITHMS



THE CONCEPT OF LOGARITHMS AND ANTILOGARITHMS

- Sample problems
  - $\text{Antilog}_2\ 2 = ?$
  - $\text{Antilog}_2\ 3 = ?$
  - $\text{Antilog}_{10}\ 2 = ?$
  - $\text{Antilog}_{10}\ 3 = ?$
  - $2^2 = ?$ $2^3 = ?$
  - $10^2 = ?$ $10^3 = ?$

Sample Problems

- Equivalent problems
  - $\text{Antilog}_2\ 2 = 2^2 = 2 \times 2 = 4$
  - $\text{Antilog}_2\ 3 = 2^3 = 2 \times 2 \times 2 = 8$
  - $\text{Antilog}_{10}\ 2 = 10^2 = 10 \times 10 = 100$
  - $\text{Antilog}_{10}\ 3 = 10^3 = 10 \times 10 \times 10 = 1{,}000$
- Thus, $\text{antilog}_x\ n = x^n$

Sample Problems

- $\text{Antilog}_{10}\ 1.7 = ?$
  - Same concept
  - $10^{1.7} = ?$
  - Simply need to learn computational procedure

SCALES OF MEASUREMENT

- Distinction between numerals and numbers
- Numerals
  - Symbols that label
  - e.g., X, II, IX, 6, 9, etc.
  - 6 and 9, as <u>numerals</u>, <u>cannot</u> be added or subtracted

SCALES OF MEASUREMENT

- Numbers
  - Symbols with fixed relation to other symbols
  - 6 and 9, as <u>numbers</u>, <u>can</u> be added or subtracted

Four Scales of Measurement

- Nominal
- Ordinal
- Interval
- Ratio

(1) Nominal Scale

- Objects are the same or different
- The letter A is different from the letter B
- The numeral 1 is different from the numeral 0
- Can sort into categories: Count the number of entries

(2) Ordinal Scale

- Two things are the same or different, and
- One object has more or less of some quantity (or the same as) than another
- Thus:
  - A > B > C > D > F
  - F < D < C < B < A
  - 4 > 3 > 2 > 1 > 0

Ordinal Scale

- Letters are not numbers: Cannot be added
- Numerals are not numbers either: Cannot be added

Ordinal Scale

- Even if letters are replaced by numerals:
  - A = 4, B = 3, C = 2, D = 1, F = 0
  - The numerals still cannot be added

Example

- Four men want to play a “competitive” golf match of doubles: Boomer (B), Draw (D), Slice (S), and Rake (R)
- Use driving range to establish rank order
  - B > D > S > R
- Assign numerals
  - B = 4, D = 3, S = 2, R = 1
  - 4 + 1 = 5; 3 + 2 = 5; So
  - B + R vs. D + S
  - D + S defeat B + R handily

Example

- What is the fallacy?
  - Numerals were treated as numbers
  - B, D, and S were players of tournament quality
  - Rake tended the sand traps; had never swung a club before
- The size of the interval between adjacent <u>numerals</u> was not known and was not a constant

(3) Interval (Linear) Scale

- Size of interval between adjacent <u>numbers</u> is known and is a constant
- Size of interval is called the BASE
- Successive units formed by adding (or subtracting) base to each number

Interval Scale

- Because BASE is known, we can say that one object is <u>a certain number of intervals more or less than another</u>
  - Base = 1
    5 is 1 interval > 4
  - Base = 2
    6 is 1 interval < 8
  - Base = 10
    20 is 3 intervals < 50

Table 3-1. Examples of Interval Scales

Base	Scale	Interval Size
1	1, 2, 3, 4, 5, 6, …, n	1
1	0, 1, 2, 3, 4, 5, …, n	1
2	0, 2, 4, 6, 8, 10, …, n	2
2	10, 8, 6, 4, 2, 0, …, n	2
10	10, 20, 30, 40, 50, 60, …, n	10

(4) Ratio (Exponential, or Logarithmic) Scale

- One unit on scale is so many <u>times</u> greater or less than another
- Successive units formed by multiplying (or dividing) each number by the BASE
- Successive units differ by a <u>constant ratio</u>, which is the BASE

Table 3-2. Examples of Ratio Scales

Base	Scale
1	1, 1, 1, 1, 1, ..., 1
2	1, 2, 4, 8, 16, 32, 64, ...…., n
1.5	1, 1.5, 2.25, 3.375, 5.0625, ..., n
10	1, 10, 100, 1,000, 10,000, ..., n
0.1	1, .1, .01, .001, .0001, ..., n

Ratio Scale

- Thus,
  - Base = 2: 8 ÷ 4 = 2; 16 ÷ 8 = 2; etc.
  - Base = 10: 100 ÷ 10 = 10; 1,000 ÷ 100 = 10; etc.
  - Base = 1.5: 2.25 ÷ 1.5 = 1.5; 3.575 ÷ 2.25 = 1.5; etc.
  - Base = .1: .01 ÷ .1 = .1; .001 ÷ .01 = .1; etc.
- If scale values are: 1, 3, 9, 27, and 81,
  What is the base?
  - ☑ 9 ÷ 3 = 3; 27 ÷ 9 = 3; 81 ÷ 27 = 3
  - ☑ Base = 3

Ratio Scale

- Why can a ratio scale be called an exponential scale?
- The scale of numbers can be represented as <u>the BASE raised to some power</u>, <u>or exponent</u>

Examples

- Base = 2
  - $2^0 = 1$
  - $2^1 = 2$
  - $2^2 = 4$
  - $2^3 = 8$
  - $2^4 = 16$

Ratio Scale

- The numbers on the scale differ by a constant ratio, and
- They can be expressed as the base, 2 in this case, raised to progressively higher powers
  - $2^0; 2^1; 2^2; 2^3; 2^4$

Ratio Scale

- Write a parallel scale where base = 3
  - ☑ $3^0 = 1$
  - ☑ $3^1 = 3$
  - ☑ $3^2 = 9$
  - ☑ $3^3 = 27$
  - ☑ $3^4 = 81$

Ratio Scale

- Defining equation for exponential series:
  - $x^n = \#$
- That means the BASE x is to be used n times in multiplication

Table 3-3. Base = 2 raised to powers of 3, 4, and 5

X^n	Operation	Result
2^3	$2 \times 2 \times 2$	8
2^4	$2 \times 2 \times 2 \times 2$	16
2^5	$2 \times 2 \times 2 \times 2 \times 2$	32

Ratio Scale

Table 3-4. Exponential series for base = 2 and base = 10

Base = 2		Base = 10	
X^n	Result	X^n	Result
2^0	1	10^0	1
2^1	2	10^1	10
2^2	4	10^2	100
2^3	8	10^3	1,000
2^4	16	10^4	10,000
2^5	32	10^5	100,000

- With either base, 2 or 10, successive entries on the scale that results differ by a constant ratio

Two Important Facts

- Any BASE raised to the zero power (X^0) equals 1
  - $X^0 = 1$
  - Thus, $2^0 = 1$, $10^0 = 1$, $3^0 = 1$, etc
- Any BASE raised to the first power (X^1) equals the BASE
  - $X^1 = X$
  - Thus, $2^1 = 2$, $10^1 = 10$, $3^1 = 3$, etc

MORE ON EXPONENTS

- Exponents specify how many times the BASE x is used in multiplication or division
- Multiplication
  - $x^n = \#$
    - >> $5^4 = 5 \times 5 \times 5 \times 5 = 625$
    - >> $5^5 = 5 \times 5 \times 5 \times 5 \times 5 = 3125$
    - >> $2^4 = ?$
      - ☑ $= 2 \times 2 \times 2 \times 2 = 16$

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MORE ON EXPONENTS

- Division
  - $x^{-n} = \#$
  - $x^{-n} = 1/x^n$
    - >> $2^{-2} = 1/2^2 = 1/4$
    - >> $10^{-4} = ?$
      - ☑ $1/10^4 = 1/(10 \times 10 \times 10 \times 10) = 1/10{,}000 = .0001$

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Three Facts Restated

- $x^0 = 1$
- $x^1 = x$
- $x^{-n} = 1/x^n$
  - $5^{-4} = ?$
    - ☑ $1/(5 \times 5 \times 5 \times 5) = 1/625$

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Sample Problems

- $2^6 = ?$
  - ☑ $2^6 = 2 \times 2 \times 2 \times 2 \times 2 \times 2 = 64$
  - ☑ Base of 2 used 6 times in multiplication
- $10^6 = ?$
  - ☑ $10^6 = 10 \times 10 \times 10 \times 10 \times 10 \times 10 = 1{,}000{,}000$
  - ☑ Base of 10 used 6 times in multiplication
- $2^{-6} = ?$
  - ☑ $2^{-6} = 1/\ 2^6 = 1/\ 64 = .015625$

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Sample Problems

- $10^{-6} = ?$
  - ☑ $10^{-6} = 1/10^6 = 1/1{,}000{,}000 = .000001$
- $7.16^1 = ?$
  - ☑ $7.16^1 = 7.16$
- $7.16^0 = ?$
  - ☑ $7.16^0 = 1$

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Laws of Exponents

- 1) Law 1: $(x^a) \bullet (x^b) = x^{a+b}$
  - $2^4 \times 2^2 = 2^{4+2} = 2^6 = 64$
  - $2^{1.4} \times 2^{3.6} = 2^{1.4+3.6} = 2^5 = 32$
- The <u>product</u> of some base x raised to some power, and the same base x raised to the same or different power, equals the base raised to the <u>sum</u> of the two powers

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Laws of Exponents

- 2) Law 2: $x^a / x^b = x^{a-b}$
  - $2^6 / 2^4 = 2^{6-4} = 2^2 = 4$
  - $2^{5.5} / 2^{3.5} = 2^{5.5-3.5} = 2^2 = 4$
- The ratio of some base x raised to some power, to the same base raised to the same or different power, equals the base raised to the difference between the powers

Law 2

- More examples
  - $10^{-8} / 10^{-13} = 10^5$
  - $10^{-13} / 10^{-8} = 10^{-5}$
  - $10^{-7} / 10^{-7} = 10^0 = 1$
- Any number divided by itself must equal 1: Hence $10^0 = 1$ and, more generally, $x^0 = 1$

Laws of Exponents

- 3) Law 3: $(x^a)^b = x^{ab}$
  - $(10^2)^3 = (10)^{2 \cdot 3} = 10^6$

LOGS AND ANTILOGS: Antilogs

- Form two exponential series: Base = 2 and Base = 10
- We ask: X^n = ?

Table 3-5. Two exponential series of numbers for base = 2 and base = 10

Base = 2 X^n	Answer	Base = 10 X^n	Answer
2^0 = ?	1	10^0 = ?	1
2^1 = ?	2	10^1 = ?	10
2^2 = ?	4	10^2 = ?	100
2^3 = ?	8	10^3 = ?	1,000
2^4 = ?	16	10^4 = ?	10,000

Antilogs

- What is 2 raised to the 0, 1, 2, 3, or 4 power?

  or
- What is 10 raised to the 0, 1, 2, 3, or 4 power?
- GENERALLY: What is the value of the base X raised to the nth power? X^n = ?

Table 3-5. Two exponential series of numbers for base = 2 and base = 10

Base = 2 X^n	Answer	Base = 10 X^n	Answer
2^0 = ?	1	10^0 = ?	1
2^1 = ?	2	10^1 = ?	10
2^2 = ?	4	10^2 = ?	100
2^3 = ?	8	10^3 = ?	1,000
2^4 = ?	16	10^4 = ?	10,000

Antilogs

- That is the same as determining the antilog of a number
- Thus,
  - X^n = ? is the same as $antilog_x$ n = ?
  - $2^5 = 32$ and $antilog_2$ 5 = 32
  - 10^3 = 1,000 and $antilog_{10}$ 3 = 1,000

Table 3-5. Two exponential series of numbers for base = 2 and base = 10

Base = 2 X^n	Answer	Base = 10 X^n	Answer
2^0 = ?	1	10^0 = ?	1
2^1 = ?	2	10^1 = ?	10
2^2 = ?	4	10^2 = ?	100
2^3 = ?	8	10^3 = ?	1,000
2^4 = ?	16	10^4 = ?	10,000

Sample Problems

- Antilog$_2$ 6 = ?
  - ☑ 64
- Antilog$_{10}$ 5 = ?
  - ☑ 100,000
- Antilog$_3$ 2 = ?
  - ☑ 9

Sample Problems

- Antilog$_{10}$ - 2 = ?
  - $x^{-n} = 1/x^n$
  - antilog$_x$ -n = 1/antilog$_x$ n
  - $1/10^2 = .01$
- Antilog$_{10}$ 0 = ?
  - ☑ 1 ($x^0 = 1$)
- Antilog$_{10}$ 1 = ?
  - ☑ 10 ($x^1 = x$)

LOGS AND ANTILOGS: Logs

- The exponent is not given
- We ask: To what power must the BASE be raised to equal some number?
  - $x^? = \#$
  - $2^? = 8$
  - $10^? = 10,000$
- Solving for an exponent

Table 3-6. Two exponential series for base = 2 and base = 10

Base = 2 X^n	Answer	Base = 10 X^n	Answer
$2^? = 1$	0	$10^? = 1$	0
$2^? = 2$	1	$10^? = 10$	1
$2^? = 4$	2	$10^? = 100$	2
$2^? = 8$	3	$10^? = 1,000$	3
$2^? = 16$	4	$10^? = 10,000$	4

Taking the Log of a Number

- Log$_2$ 8 = 3
  $2^? = 8$
- Log$_{10}$ 10,000 = 4
  $10^? = 10,000$
- Log$_{10}$ 1,000,000 = 6
  $10^? = 1,000,000$

Table 3-6. Two exponential series for base = 2 and base = 10

Base = 2 X^n	Answer	Base = 10 X^n	Answer
$2^? = 1$	0	$10^? = 1$	0
$2^? = 2$	1	$10^? = 10$	1
$2^? = 4$	2	$10^? = 100$	2
$2^? = 8$	3	$10^? = 1,000$	3
$2^? = 16$	4	$10^? = 10,000$	4

Taking the Log of a Number

	Ratio Scale	Linear Scale
Log$_{10}$ 10,000 =		4
	10:1	
Log$_{10}$ 1,000 =		3
	10:1	
Log$_{10}$ 100 =		2
	10:1	
Log$_{10}$ 10 =		1
	10:1	
Log$_{10}$ 1 =		0

Taking the Log of a Number

	Between	Thus
Log$_{10}$ 200 =	2 & 3	2.xx
Log$_{10}$ 700 =	2 & 3	2.xx
Log$_{10}$ 3,000 =	3 & 4	3.xx
Log$_{10}$ 27 =	1 & 2	1.xx
Log$_{10}$ 5 =	0 & 1	0.xx
Log$_{10}$ 0.5=	0 & -1	?

- We will see answer later

Bases for Logs and Antilogs

- The BASE must be specified
- Any number (other than 1) can be the BASE
- Three BASES are ordinarily encountered
  - 2
  - 10 (Common or Briggsian Log)
  - e (2.718: Natural or Naperian Log)

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Summary

- When you take the log of a number, you are solving for an exponent
  - An exponent is a log
  - A log is an exponent

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PROCEDURES FOR SOLVING LOG AND ANTILOG PROBLEMS: Logs

- Log_{10} 100 = ? Obvious
  - ☑ 2
- Log_{10} 1,000 = ? Obvious
  - ☑ 3
- Log_{10} 150 = ? Not so obvious
  - ☑ Between 2 and 3: 2.xxxx
  - ☑ 2.1761

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Components (Anatomy) of a Log

Integer Decimal Values

- Log_{10} 100 = 2.000000000
- Log_{10} 1,000 = 3.000000000
- Log_{10} 150 = 2.176091259

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Components of a Log

- Integer: the characteristic
- Decimals: the mantissa
  - Log_{10} 150 = 2.176091259
  - Characteristic = 2.
  - Mantissa = .176091259

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How to Solve Log Problems

- Calculator
- Log table
  - If log table, it is helpful to convert conventional number into scientific notation
  - Scientific notation, however, is important in its own right

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Scientific Notation

- A number written in scientific notation is expressed as the product of a coefficient and the base 10 raised to some power
- The coefficient
  - A number equal to or greater than 1.00, but
  - less than 10 (e.g., 1.0000; 3.14159; 9.9999)
- See Table 3-7

Scientific Notation

Table 3-7. Comparison of conventional and scientific notation

Conventional Notation	Scientific Notation
10	1.00×10^{1}
100	1.00×10^{2}
1,000	1.00×10^{3}
121	1.21×10^{2}
800	8.00×10^{2}
0.1	1.00×10^{-1}
0.0121	1.21×10^{-2}

Procedure

- Move decimal point leftward (successive division by 10) or rightward (successive multiplication by 10) until requirements for <u>coefficient</u> are met
- The number of places moved specifies the <u>value</u> of the exponent
  - Successive division: + exponent
  - Successive multiplication: - exponent

Examples

- $100 = 1.00 \times 10^{2}$
- $200 = 2.00 \times 10^{2}$
- $300 = 3.00 \times 10^{2}$
- $315 = 3.15 \times 10^{2}$
- 0.125 = ?
  - ☑ 1.25×10^{-1}
- 0.0367 = ?
  - ☑ 3.67×10^{-2}
- 0.000001 = ?
  - ☑ $1 \times 10^{-6} = 10^{-6}$

Examples

- $100 = 10^{2}$ (or) 1×10^{2}
- $1{,}000 = 10^{3}$ (or) 1×10^{3}
- 200 = ?
  - ☑ 2×10^{2}
- 2,000 = ?
  - ☑ 2×10^{3}

Scientific Notation

- A number, in scientific notation, is the product of some simple number (the <u>coefficient</u>) and 10 raised to some <u>power</u>
- 12500 = ?
  - ☑ 1.25×10^{4}
- 12541 = ?
  - ☑ 1.2541×10^{4}, or just 1.25×10^{4}

Scientific Notation

- When the number, in conventional notation, is 10 or greater:
  - Count the number of places that the decimal point must be moved to the left to lie between 1 and 9 (successive division by 10)
- This specifies the positive exponent
  - $114 = 1.14 \times 10^2$

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Scientific Notation

- When the number, in conventional notation, is less than 1:
  - Count the number of places that the decimal point must be moved to the right (successive multiplication by 10)
- This specifies the negative exponent
  - $.114 = 1.14 \times 10^{-1}$

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Scientific Notation

- When the number, in conventional notation, equals 1:
  - The decimal point need not be moved
- The exponent is zero
  - $1.00 = 1.00 \times 10^0$
  - $9.00 = 9.00 \times 10^0$

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Solution For Logs

- Three steps for solution of log problems: $\text{Log}_{10}\ 145 = ?$
- Step 1: Express number in scientific notation
  - $\text{Log}_{10}\ 145 = \log_{10}\ 1.45 \times 10^2$
- Step 2: The exponent in scientific notation is the characteristic of the log
  - $\text{Log}_{10}\ 1.45 \times 10^2 = 2.\text{xxxx}$

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Solution For Logs

- Step 3: Look up mantissa in a log table
  - The first two digits of coefficient indicate proper row in log table; the third digit specifies the correct column. Thus, 1.45 directs you to row 14 and column 5
  - $\text{Log}_{10}\ 1.45 \times 10^2 = 2.1614$

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Log Table

N	0	1	2	3	4	5	6	7	8	9
10	0.0000	0.0043	0.0086	0.0128	0.0170	0.0212	0.0253	0.0294	0.0334	0.0374
11	0.0414	0.0453	0.0492	0.0531	0.0569	0.0607	0.0645	0.0682	0.0719	0.0755
12	0.0792	0.0828	0.0864	0.0899	0.0934	0.0969	0.1004	0.1038	0.1072	0.1106
13	0.1139	0.1173	0.1206	0.1239	0.1271	0.1303	0.1335	0.1367	0.1399	0.1430
14	0.1461	0.1492	0.1523	0.1553	0.1584	0.1614	0.1644	0.1673	0.1703	0.1732
15	0.1761	0.1790	0.1818	0.1847	0.1875	0.1903	0.1931	0.1959	0.1987	0.2014
16	0.2041	0.2068	0.2095	0.2122	0.2148	0.2175	0.2201	0.2227	0.2253	0.2279
17	0.2304	0.2330	0.2355	0.2380	0.2405	0.2430	0.2455	0.2480	0.2504	0.2529
18	0.2553	0.2577	0.2601	0.2625	0.2648	0.2672	0.2695	0.2718	0.2742	0.2765
19	0.2788	0.2810	0.2833	0.2856	0.2878	0.2900	0.2923	0.2945	0.2967	0.2989
20	0.3010	0.3032	0.3054	0.3075	0.3096	0.3118	0.3139	0.3160	0.3181	0.3201
21	0.3222	0.3243	0.3263	0.3284	0.3304	0.3324	0.3345	0.3365	0.3385	0.3404
22	0.3424	0.3444	0.3464	0.3483	0.3502	0.3522	0.3541	0.3560	0.3579	0.3598
23	0.3617	0.3636	0.3655	0.3674	0.3692	0.3711	0.3729	0.3747	0.3766	0.3784
24	0.3802	0.3820	0.3838	0.3856	0.3874	0.3892	0.3909	0.3927	0.3945	0.3962
25	0.3979	0.3997	0.4014	0.4031	0.4048	0.4065	0.4082	0.4099	0.4116	0.4133
26	0.4150	0.4166	0.4183	0.4200	0.4216	0.4232	0.4249	0.4265	0.4281	0.4298
27	0.4314	0.4330	0.4346	0.4362	0.4378	0.4393	0.4409	0.4425	0.4440	0.4456
28	0.4472	0.4487	0.4502	0.4518	0.4533	0.4548	0.4564	0.4579	0.4594	0.4609
29	0.4624	0.4639	0.4654	0.4669	0.4683	0.4698	0.4713	0.4728	0.4742	0.4757

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Sample Problems

- Log_{10} 846 =
  - ☑ 2.9274
- Log_{10} 923 =
  - ☑ 2.9652
- Log_{10} 1,000 =
  - ☑ 3.0000

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Sample Problems

- Log_{10} 2,315 =
  - ☑ 3.3646
- Log_{10} 1 =
  - ☑ 0.0000
- NOTE: If $x^0 = 1$, and if an exponent is a log, then the Log_{10} 1 = 0 !

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Sample Problems

- Log_{10} 2 =
  - ☑ 0.3010 (Remember !)
- Log_{10} 0.0002 =
  - ☑ $\bar{4}.3$
- NOTE: The characteristic can be positive <u>or</u> negative, but the mantissa can <u>only</u> be positive

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Explanation

Log 2000	3.3
Log 1000	3
Log 200	2.3
Log 100	2
Log 20	1.3
Log 10	1
Log 2	0.3
Log 1	0

- Note: Each bracket spans one power of 10 and represents 1 log unit because log_{10} 10 = 1

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Explanation

Log .2	-1.3? NO! $\bar{1}.3$ = - 0.7
Log .1	$\bar{1}$
Log .02	$\bar{2}.3$
Log .01	$\bar{2}$
Log .002	$\bar{3}.3$
Log .001	$\bar{3}$
Log .0002	$\bar{4}.3$
Log .0001	$\bar{4}$

- .2 is one power of 10 <u>less</u> than 2 and therefore is 1 log unit <u>less</u> than the log of 2
  - ♦ 0.3 - 1 = - 0.7

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Logs With Bases Other Than 10

- $log_Y X = log_{10} X / log_{10} Y$
  - ♦ $log_2 8 = log_{10} 8 / log_{10} 2$
  - ♦ = .9031 / .3010
  - ♦ = 3

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PROCEDURES FOR SOLVING LOG AND ANTILOG PROBLEMS: Antilogs

- Same three steps used for solving log problems, but in reverse order
  - ♦ Antilog_{10} 2.1614 (>100; <1,000)
- Step 1

  .1614 is the mantissa. Find 1614 as cell entry in log table. The two-digit row and one-digit column designators yield the coefficient in scientific notation: 1.45

  - ♦ Antilog_{10} 2.1614 = $1.45 \times 10^{?}$

Ch3-67

Solutions For Antilogs

- Step 2:

  The characteristic is 2. It yields the exponent in scientific notation.

  - ♦ Therefore: Antilog_{10} 2.1614 = 1.45×10^2 = 145

Ch3-68

Logs and Antilogs with a Calculator

- Logs: Log_{10} 167 = ?
  - ♦ Enter # in key pad: 167
  - ♦ Press log key
  - ♦ Display shows 2.2227
- Antilogs: Antilog_{10} 2.2227
  - ♦ Enter # in key pad: 2.2227
  - ♦ Press 10^x key
  - ♦ Display shows 167

Ch3-69

Laws of Logarithms

- 1. Law 1: Log ab = Log a + Log b
  - ♦ Log (10×10) = ?
  - ♦ Log 10 + Log 10 = 2
- You have encountered this law before: when a conventional number is expressed in scientific notation, you find the log of the product of a coefficient and 10^x by summing the log of the coefficient and the log of 10^x

Ch3-70

Law 1

- Log 145 = ?
  - ♦ Log (1.45×10^2) =
  - ♦ Log 1.45 + Log 10^2 =
  - ♦ 2 + .1614 = 2.1614

Ch3-71

Laws of Logarithms

- 2. Law 2: Log a / b = Log a - Log b
  - ♦ Log (100 / 10) = ?
  - ♦ Log 100 - Log 10 =
  - ♦ 2 - 1 = 1
- Law 2 will be encountered repeatedly in solution of decibel problems

Ch3-72

Law 2

- Log (2.16 / 1.58) = ?
  - Log 2.16 - Log 1.58 =
  - 0.3345 - 0.1987 =
  - 0.1358
- Log $(1 \times 10^4) / (2 \times 10^2)$ = ?
  - Log 10^4 - Log (2×10^2) =
  - 4 - 2.3 = 1.7
  - Note: in this problem we applied both Law 1 and Law 2

Ch3-73

Laws of Logarithms

- 3. Law 3: Log a^b = b Log a
  - Log 10^2 = 2 Log 10 = $2 \times 1 = 2$
  - Log 10^3 = 3 Log 10 = $3 \times 1 = 3$
  - Log $10^{2.75}$ = 2.75 Log 10 = 2.75
  - Log $6^{3.5}$ = 3.5 Log 6 = $3.5 \times .78$ = 2.72
- This law will be used to derive the equation for decibels for pressure from the equation for decibels for intensity in Chapter 4

Ch3-74

Laws of Logarithms

- 4. Law 4: Log 1 / a = - Log a
  - Log (1 / 10) = - Log 10 = - 1
  - Log (1 / 12) = - Log 12 = - 1.08
- This law will be encountered in solving problems in Chapters 5 and 8

Ch3-75

Logs Without Log Tables or Calculators

- Log 1 = 0 — MEMORIZE
- Log 2 = .3 — MEMORIZE
- Log 3 = .48 — MEMORIZE
- Log 4 =
  - Log 4 = Log (2×2) = .60 (.30 + .30)
- Log 5 =
  - Log 5 = Log (10 / 2) = .70 (1.0 - .30)
- Log 6 =
  - Log 6 = Log (2×3) = .78 (.30 + .48)

Ch3-76

Logs Without Log Tables or Calculators

- Log 7 = .85 — MEMORIZE
- Log 8 =
  - Log 8 = Log (4×2) = .90 (.60 + .30)
- Log 9 =
  - Log 9 = Log (3×3) = .96 (.48 + .48)
- Log 10 =
  - Log 10 = 1

Ch3-77