FID Day 3

The Pennsylvania State University
Workforce Education and Development

Lesson Plan Template

Name of Instructor: Barry Sunderland
Program Title: Electrical and Power Transmission Installers
Course Title: Electrical Occupations
Unit Title: Electrical Theory
Lesson Title: Ohm's Law
Lesson Performance Objective: Given a presentation of Ohms law, the student will complete a worksheet of Ohms law calculations with 80% accuracy.
Time (length of lesson): 25 Mintes
Equipment and Materials needed: Student Worksheets Textbooks Ohms Law Handout Calculators (if needed)
Technical Standard(s): NOCTI Testing Equipment NOCTI Construction Math
Academic Standard(s): CC.2.1.HS.F.2 - Apply properties of rational and irrational numbers to solve real-world or mathematical problems.

Introduction

At your home school, how many of you have complained about your classes that you were "never going to need this" ? How is math class going to relate to my hands-on skills? Electricity is a principle that can be proven several ways. Ohms law is a standard way of designing and troubleshooting circuits with basic multiplication and division.

Body:

- Introduce Ohms Law
- Distribute handouts of Ohms law wheel
- Give several examples of how Volts, Amps, and Watts relate to each other
- Explain why this principle is vital is troubleshooting problems
- Most "bad" equipment can be found using Ohms law preventing breakdowns or emergencies

Summary:

How do we relate your home school studies to what we do here at the CTC school? Why is Ohms law important to service work and troubleshooting? Give several problems to class on the board for them to solve together as a class.

Student Assessment:

A worksheet will be given to each student. The student should be able to complete the worksheet by the end of class or before they enter the shop area. Students will complete the assignment again until at least an 80% score has been reached.

Universal Design for Learning (UDL)

students may take worksheets to resource room or Zoom; student may have calculator if needed; extended time; use a handout with several more examples of the equations

EXAMPLE 1

An elevator must lift a load of 4000 lb to a height of 50 ft in 20 s. How much horsepower is required to operate the elevator?

Solution

Find the amount of work that must be performed, and then convert that to horsepower.

$$4000 \text{ lb} \times 50 \text{ ft} = 200{,}000 \text{ ft-lb}$$

$$\frac{200{,}000 \text{ ft-lb}}{20 \text{ s}} = 10{,}000 \text{ fb-lb/s}$$

$$\frac{10{,}000 \text{ ft-lb./s}}{550 \text{ ft-lb./s}} = 18.18 \text{ hp}$$

EXAMPLE 2

A water heater contains 40 gallons of water. Water weighs 8.34 lb per gallon. The present temperature of the water is 68°F. The water must be raised to a temperature of 160°F in 1 hour. How much power will be required to raise the water to the desired temperature?

Solution

First determine the weight of the water in the tank, because a BTU is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

$$40 \text{ gal} \times 8.34 \text{ lb per gal} = 333.6 \text{ lb}$$

The second step is to determine how many degrees of temperature the water must be raised. This amount will be the difference between the present temperature and the desired temperature.

$$160°\text{F} - 68°\text{F} = 92°\text{F}$$

The amount of heat required in BTUs will be the product of the pounds of water and the desired increase in temperature.

$$333.6 \text{ lb} \times 92° = 30{,}691.2 \text{ BTU}$$

$$1 \text{ W} = 3.412 \text{ BTU/hr}$$

Therefore

$$\frac{30{,}691 \text{ BTU}}{3.412 \text{ BTU/hr}} = 8995.1 \text{ W/hr}$$

OHM'S LAW

In its simplest form, **Ohm's law** states that **it takes one volt to push one amp through one ohm.** Ohm discovered that all electrical quantities are proportional to each other and can therefore be expressed as mathematical formulas. He found if the resistance of a circuit remained constant and the voltage increased, there was a corresponding proportional increase of current. Similarly, if the resistance remained constant and the voltage decreased, there would be a proportional decrease of current. He also found that if the voltage remained constant and the resistance increased, there would be a decrease of current, and if the voltage remained constant and the resistance decreased, there would be an increase of current. This finding led Ohm to the conclusion that **in a DC circuit, the current is directly proportional to the voltage and inversely proportional to the resistance.**

Since Ohm's law is a statement of proportion, it can be expressed as an algebraic formula when standard values such as the volt, amp, and ohm are used. The three basic Ohm's law formulas are shown.

$$E = I \times R$$

$$I = \frac{E}{R}$$

$$R = \frac{E}{I}$$

where

E = EMF, or voltage
I = intensity of current, or amperage
R = resistance

The first formula states that the voltage can be found if the current and resistance are known. Voltage is equal to amps multiplied by ohms. For example, assume a circuit has a resistance of 50 Ω and a current flow through it of 2 A. The voltage connected to this circuit is 100 V.

$$E = I \times R$$
$$E = 2 \times 50$$
$$E = 100$$

The second formula states that the current can be found if the voltage and resistance are known. In the example shown, 120 V are connected to a resistance of 30 Ω. The amount of current flow will be 4 A.

$$I = \frac{E}{R}$$
$$I = \frac{120}{30}$$
$$I = 4$$

The third formula states that if the voltage and current are known, the resistance can be found. Assume a circuit has a voltage of 240 V and a current flow of 10 A. The resistance in the circuit is 24 Ω.

$$R = \frac{E}{I}$$
$$R = \frac{240}{10}$$
$$R = 24$$

Figure 3-18 shows a simple chart that can be a great help in remembering an Ohm's law formula. To use the chart, cover the quantity that is to be found. For example, if the voltage, E, is to be found, cover the E on the chart. The chart now shows the remaining letters IR (**Fig. 3-19**), thus E = I × R. The same method reveals the formulas for current (I) and resistance (R).

A larger chart that shows the formulas needed to find watts as well as voltage, amperage, and resistance is shown in **Figure 3-20**. The letter *P* (power) is used to represent the value of watts. Notice that this chart is divided into four sections and that each section contains three different formulas. To use this chart, select the section containing the quantity to be found and then choose the proper formula from the given quantities.

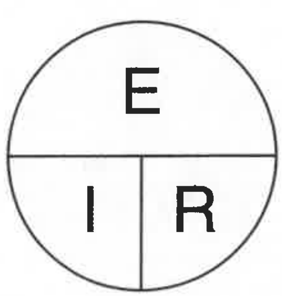


FIGURE 3-18 Chart for finding values of voltage, current, and resistance.

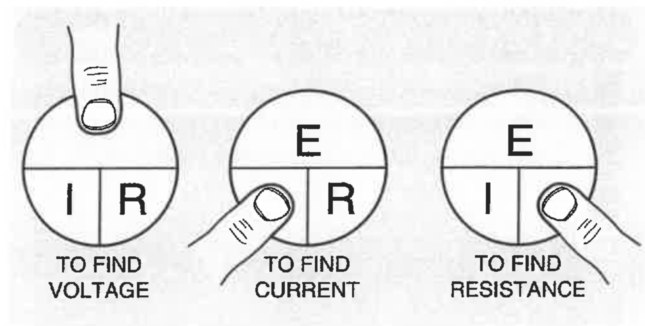


FIGURE 3-19 Using the Ohm's law chart.

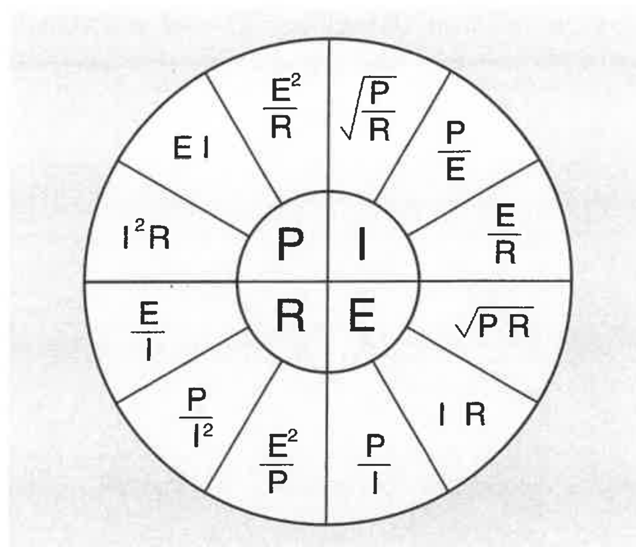


FIGURE 3-20 Formula chart for finding values of voltage, current, resistance, and power.

Metric Units

Metric units of measure are used in the electrical field just as they are in most scientific fields. A special type of metric notation, known as engineering notation, is used in electrical measurements. Engineering notation is the same as any other metric

EXAMPLE 3

An electric iron is connected to 120 V and has a current draw of 8 A. How much power is used by the iron?

Solution

The quantity to be found is watts, or power. The known quantities are voltage and amperage. The proper formula to use is shown in **Figure 3-21**.

$$P = EI$$
$$P = 120 \times 8$$
$$P = 960\ W$$

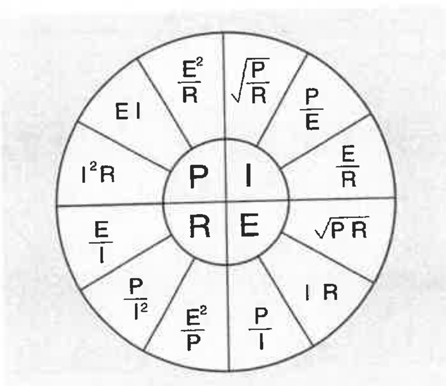


FIGURE 3-21 Finding power when voltage and current are known.

EXAMPLE 4

An electric hair dryer has a power rating of 1000 W. How much current will it draw when connected to 120 V?

Solution

The quantity to be found is amperage, or current. The known quantities are power and voltage. To solve this problem, choose the formula shown in **Figure 3-22**.

$$I = \frac{P}{E}$$
$$I = \frac{1000}{120}$$
$$I = 8.33\ A$$

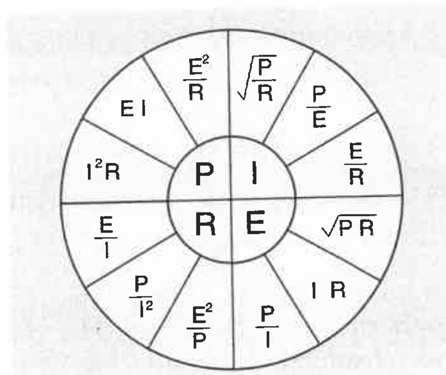


FIGURE 3-22 Finding current when power and voltage are known.

measure except that it is in steps of one thousand instead of ten. The chart in **Figure 3-24** shows standard metric units. The first step above the base unit is deka, which means 10. The second unit is hecto, which means 100, and the third unit is kilo, which means 1000. The first unit below the base unit is deci, which means 1/10; the second unit is centi, which means 1/100; and the third is milli, which means 1/1000.

The chart in **Figure 3-25** shows engineering units. The first unit above the base unit is kilo, or 1000; the second unit is mega, or 1,000,000; and the third unit is giga, or 1,000,000,000. Notice that each unit is 1000 times greater than the previous unit. The chart also shows that the first unit below the base unit is milli, or 1/1000; the second is micro, represented by the Greek mu (μ), or 1/1,000,000; and the third is nano, or 1/1,000,000,000.

Metric units are used in almost all scientific measurements for ease of notation. It is much simpler to write a value such as 10 MΩ than it is to write 10,000,000 ohms, or to write 0.5 ns than to write 0.000,000,000,5 second. Once the metric system has been learned, measurements such as 47 kilohms (kΩ) or 50 milliamps (mA) become commonplace to the technician.

EXAMPLE 5

An electric hotplate has a power rating of 1440 W and a current draw of 12 A. What is the resistance of the hotplate?

Solution

The quantity to be found is resistance, and the known quantities are power and current. Use the formula shown in **Figure 3-23**.

$$R = \frac{P}{I^2}$$

$$R = \frac{1440}{12 \times 12}$$

$$R = \frac{1440}{144}$$

$$R = 10\ \Omega$$

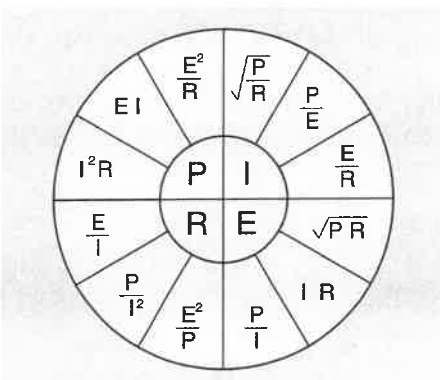


FIGURE 3-23 Finding resistance when power and current are known.

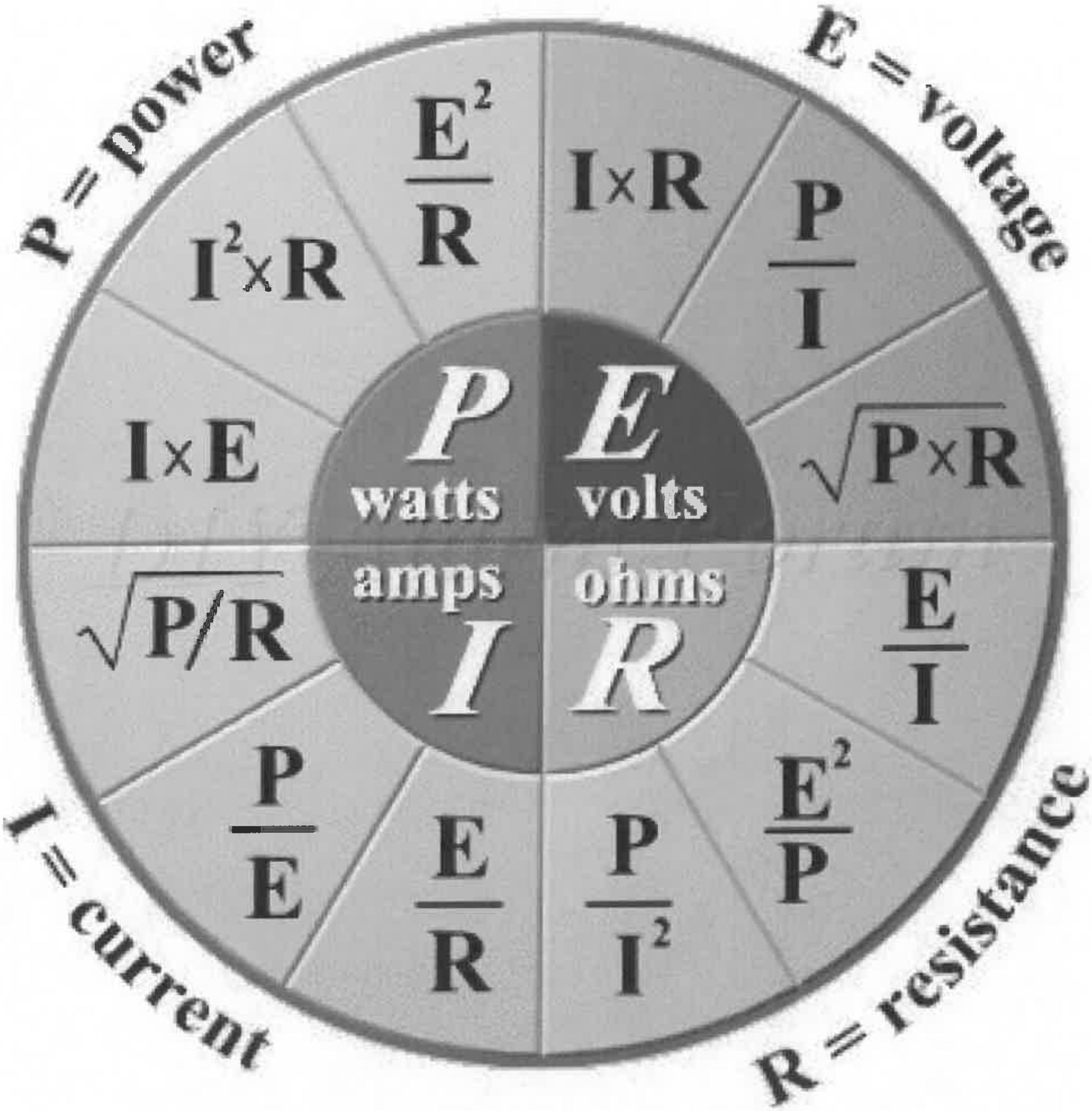
KILO	1000
HECTO	100
DEKA	10
BASE UNIT	1
DECI	1/10 OR 0.1
CENTI	1/100 OR 0.01
MILLI	1/1000 OR 0.001

FIGURE 3-24 Standard units of metric measure.

ENGINEERING UNIT	SYMBOL	MULTIPLY BY	
TERA	T	1,000,000,000,000	X 10^{12}
GIGA	G	1,000,000,000	X 10^{9}
MEGA	M	1,000,000	X 10^{6}
KILO	k	1,000	X 10^{3}
BASE UNIT		1	
MILLI	m	0.001	X 10^{-3}
MICRO	μ	0.000,001	X 10^{-6}
NANO	n	0.000,000,001	X 10^{-9}
PICO	p	0.000,000,000,001	X 10^{-12}

FIGURE 3-25 Standard units of engineering notation.

OHM'S LAW WHEEL



NAME: ______________________________

Using the formulas of Ohm's law, fill in the missing values of the table below.

Volts (E)	Amps (I)	Ohms (R)	Watts (P)
153	0.056		
	.65	470 Ω	
24			124
	0.00975		0.035
		6.8 kΩ	0.86
460		72Ω	
48	1.2		
	154	0.8 Ω	
277			760
	0.0043		0.0625
		130 kΩ	0.0225
96		2.2 kΩ	