PHYSICS 11

OHM'S LAW

The Ohm's Law states that the electric potential difference between two points on a circuit is equivalent to the product of the current between those two points and the total resistance of all electrical devices present between those two points.

$$\Delta V = I \cdot R$$

$\Delta V = potential\ difference = voltage\ measured\ in\ Volts\ [V]$

$I = the\ electric\ current\ measured\ in\ Amperes\ [A]$

$R = resistance\ measured\ in\ Ohms\ [\Omega]$

RESISTANCE

- Resistance is a numerical quantity that can be measured and expressed mathematically.
- For any cylindrically shaped conductor the following is true:

$$R = \rho \cdot \frac{l}{A}$$

  - $\rho = resistivity\ of\ the\ material\ measured\ in\ Ohm - meters\ [\Omega \cdot m]$
  - $l = length\ of\ the\ conductor\ (wire)\ measured\ in\ meters\ [m]$
  - $A = area\ of\ the\ cross - section\ measured\ in\ meters\ squared\ [m^2]$

- Resistivity of a material is a property dependent on the material's electronic (and atomic) structure and on the material's temperature. For most materials, resistivity increases with increasing temperature.

Examples of resistivity at 20°C:

Material	Resistivity $[\Omega \cdot m]$	Material	Resistivity $[\Omega \cdot m]$
Silver	1.59×10^{-8}	Iron	10×10^{-8}
Copper	1.7×10^{-8}	Lead	22×10^{-8}
Gold	2.2×10^{-8}	Glass	$10^{10} - 10^{14}$
Aluminum	2.8×10^{-8}	Hard rubber	10^{13}

Ex.1: Determine the resistance in a 2.5 km long copper wire with a diameter of 0.2117cm.

Ex.2: Two wires, wire A and wire B, with circular cross-sections have identical lengths and are made of the same material. Yet, wire A has four times the resistance of wire B. How many times greater is the diameter of the wire B than wire A? **What other assumptions do you make to answer this question?**

Conclusion:

Definitions of quantities and units:

V = electric potential = $\frac{EPE}{q}$

Voltage = potential difference = $\frac{\Delta EPE}{q}$

Volt [V] = $\frac{J}{C}$

Electric charge = q

Coulomb [C] = unit charge = charge on one proton (or electron) = $1.6 \times 10^{-19} C$

Electric current = I = The amount of charge that passes through a given point in one second.

Ampere [A] = $\frac{C}{s}$

Ex.1: How many electrons has a negatively charged object in surplus if its charge is 20.0 μC ?

Check your understanding:

1. Which of the following will cause the current through an electrical circuit to decrease? Choose all that apply.

a. decrease the voltage

b. decrease the resistance

c. increase the voltage

d. increase the resistance

2. A certain electrical circuit contains a battery with three cells, wires and a light bulb. Which of the following would cause the bulb to shine less brightly? Choose all that apply.

a. increase the voltage of the battery (add another cell)

b. decrease the voltage of the battery (remove a cell)

c. decrease the resistance of the circuit

d. increase the resistance of the circuit

3. You have likely been warned to avoid contact with electrical appliances or even electrical outlets when your hands are wet. Such contact is more dangerous when your hands are wet (vs. dry) because wet hands cause _____.

a. the voltage of the circuit to be higher

b. the voltage of the circuit to be lower

c. your resistance to be higher

d. your resistance to be lower

e. the current through you to be lower

4. If the resistance of a circuit were tripled, then the current through the circuit would be ___.

a. one-third as much

b. three times as much

c. unchanged

d. ... nonsense! There would be no way to make such a prediction.

5. If the voltage across a circuit is quadrupled, then the current through the circuit would be ___.

a. one-fourth as much

b. four times as much

c. unchanged

d. ... nonsense! There would be no way to make such a prediction.

6. A circuit is wired with a power supply, a resistor and an ammeter (for measuring current). The ammeter reads a current of 24 mA (milliAmps). Determine the new current if the voltage of the power supply was ...

a. ... increased by a factor of 2 and the resistance was held constant.

b. ... increased by a factor of 3 and the resistance was held constant.

c. ... decreased by a factor of 2 and the resistance was held constant.

d. ... held constant and the resistance was increased by a factor of 2.

e. ... held constant and the resistance was increased by a factor of 4.

f. ... held constant and the resistance was decreased by a factor of 2.

g. ... increased by a factor of 2 and the resistance was increased by a factor of 2.

h. ... increased by a factor of 3 and the resistance was decreased by a factor of 2.

i. ... decreased by a factor of 2 and the resistance was increased by a factor of 2.

7. Use the Ohm's law equation to provide numerical answers to the following questions:

a. An electrical device with a resistance of 3.0 Ω will allow a current of 4.0 amps to flow through it if a voltage drop of _____ Volts is impressed across the device.

b. When a voltage of 120 V is impressed across an electric heater, a current of 10.0 amps will flow through the heater if the resistance is _____ Ω.

c. A flashlight that is powered by 3 Volts and uses a bulb with a resistance of 60 Ω will have a current of _____ Amps.

8. Use the Ohm's law equation to determine the missing values in the following circuits.

Diagram A

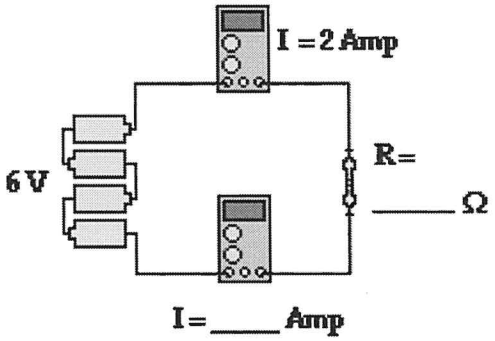


Diagram B

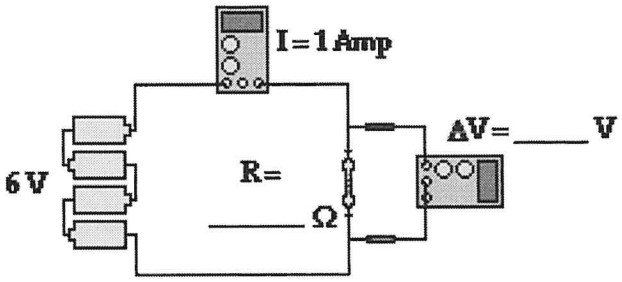


Diagram C

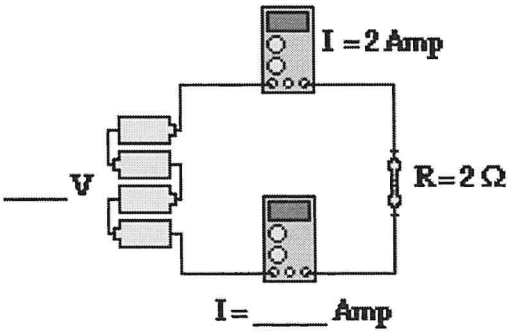
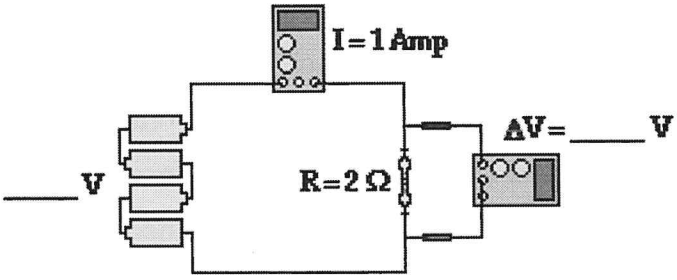


Diagram D



9. Refer to question 8 above. In the circuits of diagrams A and B, what method was used to control the current in the circuits? And in the circuits of diagrams C and D, what method was used to control the current in the circuits?