OHM'S LAW

The relationship of current, voltage, and resistance was first proven by George Simon Ohm, a German physicist. Using very poor and deficient apparatus, he performed a series of experiments which completely settled the questions of (1) The way EMF (electromotive force) is distributed throughout a circuit, and (2) The relationship of voltage, current, and resistance. During this conference the above relationships will be explained and how they are applied to different circuit configurations will be shown.

Some definitions are in order

Voltage is defined as the electrical force or pressure that causes electrons to flow in a conductor.

VOLTAGE

... THE ELECTRICAL FORCE OR PRESSURE
THAT CAUSES ELECTRONS TO FLOW.

SYMBOL IS E.

UNIT OF MEASURE IS VOLT (V,C).

FIGURE 3 (EP06AL-S03)

The symbol for voltage is the capital letter E. The unit of measure is expressed as volts and is symbolized by a capital or small letter V. Record this in your notes.

A study of FIGURE 4, will help you understand the relationship of voltage to current and resistance.

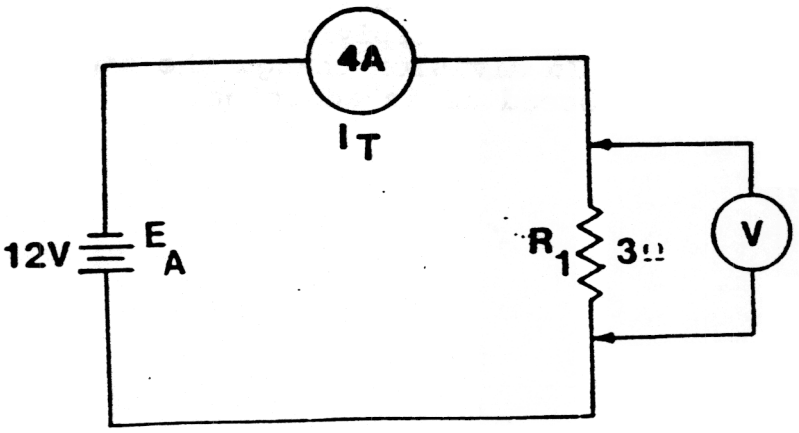


FIGURE 4

The pressure of the electromotive force (EMF), on the resistor R_1, causes current I_T, to flow through the conductor and resistor R_1.

A mathematical expression for this condition is. The voltage applied is equal to the product of the current and the resistance. This may be written, Voltage = Current x Resistance, and expressed symbolically as;

$$E_A = I_T \times R_1$$

Example:

If I_T = 4A and R = 3, then by substituting these values into the formula $E_A = I_T \times R_1$ the results would be;

$$E_A = I_T \times R_1$$

$$E_A = 4 \times 3$$

$$E_A = 12V$$

The voltage drop across R_1, is determined by the current I_T through it. If there is no current flow, then no voltage will be dropped across the resistor. Thus we have an open.

When current flows through the resistor, a difference of potential is developed. This difference of potential is called a voltage drop.

Ohm's Law may be used to compute voltage, if current and resistance are known. The formula for the voltage drop across R_1 is: The voltage drop across resistor one is the current through resistor one times the resistance of resistor one.

or $E_{R1} = I_1 \times R_1$

$$E_{R1} = 4 \times 3$$

$$E_{R1} = 12V$$

The voltage drop across R_1 is 12 volts. Thus it may be concluded from this, that since the voltage drop across R_1 is equal to the supplied or battery voltage, the sum of the voltage drops around a series circuit must equal the applied voltage.

$E_A = 12V$

$E_{R1} = 12V$

$E_A = E_{R1} = 12V$

As shown in FIGURE 5, if there is more than one resistor, the voltage drop across each resistor will be determined by its value of resistance and current in the circuit.

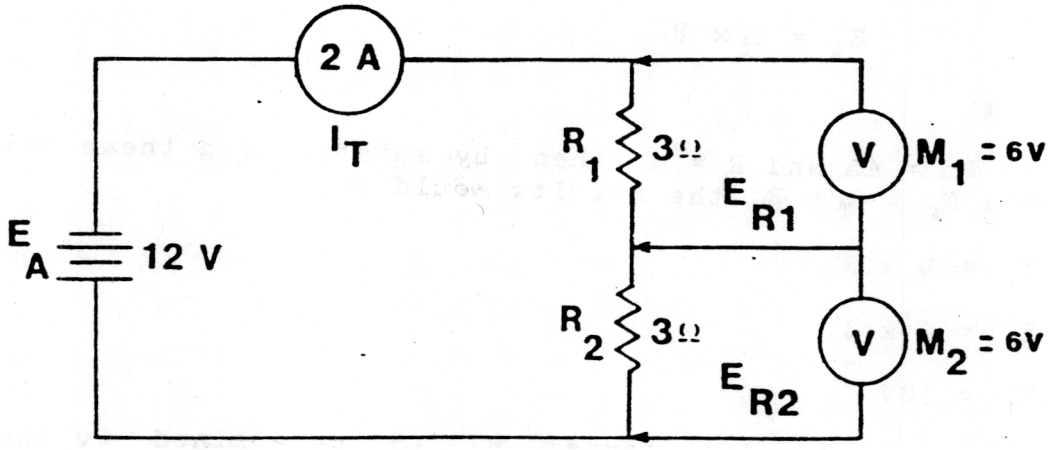


FIGURE 5 (EP06AL-S05)

The substituting of values into Ohm's Law for voltage will show how the voltage is divided between the two resistors in direct proportion to their sizes.

From the statement above; the sum of the voltage drops are equal to the applied voltage. This is called Kirchhoff's Voltage Law. Where there is opposition to current flow there will be voltage dropped.

Example:

$E_A = E_{RT}$

$E_A = E_{R1} + E_{R2}$

$E_A = I_T \times R_1 + I_T \times R_2$

$E_A = 2 \times 3 + 2 \times 3$

$E_A = 6 + 6$

$E_A = 12V$

$E_{RT} = E_{R1} + E_{R2}$

$E_{R1} = I_T \times R_1$

$E_{R2} = I_T \times R_2$

$E_{R1} = 6V$

$E_{R2} = 6V$

OHM'S LAW

A convenient device to help the student keep the relationships straight is called the Magic Circle.

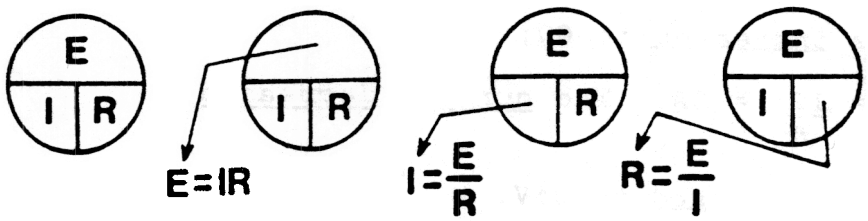


FIGURE 6 (EP06AL-S06)

To be able to understand Ohm's Law for current, the method of measuring current must be observed.

Current flow in a series circuit has only one path to flow in. If this current is to be measured, it can be measured any where in the one path. The circuit must be broken and the current meter or ammeter, as it is called, is connected in series with the circuit. The current flow for the circuit passes through the current meter. The ammeter displays the current or volts/ohm.

If as shown in FIGURE 6, the I is removed from the magic circle E is left over R, or

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

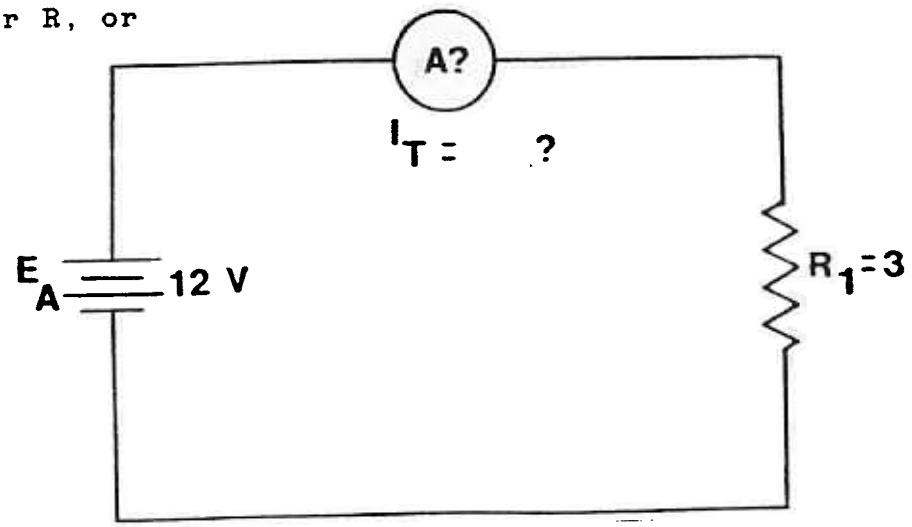


FIGURE 7 (EP06AL-S07)

OHM'S LAW

From the current formula it may be shown that current is inversely proportional to resistance. Therefore, if resistance increases, current will decrease if voltage remains the same.

Example:

In FIGURE 7, current is unknown, that is;

$I_T = \frac{E_A}{R_1} = \frac{12}{3} = 4A.$

If R_1 is increased to 6Ω;

$I_T = \frac{E_A}{R_1} = \frac{12}{6} = 2A.$ The current decreased.

If E_A is increased to 24V;

$I_T = \frac{E_A}{R_1} = \frac{24}{3} = 8A.$ The current increased.

SUMMARIZE: Ohm's law states that current is directly proportional to voltage and inversely proportional to resistance.

QUESTION: What is the relationship between current and voltage?

ANSWER: Direct

Resistance is the opposition to current in an electrical circuit. In other words resistance is that property which opposes electron flow.

RESISTANCE

...THE OPPOSITION TO CURRENT FLOW IN A ELECTRICAL CIRCUIT.

SYMBOL = R

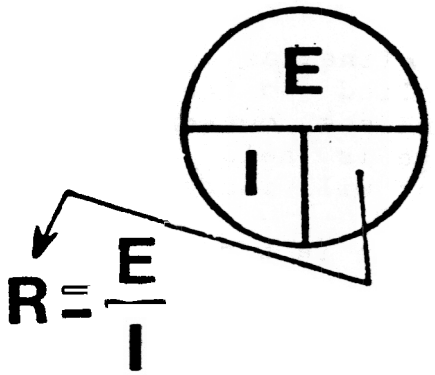
UNIT OF MEASURE = OHM (Ω)

FIGURE 8 (EP06AL-S08)

The symbol for resistance is the capital letter R. The unit of measure is the ohm and is symbolized by the greek letter omega, (Ω). Record this in your notes.

Using the magic circle as shown will give the formula for finding resistance.

OHM'S LAW



In the simple electrical circuit shown in FIGURE 9, calculate the resistance of R_1 .

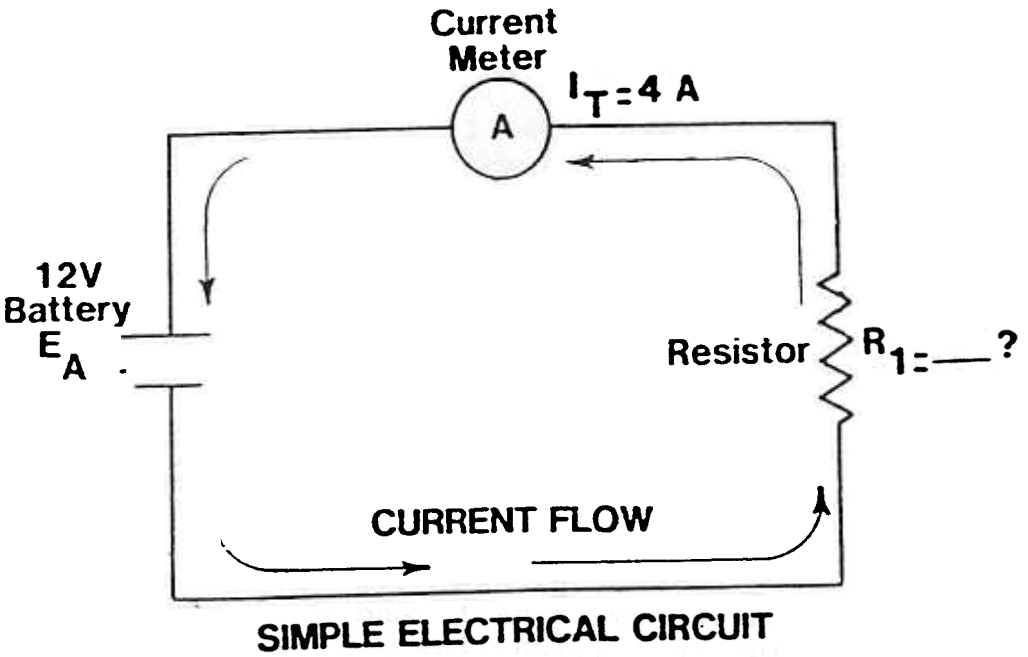


FIGURE 9 (EP06AL-S09)

Example:

$$R_1 = \frac{E_A}{I_T} = \frac{12}{4} = 3\Omega$$

If E_A is <u>increased</u> to 24V;

$$R_1 = \frac{24}{4} = 6\Omega \text{ ; } R_1 \text{ } \underline{\text{increased}}.$$

If I_T is increased to 6A;

$$R_1 = \frac{12}{6} = 2\Omega \text{ ; } R_1 \text{ decreased.}$$

OHM'S LAW

SUMMARIZE: Resistance is defined as opposition to current flow. If the voltage applied to the circuit is constant and the resistance increases, current will decreases; likewise if the voltage is held constant and resistance decreases, current will increase.

QUESTION: What is resistance in a circuit?

ANSWER: Opposition to current flow

SUMMARY:

After Ohm's Law was expressed as a formula, an aid called the 'magic circle' was developed. It provided an easy method of remembering the formula for Ohm's Law.

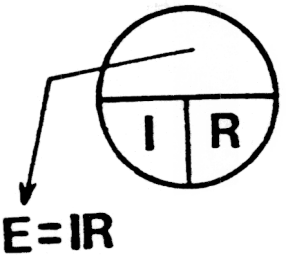
The E represents voltage, the I represents current, and the R represents resistance. There is an important reason for the formula being sectioned as shown.

The horizontal line represents a <u>dividing</u> line. E is above the line while I and R are below the line.

The vertical line represents a <u>multiplication</u> line which separates I and R.

Since the three quantities of <u>voltage</u>, <u>current</u>, and <u>resistance</u> are interrelated, if two quantities are known, the unknown quantity can easily be solved.

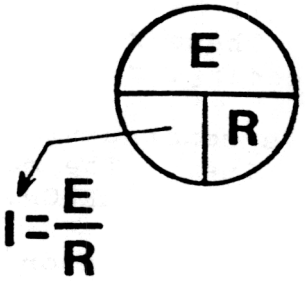
To solve for an unknown <u>voltage</u>, you simply place your finger over the E and you have remaining I and R. Remembering that the vertical line is a multiplication line you can see the formula would be E equals I multiplied by R.



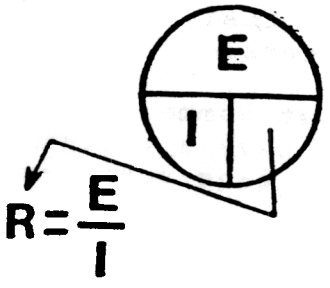
Even if you said E equals IR or E equals I times R, it still remains the same. Record the formula for voltage in your notes.

OHM'S LAW

In order to solve for I, cover the I and you have E over R. Therefore, the formula is I equals E divided by R. Simple, isn't it? Record this formula.



What formula would you use to solve for resistance?



Cover the R and see that the formula is R equals E divided by I Record this formula.

NOTE: The wise student will write down on his paper the formula before completing the calculation.