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OHM’S LAW

- George Simon Ohm – formulated the law
  “The current is proportional to voltage and inversely proportional to the resistance”
- The formula:
  \[ I = \frac{V}{R} \]
  Where:
  - \( I \) = the electric current
  - \( V \) = the voltage
  - \( R \) = the resistance
Graphical Aid:

- VOLTAGE
- RESISTANCE
- CURRENT
Example 1. For the $V$ and $R$ given in the circuit below, determine $I$.

\[ I = \frac{V}{R} = \frac{100}{20} = 5 \text{ A} \]
Example 2. How much current will flow through a 10,000,000-ohm resistor when 50,000 volts are applied?

\[ I = \frac{V}{R} \]

\[ = \frac{50,000}{10,000,000} \]

\[ I = 0.005 \text{ A or 5 mA} \]
Example 3. How much voltage is needed to produce 5 A of current?

\[ V = IR \]
\[ = 5 \times 100 \]
\[ V = 500 \text{ Volts} \]
KIRCHHOFF’S CURRENT LAW

“The summation of currents entering a node is equal to the summation of currents leaving the node”

\[
\sum I_{\text{entering node}} = \sum I_{\text{leaving node}}
\]

\[
\sum I_{\text{in}} = \sum I_{\text{out}}
\]

\[
5 \text{ A} + 3 \text{ A} = 2 \text{ A} + 4 \text{ A} + 8 \text{ A}
\]

\[
8 \text{ A} = 8 \text{ A} \quad \text{(checks!)}
\]
Example 4:

\[3 \text{ mA} + 6 \text{ mA} + 1 \text{ mA} = 2 \text{ mA} + 4 \text{ mA} + 4 \text{ mA}\]
Example 5. Determine the magnitude and correct direction of the currents $I_3$ and $I_5$ for the network of Figure

KCL must be valid at point $a$, the expression for this node;

$$I_1 = I_2 + I_3$$

$$I_3 = I_1 - I_2 = 2\ A - 3\ A = -1\ A$$
Using KCL at point $b$ gives:

$$I_3 = I_4 + I_5$$

$$I_5 = I_3 - I_4 = -1A - 6A = -7A$$

The negative sign indicates that the current $I_5$ is actually towards node $b$ rather than away from the node.
KIRCHHOFF’S VOLTAGE LAW

The applied voltage of a series circuit equals the sum of the voltage drops across the series elements.

\[ \sum V_{\text{rises}} = \sum V_{\text{drops}} \]
Example 6. Determine the unknown voltages for the network of figure below.

Solution:

\[ +E_1 - V_1 - V_2 - E_2 = 0 \]

\[ V_1 = E_1 - V_2 - E_2 = 16\,\text{V} - 4.2\,\text{V} - 9\,\text{V} \]

\[ = 2.8\,\text{V} \]
Example 7. Determine the unknown voltages for the network of figure below.

Solution: Using the clockwise path, including the voltage source $E$, will result in

\[ +E - V_1 - V_x = 0 \]

\[ V_x = E - V_1 = 32 \text{ V} - 12 \text{ V} = 20 \text{ V} \]
Example 7. Determine the unknown voltages for the network of figure below.

Solution

Using the clockwise direction for the other loop involving $R_2$ and $R_3$ will result in

$$+V_x - V_2 - V_3 = 0$$

$$V_x = V_2 + V_3 = 6\, \text{V} + 14\, \text{V} = 20\, \text{V}$$
Example 8. Find $V_1$ and $V_2$ for the network of figure below.

For Path 1, starting at point $a$ in a clockwise direction:

$$+25V - V_1 + 15V = 0$$

$$V_1 = 40V$$

For Path 2, starting at point $a$ in a clockwise direction:

$$-V_2 - 20V = 0$$

$$V_2 = -20V$$
Example 9. Using Kirchhoff’s voltage law, determine the unknown voltage for the network of figure below.

Solution: Note that there are various polarities across the unknown elements since they can contain any mixture of components. Applying Kirchhoff’s voltage law to the network in the clockwise direction will result in

\[ 60 \, \text{V} - 40 \, \text{V} - V_x + 30 \, \text{V} = 0 \]

\[ V_x = 60 \, \text{V} + 30 \, \text{V} - 40 \, \text{V} = 90 \, \text{V} - 40 \, \text{V} = 50 \, \text{V} \]
WORK AND ENERGY

- Work is done when a force acts to the body.
- If the force and the body’s direction are perpendicular to each other, no work is done.
- SI unit for work is joule, J.
- Energy is the ability to do work.
- Types of energy:
  - Kinetic is possessed by the body by virtue of its motion.
  - Potential is possessed by a system by virtue of its position, or condition.
Work is performed when mechanical energy is converted to its electrical energy.

“One joule of electric energy is required to raise one coulomb of electric charge through a potential difference of one volt”

1 joule of energy = 1 coulomb x 1 volt

\[ W = Q \times E \]

Where:  
- \( W \) = energy, in joules
- \( Q \) = charge, in coulomb
- \( E \) = potential difference, in volts
POWER

- Power is the rate at which work is done or energy expended.
- Power is measured in joules per second.
- Electrical Unit is watt, W.
  "One watt is the rate of doing work when one joule of work is done in one second."
- The equation form:
  \[ P = \frac{W}{t} \]
  Where:
  \( P \) = power, watts
  \( W \) = work, joules
  \( t \) = time, seconds
The unit watt was originated in 1782 by James Watt, the developer of the steam engine.

Power may be expressed in foot-pounds per seconds or horsepower, hp:

1 horsepower = 550 ft-lb/s = 746 watts

“One watt is the power expended when one ampere of direct current flows through a resistance of one ohm.”
From the previous equation;

\[ E = \frac{W}{Q} \]

Current is also;

\[ I = \frac{Q}{t} \]

If multiplied;

\[ E \times I = \frac{W}{t} \]

It is the formula of power
Therefore;

\[ P = E \times I \]

Where:
- \( P \) = power dissipated, watts
- \( E \) = applied voltage, volts
- \( I \) = current flow, amperes

Can be obtained in two other forms from Ohm’s Law:

\[ P = \frac{E^2}{R} \]

and

\[ P = I^2R \]
Example 10. What is the power delivered to a DC circuit when the input current is 8 mA and the supply voltage is 24 V?

Solution:

\[ P = E \times I \]
\[ = (24\text{V}) \times (8 \text{ mA}) \]
\[ P = 192 \text{ mW} \]
Example 11. What is the resistance of a device that dissipates 5 W of power when 30 V is applied?

Solution:

\[ R = \frac{E^2}{P} \]

\[ = \frac{(30)^2}{5} \]

\[ R = 180 \ \Omega \]
POWER DISSIPATION & RATING OF CIRCUIT COMPONENTS

- Power dissipated is the conversion of electric energy to heat energy.
- All types of the circuit components are rated for a maximum wattage or in terms of current and voltage.
- Generally, a safety factor of at least 100% is used when determining power requirements for a circuit components.
- When resistor of wattage rating more than 2 watts are required, wire-wound resistors are often used.
- These resistors are made in ranges between 5 watts and 200 watts.
Example 12. The maximum current expected to flow through a 1 kΩ resistor is 20 mA. Determine the wattage rating of the resistor using a 100% safety factor.

Solution:

\[
P = I^2R = (0.02)^2(1000)\]

\[
P = 400 \text{ mW}\]

For 100% safety factor = 400 x 2 = 800 mW or a 1 watt resistor is required.
EFFICIENCY

- Efficiency is a measure of how completely the power put into a circuit is used as output.
- There is a substantial amount of the input power is lost as waste heat
  power input = power output + power losses
  - Efficiency is the ratio of useful output energy to total input energy.
EFFICIENCY

- Efficiency is expressed by the equation:

\[ \eta = \left( \frac{P_{\text{out}}}{P_{\text{in}}} \right) \times 100\% \]

Where:

- \( \eta \) = efficiency
- \( P_{\text{out}} \) = useful output power, watts
- \( P_{\text{in}} \) = useful input power, watts
Example 13. Determine the efficiency of a circuit that has a useful output power of 15 W for each 20 W of input power.

Solution:

\[ \eta = \left( \frac{P_{out}}{P_{in}} \right) \times 100\% \]
\[ = \left( \frac{15}{20} \right) \times 100\% \]
\[ \eta = 75\% \]
Example 14. A motor has an efficiency of 85%. What current does it draw from a 120 V source when its output is $\frac{3}{4}$ hp?

Solution:

\[
P_{\text{out}} = \left(\frac{3}{4}\right) \times 746
= 559.5 \text{ W}
\]

\[
P_{\text{in}} = \frac{P_{\text{out}}}{\eta}
= \frac{559.5}{0.85}
\]

\[
P_{\text{in}} = 658.24 \text{ W}
\]

\[
I = \frac{P}{E}
= \frac{658.24}{120}
\]

\[
I = 5.49 \text{ A} \quad \text{(answer)}
\]
THE KILOWATT-HOUR

- The basic unit of electric energy is watt-hour

\[ W = Pt \]

Where:

- \( W \) = electric energy, \( W \)-hr.
- \( P \) = power, Watt
- \( t \) = time, second

- Watt-hour Meter is an instrument for measuring the energy supplied.
Example 15. A generator delivers 4 kW to a customer for 60 hours. How much energy does the customer receive in this time?

Solution:

\[ W = Pt \]
\[ = (4 \text{ kW})(60 \text{ hr}) \]
\[ W = 240 \text{ kW-hr} \quad \text{(answer)} \]
Example 16. At Php3.85 per kW-hr, how much will it cost to use a 60 W lamp for 20 days?

Solution:

\[
\text{cost} = \frac{\text{Php 3.85 per kW-hr} \times 60 \text{ watts} \times 20 \text{ days} \times 24 \text{ hr/day}}{1000}
\]

\[
\text{cost} = \text{Php110.88}
\]
Thank You!