Problems Manual for

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GROB'S BASIC ELECTRONICS

MITCHEL E. SCHULTZ

Mc Graw Hill Education

Problems Manual

for

Grob's
Basic Electronics

Twelfth Edition

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Preface

The *Problems Manual for Grob's Basic Electronics* is designed to provide students and instructors with a source of hundreds of practical problems for self-study, homework assignments, tests, and review. Every major topic of a course in basic electronics has been covered. Although the book was written to accompany *Grob's Basic Electronics,* its contents are universal and applicable to any introductory text in electricity and electronics.

The chapters in this book exactly parallel the first 26 chapters of *Grob's Basic Electronics,* twelfth edition. However, some chapters in this book provide expanded coverage of the topics presented in the textbook.

Each chapter contains a section of solved illustrative examples demonstrating, step-by-step, how representative problems on a particular topic are solved. Following these examples are sets of problems for the students to solve. Troubleshooting problems are included in appropriate areas throughout the book. Such problems fill a long-standing need in the traditional DC/AC coverage. Practical experience in electricity and electronics is emphasized by using standard component values in most problems. Not only does the student gain knowledge about these standard values, but their use also allows many of the circuits to be constructed so that problem solutions can be verified and further circuit behavior studied. New to the twelfth edition is a short true/false test at the end of every chapter in the book. Each end-of-chapter test quizzes students on the general content presented in the chapter. The answers to all of the end-of-chapter tests are at the back of the book.

The abundance of graded problem material provides a wide choice for student assignments; the huge selection also means that short-term repetition of assignments can be successfully avoided.

I would like to thank Susan Bye Bernau for her many long hours of hard work in the preparation of the original manuscript for this book. Without her help, the first edition of this book may have never happened. I would also like to thank Cathy Welch for her contributions in typing manuscript for this book. Your help has been greatly appreciated. And finally, I would like to thank my lovely wife, Sheryl, for her tremendous support and patience during the long period of manuscript preparation.

Mitchel E. Schultz

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I Introduction to Powers of 10

In the field of electronics, the magnitudes of the various units are often extremely small or extremely large. For example, in electronics it is not at all uncommon to work with extremely small decimal fractions such as 0.000000000047 or extremely large numbers such as 100,000,000. To enable us to work conveniently with both very small and very large numbers, powers of 10 notation is used. *Powers of ten notation* allows us to express any number, no matter how large or how small, as a decimal number multiplied by a power of 10. A power of 10 is an exponent written above and to the right of 10, which is called the base. The power or exponent indicates how many times the base is to be multiplied by itself. For example, 10^2 means 10×10 and 10^4 means $10 \times 10 \times 10 \times 10$. In electronics, the base 10 is common because multiples of 10 are used in the metric system of units. As you will see, powers of 10 allow us to keep track of the decimal point when working with extremely small and extremely large numbers.

Positive powers of 10 are used to indicate numbers greater than 1, and negative powers of 10 are used to indicate numbers less than 1. Table I-1 shows the powers of 10 ranging from 10^{-12} to 10^9. As you will discover in your study of electronics, seldom will you encounter powers of 10 which fall outside this range. From Table I-1 notice that $10^0 = 1$ and $10^1 = 10$. In the case of $10^0 = 1$, it is important to realize that any number raised to the zero power equals 1. In the case of $10^1 = 10$, it is important to realize that any number written without a power is assumed to have a power of 1.

TABLE I-1 POWERS OF 10

$1{,}000{,}000{,}000 = 10^9$	$10 = 10^1$	$0.000001 = 10^{-6}$
$100{,}000{,}000 = 10^8$	$1 = 10^0$	$0.0000001 = 10^{-7}$
$10{,}000{,}000 = 10^7$	$0.1 = 10^{-1}$	$0.00000001 = 10^{-8}$
$1{,}000{,}000 = 10^6$	$0.01 = 10^{-2}$	$0.000000001 = 10^{-9}$
$100{,}000 = 10^5$	$0.001 = 10^{-3}$	$0.0000000001 = 10^{-10}$
$10{,}000 = 10^4$	$0.0001 = 10^{-4}$	$0.00000000001 = 10^{-11}$
$1{,}000 = 10^3$	$0.00001 = 10^{-5}$	$0.000000000001 = 10^{-12}$
$100 = 10^2$		

SEC. I-1 SCIENTIFIC NOTATION

The procedure for using powers of 10 is to write the original number as two separate factors. Scientific notation is a special form of powers of 10 notation. Using scientific notation, any number can be expressed as a number between 1 and 10 times a power of 10. The power of 10 is used to place the decimal point correctly. In fact, the power of 10 indicates the number of places the decimal point has been moved to the left or right in the original number. If the decimal point is moved to the left in the original number, then the power of 10 will increase (become more positive). Conversely, if the decimal point is moved to the right in the original number then the power of 10 will decrease (become more negative).

Solved Problem

Express the numbers 27,000 and 0.000068 in scientific notation.

Answer

To express 27,000 in scientific notation the number must be expressed as a number between 1 and 10, which is 2.7 in this case, times a power of 10. To do this the decimal point must be shifted four places to the left. The number of places the decimal point has been moved to the left indicates the positive power of 10. Therefore, $27{,}000 = 2.7 \times 10^4$ in scientific notation.

To express 0.000068 in scientific notation the number must be expressed as a number between 1 and 10, which is 6.8 in this case, times a power of 10. This means the decimal point must be shifted five places to the right. The number of places the decimal point moves to the right indicates the negative power of 10. Therefore, $0.000068 = 6.8 \times 10^{-5}$ in scientific notation.

When expressing numbers in scientific notation, remember the following rules.

Rule 1 Express the number as a number between 1 and 10 times a power of 10.

Rule 2 When moving the decimal point to the left in the original number, make the power of 10 positive. When moving the decimal point to the right in the original number, make the power of 10 negative.

Rule 3 The power of 10 always equals the number of places the decimal point has been shifted to the left or right in the original number.

PRACTICE PROBLEMS

Sec. I-1 Express the following numbers in scientific notation.

1. 56,000
2. 1,200,000
3. 0.05
4. 0.000472
5. 0.000000000056
6. 120
7. 330,000
8. 8,200
9. 0.001
10. 0.000020
11. 0.00015
12. 4.7
13. 4,700,000,000
14. 0.246
15. 0.0055
16. 0.00096
17. 100,000
18. 150
19. 0.000066
20. 750,000
21. 5,000,000,000
22. 0.00000000000004
23. 215
24. 5,020
25. 0.658

Decimal Notation

Numbers that are written without powers of 10 are said to be written in decimal notation (sometimes referred to as floating decimal notation). In some cases it may be necessary to change a number written in scientific notation back into decimal notation. To convert from scientific notation to decimal notation use Rules 4 and 5.

Rule 4 If the exponent or power of 10 is positive, move the decimal point to the right, the same number of places as the exponent.

Rule 5 If the exponent or power of 10 is negative, move the decimal point to the left, the same number of places as the exponent.

Solved Problem

Convert the number 3.56×10^4 back into decimal notation.

Answer

Since the power of 10 is 4, the decimal point must be shifted four places to the right: 3.5600. Therefore, $3.56 \times 10^4 = 35{,}600$.

MORE PRACTICE PROBLEMS

Sec. I-1 Convert the following numbers expressed in scientific notation back into decimal notation.

1. 2.66×10^7
2. 3.75×10^{-8}
3. 5.51×10^{-2}
4. 1.67×10^4
5. 7.21×10^1
6. 2.75×10^{-3}
7. 1.36×10^{-11}
8. 4.4×10^9
9. 3.6×10^{-1}
10. 3.65×10^{-4}
11. 1.36×10^{-5}
12. 2.25×10^5
13. 7.56×10^8
14. 1.8×10^{-3}
15. 6.8×10^1
16. 5.5×10^2
17. 3.0×10^{-1}
18. 2.7×10^{-2}
19. 3.3×10^{-8}
20. 5.6×10^{-12}
21. 4.7×10^3
22. 1.27×10^3
23. 3.3×10^0
24. 2.33×10^{-4}
25. 4.7×10^6

SEC. I-2 ENGINEERING NOTATION AND METRIC PREFIXES

Another popular way of expressing very small and very large numbers is with engineering notation. Engineering notation is very much like scientific notation except that with engineering notation the powers of 10 are always multiples of 3 such as 10^{-12}, 10^{-9}, 10^{-6}, 10^{-3}, 10^3, 10^6, 10^9, 10^{12}, etc. More specifically, a number written in engineering notation is always written as a number between 1 and 1,000 times a power of 10 that is a multiple of 3.

Solved Problem

Express the number 330,000 in engineering notation.

Answer

To express the number 330,000 in engineering notation, it must be written as a number between 1 and 1,000 times a power of 10 that is a multiple of 3. It is often helpful to begin by expressing the number in scientific notation: $330{,}000 = 3.3 \times 10^5$. Next, examine the power of 10 to see if it should be increased to 10^6 or decreased to 10^3. If the power of 10 is increased to 10^6, then the decimal point in the number 3.3 would have to be moved one place to the left. Since 0.33 is not a number between 1 and 1,000, the answer of 0.33×10^6 is not representative of engineering notation. If the power of 10 were decreased to 10^3, however, then the decimal point in the number 3.3 would have to be moved two places to the right and the answer would be 330×10^3, which is representative of engineering notation. In summary: $330{,}000 = 3.3 \times 10^5 = 330 \times 10^3$.

Solved Problem

Express the number 0.000015 in engineering notation.

Answer

To express the number 0.000015 in engineering notation, it must be written as a number between 1 and 1,000 times a power of 10 that is a multiple of 3. Begin by expressing the number in scientific notation: $0.000015 = 1.5 \times 10^{-5}$. Next, examine the power of 10 to see if it should be increased to 10^{-3} or decreased to 10^{-6}. If the power of 10 were increased to 10^{-3}, then the decimal point in the number 1.5 would have to be moved two places to the left. Since 0.015 is not a number between 1 and 1,000, the answer of 0.015×10^{-3} is not representative of engineering notation. If the power of 10 were decreased to 10^{-6}, however, then the decimal point in the number 1.5 would have to be moved one place to the right and the answer would be 15×10^{-6}, which is representative of engineering notation. In summary: $0.000015 = 1.5 \times 10^{-5} = 15 \times 10^{-6}$.

PRACTICE PROBLEMS

Sec. I-2 Express the following numbers in engineering notation.

1. 47,200
2. 0.00047
3. 0.65
4. 22,000,000
5. 1,875
6. 39,000
7. 0.075
8. 0.00000055
9. 0.000000000082
10. 910,000
11. 1,680,000
12. 0.0072
13. 0.00065
14. 0.350
15. 12,500
16. 15,000,000,000,000
17. 0.000000000470
18. 0.0005
19. 0.00000033
20. 156,000
21. 68,000
22. 25,030,000
23. 0.000000000068
24. 0.057
25. 0.0088

Metric Prefixes

The metric prefixes represent the powers of 10 that are multiples of 3. In electronics, engineering notation is preferred over scientific notation because most values of voltage, current, resistance, power, etc. are specified in terms of the metric prefixes. Table I-2 lists the most common metric prefixes and their corresponding powers of 10. Notice that uppercase letters are used for the abbreviations for the prefixes involving positive powers of 10, and lowercase letters are used for negative powers of 10. There is one exception to the rule, however; the lowercase letter "k" is used for kilo, corresponding to 10^3. Because metric prefixes are used so often in electronics, it is common practice to express the value of a given quantity in engineering notation so that the power of 10 (that is a multiple of 3) can be replaced with its corresponding metric prefix. For example, a resistor whose value is 2,700 Ω can be expressed in engineering notation as 2.7×10^3 Ω. In Table I-2, we see that the metric prefix kilo (k) corresponds to 10^3. Therefore, 2,700 Ω or 2.7×10^3 Ω can be expressed as 2.7 kΩ. As another example, a current of 0.025 A can be expressed in engineering notation as 25×10^{-3} A. In Table I-2, we see that the metric prefix milli (m) corresponds to 10^{-3}. Therefore, 0.025 A or 25×10^{-3} A can be expressed as 25 mA. In general, when using the metric prefixes to express the value of a quantity, write the original number in engineering notation and then substitute the appropriate metric prefix corresponding to the power of 10 involved. As this procedure shows, the metric prefixes are just a substitute for the powers of 10 used in engineering notation.

TABLE I-2 METRIC PREFIXES

Power of 10	Prefix	Abbreviation
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

Table I-3 lists many of the electrical quantities that you will encounter in your study of electronics. For each electrical quantity listed in Table I-3, take special note of the units and symbols shown. In the practice problems that follow, we will use several numerical values with the various units from this table.

TABLE I-3 ELECTRICAL QUANTITIES WITH THEIR UNITS AND SYMBOLS

Quantity	Unit	Symbol
Current	Ampere (A)	I
Electromotive force (voltage)	Volt (V)	V
Resistance	Ohm (Ω)	R
Frequency	Hertz (Hz)	f
Capacitance	Farad (F)	C
Inductance	Henry (H)	L
Power	Watt (W)	P

Solved Problem

Express the resistance value of 2,200,000 Ω using the appropriate metric prefix from Table I-2.

Answer

First, express 2,200,000 Ω in engineering notation: 2,200,000 Ω $= 2.2 \times 10^6$ Ω. Next, replace 10^6 with its corresponding metric prefix. Since the uppercase letter "M" (abbreviation for mega) represents 10^6, the value 2,200,000 Ω can be expressed as 2.2 MΩ. In summary: 2,200,000 Ω $= 2.2 \times 10^6$ Ω $=$ 2.2 MΩ.

Solved Problem

Express the current value of 0.0005 A using the appropriate metric prefix from Table I-2.

Answer

First, express 0.0005 A in engineering notation: 0.0005 A $= 500 \times 10^{-6}$ A. Next, replace 10^{-6} with its corresponding metric prefix. Since the metric prefix micro (μ) corresponds to 10^{-6}, the value of 0.0005 A can be expressed as 500 μA. In summary: 0.0005 A $= 500 \times 10^{-6}$ A $=$ 500 μA.