Electronic Circuits

Week 3: Ohm Law

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Ohm's Law

There are three forms of Ohm's Law:

I = Current.
V = Voltage.
R = Resistance.

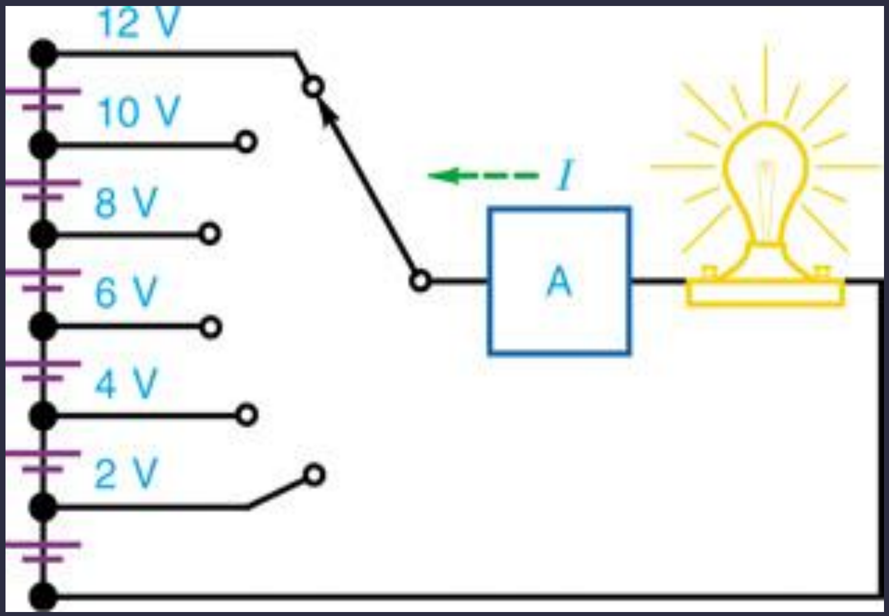
$V = IR.$
$I = V/R.$
$R = V/I.$

The Current I = V/R

$I = V/R$

In practical units, this law may be stated as:

amperes = volts / ohms.



Increasing the applied voltage *V* produces more current *I* to light the bulb with more intensity.

Practical Units

The three forms of Ohm's law can be used to define the practical units of current, voltage, and resistance:

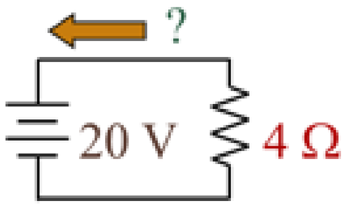
1 ampere = 1 volt / 1 ohm.

1 volt = 1 ampere × 1 ohm.

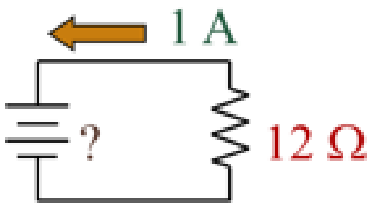
1 ohm = 1 volt / 1 ampere.

Practical Units

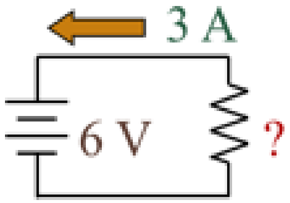
Applying Ohm's Law



$$I = \frac{20\ \text{V}}{4\ \Omega} = 5\ \text{A}$$



$$V = 1\ \text{A} \times 12\ \Omega = 12\ \text{V}$$



$$R = \frac{6\ \text{V}}{3\ \text{A}} = 2\ \Omega$$

Multiple and Submultiple Units

Units of Voltage

The basic unit of voltage is the **volt (V).**

Multiple units of voltage are:

kilovolt (kV):

1 thousand volts or

- **megavolt (MV):** 10^6 V.
  1 million volts or

- Submultiple units of voltage are:
  - **millivolt (mV):** 10^{-3} V.
    1-thousandth of a volt or
  - **microvolt** $(\mu V): 10^{-6}$ V.
    1-millionth of a volt or

Multiple and Submultiple Units

Units of Current

The basic unit of current is the **ampere (A).**

Submultiple units of current are:

milliampere (mA): 10^{-3} A.
1-thousandth of an ampere or

- **microampere** (μA): 10^{-6} A.
  1-millionth of an ampere or

Multiple and Submultiple Units

Units of Resistance
The basic unit of resistance is the **Ohm** (Ω).

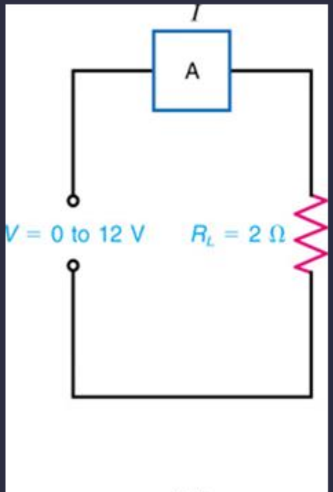
- Multiple units of resistance are:
  - **kilohm** $(k\Omega)$: $10^3\ \Omega$.

    1 thousand ohms or
  - **Megohm** $(M\Omega)$: $10^6\ \Omega$.

    1 million ohms or

The Linear Proportion between *V* and *I*

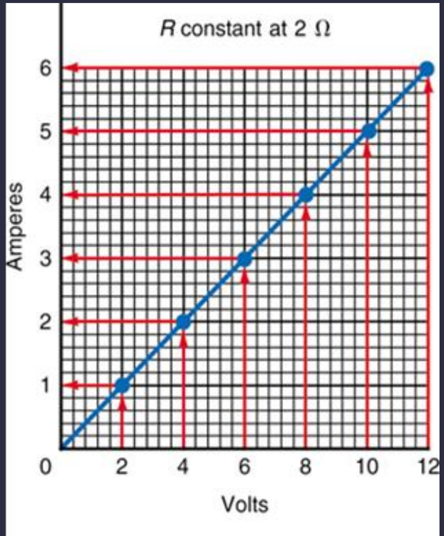
The Ohm's Law formula *I* = *V*/*R* states that *V* and *I* are directly proportional for any one value of *R.*



(*a*)

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

(*b*)

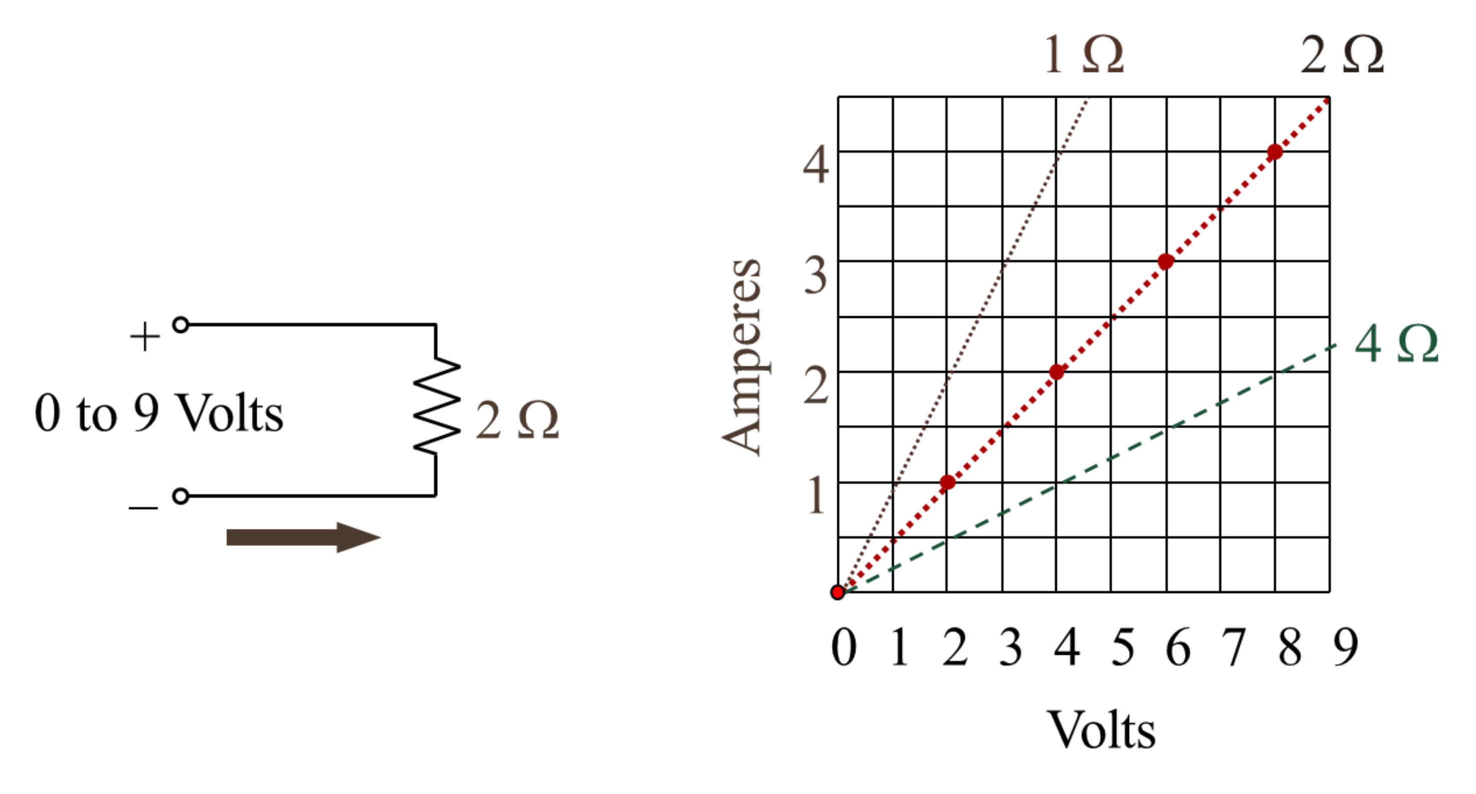


(*c*)

Experiment to show that *I* increases in direct proportion to *V* with the same *R*.

The Linear Proportion between *V* and *I*

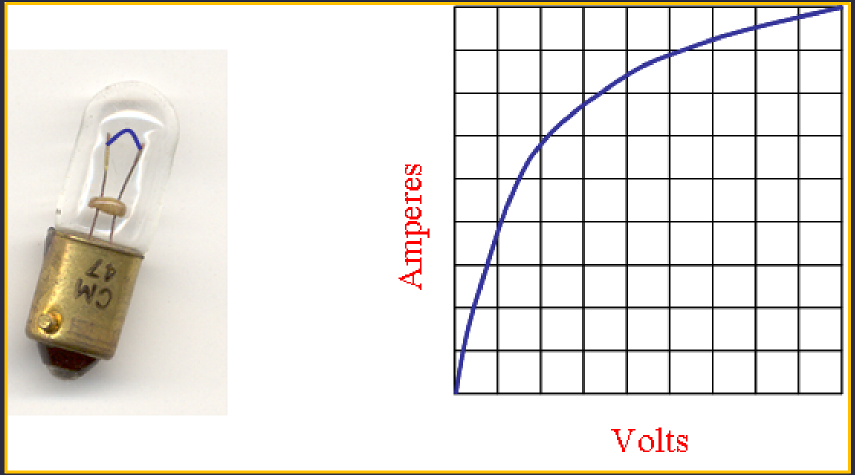
The smaller the resistor, the steeper the slope.



The Linear Proportion between *V* and *I*

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 a Nonlinear Volt–Ampere Relationship:
    - As the tungsten filament in a light bulb gets hot, its resistance increases.

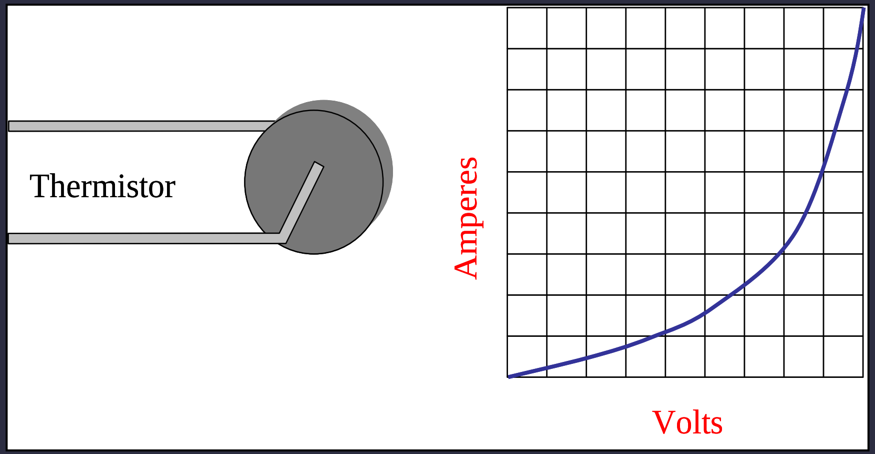


The Linear Proportion between *V* and *I*

Another nonlinear resistance is a **thermistor.**

A thermistor is a resistor whose resistance value changes with its operating temperature.

As an **NTC (negative temperature coefficient)** thermistor gets hot, its resistance decreases.



Electric Power

The basic unit of power is the watt (W).

Multiple units of power are:

kilowatt (kW): 10^3watts.
1000 watts or

- **megawatt (MW):** 10^6watts.
  1 million watts or

- Submultiple units of power are:
  - **milliwatt (mW):** 10^{-3}watt.
    1-thousandth of a watt or
  - **microwatt** (μW): 10^{-6}watt.

    1-millionth of a watt or

Electric Power

Power = Volts × Amps, or

$P = V \times I$

Electric Power

Kilowatt Hours

The kilowatt hour (kWh) is a unit commonly used for large amounts of electrical work or energy.

For example, electric bills are calculated in kilowatt hours. The kilowatt hour is the billing unit.

The amount of work (energy) can be found by multiplying power (in kilowatts) × time in hours.

Electric Power

To calculate electric cost, start with the power:

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.

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 Dissipation in Resistance

When current flows in a resistance, heat is produced from the friction between the moving free electrons and the atoms obstructing their path.

Heat is evidence that power is used in producing current.

Power Dissipation in Resistance

The amount of power dissipated in a resistance may be calculated using any one of three formulas, depending on which factors are known:

$$P = I^2 \times R.$$

$$P = \frac{V^2}{R}.$$

$$P = V \times I.$$

Power Formulas

There are three basic power formulas, but each can be in three forms for nine combinations.

$$P = VI \qquad P = I^2R \qquad P = \frac{V^2}{R}$$

$$I = \frac{P}{V} \qquad R = \frac{P}{I^2} \qquad R = \frac{V^2}{P}$$

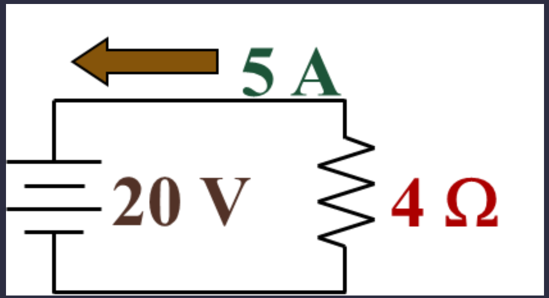
$$V = \frac{P}{I} \qquad I = \sqrt{\frac{P}{R}} \qquad V = \sqrt{PR}$$

Where:

P = Power V = Voltage I = Current R = Resistance

Power Formulas

Applying Power Formulas:



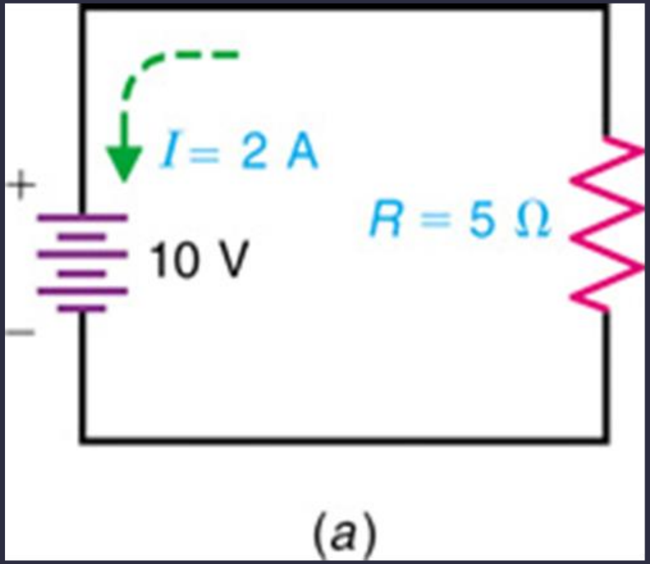
$$P = VI = 20 \times 5 = 100 \text{ Watts}$$

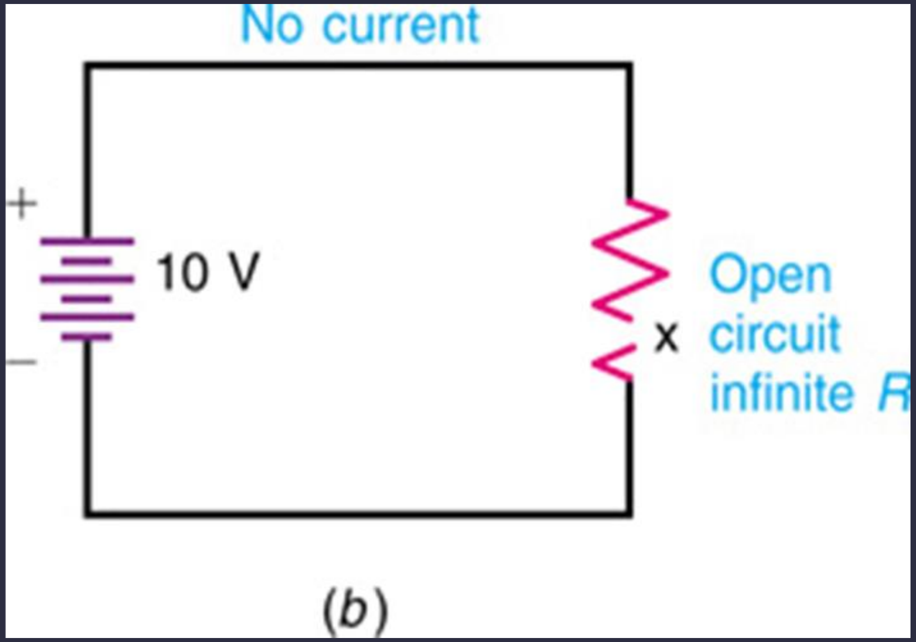
$$P = I^2R = 25 \times 4 = 100 \text{ Watts}$$

$$P = \frac{V^2}{R} = \frac{400}{4} = 100 \text{ Watts}$$

Open-Circuit and Short-Circuit Troubles

An open circuit has zero current flow.





Open-Circuit and Short-Circuit Troubles

A short circuit has excessive current flow.

As *R* approaches 0, *I* approaches ∞.