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ABSTRACT

This document contains both an instructor's guide and a reference manual. It was developed as part of a cooperative venture between Industrial Technology Institute (ITI), Wayne County (Michigan) Community College, and Great Lakes Steel (GLS). The instructor's guide has four sections: math for success in electronics, student materials, electronics curricula linkage, and working with adult learners. The reference manual (the greater part of the document) contains 29 self-instructional units: rounding numbers; signed numbers; decimal numbers; fractions; converting fractions and decimal numbers; percents; converting fractions and percents; calculations with fractions, decimal numbers, and percents; scientific notation; adding and subtracting powers of 10; multiplying and dividing powers of 10; coordinates; plotting and drawing line graphs; extrapolating information from line graphs; converting metric measurements; converting English and metric measurements; converting English measurements; proportions; solving equations with whole numbers; solving equations with decimal numbers; solving equations with signed numbers; solving equations with scientific notation; solving equations with squares and square roots; solving equations with fractions; solving nonlinear equations with whole numbers; solving linear equations by transposing; solving non-linear equations by transposing; key words--electrical/electronic; and key words--math. Each unit contains the following: prerequisites, focus, job examples, key words, examples, practice problems, and answers to problems. (NLA)

Math for Success in Electronics

Instructor's Guide

Reference Manual

Math for Success in Electronics

Instructor's Guide

Prepared by: Connie DeVantier, Georges Lakkis, Kelly Smith, Barbara Skrepnek, James Shearer, Michelle Schiller, Dale Brandenburg and Daniel Bugajski

The material in this project was prepared under Grant No. V198A00020 from the National Workplace Literacy Program, Office of Vocational and Adult Education, U.S. Department of Education, under the authority of the Adult Education Act P.L. 91-230. Grantees undertaking such projects under government sponsorship are encouraged to express freely their professional judgement. Therefore, points of view or opinions stated in this document do not necessarily represent the official position or policy of the Department of Education.

Purpose of This Guide

The purpose of this Guide is to provide instructors of **Math for Success in Electronics** with:

- an overview of the **Math for Success in Electronics** program
- an overview of the program materials
- some suggestions for working with adult learners

Table of Contents

1. Math for Success in Electronics

A. Background

Math for Success in Electronics is designed to assist steelworkers in preparing to enter an electronic-based community college curriculum. It is based on the needs of Great Lakes Steel - United Steelworkers of America employees, Ecorse, MI.

Math for Success in Electronics assists individuals in developing and strengthening *select* math competencies required as a foundation for an electronics-based curriculum. In **Math for Success in Electronics**, math is presented in the context of electrical/electronic and physics applications.

B. Audience

Math for Success in Electronics was initially designed for steelworkers interested in preparing to enter an electronics-based community college program. Evaluation results suggest that others interested in strengthening their math competencies may also find these materials helpful.

C. Materials

Math for Success in Electronics contains:

- 27 self-administered student workbooks
- two student reference books
- one instructor's guide

D. Objectives

Math for Success in Electronics is designed to assist individuals in acquiring and strengthening select math competencies required as a foundation for an electronics-based curriculum. **Math for Success in Electronics** is designed to *assist* and *support* individuals in developing and strengthening the following math competencies:

- adding, subtracting, multiplying and dividing signed numbers
- adding, subtracting, multiplying and dividing fractions
- adding, subtracting, multiplying and dividing decimal numbers
- adding, subtracting, multiplying and dividing powers of ten
- adding, subtracting, multiplying and dividing numbers written in scientific notation
- defining independent and dependent variables when working with coordinates
- plotting and drawing line graphs
- extrapolating information from line graphs
- converting metric measurements
- converting English and metric measurements
- converting English Measurements
- cross multiplying when working with proportions
- converting fractions and decimal numbers
- converting fractions and percents
- converting decimal numbers and percents
- calculating percents
- rounding numbers
- solving equations with fractions
- solving equations with whole numbers
- solving equations with decimal numbers
- solving equations with signed numbers
- solving equations with squares and square roots
- solving equations with scientific notation
- solving non-linear equations with whole numbers
- solving linear equations by transposing
- solving non-linear equations by transposing

2. Student Materials

A. Book Types

Math for Success in Electronics contains four types of student books. Three of these types are workbooks; the fourth type is reference books. The following information describes each book type and lists the quantity of each type in the program:

Type of Book	*Description*	*Title Identification*	*Quantity*
Learn and Practice	These workbooks *instruct* the learner on a specific math competency. Contextual examples are provided. Practice problems and answers are included.	"How to. . . "	20
Review and Practice	These workbooks *review* math principles associated with a specific math competency. Practice problems and answers are included for building skill fluency.	"Working with. . . "	6
Practice	This workbook provides additional opportunity for building skill fluency. It contains practice problems and answers.	"Practice Problems with. . . "	1
Reference	These books *reference* the math and electrical/electronic terms used throughout the workbooks.	"Key Words: . . . " Additionally, these books are marked as **Reference** on book covers.	2

B. Book Titles/Competencies

Math for Success in Electronics contains 29 workbooks and reference books. Book titles identify the content of each book. These books are listed below; the workbooks are listed in order of lowest to highest competency level:

Workbooks:

1. How to Round Numbers
2. Working with Signed Numbers
3. Working with Decimal Numbers
4. Working with Fractions
5. How to Convert Fractions and Decimal Numbers
6. Working with Percents
7. How to Convert Fractions and Percents
8. Practice Calculations with Fractions, Decimals and Percents
9. Working with Scientific Notation
10. How to Add and Subtract Powers of Ten
11. How to Multiply and Divide Powers of Ten
12. Working with Coordinates
13. How to Plot and Draw Line Graphs
14. How to Extrapolate Information from Line Graphs
15. How to Convert Metric Measurements
16. How to Convert English and Metric Measurements
17. How to Convert English Measurements
18. How to Work with Proportions
19. How to Solve Equations with Whole Numbers
20. How to Solve Equations with Decimal Numbers
21. How to Solve Equations with Signed Numbers
22. How to Solve Equations with Scientific Notation
23. How to Solve Equations with Squares and Square Roots
24. How to Solve Equations with Fractions
25. How to Solve Non-Linear Equations with Whole Numbers
26. How to Solve Linear Equations by Transposing
27. How to Solve Non-Linear Equations by Transposing

Reference

28. Key Words: Electrical/Electronic
29. Key Words: Math

The following information lists the books by type:

Learn and Practice:

1. How to Round Numbers
5. How to Convert Fractions and Decimal Numbers
7. How to Convert Fractions and Percents
10. How to Add and Subtract Powers of Ten
11. How to Multiply and Divide Powers of Ten
13. How to Plot and Draw Line Graphs
14 How to Extrapolate Information from Line Graphs
15. How to Convert Metric Measurements
16. How to Convert English and Metric Measurements
17. How to Convert English Measurements
18. How to Work with Proportions
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24. How to Solve Equations with Fractions
25. How to Solve Non-Linear Equations with Whole Numbers
26. How to Solve Linear Equations by Transposing
27. How to Solve Non-Linear Equations by Transposing

Review and Practice:

2. Working with Signed Numbers
3. Working with Decimal Numbers
4. Working with Fractions
6. Working with Percents
9. Working with Scientific Notation
12. Working with Coordinates

Practice:

8. Practice Calculations with Fractions, Decimals and Percents

Reference:

28. Key Words: Electrical/Electronic
29. Key Words: Math

C. Prerequisites

Math for Success in Electronics is suitable for individuals who read comfortably at a high school level. Each workbook in the program has defined prerequisite skills listed on the workbook cover. Should instructors require additional information about preparing students to use **Math for Success in Electronics** workbooks, the following matrix, *Preparations Topics*, may be helpful. In this matrix, some listings are followed by a number; this number refers to the corresponding document in the *Learning Unlimited* math series.

Preparation Topics

Math for Success in Electronics Workbooks	Preparation Topics
How to Round Numbers	Rounding up to 3 - Digit Numbers (N301A) Rounding to the Nearest Thousand, Ten Thousand (N302B) Rounding Millions, Billions (N303C)
Working with Signed Numbers	Positive and Negative Numbers (A101G-3042) Adding and Subtracting Signed Numbers (A102G-3043) Multiplying and Dividing Signed Numbers (103G-3044)
Working with Decimal Numbers	Adding Decimals to Thousandths with Regrouping (R310E) Subtracting Decimals to Thousandths with Regrouping (R320E) Multiplying Decimals to Thousandths with Regrouping (R330E) Dividing Decimals to Thousandths with Regrouping (R340E)
Working with Fractions	dding, Subtracting, Multiplying and Dividing Fractions (R270F)
How to Convert Fractions and Decimal Numbers	Changing Decimals to Fractions and Fractions to Decimals (R371C)
Working with Percents	Concept of Percent: Conversions (R401D)
How to Convert Fractions and Percents	Decimals and Fractions (R370G-3016) Percents, Fractions and Decimals (R400G-3017)
Practice Calculations with Fractions, Decimal Numbers and Percents	Adding, Subtracting, Multiplying and Dividing Fractions (R270F) Adding, Subtracting, Multiplying and Dividing Decimals (R360F)
Working with Scientific Notation	Exponents and Bases (A204D) The Concept of Decimal Numbers (R300G-3012)
How to Add and Subtract Powers of Ten	The Concept of Decimal Numbers (R300G-3012) Exponents and Bases (A204D) Scientific Notation

Math for Success in Electronics Workbooks	Preparation Topics
How to Multiply and Divide Powers of Ten	The Concept of Decimal Numbers (R300G-3012) Exponents and Bases (A204D) Scientific Notation Adding and Subtracting Signed Numbers (A102G- 3043)
Working with Coordinates	Concept of Coordinates (A601F) Plotting Coordinates (A610G-3063)
How to Plot and Draw Line Graphs	Plotting Coordinates (A610G-3063) Reading a Graph of an Equation (A612G-3064) Making a Graph of a Linear Equation (A613G-3065)
How to Extrapolate Information from Line Graphs	Reading and Solving Problems with Line Graphs (S122C) Plotting Coordinates (A610G-3063)
How to Convert Metric Measurements	Metric Length (M320E) The Metric System of Measurement (M300G-3027)
How to Convert English and Metric Measurements	The Concept of Decimal Numbers (R300G-3012)
How to Convert English Measurements	Standard Length (M220E)
How to Work with Proportions	Using Proportions (A502G-3061) Using Ratio and Proportion to Solve Practical Problems (A510G-3062)
How to Solve Equations with Whole Numbers	The Concept of Equations (A300G-3051) Solving Equations by Adding and Subtracting (A302G-3052) Simplifying Equations (A304G-3054) Order of Operation (A206D)
How to Solve Equations with Decimal Numbers	The Concept of Equations (A300G-3051) Solving Equations by Adding and Subtracting (A302G-3052) Simplifying Equations (A304G-3054) Order of Operation (A206D)

Math for Success in Electronics Workbooks	Preparation Topics
How to Solve Equations with Signed Numbers	The Concept of Equations (A300G-3051) Solving Equations by Adding and Subtracting (A302G-3052) Simplifying Equations (A304G-3054) Order of Operation (A206D)
How to Solve Equations with Scientific Notation	The Concept of Decimal Numbers (R300G-3012) Exponents and Bases (A204D) Order of Operation (A206D)
How to Solve Equations with Squares and Square Roots	Square Roots (A205G-3048) Order of Operation (A206D)
How to Solve Equations with Fractions	Parentheses Within Equations (A307G-3057) Order of Operation (A206D) Adding Fractions (R210G-3008) Subtracting Fractions (R220G-3009) Multiplying Fractions (R240G-3010) Dividing Fractions (R250G-3011)
How to Solve Non Linear Equations with Whole Numbers	Square Roots (A205G-3048) Order of Operation (A206D)
How to Solve Linear Equations by Transposing	The Concept of Equations (A300G-3051) Solving Equations by Adding and Subtracting (A302G-3052) Solving Equations by Multiplying and Dividing (A303G-3053) Order of Operation (A206D)
How to Solve Non Linear Equations by Transposing	The Concept of Decimal Numbers (R300G-3012) Exponents and Bases (A204D) Order of Operation (A206D)

D. Features

The following information highlights common features of the **Math for Success in Electronics** workbooks and reference books:

• Focus Statement:	a statement describing the content of the workbook
• Job Examples:	a references to how the math competency is used in electrical/electronic job applications
• Key Words:	math terms, definitions and examples associated with workbook content
• Sample Problems:	examples used as reference for explaining a math methodology
• Practice Problems:	work problems (and answers) emphasizing electronics and physics curriculum contexts
• Technical Definitions:	simple definitions for electrical/electronic and physics terms
• Self-administered Format:	format suitable for individual, dyad or small group implementation

E. Implementation Options

The **Math for Success in Electronics** materials are designed for implementation flexibility. Books may be used by an individual at his/her own pace; they may also be used as a foundation for group discussion and learning. Depending on student learning needs, these books may be used alone or as an introduction or supplement to other materials. They are easily reproduced for using in a variety of settings such as home, library, campus tutoring lab and work site.

3. Electronics Curricula Linkage

The following matrix identifies the relationship between the math competencies presented in **Math for Success in Electronics** and math competencies emphasized in the core courses of an electronics curriculum:

Electronics Curriculum Math Competency Emphasis

Math for Success in Electronics Workbooks	DC Fundamentals (EE 101)	DC Lab (EE 103)	Math for Electrical Engineering I (EE 107)	Electronics Fabrication and Design (EE 105)	AC Fundamentals (EE 102)	AC Lab (EE 113)	Math For Electrical Engineering II (EE 116)	Solid State Fundamentals (EE 111)	Digital Principles (CT 201)	Mechanisms (ET 209)	General Physics (PHY 235)
How to Round Numbers	•	•	•	•	•	•	•	•		•	•
Working with Signed Numbers	•	•	•	•	•	•	•	•	•	•	•
Working with Decimal Numbers	•	•	•	•	•	•	•	•	•	•	•
Working with Fractions	•	•	•	•	•	•	•	•	•	•	•
How to Convert Fractions and Decimal Numbers	•	•	•	•	•	•	•	•		•	•
Working with Percents	•	•	•	•	•	•	•	•		•	•
How to Convert Fractions and Percents	•	•	•	•	•	•	•	•		•	•
Practice Calculations with Fractions, Decimal Numbers and Percents	•	•	•	•	•	•	•	•		•	•
Working with Scientific Notation	•	•	•	•	•	•	•	•		•	•
How to Add and Subtract Powers of Ten	•	•	•		•	•	•	•		•	•
How to Multiply and Divide Powers of Ten	•	•	•		•	•	•	•		•	•
Working with Coordinates	•	•	•		•	•	•	•		•	•
How to Plot and Draw Line Graphs	•	•	•		•	•	•	•		•	•
How to Extrapolate Information from Line Graphs	•	•	•	•	•	•	•	•		•	•

Math for Success in Electronics **Workbooks**	DC Fundamentals (EE 101)	DC Lab (EE 103)	Math for Electrical Engineering I (EE 107)	Electronics Fabrication and Design (EE 105)	AC Fundamentals (EE 102)	AC Lab (EE 113)	Math For Electrical Engineering II (EE 115)	Solid State Fundamentals (EE 111)	Digital Principles (CT 201)	Mechanisms (ET 209)	General Physics (PHY 235)
How to Convert Metric Measurements	•	•			•	•		•		•	•
How to Convert English and Metric Measurements	•		•	•	•	•	•			•	•
How to Convert English Measurements			•	•						•	•
How to Work with Proportions	•	•	•	•	•	•	•	•		•	•
How to Solve Equations with Whole Numbers	•		•		•	•	•	•		•	•
How to Solve Equations with Decimal Numbers	•		•		•	•	•	•		•	•
How to Solve Equations with Signed Numbers	o		•		•	•	•	•		•	•
How to Solve Equations with Scientific Notation	•		•		•	•	•	•		•	•
How to Solve Equations with Squares and Square Roots	•		•		•	•	•	•		•	•
How to Solve Equations with Fractions	•		•		•	•	•	•		•	•
How to Solve Non Linear Equations with Whole Numbers	•		•		•	•	•	•		•	•
How to Solve Linear Equations by Transposing	•		•		•	•	•	•		•	•
How to Solve Non Linear Equations by Transposing	•		•		•	•	•	•		•	•

4. Working with Adult Learners

Adults learn best when they understand the relationship between what they are learning and the practical use for it; they learn what they consider to be important.

Individuals have different styles of learning. Some prefer to work alone to understand the materials before discussing it. Others learn more easily when they are able to discuss the material with others first before working alone with the materials. Some individuals prefer a combination of both depending on the content of material they are learning.

When working with adult learners, it may be helpful to keep the following things in mind:

- recognize that some individuals may not have engaged in formal learning since their school days and that they may require some encouragement to engage in learning activities; help them generalize what they are learning to their life and work experiences and goals

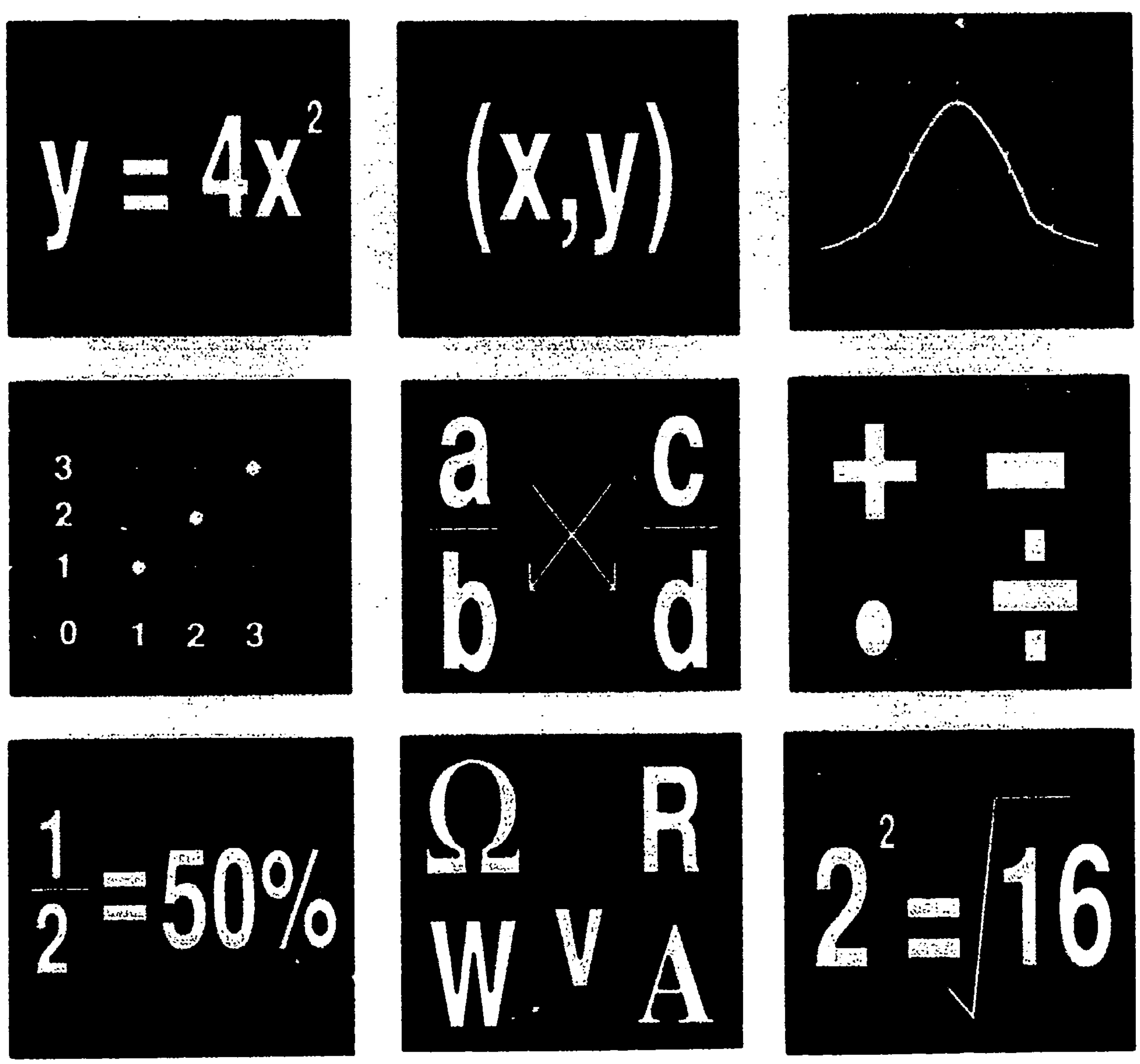
- be approachable to allow individuals to feel comfortable participating, asking questions and discussing their own experiences and learning needs

- create a participatory environment to encourage learners to assume responsibility for their own learning

- incorporate a variety of instructional techniques when possible to accommodate learning style differences among learners

Reference Manual

Math for Success in Electronics



Math for Success in Electronics

1. How to Round Numbers
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8. Practice Calculations with Fractions, Decimal Numbers and Percents
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21. How to Solve Equations with Signed Numbers
22. How to Solve Equations with Scientific Notation
23. How to Solve Equations with Squares and Square Roots

continued

24. How to Solve Equations with Fractions

25. How to Solve Non-Linear Equations with Whole Numbers

26. How to Solve Linear Equations by Transposing

27. How to Solve Non-Linear Equations by Transposing

28. Key Words: Electrical/Electronic

29. Key Words: Math

Math
for
Success
in
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How to Round Numbers

8.3 → 8
8.7 → 9

Prerequisites:

Workbook users should understand:

- *the concept of decimal points*
- *the concept of decimal places*

Acknowledgements

Several people contributed to the development of the **Math for Success in Electronics** books. These individuals include: Georges Lakkis, technical content, editing, pilot testing; Connie DeVantier, design and development; Barbara Skrepnek, development, production, administration; Kristen Luba, Kathleen Gilevich and Nancy Zebko, project administration; Caron Wiesner and Ellen Sudia, formatting, production; James Shearer and Michelle Schiller, cover designs; James Borowski, Brian Diedrich, Nancy Ruetz, Darnell Tolbert and Kelly Smith, technical editing; Bob Tait, technical advising; Jon Morell and Judith Wheeler-Robinson, pilot testing and evaluation; Dale Brandenburg, project management. In addition, numerous Great Lakes Steel - United Steelworkers of America employees and Wayne County Community College students contributed time and valuable suggestions throughout the development process.

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How to Round Numbers

Focus

This lesson explains how to round numbers in order to change them into a more convenient form.

Job Examples

Job examples of when you will round numbers include:

- recording measured data that has a predetermined accuracy
- recording calculated data that has a predetermined accuracy

Key Words

Word	***Explanation***	***Example***
round	the process of slightly increasing or decreasing a number to make it more convenient to use	2307 rounds to 2300 998 rounds to 1000 74.0012 rounds to 74 19.482 rounds to 19.5
digit	a numerical figure	0, 1, 2, 3, 4, 5, 6, 7, 8, 9
significant digit	all non-zero digits (1 through 9); the zero is significant when it holds *any* place value to the right of a non-zero digit	↓↓↓↓ .003405 ↓↓↓↓↓ 50900
decimal point	a dot between the ones place and tenths place in a number	3.2, 100.24, .6, 78.1
decimal number	a number with a decimal point between the ones place and the tenths place	1.3, .5, 24.89, 110.75
decimal place	the position of a digit in a decimal number	millions, hundred thousands, ten thousands, thousands, hundreds, tens, ones or units, tenths, hundredths, thousandths, ten thousandths 4,896,328.9721

How to Round Numbers

Example 1: *Current* (I) is the flow of electrical charge; it is measured in amps (A). You measured the electrical current in a circuit and found the current was 12.384 amps (A). You only need the accuracy to *three significant digits*, so you must round the value.

1.	Identify the number of significant digits to which you must round.	12.384 round to 3 significant digits
2.	Counting from the left, place a caret to the *right* of the last significant digit.	$12.3_{\wedge}84$ A
3.	If the first digit to the *right* of the caret is *less than 5*, replace all digits to the right of the caret with zeros.	This step is not applicable to this problem
4.	If the first digit to the *right* of the caret is *5 or higher*, replace all digits to the right of the caret with zeros *and* add one (1) to the digit to the *left* of the caret.	$12.3_{\wedge}84$ A 12.400 A 12.4 A 12.384 A rounded to three significant digits is 12.4.

Example 2: A *resistor* is a component that controls the flow of current and/or voltage in a circuit. The calculated value of a certain resistor is 1,037,013. You need to round this value to the nearest *thousand* to obtain the required accuracy.

1.	Identify the number of significant digits to which you must round.	1,037,013 round to the nearest thousand (4 significant digits)
2.	Counting from the left, place a caret to the *right* of the last significant digit.	$1037_{\wedge}013$
3.	If the first digit to the *right* of the caret is *less than 5*, replace all digits to the right of the caret with zeros.	$1037_{\wedge}000$
4.	If the first digit to the *right* of the caret is *5 or higher*, replace all digits to the right of the caret with zeros *and* add one (1) to the digit to the *left* of the caret.	This step is not applicable to this problem. The rounded value of the resistor is 1,037,000.

Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

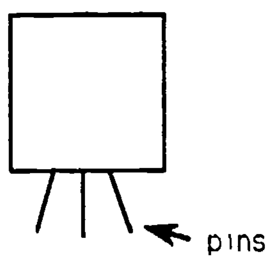
Some Practice Problems refer to the following information:

- *resistance* (R) -- the ability of a device, material or component to oppose the flow of electric current; it is measured in ohms (Ω)
- *current* (I) -- the flow of electrical charge; it is measured in amps (A)
- *power* (P) -- in general, energy delivered or consumed per second; it is measured in watts (W)
- *voltage* (V) -- electrical force or pressure; it is measured in volts (v)

1. The resistance (R) of a component is calculated at 54382 ohms (Ω). What is the resistance (R) rounded to three significant digits?

2. The current (I) of an electrical device is 2.3072 amps (A). What is the current (I) rounded to three significant digits?

3. A *transistor* is a device that is used as an amplifier or a switch. The current (I) of a certain transistor is calculated at .0000138 A. What is the current (I) rounded to the nearest millionth?



transistor

4. A *resistor* is a component that controls the flow of current and/or voltage in a circuit. The power (P) consumed by a certain resistor is .342 watt (W). What is the power (P) rounded to two significant digits?

resistor

5. The voltage (V) in a power line is 13,800 volts (v). What is the voltage (V) rounded to the nearest thousand?

6. The power (P) of an electric motor is 2238 watts (W). What is the power (P) rounded to the nearest hundred?

7. The current (I) of a certain electrical device is calculated at .08572 amps (A). What is the current (I) rounded to the nearest thousandth?

8. The resistance (R) of a certain electrical device is 22,081 Ω. What is the resistance (R) rounded to the nearest thousand?

9. The power (P) consumed by a certain device is 45.38 watts (W). What is the power (P) rounded to three significant digits?

Answers

1. 54400 Ω
2. 2.31 A
3. .000014 A
4. .34 W
5. 14,000 v
6. 2200 W
7. .086 A
8. 22,000 Ω
9. 45.4 W

Math
for
Success
in
Electronics

Working with Signed Numbers

$$5 + (-7) = -2$$

Prerequisites:

Workbook users should understand:

- *the concept of positive and negative numbers*
- *how to add, subtract, multiply and divide whole numbers*

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Working with Signed Numbers

Focus

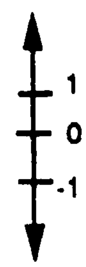
This lesson reviews how to add, subtract, multiply and divide signed numbers.

Job Examples

A job example of when you will use signed numbers is measuring positive and negative voltages.

Key Words

Word	*Explanation*	*Example*
signed number	a negative number or a positive number	-4, -12, 3, 802
number line	a line showing the relationship of signed numbers to each other	<---|-----|-----|-----|-----|---> -2 -1 0 1 2
negative number	a number; written with a minus sign (-) before it	-207, -.05, -15
positive number	a number greater than zero; the plus sign (+) indicates the number is positive; but this is understood and usually not included with the number	+749, +.58892, $+\frac{5}{13}$ or 749, .58892, $\frac{5}{13}$
zero	a digit that has no quantified value	0
sum	the result when adding numbers	2 + 3 5
difference	the result when subtracting numbers	7 - 6 = 1
product	the result when multiplying numbers	4 • 3 = 12
quotient	the result when dividing numbers	8 ÷ 2 = 4



Rules for Working with Signed Numbers

Addition:

- *like* signs: to add numbers with like (same) signs, add the value of the numbers. The sum has the same sign as the numbers added.

  8 + 3 = 11

  (-4) + (-5) = -9
  This can also be written as:
  -4 - 5 = -9

- *unlike* signs: to add numbers with unlike (different) signs, subtract the smaller number from the larger number. The sum has the same sign as the larger number.

  12 + (-4) = 8
  This can also be written as:
  12 - 4 = 8

  5 + (-7) = -2
  This can also be written as:
  5 - 7 = -2

Subtraction:

- like *or* unlike signs: to subtract a signed number, change the sign of the second number and add it to the first number.

  5 - (-2) = 5 + 2 = 7

  (-8) - 1 = (-8) + (-1) = -9

Multiplication:

- *like* signs: multiply the numbers; the product is positive

  4 • 6 = 24

  (-5) • (-3) = 15

- *unlike* signs: multiply the numbers; the product is negative.

  (-6) • 2 = -12

Division:

- *like* signs: divide the numbers; the quotient is positive.

  $100 \div 4 = 25$

  $(-10) \div (-2) = 5$

- *unlike* signs: divide the numbers; the quotient is negative

  $(-8) \div 2 = -4$

Practice Problems

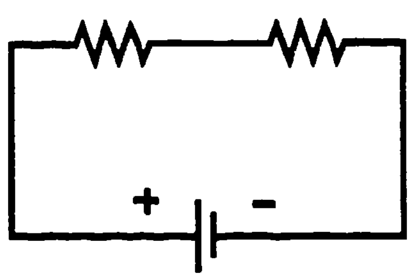
Read each problem and solve for the answer. Answers are provided in the back of this workbook.

Some Practice Problems refer to the following information:

- *current* (I) -- the flow of electrical charge; it is measured in amps (A)
- *voltage* (V) -- electrical force or pressure; it is measured in volts (v)
- to calculate the voltage (V) between two points, the lower value voltage is subtracted from the higher value voltage

1. The time (t) required to charge a certain electronic device is $t = (-2) \cdot (-3)$. What is the time (t)?

2. A *circuit* is electrical components connected together to a power source. The current (I) in a circuit's branch is represented by $I = \frac{-6}{-3}$ A. What is the current (I)?



3. The current (I) in a circuit's branch is represented by $I = \frac{-6}{2}$ A. What is the current (I)?

4. The voltage (V) at point A is -5 volts (v). The voltage at point B is +3 volts (v). What is the difference in voltage between points B and A?

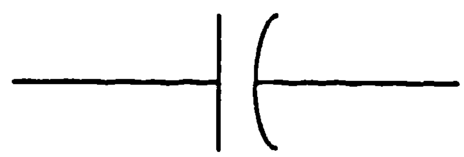
5. Voltage at point A is 7 volts (v). Voltage at point B is -5 volts (v). What is the voltage difference between points A and B?

6. Voltage at point A is 8 volts (v). Voltage at point B is 3 volts (v). What is the voltage difference between points A and B?

7. Voltage at point A is -2 volts (v). Voltage at point B is -8 volts (v). What is the voltage difference between points A and B?

8. Voltage at point A is -3 volts (v). Voltage at point B is 6 volts (v). What is the voltage difference between points A and B?

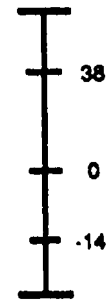
9. A *capacitor* is a device that stores electrical charge. The current (I) of a capacitor is represented by I = -20 • (-2) A. What is I?



10. The temperature increased from -12 °F to 72 °F. What is the increase?

11. The temperature increased from 45 °F to 81 °F. What is the increase?

12. The temperature dropped from 38 °F to -14 °F. What is the drop in temperature?



13. Calculate: 15 - (-3) + (-2) =

14. Calculate: 18 - 12 -(-14) =

Answers

1. $t = (-2) \cdot (-3)$

   $t = 6$ seconds

2. $I = \frac{-6}{-3}$

   $I = 2$ amps

3. $I = \frac{-6}{2}$

   $I = -3$ amps

4. Point A = -5 and Point B = 3

   $3 - (-5) =$

   $3 + (+5) =$

   $3 + 5 = 8$ v

5. Point A = 7 and Point B = -5

   $7 - (-5) =$

   $7 + (+5) =$

   $7 + 5 = 12$ v

6. Point A = 8 and Point B = 3

   $8 - 3 = 5$ v

7. Point A = -2 and Point B = -8

$-2 - (-8) =$

$-2 + (+8) =$

$-2 + 8 = 6$ v

8. Point A = -3 and Point B = 6

$6 - (-3) =$

$6 + (+3) =$

$6 + 3 = 9$ v

9. $I = -20 \bullet (-2)$

$I = 40$ A

10. $72 - (-12) =$

$72 + (+12) =$

$72 + 12 = 84$ degrees

11. $81 - 45 = 36$ degrees

12. $38 - (-14) =$

$38 + (+14) =$

$38 + 14 = 52$ degrees

13. $15 - (-3) + (-2) =$

$15 + (+3) + (-2) =$

$15 + 3 + (-2) =$

$18 + (-2) =$

$18 - 2 = 16$

14. $18 - 12 - (-14) =$

$18 - 12 + (+14) =$

$18 - 12 + 14 =$

$6 + 14 = 20$

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Working with Decimal Numbers

Prerequisites:

Workbook users should understand:

- *the concept of decimal point*
- *the concept of adding, subtracting, multiplying and dividing*
- *how to use a calculator for adding, subtracting, multiplying and dividing*

Acknowledgements

Several people contributed to the development of the **Math for Success in Electronics** books. These individuals include: Georges Lakkis, technical content, editing, pilot testing; Connie DeVantier, design and development; Barbara Skrepnek, development, production, administration; Kristen Luba, Kathleen Gilevich and Nancy Zebko, project administration; Caron Wiesner and Ellen Sudia, formatting, production; James Shearer and Michelle Schiller, cover designs; James Borowski, Brian Diedrich, Nancy Ruetz, Darnell Tolbert and Kelly Smith, technical editing; Bob Tait, technical advising; Jon Morell and Judith Wheeler-Robinson, pilot testing and evaluation; Dale Brandenburg, project management. In addition, numerous Great Lakes Steel - United Steelworkers of America employees and Wayne County Community College students contributed time and valuable suggestions throughout the development process.

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Working with Decimal Numbers

Focus

This lesson reviews how to add, subtract, multiply and divide numbers with decimals.

Job Examples

Job examples of when you will use decimals include:
- selecting resistors
- measuring the length of a part with a specified tool

Key Words

Word	*Explanation*	*Example*
decimal point	a dot between the ones place and tenths place in a number	3.2, 100.24, .6, 78.1
decimal number	a number with a decimal point between the ones place and tenths place	1.3, .5, 24.89, 110.75
decimal place	the postion of a digit in a decimal number	millions, hundred thousands, ten thousands, thousands, hundreds, tens, ones or units, tenths, hundredths, thousandths, ten thousandths 4 . 8 9 6 . 3 2 8 . 9 7 2 1
divisor	a number being divided into another number	.1 ÷ **.6**, **.12**).13, **divisor**)dividend
dividend	a number being divided by another number	**.1** ÷ .6, .12)**.13**, divisor)**dividend**
sum	the result when adding numbers	.2 + .3 = **.5**
difference	the result when subtracting numbers	.7 - .6 = **.1**

product	the result when multiplying numbers	$.4 \bullet .3 = .12$
quotient	the result when dividing numbers	$.8 \div .2 = 4$

Rules for Working with Decimal Numbers

Addition:

3.74 + 32.1

1. Line up the decimal points of the numbers being added.

$$\begin{array}{r} 3.74 \\ \underline{+32.1} \end{array}$$

2. Add zeros as needed to obtain the same number of decimal places in both numbers (a zero added to the right of a decimal number does not change the number's value)

$$\begin{array}{r} 3.74 \\ \underline{+32.10} \end{array}$$

3. Add the numbers without regard to the decimal point(s).

$$\begin{array}{r} 3.74 \\ \underline{+32.10} \\ 3\,5\,8\,4 \end{array}$$

4. Carry the decimal point straight down into sum.

$$\begin{array}{r} 3.74 \\ \underline{+32.10} \\ 35.84 \end{array}$$

Subtraction:

4.5 - 3.26

1. Line up the decimal points of the numbers being subtracted.

$$\begin{array}{r} 4.5 \\ \underline{-3.26} \end{array}$$

2. Add zeros as needed to obtain the same number of decimal places in both numbers (a zero added to the right of a decimal number does not change the number's value)

$$\begin{array}{r} 4.50 \\ \underline{-3.26} \end{array}$$

3. Subtract numbers without regard to the decimal point(s).

$$\begin{array}{r} 4.50 \\ \underline{-3.26} \\ 1\,24 \end{array}$$

4. Carry the decimal point straight down into remainder.

$$\begin{array}{r} 4.50 \\ \underline{-3.26} \\ 1.24 \end{array}$$

Multiplication:

$1.2 \cdot .5$

1. Multiply the numbers without regard to the decimal point(s).

$$\begin{array}{r} 1.2 \\ \underline{x\ .5} \\ 60 \end{array}$$

2. Add together the number of decimal places to the right of the decimal point in each number being multiplied.

1.2 = 1 place to right
<u>.5 = 1 place to right</u>
Total = 2 places to right

3. In the product, place the decimal point that many places (total places from step 2) from the right.

.60
2 places from right

Division:

$8.64 \div 3.2$

1. Set up problem in division format.

$3.2\overline{)8.64}$

2. Move the decimal point in the *divisor* all the way to the right. Count the number of places the decimal point moves to the right.

$3.2\overline{)8.64}$
1 place to right

3. Move the decimal point in the *dividend* to the right the same number of places as divisor decimal was moved.

$32\overline{)8.64}$
1 place to right

4. Move the decimal point in the *dividend* straight up to position it in the quotient.

$32\overline{)86.4}$

5. Divide.

$$\begin{array}{r} 2.7 \\ 32\overline{)86.4} \end{array}$$

Practice Problems

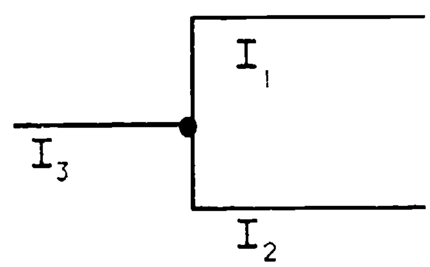
Read each problem and solve for the answer. Answers are provided in the back of this workbook.

Some Practice Problems refer to the following information:

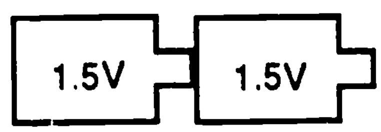
- *resistance* (R) -- the ability of a device, material or component to oppose the flow of electric current; it is measured in ohms (Ω)
- *current* (I) -- the flow of electrical charge; it is measured in amps (A)
- *voltage* (V) -- electrical force or pressure; it is measured in volts (v)

1. In an electric circuit the *total resistance* of two components connected in series (end to end) is the sum of both component resistances. If the first component has a resistance of 2.2 Ω and the second has a resistance of 4.7 Ω, what is the total resistance?

2. A particular current I_3, is the sum of two other currents, I_1 and I_2. If I_1 is .68 A and I_2 is 1.2 A, what is I_3?



3. When dry cell batteries are connected as in the drawing, their voltages add to obtain the total voltage. What is the total voltage of the two dry cells if each has 1.5 volts (V)?



4. In a particular electric circuit, the current (I) is 1.2 A and the resistance (R) is 4.7 Ω. What is the voltage (V) in the circuit if $V = I \cdot R$?

5. In electrical components, the current (I) is calculated by dividing the voltage (V) by the resistance (R). This is written as $I = \frac{V}{R}$. If a particular circuit has a voltage of 1.5 V and a resistance of 3 Ω. What is the current (I)?

6. In an electrical component, the current (I) is calculated by dividing the voltage (V) by the resistance (R). This is written as $I = \frac{V}{R}$. Calculate I if V = 4.5 V and R = 1.5 Ω.

7. To calculate the speed (v) of an object, the distance (x) traveled by the object is divided by the travel time (t) of the object. This is written as $v = \frac{x}{t}$. If x = 3.5 feet (ft) and t = .7 seconds (s), calculate v in feet per second.

8. What is the total volume of lubricating oil from *five* bottles, when each bottle contains .75 liters of lubricating oil?

9. Two trucks are carrying steel. One is carrying 17.36 tons of steel and the other is carrying 23.94 tons of steel. What is the total steel load of the two trucks?

10. In a machine shop, a piece of pipe is 1.53 meters long. From this pipe, you want to cut a piece 1.2 meters long. What length of pipe will remain?

Answers

1. $$\begin{array}{r} 2.2 \\ \underline{4.7} \\ 6.9\ \Omega \end{array}$$

2. $$\begin{array}{r} 1.2 \\ \underline{.68} \\ 1.88\ \text{A} \end{array}$$

3. $$\begin{array}{r} 1.5 \\ \underline{1.5} \\ 3.0\ \text{v} \end{array}$$

4. $V = 1.2 \cdot 4.7 = 5.64$ volts

5. $I = \frac{1.5}{3} = .5\ \text{A}$

6. $I = \frac{4.5}{1.5} = 3\ \text{A}$

7. $v = \frac{3.5\text{ft}}{.7\text{s}} = 5\ \text{ft/s}$

8. $.75 \cdot 5 = 3.75$ liters

9. $$\begin{array}{r} 23.94 \\ \underline{17.36} \\ 41.30\ \text{tons} \end{array}$$

10. $$\begin{array}{r} 1.53 \\ \underline{-1.2\ } \\ 0.33\ \text{meter} \end{array}$$

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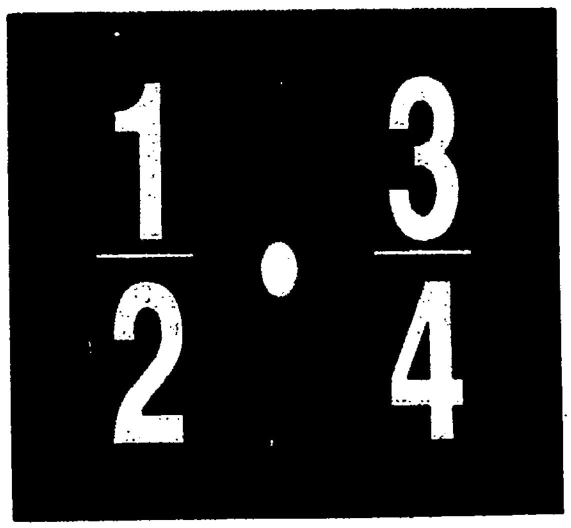
Working with Fractions



Prerequisites:

Workbook users should understand

- *the concept of adding, subtracting, multiplying and dividing*
- *the concept of fractions*

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Working with Fractions

Focus

This lesson reviews how to add, subtract, multiply and divide fractions.

Job Examples

Job examples of when you will use fractions include:

- calculating the voltage output of transformers
- calculating the mechanical advantage of various tools
- calculating the current in parallel circuits
- calculating the voltage in series circuits

Key Words

Word	***Explanation***	***Example***
fraction	two numbers separated by a fraction bar; the top number is the *numerator*, the bottom number is the *denominator*.	$\frac{4}{5}, \frac{6}{12}, \frac{6}{8}, \frac{7}{2}$
numerator	the top number of a fraction	$\frac{1}{5}, \frac{4}{6}, \frac{3}{8}, \frac{2}{5}$
denominator	the bottom number of a fraction	$\frac{3}{4}, \frac{2}{3}, \frac{34}{50}, \frac{12}{65}$
proper fraction	a fraction with a numerator (top number) smaller than the denominator (bottom number)	$\frac{2}{5}, \frac{5}{9}, \frac{101}{209}, \frac{23}{51}$
improper fraction	a fraction representing a number larger than one; the numerator (top number) is *larger* than the denominator (bottom number)	$\frac{3}{2}, \frac{9}{4}, \frac{23}{4}, \frac{54}{13}$

common denominator	a denominator (bottom number) that is the same in two or more fractions	$\frac{1}{6}, \frac{3}{6}, \frac{5}{6}$
reciprocal	one divided by a number	$\frac{1}{9}$ is the reciprocal of $\frac{9}{1}$
mixed number	a number consisting of a whole number and a fraction	$53\frac{1}{4}, 8\frac{1}{2}$
sum	the result when adding numbers	$\frac{1}{5} + \frac{2}{5} = \frac{3}{5}$
difference	the result when subtracting numbers	$\frac{8}{9} - \frac{1}{9} = \frac{7}{9}$
product	the result when multiplying numbers	$\frac{1}{25} \cdot \frac{1}{4} = \frac{1}{100}$
quotient	the result when dividing numbers	$\frac{9}{36} \div \frac{1}{3} = \frac{3}{4}$

Rules for Working with Fractions

Addition:

- For *Proper and/or Improper Fractions*:

1. Change the fractions as necessary to find a common denominator. $\frac{1}{5} + \frac{3}{10} = \frac{2}{10} + \frac{3}{10}$

2. Add the numerators (the denominators do not change). $\frac{2}{10} + \frac{3}{10} = \frac{5}{10}$

3. Reduce the result fraction if possible. $\frac{5}{10} = \frac{1}{2}$

- For *Mixed Numbers*:

1. Find a common denominator for the fractions. $2\frac{3}{4} + 5\frac{1}{2} = 2\frac{3}{4} + 5\frac{2}{4}$

2. Change the mixed numbers to improper fractions. $2\frac{3}{4} + 5\frac{2}{4} = \frac{11}{4} + \frac{22}{4}$

3. Add the numerators (the denominators do not change). $\frac{11}{4} + \frac{22}{4} = \frac{33}{4}$

4. Reduce the result fraction or convert it to a mixed number. $\frac{33}{4} = 8\frac{1}{4}$

Subtraction:

- For *Proper and/or Improper Fractions*:

1. Find a common denominator.

   $\frac{7}{8} - \frac{1}{2} = \frac{7}{8} - \frac{4}{8}$

2. Subtract the numerators
   (the denominators do not change).

   $\frac{7}{8} - \frac{4}{8} = \frac{3}{8}$

3. Reduce the result fraction or
   change it to a mixed number.

   $\frac{3}{8}$
   (The result fraction is already in its lowest form.)

- For *Mixed Numbers*:

1. Find a common denominator.

   $2\frac{2}{3} - 1\frac{1}{2} = 2\frac{4}{6} - 1\frac{3}{6}$

2. Change the mixed numbers to improper fractions.

   $2\frac{4}{6} - 1\frac{3}{6} = \frac{16}{9} - \frac{9}{6}$

3. Subtract the numerators
   (the denominators do not change).

   $\frac{16}{6} - \frac{9}{6} = \frac{7}{6}$

4. Reduce the result fraction or
   change it to a mixed number.

   $\frac{7}{6} = 1\frac{1}{6}$

Multiplication:

- For *Proper and/or Improper Fractions*:

 1. Multiply the numerators; multiply the denominators. $\frac{2}{5} \cdot \frac{5}{4} = \frac{10}{20}$

 2. Reduce the result fraction to its lowest form. $\frac{10}{20} = \frac{1}{2}$

- For *Mixed Numbers*:

 1. Change the mixed numbers to improper fractions. $2\frac{2}{3} \cdot 5\frac{1}{2} = \frac{8}{3} \cdot \frac{11}{2}$

 2. Multiply the numerators; multiply the denominators. $\frac{8}{3} \cdot \frac{11}{2} = \frac{88}{6}$

 3. Reduce the result fraction or change to a mixed number. $\frac{88}{6} = 14\frac{4}{6} = 14\frac{2}{3}$

(SHORTCUT: If possible, reduce fractions before multiplying. This way, you work with smaller numbers.)

Division:

- For *Proper and/or Improper Fractions*:

1. Change the second fraction to its reciprocal; change the division sign to a multiplication sign. $\frac{4}{5} \div \frac{2}{6} = \frac{4}{5} \cdot \frac{6}{2}$
2. Multiply the numerators; multiply the denominators. $\frac{4}{5} \cdot \frac{6}{2} = \frac{24}{10}$
3. Reduce the result fraction or change to a mixed number. $\frac{24}{10} = \frac{12}{5} = 2\frac{2}{5}$

- For *Mixed Numbers*:

1. Change mixed numbers to improper fractions. $2\frac{1}{2} \div 1\frac{1}{3} = \frac{5}{2} \div \frac{4}{3}$
2. Change the second fraction to its reciprocal change the division sign to a multiplication sign. $\frac{5}{2} \div \frac{4}{3} = \frac{5}{2} \cdot \frac{3}{4}$
3. Multiply the numerators; multiply the denominators. $\frac{5}{2} \cdot \frac{3}{4} = \frac{15}{8}$
4. Reduce the result fraction or change it to a mixed number. $\frac{15}{8} = 1\frac{7}{8}$

(SHORTCUT: If possible, reduce fractions before multiplying. This way, you work with smaller numbers.)

Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

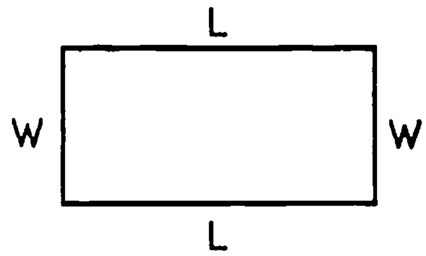
1. In a machine shop, three sheets of metal are $\frac{3}{8}$ inch, $\frac{1}{4}$ inch, and $\frac{5}{16}$ inch in thickness. What is the total thickness of these metal sheets when they are placed on top of each other?

2. $2\frac{3}{4}$ gallons of oil for lubricating motors are to be added to $3\frac{1}{2}$ gallons of oil. What will the total amount of oil be?

3. You need to solder electrical circuits. If you use $\frac{1}{4}$ lb. of solder from a roll of $1\frac{3}{8}$ lbs., what would the remaining weight of the roll be?

4. In a machine shop, you want to cut $2\frac{7}{16}$ inches in length from a 6 inch length of metal. What will the length of the remaining piece be?

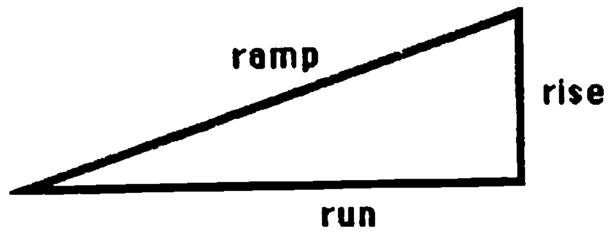
5. The area of a rectangle is calculated by multiplying its length (L) by its width (W). What is the area of a rectangle with a length (L) of $\frac{3}{4}$ inch and a width (W) of $\frac{1}{8}$ inch?



6. What is the area of a rectangle if $L = 4\frac{1}{4}$ inch and $W = \frac{3}{4}$ inch?

7. The area of a rectangle is $3\frac{3}{4}$ square inch, its width is $1\frac{1}{4}$ inch. Calculate its length. *(Hint: length = area ÷ width.)*

8. The slope (steepness) of a ramp is calculated by dividing the rise by the run (slope = rise ÷ run). Calculate the slope if the rise is $1\frac{3}{4}$ ft. and the run is $5\frac{3}{8}$ ft.



9. In a circuit, current (I) is the flow of electrical charge. Current is measured in amps (A). If one current (I_1) is $1\frac{1}{2}$ A, and a second current (I_2) is $\frac{3}{4}$ A, what is the sum of these two currents?

10. Two opposing electric currents are I_1 and I_2. $I_1 = 8\frac{3}{4}$ A and $I_2 = 2\frac{3}{8}$ A. Subtract I_2 from I_1.

Answers

1. $\frac{3}{8} + \frac{1}{4} + \frac{5}{16} =$

   $\frac{6}{16} + \frac{4}{16} + \frac{5}{16} =$

   $\frac{15}{16}$ inch

2. $2\frac{3}{4} + 3\frac{1}{2} =$

   $2\frac{3}{4} + 3\frac{2}{4} =$

   $\frac{11}{4} + \frac{14}{4} =$

   $\frac{11+14}{4} = \frac{25}{4} =$

   $6\frac{1}{4}$ gallons

3. $1\frac{3}{8} - \frac{1}{4} =$

   $1\frac{3}{8} - \frac{2}{8} =$

   $\frac{11}{8} - \frac{2}{8} =$

   $\frac{11-2}{8} = \frac{9}{8} =$

   $1\frac{1}{8}$ lbs.

4. $6 - 2\frac{7}{16} =$

$\frac{96}{16} - \frac{39}{16} =$

$\frac{96-39}{16} =$

$3\frac{9}{16}$ inches

5. Area $= \frac{3}{4} \cdot \frac{1}{8} = \frac{3}{32}$ square inch

6. $4\frac{1}{4} \cdot \frac{3}{4} =$

$\frac{17}{4} \cdot \frac{3}{4} =$

$\frac{51}{16} =$

$3\frac{3}{16}$ square inches

7. length $= 3\frac{3}{4} \div 1\frac{1}{4} =$

$\frac{15}{4} \div \frac{5}{4} =$

$\frac{15}{4} \cdot \frac{4}{5} =$

$\frac{60}{20} = 3$ inches

8. slope $= 1\frac{3}{4} \div 5\frac{3}{8} =$

$1\frac{6}{8} \div 5\frac{3}{8} =$

$\frac{14}{8} \div \frac{43}{8} =$

$\frac{14}{8} \bullet \frac{8}{43} =$

$\frac{14}{1} \bullet \frac{1}{43} =$

$\frac{14}{43}$

9. sum $= 1\frac{1}{2} + \frac{3}{4} =$

$1\frac{2}{4} + \frac{3}{4} =$

$\frac{6}{4} + \frac{3}{4} =$

$\frac{9}{4} = 2\frac{1}{4}$ A

10. $I_1 - I_2 =$

$8\frac{3}{4} - 2\frac{3}{8} =$

$\frac{70}{8} - \frac{19}{8} =$

$\frac{51}{8} = 6\frac{3}{8}$ A

Math
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How to Convert Fractions and Decimal Numbers

$$.5 = \frac{1}{2}$$

Prerequisites:

Workbook users should understand:

- *the concept of fractions*
- *how to multiply and divide fractions*
- *how to reduce fractions*
- *the concept of decimal numbers*
- *how to add decimal numbers*
- *that a fraction can be represented as a decimal number*
- *that a decimal number can be represented as a fraction*

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How to Convert Fractions and Decimal Numbers

Focus

This lesson explains how to change a fraction into a decimal number and a decimal number into a fraction.

Job Examples

Job examples of when you will convert a fraction to a decimal number or a decimal number to a fraction are:

- selecting resistor values
- measuring the length of a part

Key Words

Word	*Explanation*	*Example*
convert	to change to a different form	.5 is equal to $\frac{1}{2}$ $\frac{75}{100}$ is equal to .75
fraction	two numbers separated by a fraction bar; top number is *numerator*, the bottom number is the *denominator*.	$\frac{1}{9}$, $\frac{3}{8}$, $\frac{17}{19}$
numerator	the top number of a fraction	$\frac{a}{b}$
denominator	the bottom number of a fraction	$\frac{6}{7}$
proper fraction	a fraction with a numerator (top number) smaller than the denominator (bottom number)	$\frac{1}{3}$, $\frac{19}{20}$, $\frac{3}{4}$

mixed number	a number consisting of a whole number and a fraction	$5\frac{3}{4}$, $8\frac{6}{7}$
decimal number	a number with a decimal point between the ones place and tenths place	1.0, 0.95, 5.33
decimal point	a dot between the ones place and tenths place in a number	3.2, 100.24, .6
decimal place	the position of a digit in a decimal number	millions, hundred thousands, ten thousands, thousands, hundreds, tens, ones or units, tenths, hundredths, thousandths, ten thousandths 4 , 8 9 6 , 3 2 8 . 9 7 2 1

How to Convert Fractions to Decimal Numbers

The goal of converting fractions and decimal numbers is to change the fraction or the decimal number into a more convenient form for reading, measuring or comparing.

> ***Example 1:*** A *Multimeter* is a meter that measures volts (v), amps (A), and ohms (Ω). A circuit's manual states that the meter should read $\frac{1}{2}$ amp (A). The meter shows readings in decimal numbers. What decimal number should the meter show to be equal to $\frac{1}{2}$ A?

1.	Write the fraction without the unit.	$\frac{1}{2}$
2.	Divide the numerator (top number) by the denominator (bottom number).	$2\overline{)1.0}$ = 0.5
3.	Write the answer from step 2 with the unit.	.5 A

The meter should show .5 A.

Sometimes you will need to convert a mixed number to a decimal number:

> ***Example 2:*** A circuit's manual states that the Multimeter should read $2\frac{1}{2}$ amps (A). The meter shows readings in decimal numbers. What decimal number should the meter show to be equal to $2\frac{1}{2}$ A?

To convert a mixed number:

1.	Set the whole number of the fraction aside temporarily.	**2** is the whole number in $2\frac{1}{2}$ A
2.	Write the fraction without the unit.	$\frac{1}{2}$
3.	Divide the numerator (top number) by the denominator (bottom number).	$2\overline{)1.0}$ = 0.5
4.	Add the whole number back in.	2.5
5.	Write the answer from step 4 with the unit.	2.5 A

The meter should show 2.5 A

How to Convert Decimal Numbers to Fractions

> ***Example 1:*** A blueprint design specifies a clearance of .125 inch. Convert this to a fraction so that you can measure the clearance with a tape measure.

1. In the decimal number, move the decimal point all the way to the right of the number. Count the number of decimal places the decimal moves to the right.

   .125 = 3 decimal places

2. Create a fraction (with a denominator of a multiple of 10). The number of zeros in the denominator equals the number of places the decimal was moved to the right.

   3 decimal places = 3 zeros in denominator

   $\frac{125}{1000}$

3. Reduce the fraction.

   $\frac{125}{1000} = \frac{25}{200} = \frac{5}{40} = \frac{1}{8}$

   $.125 = \frac{1}{8}$

Sometimes you will need to convert a decimal number with a whole number to a fraction:

> ***Example 2:*** A blueprint design specifies a clearance of 5.125 inches. Convert this to a fraction so that you can measure the clearance with a tape measure.

1. Set the whole number of the fraction aside temporarily.

   5 is the whole number in 5.125

2. In the decimal number, move the decimal point all the way to the right of the number. Count the number of decimal places the decimal moves to the right.

   .125 = 3 decimal places

3. Create a fraction (with a denominator of a multiple of 10). The number of zeros in the denominator equals the number of places the decimal was moved to the right.

   3 decimal places = 3 zeros in denominator

   $\frac{125}{1000}$

4. Reduce the fraction.

   $\frac{125}{1000} = \frac{25}{200} = \frac{5}{40} = \frac{1}{8}$

   $.125 = \frac{1}{8}$

5. Add the whole number back in.

   $5\frac{1}{8}$

Practice Problems

Read each problem and solve for the answers. Answers are provided in the back of this workbook.

1. A *resistor* is a device that controls the current and/or voltage in a circuit. You need a resistor that operates at .38 watt (W) or higher. In storage, there are 4 resistors; they operate at $\frac{1}{8}$ W, $\frac{1}{4}$ W and $\frac{1}{2}$ W. Which one will you choose?

2. *Milling* refers to grinding an object to change or reduce its size. You need to mill a metal bar to .437" in thickness. Metal bars of $\frac{3}{4}$", $\frac{3}{8}$", $\frac{1}{2}$", $\frac{5}{8}$" in thickness are available for milling. Which size bar should you use? *(Hint: the correct bar will not be exact; it will be a bit larger than .437).*

3. A few mechanical parts are hooked up together in a line. These parts individually measure $5\frac{1}{8}$", $4\frac{3}{8}$", $2\frac{1}{2}$", and 6". What is the total length of these parts in a decimal form?

4. A *wave* is a shape that repeats periodically. A *period* is the time of one wave. A particular wave has a period of $\frac{1}{50}$ second. Convert this to a decimal number.

5. A *wave* is a shape that repeats periodically. A *period* is the time of one wave. A particular wave has a *period* of .01 second. Convert this to a fraction.

6. *Conductance* is the degree to which wires and components conduct electrical current. The conductance of a particular component is $\frac{1}{20}$. Convert this to a decimal number.

7. *Power*, in general, is energy delivered or consumed per second; it is measured in watts (W). The power of a particular circuit is $\frac{3}{4}$ watt (W). Convert this to a decimal number.

8. An unmarked drill bit is measured with a caliper. The bit has .125 inch diameter. Standard bit sizes are represented in fraction form. What bit size (in fraction form) is this?

9. A piece of pipe of 17.375" is needed. The cutting machine cuts exact to the 1/8". Find the length in fraction form to the nearest $\frac{1}{8}$".

10. A machine part was measured with a caliper. The part is 1.75 inches. Convert this to a fraction.

11. A conduit is a pipe for encasing electrical wires. A piece of conduit is 12.4 feet long. Convert this to a fraction.

12. A roll of wire is 1.4 miles long. Convert this to a fraction.

13. *Power rating* is the highest power at which a device can operate. The power rating of a particular device is 2.25 watts (W). Convert this to a fraction.

14. A particular battery has 1.5 volts (v). Convert this to a fraction.

15. A *Multimeter* is a meter that measures volts (v), amps (A), and ohms (Ω). A particular Multimeter reads 1.47 A. Change this to a fraction.

16. A fixture needs to be placed 3.75 inches from the wall. Change this to a fraction so that a tape measure may be used for properly placing the fixture.

Answers

1. $\frac{1}{8} = .125$, $\frac{1}{4} = .25$, $\frac{1}{2} = .5$

   .125 W and .25 W are lower than the .38 W needed. Therefore, .5 W is the rating you should chose.

2. $\frac{3}{4} = .75$, $\frac{3}{8} = .375$, $\frac{1}{2} = .5$, and $\frac{5}{8} = .625$

   .375" is too small. .75" and .625" are too large. .5" is the one closest to the size you need (.457"), being just a bit larger. Therefore, .5" is the thickness to use.

3. $5\frac{1}{8} + 4\frac{3}{8} + 2\frac{1}{2} + 6 =$

   $5.125 + 4.375 + 2.5 + 6 = 18$"

4. $\frac{1}{50} = \frac{2}{100} = .02$ second

5. F = .01

   $F = .01 = \frac{1}{100}$ second

6. Conductance $= \frac{1}{20} = \frac{5}{100} = .05$

7. $\frac{3}{4} = \frac{75}{100} = .75$ W

8. $.125 = .125 \cdot \frac{16}{16} = \frac{2}{16} = \frac{1}{8}$

The bit size is $\frac{1}{8}$ inch.

9. 17.375

Set the whole n...nber (17) aside.

$.375 = \frac{375}{1000} = \frac{15}{40} = \frac{3}{8}$

Add the whole number (17) back in.

The length is $17\frac{3}{8}$".

10. 1.75

Set the whole number (1) aside.

$.75 = \frac{75}{100} = \frac{3}{4}$

Add the whole number (1) back in.

The measurement is $1\frac{3}{4}$ inches.

11. 12.4 feet

Set the whole number (12) aside.

$.4 = \frac{4}{10} = \frac{2}{5}$

Add the whole number (12) back in.

The conduct is $12\frac{2}{5}$ feet long.

12. 1.4 miles

Set the whole number (1) aside.

$.4 = \frac{4}{10} = \frac{2}{5}$

Add the whole number (1) back in.

The wire is $1\frac{2}{5}$ miles long.

13. 2.25 W

Set the whole number (2) aside.

$.25 = \frac{25}{100} = \frac{1}{4}$

Add the whole number (2) back in.

The power rating is $2\frac{1}{4}$ W.

14. 1.5 V

Set the whole number (1) aside.

$.5 = \frac{5}{10} = \frac{1}{2}$

Add the whole number back in.

The battery has $1\frac{1}{2}$ v.

15. 1.47 A

Set whole number (1) aside.

$.47 = \frac{47}{100}$

Add whole number back in.

The meter reads $1\frac{47}{100}$ A.

16. 3.75 inches

Set whole number (3) aside.

$.75 = \frac{75}{100} = \frac{3}{4}$

Add whole number back in.

The measurement is $3\frac{3}{4}$ inches.

Math
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Working with Percents

$$70\% = \frac{70}{100}$$

Prerequisites:

Workbook users should understand:

- *how to use a calculator for adding, subtracting, multiplying and dividing*
- *the concept of fractions*
- *the concept of decimal numbers*
- *how to convert fractions and decimal numbers*
- *how to convert fractions and percents*

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Working with Percents

Focus

This lesson reviews how to work with percents by identifying the *part, percent and whole* in percent problems.

Job Examples

Job examples of when you will work with percents include:
- calculating the tolerance of resistors
- calculating the maximum voltage allowed for a capacitor

Key Words

Word	*Explanation*	*Example*
fraction	two numbers separated by a fraction bar the top number is the *numerator*, the bottom number is the *denominator*.	$\frac{1}{3}$, $\frac{5}{4}$, $\frac{9}{100}$
proper fraction	a fraction with a numerator (top number) smaller than the denominator (bottom number)	$\frac{2}{5}$, $\frac{7}{100}$, $\frac{83}{100}$
part	a portion of · whole; can be represented by a numerator (top number) in a proper fraction	$\frac{7}{8}$ = 7 parts of 8
percent	a fraction with a denominator (bottom number) of 100; % is the symbol for percent	70% = $\frac{70}{100}$ 120% = $\frac{120}{100}$
whole	the total number of parts	20%, 30% and 50% = 100% 100% is the whole

Rules for Working with Percents

Every percent problem has information that identifies a *part, percent, and/or whole.* Use the information given in the problem to find the information you need.

part = percent • whole $\quad$ **percent = $\frac{\text{part}}{\text{whole}}$ • 100** $\quad$ **whole = $\frac{\text{part}}{\text{percent}}$**

To Find the Part:

A roll of cable is 200 lbs.
How many pounds are 80% of the roll?

1. Identify the percent; change the percent to a decimal.

   percent = 80 = $\frac{80}{100}$ = .8

2. Identify the whole.

   whole = 200 lbs.

3. Multiply the decimal value of the percent and whole.

   percent • whole = .8 • 200 = 160 lbs.
   80% of 200 = 160 lbs.

To Find the Percent:

A roll of cable in 200 lbs.
160 lbs. is what percent of 200?

1. Identify the part.

   part = 160 lbs.

2. Identify the whole.

   whole = 200

3. Divide the part *by* the whole and multiply by 100.

   $\frac{\text{part}}{\text{whole}} \cdot 100 = \frac{160}{200} \cdot 100 = 80$

4. Add a percent sign to the resulting answers.

   80%
   160 is 80% of 200

To Find the Whole:

160 lbs. is 80% of a roll of cable.
How many pounds is the roll?

1. Identify the part.

   part = 160 lbs.

2. Identify the percent.

   percent = 80% or .8

3. Divide the part *by* the decimal of the percent.

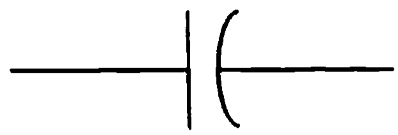
   $\frac{\text{part}}{\text{percent}} = \frac{160}{.8} = \frac{1600}{8} = 200$ lbs.

   160 lbs. is 80% of 200 lbs.

Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

1. A *capac·tor* is a device that stores electrical charge and releases it upon demand. A certain capacitor can be charged to 10 volts maximum. It is presently charged to 60% of its capacity. What is the present voltage of the capacitor? (*Hint: find the part.*)



2. An electric motor is rotating at a speed of 900 rpm (revolutions per minu' .). This speed is 50% of the motor's maximum speed. What is the maximum speed?

3. *Current* is the flow of electrical charge. Current is measured in amps (A). The current in a particular circuit is 3 A, which is 60% of its original value. What was the original value?

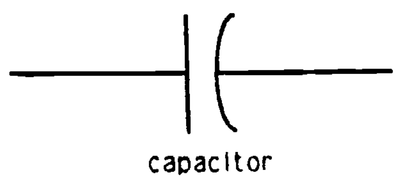
4. A 200 gallon container of lubricating oil is 75% full. How much oil is in the container?

5. In a shipment of 8000 electronic parts, 400 parts are expected to fail within 1000 hours of operation. What percent of the parts are expected to fail?

6. A particular electric motor is receiving 2000 watts (W) of electrical power. 1700 watts (W) are converted to mechanical energy; the remaining watts (W) are converted to heat. What is the percentage of power converted to mechanical energy?

7. A particular electric motor is receiving 2000 watts (W) of electrical power. Nine percent of this electrical power is converted to heat. How much power is converted to heat?

8. A *capacitor* is a device that stores electrical charge. A particular capacitor is presently charged to 15 volts (v); this is 75% of the capacitor's maximum capacity. What is the maximum capacity of this capacitor?



9. A 50 gallon tank of oil is filled to 60% of its capacity. How much oil is in the tank?

Answers

1. percent = 60% or .6
whole = 10
$.6 \cdot 10 = 6$ volts

2. part = 900
percent = 50% or .5
$\frac{900}{.5} = \frac{90,000}{50} = 1800$ rpm

3. part = 3
percent = 60% or .6
$\frac{3}{.6} = \frac{30}{6} = 5$ A

4. percent = 75% or .75
whole = 200
$.75 \cdot 200 = 150$ gallons

5. part = 400
whole = 8000
$\frac{400}{8000} \cdot 100 = 5\%$

6. part = 1700
whole = 2000
$\frac{1700}{2000} \cdot 100 = 85\%$

7. percent = 9% or .09
whole = 2000
$.09 \cdot 2000 = 180$ W

8. part = 15
percent = 75% or .75
$\frac{15}{.75} = \frac{1500}{75} = 20$ V

9. percent = 60% or .6
whole = 50
$.6 \cdot 50 = 30$ gallons

Math
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How to Convert Fractions and Percents

$$\frac{1}{2} = 50\%$$

Prerequisites:

Workbook users should understand:

- *how to convert fractions and decimal numbers*
- *the concept of percents*
- *how to reduce fractions*
- *how to solve linear equations*
- *how to use order of operation*

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H. to Convert Fractions and Percents

Focus

This lesson reviews how to change a fraction to a percent and how to change a percent to a fraction.

Job Examples

Job examples of when you will convert fractions and percents include:

- selecting resistor values
- measuring the length of a part with a specified tolerance

Key Words

Word	*Explanation*	*Example*
fraction	two numbers separated by a fraction bar; the top number is the *numerator*, the bottom number is the *denominator*	$\frac{1}{3}$, $\frac{5}{4}$, $\frac{9}{100}$
decimal number	a number with a decimal point between the ones place and tenths place	1.3, .5, 24.89, 110.75
decimal point	a dot between the ones place and tenths place in a number	3.2, 100.24, .6, 78.1
percent	a fraction with a denominator of 100; % is the symbol for percent	$70\% = \frac{70}{100}$ $120\% = \frac{120}{100}$

How to Convert Fractions to Percents

The goal of converting a fraction to a percent is to change the fraction into a more convenient form for reading, measuring or comparing.

> ***Example:*** The efficiency of a transformer is calculated by its power output divided by its power input. A specific transformer has a power input of 5 Kilowatts. Its power output is 4 Kilowatts. You need to know the transformer's percentage of efficiency.

1. Change the fraction to a decimal number. $\frac{4}{5} = .8$

2. Multiply decimal number from step 1 by 100%. (Do this by moving the decimal point two places to the right and adding a percent sign)

   .8
   $.8 \cdot 100\%$
   80. or 80%

How to Convert Percents to Fractions

> ***Example:*** A piece of metal is one inch thick. You need to reduce the thickness of the metal to 75% of its present thickness. You want to convert the percent to a fraction in order to measure the thickness of the metal with a tape measure.

1. Remove the percent sign and divide by 100.

   75%
   $\frac{75}{100}$

2. Reduce the fraction if necessary. $\frac{75}{100} = \frac{3}{4}$

   The reduced metal thickness is $\frac{3}{4}$ inch.

Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

1. *Efficiency* is calculated by $\frac{\text{power output}}{\text{power input}} \cdot 100\%$. An electric motor receives 800 watts (W) of electric power and produces 600 watts (W) of mechanical power (200 W are wasted). Calculate the efficiency (mechanical power produced). This is represented as $\frac{600}{800} \cdot 100\%$.

2. Some electronic devices have voltage ratings. For safe operation, the actual voltage of an electronic device should be no more than 80% of its voltage rating.

   A particular electronic device has a voltage rating of 30 volts (v). When this device was turned on, its voltage was 21 volts (v). You need to represent the 21 v as a percentage to see if the device is operating at a safe level.

3. Two motors together consume 1500 watts (W) of power. The first motor consumes 600 W and the second motor consumes 900 W. What is the percentage of power consumed by each motor?

4. You are periodically monitoring the resistance of wire insulation in a motor. The resistance has dropped from 5 Megaohms (MΩ) to 3 Megaohms (MΩ). What is the percentage that the resistance dropped? This is calculated by $\frac{\text{difference}}{\text{original value}} \cdot 100\%$.

5. Ten pumps are used for a certain pumping operation. However, you now need to reduce the pumping to 60% of its original value. How many pumps (in fraction form) will remain in operation?

6. Percent increase is calculated by $\frac{\text{difference}}{\text{original value}} \cdot 100\%$. The production of a certain machine was increased from 180 units a day to 200 units a day. What is the percent increase in this machine's units?

7. A certain machine, at full capacity, holds one gallon of lubrication oil. You need to fill the machine with oil to 75% of its capacity. How many gallons of oil (in fraction form) will you add to the machine?

8. Percent (%) error is calculated by $\frac{\text{difference}}{\text{original value}} \cdot 100\%$. A resistance has a manufactured value of 1000 ohms (Ω). It was measured at 1100 ohms (Ω). What is the % error? *(Hint: the manufactured value is the original value.)*

9. Percent (%) efficiency is $\frac{\text{output}}{\text{input}} \cdot 100\%$. What is the % efficiency of a pump receiving (input) 2000 watts (W) of electrical power and producing (output) 1700 watts (W) in mechanical power?

Answers

1. $\frac{600}{800} = \frac{6}{8} = .75$

   $.75 \cdot 100\% = 75\%$

2. $\frac{21}{30} = \frac{7}{10} = .7$

   $.7 \cdot 100\% = 70\%$ (Yes, it is at a safe level.)

3. 1st motor: $\frac{600}{1500} = \frac{6}{15} = \frac{2}{5} = .4$

   $.4 \cdot 100\% = 40\%$

   2nd motor: $\frac{900}{1500} = \frac{9}{15} = \frac{3}{5} = .6$

   $.6 \cdot 100\% = 60\%$

4. drop = 5 MΩ - 3 MΩ = 2 MΩ

   $\frac{2}{5} = .4$

   $.4 \cdot 100\% = 40\%$

5. $60\% = \frac{60}{100} =$

   $\frac{6}{10}$ or six out of ten pumps are needed

6. difference = 200 - 180 = 20

$$\frac{20}{180} = \frac{2}{18} = \frac{1}{9} = .11$$

$.11 \cdot 100\% = 11\%$

7. $75\% = \frac{75}{100} =$

$\frac{3}{4}$ gallon

8. $\frac{100}{1000} = .1$

$.1 \cdot 100\% = 10\%$

9. $\frac{1700}{2000} = \frac{17}{20} = .85$

$.85 \cdot 100\% = 85\ \%$

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Practice Calculations with Fractions, Decimal Numbers and Percents

$$.5 = \frac{1}{2} = 50\%$$

Prerequisites:

Workbook users should understand how to:

- *convert fractions and decimal numbers*
- *convert fractions and percents*
- *convert decimal numbers and percents*
- *solve linear equations*
- *use order of operations*

Acknowledgements

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Practice Calculations with Fractions, Decimals and Percents

Focus

This lesson presents practice problems for calculating the unknown value in equations with fractions, decimals and percents.

Job Examples

Job examples of when you will calculate equations with fractions, decimals and percents include:

- selecting resistor values
- measuring the length of a part with a specified tolerance

Key Words

Word	*Explanation*	*Example*
equality	two mathematical quantities separated by an equal sign (=); the equal sign means the two quantities are equal	$.2 + .3 = .5$ $\frac{1}{4} + \frac{1}{2} = \frac{3}{4}$
equation	an equality with numbers and unknown values	$a + b = c$ $3 + 5 = 8$
fraction	two numbers separated by a fraction bar; the top number *is the numerator, the bottom* number is the *denominator*	$\frac{1}{x}$ or $\frac{2}{3}$ or $\frac{y}{z}$
numerator	the top number of a fraction	$\frac{\mathbf{a}}{b}$
denominator	the bottom number of a fraction	$\frac{6}{\mathbf{7}}$

reciprocal	one divided by a number	$\frac{1}{9}$ is the reciprocal of $\frac{9}{1}$
decimal number	a number with a decimal point between the ones place and tenths place	1.0 or 0.95 or 5.33
percent	a fraction with a denominator (bottom number) of 100; % is the symbol for percent	$70\% = \frac{70}{100}$
unknown value	a letter in an equation with a value that is not stated	$\frac{7}{10} + \frac{x}{5} = \frac{20}{10}$ $\frac{a}{z} \cdot \frac{5}{6} = \frac{1}{3}$ $\frac{5}{7} + \frac{y}{3} + \frac{z}{2} = \frac{1}{2} \cdot \frac{z}{3}$

Practice Problems

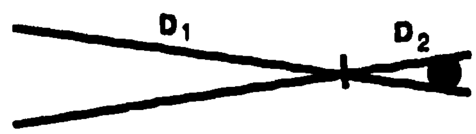
Read each problem and solve for the answer. Answers are provided in the back of this workbook.

1. *Resistance* (R) is the ability of a device, material or component to oppose the flow of electric current. Resistance is measured in ohms (Ω). A *resistor* is a component that controls the flow of current and/or voltage in a circuit. In a particular situation, the *total* resistance (R_T) of two resistors (R_1 and R_2) is given by $R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$. Calculate R_T if R_1 is 8Ω and R_2 is 4Ω.

2. *Conductance* is the degree to which wires and other components conduct electrical current. *Resistance* is the ability of a device, material or component to oppose the flow of electric current. The conductance and resistance of wires vary with the temperature. In a particular situation, the temperature is normally given in Celsius (C) but is sometimes needed in Fahrenheit (F). Convert 23 °C to °F using the formula $°F = \frac{9}{5}\ °C + 32$.

3. Changing Fahrenheit (°F) to Celsius (°C) is done by using the formula $°C = (°F - 32) \cdot \frac{5}{9}$. Convert 68°F to °C.

4. *Mechanical Advantage* (MA) is a term that describes how much easier a job will be due to using a specific tool. For a bolt cutter, the Mechanical Advantage is calculated with the formula $MA = \frac{D_1}{D_2}$. In this formula, D_1 and D_2 refer to the two lengths of the bolt cutter. What is the Mechanical Advantage (MA) when D_1 is 25 inches and D_2 is 1.25 inches?



5. What is the Mechanical Advantage (MA) when D_1 is .45 yards and D_2 is .05 yards?

6. Resistance (R) is the ability of a device, material or component to oppose the flow of electric current. The resistance (R) of a particular device is given by $R = 2000 + .05 \cdot (2000)$. What is the resistance (R)?

7. The force (F) in pounds (lbs.) pushing a vehicle downhill is given by $F = 1000 - .3\ (1000)$. What is the force (F)?

8. Power (P), in general, is energy delivered or consumed per second. Power is measured in watts (W). The power (P) of a particular system is given by P = 85% (.5). What is the power (P) in decimal number form?

9. Resistance (R) is the ability of a device, material or component to oppose the flow of electric current. Resistance is measured in ohms (Ω). The resistance (R) of a circuit is given by $R = \frac{8}{.4}$. What is the resistance (R)?

Answers

1. $R_T = \dfrac{1}{\dfrac{1}{R_1} + \dfrac{1}{R_2}}$ where $R_1 = 8\Omega$ and $R_2 = 4\Omega$

$$R_T = \frac{1}{\frac{1}{8} + \frac{1}{4}}$$

$$R_T = \frac{1}{.125 + .25}$$

$$R_T = \frac{1}{.375}$$

$$R_T = 2.66\Omega$$

2. $°F = \frac{9}{5} \cdot °C + 32$ where $°C = 23$

$$°F = \frac{9}{5} \cdot 23 + 32$$

$$°F = 1.8 \cdot 23 + 32$$

$$°F = 41.4 + 32$$

$$° = 73.4$$

3. $°C = (°F = -32) \cdot \frac{5}{9}$ where $°F = 68$

$$°C = (68 - 32) \cdot \frac{5}{9}$$

$$°C = 36 \cdot \frac{5}{9}$$

$$°C = \frac{180}{9}$$

$$°C = 20$$

4. $MA = \frac{D_1}{D_2}$ where $D_1 = 25$ and $D_2 = 1.25$

$MA = \frac{25}{1.25}$

$MA = \frac{2,500}{125}$

$MA = \frac{500}{25}$

$MA = 20$

5. $MA = \frac{D_1}{D_2}$ where $D_1 = .45$ and $D_2 = .05$

$MA = \frac{.45}{.05}$

$MA = \frac{45}{5}$

$MA = 9$

6. $R = 2,000 + .05 \cdot (2,000)$

$R = 2,000 + 100$

$R = 2,100\ \Omega$

7. $F = 1,000 - .3 \cdot (1,000)$

$F = 1,000 - 300$

$F = 700$ lbs.

8. $P = 85\% \cdot (.5)$

$P = \frac{85}{100} \cdot \frac{5}{10}$

$P = \frac{425}{1,000}$

$P = .425\ W$

9. $R = \frac{8}{.4}$

$R = \frac{80}{4}$

$R = 20\ \Omega$

Math
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Working with Scientific Notation

$$2.3 \cdot 10^2 = 230$$

Prerequisites:

Workbook users should understand:

- *the concept of decimal numbers*
- *the concept of base numbers and exponents*

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Working with Scientific Notation

Focus

This lesson reviews how to convert a number in ordinary notation to scientific notation and how to convert a number in scientific notation to ordinary notation.

Job Examples

Job examples of when you will use scientific notation include:
- measuring electrical power in Megawatts (MW)
- measuring electrical current in microamp (μA)
- measuring insulation resistance in Megaohm (MΩ)

Key Words

Word	*Explanation*	*Example*
ordinary notation	a decimal number; a number with a decimal point between the ones place and tenths place; when there are no numbers to the right of the decimal point, the decimal point is usually not written	7.5, 30, -.004
exponent	a number that tells how many times a certain other number is multiplied by itself	$10^3 = 10\ 10\ 10$ 3 is the exponent
base	a number with an exponent	8^4 8 is the base
power of 10	the number 10 with an exponent	10^{-7}, 10^5, 10^{21}
scientific notation	a way to represent a number; a number number written in scientific notation is a number (between 1 and 10) multiplied by 10 raised to a specific exponent	$823{,}000 = 8.23 \cdot 10^5$ $.0000009 = 9 \cdot 10^{-7}$

Rules for Working with Scientific Notation

Converting Ordinary Notation to Scientific Notation

- Numbers greater than one

1. Identify the first nonzero number (reading left to right) and place a caret (^) to the right of it.	$7_{\wedge}530000.$
2. Count the number of places between the caret and the decimal point.	$7_{\wedge}530000.$ (6 places to right)
3. The number of places identified in Step 2 becomes the exponent of base 10.	10^6 (note: the exponent is *positive*)
4. Place a decimal where the caret is; remove the zeros from the number.	7.53
5. Multiply the value obtained in Step 4 by the base 10 number obtained in Step 3.	$7.53 \cdot 10^6$

- Numbers less than one

1. Identify the first nonzero number (reading left to right) and place a caret (^) to the right of it.	$.0000005_{\wedge}2$
2. Count the number of places between the caret and the decimal point.	$.0000005_{\wedge}2$ (7 places to left)
3. The number of places identified in Step 2 becomes the *negative* exponent of base 10.	10^{-7} (note: the exponent is *negative*)
4. Place a decimal where the caret is; remove the zeros from the number.	5.2
5. Multiply the value obtained in Step 4 by the base 10 number obtained in Step 3.	$5.2 \cdot 10^{-7}$

Converting Scientific Notation to Ordinary Notation

- Positive exponents

1. Identify the exponent value — $5.4 \cdot 10^4$

2. Move the decimal point to the *right as* many places as the exponent value (add zeros as needed) — 5.4000 (4 places to right)

   54000.

   54,000

- Negative exponents

1. Identify the exponent value — $9 \cdot 10^{-5}$ (exponent value is -5)

2. Move the decimal point to the *left* as many places as the exponent value (add zeros as needed) — 00009. (5 places to left)

   .00009

Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

1. A particular electrical motor has a speed of 1800 revolutions per minute (rpm). What is this number in scientific notation?

2. Radio waves travel at the speed of light of 300,000,000 meters per second (m/s). What is this number in scientific notation?

3. The number 6,250,000,000,000,000,000 is used often in electronics. This number is called a *coulomb* (C). A coulomb (C) represents the number of electrons moving together across a point in one second to create an electric current of one amp (A). An amp is the unit by which current is measured. What is coulomb in scientific notation?

4. In physics, the attractional force between the moon and the earth is calculated with three values. These three values are the:

- mass of the earth (M_e) = 5,980,000,000,000,000,000,000,000 Kilograms (Kg)
- mass of the moon (M_m) = 73,500,000,000,000,000,000,000 Kilograms (Kg)
- moon's distance from the earth (d) = 380,000 kilometers (Km)

a. What is the mass of the earth (M_e) in scientific notation?

b. What is the mass of the moon (M_m) in scientific notation?

c. What is the moon's distance from the earth (d) in scientific notation?

5. In physics, the speed of light is $1.86 \cdot 10^5$ miles per second (mi/s). What is this number in ordinary notation?

6. In physics, the speed of light is $3 \cdot 10^8$ meters per second (m/s). What is this number in ordinary notation?

7. *Resistance* (R) is the ability of a device, material or component to oppose the flow of electric current. The resistance (R) of a particular copper wire is $1.723 \cdot 10^{-6}$ ohms per centimeters (Ω/cm). What is this number in ordinary notation?

8. A certain electronic component has a current (I) of .000008 amp (A). What is this number in scientific notation?

Answers

1. $1800 = 1.8 \cdot 10^3$ rpm

2. $3{,}000{,}000{,}000 = 3 \cdot 10^8$ m/s

3. $6{,}250{,}000{,}000{,}000{,}000{,}000 = 6.25 \cdot 10^{18}$

4. a. $M_e = 5{,}980{,}000{,}000{,}000{,}000{,}000{,}000{,}000 = 5.98 \cdot 10^{24}$ Kg

   b. $M_m = 73{,}500{,}000{,}000{,}000{,}000{,}000{,}000 = 7.35 \cdot 10^{22}$ Kg

   c. $d = 380{,}000 = 3.8 \cdot 10^5$ Km

5. $1.86 \cdot 10^5 = 186{,}000$ mi/s

6. $3 \cdot 10^8 = 300{,}000{,}000$ m/s

7. $1.723 \cdot 10^{-6} = .000001723$ Ω/cm

8. 8×10^{-6} A

Math for Success in Electronics

How to Add and Subtract Powers of Ten

$$1.2 \cdot 10^{5} + 4.5 \cdot 10^{6}$$

Prerequisites:

Workbook users should understand:

- *the concept of decimal numbers*
- *the concept of base numbers and exponents*
- *how to work with scientific notation*

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How to Add and Subtract Powers of Ten

Focus

This lesson explains how to add and subtract powers of ten.

Job Example

A job example of when you will add and subtract powers of ten is calculating the resistance and current of an electrical circuit.

Key Words

Word	*Explanation*	*Example*
decimal number	a number with a decimal point between the ones place and tenths place	7.5, 30, -.004
exponent	a number that tells how many times a certain other number is multiplied by itself	$10^3 = 10 \cdot 10 \cdot 10$ 3 is the exponent
base	a number with an exponent	8^4 8 is the base
power of 10	the number 10 with an exponent	10^{-7}, 10^5, 10^{21}
scientific notation	a way to represent a number; a number written in scientific notation is a number (between 1 and 10) multiplied by 10 raised to a specific exponent	$823{,}000 = 8.23 \cdot 10^5$ $.0000009 = 9 \cdot 10^{-7}$

How to Add Powers of Ten

Example 1: A *resistor* is a component that controls the flow of current and/or voltage in a circuit. Two resistors (R_1 and R_2) are connected in series (end to end). Their resistance values can be added to find the total resistance of the circuit. Resistance is measured in ohms (Ω). You need to know the total resistance when R_1 is $2.2 \cdot 10^6\ \Omega$ and R_2 is $680 \cdot 10^3\ \Omega$.

1. Eliminate the powers of ten.

$2.2 \cdot 10^6\ \Omega + 680 \cdot 10^3\ \Omega$
$2{,}200{,}000\ \Omega + 680{,}000\ \Omega$

2. Add

$$\begin{array}{r} 2{,}200{,}000\ \Omega \\ \underline{+\ 680{,}000\ \Omega} \\ 2{,}880{,}000\ \Omega \end{array}$$

The total resistance is $2{,}880{,}000\ \Omega$.

Example 2: *Current* (I) is the flow of electrical charge. Current is measured in amps (A). You want to add the values of two currents (I_1 and I_2) to find the total current in a circuit. If I_1 is $3.4 \cdot 10^{-3}$ A and I_2 is $950 \cdot 10^{-6}$ A, what is the total current?

1. Eliminate powers of ten.

$3.4 \cdot 10^{-3}\ A + 950 \cdot 10^{-6}\ A$
$.0034\ A + .00095\ A$

2. Add

$$\begin{array}{r} .0034\ A \\ \underline{+.00095\ A} \\ .00435\ A \end{array}$$

The total current is .00435 A.

How to Subtract Powers of Ten

Example 1: *Resistance* is the ability of a device, material or component to oppose the flow of electric current. Resistance is measured in ohms (Ω). The resistance of a device dropped due to temperature changes. The original resistance was $1.2 \cdot 10^5\ \Omega$. The present resistance is $4.6 \cdot 10^4 \Omega$. You need to find out how much the resistance dropped.

1. Eliminate powers of ten.

   $1.2 \cdot 10^5\ \Omega - 4.6 \cdot 10^4\ \Omega$
   $120{,}000\ \Omega - 46{,}000\ \Omega$

2. Subtract

   $$\begin{array}{r} 120{,}000\ \Omega \\ \underline{-\ 46{,}000\ \Omega} \\ 74{,}000\ \Omega \end{array}$$

   The resistance dropped 74,000 Ω.

Example 2: Two devices in an electrical circuit together consumed a total power of $1.6 \cdot 10^{-2}$ watts (W). One device consumed $9.5 \cdot 10^{-3}$ W. You need to calculate the power (in watts) consumed by the second device.

1. Eliminate powers of ten

   $1.6 \cdot 10^{-2}\ W - 9.5 \cdot 10^{-3}\ W$
   $.016\ W - .0095\ W$

2. Subtract
   (Note: extra zeros can be added to the right of the number if needed.)

   $$\begin{array}{r} .0160\ W \\ \underline{-\ .0095\ W} \\ .0065\ W \end{array}$$

   The second device consumed .0065 W.

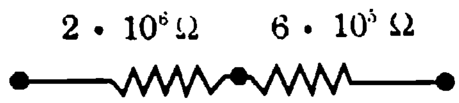
Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

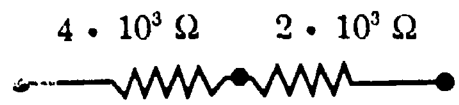
Some Practice Problems refer to the following information:

- *resistance*(R) -- the ability of a device, material or component to oppose the flow of electrical current; it is measured in ohms (Ω)
- *current* (I) -- the flow of electrical charge; it is measured in amps (A)
- *capacitor* -- a device that stores electricity; a capacitor's *capacitance* (storing capacity) is measured in Farad (F)
- When two components are connected *in series* (end to end) their resistances are *added.*

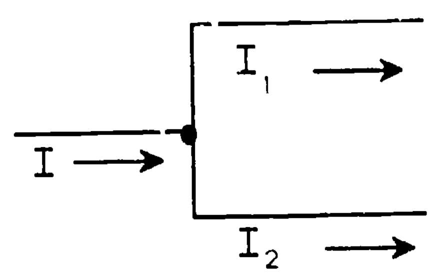
1. What is the total resistance of two components in series if their resistances are $2 \cdot 10^6\ \Omega$ and $6 \cdot 10^5\ \Omega$? (*Hint: add the two resistance values*)



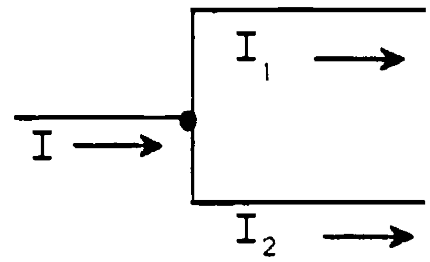
2. What is the total resistance of two components in series if their resistances are $4 \cdot 10^2\ \Omega$ and $2 \cdot 10^3\ \Omega$? (*Hint: add the two resistance values*)



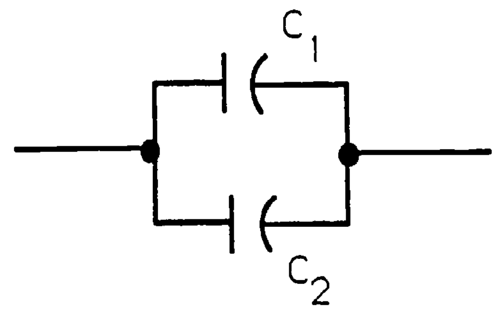
3. In this drawing the current (I) can be calculated by *adding* the values of current I_1 and current I_2. What is the value of current I if I_1 is $3 \cdot 10^{-3}$ A and I_2 is $8 \cdot 10^{-2}$ A?



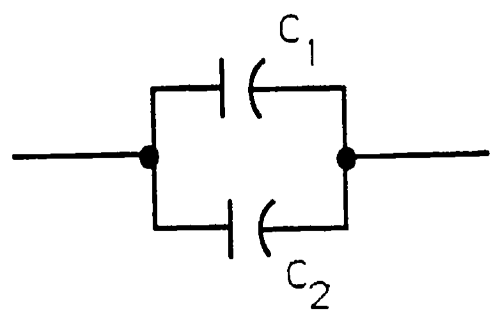
4. In this drawing, the value of current I_1 can be calculated by *subtracting* the values of current I_2 from current I. What is the value of current I_1 if I is $5 \cdot 10^{-2}$ A and I_2 is $30 \cdot 10^{-3}$ A?



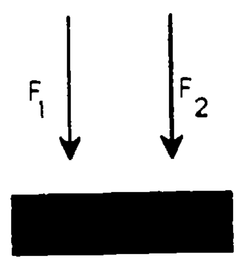
5. The capacitance values of two capacitors (C_1 and C_2) can be added together to get a total capacitance. If C_1 is $47 \cdot 10^{-6}$ F and C_2 is $6 \cdot 10^{-3}$ F, what is the total capacitance?



6. The capacitance values of two capacitors (C_1 and C_2) can be added together to get a total capacitance. If C_1 is $22 \cdot 10^{-9}$ F and C_2 is $6 \cdot 10^{-9}$ F, what is the total capacitance?



7. When two forces F_1 and F_2 are applied to the same object from the same direction, they *add* together. What is the resulting force of $F_1 + F_2$ if F_1 if $4 \cdot 10^3$ lbs. and F_2 is $9 \cdot 10^2$ lbs.?



8. When two forces F_1 and F_2 are applied to the same object from opposite directions, they *subtract*. What is the resulting force of $F_1 - F_2$ if F_1 is $8 \cdot 10^3$ lbs. and F_2 is $45 \cdot 10^2$ lbs.?

9. When two electrical components are connected in series (end to end) their voltages add together. What is the total voltage of two components in series if their voltages are $2 \cdot 10^2$ volts (v) and $4 \cdot 10^3$ volts (v)?


components connected in series

10. *Power* (P), in general, is electrical energy delivered or consumed per second. Power (P) is measured in watts (W). A particular electrical circuit contains three devices. The total electrical power consumed by this circuit is calculated by *adding* the electrical power consumed by each of the three devices. What is the total power consumed by the circuit if the three devices consumed $4 \cdot 10^2$ W, $25 \cdot 10^{-3}$ W, and $8 \cdot 10^{-3}$ W?

Answers

1. $2 \cdot 10^6 + 6 \cdot 10^5$

   $2 \cdot 1{,}000{,}000 + 6 \cdot 100{,}000 =$

   $2{,}000{,}000 + 600{,}000 =$

   $2{,}600{,}000\ \Omega$

2. $4 \cdot 10^2 + 2 \cdot 10^3 =$

   $4 \cdot 100 + 2 \cdot 1000 =$

   $400 + 2000 =$

   $2{,}400\ \Omega$

3. $3 \cdot 10^{-3} + 8 \cdot 10^{-2} =$

   $.003 + .08 =$

   $.083$ A

4. $I_1 = 5 \cdot 10^{-2} - 30 \cdot 10^{-3} =$

   $.05 - .03 =$

   $.02$ A

5. $47 \cdot 10^{-6}\text{ F} + 6 \cdot 10^{-6}\text{ F} =$

   $.000047\text{ F} + .000006\text{ F} =$

   $.000053$ F

6. $22 \cdot 10^{-9}F + 6 \cdot 10^{-9}F =$

$.000000022\ F + .000000006\ F =$

$.000000028\ F$

7. $F_1 + F_2 =$

$4 \cdot 10^3 + 9 \cdot 10^2 =$

4,000 + 900 =

4,900 lbs.

8. $F_1 - F_2 =$

$8 \cdot 10^3 - 45 \cdot 10^2 =$

8000 - 4500 =

3,500 lbs.

9. $2 \cdot 10^2 + 4 \cdot 10^3 =$

200 + 4000 =

4,200 v

10. $4 \cdot 10^{-2} + 25 \cdot 10^{-3} + 8 \cdot 10^{-3} =$

.04 + .025 + .008 =

.073 W

Math
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How to Multiply and Divide Powers of Ten

$$10^4 \cdot 6 \cdot 10 \cdot 2$$

Prerequisites:

Workbook users should understand:

- *the concept of decimal numbers*
- *the concept of base numbers and exponents*
- *the concept of scientific notation*
- *how to add and subtract signed numbers*

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How to Multiply and Divide Powers of Ten

Focus

This lesson explains how to multiply and divide powers of ten.

Job Examples

Job examples of when you will multiply and divide powers of ten include calculating
- current of electrical components
- voltage of electrical devices
- resistance of circuits

Key Words

Word	*Explanation*	*Example*
decimal number	a number with a decimal point between the ones and tenths place	7.5, 30, -.004
exponent	a number that tells how many times a certain other number is multiplied by itself	$10^3 = 10 \cdot 10 \cdot 10$ 3 is the exponent
base	a number with an exponent	8^4 8 is the base
power of 10	the number 10 with an exponent	10^{-7}, 10^5, 10^{21}
scientific notation	a way to represent a number; a number written in scientific notation is a number (between 1 and 10) multiplied by 10 raised to a specific exponent	$823{,}000 = 8.23 \cdot 10^5$ $.0000009 = 9 \cdot 10^{-7}$

How to Multiply Powers of Ten

Example: *Current* (I) is the flow of electrical charge. *Resistance* is the ability of a device, material or component to oppose the flow of current and/or voltage. Resistance (R) is measured in ohms (Ω). In an electrical circuit, the voltage (V) can be calculated by multiplying its resistance by its current. You need to find the voltage (V) of a circuit with a resistance (R) of $6.8 \cdot 10^4\ \Omega$ and a current (I) of $2.2 \cdot 10^{-2}\ \Omega$.

1. Rearrange the problem to place decimal numbers together and power of ten numbers together.

   $6.8 \cdot 10^4 \cdot 2.2 \cdot 10^{-2}$
   $6.8 \cdot 2.2 \cdot 10^4 \cdot 10^{-2}$

2. Multiply the decimal numbers together.

   $\mathbf{6.8} \cdot \mathbf{2.2} \cdot 10^4 \cdot 10^{-2}$
   $\mathbf{14.96} \cdot 10^4 \cdot 10^{-2}$

3. Combine power of ten numbers by *adding* the exponents.

   $14.96 \cdot \mathbf{10^4} \cdot \mathbf{10^{-2}}$
   $14.96 \cdot \mathbf{10^{4-2}}$
   $14.96 \cdot \mathbf{10^2}$

   The voltage of the circuit is $14.96 \cdot 10^2$ volts.

How to Divide Powers of Ten

Example: The voltage (V) of an electric circuit (measured in volts) can be calculated by dividing its power (P) (measured in watts) by its current (I) (measured in amps). You need to find the voltage of a circuit that has a power (P) of $12 \cdot 10^{-2}$ watts and a current (I) of $3 \cdot 10^{-3}$ amps.

1. Write the problem in fraction format.

$$\frac{12 \cdot 10^{-2}}{3 \cdot 10^{-3}}$$

2. Separate the decimal number fraction from the power of ten fraction.

$$\frac{12 \cdot 10^{-2}}{3 \cdot 10^{-3}} = \frac{12}{3} \cdot \frac{10^{-2}}{10^{-3}}$$

3. In the power of ten fraction, change the sign of the power of ten number in the denominator (bottom number) and multiply it with the power of ten in the numerator.

$$\frac{12 \cdot 10^{-2}}{3 \cdot \mathbf{10^{-3}}}$$

$$\frac{12}{3} \cdot 10^{-2} \cdot \mathbf{10^{3}}$$

$$\frac{12}{3} \cdot 10^{-2+3}$$

$$\frac{12}{3} \cdot 10$$

4. Divide the decimal fraction

$$\frac{12}{3} \cdot 10$$

$4 \cdot 10$

The voltage of the circuit is $4 \cdot 10$ volts.

Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

Some Practice Problems refer to the following information:

- *current* (I) -- the flow of electrical charge; it is measured in amps (A)
- *voltage* (V) -- electrical force or pressure; it is measured in volts (v)
- *resistance* (R) -- the ability of a device, material or component to oppose the flow of electric current; it is measured in ohms (Ω)
- *power* (P) -- in general, energy delivered or consumed per second; it is measured in watts (W)

1. The current (I) of an electrical component can be calculated by dividing the component's voltage (V) by its resistance (R). What is the current (I) of a component if the voltage (V) is $1.1 \cdot 10^3$ volts and resistance (R) is $22 \cdot 10^3$ Ω?

2. The current (I) of an electrical component can be calculated by dividing the component's voltage (V) by its resistance (R). What is the current (I) of an electrical component if the component's voltage (V) is 9 volts and its resistance (R) is $45 \cdot 10^3$ Ω?

3. The voltage (V) of an electrical device can be calculated by multiplying the device's current (I) and resistance (R). What is the voltage of an electrical device if its current (I) is $2 \cdot 10^{-3}$A and resistance (R) is $5 \cdot 10^{3}\ \Omega$?

4. The power (P) of an electrical component can be calculated by multiplying the component's voltage (V) and current (I). What is the power (P) of a component if its voltage (V) is 25 volts and its current (I) is $8 \cdot 10^{-3}$A?

5. The power (P) of an electrical component can be calculated by multiplying the component's voltage (V) and current (I). What is the power (P) of a component if its voltage (V) is $2 \cdot 10^{3}$ volts and current (I) is 15 A?

6. The conductance (G) of an electrical component is the reciprocal of its resistance (R). This is written as $G = \frac{1}{R}$. Conductance (G) is measured in Mho (℧) or Siemens (S). Resistance is measured in ohms (Ω). What is the conductance in Mho (℧) of a certain component if the component's resistance is $2 \cdot 10^6\ \Omega$?

7. The current of an electrical device can be calculated by dividing its power (P) by its voltage (V). What is the current (I) of an electrical device if its power (P) is 10 watts (W) and its voltage is $5 \cdot 10^2$ volts (v)?

8. The voltage (V) of an electrical device can be calculated by dividing its power (P) and its current (I). Power is measured in watts (W); current is measured in amps (A). What is the voltage (V) of a device if its power (P) is 5 W and its current (I) is $2 \cdot 10^{-3}$ A?

9. A *wave* is a shape that repeats periodically. *Frequency* is the number of waves generated per second. Frequency is measured in hertz (Hz).

   The length of an electrical wave (wavelength) is calculated by dividing the wave's speed ($3 \cdot 10^8$ meters per second) by the wave's frequency. What is the length of a wave with a frequency of $2 \cdot 10^6$ Hz?

10. *Coulomb* (C) is the unit of measure of electrical charge. The electrical charge of one electron is $1.6 \cdot 10^{-19}$ Coulomb (C). What is the electrical charge of $5 \cdot 10^{20}$ electrons?

Answers

1. $I = \frac{V}{R} = \frac{1.1 \cdot 10^3}{22 \cdot 10^3} = \frac{1.1}{22} = .05\ A$

2. $I = \frac{9}{45 \cdot 10^3}$

   $I = \frac{9}{45} \cdot 10^{-3}$

   $I = .2 \cdot 10^{-3}\ A$

3. $V = I \cdot R$

   $V = 2 \cdot 10^{-3} \cdot 5 \cdot 10^3$

   $V = 2 \cdot 5 \cdot 10^{-3} \cdot 10^3$

   $V = 10 \cdot 10^{-3} \cdot 10^3$

   $V = 10$ or 10 volts

4. $P = V \cdot I$

   $P = 25 \cdot 8 \cdot 10^{-3}$

   $P = 200 \cdot 10^{-3}\ W$

5. $P = V \cdot I$

   $P = 2 \cdot 10^3 \cdot 15$

   $P = 30 \cdot 10^3 W$

6. $G = \frac{1}{R}$

$G = \frac{1}{2 \cdot 10^6}$

$G = \frac{1}{2} \cdot 10^{-6}$

$G = .5 \cdot 10^{-6} \mho$

7. $I = \frac{P}{V}$

$I = \frac{10}{5 \cdot 10^2}$

$2 \cdot 10^{-2}$ A

8. $V = \frac{P}{I}$

$V = \frac{5}{2 \cdot 10^{-3}}$

$V = \frac{5}{2} \cdot 10^3$

$2.5 \cdot 10^3$ Volts

9. Length of wave = $\frac{\text{speed}}{\text{frequency}}$

Length of wave = $\frac{3 \cdot 10^8}{2 \cdot 10^6}$

Length of wave = $\frac{3}{2} \cdot \frac{10^8}{10^6}$

Length of wave = $1.5 \cdot 10^8 \cdot 10^{-6}$

Length of wave = $1.5 \cdot 10^2$ meters

10. $1.6 \cdot 10^{-19} \cdot 5 \cdot 10^{20} =$

$1.6 \cdot 5 \cdot 10^{-19} \cdot 10^{20} =$

$8 \cdot 10^{1} =$

$8 \cdot 10 = 80$ C

Math
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Electronics

Working with Coordinates

(x,y)

Prerequisites:

Workbook users should understand:

- *the concept of a number line*
- *the concept of positive and negative numbers*
- *the concept of a grid*

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Working with Coordinates

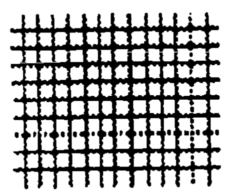
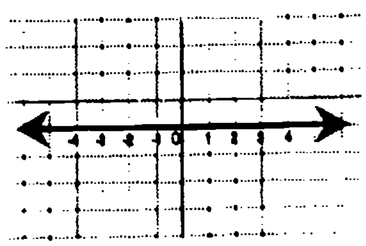
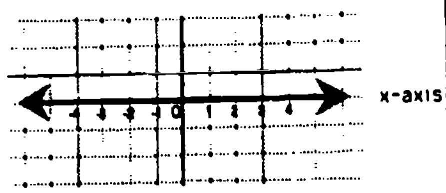
Focus

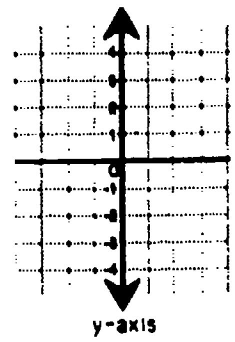
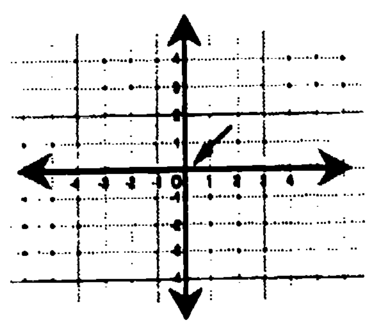
This lesson reviews terms and concepts for working with coordinates.

Job Examples

A job example of when you will work with coordinates is determining ambient temperature effects on industrial fuse operating characteristics.

Key Words

Word	*Explanation*	*Example*
horizontal	on a grid, a left to right direction	
vertical	on a grid, an up and down direction	
grid	a grating of horizontal and vertical lines	
axis	a number line on a grid	
X axis	the horizontal number line on a grid	

Y axis	the vertical number line on a grid	
variable	a symbol (or letter) that can vary in value	**a, x**
independent variable	a variable that controls another variable; the horizontal axis on a grid	A lamp's dimmer switch (independent variable) controls the brightness of the bulb (dependent variable)
dependent variable	a variable that is controlled by another variable; the vertical axis on a grid	When driving a car, the car's speed (dependent variable) depends on the amount of accelerator pedal pressure (independent variable)
coordinates	two values representing one point on a grid. Coordinates are written as a pair of numbers; the first number represents the X axis value (independent variable); the second number represents the Y axis value (dependent variable).	(-3,2); (x,y)
ordered pair	another name for coordinates	(147, -18)
zero (0)	a digit that has no quantified value; on a grid, the point at which the X and Y axes cross	

Rules for Working with Coordinates

- the X (horizontal) axis = first coordinate in an ordered pair = independent variable
- the Y (vertical) axis = second coordinate in an ordered pair = dependent variable

Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

1. The settings on an electric stove are: simmer, low, medium, and high. The time it takes to boil one gallon of water depends on the stove's setting. Name the independent and dependent variables in this example.

2. Which number represents the horizontal value for coordinates (8,-3)?

3. Which number represents the vertical value for coordinates (8,-3)?

4. *Voltage* (V) is electrical force or pressure; it is measured in volts (v). *Current* (I) is the flow of electrical charge. The amount of a circuit's voltage (V) affects the amount of the circuit's current (I). This means that voltage (V) is the independent variable and current (I) is the dependent variable. A particular circuit has a voltage of 5 and a current of 6. Write these as an ordered pair.

5. Write the ordered pair for coordinates representing a circuit's time (t) of 5 (independent variable) and voltage (V) of 8 (dependent variable).

6. Write the ordered pair for coordinates representing a circuit's time (t) of 1 (independent variable) and voltage (V) of 4 (dependent variable).

7. Write the ordered pair for coordinates if a circuit's current (I) is 5 (dependent variable) and its voltage (V) is -3 (independent variable).

Answers

1. The time it takes to boil one gallon of water depends on the stove's setting (simmer, low, medium or high). The stove's setting is the independent variable; the time it takes to boil the water is the dependent variable.

2. (8,-3): the X axis (horizontal) value is 8. The x-axis value is always listed *first* in an ordered pair.

3. (8,-3): the dependent variable (Y axis) value is -3. The dependent variable is always listed *second* in an ordered pair.

4. voltage = 5 = independent variable = X axis value
   current = 6 = dependent variable = Y axis value
   ordered pair: (5,6)

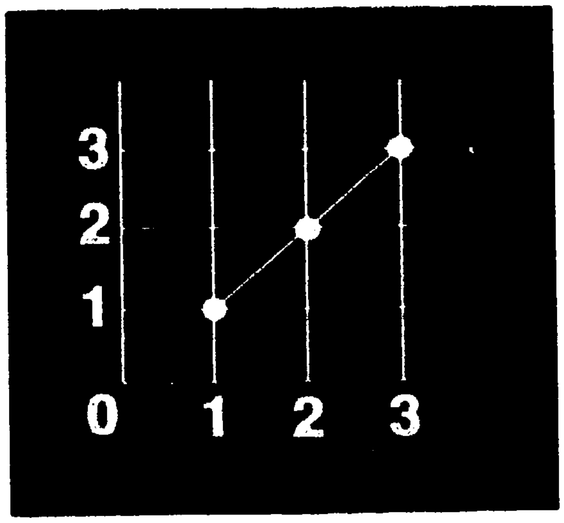
5. time = 5 = independent variable = X axis value
   voltage = 8 = dependent variable = Y axis value
   ordered pair: (5,8)

6. time = 1 = independent variable = X axis value
   voltage = 4 = dependent variable = Y axis value
   ordered pair: (1,4)

7. voltage = -3 = independent variable = X axis value
   current = 5 = dependent variable = Y axis value
   ordered pair: (-3,5)

Math for Success in Electronics

How to Plot and Draw Line Graphs



Prerequisites:

Workbook users should understand:

- *the concept of grids*
- *the concept of horizontal and vertical axes*
- *how to write numbers as coordinates*
- *the concept of independent and dependent variables*

How to Plot and Draw Line Graphs

Focus

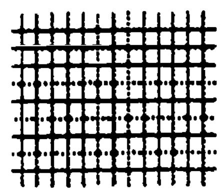
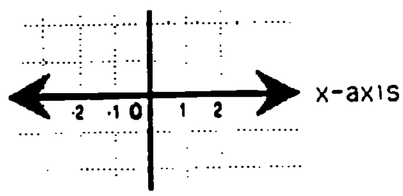
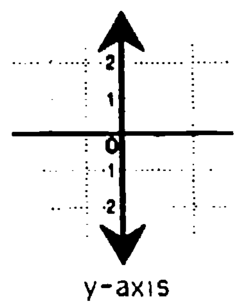
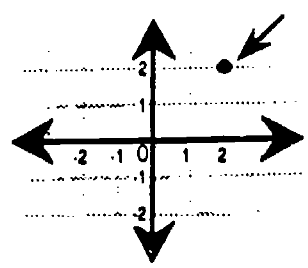
This lesson explains how to plot and draw line graphs.

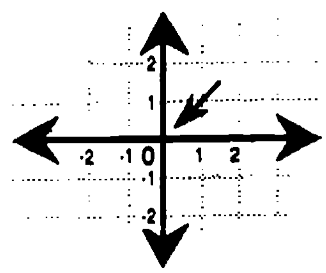
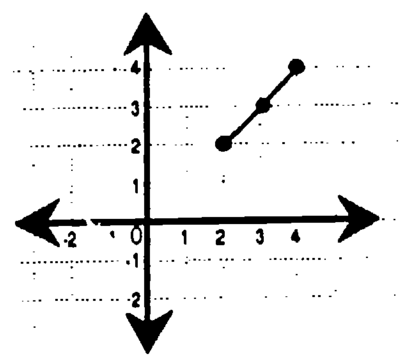
Job Examples

Job examples of when you will plot and draw line graphs include determining:

- the starting current of a motor in relation to the time characteristics of the motor
- ambient temperature effects on industrial fuse operating characteristics

Key Words

Word	***Explanation***	***Example***
grid	a grating of horizontal and vertical lines	
X axis	the horizontal number line on a grid	
Y axis	the vertical number line on a grid	
graph point	a specific location on an axis; also the location where two lines intersect	

coordinates	two values representing one point on a grid. Coordinates are written as a pair of numbers; the first number represents the X axis value (independent variable); the second number represents the Y axis value (dependent variable).	(-3,2); (x,y)
ordered pair	another name for coordinates	(5,3); (a,-b)
independent variable	a variable that controls another variable; the horizontal (X) axis on a grid	a lamp's dimmer switch (independent variable) controls the bulb's brightness (dependent variable)
dependent variable	a variable that is controlled by another variable; the vertical (Y) axis on a grid	When driving a car, the car's speed (dependent variable) depends on the amount of accelerator pedal pressure (independent variable)
zero (0)	a digit that has no quantified value; on a grid, the point at which the X and Y axes cross on a grid	
line graph	a line drawn through two or more points plotted on a grid	

How to Plot a Line Graph

The goal of plotting a line graph is to visually see how one number in the ordered pair (independent variable) changes the other number in the ordered pair (dependent variable).

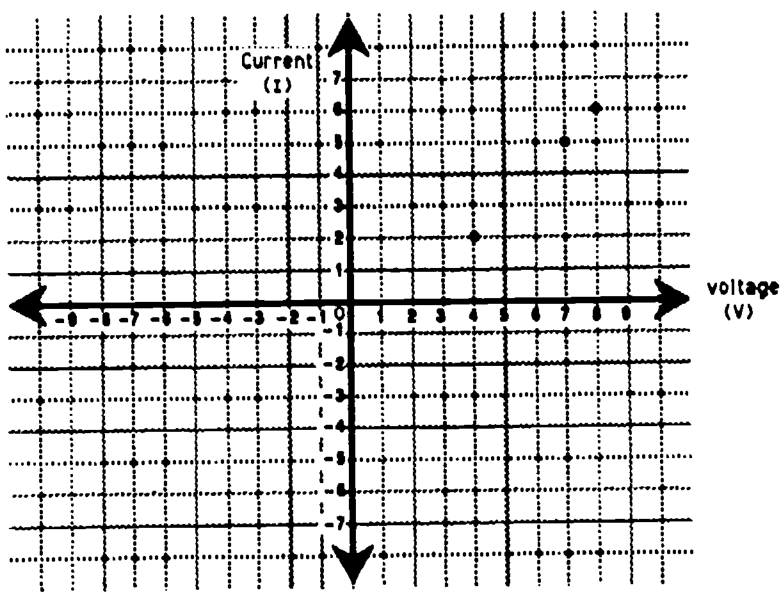
> ***Example 1:*** Voltage (V) is electrical force or pressure. Current (I) is the flow of electrical charge. In any electric circuit, varying the voltage will vary the current. For example, when the voltage (V) is 8, the current (I) is 6. When the voltage (V) is 7, the current (I) is 5. And when the voltage (V) is 4, the current (I) is 2. You want to create a graph to see how the voltage (V) varies the current (I).

1. **Identify the independent and dependent variables.**
   - current **depends** on voltage
   - independent variable = voltage
   - dependent variable = current

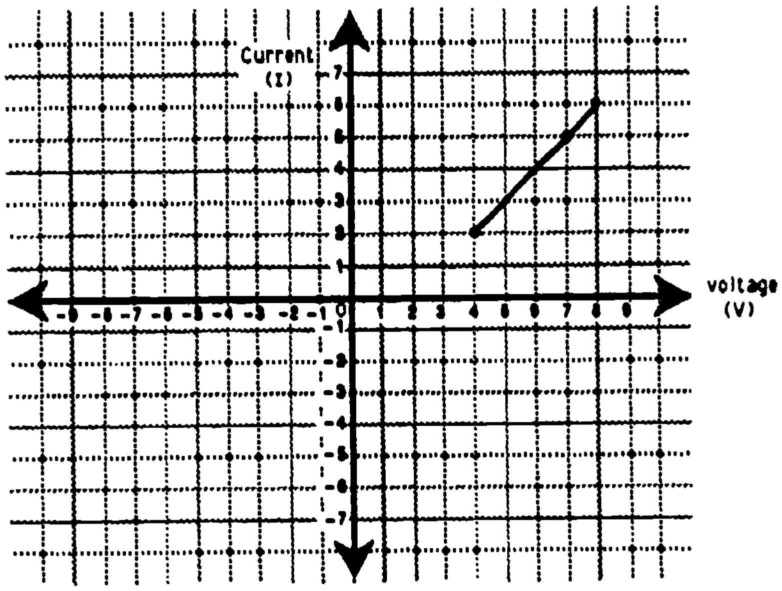
2. **Write the variable values as** ordered pairs. (Ordered paires can also be written in table form.)
   - (independent variable, dependent variable)
   - (voltage, current)
   - (8,6); (7,5); (4,2) or

voltage	8	7	4
Current	6	5	2

3. **For each ordered pair**:
   - locate the independent variable (first coordinate) on the X (horizontal) axis
   - locate the dependent variable (second coordinate) on the Y (vertical) axis
   - draw a graph point on the grid where the independent and dependent variables (coordinates) meet



4. Connect the grid points to create a graph.



The graph shows the relationship between voltage (independent variable; X-axis) and current (dependent variable; Y-axis). When the voltage has a certain value, the current has a certain value.

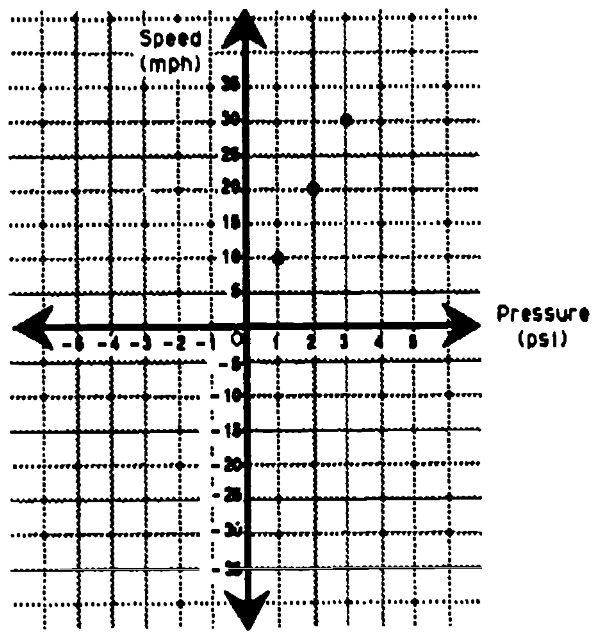
Example 2: When driving a car, your foot exerts pressure on the accelerator to determine the speed of the car. One pound per square inch (psi) of foot pressure causes a speed of 10 miles per hour (mph). Two psi of pressure cause a speed of 20 mph, and three psi cause a speed of 30 mph. You want to create a graph to see how pressure affects speed.

1. **Identify the independent and dependent variables.**
   - speed **depends** on pressure
   - independent variable = pressure
   - dependent variable = speed

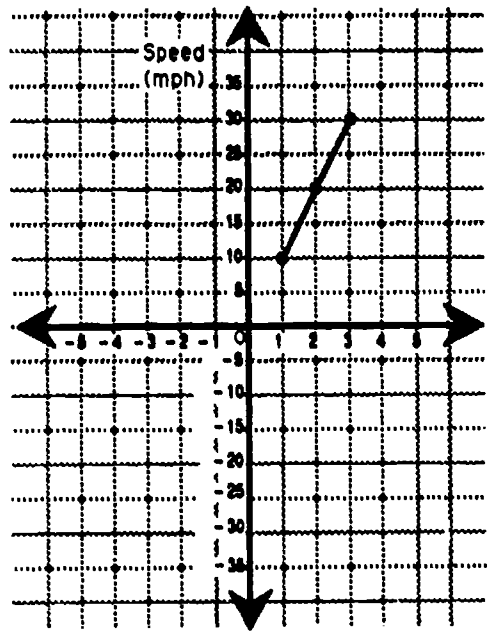
2. **Write the variable values as** ordered pairs. (Ordered pairs can also be written in table form.)
   - (independent variable, dependent variable)
   - (pressure, speed)
   - (1,10); (2,20); (3,30) or

Pressure	1	2	3
Speed	10	20	30

3. **For each ordered pair:**
   - locate the independent variable (first coordinate) on the X (horizontal) axis
   - locate the dependent variable (second coordinate) on the Y (vertical) axis
   - draw a graph point on the grid where the independent and dependent variables (coordinates) meet



4. Connect the grid points to create a graph.



The graph shows the relationship between the pressure (independent variable; X axis) and speed (dependent variable; Y axis). When the pressure has a certain value, the speed has a certain value.

Practice Problems

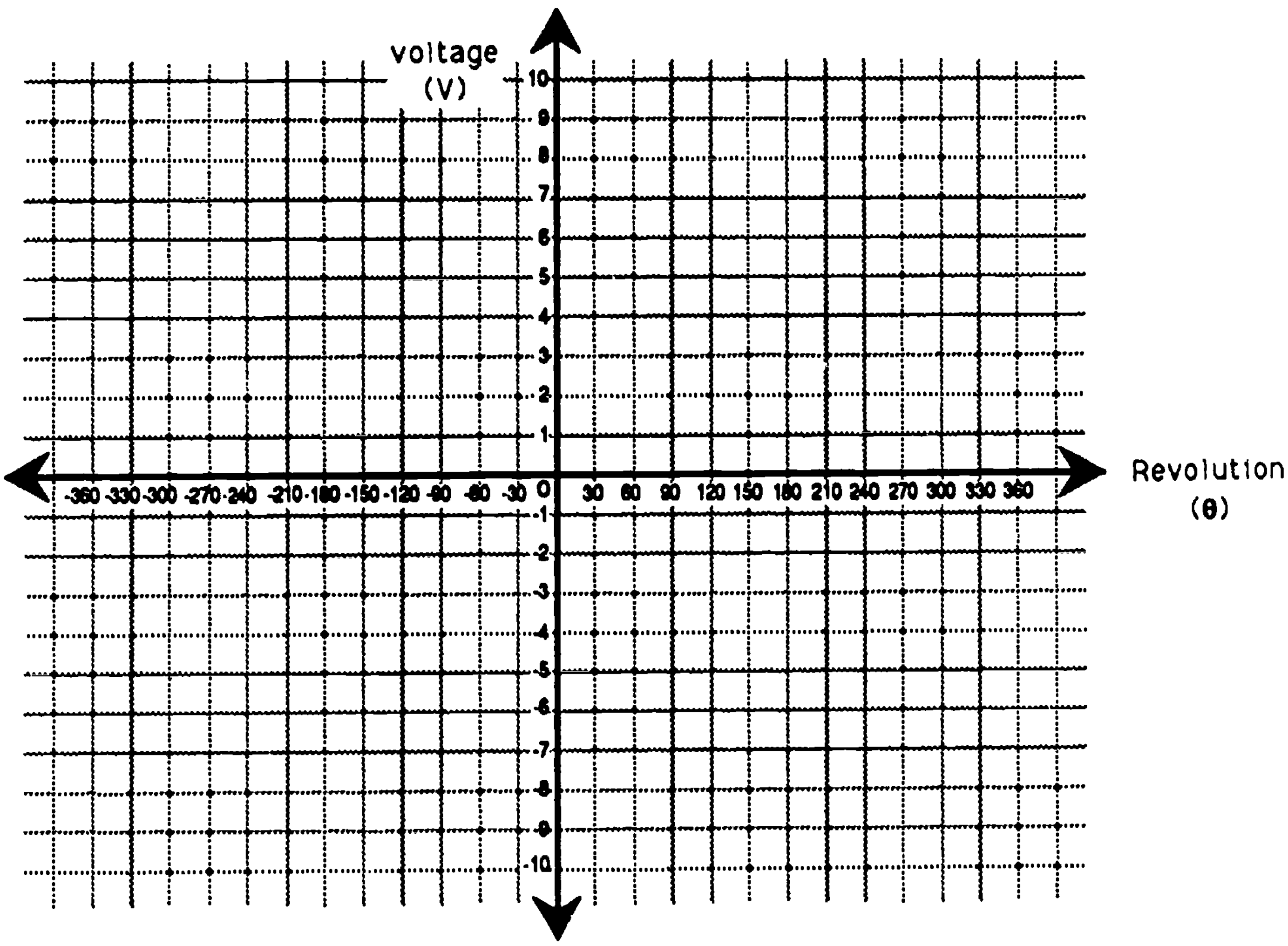
Read each problem and solve for the answer. Answers are provided in the back of this workbook.

Some Practice Problems refer to the following information:

- *current* (I) -- the flow of electrical charge; it is measured in amps (A)
- *voltage* (V) -- electrical force or pressure; it is measured in volts (v)
- *power* (P) -- in general, energy delivered or consumed per second; it is measured in watts (W)

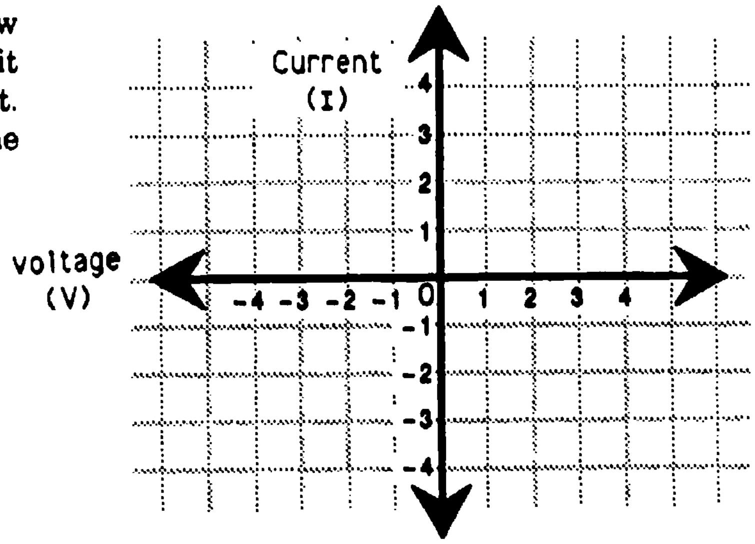
1. The angle of revolution (θ) of a mechanical generator determines the generator's voltage. This table represents the voltage (V) generated by a complete revolution (θ) of a mechanical generator. Plot and draw a line graph using the information provided in the table.

θ	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°	360°
V	0	5	8.7	10	8.7	5	0	-5	-8.7	-10	-8.7	-5	0



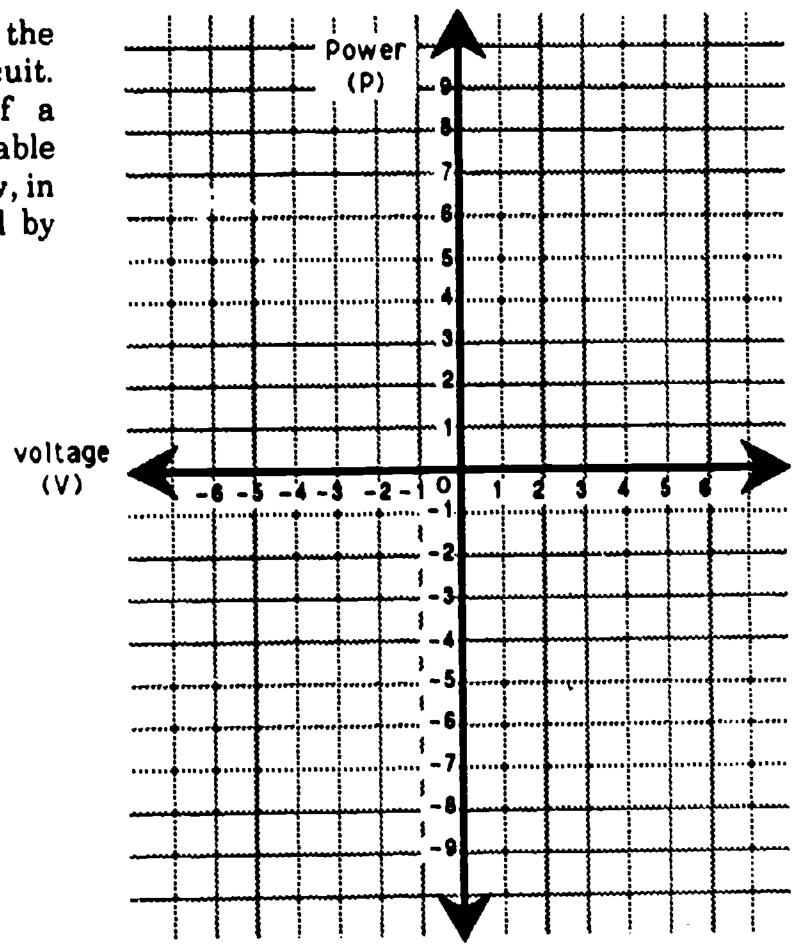
2. The table below gives information on how the voltage (V) of a particular circuit determines the current (I) of the circuit. Plot and draw a line graph using the information provided in the table.

V	0	2	4
I	0	1	2



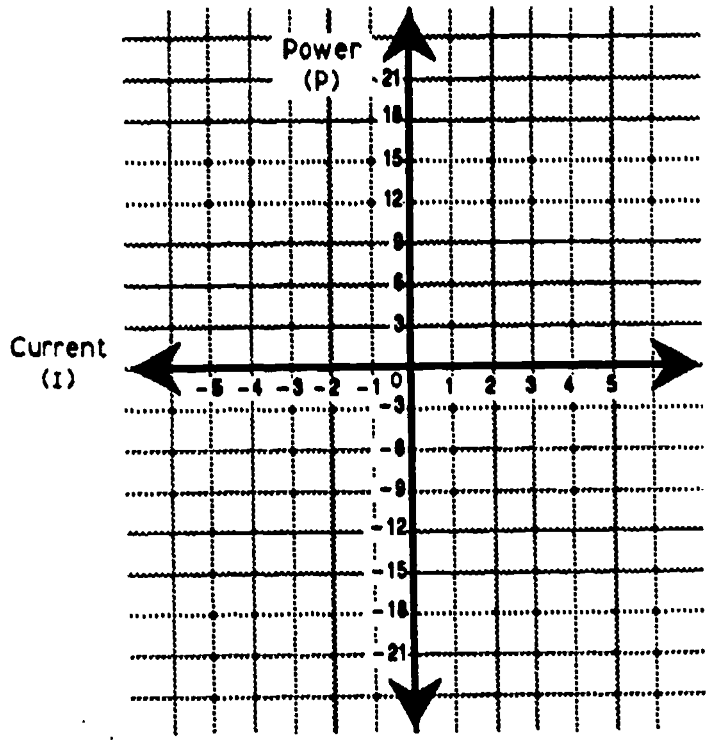
3. A *resistor* is a component that controls the flow of current and/or voltage in a circuit. The voltage (V) and power (P) of a particular resistor are given in the table below. Draw a line graph showing how, in this resistor, power (P) is determined by voltage (V).

V	0	1	2	3	4
P	0	.5	2	4.5	8



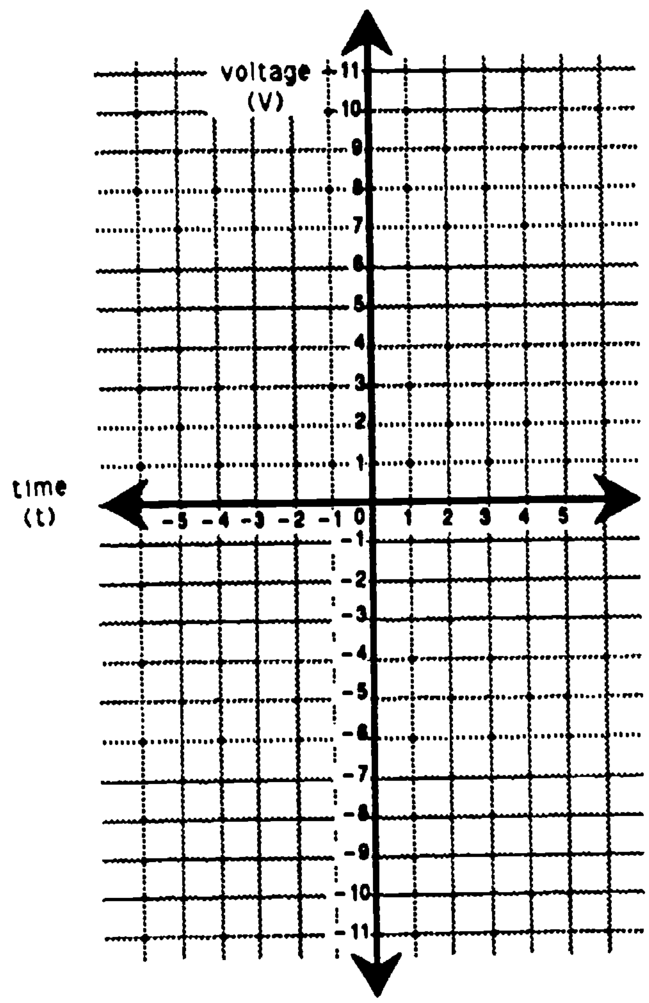
4. The current (I) and power (P) of a particular electric circuit are represented in the table below. Draw a line graph showing how, in this circuit, current (I) determines power (P).

I	0	1	1.5	2	2.5	3
P	0	2	4.5	8	12.5	18



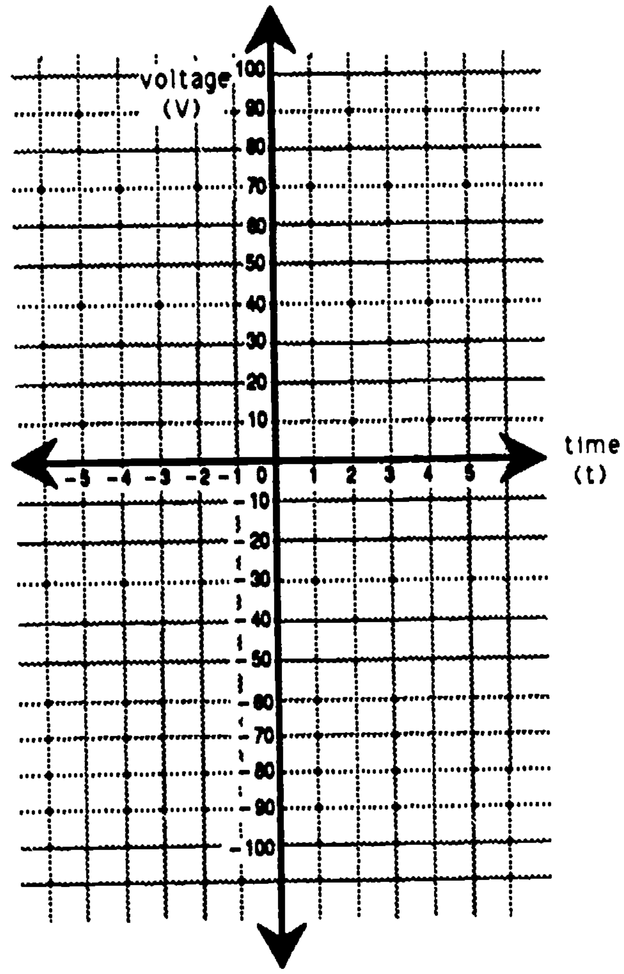
5. A *capacitor* is a device that stores electricity. The table below shows the voltage (V) of a particular capacitor at various times (t) in the capacitor's discharge cycle. Plot and draw a line graph using information provided in the table.

t	0	1	2	3
V	10	3.7	1.4	0.5



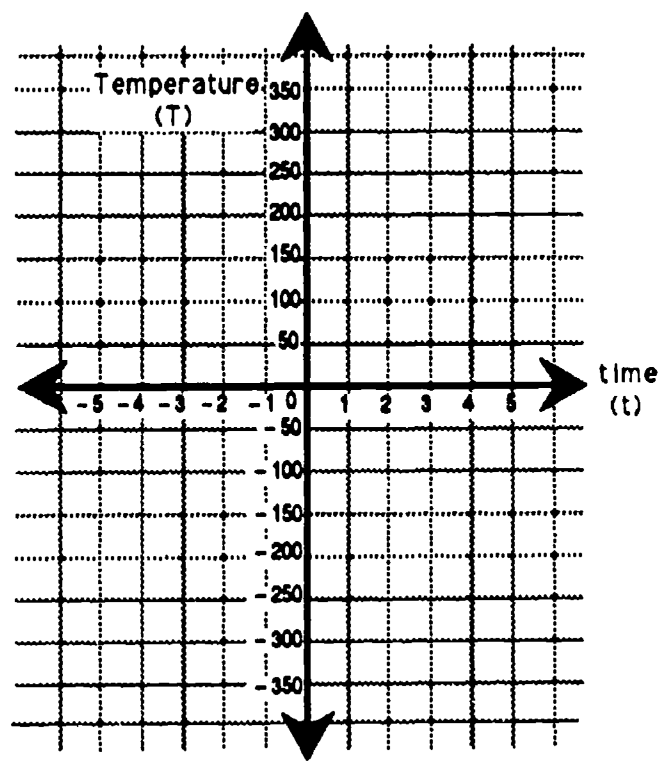
6. A *capacitor* is a device that stores electricity. When charging a capacitor, time (t) is required for the electrical voltage (V) to build up to its maximum value. The table below gives voltage and time information for charging a particular capacitor. Plot and draw a line graph using this information.

t	0	1	2	3	4
V	0	63	86	95	98



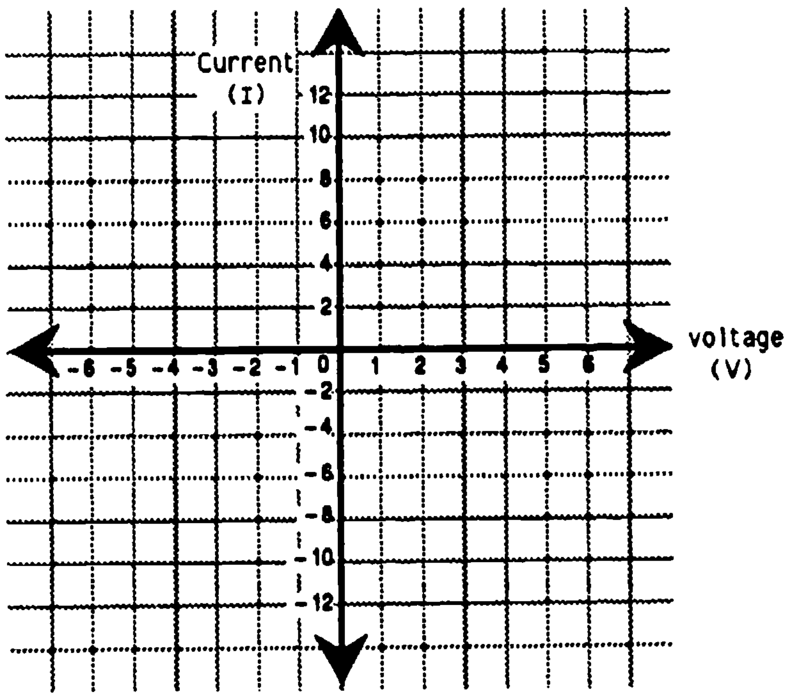
7. The table below gives temperatures (T) of a particular furnace at various times (t). Plot and draw a line graph showing this information.

t	1	2	3	4	5
T	100	150	200	250	300



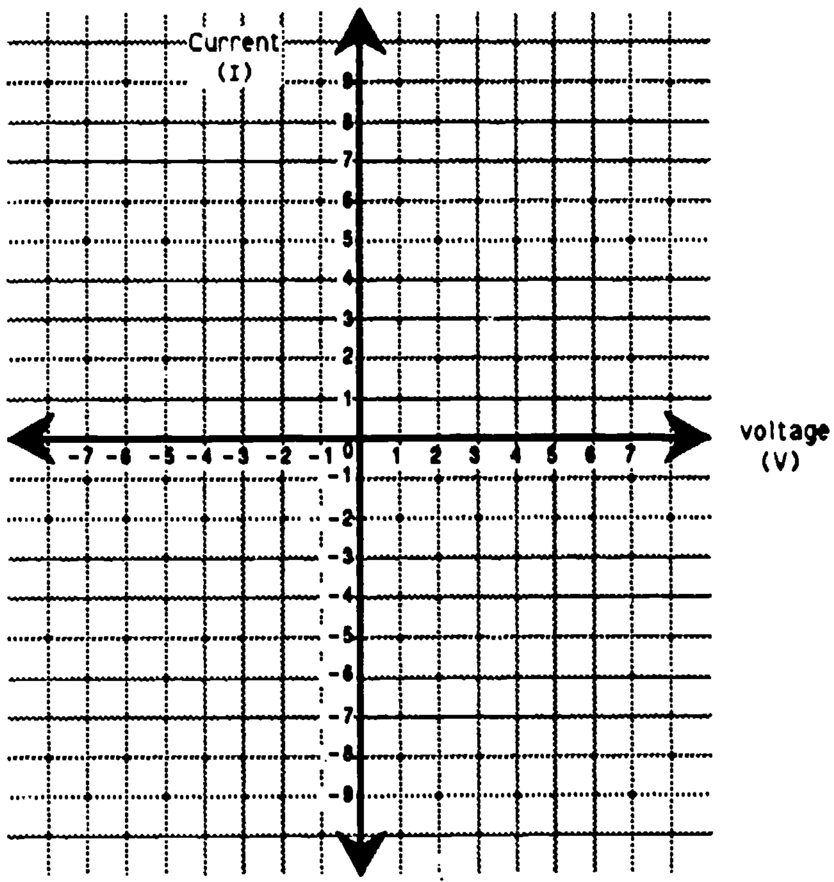
8. A *transistor* is a device that is used as an amplifier or switch. The current (I) and voltage (V) of a particular transistor are represented in the following table. Plot and draw a line graph showing how voltage (V) affects current (I).

V	0	1	2	3	4	5
I	10	6.4	3.6	1.6	.4	0



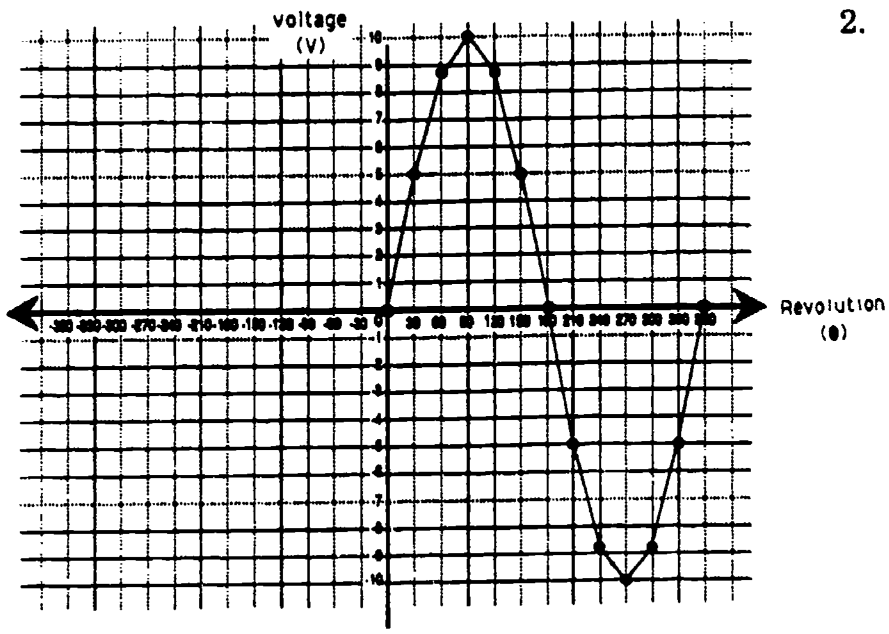
9. A *transistor* is a device that is used as an amplifer or a switch. The current (I) and voltage (V) of a particular transistor are represented in the following table. Plot and draw a line graph to show how the current (I) is affected by voltage (V).

V	0	1	2	3	4	5	6	7
I	4.5	2	.5	0	.5	2	4.5	8

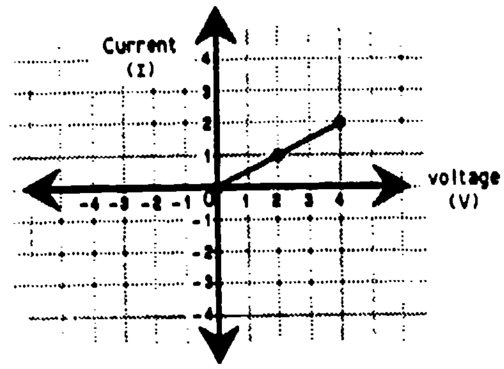


Answers

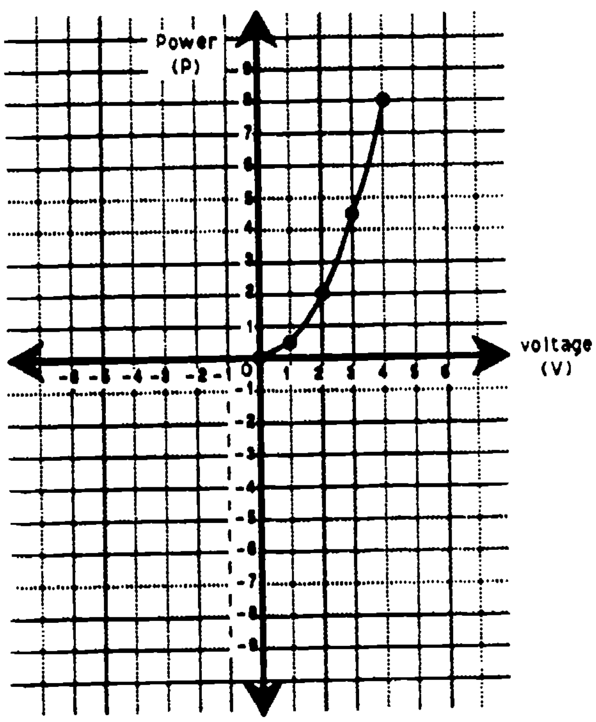
1.



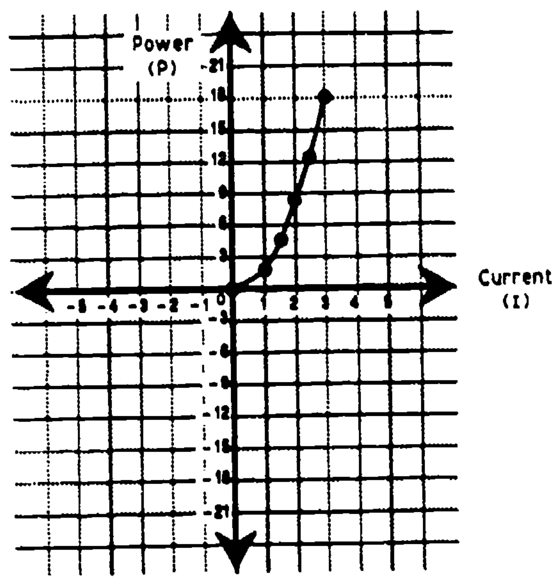
2.



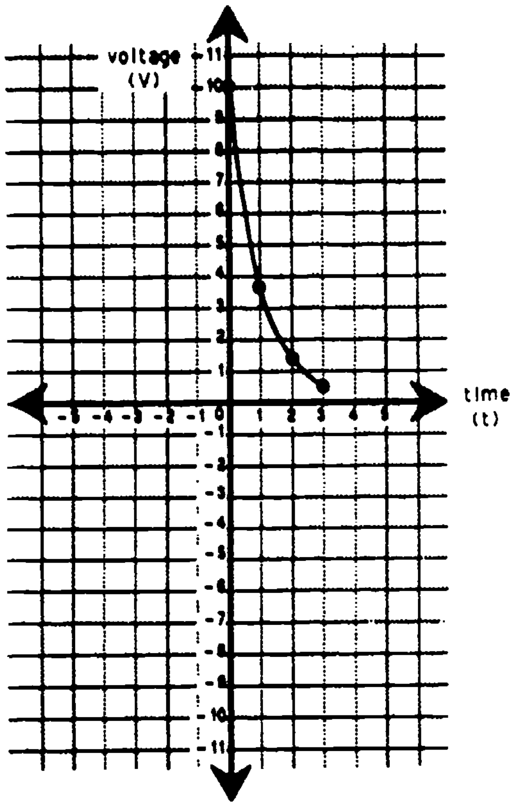
3.



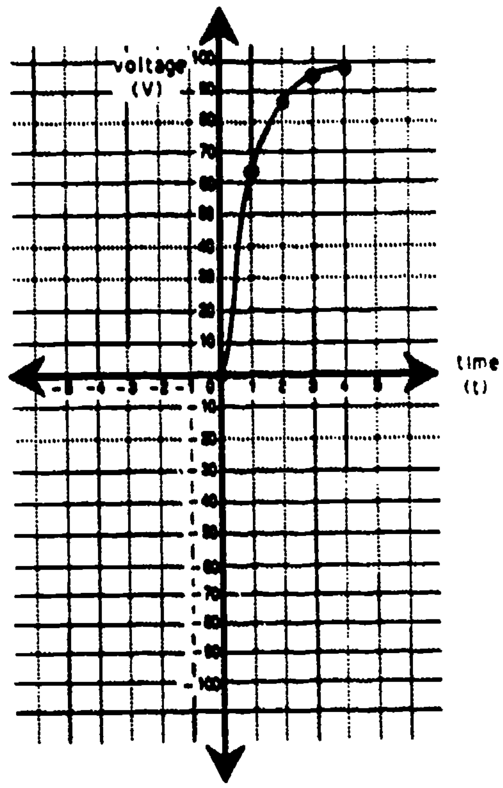
4.



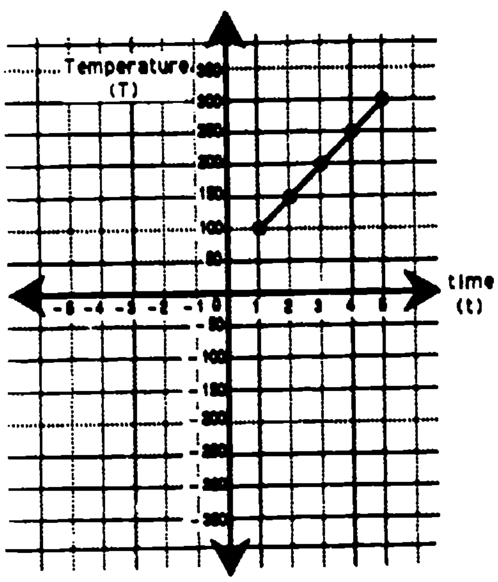
5.


voltage
(V)
time
(t)

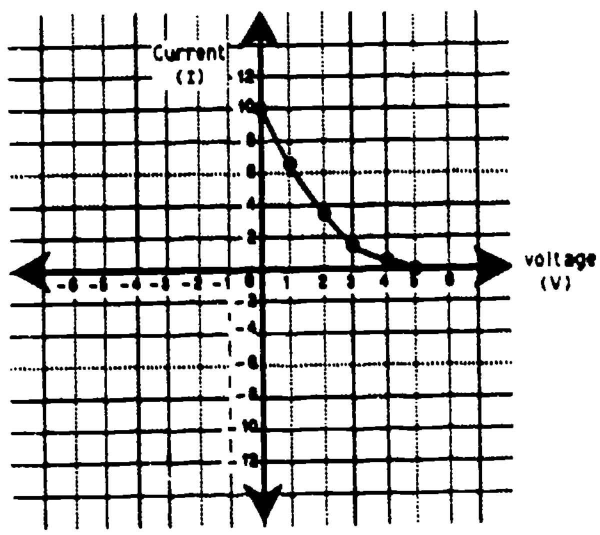
6.


voltage
(V)
time
(t)

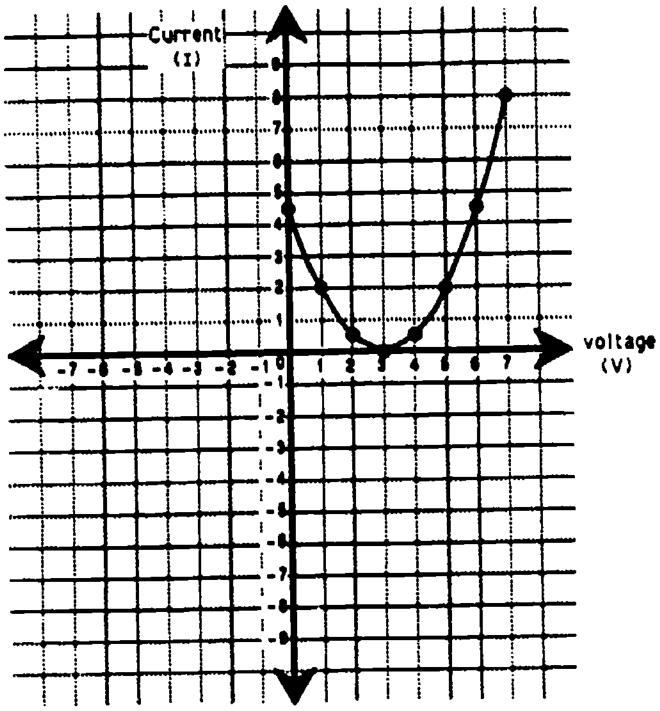
7.


Temperature
(T)
time
(t)

8.


Current
(I)
voltage
(V)

9.



Math
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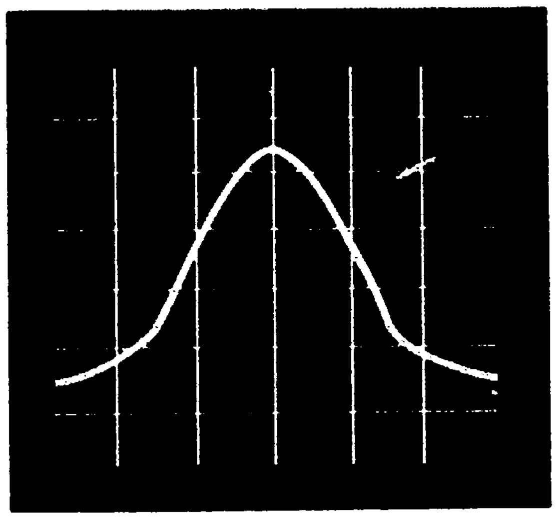
How to Extrapolate Information from Line Graphs



Prerequisites:

Workbook users should understand:

- *the concept of line graphs*
- *the concept of horizontal and vertical axes*
- *the concept of independent and dependent variables*

Acknowledgements

Several people contributed to the development of the **Math for Success in Electronics** books. These individuals include: Georges Lakkis, technical content, editing, pilot testing; Connie DeVantier, design and development; Barbara Skrepnek, development, production, administration; Kristen Luba, Kathleen Gilevich and Nancy Zebko, project administration; Caron Wiesner and Ellen Sudia, formatting, production; James Shearer and Michelle Schiller, cover designs; James Borowski, Brian Diedrich, Nancy Ruetz, Darnell Tolbert and Kelly Smith, technical editing; Bob Tait, technical advising; Jon Morell and Judith Wheeler-Robinson, pilot testing and evaluation; Dale Brandenburg, project management. In addition, numerous Great Lakes Steel - United Steelworkers of America employees and Wayne County Community College students contributed time and valuable suggestions throughout the development process.

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How to Extrapolate Information from Line Graphs

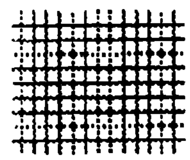
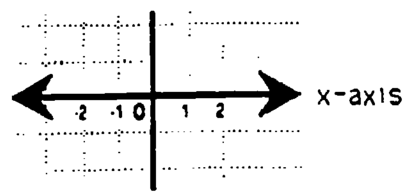
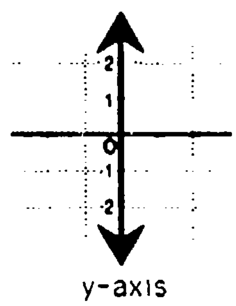
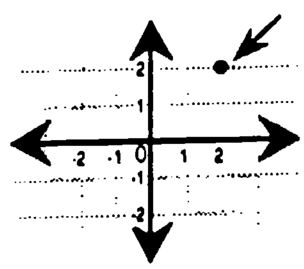
Focus

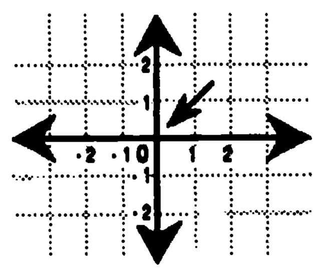
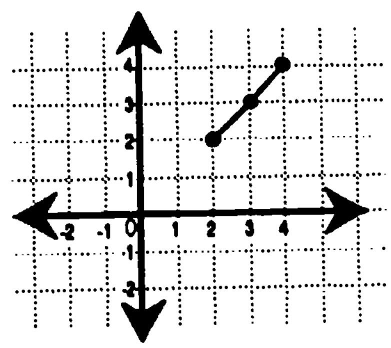
This lesson explains how to extrapolate (estimate, infer or project) information from a line graph.

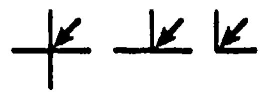
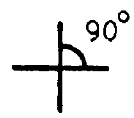
Job Examples

Job examples of when you will extrapolate information from a line graph include:
- interpreting when wire insulation has deteriorated below safety level
- interpreting types of vibrations for diagnosis purposes

Key Words

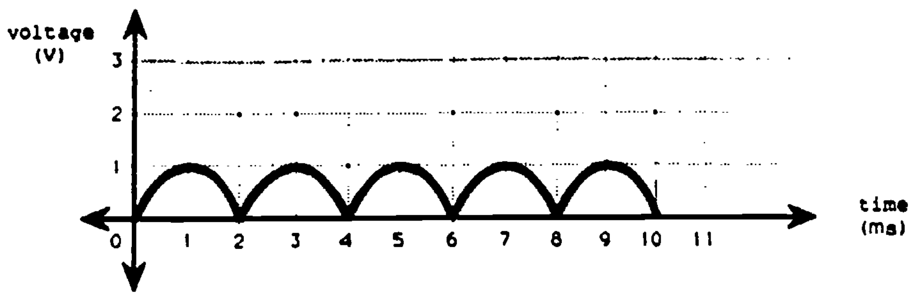
Word	Explanation	Example
grid	a grating of horizontal and vertical lines	
X axis	the horizontal number line on a grid	
Y axis	the vertical number line on a grid	
graph point	a specific location on an axis; also the location where two lines intersect	

coordinates	two values representing one point on a grid. Coordinates are written as a pair of numbers; the first number represents the X axis value (independent variable); the second number represents the Y axis value (dependent variable).	(-3,2); (x,y)
ordered pair	another name for coordinates	(5,3); (a,-b)
independent variable	a variable that controls another variable; the horizontal (X) axis on a grid	a lamp's dimmer switch (independent variable) controls the bulb's brightness (dependent variable)
dependent variable	a variable that is controlled by another variable; the vertical (Y) axis on a grid	When driving a car, the car's speed (dependent variable) depends on the amount of accelerator pedal pressure (independent variable)
zero (0)	a digit that has no quantified value; on a grid, the point at which the X and Y axes cross on a grid	
line graph	a line drawn through two or more points plotted on a grid	

intersect	to touch or cross	
perpendicular	two lines intersecting at a 90° angle	
extrapolate	to estimate, infer, or project	"The information **extrapolated** from the graph is. . ."

How to Extrapolate Information from Line Graphs

Example 1: *Voltage* (V) is the amount of volts available in a circuit or component. This graph represents the voltage coming out of an electric circuit at various time intervals. You are interested in finding the voltage (V) at a particular time. What is the voltage (V) at 7 milliseconds (ms)?



1. **Identify the variable represented by the horizontal axis.**

   time in milliseconds (ms)

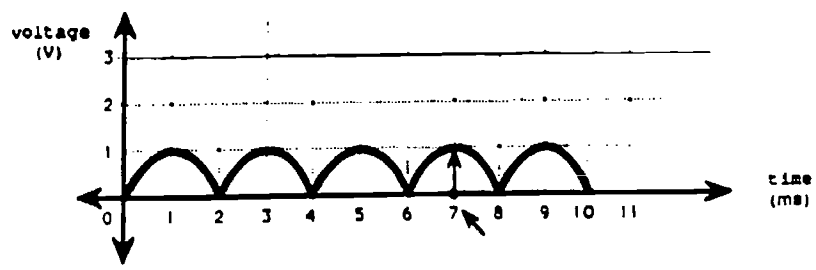
2. **Identify the variable represented by the vertical axis.**

   voltage (V)

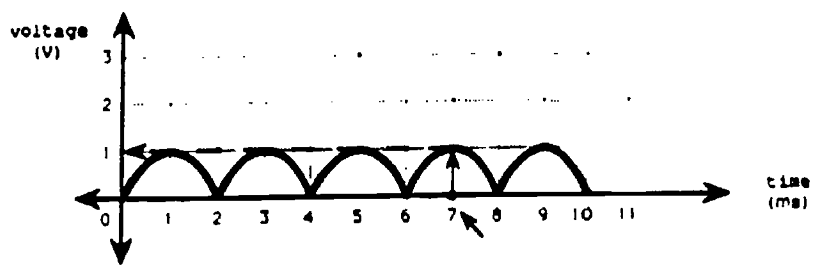
3. **Locate the *known* information on the graph (identify the point on an axis).**

   7 milliseconds (ms)

4. **From the known information point (and axis) identified in step 3, draw a perpendicular line until it intersects (touches) the graph.**

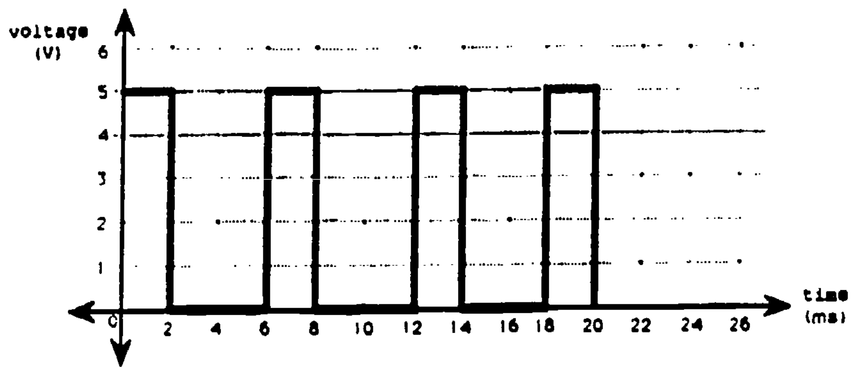


5. **From the intersection point identified in step 4, draw a perpendicular line to the *other* axis. This line intersects the axis at the value you want to extrapolate.**



The voltage (V) at 7 milliseconds (ms) is 1.

Example 2: A *circuit* is electrical components connected together to a power source. *Voltage* (V) is electrical force or pressure. This graph represents the voltage (V) coming out of an electric circuit. You are interested in finding the voltage (V) at a particular time. What is the voltage (V) at 3 milliseconds (ms)?



1. **Identify the variable represented by the horizontal axis.**

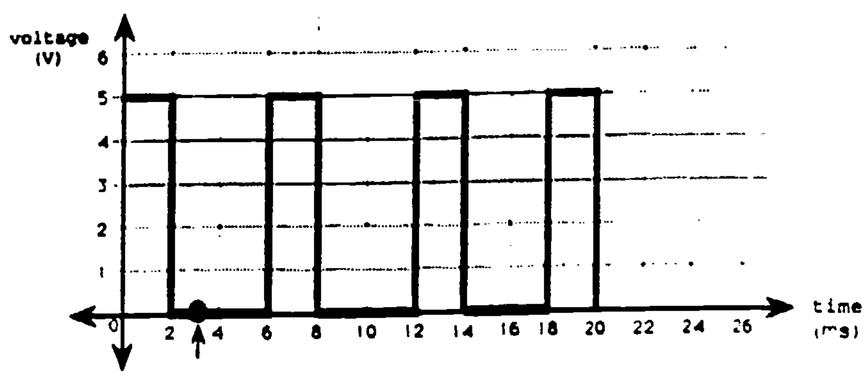
   time in milliseconds (ms)

2. **Identify the variable represented by the vertical axis.**

   voltage (V)

3. **Locate the *known* information on the graph (identify the point on an axis).**

   3 milliseconds (ms)



4. **From the known information point (and axis) identified in step 3, draw a perpendicular line until it intersects (touches) the graph.**

   This step is not applicable; the known information point intersects the graph.

5. **From the intersection point identified in step 4, draw a perpendicular line to the *other* axis. This line intersects the axis at the value you want to extrapolate.**

   This step is not applicable; the known information point intersects the graph. The voltage (V) at 3 milliseconds (ms) is 0.

Practice Problems

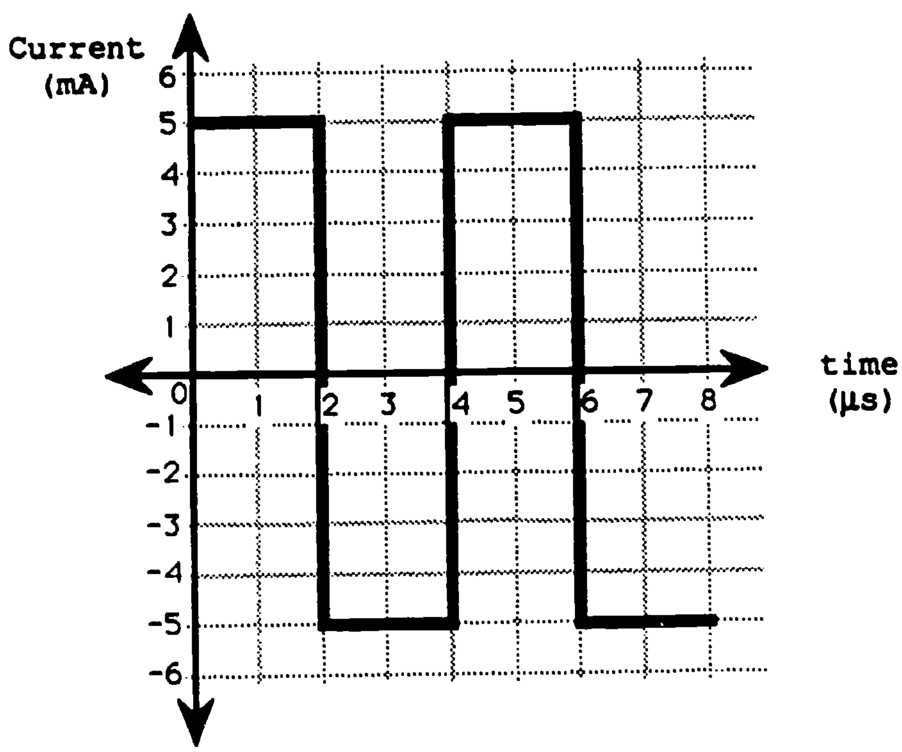
Read each problem and solve for the answer. Answers are provided in the back of this workbook.

Some Practice Problems refer to the following information:

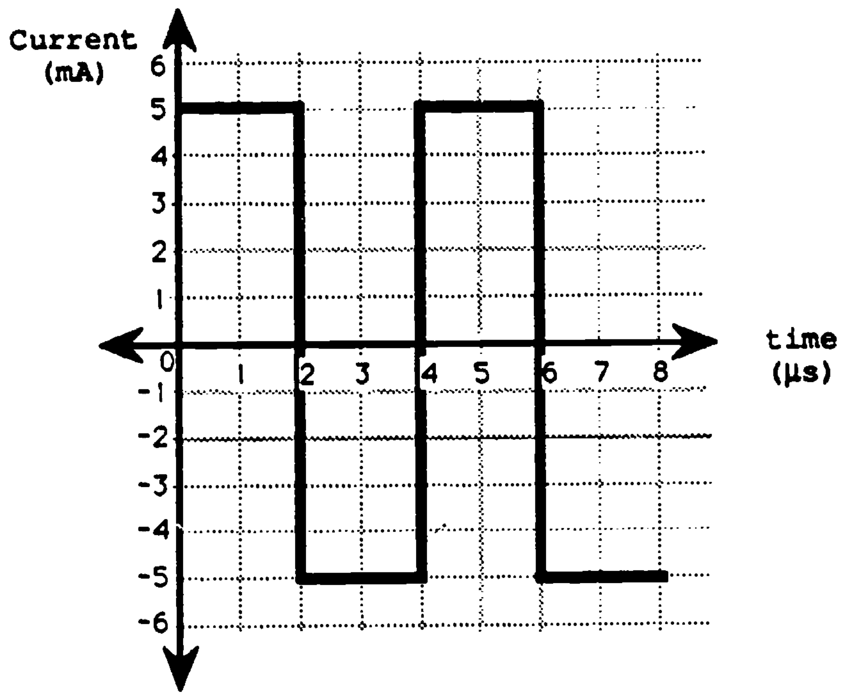
- *circuit* -- electrical components commectd together to a power source
- *current* (I) -- the flow of electrical charge; it is measured in amps (A)
- *voltage* (V) -- electrical force or pressure; it is measured in volts (v)

1. A *square wave generator* is a type of circuit. This graph represents the output of a square wave generator. (Note the square pattern of the graph.) The output represented is given in current (mA) per microseconds (μs).

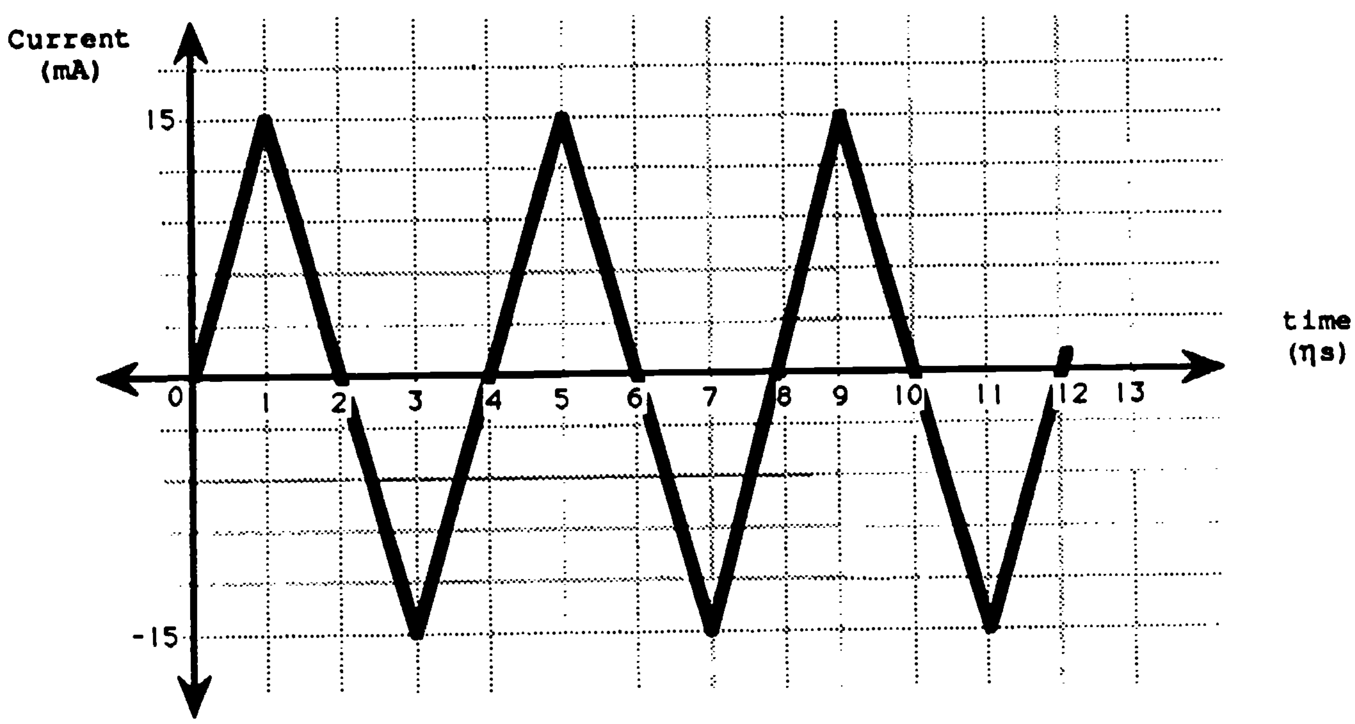
   - What is the current in milliamps (mA) at 1 microsecond (μs)?
   - What is the current in milliamps (mA) at 7 microseconds (μs)?



2. A *square wave generator* is a type of circuit. This graph represents the output of a square wave generator. (Note the square pattern of the graph.) The output represented is given in current (I) per microseconds (µs). What is the current (I) in milliamps (mA) at 9 microseconds (µs)?

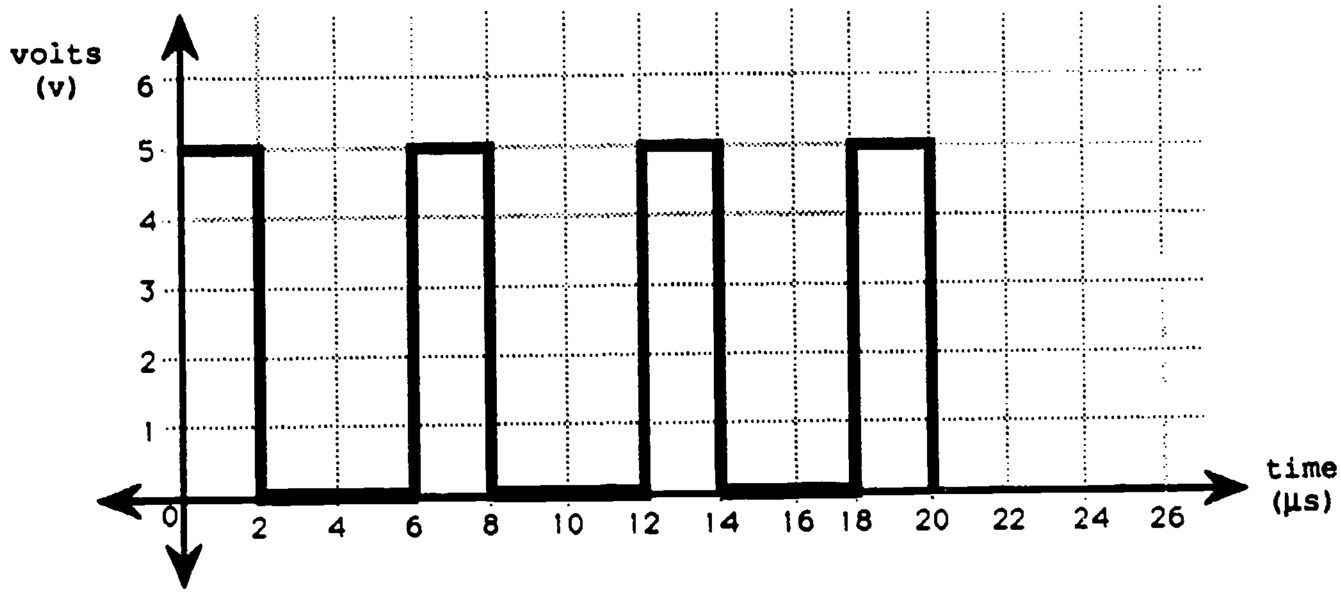


3. A *triangular wave generator* is a type of circuit. This graph represents the output of a triangular wave generator. (Note the triangular pattern of the graph). The output represented is given in current (I) per nanoseconds (ηs). What is the current (I) in milliamps (mA) at 5 nanoseconds (ηs)?

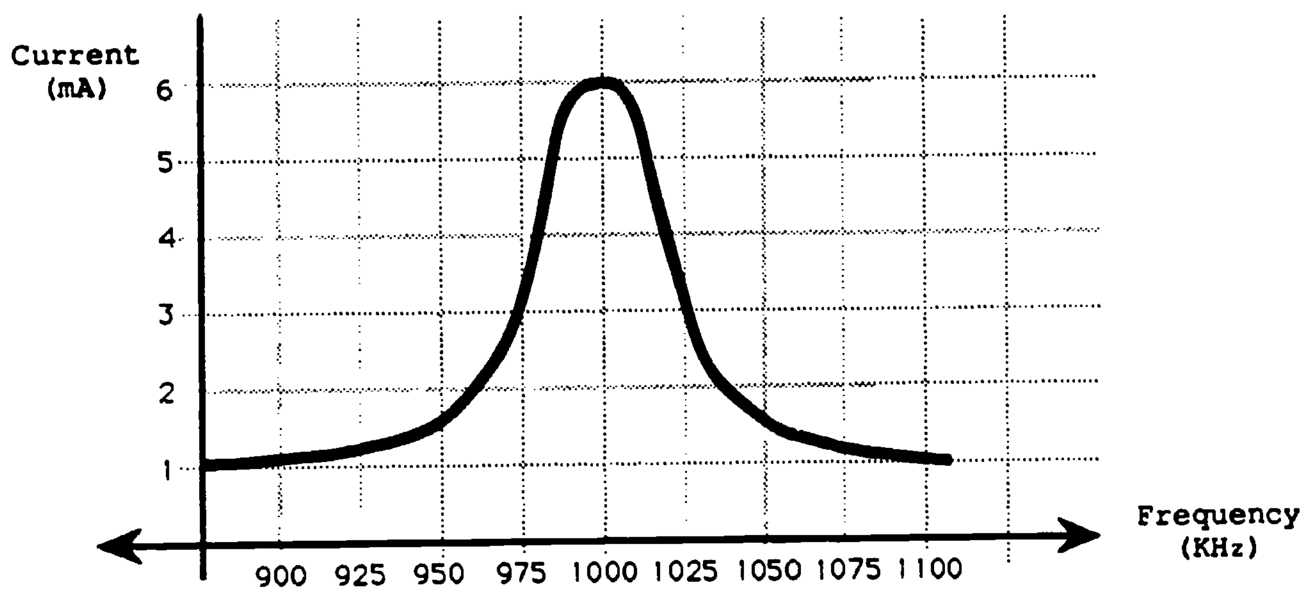


4. This graph represents the output from a computer microchip. This graph pattern is called *square pulse*. The output represented by the graph is voltage (V) per microseconds (μs).

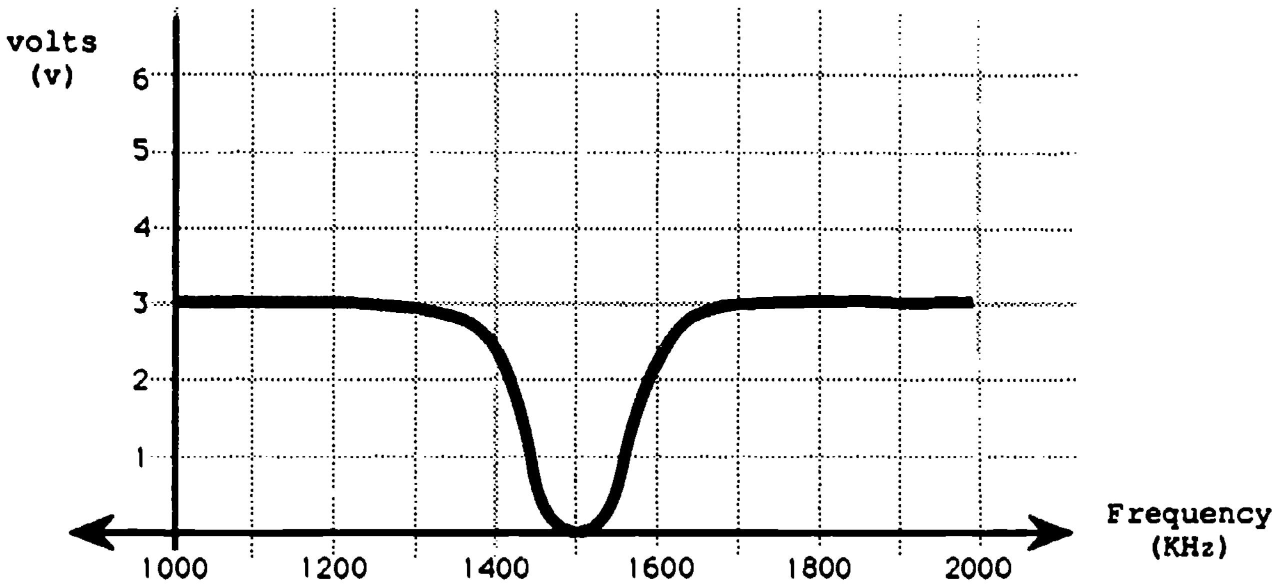
- What voltage (V) can be projected at 23 microseconds (μs)?
- What is the width (or time) in microseconds (μs) separating two pulses in the graph?



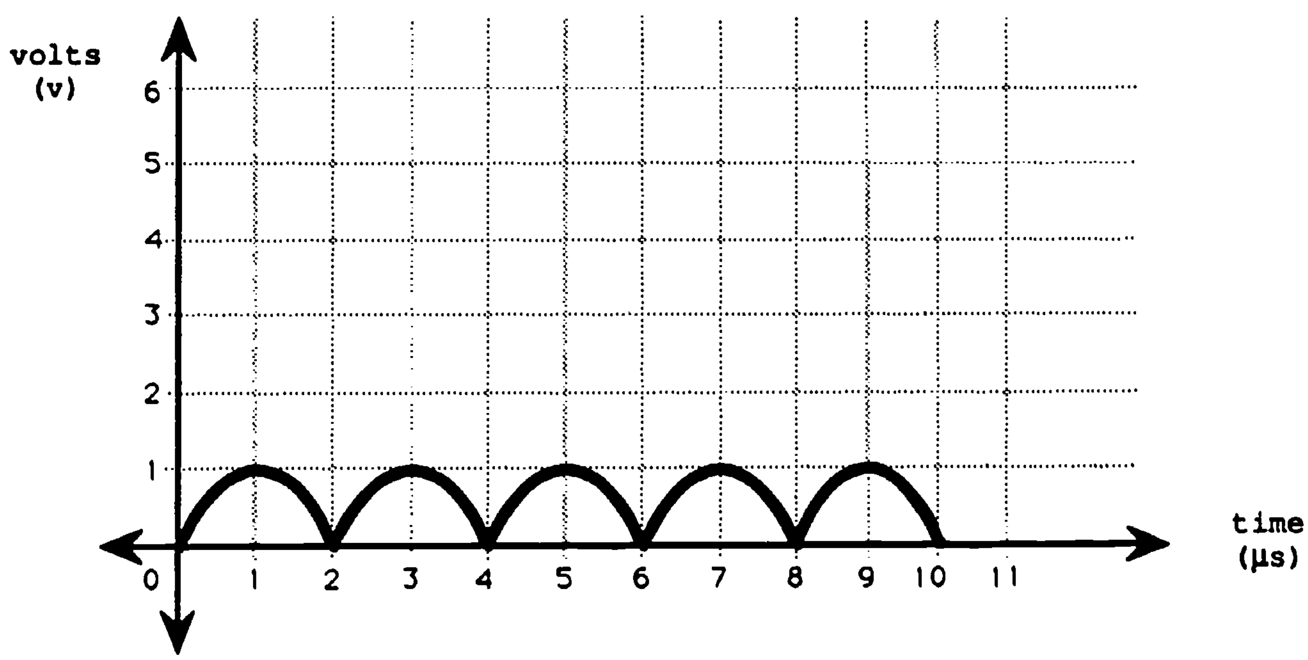
5. *Frequency* is the number of waves generated per second; frequency is measured in hertz (Hz). This graph represents the response of a radio's tuning circuit to frequency variations. The graph shows current (I) per Kilohertz (KHz). What is the current (I) in milliamps (mA) at 1050 Kilohertz (KHz)?



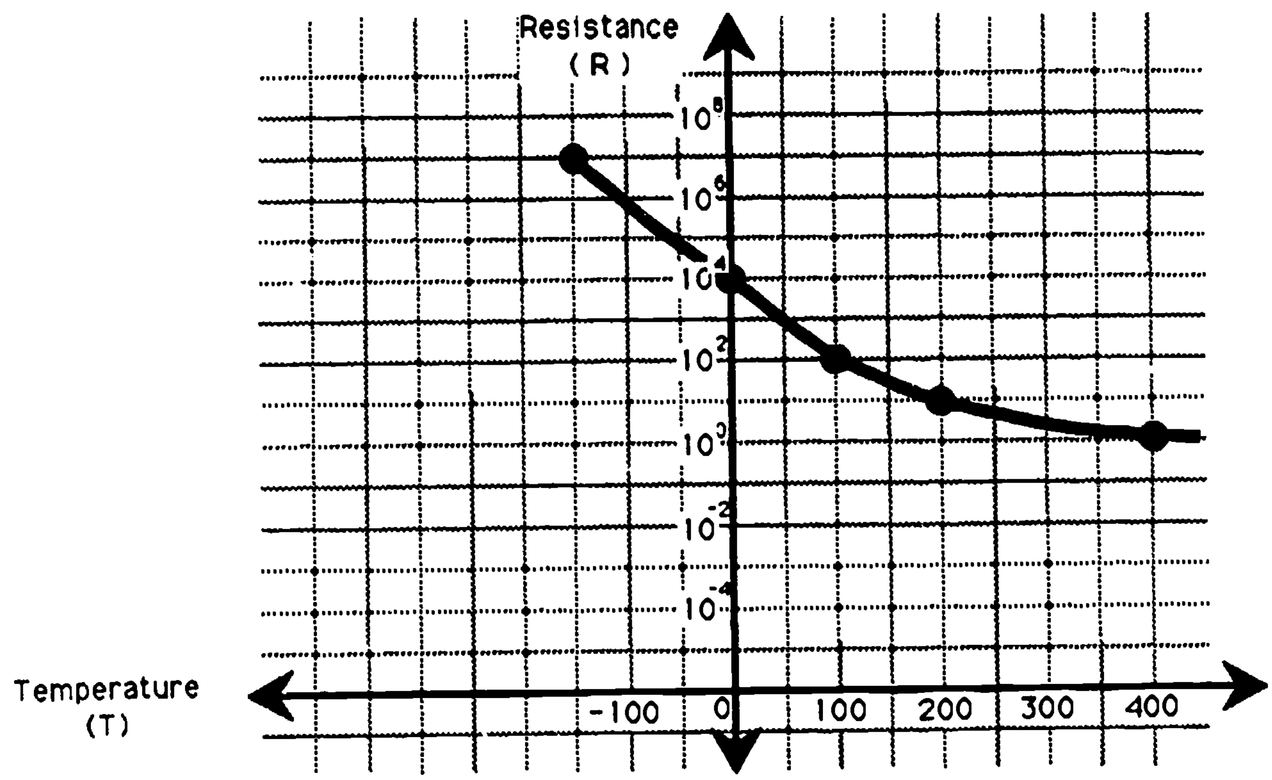
6. This graph represents the output from a filtering circuit. The output is represented in volts (v) per Kilohertz (KHz). What is the output voltage (V) at 1250 Kilohertz (KHz)?



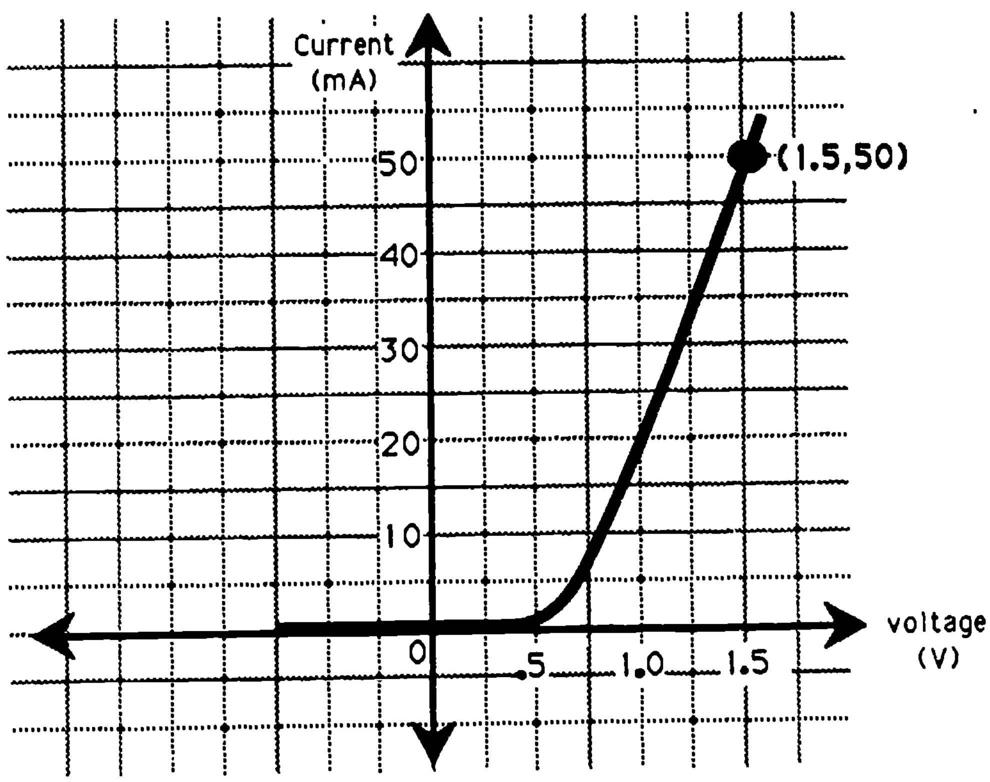
7. A *rectifier* is a circuit or component used to change an alternating current (AC) to a direct current (DC). This graph shows the output of a rectifier circuit in volts (v) per microseconds (µs). How many volts (v) are projected for 11 microseconds (µs)?



8. *Resistance* (R) is the ability of a device, material or component to oppose the flow of electric current. This graph shows the resistance (R) of a component at various temperatures (T). What is the resistance (R) at 100°?

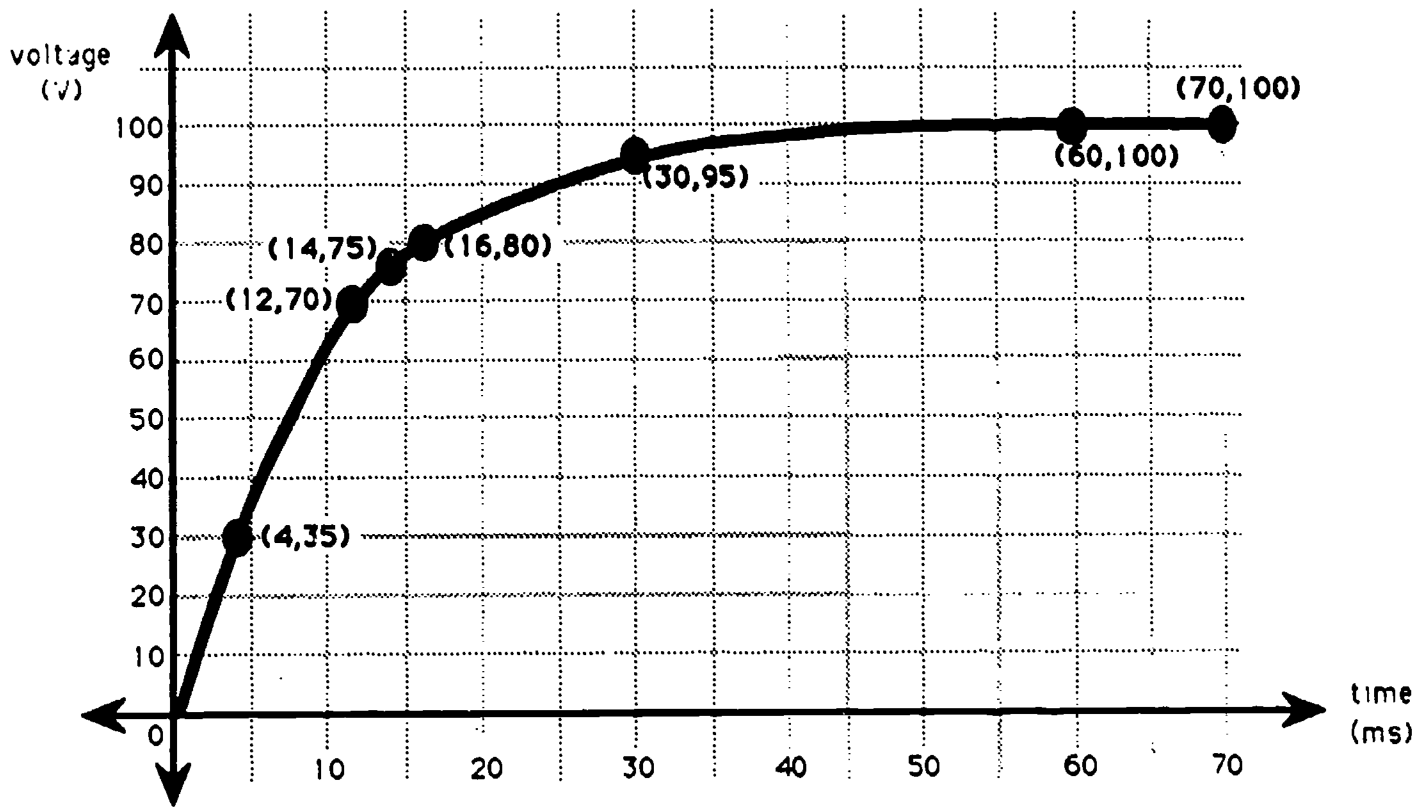


9. A *diode* is an electrical component. This graph shows the output of a diode in current (I) per voltage (V). What is the current (I) in milliamps (mA) at one volt (v)?



10. A *capacitor* is a device that stores electrical charge. Voltage (V) is electrical force or pressure. This graph shows the voltage (V) per millisecond (ms) when charging a capacitor.

- What is the voltage (V) at 20 milliseconds (ms)?
- What is the voltage (V) at 80 milliseconds (ms)?



Answers

1. 5 mA, -5 mA

2. 5 mA

3. 15 mA

4. 0 v, 4μs

5. 1.5 mA

6. 3 v

7. 1 v

8. 10^2

9. 20 mA

10. 85 volts, 100 volts

Math
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How to Convert Metric Measurements

**1 meter =
100 centimeters**

Prerequisites:

Workbook users should understand:

- *the concept of fractions*
- *how to multiply, divide and reduce fractions*
- *the concept of decimal numbers*
- *how to multiply decimal numbers*
- *the concept of exponents*

How to Convert Metric Measurements

Focus

This lesson explains how to change a metric measurement from one metric measurement scale to another.

Job Examples

Job examples of when you will change a metric measurement to a different metric measurement scale include:

- testing wire insulation
- measuring electrical current

Key Words

Word	*Explanation*	*Example*
convert	to change to a different form	100 centimeters = 1 meter
quantity	numerical value	6, 9
unit of measure	a defined measurement increment	inch, meter, watt, volt, amp
measurement	a quantity followed by a unit of measure	2 Megawatts 4 Kilovolts 1 Millimeter
metric system	a measurement system based on powers of ten	1 meter = 100 centimeters 1 meter = 1000 millimeters 1 meter = .01 hectometers
metric measurement scale	a power of ten which can also be represented by a specific name	10^{-3} = milli 10^{6} = mega 10^{3} = kilo See next page

Metric Measurement Scales		
Scale Name	**Symbol**	**Value**
Giga	G	$10^9 = 1{,}000{,}000{,}000$
Mega	M	$10^6 = 1{,}000{,}000$
Kilo	K	$10^3 = 1000$
Hecto	h	$10^2 = 100$
Deka	D	$10^1 = 10$
Basic Unit		**1**
Deci	d	$10^{-1} = \frac{1}{10^1} = .1$
Centi	c	$10^{-2} = \frac{1}{10^2} = .01$
Milli	m	$10^{-3} = \frac{1}{10^3} = .001$
Micro	μ	$10^{-6} = \frac{1}{10^6} = .000001$
Nano	n	$10^{-9} = \frac{1}{10^9} = .000000001$
Pico	p	$10^{-12} = \frac{1}{10^{12}} = .000000000001$

How To Convert Metric Measurements

Example 1: Wire insulation is measured in ohm (Ω). Adequate insulation should be at least one mega-ohm (MΩ). The meter testing a wire's insulation reads 2000 kilo-ohm (KΩ). You want to convert the 2000 KΩ to MΩ to see if the wire insulation is adequate.

1.	Identify the given metric measurement scale.	KΩ or $10^3\Omega$ or 1000Ω
2.	Identify the desired metric measurement scale.	MΩ or $10^6\Omega$ or 1,000,000Ω
3.	Multiply the given quantity by the given metric measurement *scale*.	**$2000 \cdot 10^3\Omega$** $2000 \cdot 1000\Omega$ 2,000,000Ω
4.	Divide by the desired metric measurement scale.	$\frac{\mathbf{2,000,000}}{\mathbf{1,000,000}}\Omega = \frac{2}{1}M\Omega = 2M\Omega$ The wire's insulation is 2MΩ. Adequate insulation should be at least 1MΩ, so this is adequate.

Example 2: You are testing an instrument that is supposed to absorb 5 amps (A) from a power source. Your measurement indicates that the instrument is absorbing 50 milliamps (mA). You need to convert the 50 mA to amps (A) to see if the instrument is absorbing too much or too little current.

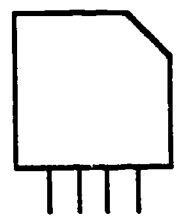
1.	Identify the given metric measurement scale.	**mA** or 10^{-3} A or .001 A
2.	Identify the desired metric measurement scale.	basic unit or **1**
3.	Multiply the given quantity by the given metric measurement.	**50 • .001 A** .05 A
4.	Divide by the desired metric measurement scale.	$\frac{.05}{1}$ A .05 A The instrument is absorbing .05 A from the power source. It should be absorbing 5 A, so it is absorbing too little current.

Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

1. Megawatts is the preferred scale for discussing electric furnace power usage. An electric furnace is using 5000 Kilowatts of power. Convert this to Megawatts.

2. A *rectifier* is a circuit or component used to change alternating current (AC) to direct current (DC). A particular rectifier can operate at .5 amps (A) without burning. The current measurement indicates the rectifier is operating at 300 milliamps (mA). Convert mA to A to determine if the rectifier is operating at a safe level.



rectifier

3. *Resistance* is the ability of device, material or component to oppose the flow of electric current. Resistance is measured in ohms (Ω). You are measuring the resistance of a wire in a transformer to make sure the resistance is at proper levels. The resistance should measure 10Ω at maximum. The actual reading is 1000 KΩ. Is the present resistance adequate?

4. A particular bolt is 48 millimeters in diameter. Wrenches are scaled from 1 to 10 centimeters. Which wrench will you choose to do the job? *(Hint: the correct wrench will not be an exact fit; it will be a bit loose.)*

5. You have a container of 1000 tablets for a cleansing process. Each tablet is 500 milligrams. Total tablets are 500,000 milligrams. Convert total tablets to Kilograms.

6. You have to fill a motor with 3000 milliliters of oil. You have a container with 3 liters of oil. Is this enough oil to fill the motor?

7. *Voltage* (V) is the amount of volts available in a circuit or component. A powerline is delivering electricity at 18,000 volts. Convert this to Kilovolts (Kv).

8. *Power*, in general, is energy delivered or consumed per second; power is measured in watts (W). A particular electronic circuit is receiving 10 Milliwatts (mW) of power. Convert this to watts (W).

9. The speed of light is 300,000,000 meters (m) per second. Convert the meters to Kilometers (Km).

10. A radio station is broadcasting at 91,500,000 hertz (Hz). Convert to Megahertz (MHz).

Answers

1. Given scale (K) = 10^3 = 1000

   Desired scale (M) = 10^6 = 1,000,000

   Multiply the given quantity by the given scale. 5000 • 1000 = 5,000,000

   Divide by the desired scale = $\frac{5,000,000}{1,000,000}$ = 5 MW
   1,000,000

2. Given scale (m) = 10^{-3} = $\frac{1}{1000}$ = .001

   Desired scale (l) = 1 (basic unit)

   Multiply the given quantity by the given scale. 300 • $\frac{1}{1000}$ = $\frac{300}{1000}$ = .3

   Divide by the desire scale = $\frac{.3}{1}$ = .3 A

   It is below the maximum limit of .5, so it is safe.

3. Given scale (K) = 10^3 = 1000

   The desired scale (1) = 1 (basic unit)

   Multiply the given quantity by the given scale. 1000 • 1000 = 1,000,000

   Divide by the desired scale = $\frac{1,000,000}{1}$ = 1,000,000Ω

   This is much higher than the safe limit of 10 Ω, so it is not safe.

4. Given scale (m) = $10^{-3} = \frac{1}{1000} = .001$

The desired scale (c) = $10^{-2} = \frac{1}{100} = .01$

Multiply the given quantity by the given scale $48 \cdot .001 = .048$

Divide by the desire scale = $\frac{.048}{.01} = 4.8$ cm

The wrench to choose is 5 cm.

5. The given scale is (m) = $10^{-3} = \frac{1}{1000} = .001$

The desired scale is (K) = $10^{3} = 1000$

Multiply the given quantity by the given scale. $500{,}000 \cdot \frac{1}{1000} = 500$

Divide by the desired scale = $\frac{500}{1000} = .5$ Kg

6. Change 3000 milliliters to liters in order to compare.

Given scale is (m) = $10^{-3} = \frac{1}{1000} = .001$

The desired scale is 1 (basic unit) = 1

Multiply the given quantity by the given scale. $3000 \cdot \frac{1}{1000} = 3$

Divide by the desired scale = $\frac{3}{1} = 3$ liters

Three (3) liters of oil is enough quantity to fill the motor.

7. The given scale is 1 (basic unit) = 1

The desired scale is K = 1000 = 10^3

Multiply the given quantity by the given scale. 18,000 • 1 = 18,000

Divide by the desired scale = $\frac{18,000}{1000}$ = 18 KV

8. The given scale is m = $10^{-3} = \frac{1}{1000}$ = .001

The desired scale is 1 (basic unit) = 1

Multiply by the given quantity by the given scale. 10 • .001 = .01

Divide by the desired scale $\frac{.01}{1}$ = .01 W

9. The given scale is 1 (basic unit) = 1

The desired scale is K = 10^3 = 1000

Multiply the given quantity by the given scale. 300,000,000 • 1 = 300,000,000

Divide by the desired scale = $\frac{300,000,000}{1000}$ = 300,000 Km

10. The given scale is 1 H (basic unit) = 1

The desired scale is M = 10^6 = 1,000,000

Multiply the given quantity by the given scale. 91,500,000 • 1 = 91,500,000

Divide by the desired scale = $\frac{91,500,000}{1,000,000}$ = 91.5 MHz

Math
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How to Convert English and Metric Measurements

1" = 2.54cm

Prerequisites:

Workbook users should understand:

- *the concept of decimal numbers*
- *how to use a calculator for multiplying and dividing decimal numbers*

How to Convert English and Metric Measurements

Focus

This lesson explains how to convert an English measurement to a metric measurement, and how to convert a metric measurement to an English measurement.

Job Examples

Job examples of when you will convert English and metric measurements include converting:

- meters to feet when using foreign designs
- centimeters to inches when using foreign manuals

Key Words

Word	*Explanation*	*Example*
convert	to change to a different form	12 inches = 1 foot 1 mile = 1.61 Kilometers
quantity	numerical value	6, 9, 101
unit of measure	a defined measurement increment	inch, meter, pound, Kilogram
measurement	a quantity followed by a unit of measure	3 centimeters, 1 inch
metric system	a measurement system based on multiples of 10	1 meter = 100 centimeters 1 meter = 1000 millimeters 1 meter = .01 hectometers
English system	the measurement system used in the U.S.; it is not based on multiples of 10	12 inches = 1 foot 3 feet = 1 yard 4 cups = 1 quart
Conversion Table	a table with information for converting from one measurement to another	see next page

Conversion Table

English Unit of Measure x →	Conversion Quantity	Metric Unit of Measure ÷ ←
foot (ft)	.305	meter (m)
inch (")	2.54	centimeter (cm)
pound (lb)	.452	Kilogram (Kg)
British thermal unit (Btu)	252	calorie
horsepower (hp)	746	watt (W)
mile (mi)	1.61	Kilometer (Km)

Note the directional arrows and associated math operations in the table headings:

- When converting from an *English* unit of measure, *multiply* by the conversion quantity.
- When converting from a *metric* unit of measure, *divide* by the conversion quantity.

How to Convert an English Measurement to Metric

> ***Example:*** You are planning to install several pieces of equipment along a particular shop wall. You know the wall is 50 feet (ft) long. The floor plan you are using states that a minimum wall length of 15 meters (m) is needed for the installation. Convert feet (ft) to meters to ensure that you will have adequate wall space for the installation.

1. Identify the English and metric units of measure.

   - **English** unit of measure is **foot**
   - **metric** unit of measure is **meter**

2. Find the line on the Conversion Table that shows the English and metric units of measure. *(Note: the directional arrows and associated math operations at the top of the table.)*

English Unit of Measure x →	Conversion Quantity	Metric Unit of Measure ÷ ←
foot (ft)	.305	meter (m)
inch (")	2.54	centimeter (cm)
pound (lb)	.452	Kilogram (Kg)
British thermal unit (Btu)	252	calorie
horsepower (hp)	746	watt (W)
mile (mi)	1.61	Kilometer (Km)

3. Place all information in this format:

English Measurement Quantity	Conversion Operation	Conversion Quantity		Metric Measurement Quantity
50	x	.305	=	

4. Perform operation.

   50 • .305 = 15.25

   15.25 meters is enough wall length for the installation.

How to Convert a Metric Measurement to English

Example: A *generator* is a device that generates electrical energy as a result of an external force acting on it. You need to install a new generator in your plant's shop. The manual states that the generator needs to be a minimum of 127 centimeters (cm) from other electrical units. Convert centimeters to inches so you can more easily measure the appropriate distance.

1. Identify the English and metric units of measure.
   - **English** unit of measure is **inch**
   - **metric** unit of measure is **centimeter**

2. Find the line on the Conversion Table that shows the English and metric units of measure.
   (Note: the directional arrow and associate math operations at the top of the table.)

English Unit of Measure × →	Conversion Quantity	Metric Unit of Measure ÷ ←
foot (ft)	.305	meter (m)
inch (")	2.54	centimeter (cm)
pound (lb)	.452	Kilogram (Kg)
British thermal unit (Btu)	252	calorie
horsepower (hp)	746	watt (W)
mile (mi)	1.61	Kilometer (Km)

3. Place all information in this format:

Metric Measurement Quantity	Conversion Operation	Conversion Quantity		English Measurement Quantity
127	÷	2.54	=	

4. Perform operation.

$$\frac{127}{2.54} = 50$$

The generator needs to be a minimum of 50 inches from other electrical units.

Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

1. In physics, the speed of a falling object increases 9.8 meters per second (m/s) every second. How much does the speed of a falling object increase in feet per second (ft/s)?

2. A *calorie* is a metric measurement for a specific amount of heat. A *Btu* (British thermal unit) is an English measurement for the same thing. A particular electric heater produced 126,000 calories of heat. How much heat did it produce in Btu (British thermal unit)?

3. An electric heater produced 400 Btu of heat. How much heat did it produce in calories?

4. A roll of steel is 80" (inches) wide. You require a width of at least 200 centimeters (cm) for a particular job. Will the 80" (inches) width be adequate for your job?

5. You need to move a piece of steel weighing 226 Kilograms (Kg). A particular lift can move a maximum weight of 500 pounds (lbs). Can you use this lift to move this piece of steel?

6. A certain plant design requires a piece of wire 6.1 meters (m) long. How long must the wire be in feet (ft)?

7. A certain vehicle travelled 50 miles. How far did it go in Kilometers (Km)?

8. A certain vehicle travelled 96.6 Kilometers (Km). How far did it go in miles (mi)?

9. A certain blueprint requires that a motor be installed 50.8 centimeters (cm) from a wall. You want to convert this to inches (") so you can measure it more easily. How far in inches must the motor be installed from the wall?

10. An electric motor has a 3 hp (horsepower) rating. How many watts (W) is this?

11. An electric motor has a 5000 watts (W) rating. What is its rating in horsepower (hp)?

Answers

1. $\frac{9.8}{.305} = 32.1$ ft/s

2. $\frac{126{,}000}{252} = 500$ Btu

3. 400 • 252 = 100,800 calories

4. 80 • 2.54 = 203.2 cm (Yes - this is adequate.)

5. $\frac{226}{.452} = 500$ lbs (Yes - this lift can be used.)

6. $\frac{6.1}{.305} = 20$ ft.

7. 50 • 1.61 = 80.5 Km

8. $\frac{96.6}{1.61} = 60$ miles

9. $\frac{50.8}{2.54} = 20''$

10. 3 • 746 = 2238 W

11. $\frac{5000}{746} = 6.7$ hp

Math
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How to Convert English Measurements

12 inches = 1 ft.

Prerequisites:

Workbook users should understand:

- *how to multiply and divide numbers*
- *how to use a calculator for multiplying and dividing decimal numbers*

How to Convert English Measurements

Focus

This lesson explains how to convert one English measurement to another English measurement.

Job Examples

A job example of when you will convert English measurements is reading distances in yards on blueprints and converting these distances to feet and inches in order to use a measuring tape.

Key Words

Word	***Explanation***	***Example***
convert	to change to a different form	12 inches = 1 foot 12 quarts = 3 gallons
quantity	numerical value	6, 9, 101
unit of measure	a defined measurement increment	inch, pound, yard
measurement	a quantity followed by a unit of measure	5 feet, 10 miles
English system	the measurement system used in the U.S. it is not based on multiples of 10	12 inches = 1 foot 3 feet = 1 yard 4 cups = 1 quart
Conversion Table	a table with information for converting from one measurement to another	see next page

Conversion Table

Higher Value Unit of Measure x →	Conversion Quantity	Lower Value Unit of Measure ÷ ←
mile	5,280	foot
mile	1,760	yard
yard	3	foot
foot	12	inch
yard	36	inch
pint	16	fluid ounce
quart	2	pint
gallon	4	quart
gallon	8	pint
quart	32	fluid ounce
pound	16	ounce

Note the directional arrows and associated math operations in the table headings:

- When converting *from* a *higher* value unit of measure, *multiply* by the conversion quantity.
- When converting *from* a *lower* value unit of measure, you *divide* by the conversion quantity.

How to Convert English Measurements

Example 1:	A manual states that you need 36 inches of wire to install a motor. You have three feet of wire. You need to change feet to inches to see if there is enough wire to install the motor.

1. Identify the *given* unit of measure *and the desired* unit of measure.

- given unit of measure is **foot**
- desired unit of measure is **inch**

2. Find the line on the Conversion Table that shows the given *and* desired units of measure. *(Note: the directional arrows and associated math operations at the top of the table.)*

Higher Value Unit of Measure x →	Conversion Quantity	Lower Value Unit of Measure ÷ ←
mile	5,280	foot
mile	1,760	yard
yard	3	foot
foot	12	inch
yard	36	inch
pint	16	fluid ounce
quart	2	pint
gallon	4	quart
gallon	8	pint
quart	32	fluid ounce
pound	16	ounce

3. Place all information in this format:

Given Measurement Quantity	Conversion Operation	Conversion Quantity		Desired Measurement Quantity
3	x	12	=	

4. Perform operation.

3 • 12 = 36 inches

This is enough wire to install the motor.

Example 2: A blueprint shows that five yards of wall space are available for installing a particular machine. The machine is 12 feet long. You need to convert feet to yards to see if the machine will fit along the wall.

1. Identify the *given* unit of measure and the *desired* unit of measure.
   - given unit of measure is **foot**
   - desired unit of measure is **yard**

2. Find the line on the Conversion Table that shows the given *and* desired units of measure; *(Note: the directional arrows and associated math operations at the top of the table.)*

Higher Value Unit of Measure × →	Conversion Quantity	Lower Value Unit of Measure ÷ ←
mile	5,280	foot
mile	1,760	yard
yard	3	foot
foot	12	inch
yard	36	inch
pint	16	fluid ounce
quart	2	pint
gallon	4	quart
gallon	8	pint
quart	32	fluid ounce
pound	16	ounce

3. Place all information in this format:

Given Measurement Quantity	Conversion Operation	Conversion Quantity		Measurement Quantity
12	÷	3	=	

4. Perform operation.

12 ÷ **3** = **4** yards

The machine is 4 yards long; it will fit along the wall.

Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

1. You need 57 feet of wire for installing a particular machine. The roll of wire in the shop has 20 yards of wire on it. Convert yards to feet to see if the roll contains enough wire for your job.

2. A motor needs to be installed 72 inches from a wall. Convert inches to feet so you can measure the distance more conveniently.

3. Two pints of lubrication oil are needed to lubricate a pump. The container of lubrication oil you have contains 48 ounces of oil. Convert pints to ounces to ensure you will have enough oil for the pumps.

4. A building blueprint requires a distance of two yards between two particular machines. You have measured the actual distance between the machines with a tape measure, and found the distance to be six feet. Convert feet to yards to see if the machines are at an appropriate distance.

5. A container has 37 ounces of a cleaning solution. You need to transfer this solution to a two-quart container. Convert quarts to ounces to see if your two-quart container is large enough to hold all of the cleaning solution.

6. Twelve quarts of grease are needed to lubricate six motors. Grease is available is one gallon containers. Convert quarts to gallons to see how many containers of grease are needed for the job.

7. Ninety-six ounces of oil are needed for lubricating four electrical machines. There are currently 10 pints of oil on the shop shelf. Covert pints to ounces to see if enough oil is available for the job.

8. The length of a motor base is 108 inches. Convert inches to yards so that you can work with this length more conveniently.

Answers

1. given unit: yard
   desired unit: foot
   20 yards x 3 = 60 feet (enough for the job)

2. given unit: inch
   desired unit: foot
   72 inches ÷ 12 = 6 feet

3. given unit: pint
   desired unit: ounce
   2 pints • 16 = 32 ounces (enough for the job)

4. given unit: foot
   desired unit: yard
   6 feet ÷ 3 = 2 yards

5. given unit: quart
   desired unit: ounce
   2 quarts x 32 = 64 ounces (enough to hold the cleaning solution)

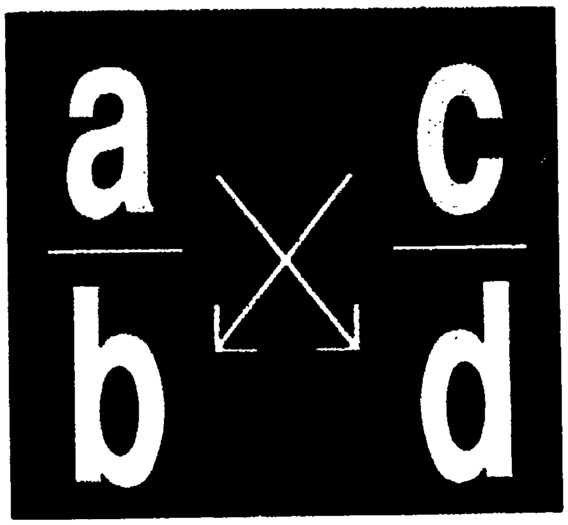
6. given unit: quart
   desired unit: gallon
   12 quarts ÷ 4 = 3 gallons

7. given unit: pint
   desired unit: ounce
   10 pints • 16 ounces = 160 ounces (enough for the job)

8. given unit: inch
   desired unit: yard
   108 inches ÷ 36 = 3 yards

Math for Success in Electronics

How to Work with Proportions



Prerequisites:

Workbook users should understand:

- *how to solve equations with fractions*
- *how to apply the Multiplication Property of Equality*

How to Work with Proportions

Focus

This lesson explains how to work with proportions.

Job Examples

Job examples of when you will work with proportions include
- calculating voltage in electric circuits
- calculating current in electric circuits

Key Words

Word	*Explanation*	*Example*
proportion	two fractions separated by an equal sign	$\frac{10}{5} = \frac{30}{15}, \frac{A}{2} = \frac{10}{4}$
fraction	two numbers separated by a fraction bar; the top number is the *numerator*, the bottom number is the *denominator*.	$\frac{a}{b}, \frac{18}{29}, \frac{523}{600}, \frac{9}{2}, \frac{a}{3}$
cross multiply	a way to restructure a proportion	$\frac{a}{b} = \frac{c}{d}$ or $\frac{a}{b} \times \frac{c}{d}$ or $a \cdot d = c \cdot b$ $\frac{6}{20} = \frac{x}{5}$ or $\frac{6}{20} \times \frac{x}{5}$ or $6 \cdot 5 = x \cdot 20$
Multiplication-Property of Equality	an algebraic concept stating that you can multiply or divide a number into *both* sides of an equation without changing the value of the equation.	$x = 4$ is an equation $x \cdot 8 = 4 \cdot 8$ $\frac{x}{2} = \frac{4}{2}$

How To Work with Proportions

Example 1: A *transformer* is a device that increases or decreases voltage and/or current. The input voltage (V) of a certain transformer is given by $\frac{110}{V} = \frac{50}{100}$. You need to find the value of the input voltage (V).

1. Cross multiply.

$$\frac{110}{V} = \frac{50}{100}$$

$$110 \cdot 100 = 50 \cdot V$$

2. Apply the Multiplication Property of Equality.

$$11{,}000 = 50 \cdot V$$

$$\frac{11{,}000}{50} = \frac{50 \cdot V}{50}$$

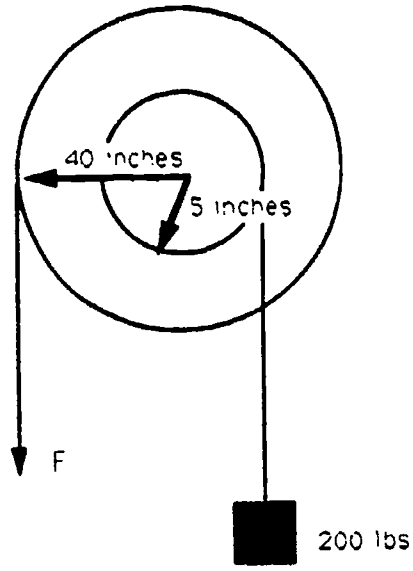
$$\frac{11{,}000}{50} = V$$

3. Reduce the result fraction.

$$\frac{11{,}000}{50} = V$$

$$220 = V \text{ or } V = 220$$

Example 2: A two pulley system is used to lift a 200 pound (lb.) motor. The force (F) in pounds needed to pull up the 200 lb. motor is represented by $\frac{F}{200} = \frac{5}{40}$. You are interested in finding the value of the force (F).



1. Cross Multiply.

$$\frac{F}{200} = \frac{5}{40}$$

$$F \cdot 40 = 5 \cdot 200$$

$$F \cdot 40 = 1000$$

2. Apply the Multiplication Property of Equality.

$$F \cdot 40 = 1000$$

$$\frac{F \cdot 40}{40} = \frac{1000}{40}$$

$$F = \frac{1000}{40}$$

3. Reduce the result fraction.

$$F = \frac{1000}{40}$$

$$F = 25 \text{ lbs.}$$

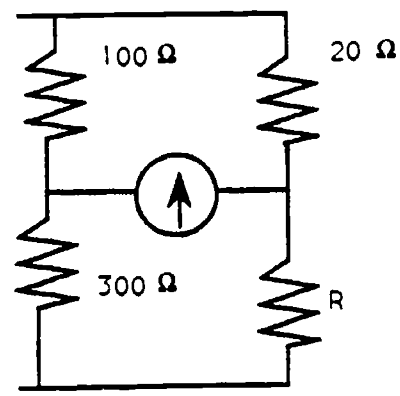
Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

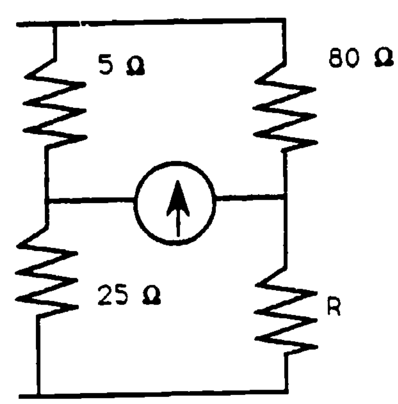
Some Practice Problems refer to the following information:

- *resistance* (R) -- the ability of a device, material or component to oppose the flow of electric current; it is measured in ohms (Ω)
- *voltage* (V) -- electrical force or pressure; it is measured in volts (v)
- *current* (I) -- the flow of electrical charge; it is measured in amps (A)

1. A *Wheatstone Bridge* is a circuit that is used to measure an unknown resistance (R). You have used a Wheatstone Bridge to identify a specific unknown resistance (R). This specific unknown resistance (R) is given as $\frac{100}{20} = \frac{300}{R}$. What is the unknown resistance (R)?



2. A *Wheatstone Bridge* is a circuit that is used to measure an unknown resistance (R). You have used a Wheatstone Bridge to identify a specific unknown resistance (R). This specific unknown resistance (R) is given as $\frac{R}{25} = \frac{80}{5}$. What is the unknown resistance (R)?



3. A certain electrical device is connected in series (end to end) with another device. Its voltage (V) can be calculated by $\frac{V}{20} = \frac{20}{4}$. What is its voltage (V)?

devices connected in series

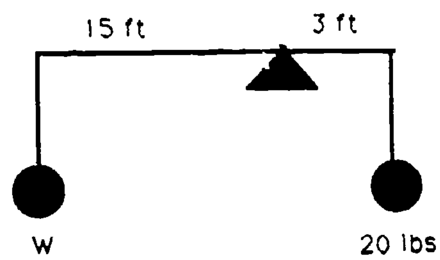
4. A particular component is connected in series (end to end) with another component. It's resistance (R) is represented by $\frac{R}{8} = \frac{20}{50}$. What is its resistance (R)?

components connected in series

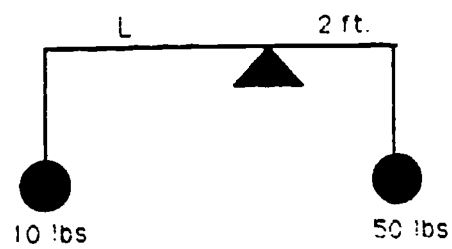
5. In a certain circuit, the current (I) is represented by $\frac{I}{3} = \frac{12}{18}$. What is the current (I)?

6. A *transformer* is a device that increases or decreases voltage and/or current. The output voltage (V) of a certain transformer is given by $\frac{V}{110} = \frac{18}{220}$. What is the output voltage (V)?

7. In physics, the lever arm problem examines weight and distance relationships. In this specific problem, weight (W) can be calculated by $\frac{W}{20} = \frac{3}{15}$. What is the weight?



8. In physics, the lever arm problem examines weight and distance relationships. In this specific problem, the distance (L) can be calculated by $\frac{10}{50} = \frac{2}{L}$. What is the distance (L)?



9. When two devices are connected in series, their powers and resistances are represented by $\frac{P_1}{P_2} = \frac{R_1}{R_2}$. If P_1 is 10 W, P_2 is 20 W, and R_2 is 60 Ω, what is R_1?

devices connected in series

Answers

1. $100 \cdot R = 300 \cdot 20$

   $100 \cdot R = 6000$

   $$\frac{100}{100} \cdot R = \frac{6000}{100}$$

   $R = 60\ \Omega$

2. $R \cdot 5 = 80 \cdot 25$

   $R \cdot 5 = 2000$

   $$R \cdot \frac{5}{5} = \frac{2000}{5}$$

   $R = 400\ \Omega$

3. $V \cdot 4 = 20 \cdot 20$

   $V \cdot 4 = 400$

   $$V \cdot \frac{4}{4} = \frac{400}{4}$$

   $V = 100$ volts

4. $R \cdot 50 = 20 \cdot 8$

   $R \cdot 50 = 160$

   $$R \cdot \frac{50}{50} = \frac{160}{50}$$

   $R = 3.2\ \Omega$

5. $I \cdot 18 = 12 \cdot 3$

   $I \cdot 18 = 36$

   $I \cdot \frac{18}{18} = \frac{36}{18}$

   $I = 2\ A$

6. $V \cdot 220 = 110 \cdot 18$

   $V \cdot 220 = 1980$

   $V \cdot \frac{220}{220} = \frac{1980}{220}$

   $V = 9$ volts

7. $W \cdot 15 = 3 \cdot 20$

   $W \cdot 15 = 60$

   $W \cdot \frac{15}{15} = \frac{60}{15}$

   $W = 4$ lbs.

8. $10 \cdot L = 2 \cdot 50$

   $10 \cdot L = 100$

   $\frac{10}{10} \cdot L = \frac{100}{10}$

   $L = 10$ ft.

9. $$\frac{P_1}{P_2} = \frac{R_1}{R_2}$$

$$\frac{10}{20} = \frac{R_1}{60}$$

$$10 \cdot 60 = 20 \cdot R_1$$

$$600 = 20 \cdot R_1$$

$$\frac{600}{20} = \frac{20}{20} \cdot R_1$$

$30 = R_1$ or $R_1 = 30\ \Omega$

Math for Success in Electronics

How to Solve Equations with Whole Numbers

$$5(2+1)=$$

Prerequisites:

Workbook users should understand:

- *the concept of whole numbers*
- *the Distributive Law*
- *how to use inverse functions*
- *how to use order of operation*

How to Solve Equations with Whole Numbers

Focus

This lesson explains how to find the unknown value in an equation with whole numbers.

Job Examples

Job examples of when you will solve equations with whole numbers include calculating:

- current of electrical components
- resistance of circuits
- power of electrical devices

Key Words

Word	***Explanation***	***Example***
equation	an equality with numbers and unknown values	$a + b = c$ $3 + 5 = 8$
equality	two mathematical quantities separated by an equal sign (=); the equal sign means the two quantities are equal	$2 + 3 = 5$
whole number	a number that is not a fraction	1, 16, -238
unknown value	a letter in an equation with a value that is not stated	$7 + \mathbf{x} = 20$ $5 + \mathbf{y} + \mathbf{z} =$ [illegible] $\cdot\ \mathbf{z}$
Distributive Law	an algebraic concept stating $a(b + c) = a \cdot b + a \cdot c$	$x(y + z) = xy + xz$ $2 \cdot 4 + 2 \cdot 3 = 2(4 + 3)$
math function	a mathematical procedure	addition (+), subtraction (-) multiplication ($\cdot$), division ($\div$) power (a^b), root ($\sqrt{\ }$)

inverse function	a math function that can be used to cancel a specific other math function	add/subtract	$7 + 2 - 2 = 7$
		multiply/divide	$\frac{7 \cdot 4}{4} = 7$
		powers/roots	$\sqrt{7^2} = 7$

How to Solve Equations with Whole Numbers

Example 1: *Resistance* (R) is the ability of a device, material or component to oppose the flow of electric current. Resistance is measured in ohms (Ω). You need to find the resistance of a certain light bulb which is in a machine area. The resistance (R) is given to you as $2(R + 20) - 110 = 0$. What is the resistance (R)?

1. Rearrange each side of the equation using the Distributive Law: $a(b + c) = a \cdot b + a \cdot c$

$$2\,(R + 20) - 110 = 0$$

$$2 \cdot R + 2 \cdot 20 - 110 = 0$$

2. Simplify each side of the equation.

$$2 \cdot R + \mathbf{2 \cdot 20} - 110 = 0$$

$$2 \cdot R + \mathbf{40 - 110} = 0$$

$$2 \cdot R - 70 = 0$$

3. Solve the equation isolating the unknown variable to one side of the equation using inverse functions; use inverse functions as needed in this order:
   - addition and subtraction
   - multiplication and division
   - powers and roots

$$2 \cdot R - 70 = 0$$

$$2 \cdot R - 70 + \mathbf{70} = 0 + \mathbf{70}$$

$$2 \cdot R = 70$$

$$\frac{\mathbf{2 \cdot R}}{\mathbf{2}} = \frac{70}{\mathbf{2}}$$

$$R = 35\ \Omega$$

4. Check by substituting your answer for the unknown value in the equation.

$$2(\mathbf{35} + 20) - 110 = 0$$

$$2(55) - 110 = 0$$

$$110 - 110 = 0$$

$$0 = 0$$

Example 2: *Current* (I) is the flow of electrical charge. Current is measured in amps (A). The current (I) of a certain electrical machine connected in a series (end to end) with another machine is represented by $40 + 10 \cdot I = 100$. What is the current (I)?

1. Rearrange each side of the equation using using the Distributive Law: $a(b + c) = a \cdot b + a \cdot c$

   $40 + 10 \cdot I = 100$

   This step is not applicable to this problem.

2. Simplify each side of the equation.

   This step is not applicable to this problem.

3. Solve the equation isolating the unknown variable to one side of the equation using inverse functions; use inverse functions as needed in this order:
   - addition and subtraction
   - multiplication and division
   - powers and roots

   $40 + 10 \cdot I = 100$

   $40 + 10 \cdot I - \mathbf{40} = 100 - \mathbf{40}$

   $10 \cdot I = 60$

   $\frac{10 \cdot I}{10} = \frac{60}{10}$

   $I = 6$ A

4. Check by substituting your answer for the unknown value in the equation.

   $40 + 10 \cdot \mathbf{6} = 100$

   $40 + 60 = 100$

   $100 = 100$

Practice Problems

Read each problem and solve for the answer. Answers provided in the back of this workbook.

Some Practice Problems refer to the following information:

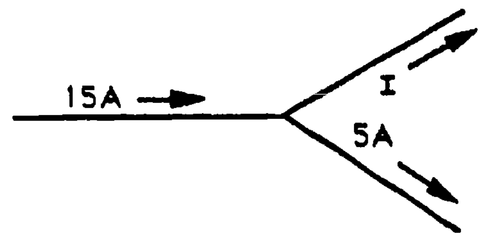
- *resistance* (R) -- the ability of a device, material or component to oppose the flow of electrical current; it is measured in ohms (Ω)
- *current* (I) -- the flow of electrical charge; it is measured in amps (A)
- *power* (P) -- in general, energy delivered or consumed per second; it is measured in watts (W)
- *voltage* (V) -- electrical force or pressure; it is measured in volts (v)

1. A light bulb is a component in a circuit. The resistance (R) of a light bulb can be calculated by solving the equation $12 = 4 \cdot R$. What is R?

2. A *resistor* is a component that controls the flow of current and/or voltage in a circuit. The voltage (V) of a certain resistor is represented by the equation, $3 \cdot V + 25 = 40$. What is the voltage (V) of this resistor?

resistor

3. You need to find the current (I) of a certain circuit. The current (I) is represented as I + 5 = 15. What is the current (I)?



4. Electric heaters can help keep motors dry from moisture. The current (I) of an electric heater is represented by the equation 110 = 22 • I. What is the current (I)?

5. In physics, the time (t) in seconds it takes a certain vehicle to accelerate from 15 miles per hour (mi/hr) to 35 mi/hr is given as 35 = 15 + 2 • t. How long does it take to reach 35 mi/hr?

6. The current (I) of a certain electrical circuit can be calculated by the equation $8(I + 4) - 48 = 0$. What is the current (I) of this circuit?

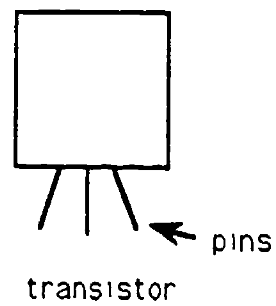
7. The resistance (R) of a certain electrical device connected in series (end to end) with another device is represented by $70 = 20 + R$. What is the resistance (R)?

series connection

8. Three resistances (R_1, R_2, and R_3) together consume 25 watts (W) of power (P). R_1 consumes 8 watts of power (8 W). R_2 consumes 10 watts of power (10 W). R_3 consumes an unknown power (P). If $8 + 10 + P = 25$, what is the value of the unknown power (P)?

9. The resistance (R) of a motor coil is represented by the equation (R + 10) 2 + 4 = 38. What is the resistance (R) of the coil?

10. A *transistor* is a device that is used as an amplifier or switch. A *pin* is the part of a transistor that is used to connect the transistor to other components. A particular transistor has three pins connected to a circuit. The current in one of the pins is represented by $4 \cdot I + 7 = 15$. What is the current (I) of this pin?



Answers

1. $12 = 4 \cdot R$

   $\frac{12}{4} = \frac{4 \cdot R}{4}$

   $3 = R$ or $R = 3\ \Omega$

   Check:

   $12 = 4 \cdot 3$

   $12 = 12$

2. $3 \cdot V + 25 = 40$

   $3 \cdot V + 25 - 25 = 40 - 25$

   $3 \cdot V = 15$

   $\frac{3 \cdot V}{3} = \frac{15}{3}$

   $V = 5$ volts

   Check:

   $3 \cdot 5 + 25 = 40$

   $15 + 25 = 40$

   $40 = 40$

3. $I + 5 = 15$

   $I + 5 - 5 = 15 - 5$

   $I = 10$ A

   Check:

   $10 + 5 = 15$

   $15 = 15$

4. $110 = 22 \cdot I$

$$\frac{110}{22} = \frac{22 \cdot I}{22}$$

$5 = I$ or $I = 5$ A

Check:

$110 = 22 \cdot I$

$110 = 22 \cdot 5$

$110 = 110$

5. $35 = 15 + 2 \cdot t$

$35 - 15 = 15 + 2 \cdot t - 15$

$20 = 2 \cdot t$

$$\frac{20}{2} = \frac{2 \cdot t}{2}$$

$10 = t$ or $t = 10$ seconds

Check:

$35 = 15 + 2 \cdot t$

$35 = 15 + 2 \cdot 10$

$35 = 15 + 20$

$35 = 35$

6. $8(I + 4) - 48 = 0$

   $8 \cdot I + 32 - 48 = 0$

   $8 \cdot I - 16 = 0$

   $8 \cdot I - 16 + 16 = 0 + 16$

   $8 \cdot I = 16$

   $\frac{8 \cdot I}{8} = \frac{16}{8}$

   $I = 2$ A

   Check:

   $8(I + 4) - 48 = 0$

   $8(2 + 4) - 48 = 0$

   $8(6) - 48 = 0$

   $48 - 48 = 0$

   $0 = 0$

7. $70 = 20 + R$

   $70 - 20 = 20 + R - 20$

   $50 = R$ or $R = 50\ \Omega$

   Check:

   $70 = 20 + R$

   $70 = 20 + 50$

   $70 = 70$

8. $8 + 10 + P = 25$

$18 + P = 25$

$18 + P - 18 = 25 - 18$

$P = 7$ Watts

Check:

$8 + 10 + P = 25$

$8 + 10 + 7 = 25$

$25 = 25$

9. $(R + 10)2 + 4 = 38$

$2R + 20 + 4 = 38$

$2R + 24 = 38$

$2R + 24 - 24 = 38 - 24$

$2R = 14$

$$\frac{2R}{2} = \frac{14}{2}$$

$R = 7\ \Omega$

Check:

$(R + 10)2 + 4 = 38$

$(7 + 10)2 + 4 = 38$

$(17)2 + 4 = 38$

$34 + 4 = 38$

$38 = 38$

10. $4 \cdot I + 7 = 15$

$4 \cdot I + 7 - 7 = 15 - 7$

$4 \cdot I = 8$

$$\frac{4 \cdot I}{4} = \frac{8}{4}$$

$I = 2$ A

Check:

$4 \cdot I + 7 = 15$

$4 \cdot 2 + 7 = 15$

$8 + 7 = 15$

$15 = 15$

Math
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How to Solve Equations with Decimal Numbers

5.2 + 2 • i =

Prerequisites:

Workbook users should understand:

- *the concept of decimal points*
- *the Distributive Law*
- *how to use inverse functions*
- *how to use order of operation*

How to Solve Equations with Decimal Numbers

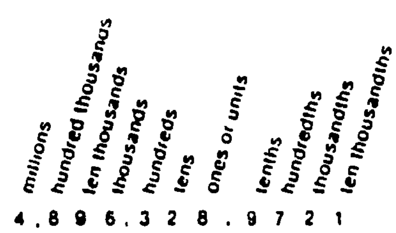
Focus

This lesson explains how to find the unknown value in an equation with decimal numbers.

Job Examples

Job examples of when you will solve equations with decimal numbers include calculating:
- current of electrical components
- resistance of circuits
- voltage of electrical devices

Key Words

Word	***Explanation***	***Example***
equation	an equality with numbers and unknown values	a + b = c 3.2 + 5.18 = 8.38
equality	two mathematical quantities separated by an equal sign (=); the equal sign means the two quantities are equal	.2 + .3 = .5
quantity	numerical value	6, 9
decimal point	a dot between the ones place and tenths place in a number	3.2, 100.24, .6, 78.1
decimal number	a number with a decimal point between the ones place and tenths place in a number	1.3, .5, 24.89, 110.75
decimal place	the position of a digit in a number	

unknown value	a letter in an equation with a value that is not stated	$7 + \mathbf{x} = 20$ $5 + \mathbf{y} + \mathbf{z} = 2 \cdot \mathbf{z}$
Distributive Law	an algebraic concept stating $a(b + c) = a \cdot b + a \cdot c$	$x(y + z) = xy + xz$ $2 \cdot 4 + 2 \cdot 3 = 2(4 + 3)$
math function	a mathematical procedure	addition (+), subtraction (-) multiplication (•), division (÷) power (a^b), root ($\sqrt{\ }$)
inverse function	a math function that cancels a specific other math function	add/subtract $7 + 2 - 2 = 7$ multiply/divide $\frac{7 \cdot 4}{4} = 7$ powers/roots $\sqrt{7^2} = 7$

How to Solve Equations with Decimal Numbers

Example 1: *Current* (I) is the flow of electrical charge. Current is measured in amps (A). The current of a certain electrical device is represented by $2(I + 2.5) - 12.8 = 0$. You need to solve the equation in order to find the current of the electrical device.

1. Rearrange each side of the equation using the Distributive Law: $a(b + c) = a \bullet b + a \bullet c$

$$2(I + 2.5) - 12.8 = 0$$

$$2 \bullet I + 2 \bullet 2.5 - 12.8 = 0$$

2. Simplify each side of the equation.

$$2 \bullet I + \mathbf{2} \bullet \mathbf{2.5} - 12.8 = 0$$

$$2 \bullet I + \mathbf{5} - \mathbf{12.8} = 0$$

$$2 \bullet I - 7.8 = 0$$

3. Solve the equation isolating the unknown variable to one side of the equation using inverse functions; use inverse functions as needed in this order:
   - addition and subtraction
   - multiplication and division
   - powers and roots

$$2 \bullet I - 7.8 = 0$$

$$2 \bullet I - \mathbf{7.8} + \mathbf{7.8} = 0 + 7.8$$

$$2 \bullet I = 7.8$$

$$\frac{\mathbf{2 \bullet I}}{\mathbf{2}} = \frac{\mathbf{7.8}}{\mathbf{2}}$$

$$I = 3.9 \text{ A}$$

4. Check by substituting your answer for the unknown value in the equation.

$$2(\mathbf{3.9} + 2.5) - 12.8 = 0$$

$$2(6.4) - 12.8 = 0$$

$$12.8 - 12.8 = 0$$

$$0 = 0$$

Example 2: *Current* (I) is the flow of electrical charge. Current is measured in amps (A). The current (I) of a certain electrical machine connected in series (end to end) with another machine is represented by $35.2 + 5 \cdot I = 56.7$. You need to solve the equations in order to find the current of the machine.

1. Rearrange each side of the equation using the Distributive Law: $a(b + c) = a \cdot b + a \cdot c$

   $35.2 + 5 \cdot I = 56.7$

   This step is not applicable to the problem.

2. Simplify each side of the equation.

   This step is not applicable to the problem.

3. Solve the equation isolating the unknown variable to one side of the equation using inverse functions; use inverse functions as needed in this order:
   - addition and subtraction
   - multiplication and division
   - powers and roots

   $35.2 + 5 \cdot I = 56.7$

   $35.2 + 5 \cdot I - \mathbf{35.2} = 56.7 - \mathbf{35.2}$

   $5 \cdot I = 21.5$

   $\frac{5 \cdot I}{5} = \frac{21.5}{5}$

   $I = 4.3$ A

4. Check by substituting your answer for the unknown value in the equation.

   $35.2 + 5 \cdot \mathbf{4.3} = 56.7$

   $35.2 + 21.5 = 56.7$

   $56.7 = 56.7$

Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

Some Practice Problems refer to the following information:

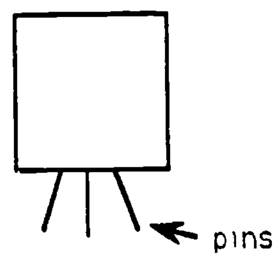
- *resistance* (R) -- the ability of a device, material or component to oppose the flow of electrical current; resistance is measured in ohms (Ω)
- *current* (I) -- the flow of electrical charge; it is measured in amps (A)
- *power* (P) -- energy delivered or consumed per second; it is measured in watts (W)
- *voltage* (V) -- electrical force or pressure; it is measured in volts (v)

1. Thermometers, the Electric Code Book, and Specifications don't always follow the same temperature scale. The formula for converting temperature from the Celsius scale (C) to the Fahrenheit scale (F) is $°F = 1.8 \cdot °C + 32$. What is the Celsius degree that is equal to 77 degrees Fahrenheit?

2. In physics, a ball was dropped from the top of a building. The ball fell at a speed of 6.2 meters per second (m/s). The time (t) it takes the ball to reach a speed of 94.4 m/s is calculated by solving $94.4 = 6.2 + 9.8 \cdot t$. How long did it take for the ball to reach a speed of 94.4 m/s?

3. You need to find the current (I) of a certain circuit. The current is represented as $4.7 = I + 3.2$. What is the current?

4. A *transistor* is a device that is used as an amplifier or switch. A *pin* is the part of the transistor that is used to connect the transistor to other components. A certain transistor has three pins which are connected to a circuit. The resistance (R) in Kilo-ohms (KΩ) connected to one of the pins is represented by $15 = .01 \cdot (R + 400) + .7$. What is the resistance (R)?



transistor

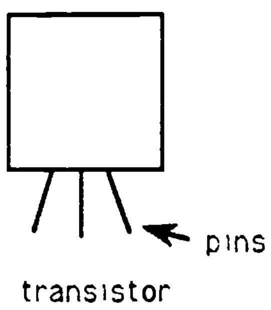
5. A *resistor* is a component that controls the flow of current and/or voltage in a circuit. You need to find the voltage (V) across a certain resistor that is connected *in series* (end to end) with another device. To find the voltage, you need to solve $2 \cdot V + 12.8 = 25.2$. What is the voltage (V)?

resistors connected in series

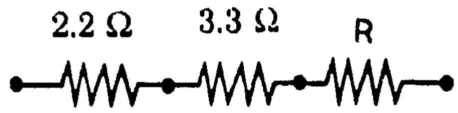
6. You need to calculate the resistance (R) of a certain electrical device by solving the equation, $18.4 = 2.3 \cdot R$. What is the resistance (R)?

7. The resistance (R) of a certain electrical device connected *in series* (end to end) with two other components is represented by the equation $.2\,(R + 50) = 25$. What is the resistance (R) of this device?

8. A *pin* is the part of a transistor that is used to connect the transistor to other components. A particular transistor has three pins connected to a circuit. The current (I) of one of the pins is represented by $2 \cdot I + 4.6 = 12$. What is the current (I) of the pin?



9. Resistances can be combined to obtain a total resistance. Three certain resistances are 2.2 Ω, 3.3 Ω and R (unknown value) Ω. The total resistance of these three resistances can be obtained by adding them together. If the total resistance is 10.2 Ω, what is the value of R? *(Hint: solve 2.2 + 3.3 + R = 10.2 Ω)*



Answers

1. $77 = 1.8 \cdot {}^\circ C + 32$

   $77 - 32 = 1.8 \cdot {}^\circ C + 32 - 32$

   $45 = 1.8 \cdot {}^\circ C$

   $\frac{45}{1.8} = \frac{1.8 \cdot {}^\circ C}{1.8}$

   $25 = {}^\circ C$

   Check:

   $77 = 1.8 \cdot 25 + 32$

   $77 = 45 + 32$

   $77 = 77$

2. $94.4 = 6.2 + 9.8 \cdot t$

   $94.4 - 6.2 = 6.2 - 6.2 + 9.8 \cdot t$

   $88.2 = 9.8 \cdot t$

   $\frac{88.2}{9.8} = \frac{9.8\ t}{9.8}$

   $9 = t$ or $t = 9$ seconds

   Check:

   $94.4 = 6.2 + 9.8 \cdot 9$

   $94.4 = 6.2 + 88.2$

   $94.4 = 94.4$

3. $4.7 = I + 3.2$

$4.7 - 3.2 = I + 3.2 - 3.2$

$1.5 = I$ or $I = 1.5$ A

Check:

$4.7 = 1.5 + 3.2$

$4.7 = 4.7$

4. $15 = .01(R + 400) + .7$

$15 = .01 \cdot R + 4 + .7$

$15 = .01 \cdot R + 4.7$

$15 - 4.7 = .01 \cdot R + 4.7 - 4.7$

$10.3 = .01 \cdot R$

$$\frac{10.3}{.01} = \frac{.01R}{.01}$$

$1030 = R$ or $R = 1030\ \Omega$

Check:

$15 = .01(1030 + 400) + .7$

$15 = .01(1430) + .7$

$15 = 14.3 + .7$

$15 = 15$

5. $2 \cdot V + 12.8 = 25.2$

$2 \cdot V + 12.8 - 12.8 = 25.2 - 12.8$

$2 \cdot V = 12.4$

$\frac{2 \cdot V}{2} = \frac{12.4}{2}$

V = 6.2 volts

Check:

$2 \cdot 6.2 + 12.8 = 25.2$

$12.4 + 12.8 = 25.2$

$25.2 = 25.2$

6. $18.4 = 2.3 \cdot R$

$\frac{18.4}{2.3} = \frac{2.3 \cdot R}{2.3}$

$8 = R$ or $R = 8\ \Omega$

Check:

$18.4 = 2.3 \cdot 8$

$18.4 = 18.4$

7. $.2(R + 50) = 25$

$.2 \bullet R + .2 \bullet 50 = 25$

$.2 \bullet R + 10 = 25$

$.2 \bullet R + 10 - 10 = 25 - 10$

$.2 \bullet R = 15$

$$\frac{.2 \bullet R}{.2} = \frac{15}{.2}$$

$R = 75\ \Omega$

Check:

$.2(75 + 50) = 25$

$.2(125) = 25$

$25 = 25$

8. $2 \bullet I + 4.6 = 12$

$2 \bullet I + 4.6 - 4.6 = 12 - 4.6$

$2 \bullet I = 7.4$

$$\frac{2 \bullet I}{2} = \frac{7.4}{2}$$

$I = 3.7\ A$

Check:

$2 \bullet 3.7 + 4.6 = 12$

$7.4 + 4.6 = 12$

$12 = 12$

9. $2.2 + 3.3 + R = 10.2$

$5.5 + R = 10.2$

$5.5 + R - 5.5 = 10.2 - 5.5$

$R = 4.7\ \Omega$

Check:

$2.2 + 3.3 + 4.7 = 10.2$

$10.2 = 10.2$

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How to Solve Equations with Signed Numbers

$$20 - V - 12 = 0$$

Prerequisites:

Workbook users should understand:

- *how to add, subtract, multiply and divide positive and negative numbers*
- *the Distributive Law*
- *how to use inverse functions*
- *how to use order of operation*

How to Solve Equations with Signed Numbers

Focus

This lesson explains how to find the unknown value in an equation with signed (positive and negative) numbers.

Job Examples

Job examples of when you will solve equations with signed numbers include:

- calculating current, voltage and resistance of electrical circuits and devices
- converting °C (Celsius) to °F (Fahrenheit) and °F to °C

Key Words

Word	*Explanation*	*Example*
equation	an equality with numbers and unknown values	$a + b = c$ $3 + 5 = 8$
equality	two mathematical quantities separated by an equal sign (=); the equal sign means the two quantities are equal	$2 + 3 = 5$
whole number	a number that is not a fraction	1, 16, 238, -5
unknown value	a letter in an equation with a value that is not stated	$7 + \mathbf{x} = 20$ $5 + \mathbf{y} + \mathbf{z} = 2 \cdot \mathbf{z}$
Distributive Law	an algebraic concept stating $a(b + c) = a \cdot b + a \cdot c$	$x(y + z) = xy + xz$ $2 \cdot 4 + 2 \cdot 3 = 2(4 + 3)$
math function	a mathematical procedure	addition (+), subtraction (-) multiplication (•), division (÷) power (a^b), root (√)
inverse function	a math function that can be used to cancel a specific other math function function	add/subtract $7 + 2 - 2 = 7$ multiply/divide $\frac{7 \cdot 4}{4} = 7$ powers/roots $\sqrt{7^2} = 7$

How to Solve Equations with Signed Numbers

Example 1: *Resistance* (R) is the ability of a device, material or component to oppose the flow of electric current; it is measured in ohms (Ω). The resistance of a certain electrical device is represented by the equation $2 \bullet (50 - R) + 4 = 30$. You need to find the resistance (R) of this device.

1. Rearrange each side of the equation using the Distributive Law: $a(b + c) = a \bullet b + a \bullet c$

$$2 \bullet (50 - R) + 4 = 30$$

$$2 \bullet 50 - 2 \bullet R + 4 = 30$$

2. Simplify each side of the equation.

$$2 \bullet 50 - 2 \bullet R + 4 = 30$$

$$100 - 2 \bullet R + 4 = 30$$

$$104 - 2 \bullet R = 30$$

3. Solve the equation isolating the unknown variable to one side of the equation using inverse functions; use inverse functions as needed in this order:
   - addition and subtraction
   - multiplication and division
   - powers and roots

$$104 - 2 \bullet R = 30$$

$$104 - 2 \bullet R - \mathbf{104} = 30 - \mathbf{104}$$

$$-2 \bullet R = -74$$

$$\frac{-2 \bullet R}{-2} = \frac{-74}{-2}$$

$$R = 37$$

4. Check by substituting your answer for the unknown value in the equation.

$$2(50 - \mathbf{37}) + 4 = 30$$

$$2 \bullet 13 + 4 = 30$$

$$26 + 4 = 30$$

$$30 = 30$$

Example 2: The manual states that a certain thermostat should read -25 degrees Celsius (°C). The thermostat, however, gives readings in degrees Fahrenheit (°F). The thermostat presently reads -13°F. You need to convert the thermostat reading to Celsius to see if it is at the correct temperature. To do this, you will use the formula $°F = 1.8 \cdot °C + 32$.

1. Rearrange each side of the equation using the Distributive Law: $a(b + c) = a \cdot b + a \cdot c$

$$°F = 1.8 \cdot °C + 32$$

This step is not applicable to this problem.

2. Simplify each side of the equation.

This step is not applicable to this problem.

3. Solve the equation isolating the unknown variable to one side of the equation using inverse functions; use inverse functions as needed in this order:
   - addition and subtraction
   - multiplication and division
   - powers and roots

$$°F = 1.8 \cdot °C + 32$$

$$-13 = 1.8 \cdot °C + 32$$

$$-13 - \mathbf{32} = 1.8 \cdot °C + 32 - \mathbf{32}$$

$$-45 = 1.8 \cdot °C$$

$$\frac{-45}{1.8} = \frac{1.8 \cdot °C}{1.8}$$

$$-25 = °C$$

4. Check by substituting your answer for the unknown value in the equation.

$$-13 = 1.8\,(\mathbf{-25}) + 32$$

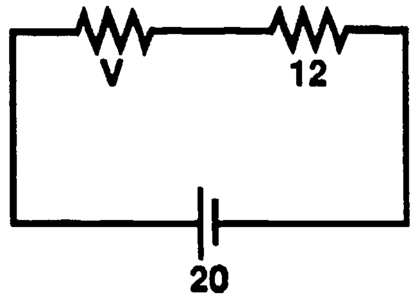
$$-13 = -45 + 32$$

$$-13 = -13$$

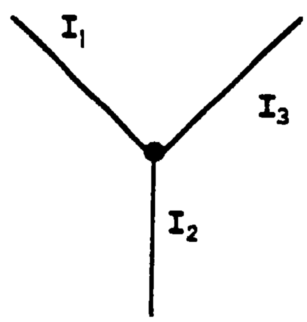
Practice Problems

Read each problem and solve for the answers. Answers are provided in the back of this workbook.

1. In a series circuit, components are connected end to end. In a series circuit, the algebraic sum of all component voltages is equal to zero. You need to find the voltage of a certain component connected in series which is presented by $20 - V - 12 = 0$.



2. *Current* (I) is the flow of electrical charge. Current is measured in amps (A). The algebraic sum of all currents coming in and going out of a point in an electric circuit is equal to zero. This is shown in the equation $I_1 + I_2 + I_3 = 0$. What is I_2 if I_1 is 12 A and I_3 is -8 A? *(Hint: $12 + I_2 - 8 = 0$)*



3. You need to calculate the voltage (V) across a device connected in series (end to end) with another device. This information is represented by $-3 \cdot V + 38 = 14$. What is the voltage (V)?

4. In physics, the time (t) in seconds it takes a certain object to reach the speed of 10 feet per second is calculated by $10 = 106 - 32 \cdot t$. What is the time (t)?

5. In physics, the time (t) in seconds it takes a certain vehicle to accelerate from 15 miles per hour (mi/hr) to 35 mi/hr is given as $35 = 15 + 2 \cdot t$. How long does it take to reach 35 mi/hr?

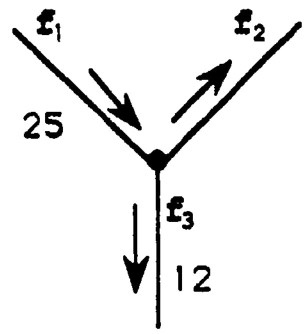
6. You need to calculate the voltage (V) across a device connected in series (end to end) with another device. This information is represented by $-2 \cdot V + 20 = 6$. What is voltage (V)?

series circuit

7. *Resistance* (R) is the ability of a device, material or component to oppose the flow of electric current. The resistance (R) of a certain electrical device is represented by the equation $(20 - R) \cdot 3 + 5 = 35$. What is the resistance (R) of this device?

8. *Current* (I) is the flow of electrical charge. A particular electrical device has a current (I) which is represented by $2 \cdot I - 10 = -4$. What is the current (I) of this device?

9. In physics, the algebraic sum of all forces acting on an object that is not moving is equal to zero. This is shown in the equation $f_1 + f_2 + f_3 = 0$. If f_1 is 25 lbs. and f_3 is -12 lbs., what is f_2? *(Hint: $25 + f_2 - 12 = 0$)*



Answers

1. $20 - V - 12 = 0$

   $8 - V = 0$

   $8 - V + V = 0 + V$

   $8 = V$ or $V = 8$ volts

2. $12 + I_2 - 8 = 0$

   $4 + I_2 = 0$

   $4 + I_2 - 4 = 0 - 4$

   $I_2 = -4$ A

3. $-3 \cdot V + 38 = 14$

   $-3 \cdot V + 38 - 38 = 14 - 38$

   $-3 \cdot V = -24$

   $$\frac{-3 \cdot V}{-3} = \frac{-24}{-3}$$

   $V = 8$ volts

4. $10 = 106 - 32 \cdot t$

   $10 - 106 = 106 - 32 \cdot t - 106$

   $-96 = -32 \cdot t$

   $$\frac{-96}{-32} = \frac{-32 \cdot t}{-32}$$

   $3 = t$ or $t = 3$ seconds

5. $35 = 15 + 2 \cdot t$

$35 - 15 = 15 + 2 \cdot t - 15$

$20 = 2 \cdot t$

$$\frac{20}{2} = \frac{2 \cdot t}{2}$$

$10 = t$ or $t = 10$ seconds

6. $-2 \cdot V + 20 = 6$

$-2 \cdot V + 20 - 20 = 6 - 20$

$-2 \cdot V = -14$

$$\frac{-2 \cdot V}{-2} = \frac{-14}{-2}$$

$V = 7$ V

7. $(20 - R) \cdot 3 + 5 = 35$

$60 - 3 \cdot R + 5 = 35$

$65 - 3 \cdot R = 35$

$65 - 3 \cdot R - 65 = 35 - 65$

$-3 \cdot R = -30$

$$\frac{-3 \cdot R}{-3} = \frac{-30}{-3}$$

$R = 10\ \Omega$

8. $2 \cdot I - 10 = -4$

$2 \cdot I - 10 + 10 = -4 + 10$

$2 \cdot I = 6$

$$\frac{2 \cdot I}{2} = \frac{6}{2}$$

$I = 3$ A

9. $25 + f_2 - 12 = 0$

$13 + f_2 = 0$

$13 + f_2 - 13 = 0 - 13$

$f_2 = -13$ lbs.

Math for Success in Electronics

How to Solve Equations with Scientific Notation

$$4 \cdot 10^5 \cdot i + 4 = 10$$

Prerequisites:

Workbook users should understand:

- *the concept of decimal numbers*
- *the concept of base numbers and exponents*
- *the Distributive Law*
- *how to use inverse functions*
- *how to use order of operation*

How to Solve Equations with Scientific Notation

Focus

This lesson explains how to find the unknown value in equations with scientific notation.

Job Example

A job example of when you will solve equations with scientific notation is calculating current, voltage and resistance of electrical circuits and devices.

Key Words

Word	Explanation	Example
equation	an equality with numbers and unknown values	$a + b = c$ $3 + 5 = 8$
equality	two mathematical quantities separated by an equal sign (=); the equal sign means the two quantities are equal	$2 + 3 = 5$
quantity	numerical value	6, 9
unknown value	a letter in an equation with a value that is not stated	$7 + \mathbf{x} = 20$ $5 + \mathbf{y} + \mathbf{z} = 2 \cdot \mathbf{z}$
Distributive Law	an algebraic concept stating $a(b + c) = a \cdot b + a \cdot c$	$x(y + z) = xy + xz$ $2 \cdot 4 + 2 \cdot 3 = 2(4 + 3)$
math function	a mathematical procedure	addition (+), subtraction (-) multiplication ($\cdot$), division ($\div$) power (a^b), root ($\sqrt{}$)

inverse function	a math function that can be used to cancel a specific other math function	add/subtract $7 + 2 - 2 = 7$ multiply/divide $\frac{7 \cdot 4}{4} = 7$ powers/roots $\sqrt{7^2} = 7$
exponent	a number that tells how many times a certain other number is multiplied by itself	$10^3 = 10 \cdot 10 \cdot 10$ 3 is the exponent
base	a number with an exponent	8^4 8 is the base
power of 10	the number 10 with an exponent	10^{-7}, 10^5, 10^{21}
scientific notation	a way to represent a number; a number written in scientific notation is a number (between 1 and 10) multiplied by 10 raised to a specific exponent.	$823{,}000 = 8.23 \cdot 10^5$ $.0000009 = 9 \cdot 10^{-7}$

How to Solve Equations with Scientific Notation

Example 1: *Resistance* (R) is the ability of a device, material or component to oppose the flow of electrical current; it is measured in ohms (Ω). You need to find the resistance (R) of a certain device which is represented by $2 \cdot 10^{-3}(4 \cdot 10^{3} + R) + 5 = 25$. What is the resistance (R) of this device?

1. Rearrange each side of the equation using the Distributive Law: $a(b + c) = a \cdot b + a \cdot c$

$$2 \cdot 10^{-3}(4 \cdot 10^{3} + R) + 5 = 25$$

$$2 \cdot 10^{-3} \cdot 4 \cdot 10^{3} + 2 \cdot 10^{-3} \cdot R + 5 = 25$$

2. Simplify each side of the equation.

$$2 \cdot 10^{-3} \cdot 4 \cdot 10^{3} + 2 \cdot 10^{-3} \cdot R + 5 = 25$$

$$8 \cdot 10^{0} + 2 \cdot 10^{-3} \cdot R + 5 = 25$$

$$8 \cdot 1 + 2 \cdot 10^{-3} \cdot R + 5 = 25$$

$$8 + 2 \cdot 10^{-3} \cdot R + 5 = 25$$

$$13 + 2 \cdot 10^{-3} \cdot R = 25$$

3. Solve the equation isolating the unknown variable to one side of the equation using inverse functions; use inverse functions as needed in this order:
   - addition and subtraction
   - multiplication and division
   - powers and roots

$$13 + 2 \cdot 10^{-3} \cdot R = 25$$

$$13 + 2 \cdot 10^{-3} \cdot R - \mathbf{13} = 25 - \mathbf{13}$$

$$2 \cdot 10^{-3} \cdot R = 12$$

$$\frac{\mathbf{2 \cdot 10^{-3} \cdot R}}{\mathbf{2 \cdot 10^{-3}}} = \frac{12}{\mathbf{2 \cdot 10^{-3}}}$$

$$\mathbf{R} = \frac{12}{2 \cdot 10^{-3}}$$

$$\mathbf{R} = \frac{12 \cdot 10^{3}}{2}$$

$$R = 6 \cdot 10^{3}\ \Omega$$

4. Check by substituting your answer for the unknown value in the equation.

$2 \cdot 10^{-3} (4 \cdot 10^{3} + 6 \cdot 10^{3}) + 5 = 25$

$.002(4000 + 6000) + 5 = 25$

$.002\ (10{,}000) + 5 = 25$

$20 + 5 = 25$

$25 = 25$

Example 2: *Current* (I) is the flow of electrical charge; it is measured in amps (A). In a series circuit, components are connected end to end. You need to find the current of a series circuit which is represented by $4 \cdot 10^5 \cdot I + 4 = 10$. What is the current (I) of this circuit?

1. Rearrange each side of the equation using the Distributive Law: $a(b + c) = a \cdot b + a \cdot c$

   $4 \cdot 10^5 \cdot I + 4 = 10$

   This step is not applicable to this problem.

2. Simplify each side of the equation.

   This step is not applicable to this problem.

3. Solve the equation isolating the unknown variable to one side of the equation using inverse functions; use inverse functions as needed in this order:
   - addition and subtraction
   - multiplication and division
   - powers and roots

   $4 \cdot 10^5 \cdot I + 4 = 10$

   $4 \cdot 10^5 \cdot I + 4 \cdot \mathbf{4} = 10 \cdot \mathbf{4}$

   $4 \cdot 10^5 \cdot I = 6$

   $\frac{\mathbf{4 \cdot 10^5}}{\mathbf{4 \cdot 10^5}} \cdot I = \frac{\mathbf{6}}{\mathbf{4 \cdot 10^5}}$

   $I = \frac{\mathbf{6 \cdot 10^{-5}}}{\mathbf{4}}$

   $I = 1.5 \cdot 10^{-5} A$

4. Check by substituting your answer for the unknown value in the equation.

   $4 \cdot 10^5 \cdot \mathbf{1.5} \cdot \mathbf{10^{-5}} + 4 = 10$

   $4 \cdot 1.5 \cdot 10^5 \cdot 10^{-5} + 4 = 10$

   $6 \cdot 10^0 + 4 = 10$

   $6 \cdot 1 + 4 = 10$

   $6 + 4 = 10$

   $10 = 10$

Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

Some Practice Problems refer to the following information:

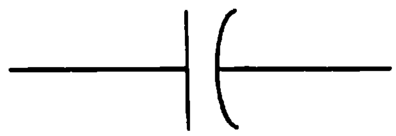
- *resistance* (R) -- the ability of a device, material or component to oppose the flow of electrical current; it is measured in ohms (Ω)
- *current* (I) -- the flow of electrical charge; it is measured in amps (A)
- *voltage* (V) -- electrical force or pressure; it is measured in volts (v)

devices connected in series

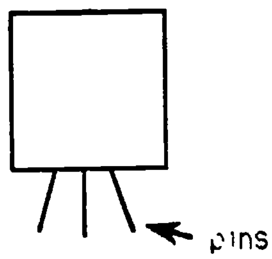
1. The resistance (R) of a certain device connected in series (end to end) with another device can be calculated by solving the equation $R + 2.2 \cdot 10^3 = 4.7 \cdot 10^3$. What is the resistance (R) of this device?

2. The current (I) of a certain component is represented by the equation $2 \cdot 10^{-3} = 9 \cdot 10^{-3} - I$. What is the current (I) of this component?

3. A *capacitor* is an electrical device that stores electrical charge. *Capacitance* (c) is the ability of a capacitor to store electrical charge. Capacitance (c) is measured in Farad (F). The capacitance (c) of a certain capacitor can be calculated by solving the equation $12 \cdot 10^{-6} = c + 4 \cdot 10^{-6}$. What is the capacitance (c) of this device?



4. A *transistor* is a device that is used as an amplifier or switch. A *pin* is the part of a transistor that is used to connect the transistor to other components. A certain transistor has 3 pins which are connected to a circuit. The resistance (R) connected to one of the pins is represented by $18 = 5 \cdot 10^{-6} (R + 400 \cdot 10^{3})$. What is the resistance (R) of this pin?



5. The current of a particular device is given by $4 \cdot 10^4 (I - 2 \cdot 10^{-3}) - 10 = 0$. What is the current (I) of this device?

6. The voltage (V) of a certain electrical circuit is represented by $\frac{V}{2 \cdot 10^4} = 7 \cdot 10^{-3}$. What is the voltage (V) of this circuit?

7. The current of a particular device is given by $60 \cdot 10^{-3} + I = 150 \cdot 10^{-3}$. What is the current (I) of this device?

8. The resistance (R) of a certain device is given the equation $3 \cdot 10^{-4} \cdot R = 15$. What is the resistance (R) of this device?

9. You need to find the current (I) of a circuit which is represented by the equation $5 \cdot 10^{4} \cdot I = 20$. What is the current (I) of this circuit?

10. What is the current (I) of a device represented by the equation $2 \cdot 10^{6} (I + 2 \cdot 10^{-3}) - 12 = 0$?

Answers

1. $R + 2.2 \cdot 10^{3} = 4.7 \cdot 10^{3}$

   $R + 2.2 \cdot 10^{3} - 2.2 \cdot 10^{3} = 4.7 \cdot 10^{3} - 2.2 \cdot 10^{3}$

   $R = 4.7 \cdot 10^{3} - 2.2 \cdot 10^{3}$

   $R = 4700 - 2200$

   $R = 2500\ \Omega$

2. $2 \cdot 10^{-3} = 9 \cdot 10^{-3} - I$

   $2 \cdot 10^{-3} - 9 \cdot 10^{-3} = 9 \cdot 10^{-3} - I - 9 \cdot 10^{-3}$

   $2 \cdot 10^{-3} - 9 \cdot 10^{-3} = -I$

   $.002 - .009 = -I$

   $-.007 = -I$

   $\frac{-.007}{-1} = \frac{-I}{-1}$

   $.007 = I$

   $I = .077\ A$

3. $12 \cdot 10^{-6} = c + 4 \cdot 10^{-6}$

   $12 \cdot 10^{-6} - 4 \cdot 10^{-6} = c + 4 \cdot 10^{-6} - 4 \cdot 10^{-6}$

   $12 \cdot 10^{-6} - 4 \cdot 10^{-6} = c$

   $.000012 - .000004 = c$

   $.000008 = c$

   $c = .000008\ F$

4. $18 = 5 \cdot 10^{-6} (R + 400 \cdot 10^{3})$

$18 = 5 \cdot 10^{-6} \cdot R + 5 \cdot 10^{-6} \cdot 400 \cdot 10^{3}$

$18 = 5 \cdot 10^{-6} \cdot R + 5 \cdot 400 \cdot 10^{-6} \cdot 10^{3}$

$18 = 5 \cdot 10^{-6} \cdot R + 2000 \cdot 10^{-6+3}$

$18 = 5 \cdot 10^{-6} \cdot R + 2000 \cdot 10^{-3}$

$18 = 5 \cdot 10^{-6} \cdot R + 2$

$18 - 2 = 5 \cdot 10^{-6} \cdot R + 2 - 2$

$16 = 5 \cdot 10^{-6} \cdot R$

$$\frac{16}{5 \cdot 10^{-6}} = \frac{5 \cdot 10^{-6}}{5 \cdot 10^{-6}} \cdot R$$

$$\frac{16}{5 \cdot 10^{-6}} = R$$

$$\frac{16 \cdot 10^{6}}{5} = R$$

$3.2 \cdot 10^{6} = R$

$R = 3.2 \cdot 10^{6}\ \Omega$

5. $4 \cdot 10^4 (I - 2 \cdot 10^{-3}) - 10 = 0$

$4 \cdot 10^4 \cdot I - 4 \cdot 10^4 \cdot 2 \cdot 10^{-3} - 10 = 0$

$4 \cdot 10^4 \cdot I - 4 \cdot 2 \cdot 10^{-3} \cdot 10^4 - 10 = 0$

$4 \cdot 10^4 \cdot I - 8 \cdot 10^1 - 10 = 0$

$4 \cdot 10^4 \cdot I - 80 - 10 = 0$

$4 \cdot 10^4 \cdot I - 90 = 0$

$4 \cdot 10^4 \cdot I - 90 + 90 = 0 + 90$

$4 \cdot 10^4 \cdot I = 90$

$$\frac{4 \cdot 10^4 \cdot I}{4 \cdot 10^4} = \frac{90}{4 \cdot 10^4}$$

$$I = \frac{90}{4 \cdot 10^4}$$

$$I = \frac{90 \cdot 10^{-4}}{4}$$

$I = 22.5 \cdot 10^{-4}$ A

6. $\dfrac{V}{2 \cdot 10^4} = 7 \cdot 10^{-3}$

$$\frac{V}{2 \cdot 10^4} \cdot 2 \cdot 10^4 = 7 \cdot 10^{-3} \cdot 2 \cdot 10^4$$

$V = 7 \cdot 2 \cdot 10^{-3} \cdot 10^4$

$V = 14 \cdot 10^1$

$V = 14 \cdot 10$

$V = 140$ v

7. $60 \cdot 10^{-3} + I = 150 \cdot 10^{-3}$

$60 \cdot 10^{-3} + I - 60 \cdot 10^{-3} = 150 \cdot 10^{-3} - 60 \cdot 10^{-3}$

$I = 150 \cdot 10^{-3} - 60 \cdot 10^{-3}$

$I = .15 - .06$

$I = .09$ A

8. $3 \cdot 10^{-4} \cdot R = 15$

$\frac{3 \cdot 10^{-4}}{3 \cdot 10^{-4}} \cdot R = \frac{15}{3 \cdot 10^{-4}}$

$R = \frac{15}{3 \cdot 10^{-4}}$

$R = \frac{15 \cdot 10^{4}}{3}$

$R = 5 \cdot 10^{4}\ \Omega$

9. $5 \cdot 10^{4} \cdot I = 20$

$\frac{5 \cdot 10^{4} \cdot I}{5 \cdot 10^{4}} = \frac{20}{5 \cdot 10^{4}}$

$I = \frac{20}{5 \cdot 10^{4}}$

$I = \frac{20 \cdot 10^{-4}}{5}$

$I = 4 \cdot 10^{-4}$ A

10. $2 \cdot 10^{6} (I + 2 \cdot 10^{-6}) - 12 = 0$

$2 \cdot 10^{6} \cdot I + 2 \cdot 10^{6} \cdot 2 \cdot 10^{-6} - 12 = 0$

$2 \cdot 10^{6} \cdot I + 2 \cdot 2 \cdot 10^{6} \cdot 10^{-6} - 12 = 0$

$2 \cdot 10^{6} \cdot I + 4 \cdot 10^{0} - 12 = 0$

$2 \cdot 10^{6} \cdot I + 4 \cdot 1 - 12 = 0$

$2 \cdot 10^{6} \cdot I + 4 - 12 = 0$

$2 \cdot 10^{6} \cdot I - 8 = 0$

$2 \cdot 10^{6} \cdot I - 8 + 8 = 0 + 8$

$2 \cdot 10^{6} \cdot I = 8$

$$\frac{2 \cdot 10^{6}}{2 \cdot 10^{6}} \cdot I = \frac{8}{2 \cdot 10^{6}}$$

$$I = \frac{8}{2 \cdot 10^{6}}$$

$$I = \frac{8 \cdot 10^{-6}}{2}$$

$I = 4 \cdot 10^{-6}$ A

Math
for
Success
in
Electronics

How to Solve Equations with Squares and Square Roots

$$2^2 = \sqrt{16}$$

Prerequisites:

Workbook users should understand:

- *the concept of squares and square roots*
- *how to find the square of a number*
- *how to find the square root of a number*
- *the Distributive Law*
- *how to use inverse functions*
- *how to use order of operation*

How to Solve Equations with Squares and Square Roots

Focus

This lesson explains how to find the unknown value in an equation with squares and/or square roots.

Job Examples

Job examples of when you will solve equations with squares and square roots include:
- using formulas for power to solve electrical problems
- solving for the parameters of circuits containing resistors, coils and capacitors

Key Words

Word	*Explanation*	*Example*
equation	an equality with numbers and unknown values	$a + b = c$ $3 + 5 = 8$
equality	two mathematical quantities separated by an equal sign (=); the equal sign means the two quantities are equal	$x^2 = 4 + 12$
exponent	a number that tells how many times a certain other number is multiplied by itself	$x^2 = x \cdot x$ 2 is the exponent
square of a number	the product of a number multiplied by itself; squared numbers are represented with an exponent of 2	$8^2 = 8 \cdot 8 = 64$ $5^2 = 5 \cdot 5 = 25$
square root	a number that when multiplied by itself results in a given number	$2 \cdot 2 = 4$ or $2 = \sqrt{4}$ $3 \cdot 3 = 9$ or $3 = \sqrt{9}$
unknown value	a letter in an equation with a value that is not stated	$7 + x = 20$ $5 + y + z = 2 \cdot z$
Distributive Law	an algebraic concept stating $a(b + c) = a \cdot b + a \cdot c$	$x(y + z) = xy + xz$ $2 \cdot 4 + 2 \cdot 3 = 2(4 + 3)$

math function	a mathematical procedure	addition (+), subtraction (-) multiplication (•), division (÷) power (a^b,) root ($\sqrt{}$)	
inverse function	a math function that can be used to cancel a specific other math function	add/subtract	$7 + 2 - 2 = 7$
		multiply/divide	$\frac{7 \bullet 4}{4} = 7$
		powers/roots	$\sqrt{7^2} = 7$

How to Solve Equations with Squares and Square Roots

Example 1: Understanding how to calculate the speed (V) of a falling object is a basic principle of physics. The speed of a particular falling object is represented by: $20 + 2(6 - V^2) = 0$. At what speed is this object falling?

1. Re-arrange each side of the equation using the Distributive Law: $a(b + c) = a \cdot b + a \cdot c$

$$20 + 2(6 - V^2) = 0$$

$$20 + 12 - 2V^2 = 0$$

2. Simplify each side of the equation.

$$20 + 12 - 2V^2 = 0$$

$$32 - 2V^2 = 0$$

3. Solve the equation isolating the unknown variable to one side of the equation using inverse functions; use inverse functions as needed in this order:
   - addition and subtraction
   - multiplication and division
   - powers and roots

$$32 - 2V^2 = 0$$

$$32 - 2V^2 + 2V^2 = 0 + 2V^2$$

$$32 = 2V^2$$

$$\frac{32}{2} = \frac{2V^2}{2}$$

$$16 = V^2$$

$$\sqrt{16} = \sqrt{V^2}$$

$$\sqrt{16} = V$$

$$4 = V$$

4. Check by substituting your answer for the unknown value in the equation.

$$20 + 2(6 - (4)^2) = 0$$

$$20 + 2(6 - 16) = 0$$

$$20 + 12 - 32 = 0$$

$$32 - 32 = 0$$

$$0 = 0$$

Example 2: *Resistance* (R) is the ability of an electrical device, material or component to oppose the flow of electric current. The resistance (R) of a particular electr al device is represented by $10 = \sqrt{R^2 + 64}$. What is the resistance (R)?

1. Re-arrange each side of the equation using the Distributive Law: $a(b + c) = a \bullet b + a \bullet c$

   $10 = \sqrt{R^2 + 64}$

   This step is not applicable to this problem.

2. Simplify each side of the equation.

   This step is not applicable to this problem.

3. Solve the equation isolating the unknown variable to one side of the equation using inverse functions; use inverse functions as needed in this order:
   - addition and subtraction
   - multiplication and division
   - powers and roots

   $10 = \sqrt{R^2 + 64}$

   $(10)^2 = (\sqrt{R^2 + 64})^2$

   $100 = R^2 + 64$

   $100 - 64 = R^2 + 64 - 64$

   $36 = R^2$

   $\sqrt{36} = \sqrt{R^2}$

   $\sqrt{36} = R$

   $6 = R$

4. Check by substituting your answer for the unknown value in the equation.

   $10 = \sqrt{6^2 + 64}$

   $10 = \sqrt{36 + 64}$

   $10 = \sqrt{100}$

   $10 = 10$

Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

Some Practice Problems refer to the following information:

- *resistance* (R) -- the ability of a device, material or component to oppose the flow of electric current; it is measured in ohms (Ω)
- *current* (I) -- the flow of electrical charge; it is measured in amps (A).
- *power* (P) -- in general, energy delivered or consumed per second; it is measured in watts (W).
- *voltage* -- electrical force or pressure; it is measured in volts (v).

1. A 100 W (P) light bulb has 25 Ω resistance (R). Calculate the bulb's current (I) using the formula $P = I^2R$.

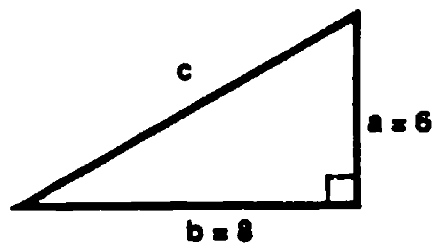
2. A particular machine has a resistance (R) of 50 Ω. It draws a current (I) of 4 A. Calculate the machine's power (P) using the formula $P = I^2 R$.

3. A particular machine has 100 W of power (P), and a resistance (R) of 25 Ω. Calculate the machine's voltage (V) using the formula $V = \sqrt{P \cdot R}$

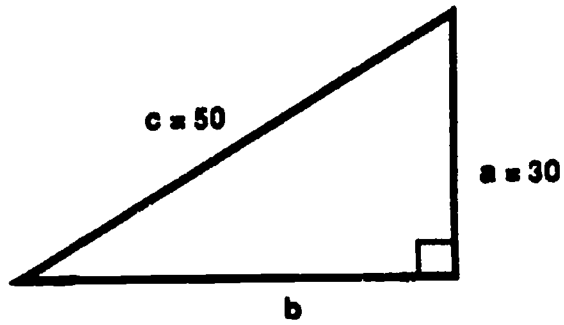
4. An instrument operating at 110 v has a resistance (R) of 100 Ω. Calculate the instrument's power (P) using the formula $P = \frac{V^2}{R}$.

5. A 500 W (P) instrument is operating at 110 v. Calculate its resistance (R) using the formula $R = \frac{V^2}{P}$.

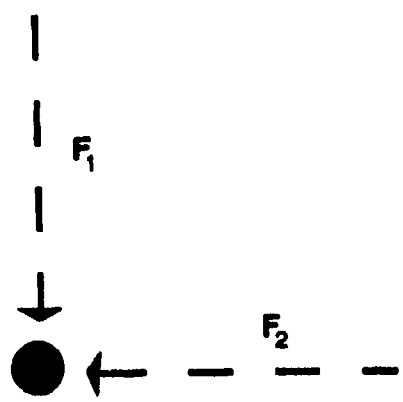
6. A floor and wall meet at a 90 degree angle (90°). A wall and the ceiling also meet at 90°. A right triangle is a triangle with a 90° angle. In any right triangle, the sides (a, b, and c) are related by the formula $c^2 = a^2 + b^2$. If a is 6 and b is 8 in a particular right triangle, what is c?



7. A right triangle is one in which there is a 90 degree angle; the sides (a, b, and c) are related by the formula $c^2 = a^2 + b^2$. If a is 30 and c is 50, what is b?



8. Two forces (F_1 and F_2) are pushing on an object at a 90° angle from each other. If F_1 is 24 lbs. and F_2 is 32 lbs., calculate the total force on the object using the formula $F_T^2 = F_1^2 + F_2^2$.



9. The time (t) in seconds it takes for an object falling from a specified height (h) in feet to hit the ground is calculated with the formula: $t = \frac{\sqrt{h}}{4}$. If an object fell from a height (h) of 100 ft, how much time (t) will it take for that object to hit the ground?

Answers

1. $P = I^2R$

   $100 = I^2 \cdot 25$

   $\frac{100}{25} = \frac{I^2 \cdot 25}{25}$

   $4 = I^2$

   $\sqrt{4} = \sqrt{I^2}$

   $2 = I$

2. $P = I^2R$

   $P = 4^2 \cdot 50$

   $P = 16 \cdot 50$

   $P = 800$ W

3. $V = \sqrt{P \cdot R}$

   $V = \sqrt{100 \cdot 25} = \sqrt{2{,}500} = 50$ volts

4. $P = \frac{V^2}{R}$

   $P = \frac{110^2}{100} = \frac{12{,}100}{100} = 121$ W

5. $R = \frac{V^2}{P}$

$R = \frac{110^2}{500}$

$R = \frac{12,100}{500}$

$R = 24.2\Omega$

6. $c^2 = a^2 + b^2$

$c^2 = 6^2 + 8^2$

$c^2 = 36 + 64$

$c^2 = 100$

$\sqrt{c^2} = \sqrt{100}$

$c = 10$

7. $c^2 = a^2 + b^2$

$50^2 = 30^2 + b^2$

$2,500 = 900 + b^2$

$2,500 - 900 = 900 + b^2 - 900$

$1,600 = b^2$

$\sqrt{1,600} = \sqrt{b^2}$

$40 = b$

8. $F_T^2 = F_1^2 + F_2^2$

$F_T^2 = 24^2 + 32^2$

$F_T^2 = 576 + 1{,}024$

$F_T^2 = 1600$

$\sqrt{F_T^2} = \sqrt{1{,}600}$

$F_T = 40$ lbs

9. $t = \dfrac{\sqrt{h}}{4}$

$t = \dfrac{\sqrt{100}}{4}$

$t = \dfrac{10}{4}$

$t = 2.5$ seconds

Math
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Electronics

How to Solve Equations with Fractions

$$\frac{3}{4}(b-8)=6$$

Prerequisites:

Workbook users should understand:

- *how to add, subtract, multiply and divide fractions*
- *the Distributive Law*
- *how to use inverse functions*
- *how to use order of operation*

How to Solve Equations with Fractions

Focus

This lesson explains how to find the unknown value in an equation with fractions.

Job Examples

Job examples of solving equations with fraction reciprocals include:

- calculating voltage output of transformers
- calculating the mechanical advantage of various tools
- calculating current in parallel circuits
- calculating voltage in series circuits

Key Words

Word	*Explanation*	*Example*
equation	an equality with numbers and unknown values	$\frac{a}{b} + \frac{c}{d} = \frac{x}{y}$ or $\frac{2}{3} - \frac{1}{3} = \frac{1}{3}$
equality	two mathematical quantities separated by an equal sign (=); the equal sign means the two quantities are equal	$\frac{1}{4} = \frac{x}{8}$
fraction	two numbers separated by a fraction bar; the top number is the *numerator*, the bottom number is the *denominator*	$\frac{1}{x}, \frac{2}{3}, \frac{y}{z}$
numerator	the top number of a fraction	$\frac{a}{b}, \frac{3}{4}$

denominator	the bottom number of a fraction	$\frac{x}{y}, \frac{6}{7}$
reciprocal	one divided by a number	$\frac{1}{9}$ is the reciprocal of $\frac{9}{1}$
unknown value	a letter in an equation with a value that is not stated	$\frac{7}{10} + \frac{2}{10}x = \frac{20}{10}$ $\frac{3a}{4} \cdot \frac{5}{6} = \frac{15}{24}$ $\frac{2}{3} + \frac{y}{3} + \frac{z}{3} = \frac{3}{4} \cdot \frac{z}{5}$
math function	a mathematical procedure	addition (+), subtraction (-) multiplication ($\cdot$), division ($\div$) power (a^b), root ($\sqrt{\ }$)
Distributive Law	an algebraic concept stating $a(b + c) = a \cdot b + a \cdot c$	$x(y + z) = xy + xz$ $2 \cdot 4 + 2 \cdot 3 = 2(4 + 3)$
inverse function	a math function that can be used to cancel a specific other math function	$7 + 2 - 2 = 7$ $\frac{7 \cdot 4}{4} = 7$ $\sqrt{7^2} = 7$

How to Solve Equations with Fractions

Example 1: The number of pumps required in a certain job is represented by $\frac{3}{4}(B-8) = 6$. How many pumps are required for the job?

1. Rearrange each side of the equation using the Distributive Law: $a(b + c) = a \cdot b + a \cdot c$

$$\frac{3}{4}(B-8) = 6$$

$$\left(\frac{3}{4} \cdot B\right) + \frac{3}{4}(-8) = 6$$

2. Simplify each side of the question.

$$\left(\frac{3}{4} \cdot B\right) + \frac{3}{4}(-8) = 6$$

$$\left(\frac{3}{4} \cdot B\right) - \left(\frac{24}{4}\right) = 6$$

$$\left(\frac{3}{4} \cdot B\right) - 6 = 6$$

3. Solve the equation isolating the unknown variable to one side of the equation using inverse functions; use inverse functions as needed in this order:
    - addition and subtraction
    - multiplication and division
    - powers and roots

$$\left(\frac{3}{4} \bullet \mathbf{B}\right) - 6 = 6$$

$$\left(\frac{3}{4} \bullet \mathbf{B}\right) - 6 + 6 = 6 + 6$$

$$\frac{3}{4} \bullet \mathbf{B} = 12$$

$$\frac{3}{4} \bullet \mathbf{B} + \frac{3}{4} = 12 + \frac{3}{4}$$

$$\frac{3}{4} \bullet \mathbf{B} + \frac{4}{3} = 12 \bullet \frac{4}{3}$$

$$\mathbf{B} = \frac{48}{3}$$

$$B = 16$$

16 pumps are required for the job.

4. Check by substituting your answer for the unknown value in the equation

$$\frac{3}{4}(16 - 8) = 6$$

$$\frac{3}{4}(8) = 6$$

$$\frac{24}{4} = 6$$

$$6 = 6$$

Example 2: A car is accelerating from 10 mph (miles per hour) to 30 mph. In physics, the time (t) in seconds it takes to do this is represented by $30 = 10 + \frac{1}{2} \bullet t$. What is t?

1. Rearrange each side of the equation using the Distributive Law: $a(b + c) = a \bullet b + a \bullet c$

   $$30 = 10 + \frac{1}{2} \bullet t$$

   This step is not applicable to this problem.

2. Simplify each side of the question.

   This step is not applicable to this problem.

3. Solve the equation isolating the unknown variable to one side of the equation using inverse functions; use inverse functions as needed in this order:
   - addition and subtraction
   - multiplication and division
   - powers and roots

   $$30 = 10 + \frac{1}{2} \bullet t$$

   $$30 - 10 = 10 + \frac{1}{2} \bullet t - 10$$

   $$20 = \frac{1}{2} \bullet t$$

   $$20 + \frac{1}{2} = \frac{1}{2} \bullet t + \frac{1}{2}$$

   $$20 \bullet \frac{2}{1} = \frac{1}{2} \bullet t \bullet \frac{2}{1}$$

   $$40 = t$$

   $t = 40$ seconds

4. Check by substituting your answer for the unknown value in the equation.

   $$30 = 10 + \frac{1}{2} \bullet 40$$

   $$30 = 10 + \left(\frac{1}{2} \bullet 40\right)$$

   $$30 = 10 + 20$$

   $$30 = 30$$

Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

1. A *transformer* is a device that increases or decreases voltage ans/or current. The relationship of a transformer's input voltage (V_1) and current (I_1), and its output voltage (V_2) and current (I_2), is given by $I_2 = I_1 \frac{V_1}{V_2}$. If $I_1 = 20$ amps, $V_1 = 110$ volts, $V_2 = 220$ volts, what is I_2?

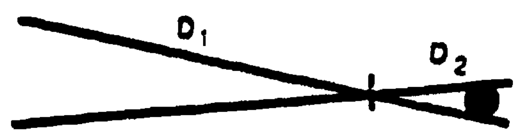
2. Resistance (R) is the ability of a device to oppose the flow of electric current. The following formula is used to show the resistance relationship of two wires:

$$R_1 = \frac{A_2}{A_1} \cdot R_2$$

R_1 represents the resistance of wire 1.
R_2 represents the resistance of wire 2.
A_1 represents the cross-sectional area of wire 1.
A_2 represents the cross-sectional area of wire 2.

If $A_2 = 20$, $A_1 = 10$, and $R_2 = 100$, what is R_1?

3. *Mechanical advantage* (MA) is a term that describes how much easier a job will be due to using a specific tool. Mechanical advantage of a bolt cutter is calculated with the formula:



$$MA = \frac{D_1}{D_2}$$

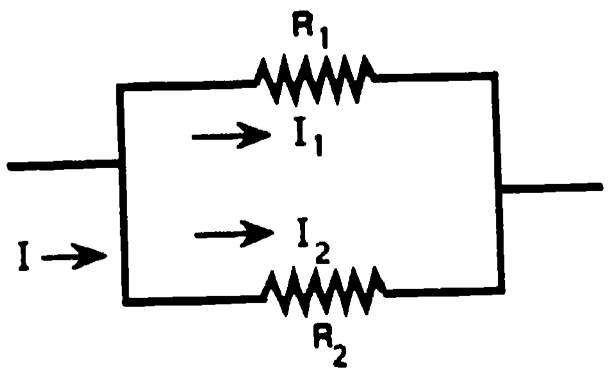
D_1 is the length of the first arm.
D_2 is the length of the second arm.

What is the mechanical advantage (MA) when D_1 is 20 inches and D_2 is 1 inch?

4. What is the mechanical advantage (MA) when D_1 is 51 inches and D_2 is 3 inches?

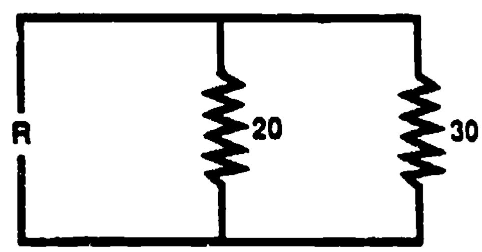
5. A current (I) entering two resistors (R_1 and R_2) will split into two currents (I_1 and I_2). The following formula calculates the value of I_1:

$I_1 = \frac{I \bullet R_2}{R_1 + R_2}$. If R_1 is 20, R_2 is 30, and I is 10, what is I_1?



6. I_2 is calculated by the formula $I_2 = \frac{I \cdot R_1}{R_1 + R_2}$. If R_1 is 5, R_2 is 10, and I is 30, what is I_2?

7. The resistance (R) of a parallel circuit is represented by: $R = \frac{20 \cdot 30}{20 + 30}$. What is the resistance (R)?



8. *Power* in general is energy delivered or consumed per second. The power (P) of a circuit is given by $2 = \frac{P}{10}$. What is the power?

9. Resistivity is the specific resistance of a material. The resistivity (R) of a wire is given by $50 = \rho \frac{10}{40}$. What is the resistivity (R)?

10. The resistance (R) of a component is given by $2 = \frac{20 \cdot 5}{5 + R}$. What is the resistance (R)?

Answers

1. $I = I_1 \cdot \frac{V_1}{V_2}$ where: $I_1 = 20$, $V_1 = 110$ and $V_2 = 220$

$I_2 = 20 \frac{110}{220}$

$I_2 = 20 \cdot \frac{1}{2}$

$I_2 = \frac{20}{2} = 10$

2. $R_1 = \frac{A_2}{A_1} \cdot R_2$ where $A_2 = 20$, $A_1 = 10$ and $R_2 = 100$

$R_1 = \frac{20}{10} \cdot 100$

$R_1 = \frac{2000}{10} = 200$

3. $MA = \frac{D_1}{D_2}$ where $D_1 = 20$ and $D_2 = 1$

$MA = \frac{20}{1} = 20$

4. $MA = \frac{D_1}{D_2}$ where $D_1 = 51$ and $D_2 = 3$

$MA = \frac{51}{3} = 17$

5. $I_1 = I \cdot \frac{R_2}{R_1 + R_2}$ where $R_1 = 20$, $R_2 = 30$ and $I = 10$

$I_1 = 10 \cdot \frac{30}{20+30}$

$I_1 = 10 \cdot \frac{30}{50}$

$I_1 = \frac{300}{50} = 6$

6. $I_2 = I \cdot \frac{R_1}{R_1 + R_2}$ where $R_1 = 5$, $R_2 = 10$ and $I = 30$

$I_2 = 30 \cdot \frac{5}{5+10}$

$I_2 = \frac{150}{15} = 10$

7. $R = \frac{20 \cdot 30}{20 + 30}$

$R = \frac{600}{50} = \frac{60}{5} = 12$

8. $2 = \frac{P}{10}$

$2 \cdot 10 = \frac{P}{10} \cdot 10$

$20 = P$

9. $50 = \rho \cdot \frac{10}{40}$

$50 \cdot 10 = \rho \cdot \frac{10}{40} \cdot 40$

$2000 = \rho \cdot 10$

$\frac{2000}{10} = \frac{\rho \cdot 10}{10}$

$200 = \rho$

10. $2 = \frac{20 \cdot 5}{5 + R}$

$2(5 + R) = \frac{20 \cdot 5}{5 + R} \cdot (5 + R)$

$2(5 + R) = 20 \cdot 5$

$2(5 + R) = 100$

$\frac{2(5+R)}{2} = \frac{100}{2}$

$5 + R = 50$

$5 + R - 5 = 50 - 5$

$R = 45$

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How to Solve Non-Linear Equations with Whole Numbers

$$y = 4x^2$$

Prerequisites:

Workbook users should understand:

- *the concept of squares and square roots*
- *how to find the square of a number*
- *how to find the square root of a number*
- *the Distributive Law*
- *how to use inverse functions*
- *how to use order of operation*

How to Solve Non-Linear Equations with Whole Numbers

Focus

This lesson explains how to find the unknown value in non-linear equations.

Job Examples

Job examples of when you will solve non-linear equations include:
- calculating current and voltage of electrical circuits
- calculating resistance and power of electrical devices

Key Words

Word	*Explanation*	*Example*
equation	an equality with numbers and unknown values	$a + b = c$ $3 + 5 = 8$
equality	two mathematical quantities separated by an equal sign (=); the equal sign means the two quantities are equal	$2 + 3 = 5$
quantity	numerical value	6, 9
whole number	a number that is not a fraction	1, 16, 238, -5
non-linear equation	any equation with one or both of the following conditions: • the unknown values (two values or more) have powers greater than one • the unknown values are multiplied and/or with each other	$y = \frac{25}{x}$ $x \cdot y = 3$ $y = 4x^2$
unknown value	a letter in an equation with a value that is not stated	$7 + x = 20$ $5 + y + z = 2 \cdot z$

Distributive Law	an algebraic concept stating $a(b + c) = a \cdot b + a \cdot c$	$x(y + z) = xy + xz$ $2 \cdot 4 + 2 \cdot 3 = 2(4 + 3)$
math function	a mathematical procedure	addition (+), subtraction (-) multiplication (•), division (÷) power (a^b), root ($\sqrt{}$)
inverse function	a math function that can be used to cancel a specific other math function	add/subtract $7 + 2 - 2 = 7$ multiply/divide $\frac{7 \cdot 4}{4} = 7$ powers/roots $\sqrt{7^2} = 7$

How to Solve Non-Linear Equations with Whole Numbers

Example 1: *Current* (I) is the flow of electrical charge; it is measured in amps (A). You need to find the current (I) of a certain electrical device which is represented by $8 + 4(5 + 2 \cdot I^2) = 100$.

1. Rearrange each side of the equation using the Distributive Law: $a(b + c) = a \cdot b + a \cdot c$

$$8 + 4(5 + 2 \cdot I^2) = 100$$

$$8 + 4 \cdot 5 + 4 \cdot 2 \cdot I^2 = 100$$

2. Simplify each side of the equation.

$$8 + 4 \cdot 5 + 4 \cdot 2 \cdot I^2 = 100$$

$$8 + 20 + 8 \cdot I^2 = 100$$

$$28 + 8 \cdot I^2 = 100$$

3. Solve the equation isolating the unknown variable to one side of the equation using inverse functions; use inverse functions as needed in this order:
   - addition and subtraction
   - multiplication and division
   - powers and roots

$$28 + 8 \cdot I^2 - 28 = 100 - 28$$

$$8 \cdot I^2 = 72$$

$$\frac{8 \cdot I^2}{8} = \frac{72}{8}$$

$$I^2 = 9$$

$$\sqrt{I^2} = \sqrt{9}$$

$$I = 3$$

4. Check by substituting your answer for the unknown value in the equation.

$$8 + 4(5 + 2 \cdot 3^2) = 100$$

$$8 + 4(5 + 2 \cdot 9) = 100$$

$$8 + 4(5 + 18) = 100$$

$$8 + 4(23) = 100$$

$$8 + 92 = 100$$

$$100 = 100$$

Example 2: *Power* (P), in general, is energy delivered or consumed per second; it is measured in watts (W). You need to find the power (P) of a certain circuit which is represented by $\sqrt{P^2+27} = 6$.

1. Rearrange each side of the equation using the Distributive Law: $a(b + c) = a \cdot b + a \cdot c$

   $\sqrt{P^2+27} = 6$

   This step is not applicable to this problem.

2. Simplify each side of the equation.

   This step is not applicable to this problem.

3. Solve the equation isolating the unknown variable to one side of the equation using inverse functions; use inverse functions as needed in this order:
   - addition and subtraction
   - multiplication and division
   - powers and roots

   $\sqrt{P^2+27} = 6$

   $(\sqrt{P^2+27})^2 = (6)^2$

   $P^2 + 27 = 36$

   $P^2 + 27 - \mathbf{27} = 36 - \mathbf{27}$

   $P^2 = 9$

   $\sqrt{P^2} = \sqrt{9}$

   $P = 3$

4. Check by substituting your answer for the unknown value in the equation.

   $\sqrt{3^2+27} = 6$

   $\sqrt{9+27} = 6$

   $\sqrt{36} = 6$

   $6 = 6$

Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

Some Practice Problems refer to the following information:

- *current* (I) -- the flow of electrical charge; it is measured in amps (A)
- *voltage* (V) -- electrical force or pressure; it is measured in volts (v)
- *resistance* (R) -- the ability of a device, material or component to oppose the flow of electrical current; it is measured in ohms (Ω)
- *power* (P) -- in general, energy delivered or consumed per second; it is measured in watts (W)

1. The current (I) of a certain electrical circuit can be calculated by solving $100 = I^2 \cdot 25$. What is the current (I) of this circuit?

2. You need to find the voltage (V) of a certain electrical circuit which is represented by $27 = \frac{V^2}{3}$. What is the voltage (V)?

3. In physics, a force (F) is measured in pounds (lbs). A certain force (F) acting on an object is represented by the equation $\sqrt{F^2+9} = 5$. What is the force (F)?

4. The resistance (R) of a particular device is represented by $\sqrt{R^2+64} = 10$. What is the resistance (R) of the device?

5. You need to find the power of a certain circuit which is represented by $\sqrt{P^2+24} = 7$. What is the power (P)?

6. In physics, the time (t) in seconds it takes a falling object to reach a distance (D) in feet is given by $D = 16 \cdot t^2$. If D = 64 feet, what is t?

7. What is the power (P) of a certain electrical circuit represented by the equation $3 = \sqrt{\frac{P}{2}}$?

8. The resistance (R) of a certain device can be calculated by solving the equation $10 = \sqrt{4 \cdot R}$. What is the resistance (R)?

9. The current (I) of a certain electrical circuit can be calculated by solving the equation $2(3 \cdot I^2 + 10) = 44$. What is the current (I) of this circuit?

10. The voltage (V) of a certain electrical circuit can be calculated by solving the equation $8 = \frac{V^2}{2}$. What is the voltage (V) of this circuit?

Answers

1. $100 = I^2 \cdot 25$

$\frac{100}{25} = \frac{I^2 \cdot 25}{25}$

$4 = I^2$

$\sqrt{4} = \sqrt{I^2}$

$2 = I$ or $I = 2$ A

2. $27 = \frac{V^2}{3}$

$3 \cdot 27 = \frac{V^2}{3} \cdot 3$

$81 = V^2$

$\sqrt{81} = \sqrt{V^2}$

$9 = V$ or $V = 9$ volts

3. $\sqrt{F^2+9} = 5$

$(\sqrt{F^2+9})^2 = 5^2$

$F^2 + 9 = 25$

$F^2 + 9 - 9 = 25 - 9$

$F^2 = 16$

$\sqrt{F^2} = \sqrt{16}$

$F = 4$ lbs

4. $\sqrt{R^2+64} = 10$

$(\sqrt{R^2+64})^2 = (10)^2$

$R^2 + 64 = 100$

$R^2 + 64 - 64 = 100 - 64$

$R^2 = 36$

$\sqrt{R^2} = \sqrt{36}$

$R = 6\ \Omega$

5. $\sqrt{P^2+24} = 7$

$(\sqrt{P^2+24})^2 = (7)^2$

$P^2 + 24 = 49$

$P^2 + 24 - 24 = 49 - 24$

$P^2 = 25$

$\sqrt{P^2} = \sqrt{25}$

$P = 5$ W

6. $64 = 16 \cdot t^2$

$$\frac{64}{16} = \frac{16 \cdot t^2}{16}$$

$4 = t^2$

$\sqrt{4} = \sqrt{t^2}$

$2 = t$ or $t = 2$ seconds

7. $3 = \sqrt{\frac{P}{2}}$

$(3)^2 = \left(\sqrt{\frac{P}{2}}\right)^2$

$9 = \frac{P}{2}$

$9 \cdot 2 = \frac{P}{2} \cdot 2$

$18 = P$ or $P = 18$ W

8. $10 = \sqrt{4 \cdot R}$

$(10)^2 = (\sqrt{4 \cdot R})^2$

$100 = 4 \cdot R$

$\frac{100}{4} = \frac{4 \cdot R}{4}$

$25 = R$ or $R = 25\ \Omega$

9. $2(3 \cdot I^2 + 10) = 44$

$2 \cdot 3 \cdot I^2 + 2 \cdot 10 = 44$

$6 \cdot I^2 + 20 = 44$

$6 \cdot I^2 + 20 - 20 = 44 - 20$

$6 \cdot I^2 = 24$

$\frac{6 \cdot I^2}{6} = \frac{24}{6}$

$I^2 = 4$

$\sqrt{I^2} = \sqrt{4}$

$I = 2$ A

10. $8 = \frac{V^2}{2}$

$8 \cdot 2 = \frac{V^2}{2} \cdot 2$

$16 = V^2$

$\sqrt{16} = \sqrt{V^2}$

$4 = V$ or $V = 4$ volts

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How to Solve Linear Equations by Transposing

$$3 \cdot i + 6 = 12$$

Prerequisites:

Workbook users should understand:

- *how to work with decimal numbers*
- *how to work with base numbers and exponents*
- *the Distributive Law*
- *how to use inverse functions*
- *how to solve equations*
- *how to use order of operation*

How to Solve Linear Equations by Transposing

Focus

This lesson explains how to solve linear equations by transposing.

Job Examples

Job examples of when you will solve linear equations by transposing include calculating:

- current of electrical components
- resistance of circuits
- power of electrical devices

Key Words

Word	*Explanation*	*Example*
equation	an equality with numbers and unknown values	$a + b = c$ $3 + 5 = 8$
equality	two mathematical quantities separated by an equal sign (=); the equal sign means the two quantities are equal	$2 + 3 = 5$
unknown value	a letter in an equation with a value that is not stated	$7 + \mathbf{x} = 20$ $5 + \mathbf{y} + \mathbf{z} = 2 \cdot \mathbf{z}$
linear equation	any equation with both of the following conditions: • the unknown values (two values or more) have powers of one • the unknown values (two values or more) cannot be multiplied or divided with each other	$x + y = 3$ $2a + 5b = 7$
term	in algebra, a number or letter; can also be a number and/or letters combined by multiplication or division	$80, X^2, 4 \cdot A \cdot B, \frac{y}{z}$

transposing	moving a term with its associated function (or moving the function alone) from one side of the equation to the other side and using the inverse function	$A + 2 = 14$ $A = 14 - 2$
Distributive Law	an algebraic concept stating $a(b + c) = a \cdot b + a \cdot c$	$x(y + z) = xy + xz$ $2 \cdot 4 + 2 \cdot 3 = 2(4 + 3)$
math function	a mathematical procedure	addition (+), subtraction (-) multiplication (•), division (÷) power (a^b), root ($\sqrt{\ }$)
inverse function	a math function that can be used to cancel a specific other math function	add/subtract $7 + 2 - 2 = 7$ multiply/divide $\frac{7 \cdot 4}{4} = 7$ power/root $\sqrt{7^2} = 7$

How to Solve Linear Equations by Transposing

Example 1: *Resistance* (R) is the ability of a device, material or component to oppose the flow of electric current. Resistance is measured in ohms (Ω). You need to find the resistance (R) of a generator coil. The information you have is $4(R + 5) + 8 = 52$. What is the resistance (R) of the coil?

1. Rearrange each side of the equation using the distributive law: $a(b + c) = a \cdot b + a \cdot c$

$$4(R + 5) + 8 = 52$$

$$4 \cdot R + 4 \cdot 5 + 8 = 52$$

$$4 \cdot R + 20 + 8 = 52$$

2. Simplify each side of the equation.

$$4 \cdot R + 20 + 8 = 52$$

$$4 \cdot R + 28 = 52$$

3. Solve the equation by *transposing*: move the term or function you want to reposition to the other side of the equation and use the inverse function.

$$4 \cdot R + \mathbf{28} = 52$$

$$4 \cdot R = 52 - \mathbf{28}$$

$$4 \cdot R = 24$$

$$R = \frac{24}{\mathbf{4}}$$

$$R = 6 \text{ or } R = 6\ \Omega$$

4. Check by substituting your answer for the unknown value in the equation.

$$4 \cdot (\mathbf{6} + 5) + 8 = 52$$

$$4 \cdot 11 + 8 = 52$$

$$44 + 8 = 52$$

$$52 = 52$$

Example 2: A *transistor* is a device that is used as an amplifier or a switch. A *pin* is the part of a transistor that is used to connect the transistor to other components. A particular transistor has three pins connected to a circuit. You need to find the current (I) of one of the pins. Current is measured in amps (A). The information you have is $3 \cdot I + 6 = 12$. What is the current (I) of the pin?

1. Rearrange each side of the equation using the distributive law: $a(b + c) = a \cdot b + a \cdot c$

   $3 \cdot I + 6 = 12$

   This step is not applicable to this problem.

2. Simplify each side of the equation.

   This step is not applicable to this problem.

3. Solve the equation by *transposing*: move the term or function you want to reposition to the other side of the equation and use the inverse function.

   $3 \cdot I + \mathbf{6} = 12$

   $3 \cdot I = 12 - \mathbf{6}$

   $\mathbf{3} \cdot I = 6$

   $I = \frac{6}{\mathbf{3}}$

   $I = 2$ or $I = 2$ A

4. Check by substituting your answer for the unknown value in the equation.

   $3 \cdot \mathbf{2} + 6 = 12$

   $6 + 6 = 12$

   $12 = 12$

Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

1. *Resistance* (R) is the ability of a device to oppose the flow of electric current. Resistance is measured in ohms (Ω). You need to find the resistance of a certain device. The resistance (R) is given to you as $4(R + 10) - 100 = 0$. What is the resistance (R)?

2. *Current* (I) is the flow of electrical charge. Current is measured in amps (A). The current (I) of a resistor connected in series (end-to-end) with another resistor is given by $10 + 20 \cdot I = 110$. What is the current (I)?

series circuit

3. A *rheostat* is a device that controls the current in a circuit. A particular rheostat has a current (I) that can be calculated by solving $3 \cdot I + 50 = 110$. What is the current (I)?

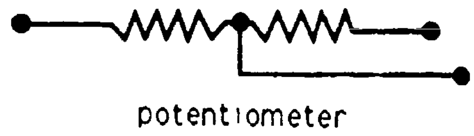
rheostat

4. The resistance (R) of a certain electrical device connected in series (end-to-end) with another device can be calculated by solving the equation $R + 50 = 90$. What is the resistance (R)?

series circuit

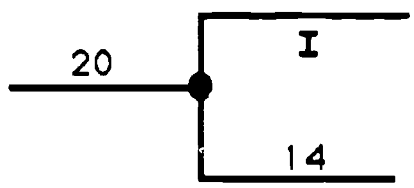
5. Two machines together consume 3589 watts (W) of power (P). One of the machines consumes 1263 W and the other consumes an unknown power (P). What is the value of the unknown power (P)? *(Hint: solve $1263 + P = 3589$)*

6. A *potentiometer* is a device that is used to control the voltage distribution in a circuit. The voltage (V) controlled by a certain potentiometer can be calculated by solving $4 \cdot V + 20 = 60$. What is the voltage (V)?



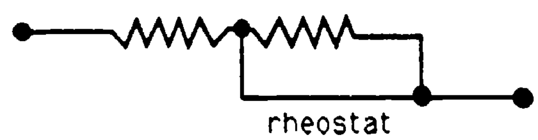
7. The current (I) of a certain electrical device is represented by the equation $5(I + 2) = 30$. What is the current (I)?

8. You need to find the current (I) in a specific electric circuit. The current (I) can be found by solving $I + 14 = 20$. What is the current (I)?



9. The current (I) of an electric motor can be calculated by solving the equation $I \cdot 8 = 440$. What is the current (I)?

10. A rheostat is a device that controls the current in a circuit. The resistance (R) of a particular rheostat is represented by the equation $3(R + 4) - 27 = 0$. What is the resistance (R) of the rheostat?



Answers

1. $4(R + 10) - 100 = 0$

   $4 \cdot R + 40 - 100 = 0$

   $4 \cdot R - 60 = 0$

   $4 \cdot R = 60$

   $R = \frac{60}{4}$

   $R = 15\ \Omega$

2. $10 + 20 \cdot I = 110$

   $20 \cdot I = 110 - 10$

   $20 \cdot I = 100$

   $I = \frac{100}{20}$

   $I = 5\ A$

3. $3 \cdot I + 50 = 110$

   $3 \cdot I = 110 - 50$

   $3 \cdot I = 60$

   $I = \frac{60}{3}$

   $I = 20\ A$

4. $R + 50 = 90$

   $R = 90 - 50$

   $R = 40\ \Omega$

5. $1263 + P = 3589$

   $P = 3589 - 1263$

   $P = 2326$ W

6. $4 \cdot V + 20 = 60$

   $4 \cdot V = 60 - 20$

   $4 \cdot V = 40$

   $V = \frac{40}{4}$

   $V = 10$ v

7. $5(I + 2) = 30$

   $5 \cdot I + 10 = 30$

   $5 \cdot I = 30 - 10$

   $5 \cdot I = 20$

   $I = \frac{20}{5}$

   $I = 4$ A

8. $I + 14 = 20$

   $I = 20 - 14$

   $I = 6$ A

9. $I \cdot 8 = 440$

   $I = \frac{440}{8}$

   $I = 55$ A

10. $3(R + 4) - 27 = 0$

$3 \cdot R + 12 - 27 = 0$

$3 \cdot R - 15 = 0$

$3 \cdot R = 15$

$R = \frac{15}{3}$

$R = 5\,\Omega$

Math
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How to Solve Non-Linear Equations by Transposing

$$y = \frac{25}{x}$$

Prerequisites:

Workbook users should understand:

- *how to work with decimal numbers*
- *how to work with base numbers and exponents*
- *how to work with squares and square roots*
- *the Distributive Law*
- *how to use inverse functions*
- *how to solve equations*
- *how to use order of operation*

How to Solve Non-Linear Equations by Transposing

Focus

This lesson explains how to solve non-linear equations by transposing.

Job Examples

Job examples of when you will solve non-linear equations by transposing include calculating:

- current of electrical components
- resistance of circuits
- power of electrical devices

Key Words

Word	*Explanation*	*Example*
equation	an equality with numbers and unknown values	$a + b = c$ $3 + 5 = 8$
equality	two mathematical quantities separated by an equal sign (=); the equal sign means the two quantities are equal	$2 + 3 = 5$
unknown value	a letter in an equation with a value that is not stated	$7 + x = 20$ $5 + y + z = 2 \cdot z$
non-linear equation	any equation with one or both of the following conditions: • the unknown values (two values or more) have powers greater than one • the unknown values are multiplied and/or with each other	$y = \frac{25}{x}$ $x \cdot y = 3$ $y = 4x^2$

term	in algebra, a number or letter; can also be a number and/or letters combined by multiplication or division	80, X^2, $4 \cdot A \cdot B$, $\frac{y}{z}$
transposing	moving a term with its associated function (or moving the function alone) from one side of the equation to the other side and using the inverse function	$A + 2 = 14$ $A = 14 - 2$
Distributive Law	an algebraic concept stating $a(b + c) = a \cdot b + a \cdot c$	$x(y + z) = xy + xz$ $2 \cdot 4 + 2 \cdot 3 = 2(4 + 3)$
math function	a mathematical procedure	addition (+), subtraction (-) multiplication ($\cdot$), division ($\div$) power (a^b), root ($\sqrt{}$)
inverse function	a math function that can be used to cancel a specific other math function	add/subtract $7 + 2 - 2 = 7$ multiply/divide $\frac{7 \cdot 4}{4} = 7$ power/root $\sqrt{7^2} = 7$

How to Solve Non-Linear Equations by Transposing

> ***Example 1:*** *Current* (I) is the flow of electrical charge; it is measured in amps (A). A *rheostat* is a device that controls current (I) in a circuit. You need to find the current (I) of a certain rheostat that is represented by $2(10 + 5 \cdot I^2) + 10 = 120$. What is the current (I)?

1. ...arrange each side of the equation using the Distributive Law: $a(b + c) = a \cdot b + a \cdot c$

$$2(10 + 5 \cdot I^2) + 10 = 120$$

$$2 \cdot 10 + 2 \cdot 5 \cdot I^2 + 10 = 120$$

2. Simplify each side of the equation.

$$20 + 2 \cdot 5 \cdot I^2 + 10 = 120$$

$$20 + 10 \cdot I^2 + 10 = 120$$

$$20 + 10 \cdot I^2 + 10 = 120$$

$$30 + 10 \cdot I^2 = 120$$

3. Solve the equation by *transposing*: move the term or function you want to reposition to the other side of the equation and use the inverse function.

$$30 + 10 \cdot I^2 = 120$$

$$10 \cdot I^2 = 120 - 30$$

$$10 \cdot I^2 = 90$$

$$I^2 = \frac{90}{10}$$

$$I^2 = 9$$

$$I = \sqrt{9}$$

$$I = 3 \text{ or } I = 3\text{ A}$$

4. Check by substituting your answer for the unknown value in the equation.

$2(10 + 5 \cdot 3^2) + 10 = 120$

$2(10 + 5 \cdot 9) + 10 = 120$

$2(10 + 45) + 10 = 120$

$2(55) + 10 = 120$

$110 + 10 = 120$

$120 = 120$

Example 2: *Resistance* (R) is the ability of a device (or component or material) to oppose the flow of electrical current. Resistance (R) is measured in ohms (Ω). A *potentiometer* is a device that controls the voltage distribution in a circuit. You need to find the resistance (R) of a certain potentiometer that is represented by $\sqrt{9+R^2} = 5$. What is the resistance (R)?

1. Rearrange each side of the equation using the Distributive Law: $a(b + c) = a \cdot b + a \cdot c$

$\sqrt{9+R^2} = 5$

This step is not applicable to this problem.

2. Simplify each side of the equation.

This step is not applicable to this problem.

3. Solve the equation by *transposing*: move the term or function you want to reposition to the other side of the equation and use the inverse function.

$\sqrt{9+R^2} = 5$

$9 + R^2 = 5^2$

$9 + R^2 = 25$

$R^2 = 25 - 9$

$R^2 = 16$

$R = \sqrt{16}$

$R = 4$ or $R = 4\ \Omega$

4. Check by substituting your answer for the unknown value in the equation.

$\sqrt{9+4^2} = 5$

$\sqrt{9+16} = 5$

$\sqrt{25} = 5$

$5 = 5$

Practice Problems

Read each problem and solve for the answer. Answers are provided in the back of this workbook.

1. *Voltage* (V) is electrical force or pressure. It is measured in volts (v). You need to find the voltage of a certain device represented by $\frac{V^2}{R} = P$. If P is 50 and R is 8, what is the voltage (V)? (*Hint: solve* $\frac{V^2}{8} = 50$)

2. *Power* (P), in general, is energy delivered or consumed per second. Power (P) is measured in watts (W). You need to find the power (P) consumed by a certain device represented by the equation $\sqrt{P^2+24} = 7$. What is the power (P)?

3. *Current* is the flow of electrical charge. Current is measured in amps (A). The current (I) of a certain electrical device is represented by $3 \cdot I^2 = 75$. What is the current (I)?

4. *Power* (P), in general, is energy delivered or consumed per second. Power (P) is measured in watts (W). Calculate the power (P) of a certain device by solving the equation $\sqrt{\frac{P}{5}} = 2$.

5. A *rheostat* is a device that is used to control the current in a circuit. The resistance (R) of a certain rheostat is represented by $\sqrt{3 \cdot R} = 9$. What is the resistance (R)?

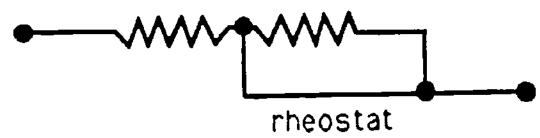

rheostat

6. A *potentiometer* is a device that is used to control the voltage distribution in a circuit. Voltage is measured in volts (v). The voltage (V) measured across a certain potentiometer is represented by $\frac{V^2}{18} = 2$. What is the voltage (V)?


potentiometer

7. In physics, a force (F) is measured in pounds (lbs). The force (F) acting on an object is represented by $\sqrt{F^2 + 16} = 5$. What is the force (F)?

8. A *rheostat* is a device that controls the current in electrical circuits. The current (I) of a certain rheostat is represented by $4(2 \cdot I^2 + 5) = 52$. What is the current (I)?



9. The current (I) of a certain electrical device is represented by $3 + 4(6 + 3 \cdot I^2) + 8 = 83$. What is the current (I)?

Answers

1. $\frac{V^2}{8} = 50$

   $V^2 = 50 \cdot 8$

   $V^2 = 400$

   $V = \sqrt{400}$

   $V = 20\ V$

2. $\sqrt{P^2 + 24} = 7$

   $P^2 + 24 = 7^2$

   $P^2 + 24 = 49$

   $P^2 = 49 - 24$

   $P^2 = 25$

   $P = \sqrt{25}$

   $P = 5\ W$

3. $3 \cdot I^2 = 75$

   $I^2 = \frac{75}{3}$

   $I^2 = 25$

   $I = \sqrt{25}$

   $I = 5\ A$

4. $\sqrt{\frac{P}{5}} = 2$

$\frac{P}{5} = 2^2$

$\frac{P}{5} = 4$

$P = 4 \cdot 5$

$P = 20$ W

5. $\sqrt{3 \cdot R} = 9$

$3 \cdot R = 9^2$

$3 \cdot R = 81$

$R = \frac{81}{3}$

$R = 27\ \Omega$

6. $\frac{V^2}{18} = 2$

$V^2 = 2 \cdot 18$

$V^2 = 36$

$V = \sqrt{36}$

$V = 6$ v

7. $\sqrt{F^2 + 16} = 5$

$F^2 + 16 = 5^2$

$F^2 + 16 = 25$

$F^2 = 25 - 16$

$F^2 = 9$

$F = \sqrt{9}$

$F = 3$ lbs.

8. $4(2 \cdot I^2 + 5) = 52$

$8 \cdot I^2 + 20 = 52$

$8 \cdot I^2 = 52 - 20$

$8 \cdot I^2 = 32$

$I^2 = \frac{32}{8}$

$I^2 = 4$

$I = \sqrt{4}$

$I = 2$ A

9. $3 + 4(6 + 3 \cdot I^2) + 8 = 83$

$3 + 24 + 12 \cdot I^2 + 8 = 83$

$35 + 12 \cdot I^2 = 83$

$12 \cdot I^2 = 83 - 35$

$12 \cdot I^2 = 48$

$I^2 = \frac{48}{12}$

$I^2 = 4$

$I = \sqrt{4}$

$I = 2\ A$

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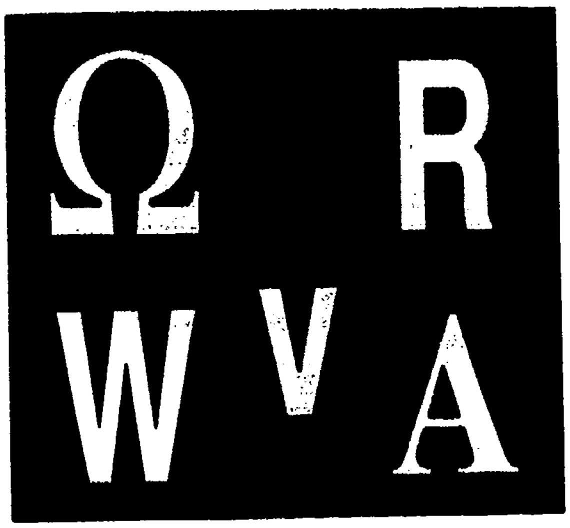
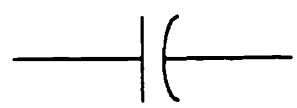
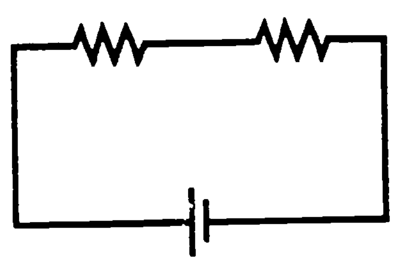
Key Words: Electrical/ Electronic

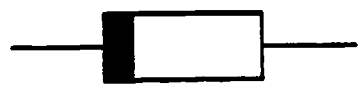


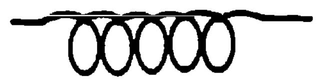
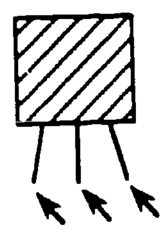
Reference

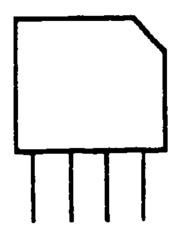
Key Words: Electrical/Electronics

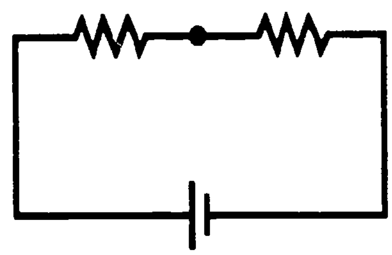
Word	Explanation	Example
AC (alternating current)	a current that changes direction periodically	
amp (A)	the unit by which current is measured	
Btu (British thermal unit)	an English unit of measure for measuring heat	
calorie	a metric unit of measure for measuring heat	
capacitance	the ability of a capacitor to store electrical charge; it is measured in Farad (F)	
capacitor	a device that stores electrical charge	
circuit	electrical components connected together to a power source; also known as *electrical circuit*	

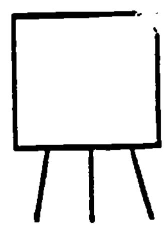
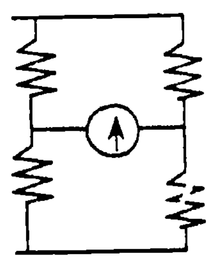
Word	Explanation	Example
component	a part of a circuit; a circuit is made up of several components	
computer microchip	a component that contains microcircuits (microscopic circuits)	
conductance	the degree to which wires and other components conduct electrical current	
conductor	any material that allows the electric current to flow with relative ease	
conduit	a pipe for encasing electrical wire	
coulomb (C)	the unit of measure of electrical charge	
current (I)	the flow of electrical charge; it is measured in amps (A)	
cycle	a process that is repeated periodically	

Word	Explanation	Example
DC (direct current)	a current that circulates in the same direction always	
diode	an electronic component	
efficiency	output divided by input	$\frac{output}{input}$
electrical circuit	see *circuit*	
Farad (F)	the unit by which capacitance is measured	
frequency	the number of waves generated per second	
generator	a device that generates electrical energy as a result of an external force acting on it	
hertz (Hz)	a unit of frequency equal to one cycle per second	
inductance	the measure of the ability of an inductor to oppose any change in the electric current passing through it	

Word	Explanation	Example
inductor	a wire wrapped in the shape of a coil	
mechanical advantage (MA)	a term that describes how much easier a job will be due to using a specific tool	
Multimeter	a meter that measures volts (v), amps (A), and ohms (Ω)	
ohm (Ω)	the unit by which resistance (R) is measured	
period	the time of one wave	
pin	the part of a device that is used to connect the device to other components	
potentiometer	a device that controls the voltage distribution in a circuit	
power (P)	in general, energy delivered or consumed per second; it is measured in watts (W)	

Word	Explanation	Example
power in	the power coming into a device or circuit	
power out	the power leaving a device or circuit	
power ratio	the relationship between power out and power in (represented in a ratio or fraction)	
power rating	the highest power at which a device can safely operate	
pulse	a shape that has a rising side followed by a falling side separated by a certain width	
rectifier	a circuit or component used to change alternating current (AC) to direct current (DC)	
resistance (R)	the ability of a device, material or component to oppose the flow of electric current; it is measured in ohms (Ω)	

Word	***Explanation***	***Example***
resistivity	the specific resistance of a certain material; it is a ratio between the resistance and the physical dimensions of the material	
resistor	a component that controls the flow of current and/or voltage in a circuit	
rheostat	a device that controls the current in a circuit	
series circuit	a circuit with the components connected end to end	
tolerance	allowed error on any measured value	
transformer	a device that increases or decreases voltage and/or current	

Word	Explanation	Example
transistor	a device that is used as an amplifier or a switch	
volt (v)	the unit by which voltage is measured	
voltage (V)	electrical force or pressure; it is measured in volts (v)	
watt (W)	the unit by which power is measured	
wave	a shape that repeats periodically	
Wheatstone Bridge	a circuit used to measure an unknown resistance	

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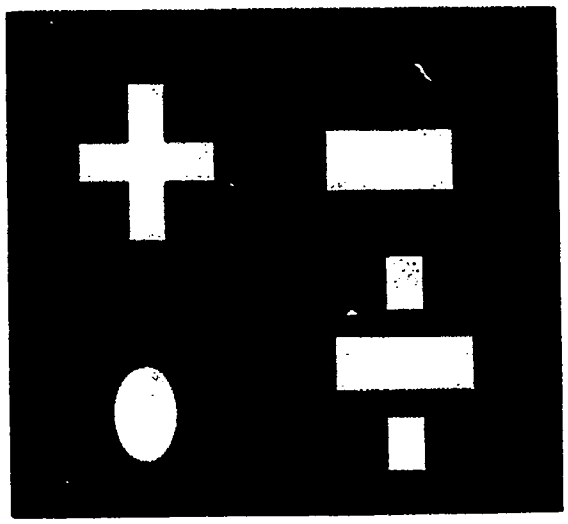
Key Words: Math



Reference

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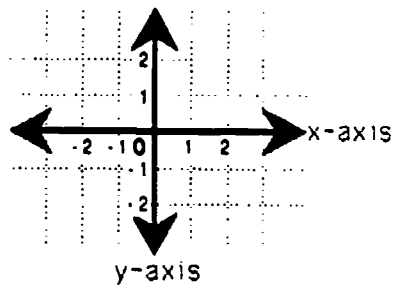
Key Words: Math

Word	*Explanation*	*Example*
axis	a number line on a grid	

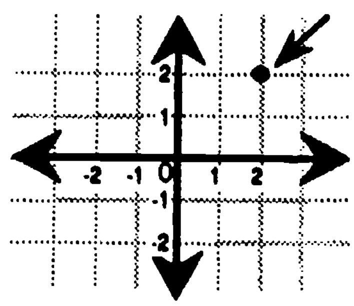
Word	*Explanation*	*Example*
base	a number with an exponent	8^4 8 is the base
common denominator	a denominator (bottom number) that is the same in two or more fractions	$\frac{1}{6}, \frac{3}{6}, \frac{5}{6}$
Conversion Table	a table with information for converting from one measurement to another	(see table below)

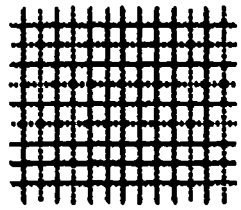
English Unit of Measure × →	Conversion Quantity	Metric Unit of Measure ÷ ←
foot (ft)	.305	meter (m)
inch (")	2.54	centimeter (cm)
pound (lb)	.452	Kilogram (Kg)
British thermal unit (Btu)	252	calorie
horsepower (hp)	746	watt (W)
mile (mi)	1.61	Kilometer (Km)

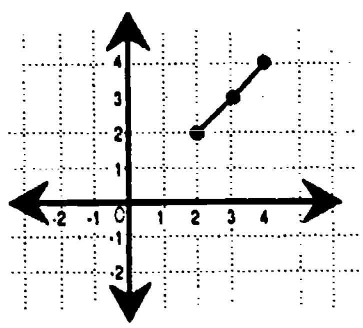
Word	*Explanation*	*Example*
convert	to change to a different form	100 centimeters = 1 meter 12 inches = 1 foot $.5 = \frac{1}{2}$ $\frac{75}{100} = .75$

Word	Explanation	Example
coordinates	two values representing one point on a grid. Coordinates are written as a pair of numbers; the first number represents the X axis value (independent variable); the second number represents the Y axis value (dependent variable).	(-3,2); (x,y)
cross multiply	a way to restructure a proportion	$\frac{a}{b} = \frac{c}{d}$ or $\frac{a}{b} \times \frac{c}{d}$ or $a \cdot d = c \cdot b$ $\frac{6}{20} = \frac{x}{5}$ or $\frac{6}{20} \times \frac{x}{5}$ or $6 \cdot 5 = x \cdot 20$
decimal number	a number with a decimal point between the ones place and tenths place	1.374, .5, .003
decimal place	the position of a digit in a decimal number	millions, hundred thousands, ten thousands, thousands, hundreds, tens, ones or units, tenths, hundredths, thousandths, ten thousandths 4,896,328.9721
decimal point	a dot between the ones place and tenths place in a number	3.2, 100.24, .6, 78.1
denominator	the bottom number of a fraction	$\frac{x}{y}$, $\frac{6}{7}$

Word	Explanation	Example
dependent variable	a variable that is controlled by another variable; the vertical axis on a grid	When driving a car, the car's speed (dependent variable) depends on the amount of accelerator pedal pressure (independent variable)
differer :e	the result when subtracting numbers	7 - 6 = 1
digit	a numerical figure	0, 1, 2, 3, 4, 5, 6, 7, 8, 9
Distributive Law	an algebraic concept stating $a(b + c) = a \cdot b + a \cdot c$	$x(y + z) = xy + xz$ $2 \cdot 4 + 2 \cdot 3 = 2(4 + 3)$
dividend	a number being divided by another number	1 ÷ .6, .12 $\overline{)\mathbf{.13}}$, divisor$\overline{)\mathbf{dividend}}$
divisor	a number being divided into another number	.1 ÷ .6, .12 $\overline{).13}$, **divisor**$\overline{)\text{dividend}}$
English system	the measurement system used in the U. S.; it is not based on multiples of 10	12 inches, = 1 foot 3 feet = 1 yard 4 cups = 1 quart

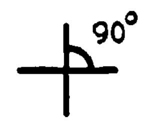
Word	Explanation	Example
equality	two mathematical quantities separated by an equal sign (=); the equal sign means the two quantities are equal	$2 + 3 = 5$
equation	an equality with numbers and unknown values	$5 + x = 18$
exponent	a number that tells how many times a certain other number is multiplied by itself	$10^3 = 10 \cdot 10 \cdot 10$ 3 is the exponent
extrapolate	to estimate, infer, or project	"The information **extrapolated** from the graph is. . ."
fraction	two numbers separated by a fraction bar; the top number is the *numerator*, the bottom number is the *denominator*	$\frac{1}{x}, \frac{2}{3}, \frac{y}{z}$
graph point	a specific location on an axis; also the location where two lines intersect	

Word	***Explanation***	***Example***
grid	a grating of horizontal and vertical lines	
horizontal	on a grid, a left and right direction	
improper fraction	a fraction representing a number larger than one; the numerator (top number) is *larger* than the denominator (bottom number)	$\frac{3}{2}, \frac{9}{4}, \frac{23}{4}, \frac{54}{13}$
independent variable	a variable that controls another variable; the horizontal axis on a grid	A lamp's dimmer switch (independent variable) controls the brightness of the bulb (dependent variable)
intersect	to touch or cross	

Word	***Explanation***	***Example***
inverse function	a math function that can be used to cancel a specific other math function	add/subtract $7 + 2 - 2 = 7$ multiply/divide $\frac{7 \cdot 4}{4} = 7$ power/root $\sqrt{7^2} = 7$
linear equation	any equation with both of the following conditions: • the unknown values (two values or more) have powers of one • the unknown values (two values or more) cannot be multiplied and/or divided with each other	$x + y = 3$ $2 \cdot a + 5 \cdot b = 7$
line graph	a line drawn through two or more points plotted on a grid	
math function	a mathematical procedure	addition(+), subtraction(-) multiplication(•), division(÷) power(a^b), root(√)
measurement	a quantity followed by a unit of measure	2 A (amps) 3 ft. (feet) 110 v (volts)

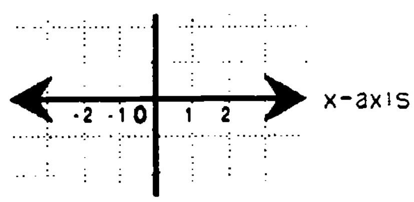
Word	***Explanation***	***Example***
metric measurement	a measurement based on the metric system	4 milligrams, 8 centimeters, 12 liters
metric measurement scale	a power of ten which can also be represented by a specific name	10^{-3} = milli 10^{6} = mega 10^{3} = kilo
metric system	a measurement system based on powers of ten	1 meter = 100 centimeters 1 meter = 1000 millimeters 1 meter = .01 hectometers
mixed number	a number consisting of a whole number and a fraction	$5\frac{3}{4}$, $8\frac{6}{7}$
Multiplication Property of Equality	an algebraic concept stating that you can multiply or divide a number into *both* sides of an equations without changing the value of the equation	x = 4 is an equation $x \cdot 8 = 4 \cdot 8$ $\frac{x}{2} = \frac{4}{2}$
negative number	a number written with a minus sign (-) before it	-207, -.03, -15

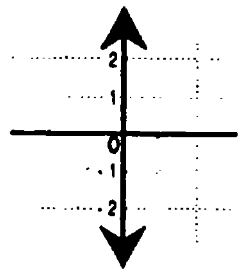
Word	***Explanation***	***Example***
non-linear equation	any equation with one or both of the following conditions: • the unknown values (two values or more) have powers greater than one • the unknown values are multiplied and/or divided with each other	$y = \frac{25}{x}$ $x \bullet y = 3$ $y = 4 \bullet x^2$
number line	a line showing the relationship of signed numbers to each other	<---|-----|-----|-----|-----|---> -2 -1 0 1 2
numerator	the top number of a fraction	$\frac{a}{b}$, $\frac{3}{4}$
ordered pair	another name for coordinates	(5,3)
ordinary notation	a decimal number; a number with a decimal point between the ones place and tenths place; when there are no numbers to the right of the decimal point, the decimal point is usually not written	7.5. 30, -.004
part	a portion of a whole; can be represented by a numerator (top number) in a proper fraction	$\frac{7}{8}$ = 7 parts of 8

Word	Explanation	Example
percent	a fraction with a denominator (bottom number) of 100; % is the symbol for percent	$70\% = \frac{70}{100}$ $120\% = \frac{120}{100}$
perpendicular	two lines intersecting at a 90° angle	
power of 10	the number 10 with an exponent	10^{-7}, 10^{5}, 10^{21}
positive number	a number greater than zero; the plus sign (+) indicates the number is positive; this is understood and usually not included with the number	+749, +.58892, $+\frac{5}{13}$ or 749, .58892, $\frac{5}{13}$
product	the result when multiplying numbers	4 • 3 = **12**
proper fraction	a fraction with a numerator (top number) smaller than the denominator (bottom number)	$\frac{2}{5}$, $\frac{7}{100}$

Word	Explanation	Example
proportion	two fractions separated by an equal sign	$\frac{10}{5} = \frac{30}{15}, \frac{A}{2} = \frac{10}{4}$
quantity	numerical value	6, 9
quotient	the result when dividing numbers	$8 \div 2 = 4$
reciprocal	one divided by a number	$\frac{1}{9}$ is the reciprocal of 9
round	the process of slightly increasing or decreasing a number to make it more convenient to use	2307 rounds to 2300 998 rounds to 1000 74.0012 rounds to 74 19.482 rounds to 19.5
scientific notation	a way to represent a number; a number written in scientific notation is a number (between 1 and 10) multiplied by 10 raised to a specific exponent	$823{,}000 = 8.23 \cdot 10^5$ $.0000009 = 9 \cdot 10^{-7}$
signed number	a negative number or a positive number	-4, -12, 3, 802

Word	***Explanation***	***Example***
significant digit	all non-zero digits (1 through 9); the zero is significant when it holds *any* place value to the *right* of a non-zero digit	↓↓↓↓ .003405 ↓↓↓↓↓ 50900
square of a number	the product of a number multiplied by itself; squared numbers are represented with an exponent of 2	$8^2 = 8 \cdot 8 = \mathbf{64}$ $5^2 = 5 \cdot 5 = \mathbf{25}$
square root	a number that when multiplied by itself results in a given number	$\mathbf{2} \cdot 2 = 4$ or $2 = \sqrt{\mathbf{4}}$ $\mathbf{3} \cdot 3 = 9$ or $3 = \sqrt{\mathbf{9}}$
sum	the result when adding numbers	$2 + 3 = \mathbf{5}$
term	in algebra, a number or letter; can also be a number and/or letters combined by multiplication or division	$80, x^2, 4 \cdot A \cdot B, \frac{x}{y}$
transpose	moving a term with its associated function (or moving the function alone) from one side of the equation to the other side and using the inverse function	$A + \mathbf{2} = 14$ $A = 14 - \mathbf{2}$ $\sqrt{x} = 3$ $x = 3^2$

Word	***Explanation***	***Example***
unknown value	a letter in an equation with a value that is not stated	$7 + \mathbf{x} = 20$
unit of measure	a defined measurement increment	inch, meter, watt, volt, amp
variable	a symbol or letter that can vary in value	a, x
vertical	on a grid, an up and down direction	
whole	the total number of parts	20%, 30% and 50% = 100% 100% is the whole
whole number	a number that is not a fraction	1, 16, 238, -5
X axis	the horizontal number line on a grid	

Word	Explanation	Example
Y axis	the vertical number line on a grid	
zero	a digit that has no quantified value	0