National University

Faculty of Engineering and Architecture

Ohm’s Law

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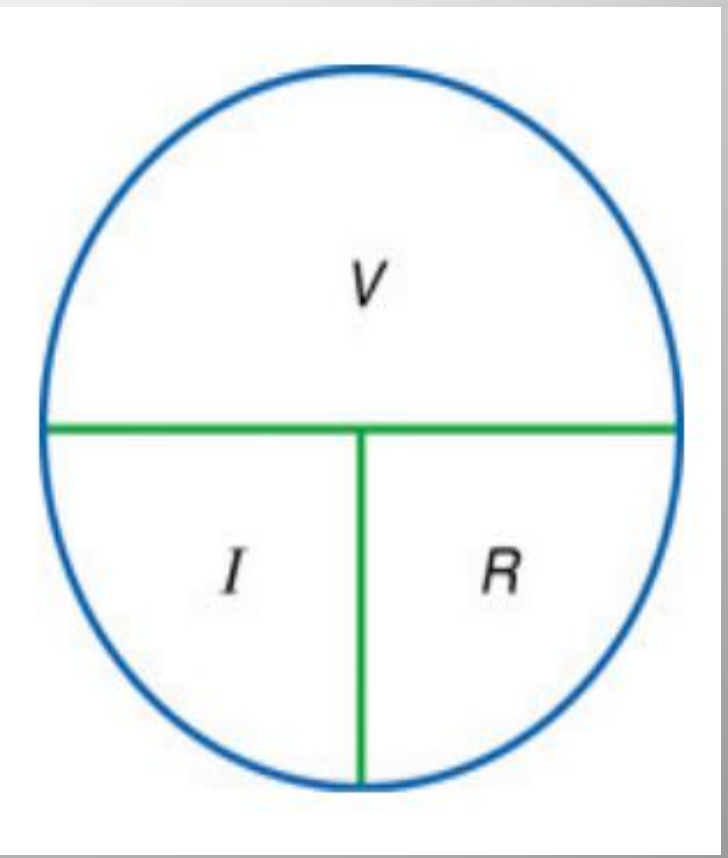
- The most fundamental law in electricity is Ohm’s law.
- Ohm's law states that, in an electrical circuit, the current passing through most materials is directly proportional to the potential difference applied across them.

There are three forms of Ohm's Law:

I = V/R V = IR R = V/I

where:

- V is for voltage which is measurement of the work required to move a unit charge between two points.
- I is current which is the measurement of the flow of charge in a circuit.
- R is resistance which resists current flow



Multiple and Submultiple Units

Units of Voltage:

- The basic unit of voltage is the volt (V).
- Multiple units of voltage are: 1- kilovolt (kV) or 10^3 V

  2- megavolt (MV) or 10^6 V
- Submultiple units of voltage are:

  1- millivolt (mV) or 10^-3 V

  2- microvolt (µV) or 10-^6 V

Units of Current

- The basic unit of current is the ampere (A).
- Submultiple units of current are:

1- milliampere (mA) or 10^-3 A

2- microampere (µA) or 10-^6 A

Continued: Units of Resistance

- The basic unit of resistance is the Ohm (Ω). Multiple units of resistance are:

1- kilo ohm (kΩ) 1 thousand ohms or 10^3 Ω

2- Mega ohm (MΩ) 1 million ohms or 10^6 Ω

Examples:

- How much is the current, I, in a 470-kΩ resistor if its voltage is 23.5 V?

- How much voltage will be dropped across a 40 kΩ resistance whose current is 250 μA?

- How much resistant will be added to electrical circuit when current throught it I = 2 mA and its voltage V=14V?

The Linear Proportion between V and I:

1- When R is constant:

- ❑ I increases as V increases
- ❑ I decreases as V decreases

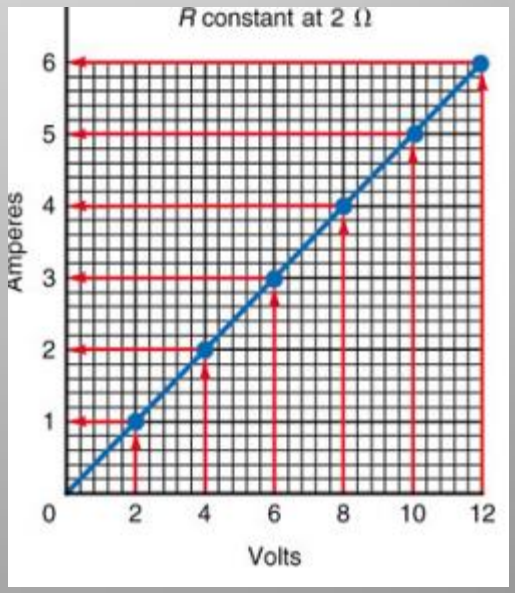
2- When V is constant:

- ❑ I decreases as R increases.
- ❑ I increases as R decreases.

- Examples:

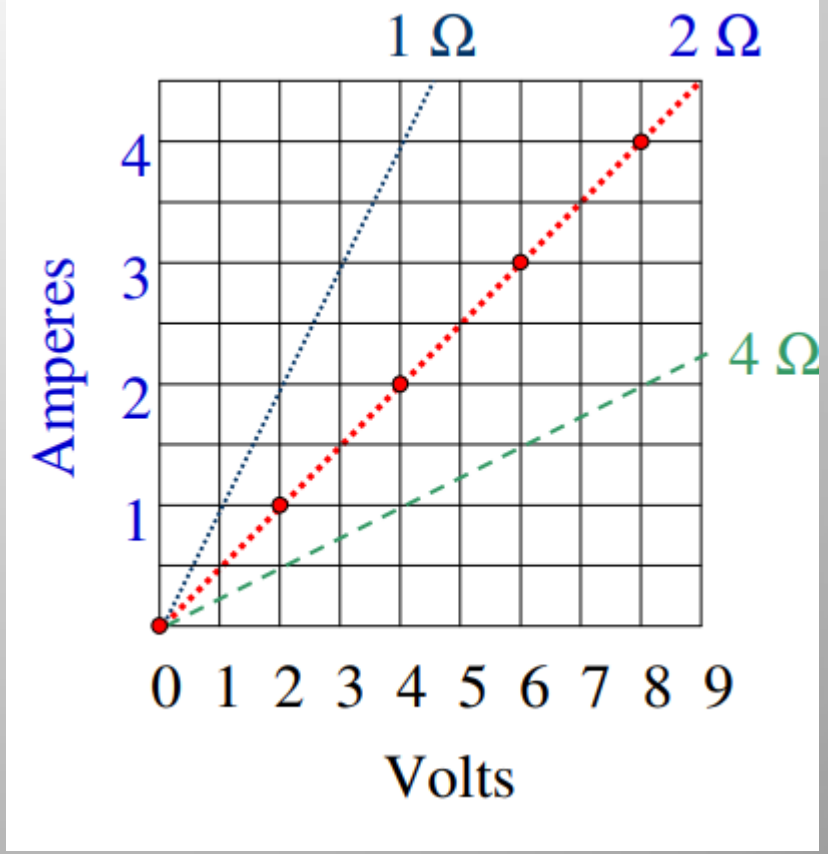
- ❑ If R doubles, I is reduced by half.
- ❑ If R is reduced to ¼, I increases by 4.

Volts V	Ohms Ω	Amperes A
0	2	0
2	2	1
4	2	2
6	2	3
8	2	4
10	2	5
12	2	6



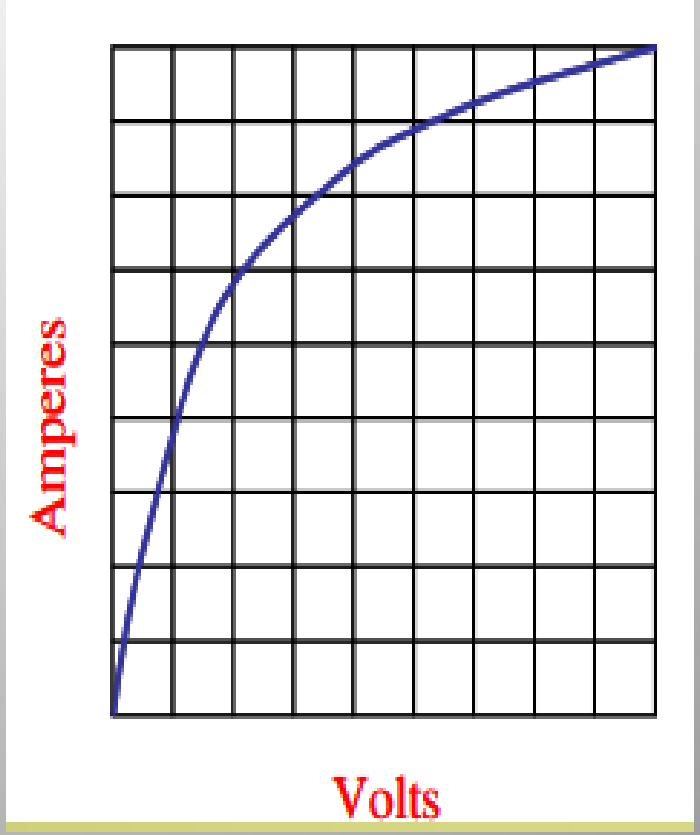
Linear Resistance:

- has a constant value of ohms.
- Its R does not change with the applied voltage, so V and I are directly proportional.
- Carbon-film and metal-film resistors are examples of linear resistors.



Nonlinear Resistance

- In a nonlinear resistance, increasing the applied V produces more current, but I does not increase in the same proportion as the increase in V.
- Example of V and I non-linear relationship:
- As the tungsten filament in a light bulb gets hot, its resistance increases.



Power:

- It is the time rate of doing work. It equals the product of voltage and current.

$$P = V \times I$$

- The basic unit of power is the watt (W).
- Multiple units of power are:

  kilowatt (kW): 10^3 W

  megawatt (MW): 10^6 W

- Submultiple units of power are:

  Milli watt (mW): 10^-3 W

  microwatt (µW): 10^-6 W

Kilowatt Hours:

- is a unit commonly used for large amounts of electrical work or energy.
- For example, electric bills.
- The amount of work (energy) can be found by multiplying power (in kilowatts) × time in hours.

Cost:

- Can be found by multiplying (KWH) by assuming rate for the device.
- Example:

An air conditioner operates at 240 volts and 20 amperes.

The power is $P = V \times I = 240 \times 20 = 4800$ watts.

Convert to kilowatts: 4800 watts = 4.8 kilowatts

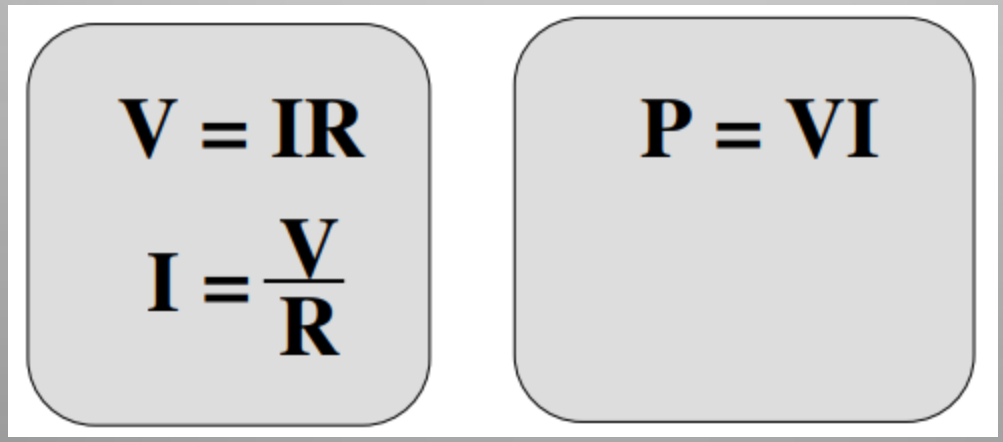
Continued:

- Multiply by hours: (Assume it runs half the day)
  energy = 4.8 kW × 12 hours = 57.6 kWh

- Multiply by rate: (Assume a rate of $0.08/ kWh)
  cost = 57.6 × $0.08 = $4.61 per day

Power Formulas:

- There are three basic power formulas, but each can be in three forms for nine combinations.
- All nine power formulas are based on Ohm's Law.



Continued:

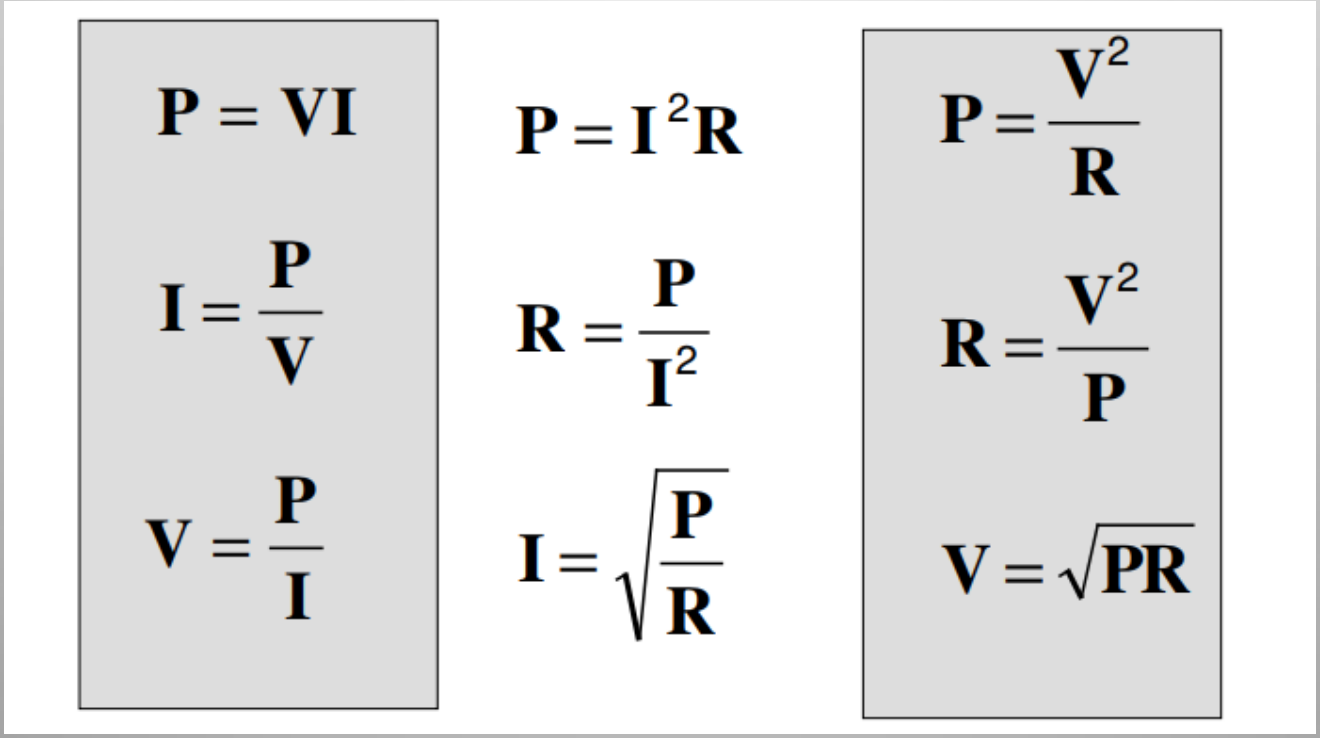
- **Substitute IR for V to obtain:**

$P = VI = (IR)I = I^2R$

- **Substitute V/R for I to obtain:**

$P = VI = V \times V/R = V^2 / R$

Continued:



- Where: P = Power V = Voltage I = Current R=Resistance

Examples:

- What is the resistance of a device that dissipates 1.2 kW of power when its current is 10 A?
- How much current does a 960 W coffeemaker draw from the 120 V power line?
- What is the resistance of a 20 W, 12 V halogen lamp?

Choosing a Resistor for a Circuit:

- Follow these steps when choosing a resistor for a circuit:

1- Determine the required resistance value as R = V / I.

2- Calculate the power dissipated by the resistor using any of the power formulas.

3- Select a wattage rating for the resistor that will provide an adequate cushion between the actual power dissipation and the resistor's power rating.

4- Ideally, the power dissipation in a resistor should never be more than 50% of its power rating.

Example:

- Determine the required resistance and appropriate wattage rating of a carbon-film resistor to meet the following requirements: The resistor has a 54-V drop when its current is 20 mA.

The resistors available have the following wattage ratings: 1/8 W, 1/4 W, 1/2 W, 1 W, and 2 W.