CHAPTER 1

ELECTRICAL FUNDAMENTALS

ESSENTIAL FOR JOURNEYMAN AND MASTER/CONTRACTOR LICENSING EXAMS

Introduction to Chapter 1—Electrical Fundamentals

Chapter 1 of *Mike Holt's Illustrated Guide to Electrical Exam Preparation* textbook focuses on the fundamentals that help to establish the foundation of preparing to take your exam. The fact that you're at a point in your electrical career where you're ready to do so indicates that you've probably spent thousands of hours in the field honing your installation skills and building quite a skillset. Because of that, it may be a good time to refresh your memory about some of the electrical fundamentals you took for granted when you began your career.

When was the last time you calculated the size of a transformer or the full-load ampacity of a motor? Do you remember how to apply efficiency and power factors? What happens to a multiwire circuit when the neutral is opened? Simple math equations and electrical calculations that you might not have used in some time may now require a bit more thought than they once did. More time is therefore required to select the correct equations and work out the calculations; time is of the essence when taking an exam.

The four units in this chapter will review the electrical fundamentals that helped to get you where you are today. Some of you may think portions of this unit seem basic. That's a good thing because it means you've retained the basics you learned long ago; but rest assured that not all of them are. The point is for you take advantage of the material covered in this first chapter to sharpen your fundamental knowledge of electrical math and theory and build up your confidence as you progress. The four units are:

- **Unit 1—Basic Math, Advanced Math, and Electrical Circuits and Ohm's Law**
- **Unit 2—Electrical Circuits**
- **Unit 3—Alternating Current**
- **Unit 4—Motors and Transformers**

UNIT 1

BASIC MATH, ADVANCED MATH, AND ELECTRICAL CIRCUITS AND OHM'S LAW

Introduction to Unit 1—Basic Math, Advanced Math, and Electrical Circuits and Ohm's Law

While some of the math and electrical theory covered in this unit may seem a bit basic, mastery of these concepts is essential to a timely and successful completion of an electrical exam. You may even be a little surprised at just how much you've forgotten about Ohm's Law or how to increase a number by a percentage. This unit is designed to make these types of calculations second nature.

Part A—Basic Math

Introduction

This unit explains how to express numeric values in the form necessary to correctly solve electrical calculations. By the time you've finished this part of Unit 1, you'll understand the various math functions needed to complete the calculations necessary for a safe, adequate, and *NEC*-compliant installation of electrical equipment and wiring systems.

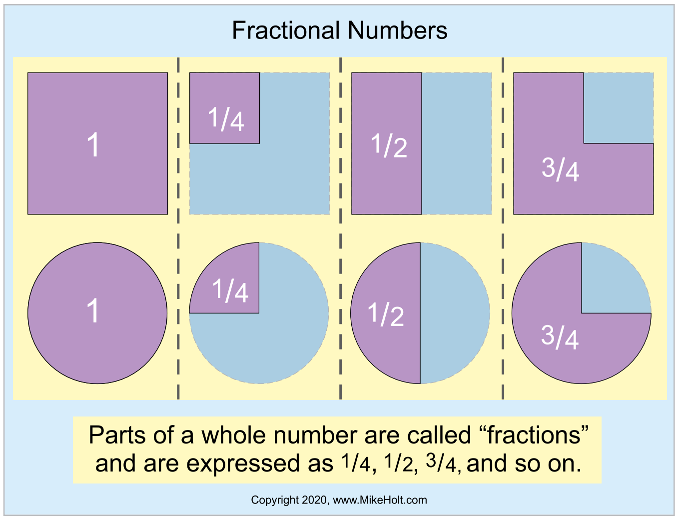
1.1 Whole Numbers and Integers

Whole numbers are positive numbers that don't contain fractions, decimals, or percentages such as 2, 5, 10, 100, and so forth. Simply put, a whole number is the quantity or value of the "whole."

Integers include negative and positive whole numbers, such as -3, -2, -1, 0, 1, 2, 3...

1.2 Fractional Numbers

Parts of a whole number are called "fractions" from the Latin word "fractus," meaning broken. They're expressed as ¼, ½, ¾, and so on. ▸Figure 1–1



▸Figure 1–1

1.3 Decimal Numbers

Fractions can be expressed as a decimal number from the Latin word "decimus," and represent a part of a whole number using the decimal system rather than fractions. A fraction can be converted to a decimal with a calculator by dividing the numerator (top number of the fraction) by the denominator (bottom number of the fraction).

▶ Fraction Converted to Decimal Examples

⅖ = two divided by five = 0.40

3⁄6 = three divided by six = 0.50

5⁄4 = five divided by four = 1.25

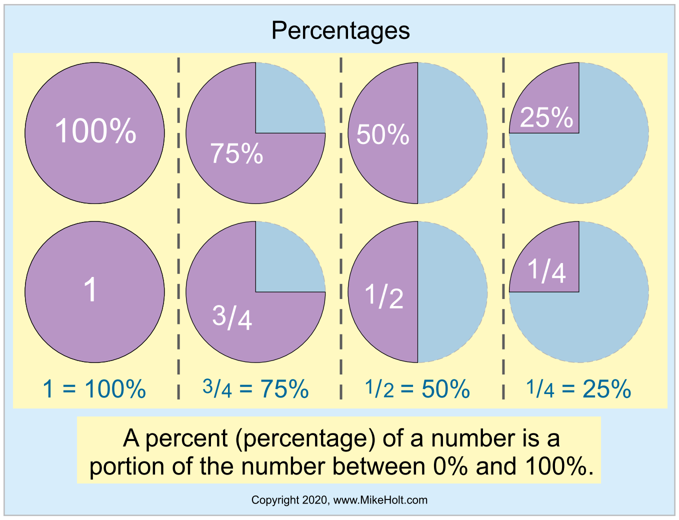
7⁄2 = seven divided by two = 3.50

The decimal system places numbers to the right of a decimal point to indicate values that are a fraction of "one." A few examples are 1⁄10 = 0.10 (one tenth of one), 1⁄100 = 0.01 (one hundredth of one), and 1⁄1,000 = 0.001 (one thousandth of one).

If the decimal number is greater than "one," whole numbers will be numbers to the left of the decimal point such as 1.25, 1.732, and 2.50.

1.4 Percentages

A percent (percentage) of a number is that portion of a number as it relates to a whole number. For example, one hundred percent (100%) means all of a number, seventy-five percent (75%) means three-quarters of a number, fifty percent (50%) means one-half of a number, and twenty-five percent (25%) means one-fourth of a number. ▶Figure 1–2



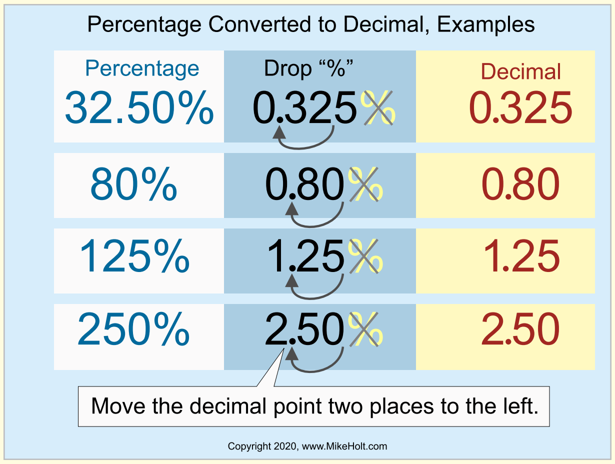
▶Figure 1–2

For convenience in multiplying or dividing by a percentage, convert the percentage value to a decimal, then use the decimal value for the calculation. To change a percentage value to a decimal, drop the percentage symbol, and move the decimal point two places to the left.

You can use your calculator's percentage key to work these problems, but you need to understand how to convert a percentage to a decimal manually.

▶ Percentage Converted to Decimal Examples ▶Figure 1–3

Percentage	*Decimal Number*
32.50%	*0.325*
80%	*0.80*
125%	*1.25*
250%	*2.50*



▶Figure 1–3

1.5 Multipliers

Sometimes a number must be multiplied by a percentage in order to arrive at the answer. First, convert the percentage to a decimal (multiplier) then multiply the original number by the multiplier (decimal value).

▶ Multiplier Example 1

Question: *What's the value of 16 multiplied by 125 percent?* ▶Figure 1–4

(a) 16 (b) 20 (c) 30 (d) 40

Solution:

Step 1: *Convert 125% to a decimal: 1.25.*

Step 2: *Multiply 16 (the original number) by 1.25.*

16 × 1.25 = 20

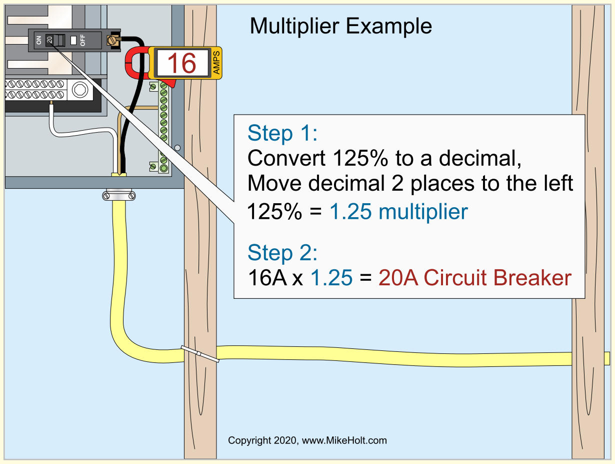


Figure 1–4

Answer: *(b) 20*

Multiplier Example 2

Question: *What's the value of 80 multiplied by 125 percent?* Figure 1–5

(a) 75 *(b) 80* *(c) 100* *(d) 125*

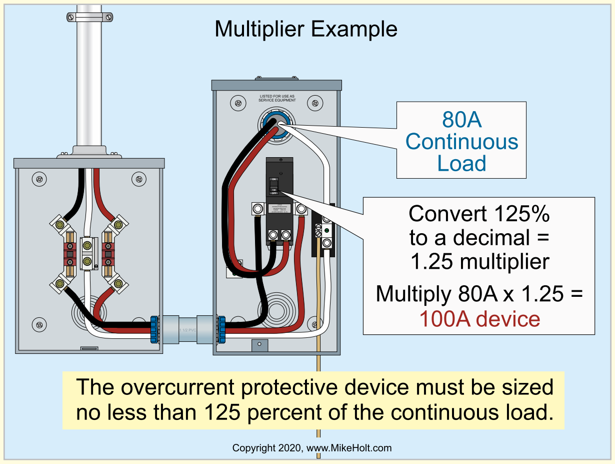


Figure 1–5

Solution:

Step 1: *Convert 125% to a decimal: 1.25.*

Step 2: *Multiply 80 (the original number) by 1.25*

80 × 1.25 = 100

Answer: *(c) 100*

Author's Comment:

- A much faster way to do this is with a calculator. For this example, press the calculator keys in the following sequence: 80 × 125% = 100. Be sure to practice until you can confidently use your calculator to arrive at the correct answer. Figure 1–6 and Figure 1–7

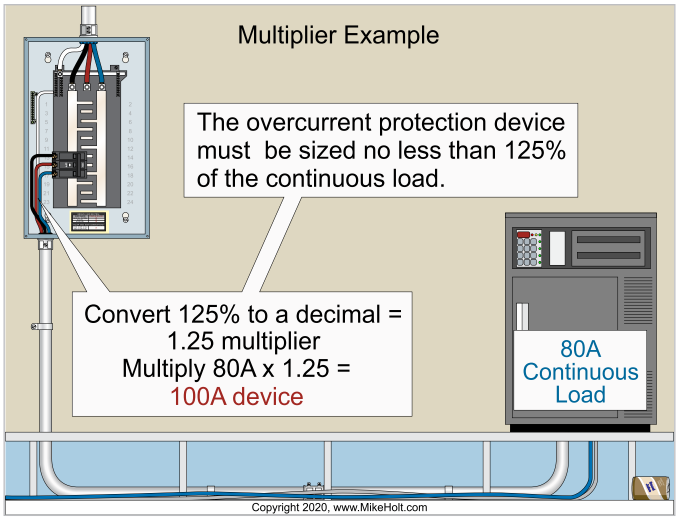


Figure 1–6

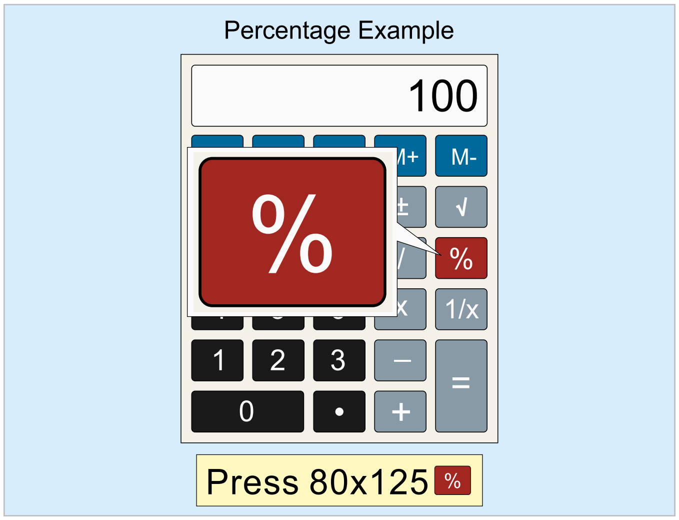


Figure 1–7

▶ Calculator Example

Question: *What's 80 percent of 100?*

(a) 80 (b) 90 (c) 100 (d) 150

Solution:

Step 1: *Enter the whole number 100 on your calculator and then press the "×" key.*

Step 2: *Enter 80 on your calculator, and then press the "%" key.*

Step 3: *Press the "=" or "enter" key = 80.*

Answer: *(a) 80*

1.6 Percentage Increase

Use the following steps to increase a number by a specific percentage:

Step 1: Convert the percentage to a decimal value.

Step 2: Add one to the decimal value (step 1) to create a multiplier.

Step 3: Multiply the original number by the multiplier (step 2).

▶ Percentage Increase Example

Question: *What's the value of 45 increased by 35 percent?*

(a) 40.50 (b) 50.90 (c) 60.75 (d) 70.80

Solution:

Step 1: *Convert 35 percent to decimal form: 0.35*

Step 2: *Add one to the decimal value: 1 + 0.35 = 1.35*

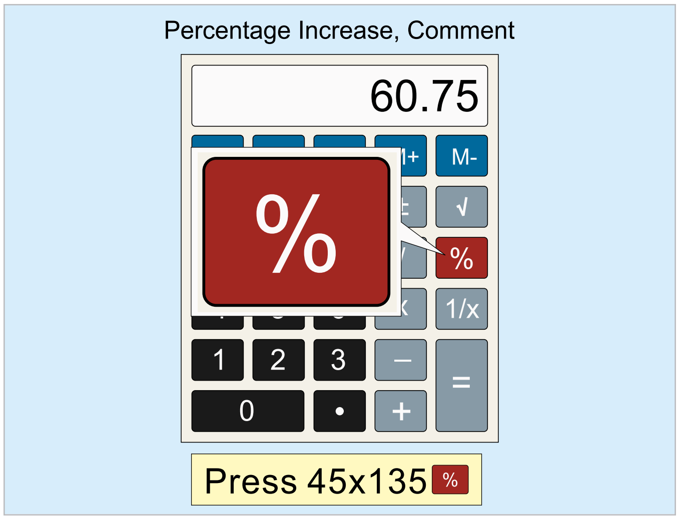
Step 3: *Multiply 45 (the original number) by the multiplier of 1.35:*

45 × 1.35 = 60.75

Answer: *(c) 60.75*

Author's Comment:

- A much faster way to do this is with a calculator. Just enter a number and then multiply it by the percentage using the percent key. Remember to add 100 percent to the percentage of increase when you enter the number in the calculator. For this example, press the calculator keys in the following sequence: 45 × 135%. Be sure to practice until you can confidently use your calculator to arrive at the correct answer. ▶**Figure 1–8**

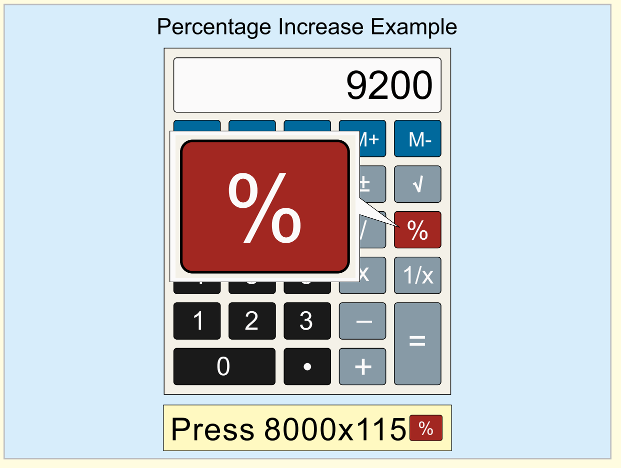


▶**Figure 1–8**

▶ Calculator Example

Question: *What's the value of 8,000 increased by 15 percent?* ▶**Figure 1–9**

(a) 6,800 (b) 8,200 (c) 9,200 (d) 11,000



▶**Figure 1–9**

Solution:

Step 1: *Enter 8,000 on your calculator, and then press the "×" key.*

Step 2: *Enter 115 (15% + 100%) on your calculator and then press the "%" key.*

Step 3: *Press the "=" key: 9,200*

Answer: *(c) 9,200*

1.7 Reciprocals

Whole Number Reciprocals. The reciprocal of a number is obtained by inverting or flipping the number so it's a fraction. For example, the reciprocal of 5 or $^5/_1$ is $^1/_5$. To determine the decimal value of a whole number reciprocal, follow these steps:

Step 1: Show the number as a fraction by placing it over the number 1.

Step 2: Invert the top and bottom numbers of the fraction.

Step 3: Convert the fraction to a decimal by dividing the top number by the bottom number.

▶ Decimal Value of Whole Number Reciprocal Example 1

Question: *What's the decimal value of the reciprocal of 4?*

(a) 0.25 (b) 0.35 (c) 0.45 (d) 0.55

Solution:

Step 1: *Show the number 4 as a fraction:* $^4/_1$.

Step 2: *Invert 4 and 1 (*$^4/_1$*) to* $^1/_4$.

Step 3: *Convert* $^1/_4$ *to a decimal by dividing 1 by 4:* $^1/_4 = 0.25$

Answer: *(a) 0.25*

▶ Decimal Value of Whole Number Reciprocal Example 2

Question: *What's the decimal value of the reciprocal of 10?*

(a) 0.05 (b) 0.10 (c) 0.15 (d) 0.20

Solution:

Step 1: *Show the number 10 as a fraction:* $^{10}/_1$.

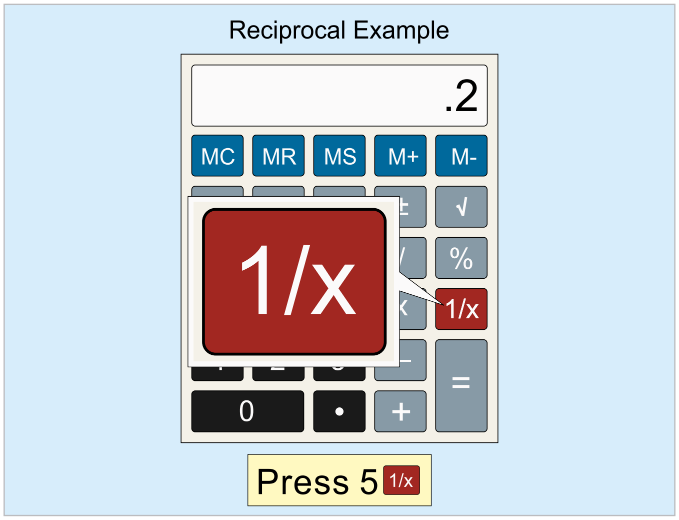
Step 2: *Invert 10 and 1 (*$^{10}/_1$*) to* $^1/_{10}$.

Step 3: *Convert* $^1/_{10}$ *to a decimal by dividing 1 by 10:* $^1/_{10} = 0.10$

Answer: *(b) 0.10*

Author's Comment:

- A much faster way to do this is with a calculator. Just enter a number and then press the "$^1/_x$" key. Make sure to practice until you can confidently use your calculator to arrive at the correct answer. ▶Figure 1–10



▶Figure 1–10

▶ Calculator Decimal Value of Whole Number Reciprocal Example

Question: *What's the decimal value of the reciprocal of 25?*

(a) 0.02 (b) 0.03 (c) 0.04 (d) 0.05

Solution:

Enter 25 on your calculator and press the "$^1/_x$*" key = 0.04*

Answer: *(c) 0.04*

1.8 Parentheses

In a math problem, parentheses are used to group steps of a mathematical function together. Whenever numbers are in parentheses, complete the mathematical function within the parentheses before proceeding with the remainder of the problem.

Note: A "sum" is the result of adding numbers and a "product" is the result of multiplying numbers.

▶ Parentheses Example 1

Question: *What's the sum of 3 and 15 added to the product of 4 and 2?*

(a) 6 *(b) 12* *(c) 16* *(d) 26*

Solution:

(3 + 15) + (4 × 2)
18 + 8 = 26

Answer: *(d) 26*

▶ Parentheses Example 2

Question: *What's the sum of 30 and 150 added to the product of 40 and 20?*

(a) 180 *(b) 800* *(c) 980* *(d) 1,260*

Solution:

(30 + 150) + (40 × 20)
180 + 800 = 980

Answer: *(c) 980*

Author's Comment:

- Many calculators have parenthesis buttons, but unless you're very careful it's easy to make a mistake while using them. It's better to just use the simple math functions of the calculator in this case and write down each of the steps to avoid calculator errors.

1.9 Squaring a Number

Some calculations require you to "square" a number, which means to multiply the number by itself. A number to be squared is shown as the number followed by a superscripted 2.

▶ Squaring a Number Example 1

$8^2 = 8 \times 8$
$8^2 = 64$

▶ Squaring a Number Example 2

$12^2 = 12 \times 12$
$12^2 = 144$

▶ Squaring a Number Example 3

Question: *Sixteen squared is equal to _____.*

(a) 64 *(b) 128* *(c) 256* *(d) 512*

Solution:

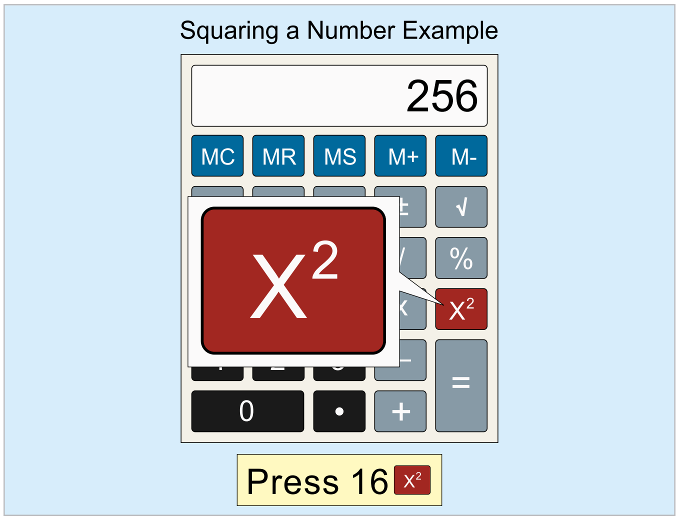
Step 1: $16^2 = 16 \times 16$

Step 2: $16^2 = 256$

Answer: *(c) 256*

Author's Comment:

- A much faster way to do this is with a calculator. Simply enter a number and then press the "x^2" key. Be sure to practice until you can confidently use your calculator to arrive at the correct answer. ▶Figure 1–11



▶Figure 1–11

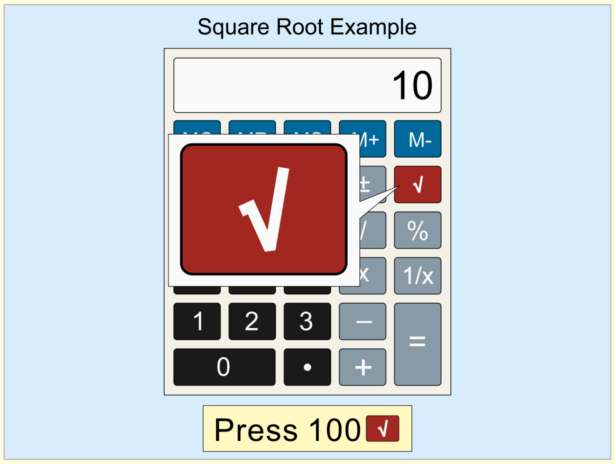
1.10 Square Root

Finding the square root ($\sqrt{n}$) of a number is the opposite of squaring a number. The square root of 36 is a number that, when multiplied by itself, gives the product 36. The square root of 36 ($\sqrt{36}$) is equal to six (6). This can be checked by multiplying six by itself (6^2) which equals 36.

Since it's difficult to calculate the square root of numbers manually, just use the square root key ($\sqrt{n}$) on your calculator.

▶ Square Root Example 1

To find the square root of 100 (√100): Following your calculator's instructions, enter the number 100, then press the square root key (√n). The answer should be 10. ▶Figure 1–12



▶Figure 1–12

▶ Square Root Example 2

To find the square root of 3 (√3): Enter the number 3 and then press the square root key (√n). The answer should be about 1.732.

Author's Comment:

- If your calculator or the calculator app on your cellphone doesn't have a square root key, don't worry about it. In this textbook, the only square root value you need to know is the √3, which is approximately 1.732.

To multiply, divide, add, or subtract a number by a square root value, determine the decimal value of the square root number, then perform the math function.

▶ Square Root Calculation Example

Question: *36,000W/(208V × √3) is equal to ______.* ▶Figure 1–13

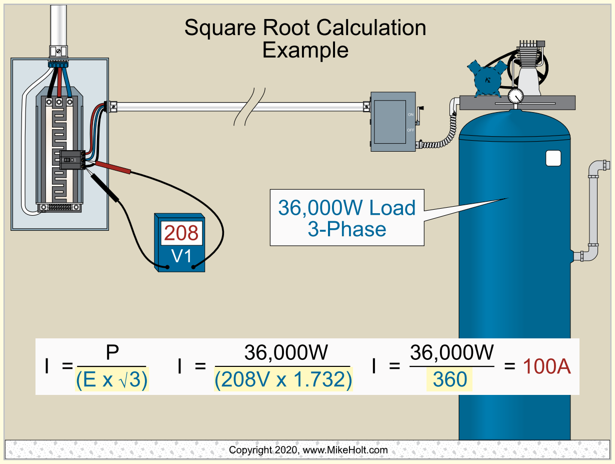
(a) 100A (b) 120A (c) 208A (d) 360A

Solution:

Step 1: *Determine the decimal value for the √3 = 1.732.*

Step 2: *Divide 36,000W by (208V × 1.732).*

36,000W/(208V × 1.732)
36,000W/360.256V = 100A



▶Figure 1–13

Answer: *(a) 100A*

1.11 Kilo

The letter "k" is the abbreviation for "kilo," which means "1,000." To convert a number that includes the "k" suffix to units, multiply the number preceding the "k" by 1,000. To convert a number to a "k" value, divide the number by 1,000 and add "k" after the number.

▶ Kilo Conversion Example 1

Question: *What's the value of 8k?*

(a) 8 (b) 800 (c) 4,000 (d) 8,000

Solution:

8 × 1,000 = 8,000

Answer: *(d) 8,000*

▶ Kilo Conversion Example 2

Question: *What's the k value of a 3,000W load?* ▶Figure 1–14

(a) 0.30 kW (b) 3 kW (c) 30 kW (d) 300 kW

Solution:

kW = 3,000W/1,000
kW = 3 kW

Answer: *(b) 3 kW*

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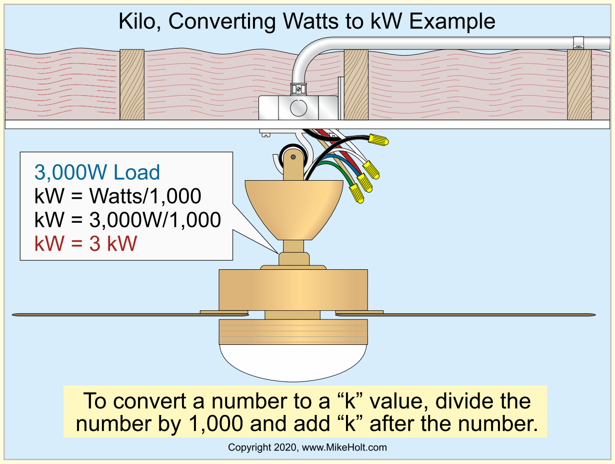


▸Figure 1–14

1.12 Rounding

There's no specific rule for how many decimal places to use in a problem but rounding to two or three decimal places should be enough. Whole numbers and integers below five are rounded down, while those five and greater are rounded up. Decimal numbers are rounded in the same manner; those below 0.50 (0.49) are rounded down, while decimal numbers 0.50 and above are rounded up.

▸ Rounding Examples

Round 0.1245 to three decimal numbers = 0.125 rounded up
Round 1.674 to two decimal numbers = 1.67 rounded down
Round 21.99 to a whole number = 22 rounded up
Round 367.20 to a whole number = 367 rounded down

Rounding Answers for Multiple-Choice Questions

When selecting an answer for a multiple-choice question you should round your answers in the same manner as the multiple-choice selections given.

▸ Rounding Answers for Multiple-Choice Questions Example 1

Question: *The sum of 12, 17, 28, and 40 is equal to ______.*

(a) 70 (b) 80 (c) 90 (d) 100

Solution:

12 + 17 + 28 + 40 = 97

The sum of these values is 97 which isn't listed as one of the choices. The multiple-choice selections in this case are rounded off to the nearest "tens," so the answer is 100.

Answer: *(d) 100*

▸ Rounding Answers for Multiple-Choice Questions Example 2

Question: *The product of 12, 17, 28, and 40 is equal to ______.*

(a) 200k (b) 210k (c) 220k (d) 230k

Solution:

12 × 17 × 28 × 40 = 228,480
228,480/1,000 = 228.480k

Answer: *(d) 230k*

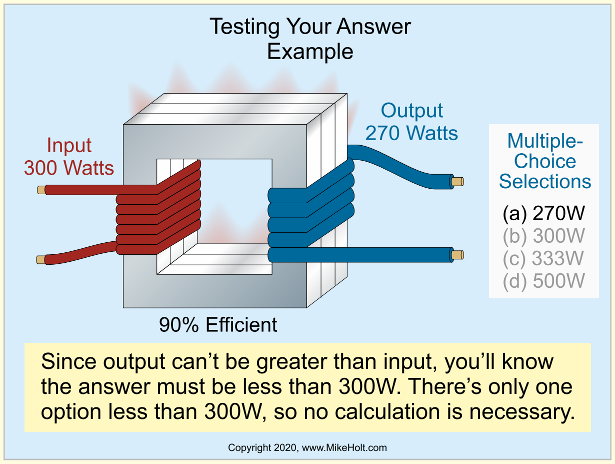
1.13 Testing Your Answer

Never assume a mathematical calculation you've done is correct. Always do a "reality check" to be sure your answer makes sense. Even the best of us make mistakes. Part of the problem might have been jotted down incorrectly, or the wrong key on the calculator might have been pressed. Always examine your answer to see if it makes sense.

▸ Example

Question: *What's 90% of 300W?* ▸Figure 1–15

(a) 270W (b) 300W (c) 333W (d) 500W



▸Figure 1–15

Solution:

Because 90 percent is less than 100%, the answer will be less than 300W. Since the answer must be less than 300W, you don't have to perform any mathematical calculation. The only multiple-choice selection that's less than 300W is (a) 270W.

The math to work out the answer is: 300W × 0.90 = 270W.

Answer: *(a) 270W*

Author's Comment:

- One of the nice things about mathematical equations is that you can usually test to see if your answer is correct. To do so, substitute your answer back into the equation with which you're working and verify that it indeed equals the correct answer. This method of checking your math will become easier once you know more formulas and how they relate to each other.

Part A—Summary

Whole numbers are positive numbers that don't contain fractions, decimals, or percentages such as 2, 5, 10, and 100. They're expressed as ¼, ½, and ¾ and can also be expressed as decimal numbers. A percentage of a number is that portion of a number as it relates to a whole number while the reciprocal of a number is obtained by inverting or flipping the number so it's a fraction. For example, the reciprocal of 5 (or $^5/_1$) is $^1/_5$.

In a math problem, parentheses are used to group steps of a mathematical function together. Whenever numbers are in parentheses, complete the mathematical function within the parentheses before proceeding with the remainder of the problem.

Some calculations require you to "square" a number, which means to multiply the number by itself. Finding the square root ($\sqrt{n}$) of a number is the opposite of squaring a number.

The letter "k" is the abbreviation for "kilo," which means "1,000."

Whole numbers and integers numbers below five are rounded down, while those five and greater are rounded up. Decimal numbers are rounded in the same manner; those below 0.50 (0.49) are rounded down, while decimal numbers 0.50 and above are rounded up. When selecting an answer for a multiple-choice question, round your answers in the same manner as the multiple-choice selections given. Never assume a mathematical calculation you've done is correct; always do a "reality check" to be sure your answer makes sense.

Part A—Conclusion

Now that you've completed this review, you should be more comfortable and confident in your ability to perform many of the math functions common in the electrical industry. You've worked through the different types of numbers, converted them from one form to another, completed basic math functions, performed rounding, and tested your answers.

Part B—Advanced Math

Introduction

Measurements come in all forms and are present everywhere in our lives. Distance, length, miles, inches, weight, square feet, and cubic inches are all forms of measurement you might use.

Performing math functions involving measurements is more than being able to read a tape measure or perform electrical calculations. From determining the amount of power required for general lighting and receptacle loads, to calculating the number of lumens per square foot for a desired lighting layout, you must be able to accurately work out calculations using various units of measurements.

1.14 Units of Measurement

Whenever you're doing any kind of calculations, it's extremely important to use the correct unit of measurement. Failure to do so will probably result in much higher (or lower) values than intended. Some of the more common units of measurements along with their equivalents and abbreviations or symbols are shown below.

Author's Comment:

- Although the Metric Conversion Act of 1975 was passed by the U.S. government making the metric system the preferred system of measurement for trade and commerce, the standard system of inches (in.), feet (ft), yards (yd.), and miles (mi.) are still used in the electrical trade.

Common Units, Equivalents, and Abbreviations or Symbols			
1 foot = 12 inches	1 meter = 39.37 inches	in. = inch(es)	oz. = ounce(s)
1 yard = 3 feet	1 foot = 30.48 centimeters	ft. = foot/feet	ft^2 = square feet
1 yard = 36 inches	1 yard = 0.914 meters	yd. = yard(s)	ft^3 = cubic feet
1 mile = 1,760 yards	1 mile = 1.609 kilometers	mm = millimeter(s)	x^2 = number squared
1 mile = 5,280 feet	1 kilometer = 0.621 miles	cm = centimeter(s)	x^3 = number cubed
1 mile = 63,360 inches	1 kilometer = 1,093.61 yards	km = kilometer	√= square root

▶ Units of Measurement Example 1

Question: *5,280 feet is equal to _____ mile(s).*

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

Solution:

5,280 ft/5,280 ft (number of feet in 1 mile) = 1

Answer: *(a) 1*

▶ Units of Measurement Example 2

Question: *5,280 yards is equal to _____ mile(s).*

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

Solution:

5,280 yards/1,760 (number of yards in 1 mile) = 3

Answer: *(c) 3*

1.15 Surface Area

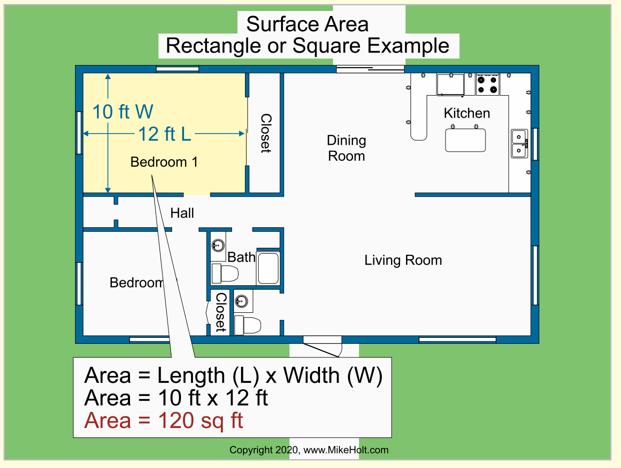
Another type of measurement used in the electrical trade is the calculation of the "surface area."

Rectangle or Square. The surface area for a rectangular or square shape is calculated using the formula: **Area = Length (L) × Width (W)**.

▶ Surface Area, Rectangle or Square Example 1

Question: *What's the surface area in square feet (sq ft) of a bedroom that's 10 ft wide and 12 ft long?* ▶**Figure 1–16**

(a) 10 sq ft (b) 50 sq ft (c) 80 sq ft (d) 120 sq ft



▶**Figure 1–16**

Solution:

Area = L × W

Area = 12 ft × 10 ft

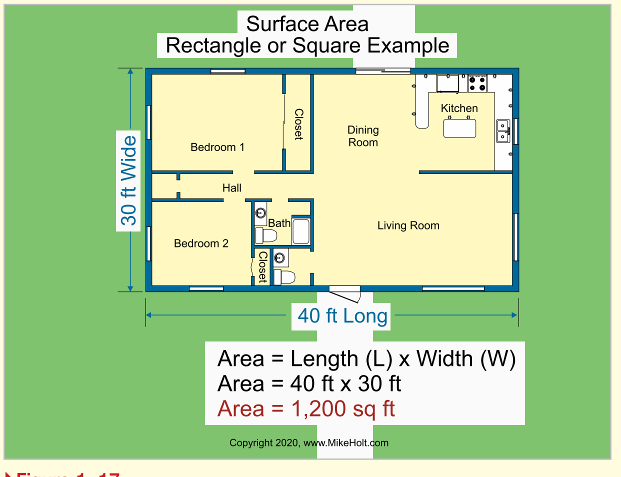
Area = 120 sq ft

Answer: *(d) 120 sq ft*

▶ Surface Area, Rectangle or Square Example 2

Question: *What's the surface area in sq ft of a house that's 30 ft wide and 40 ft long?* ▶**Figure 1–17**

(a) 1,000 sq ft (b) 1,200 sq ft (c) 1,800 sq ft (d) 2,000 sq ft



▶**Figure 1–17**

Solution:

Area = L × W

Area = 40 ft × 30 ft

Area = 1,200 sq ft

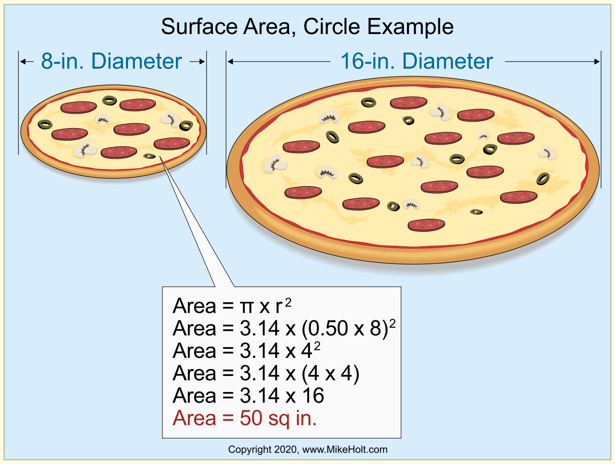
Answer: *(b) 1,200 sq ft*

Circle. The surface area of a circle is calculated using the formula: **Area = pi (π) × radius² (r^2)** where the pi symbol (π) represents the number 3.14, and the radius (r) of the circle is equal one half (0.50) the diameter of the circle.

▶ Surface Area, Circle Example 1

Question: *What's the surface area of an 8-in. pizza?* ▸Figure 1–18

(a) 25 sq in. (b) 50 sq in. (c) 64 sq in. (d) 75 sq in.



▸Figure 1–18

Solution:

Area = π × r^2

π is equal to 3.14. Radius (r) is equal to the diameter multiplied by 0.50.

Area = 3.14 × (8 in. × 0.50)²

Area = 3.14 ×4 in.²

Area = 3.14 × (4 in. × 4 in.)

Area = 3.14 × 16 sq in.

Area = 50 sq in.

Answer: *(b) 50 sq in.*

If you prefer to use a calculator, then follow these steps:

Step 1: *Find the radius (½ the diameter) of the circle by multiplying 8 in. by 0.50:*

8 in. × 0.50 = 4 in.

Step 2: *Press the square "x^2" key = 16 sq in.*

Step 3: *Multiply 16 sq in. (step 2) by 3.14.*

16 sq in. × 3.14 = 50.26 sq in.

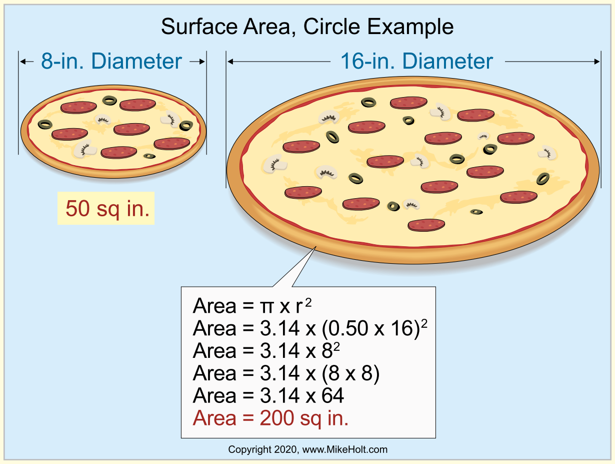
Step 4: *Round to match the answer choices: 50 sq in.*

Answer: *(b) 50 sq in.*

▶ Surface Area, Circle Example 2

Question: *What's the area of a 16-in. pizza?* ▸Figure 1–19

(a) 100 sq in. (b) 150 sq in. (c) 200 sq in. (d) 256 sq in.



▸Figure 1–19

Solution:

Area = π × r^2

π is equal to 3.14. Radius (r) is equal to the diameter multiplied by 0.50.

Area = 3.14 × (16 in. × 0.50)²

Area = 3.14 ×8 in.²

Area = 3.14 × (8 in. × 8 in.)

Area = 3.14 × 64 sq in.

Area = 200 sq in.

Answer: *(c) 200 sq in.*

When using your calculator, follow these steps:

Step 1: *Find the radius (1/2 the diameter) of the circle by multiplying 16 by 0.50.*

16 in. × 0.50 = 8 in.

Step 2: *Press the "x^2" key = 64 sq in.*

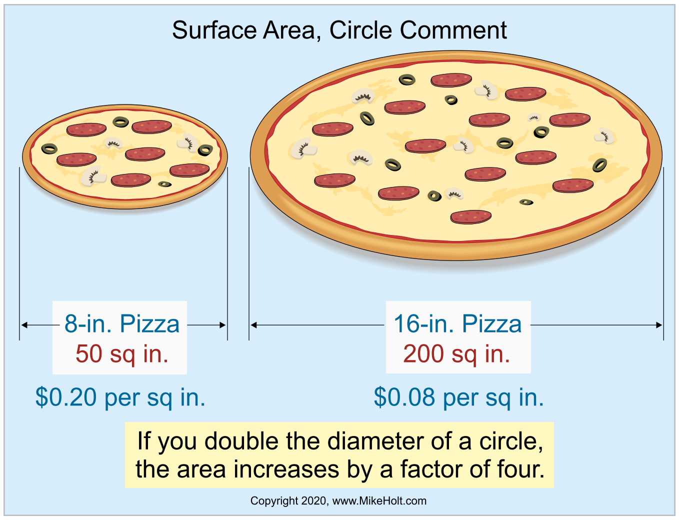
Step 3: *Multiply 64 sq in. (step 2) by 3.14.*

64 sq in. × 3.14 = 200.96 sq in.

Step 4: *Round to match the answer choices: 200 sq in.*

Author's Comment:

- As you can see, if you double the diameter of the circle (an 8-inch pizza versus a 16-inch pizza), the circle's area is increased by a factor of four! By the way, a large (or extra-large) pizza is always cheaper per square inch. than a small one! ▸Figure 1–20



▸Figure 1–20

▸ Surface Area, Circle Example 3

Question: *What's the area of a raceway that has an inside diameter of 1.049 in.?* ▸Figure 1–21

(a) 0.34 sq in. (b) 0.50 sq in. (c) 0.86 sq in. (d) 1 sq in.

Solution:

Area = π × r²

π is equal to 3.14

Radius (r) is equal to the diameter multiplied by 0.50.

Area = 3.14 × (1.049 in. × 0.50)²
Area = 3.14 × 0.5245 in.²
Area = 3.14 × (0.5245 in. × 0.5245 in.)
Area = 3.14 × 0.2751 sq in.
Area = 0.86 sq in.

Answer: *(c) 0.86 sq in.*

When using your calculator, follow these steps:

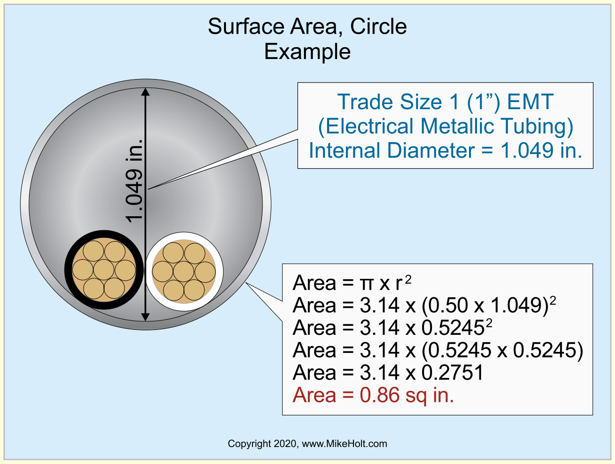
Step 1: *Find the radius by multiplying 0.50 by 1.049.*

1.049 in. × 0.50 = 0.5245 in.

Step 2: *Press the square "×²" key = 0.2751 sq in.*

Step 3: *Multiply 0.2751 sq in. by 3.14.*

0.2751 sq in. × 3.14 = 0.86 sq in.



▸Figure 1–21

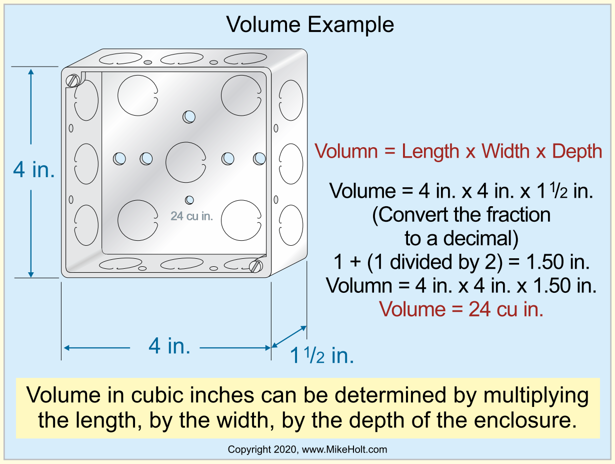
1.16 Volume

The volume of an enclosure is expressed in cubic inches (cu in. or in³), and is determined by multiplying the enclosure's length, by its width, then by its depth.

▸ Example

Question: *What's the volume of a 4 in. × 4 in. × 1½ in. box?* ▸Figure 1–22

(a) 12 cu in. (b) 20 cu in. (c) 24 cu in. (d) 30 cu in.



▸Figure 1–22

Solution:

Volume = Length (L) × Width (W) × Depth
Volume = 4 in. × 4 in. × 1½ in.

Convert the fraction to a decimal.
1 + (1 divided by 2) = 1.50

Volume = 4 in. × 4 in. × 1.50 in.
Volume = 24 cu in.

Answer: *(c) 24 cu in.*

Author's Comment:

- The minimum volume of a 4 in. × 4 in. × 1½ in. electrical box according to Table 314.16(A) in the *NEC* is 21 cu in., not 24 cu in. This is because the Table's volume is based on the interior dimensions of the 4 in. × 4 in. × 1½ in. box, not its outside dimensions.

1.17 Geometry and Trigonometry

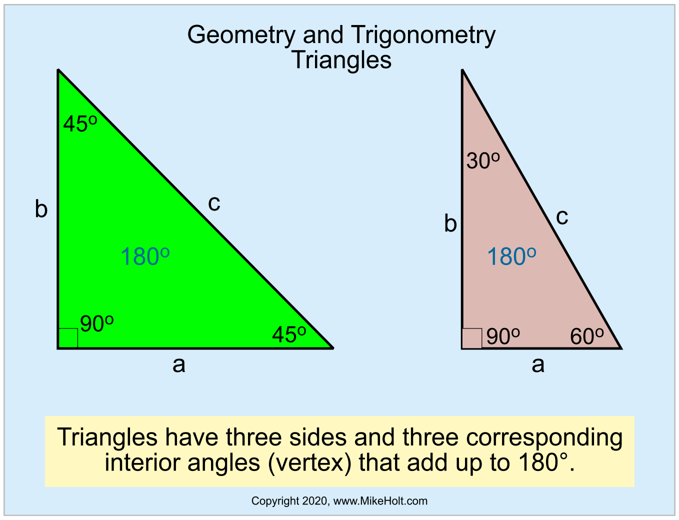
While this topic might sound intimidating, the information that's been covered up to this point has been basic math and algebra so you're ready for these next steps.

Angles are commonly used in a type of math called "geometry," while specific math functions related to the angles of triangles is called "trigonometry." For the purposes of this material, we'll only cover the basics of angles, and how they relate to basic electrical applications. However, the study of power engineering relies heavily on understanding and using advanced geometry and trigonometry.

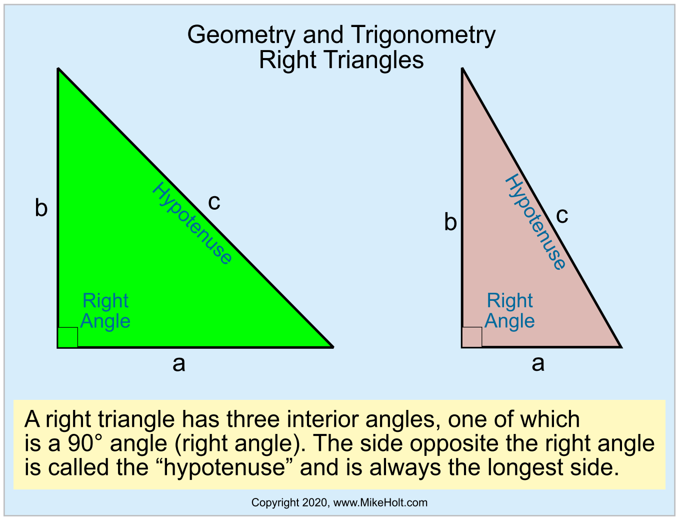
Triangles. Triangles are used in everything from bending raceways to calculating phase angles for sizing power factor correction capacitors. The basic things you need to remember when dealing with trigonometry, and specifically with math problems involving triangles, are that:

- Triangles have three sides and three corresponding angles.
- The sum of the interior angles of the triangle always add up to 180°.
- Each of the interior angles of the triangle have a common corner point (vertex). ▸Figure 1–23

Right Triangles. A right triangle is particularly useful for electrical calculations. One of the three inside angles is a 90° angle and is called a "right angle." The side opposite the right angle is called the "hypotenuse" and is always the longest side of the triangle. ▸Figure 1–24



▸Figure 1–23

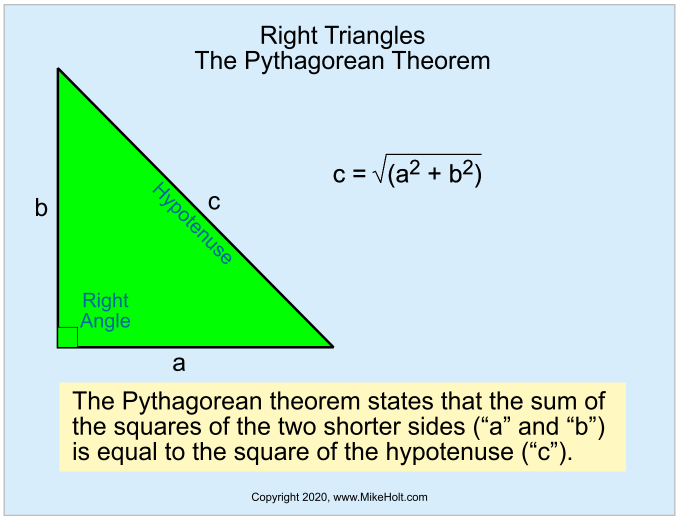


▸Figure 1–24

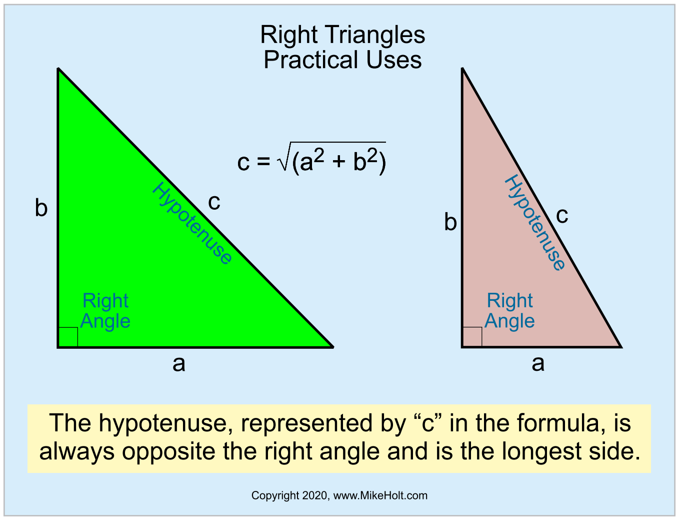
The mathematical relationship between the sides and angles of right triangles are described by the Pythagorean theorem. It states that the sum of the square of the two shorter sides ("a" and "b") is equal to the square of the hypotenuse ("c"). Another way to say this is that the hypotenuse is equal to the square root of one side squared, plus the other side squared. The formula is $c = \sqrt{(a^2 + b^2)}$. ▸Figure 1–25

There are many practical uses for this theorem. They range from calculating unknown distances and lengths, to calculating transformer voltages for a three-phase system.

To tackle a real-world problem involving a triangle, you must start by assigning each of its three sides to the problem. Once you do that, the rest is easy. Remember that the hypotenuse, represented by "c" in the formula, is always opposite the right angle and is always the longest side. ▸Figure 1–26



▸Figure 1–25



▸Figure 1–26

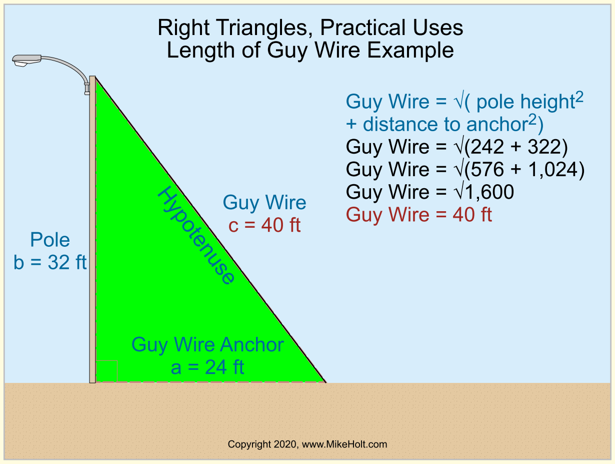
▸ Example

Question: *What length of cable is needed if a 32-ft tall pole needs a guy wire installed 24 ft away from the pole?* ▸Figure 1–27

Formula: $c = \sqrt{(a^2 + b^2)}$

a = Distance to Anchor
b = Height of Pole
c = Length of Guy Wire

(a) 10 ft *(b) 20 ft* *(c) 30 ft* *(d) 40 ft*



▸Figure 1–27

Solution:

$c = \sqrt{(a^2 + b^2)}$

a = Distance to Anchor = 24 ft
b = Pole Height = 32 ft
c = Length of Guy Wire

Guy Wire = $\sqrt{(24^2 + 32^2)}$
Guy Wire = $\sqrt{(576 + 1{,}024)}$
Guy Wire = $\sqrt{1{,}600}$
Guy Wire = 40 ft

Note: *To solve for the square root of a number, use the square root key on your calculator.*

Answer: *(d) 40 ft*

Other Trigonometry Uses. Trigonometry is also used to find the height of a light pole without ever leaving the ground. Imagine ordering a lift that's too short because your guess was wrong. Get it right the first time by learning how to use the tangent (tan) function and a speed square to calculate the exact height of poles and buildings.

A speed square (sometimes referred to as a "rafter square" or "triangle square") is a triangular carpenter tool. Since it's marked with angles, it can be used to measure angles on the job site, making it useful for trigonometry.

Speed Square Method of Measuring Height.

Step 1: Walk away from the pole until you can see the top without looking up.

Step 2: Hold a speed square at eye level in your line of sight with the bottom of the speed square level with the ground. Note the angle mark on the speed square that lines up with the top of the pole.

Step 3: Measure (in feet) the distance you're standing away from the pole.

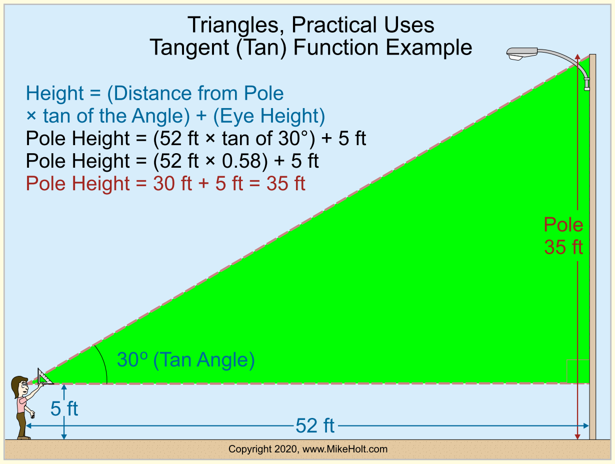
Step 4: Using your calculator, find the approximate height of the pole using the formula: **Height = (Distance from Pole × Tan of the Angle) + Eye Level**

Note: The "tan of the angle" is determined by entering the angle into the calculator and pressing the "tan" key.

▶ Calculator Example 1

Question: *What's the height of a light pole if the distance from the pole is 52 ft, the angle is 30°, and the eye level is 5 ft above the ground level?* ▶Figure 1–28

(a) 25 ft (b) 35 ft (c) 45 ft (d) 75 ft



▶Figure 1–28

Solution:

Height = (Distance from Pole × Tan of the Angle) + Eye Level

Distance = 52 ft
Angle = 30°

Tan of 30° is equal to 0.58 (from calculator)
Eye Level = 5 ft

Height of Light Pole = [(52 ft × (tan of 30°)] + 5 ft
Height of Light Pole = (52 ft × 0.58) + 5 ft
Height of Light Pole = 30 ft + 5 ft
Height of Light Pole = 35 ft

Answer: *(b) 35 ft*

▶ Calculator Example 2

Question: *What's the height of a building if you're standing 100 ft away from the building, the angle is 22°, and the eye level is 5 ft above the ground level?*

(a) 25 ft (b) 35 ft (c) 45 ft (d) 75 ft

Answer: *(b) 35 ft*

Solution:

Height = (Distance from Building × Tan of the Angle) + Eye Level

Distance = 100 ft
Angle = 22°
Tan of 22° is equal to 0.40 (from calculator)
Eye Level = 5 ft

Height of Building = [100 ft × (tan of 22°)] + 5 ft
Height of Building = (100 ft × 0.40) + 5 ft
Height of Building = 40 ft + 5 ft
Height of Building = 45 ft

Answer: *(c) 45 ft*

Part B—Summary

Whenever you're doing any kind of calculations, it's extremely important to use the correct unit of measurement. In the United States, the standard system of inches (in.), feet (ft), yards (yd.), and miles (mi.) are still used in the electrical trade.

The surface area for a rectangular or square shape is calculated using the formula: **Area = Length (L) × Width (W)**.

The surface area of a circle is calculated using the formula: **Area = pi (π) × radius^2 (r^2)** where the pi symbol (π) represents the number 3.14, and the radius (r) of the circle is equal one half (0.50) the diameter of the circle.

The volume of an enclosure is expressed in cubic inches (cu in. or in^3), and is determined by multiplying the enclosure's length, by its width, then by its depth. The formula is: **Volume = Length (L) x Width (W) x Depth**. In the *NEC*, volume is based on the interior dimensions of an electrical box in accordance with Table 314.16(A), not its outside dimensions.

Triangles have three sides and three corresponding angles. The sum of the interior angles always add up to 180°. Each of the interior angles of the triangle have a common corner point called a "vertex." The formula when using the Pythagorean theorem is **$c = \sqrt{(a^2 + b^2)}$**.

When measuring height with a speed square, use this formula: **Height = (Distance from Pole or Building x Tan of the Angle) + Eye Level**.

Part B—Conclusion

The material covered in this part may seem like a lot to remember, but fortunately there are calculators with built-in functions to perform most of these tasks quite efficiently. We discussed calculations such as area in square feet, volume in cubic feet, and the Pythagorean theorem. We also covered degrees of angles, and that trigonometry can play a role in the math we use on the job.

Part C—Electrical Circuits and Ohm's Law

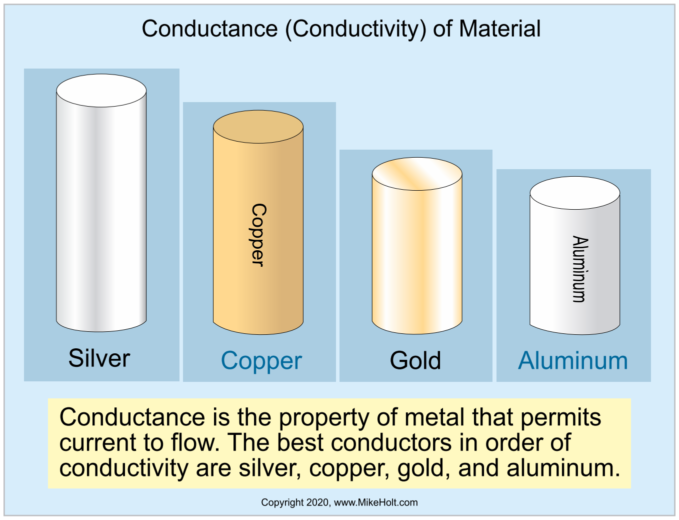
Introduction

Now that you've reviewed some math, you're ready to take your knowledge to the next level and improve your proficiency with electrical formulas. In this part, you'll learn how to apply Ohm's Law and the Ohm's Law Formula Circle to an electrical circuit calculation and solve for the missing value when two of the components are known.

1.18 Electrical Circuit

Electricity is the flow of electrons through a conductive path called an "electrical circuit." Electrical formulas describe what happens to electricity while it's flowing through different points in that circuit.

An electrical circuit consists of a power source, wires, and equipment that use the energy for a useful purpose. Electricity is the movement of electrons from the power source, through a conductive path, and back to the power source. ▸Figure 1–29



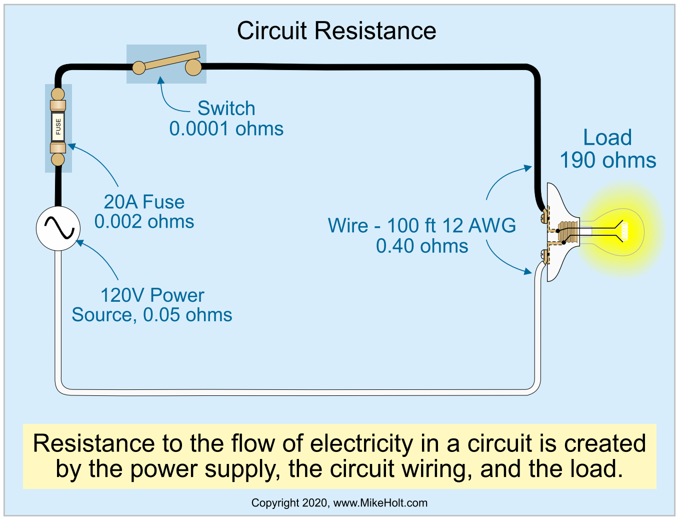
▸Figure 1–29

1.19 Electrical Power Source

An electrical power source supplies the energy needed to move valance electrons out of an atom's orbitals causing them to flow from the power source, through a circuit, and back again to the power source. The energy needed to move the valance electrons can be provided by mechanical devices, chemical activity, magnetic attraction or repulsion, photovoltaic (light) exposure, or even heat or pressure.

1.20 Circuit Resistance

Resistance to the flow of electricity in a circuit is created by the power supply, the circuit wiring, and the load. ▸Figure 1–30



▸Figure 1–30

Power Supply. The resistance of the power source (supply) is typically very small compared to that of the load, so it's generally ignored in circuit calculations.

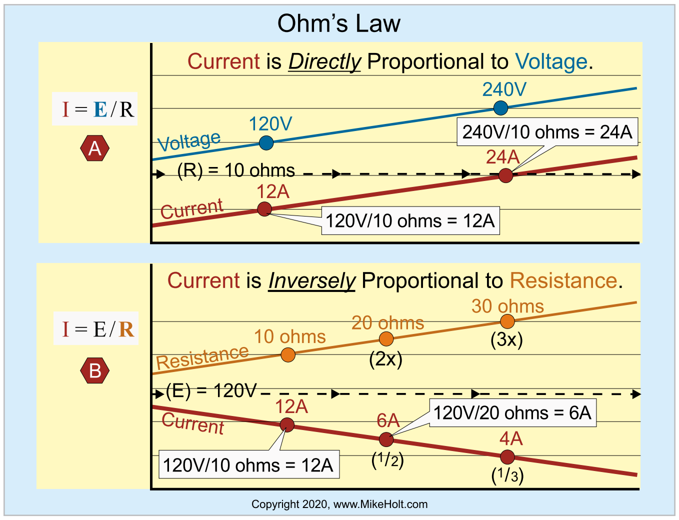
Circuit Wiring. The circuit conductor resistance can vary greatly and effects the performance of the equipment to which it's connected. The length of the conductors and the type of material from which they're made effect the resistance of each circuit.

Loads. The load is the equipment that's utilizing the power being delivered by the circuit conductors. The resistance can be very high for equipment like heaters and incandescent lamps, or very low for small electronic devices.

1.21 Ohm's Law

In 1827, German physicist Georg Simon Ohm published a book containing his theory of electricity. That theory has become known as "Ohm's Law." It expresses the relationship between the circuit's current intensity (I), the applied electromotive force (E), and the resistance (R).

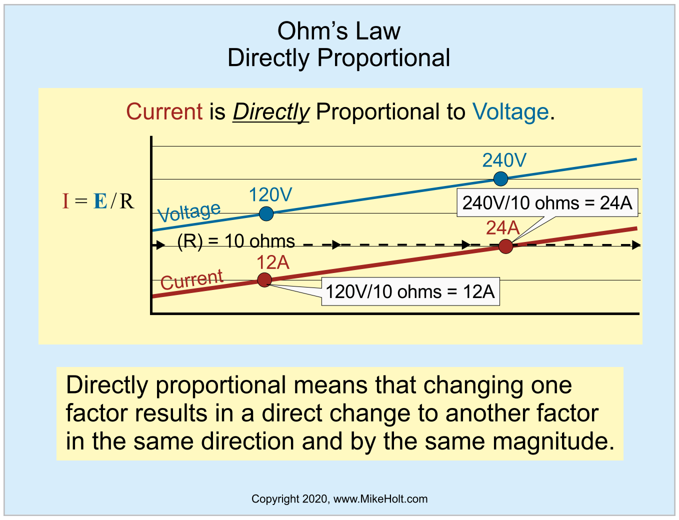
According to Ohm's Law, the intensity of the circuit (what we call current) is directly proportional to the voltage applied and inversely proportional to the resistance. ▸Figure 1–31



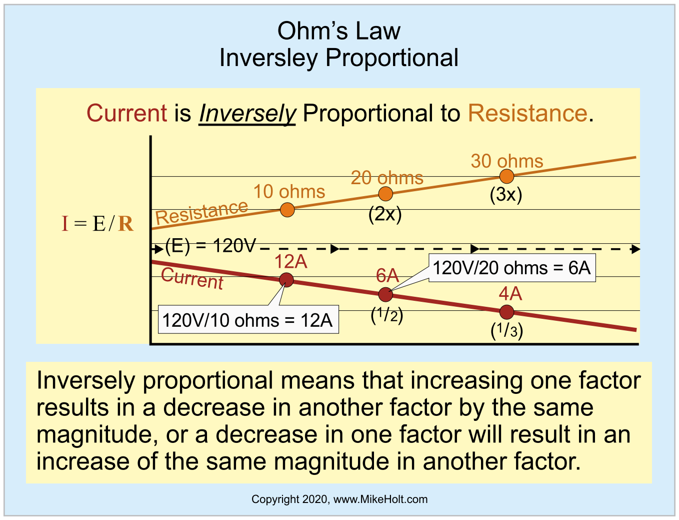
▸Figure 1–31

Current being directly proportional to the voltage means that if the applied voltage increases and the resistance remains the same, then the current will increase in direct proportion to the voltage change. If the applied voltage decreases and the resistance remains the same, then the current will decrease in direct proportion to the voltage change. ▸Figure 1–32

Current being inversely proportional to the resistance means that if the resistance increases and the applied voltage remains the same, then the current will decrease in direct proportion change in resistance. If the resistance decreases and the applied voltage remains the same, then the current will increase in direct proportion change in resistance. ▸Figure 1–33



▸Figure 1–32

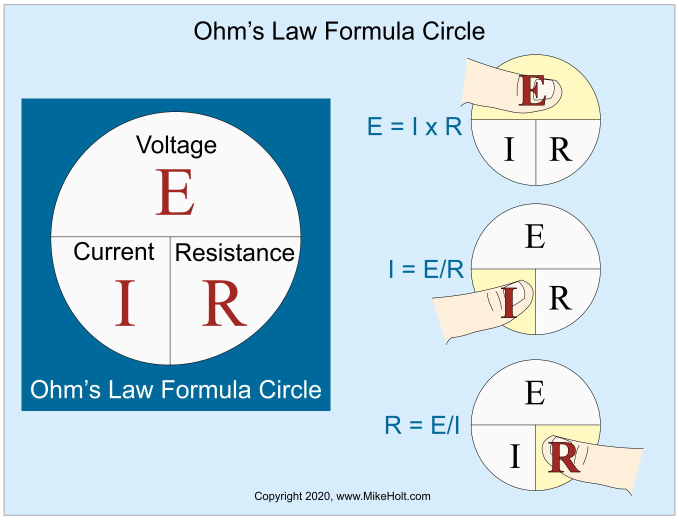


▸Figure 1–33

1.22 Ohm's Law Formula Circle

Ohm's Law, which identifies the relationship between current (I), voltage (E), and resistance (R), is expressed by these formulas: E = I × R, I = E/R, or R = E/I.

An easy way to determine which formula of the Ohm's Law Formula Circle to use, is to place your thumb or a finger on the unknown value. The two remaining variables will "show" you the formula you need to use. ▸Figure 1–34

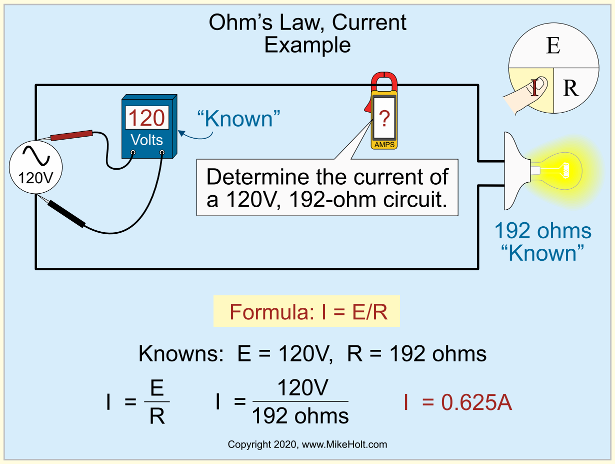


▸Figure 1–34

▶ Current Example

Question: *If 120V supplies a 192-ohm light bulb, what's the current flow in the circuit?* ▸**Figure 1–35**

(a) 0.50A (b) 0.60A (c) 1.30A (d) 2.50A



▸Figure 1–35

Solution:

Step 1: *What's the question? What is "I"?*

Step 2: *What do you know?*

Voltage (E) = 120V and Resistance (R) = 192 ohms.

Step 3: *The formula to use is **I = E/R**.*

Step 4: *The answer is I = 120V/192 ohms.*

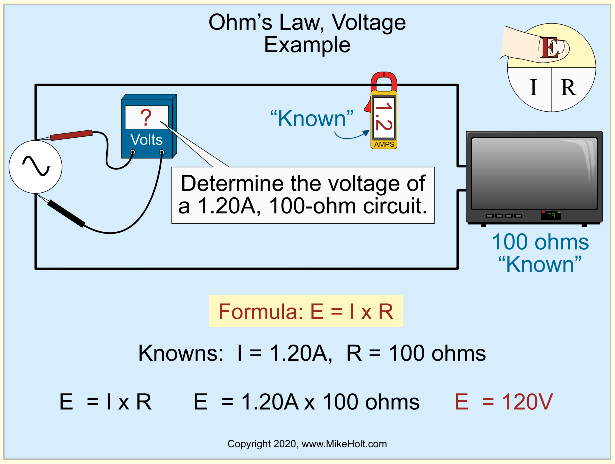
Step 5: *The answer is I = 0.625A.*

Answer: *(b) 0.60A*

▶ Voltage Example

Question: *What's the voltage of a circuit carrying 1.20A supplying a 100-ohm resistor?* ▸**Figure 1–36**

(a) 110V (b) 120V (c) 160V (d) 320V



▸Figure 1–36

Solution:

Step 1: *What's the question? What is "E"?*

Step 2: *What do you know?*

Current (I) = 1.20A and Resistance (R) = 100 ohms.

Step 3: *The formula to use is **E = I × R**.*

Step 4: *The answer is E = 1.20A × 100 ohms.*

Step 5: *The answer is E = 120V.*

Answer: *(b) 120V*

▶ Resistance Example

Question: *What's the resistance of two wires where each has a voltage drop of 1.50V (3V total) and the current flowing in the circuit is 100A?* ▸**Figure 1–37**

(a) 0.03 ohms (b) 2 ohms (c) 30 ohms (d) 300 ohms

Solution:

Step 1: *What's the question? What is "R"?*

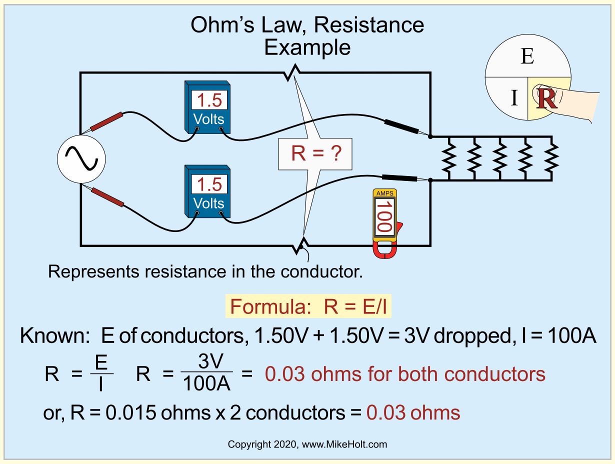
Step 2: *What do you know?*

Voltage (E) = 3V dropped and Current (I) = 100A

Step 3: *The formula to use is **R = E/I**.*

Step 4: *The answer is R = 3V/100A.*

Step 5: *The answer is R = 0.03 ohms.*



▸Figure 1–37

Answer: *(a) 0.03 ohms*

Part C—Summary

Electrical formulas use math to describe what happens to electricity while it's flowing through different points in the electrical circuit. According to Ohm's Law, the intensity of the circuit (what we call current) is directly proportional to the voltage applied and inversely proportional to the resistance.

Ohm's Law identifies the relationship between current (I), voltage (E), and resistance (R) and is expressed by the formulas **E = I × R**, **I = E/R**, or **R = E/I**. An easy way to determine which formula of the Ohm's Law Formula Circle to use, is to place your thumb or a finger on the unknown value. The two remaining variables will "show" you the formula you need to use.

Part C—Conclusion

You now understand that resistance to the flow of electricity in a circuit is created by the power supply, the circuit wiring, and the load. Thanks to Ohm's Law, we can use math to describe what happens to electricity while it's flowing through different parts of the electrical circuit and you learned that the intensity of the circuit (what we call current) varies with the voltage and resistance. Make sure to take time to complete the practice and review questions in the following section.

UNIT
1
REVIEW QUESTIONS

The following questions are based on the material you just reviewed. If you struggle with any of the answers, go back and review that question's section again.

UNIT 1—BASIC MATH, ADVANCED MATH, ELECTRICAL CIRCUITS, AND OHM'S LAW REVIEW QUESTIONS

PART A—BASIC MATH

1.3 Decimal Numbers

1. Fractions can be expressed as a decimal number and represent part of a whole number using the decimal system.

    (a) True
    (b) False

2. A fraction can be converted to a decimal with a calculator by dividing the numerator (top number of the fraction) by the denominator (bottom number of the fraction).

    (a) True
    (b) False

3. The decimal system places numbers to the right of a decimal point to indicate values that are a fraction of "one."

    (a) True
    (b) False

4. One-quarter expressed as a decimal is ______.

    (a) 25.0
    (b) 2.50
    (c) 0.25
    (d) 0.025

1.4 Percentages

5. To change a percentage value to a decimal, drop the percentage symbol, and move the decimal point two places to the right.

    (a) True
    (b) False

6. Three-quarters expressed as a percentage is ______ percent.

    (a) 34
    (b) 50
    (c) 75
    (d) 175

1.5 Multipliers

7. When a number must be multiplied by a percentage, convert the percentage to a decimal (multiplier) then multiply the original number by the multiplier (decimal value).

    (a) True
    (b) False

1.7 Reciprocals

8. The reciprocal of a number is obtained by ______.

    (a) showing the number as a fraction by placing it over 1
    (b) inverting the top and bottom numbers of the fraction
    (c) converting the fraction to a decimal by dividing the top number by the bottom number
    (d) all of these

1.8 Parentheses

9. In a math problem, ______ are used to group steps of a mathematical equation together.

    (a) brackets
    (b) commas
    (c) parentheses
    (d) italics

10. Whenever numbers are in parentheses, complete the mathematical function within the parentheses before proceeding with the remainder of the problem.

    (a) True
    (b) False

1.9 Squaring a Number

11. When calculations require you to "square" a number, it means to multiply the number by ______.

    (a) one
    (b) two
    (c) its reciprocal
    (d) itself

1.10 Square Root

12. The square root ($\sqrt{n}$) of a number is the number, when multiplied by itself, results in the original number.

    (a) True
    (b) False

13. The square root of 49 ($\sqrt{49}$) is equal to ______.

    (a) 6
    (b) 7
    (c) 9
    (d) 49

1.11 Kilo

14. The letter "k" is the abbreviation for "kilo" which means ______.

    (a) 10
    (b) 100
    (c) 1,000
    (d) 10,000

1.12 Rounding

15. When rounded to the nearest tenth, 0.1153 will be ______.

    (a) 0.115
    (b) 0.10
    (c) 0.12
    (d) 1.20

16. When rounded to the nearest one-hundredth, 0.1254 will be ______.

    (a) 0.126
    (b) 0.13
    (c) 1.254
    (d) 12.50

1.13 Testing Your Answer

17. When doing a mathematical calculation, you can always assume the answer is correct if a calculator was used.

    (a) True
    (b) False

PART B—ADVANCED MATH

1.14 Units of Measurement

18. Failure to use the correct units of measurement in a calculation can result in higher or lower values than intended.

    (a) True
    (b) False

1.16 Volume

19. The volume of an enclosure is expressed in ______.

    (a) r^2 (radius squared)
    (b) in^3 (cubic inches)
    (c) in^2 (square inches)
    (d) liters

1.17 Geometry and Trigonometry

20. Triangles are used in everything from bending raceways to calculating phase angles for sizing power factor correction capacitors.

    (a) True
    (b) False

21. When one of the three inside angles of a triangle is a 90° angle it's called a "right angle."

    (a) True
    (b) False

PART C—ELECTRICAL CIRCUITS AND OHM'S LAW

1.18 Electrical Circuit

22. Electricity is the movement of ______ from the power source, through a conductive path, and back to the power source.

    (a) protons
    (b) neutrons
    (c) electrons
    (d) atoms

1.19 Electrical Power Source

23. An electrical power source supplies the energy needed to move ______ out of an atom's orbitals causing them to flow from the power source, through a circuit, and back again to the power source.

    (a) valance electrons
    (b) protons
    (c) neutrons
    (d) particles

1.20 Circuit Resistance

24. Resistance to the flow of electricity in a circuit is created by the ______.

    (a) power supply
    (b) circuit wiring
    (c) load
    (d) all of these

1.21 Ohm's Law

25. Ohm's Law expresses the relationship between the circuit's current intensity (I), the applied electromotive force (E), and the resistance (R).

    (a) True
    (b) False

26. According to Ohm's Law, the intensity of the circuit (what we call current) is inversely proportional to the voltage applied and directly proportional to the resistance.

    (a) True
    (b) False

1.22 Ohm's Law Formula Circle

27. Ohm's Law, which identifies the relationship between current (I), voltage (E), and resistance (R), is expressed by these formulas: ($E = I \times R$), ($I = E/R$), or ($R = E/I$).

    (a) True
    (b) False

UNIT
1

CHALLENGE QUESTIONS

The following advanced-level questions are based on the material you just covered and are intended to challenge your ability to answer them correctly.

UNIT 1—BASIC MATH, ADVANCED MATH, AND ELECTRICAL CIRCUITS AND OHM'S LAW CHALLENGE QUESTIONS

PART A—BASIC MATH

1.5 Multiplier

1. What's the value of 30 multiplied by 150 percent?

(a) 15
(b) 30
(c) 45
(d) 450

2. What's the value of 20 multiplied by 80 percent?

(a) 2
(b) 10
(c) 16
(d) 160

3. What's 75 percent of 200?

(a) 75
(b) 100
(c) 125
(d) 150

1.6 Percentage Increase

4. What's the value of 160 increased by 75 percent?

(a) 120
(b) 280
(c) 335
(d) 28,000

5. What's the value of 6,400 increased by 25 percent?

(a) 1,600
(b) 8,000
(c) 9,200
(d) 11,000

1.7 Reciprocals

6. What's the decimal value of the reciprocal of 8?

(a) 0.125
(b) 0.135
(c) 0.145
(d) 0.155

7. What's the decimal value of the reciprocal of 80?

(a) 0.0125
(b) 0.0150
(c) 0.1005
(d) 0.2005

8. What's the decimal value of the reciprocal of 125?

(a) 0.002
(b) 0.003
(c) 0.004
(d) 0.008

1.8 Parentheses

9. What's the sum of 25 and 15 added to the product of 40 and 2?

(a) 42
(b) 82
(c) 120
(d) 180

10. What's the sum of 80 and 250 added to the product of 30 and 6?

    (a) 286
    (b) 330
    (c) 510
    (d) 836

1.9 Squaring a Number

11. One hundred squared is equal to ______.

    (a) 200
    (b) 1,000
    (c) 2,500
    (d) 10,000

1.10 Square Root

12. 50,000W/(480V × √3) is equal to ______.

    (a) 60A
    (b) 100A
    (c) 200A
    (d) 480A

1.11 Kilo

13. What's the value of 50k?

    (a) 50
    (b) 500
    (c) 10,000
    (d) 50,000

14. What's the k value of a 22,000W load?

    (a) 0.22 kW
    (b) 22 kW
    (c) 220 kW
    (d) 2,200 kW

1.12 Rounding

15. The sum of 37, 42, 53, and 65 is equal to ______.

    (a) 95
    (b) 105
    (c) 115
    (d) 200

16. The product of 9, 18, 30, and 34 is equal to ______.

    (a) 100k
    (b) 125k
    (c) 150k
    (d) 165k

PART B—ADVANCED MATH

1.14 Units of Measurement

17. One hundred forty-four inches is equal to _____ feet.

    (a) 8
    (b) 10
    (c) 12
    (d) 14

18. Twenty yards is equal to _____ meters.

    (a) 6.70
    (b) 10
    (c) 18.29
    (d) 60

1.15 Surface Area

19. What's the surface area in square feet (sq ft) of a bedroom that's 12 ft wide and 15 ft long?

    (a) 27 sq ft
    (b) 108 sq ft
    (c) 120 sq ft
    (d) 180 sq ft

20. What's the surface area in sq ft of a two-story house that's 28 ft wide and 42 ft long?

    (a) 1,176 sq ft
    (b) 2,200 sq ft
    (c) 2,352 sq ft
    (d) 2,500 sq ft

21. What's the area of a raceway that has an inside diameter of 2½ in.?

    (a) 4.91 sq in.
    (b) 7.85 sq in.
    (c) 15.70 sq in.
    (d) 19.63 sq in.

1.16 Volume

22. What's the volume of a 28 in. × 14½ in. × 3½ in. enclosure?

    (a) 1,200 cu in.
    (b) 1,421 cu in.
    (c) 1,524 cu in.
    (d) 1,830 cu in.

1.17 Geometry and Trigonometry

23. The length of the hypotenuse ("c") is ______ ft when "a" measures 3 ft and "b" measures 4 ft.

    (a) 3
    (b) 4
    (c) 5
    (d) 12

24. What length of cable is needed if a 30-ft tall pole needs a guy wire installed 22 ft away from the pole?

    (a) 10 ft
    (b) 20 ft
    (c) 30 ft
    (d) 38 ft

25. What's the height of a light pole if the distance from the pole is 48 ft, the angle is 30°, and the eye level is 6 ft above the ground level?

    (a) 25 ft
    (b) 34 ft
    (c) 45 ft
    (d) 75 ft

26. What's the height of a building if the distance from where you're standing is 100 ft from the building, the angle is 26°, and the eye level is 6 ft above the ground level?

    (a) 25 ft
    (b) 35 ft
    (c) 45 ft
    (d) 55 ft

PART C—ELECTRICAL CIRCUITS AND OHM'S LAW

1.22 Ohm's Law Formula Circle

27. If 240V supplies a resistive load of 112 ohms, what's the current flow in the circuit?

    (a) 2.14A
    (b) 10A
    (c) 12A
    (d) 20A

28. If 240V supplies a load of 12A, what's the resistance in the circuit?

    (a) 20 ohms
    (b) 228 ohms
    (c) 252 ohms
    (d) 2,880 ohms

29. What's the resistance of two wires where each has a voltage drop of 3.60V (7.20V total) and the current flowing in the circuit is 36A?

    (a) 0.10 ohms
    (b) 0.20 ohms
    (c) 0.50 ohms
    (d) 0.72 ohms