

# Electricity and Ohm's Law Lesson Plan

## Concept/principle to be demonstrated:

This lesson plan shows students how to manipulate a formula to solve algebraic equations, using Ohm's Law. Knowing how to manipulate a formula by isolating the unknown is as easy as covering the symbol and reading the remaining formula. Students will be able to demonstrate understanding by applying the formula  $E=IxR$  to solve problems using a calculator.

## Lesson objectives/Evidence of Learning:

- Comprehends concept of Ohm's Law
- Knows what it means to have a solution to an equation
- Uses properties of equality to solve an equation through a series of equivalent equations
- Solves equations for a particular variable
- Applies formula to solve variety of construction problems
- Uses calculator to compute accurately

## How this math connects to construction jobs:

Ohm's Law shows the relationship between ohms, watts, volts and amps. Manipulating the formulas to solve for an unknown when any two are given illustrates this relationship. This lesson will help students comprehend how Ohm's Law is used daily by electricians.

- Electricians use the formulas to install the correct gauge of wire to carry the load.
- Millwrights use the formulas when installing machinery and equipment.
- All construction workers must verify that their extension cords are adequate for the power tools being used.

## Teacher used training aids:

- 9 volt battery
- 18" lengths of insulated wire with clips
- 10 ohm 1/4 watt resistor
- 220 ohm 1/2 watt resistor

## Additional online aids:

- <http://jersey.uoregon.edu/vlab/Voltage/>
- <http://micro.magnet.fsu.edu/electromag/java/ohmslaw/>

## Materials needed per student:

- Pencil
- Calculator with  $\sqrt{\quad}$  key & memory +/- functions
- **Electricity and Ohm's Law Worksheets**
- **Electricity and Ohm's Law Example Problem** handout
- **Formulas, Equations, and Laws** handout and two **Ohm's Law** handouts

## Terms:

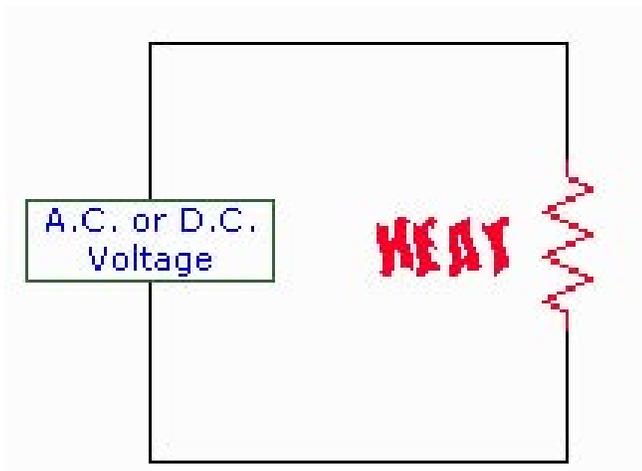
- **( I ) Current** is what flows on a wire or conductor like water flowing down a river. Current flows from points of high voltage to points of low voltage on the surface of a conductor. Current is measured in (A) amperes or amps.
- **( E ) Voltage** is the difference in electrical potential between two points in a circuit. It's the push or pressure behind current flow through a circuit, and is measured in (E) volts.
- **( R ) Resistance** determines how much current will flow through a component. Resistors are used to control voltage and current levels. A very high resistance allows a small amount of current to flow. A very low resistance allows a large amount of current to flow. Resistance is measured in ohms.
- **( P ) Power** is the amount of current times the voltage level at a given point measured in wattage or watts.

## Lesson Introduction:

Ohms law, sometimes more correctly called Ohm's Law, named after Mr. Georg Ohm, mathematician and physicist born 1789 and died 1854 in Bavaria, defines the relationship between power, voltage, current and resistance. These basic electrical units apply to direct current, or alternating current. Ohm's Law is the foundation of electronics and electricity. These formulae are **very easy to learn** and are used extensively by electricians. Without a thorough understanding of "Ohm's Law" an electrician would either design or troubleshoot even the simplest of electronic or electrical circuits. Ohm established in the late 1820's that if a voltage was applied to a resistance then "current would flow and then **power** would be consumed".

## Lesson Components:

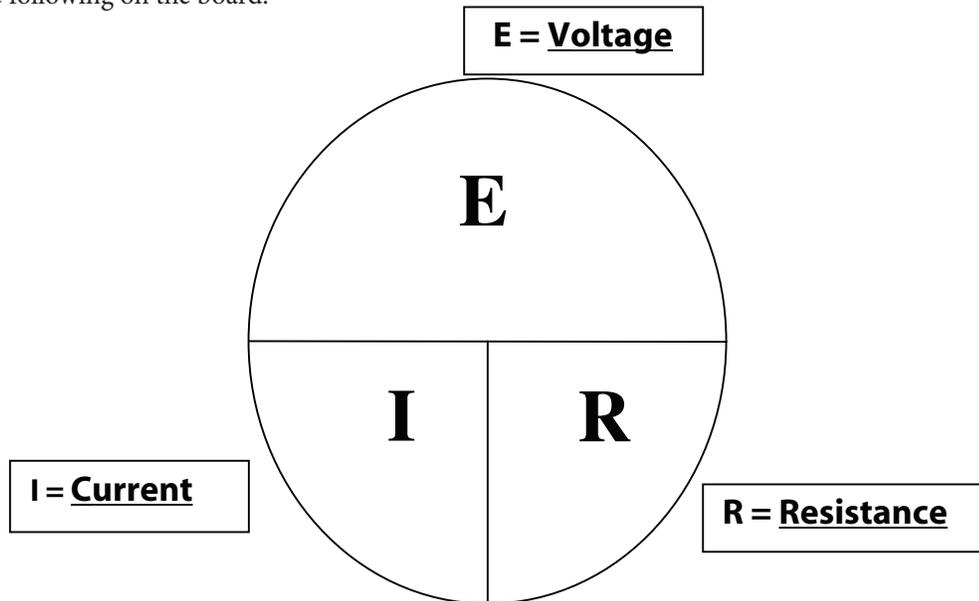
1. Draw on white board and explain:



## Ohm's Law power consumption through a resistance

Some practical every day examples of this basic rule are: base board heaters, electric frying pans, toasters and electric light bulbs. The heater consumes power producing heat for warmth, the frying pan consumes power producing heat for general cooking, the toaster consumes power producing heat for cooking toast, and the electric light bulb consumes power producing heat and more important light. A further example is an electric hot water system. All are examples of Ohm's Law at its most basic.

2. Current is directly proportional to voltage. If voltage is increased by a given percentage, current increase by the same percentage. If the voltage is decreased by a given percentage, current decreases by the same percentage.
3. Current is inversely proportional to resistance. An increase in resistance results in a decrease in current. A decrease in resistance results in an increase in current. It is important to note that resistance cannot be changed by changing voltage or current. Resistance in a circuit is a physical constant. Resistance in a circuit can only be changed by changing components or resistors rated at more or fewer ohms.
4. Draw the following on the board:



**Show students how easy the formula is to use by covering the desired value and solving the equation**

5. For the following examples, voltage is E with an assigned a value of 12V, Current is I and is 2 amperes while resistance is R of 6 ohms. Note that “x” means multiply by, while “/” means divide by.
  - a. For voltage [E = I x R] (COVER “E” WITH HAND)
    1. E (volts) = I (current) x R (resistance) OR
    2. 12 volts = 2 amperes x 6 ohms
  - b. For current [I = E / R] (COVER “I” WITH HAND)
    1. I (current) = E (volts) / R (resistance) OR
    2. 2 amperes = 12 volts / 6 ohms
  - c. For resistance [R = E / I] (COVER “R” WITH HAND)
    1. R (resistance) = E (volts) / I (current) OR
    2. 6 ohms = 12 volts / 2 amperes

Another way to look at the relationships between (P) power, (E) voltage, (I) current, and (R) resistance is: One ohm is the resistance value through which one volt will maintain a current of one ampere.

$$E = I \times R$$

Voltage = current x resistance

Volts = amps x ohms

$$V = A \times$$

Ohm's Law with letter symbols

Ohm's Law formula with electrical quantities

Ohm's Law formula with units of measure

Ohm's Law formula with unit symbols

6. **Demonstration** for determining amps (current):

- a. Show a 9 volt battery, a 10 ohm resistor and two wires with clips.
- b. Ask the students what the current (amps) will be.
- c. Correct answer is: 9 volts (E) / 10 ohms = 0.9 amps
- d. Ask the students if the circuit will work.
- e. Connect the circuit.
- f. Wait a minute for the resistor to smoke and smell.
- g. Disconnect and ask what happened.
- h. Show students the package (1/4 watt)
- i. Watts (P) are power.
- j. Reconnect circuit using 220 ohm resistor. Wait and watch.

**For power:**

$$P = E^2 / R \quad \text{OR} \quad \text{Power} = 24 \text{ watts} = 122 \text{ volts} / 6 \text{ ohms}$$

$$\text{Also} \quad P = I^2 \times R \quad \text{OR} \quad \text{Power} = 24 \text{ watts} = 22 \text{ amperes} \times 6 \text{ ohms}$$

$$\text{Also} \quad P = E \times I \quad \text{OR} \quad \text{Power} = 24 \text{ watts} = 12 \text{ volts} \times 2 \text{ amperes}$$

That's all you need for Ohm's Law - remember just two formulas:

- For voltage:  $E = I \times R$
- For power:  $P = E^2 / R$

7. Why does this work?

8. Review relationship of the formula for voltage, resistance and current

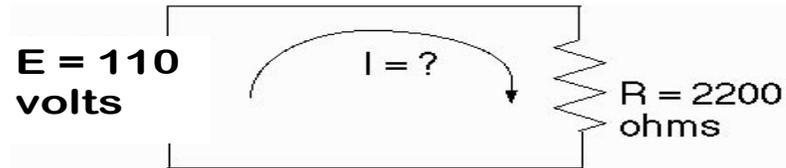
- a.  $E=I \times R$
- b.  $R=E/I$
- c.  $I= E/R$

9. Hand out calculators, worksheet and examples pages, having students complete worksheet in teams.

# Electricity and Ohm's Law Worksheets

## Problem #1

A 110 volt wall outlet supplies power to a strobe light with a resistance of 2200 ohms. How much current is flowing through the strobe light?



Choose your answer below

1. 0.5 amps
2. 2.0 amps
3. 0.05 amps
4. 1.0 amps

## Problem #2

A CD player with a resistance of 40 ohms has a current of 0.1 amps flowing through it. Sketch the circuit diagram and calculate how many volts supply the CD player.

Choose your answer below

1. 0.0025 volts
2. 4.0 volts
3. 10.0 volts
4. 400.0 volts

## Problem #3

A 120-volt power source supplies a lamp with a resistance of 192 ohms. What is the current flow of the circuit?



**Problem #4**

What is the resistance of the circuit conductors when the conductor voltage drop is 3 volts and the current flowing through the conductors is 100 amperes?

**Problem #5**

Given:  $I = 15\text{A}$ ,  $R = 2$ , find  $E$

**Problem #6**

Given:  $E = 250\text{V}$ ,  $R = 5$ , find  $I$

**Problem #7**

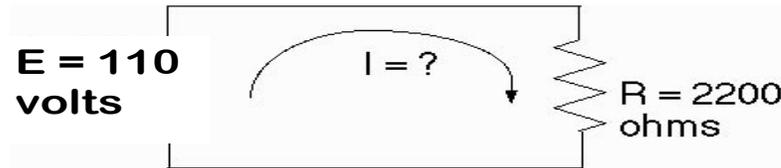
Given:  $E = 100\text{V}$ ,  $I = 0.01\text{A}$ , find  $R$



## Electricity and Ohm's Law Worksheets

### Problem #1

A 110 volt wall outlet supplies power to a strobe light with a resistance of 2200 ohms. How much current is flowing through the strobe light?



$$E = I \times R \quad 110 = I \times 2200$$

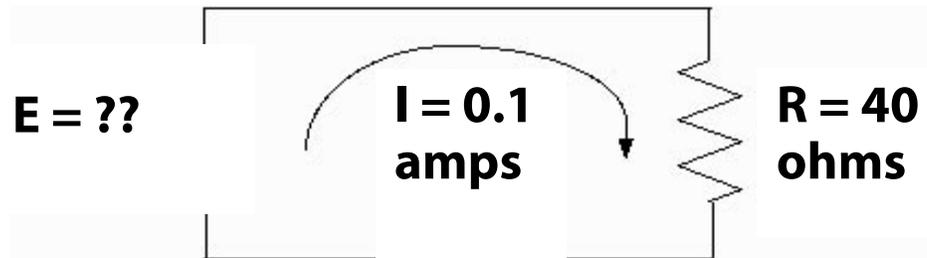
$$110/2200 = I \quad I = 0.05 \text{ amps}$$

Choose your answer below

1. 0.5 amps
2. 2.0 amps
- ③. 0.05 amps
4. 1.0 amps

### Problem #2

A CD player with a resistance of 40 ohms has a current of 0.1 amps flowing through it. Sketch the circuit diagram and calculate how many volts supply the CD player.



Choose your answer below

1. 0.0025 volts
- ②. 4.0 volts
3. 10.0 volts
4. 400.0 volts

$$E = I \times R \quad E = 0.1 \times 40 \quad E = 4.0 \text{ volts}$$

### Problem #3

A 120-volt power source supplies a lamp with a resistance of 192 ohms. What is the current flow of the circuit?

$$E = I \times R \quad E = 120 \text{ volts} \quad R = 192$$

Replace known values in sentence:  $120 = I \times 192$

Divide both sides by 192:  $120/192 = I \quad I = 0.625$

Check answer:  $120 = 0.625 \times 192$



**Problem #4****KEY**

What is the resistance of the circuit conductors when the conductor voltage drop is 3 volts and the current flowing through the conductors is 100 amperes?

$$E = I \times R \quad E = 3 \text{ volts} \quad I = 100 \text{ amps}$$

$$\text{Replace known values in sentence:} \quad 3 = 100 \times R$$

$$\text{Divide both sides by 100: } 3/100 = R \quad R = 0.03 \text{ Ohms}$$

$$\text{Check answer:} \quad 3 = 100 \times 0.03$$

**Problem #5**

Given:  $I = 15\text{A}$ ,  $R = 2$ , find  $E$

$$E = I \times R$$

$$\text{Replace known values in sentence:} \quad E = 15 \times 2$$

$$\text{Complete multiplication: } E = 30$$

$$\text{Check answer:} \quad 30 = 15 \times 2$$

**Problem #6**

Given:  $E = 250\text{V}$ ,  $R = 5$ , find  $I$

$$E = I \times R$$

$$\text{Replace known values in sentence:} \quad 250 = I \times 5$$

$$\text{Divide both sides by 5: } 250/5 = I \quad I = 50 \text{ amps}$$

$$\text{Check answer:} \quad 250 = 50 \times 5$$

**Problem #7**

Given:  $E = 100\text{V}$ ,  $I = 0.01\text{A}$ , find  $R$

$$E = I \times R$$

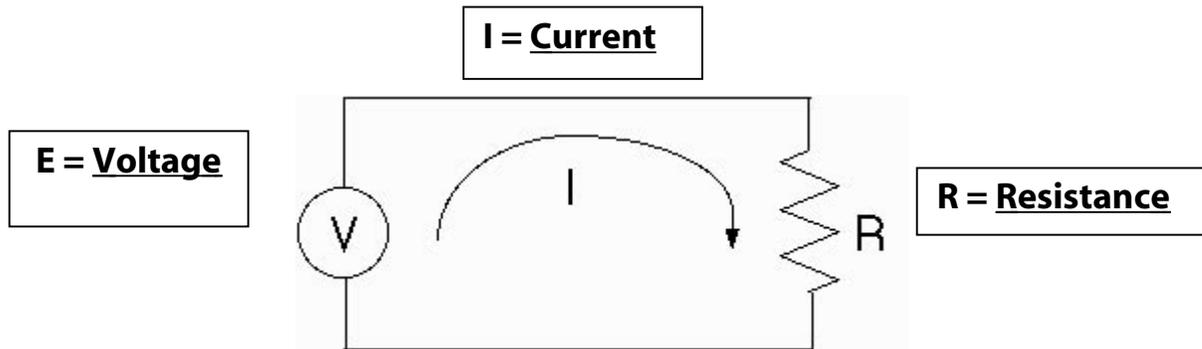
$$\text{Replace known values in sentence:} \quad 100 = 0.01 \times R$$

$$\text{Divide both sides by 0.01: } 100/0.01 = R \quad R = 10,000 \text{ Ohms}$$

$$\text{Check answer:} \quad 100 = 0.01 \times 10,000$$

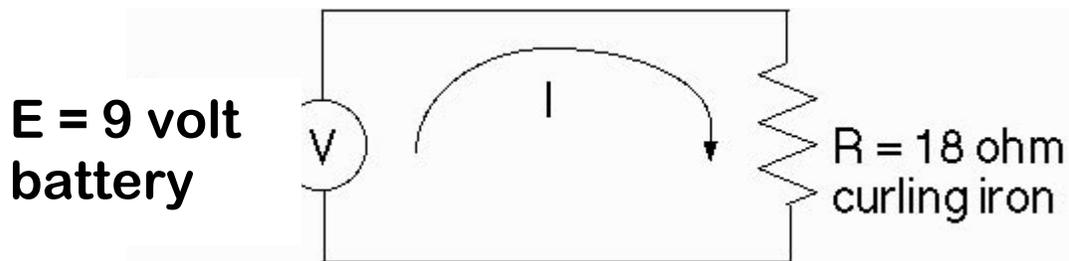


## Electricity and Ohm's Law Example Problem



### Example Problem:

A nine volt battery supplies power to a cordless curling iron with a resistance of 18 ohms. How much current is flowing through the curling iron?



### Solution: OHM'S LAW $E = I \times R$

1.) Since E (Voltage) and R (Resistance) are known, solve for I (Current) by dividing both sides of the equation by R.	$\frac{E}{R} = \frac{I \times R}{R}$
2.) The R's on the right hand side of the equation cancel. This will isolate I.	$\frac{E}{R} = I$
3.) I is then left in terms of E and R.	$I = \frac{E}{R}$
4.) Substitute in the values for E (Voltage) and R (Resistance).	$\frac{9}{18} = I$
5.) Solve for I (Current).	$I = 0.5 \text{ amps}$



# FORMULAS, EQUATIONS & LAWS

Symbolic:

$$E = \text{VOLTS} \sim \text{or} \sim (V = \text{VOLTS})$$

$$P = \text{WATTS} \sim \text{or} \sim (W = \text{WATTS})$$

$$R = \text{OHMS} \sim \text{or} \sim (R = \text{RESISTANCE})$$

$$I = \text{AMPERES} \sim \text{or} \sim (A = \text{AMPERES})$$

$$\text{HP} = \text{HORSEPOWER}$$

$$\text{PF} = \text{POWER FACTOR}$$

$$\text{kW} = \text{KILOWATTS}$$

$$\text{kWh} = \text{KILOWATT HOUR}$$

$$\text{VA} = \text{VOLT-AMPERES}$$

$$\text{kVA} = \text{KILOVOLT-AMPERES}$$

$$C = \text{CAPACITANCE}$$

$$\text{EFF} = \text{EFFICIENCY (expressed as a decimal)}$$

## DIRECT CURRENT

$$\text{AMPS} = \text{WATTS} \div \text{VOLTS} \quad I = P \div E \quad A = W \div V$$

$$\text{WATTS} = \text{VOLTS} \times \text{AMPS} \quad P = E \times I \quad W = V \times A$$

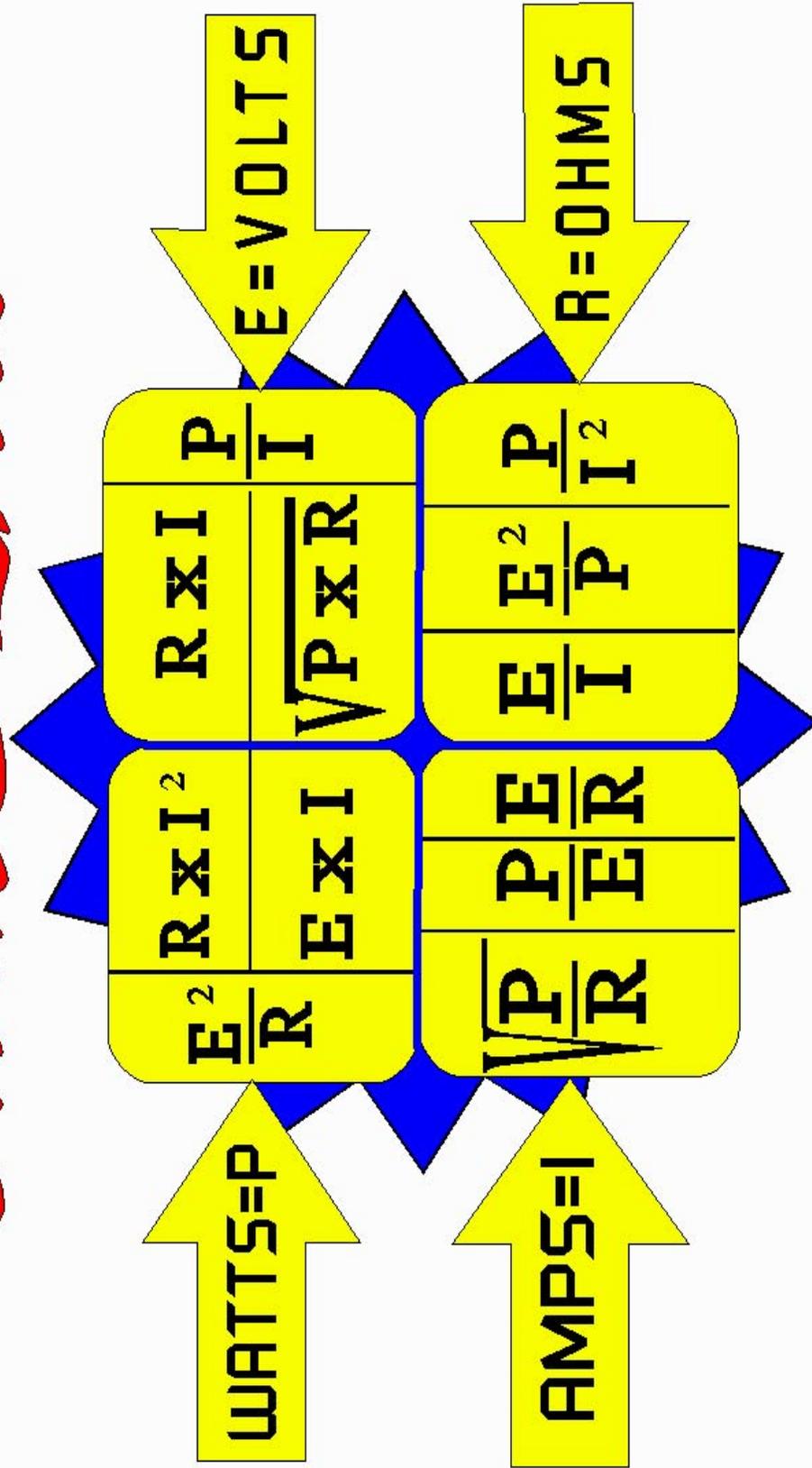
$$\text{VOLTS} = \text{WATTS} \div \text{AMPS} \quad E = P \div I \quad V = W \div A$$

$$\text{HORSEPOWER} = (V \times A \times \text{EFF}) \div 746$$

$$\text{EFFICIENCY} = (746 \times \text{HP}) \div (V \times A)$$



# OHM'S LAW





# Ohm's Law

