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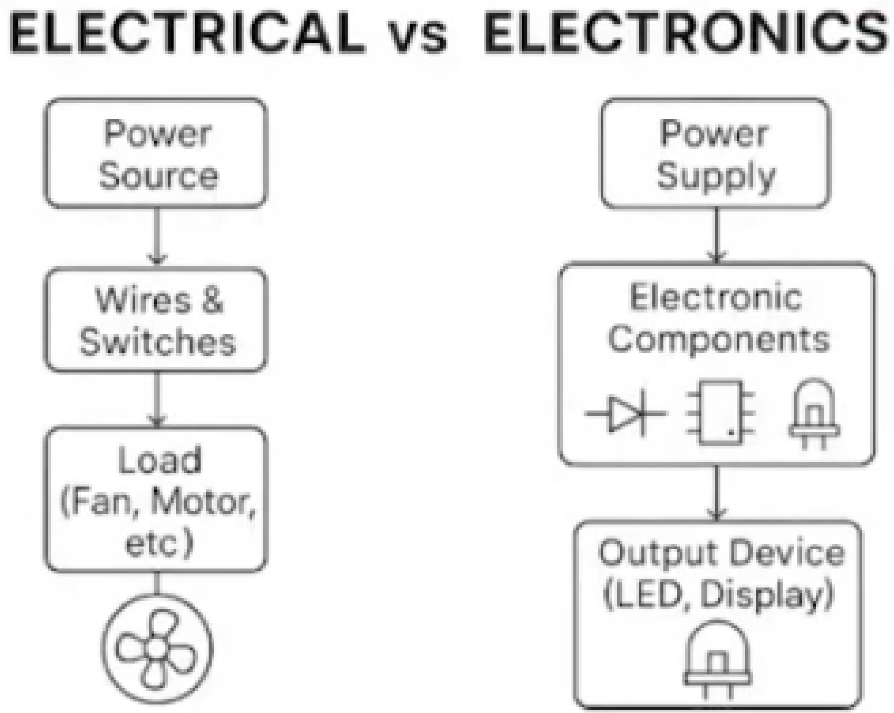
Bridge Class
(Fundamentals of Electrical & Electronics Engineering)

Dr. Vivek Upadhyaya
School of Electronics Engineering

Difference Between Electrical and Electronics



Examples for Electrical Appliances: Ceiling Fan, Electric Iron, Water Heater (Geyser), Washing Machine (basic models), Refrigerator (compressor unit), Air Conditioner (compressor unit), Vacuum Cleaner, Drilling Machine, Table Lamp, Electric Kettle, etc.

Examples for Electronic Appliances: Smartphone, Laptop, Television, Microwave Oven, Remote Control, Digital Camera, DVD Player, Set-Top Box, Smart Watch, Gaming Console, Home Automation System, Digital Thermostat, Bluetooth Speaker, Wi-Fi Router, Calculator, etc.

Difference Between Electrical and Electronics

Feature	Electrical	Electronics
Definition	Deals with generation, transmission, and distribution of electric power	Deals with the control and processing of electrical signals
Current Type	Mostly AC (Alternating Current)	Mostly DC (Direct Current)
Frequency	Works at low frequencies (typically 50/60 Hz)	Works at high frequencies (up to GHz range)
Power Level	High power (watts to megawatts)	Low power (milliwatts to watts)
Signal Type	Power signals	Information/control signals
Components	Generators, transformers, motors, switches	Diodes, transistors, ICs, microcontrollers
Applications	Power grids, home wiring, industrial motors	Mobile phones, computers, control systems
Control	Mechanical or electromechanical	Digital/analog signal processing
Example Devices	Ceiling fan, pump, electric heater	Smartphone, LED TV, remote control

Application Areas of Electronics

- Consumer Electronics
- Communication Systems
- Computing and Information Technology
- Industrial Automation and Robotics
- Medical Electronics
- Automotive Electronics
- Defense and Aerospace
- Energy and Power Systems
- Smart Systems and IoT
- Education and Research

Classification of Materials

◆ CLASSIFICATION OF MATERIALS

- ◆ Based on Electrical Properties
  - Conductors
  - Semiconductors
  - Insulators
- ◆ Based on Mechanical Properties

  Ductile
  Brittle
  Malleable
  Hard
  Tough

- ◆ Based on Magnetic Properties

  Ferromagnetic
  Paramagnetic
  Diamagnetic

- ◆ Based on Physical state

  Solids
  Liquids
  Gases

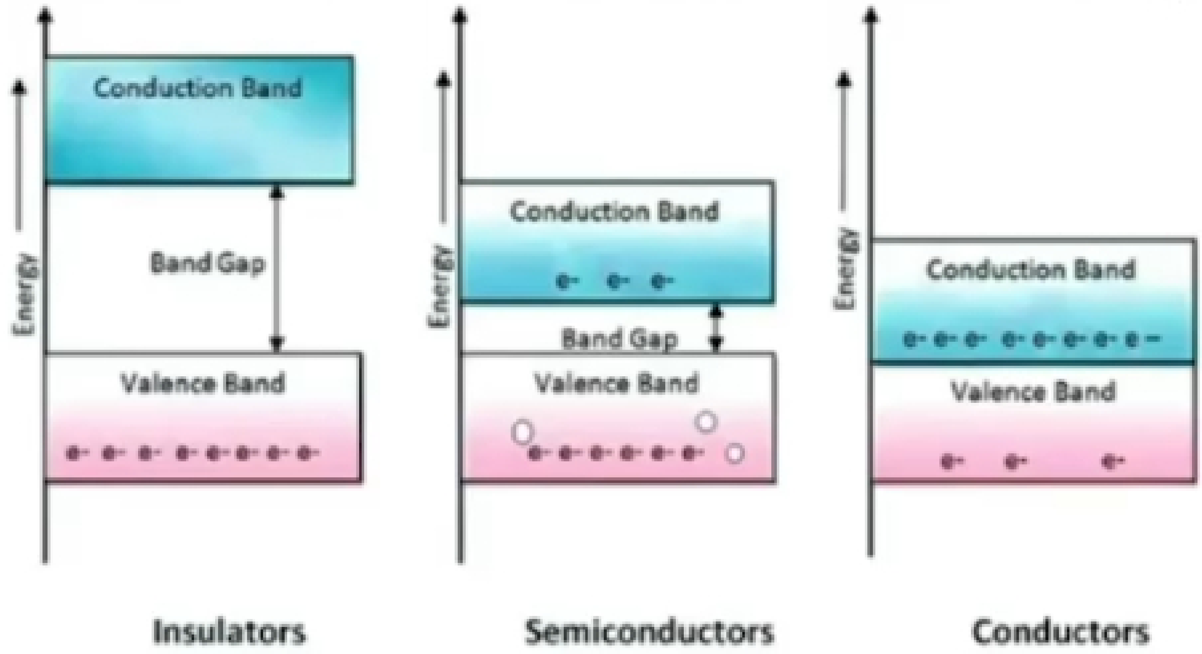
- ◆ Based on Physical state
  - Crystalline
  - Amorphous
- ◆ Based on Naturalmaterais

  Synthetic (man-made) materials

- ◆ Based on Composition
  - Metals
  - Non-metals
  - Alloys
  - Polymers
  - Ceramics
  - Composites

Conductors, Semiconductors, and Insulators

- **Conductors:** Materials that allow electric current to flow easily due to free electrons.
- **Semiconductors:** Materials with conductivity between conductors and insulators, controllable by temperature or doping.
- **Insulators:** Materials that resist the flow of electric current due to tightly bound electrons.



Conductors, Semiconductors, and Insulators (Diff.)

Property	Conductors	Semiconductors	Insulators
Electrical Conductivity	Very high	Moderate (between conductors and insulators)	Very low
Band Gap	No or negligible band gap	Small band gap (~1 eV)	Large band gap (>5 eV)
Examples	Copper, Silver, Aluminum	Silicon, Germanium	Rubber, Glass, Plastic
Electron Movement	Free electrons move easily	Electrons move under certain conditions	Electrons are tightly bound
Temperature Effect	Resistance increases with temperature	Conductivity increases with temperature	Almost no effect on conductivity
Use	Wires, cables, electrical parts	Diodes, transistors, ICs	Insulating coverings, support materials

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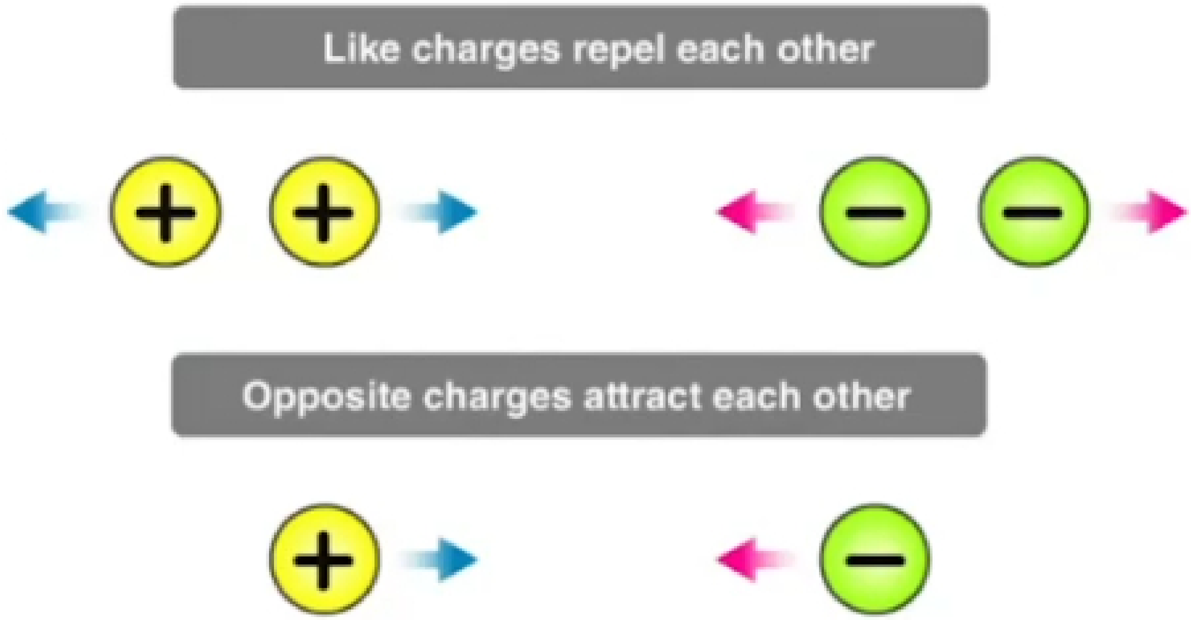
Electric Charge

Electric charge is a fundamental property of matter that governs how objects interact through the electromagnetic force

- Electric charge types: **positive and negative charges.**
- **Coulomb** is the unit of electric charge.



What is Electric Current?

Electric current is the flow of electric charge (usually electrons) through a conductor, such as a wire.

Symbol: I
SI Unit: Ampere (A)

Formula:
$I = Q / t$
Where: I = current, Q = charge (in coulombs), t = time (in seconds)

Types of Current:
- Direct Current (DC): Flows in one direction (e.g., batteries)
- Alternating Current (AC): Changes direction periodically (e.g., household supply)

Example:
A current of 1 ampere means 1 coulomb of charge passes through a point in 1 second.

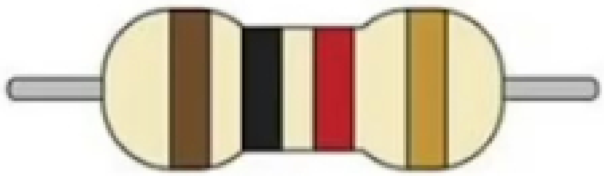
Resistance (R)

Resistance is the opposition offered by a material to the flow of electric current.

Resistor

Symbol: R
Unit: Ohm (Ω)

Factors affecting resistance:
- Material
- Length ($R \propto L$)
- Cross-sectional Area ($R \propto 1/A$)
- Temperature



Capacitance (C)

Capacitance is the ability of a system to store electric charge

Symbol: C

Unit: Farad (F)

Formula:

$C = Q / V$

Here:

C = capacitance, Q = charge, V = potential difference

Used in filtering, energy storage, and tuning circuits.

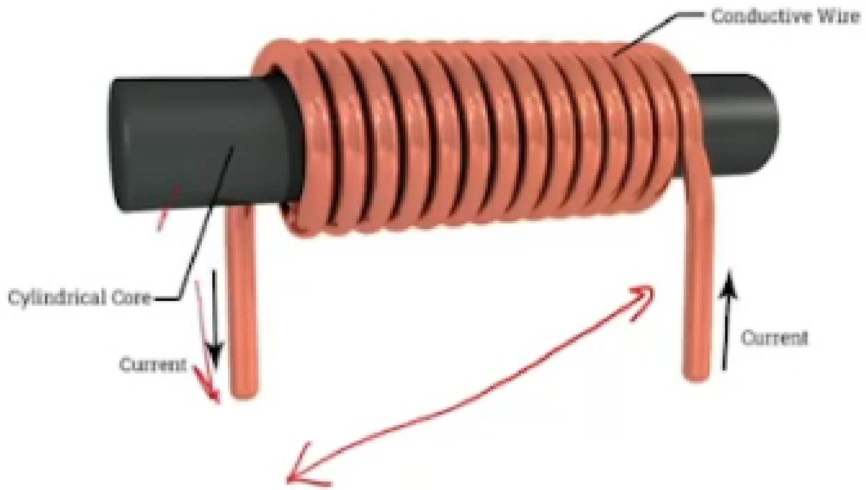
R, C, L

Inductance (L)

Inductance is the property of a conductor by which a change in current induces an electromotive force (EMF).

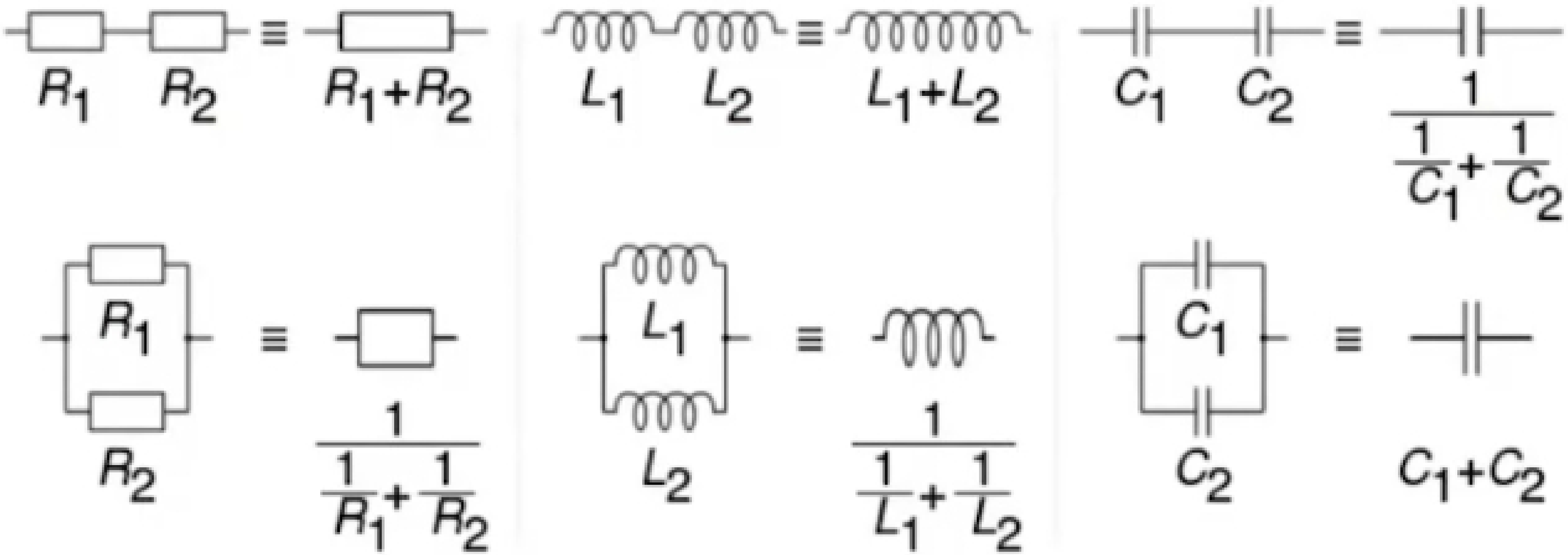
Symbol: L
Unit: Henry (H)

Formula:
$V = L\,(dI/dt)$



Used in transformers, motors, and filters.

Series and Parallel Combinations of R, L, & C



Series and Parallel Combinations of R, L, & C

✅ Resistance (R)

Configuration	Total Resistance Formula	Current	Voltage
Series	$R_{eq} = R_1 + R_2 + \cdots + R_n$	Same through all resistors	Divided
Parallel	$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$	Divided	Same across all resistors

✅ Capacitance (C)

Configuration	Total Capacitance Formula	Voltage	Charge
Series	$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n}$	Divided	Same on all capacitors
Parallel	$C_{eq} = C_1 + C_2 + \cdots + C_n$	Same across all capacitors	Divided

Series and Parallel Combinations of R, L, & C

✅ Inductance (L)

Configuration	Total Inductance Formula	Current	Voltage
Series	$L_{eq} = L_1 + L_2 + \cdots + L_n$	Same through all inductors	Additive
Parallel	$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \cdots + \frac{1}{L_n}$	Divided	Same across all inductors

Key Points:

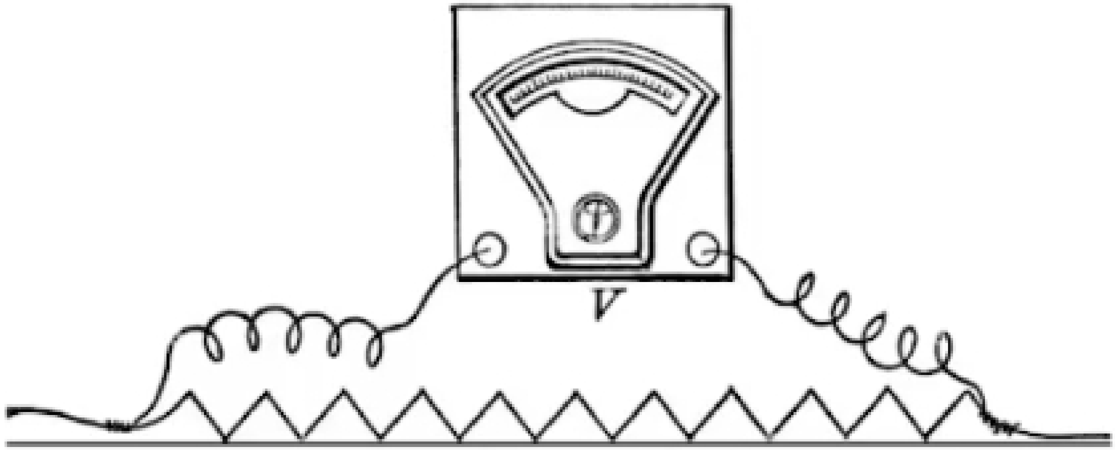
- Resistance adds in series, conductance adds in parallel.
- Capacitance adds in parallel, inverse adds in series.
- Inductance adds in series, inverse adds in parallel (like resistance).

Potential and Potential Difference

Electric potential is the amount of electric potential energy per unit charge at a point.

Potential Difference is the work done to move a unit charge between two points.

Unit: Volt (V)



Formula:
$V = W / Q$

Here:

V = potential difference, W = work done, Q = charge

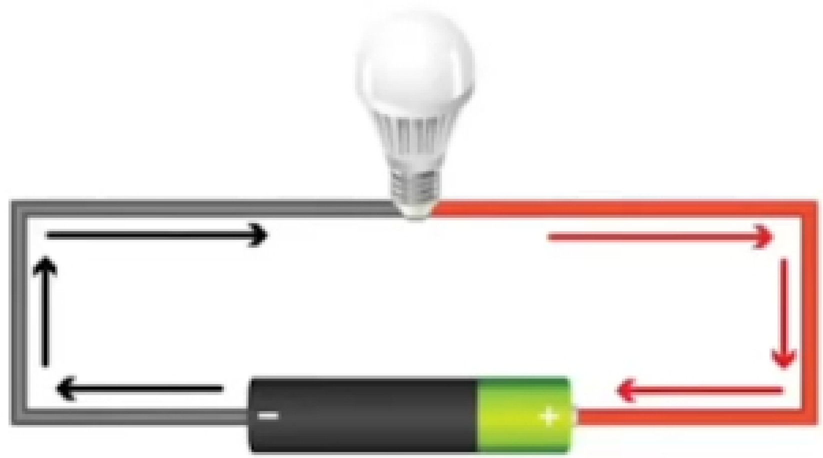
Voltage

Voltage is the measure of electric potential difference between two points.

Symbol: V
Unit: Volt (V)

It drives the electric current through a circuit.

Sources: Batteries, generators, power supplies.



Power

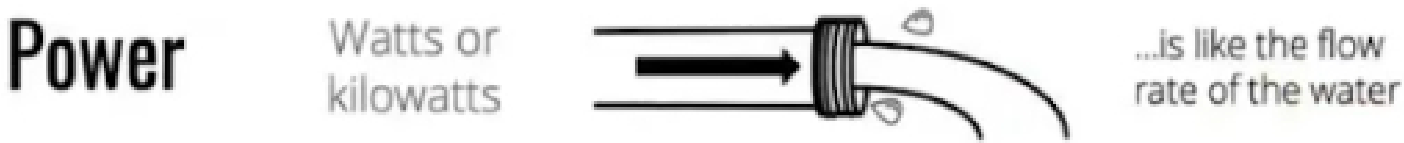
Electric power is the rate at which electrical energy is consumed or generated.

Symbol: P

Unit: Watt (W)

Formulas:

$P = VI$
$P = I^2R$
$P = V^2 / R$

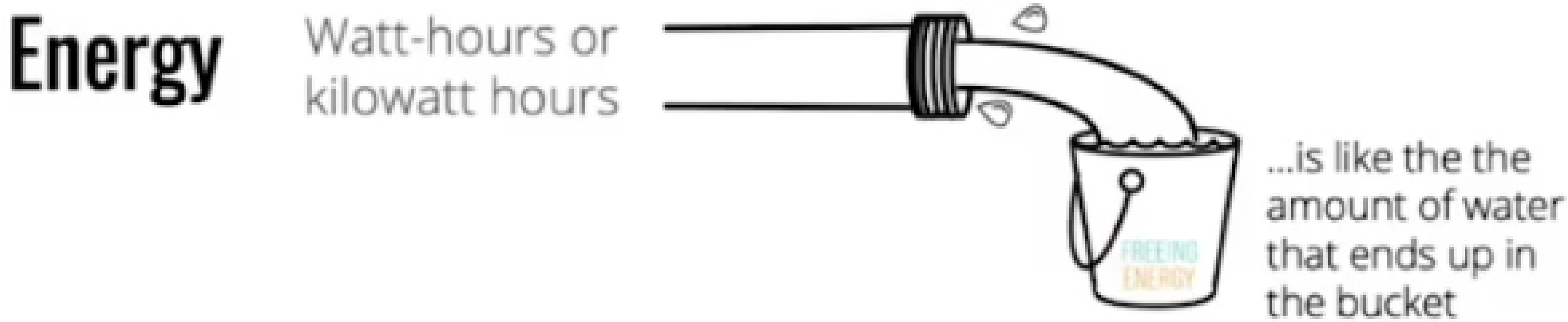


Energy

Electric energy is the total work done by an electric current in a given time.

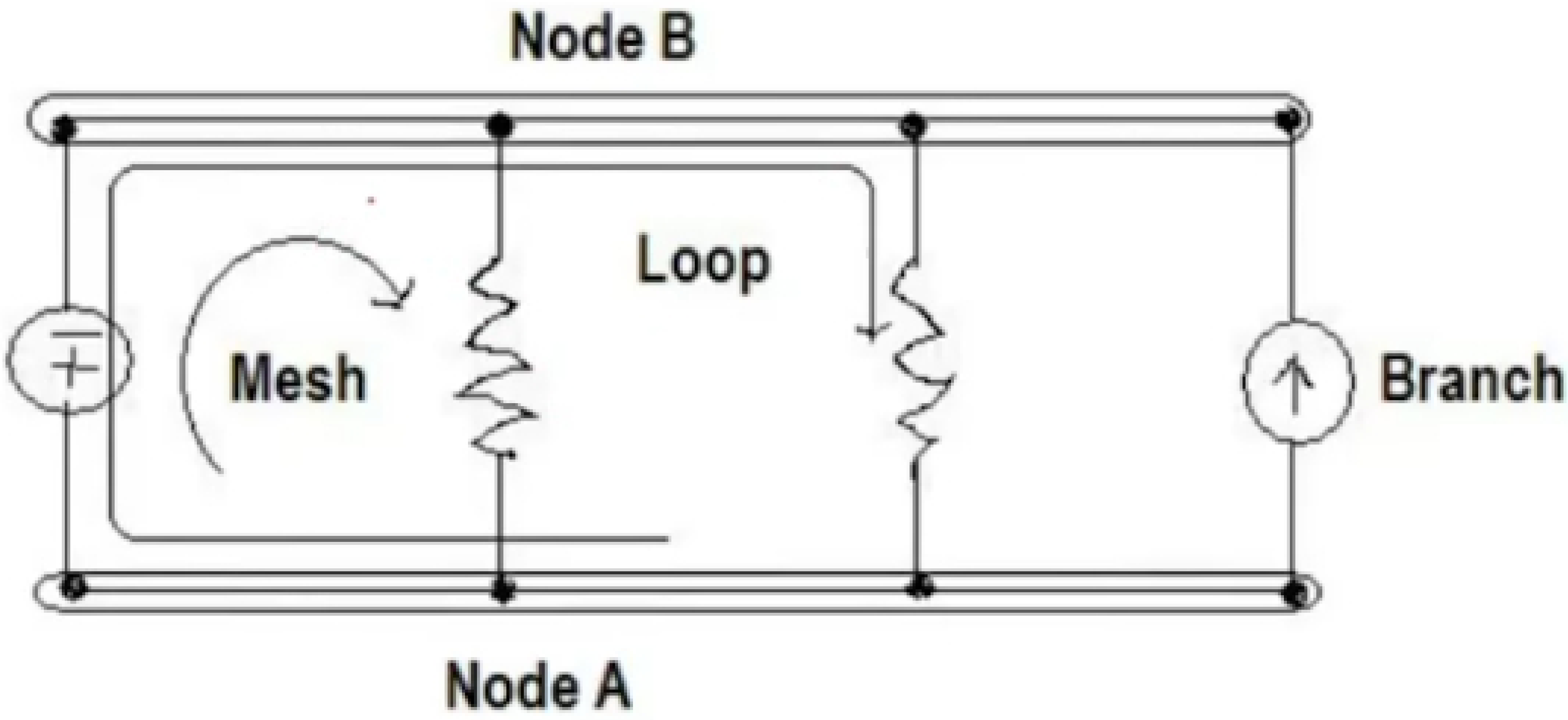
Symbol: E
Unit: Joule (J) or kilowatt-hour (kWh)
Formula:

$E = P \times t$
Used in measuring electricity consumption in households and industries.



Electric Circuit

- A **loop** is any **closed path** in a circuit. It **starts and ends at the same node** and may include several meshes.
  - A loop **can contain multiple meshes**.
  - Every mesh is a loop, but not every loop is a mesh.
- A **mesh** is a special type of loop — it is the **smallest possible closed loop** that **does not enclose any other loop** inside it.
  - Meshes are used in **Mesh Analysis** (Kirchhoff's Voltage Law).
  - Meshes help to simplify complex circuits into solvable equations.
- A **node** is a **point where two or more circuit elements connect**.
  - Used in **Node Voltage Analysis** (Kirchhoff's Current Law).
  - A node can be a **junction point** for multiple components.


Node B
Loop
Mesh
Branch
Node A

Classification of Circuits Components

Feature	Active Components	Passive Components
Power Requirement	Needs external power	No external power needed
Signal Amplification	Yes	No
Energy Control	Controls electron flow	Cannot control the flow
Function	Amplify, switch, generate	Store, resist, filter
Example	Transistor, IC, Diode	Resistor, Capacitor, Inductor

Ohm's Law

Georg Simon Ohm

- Discovered in 1825
- Relates 3 key quantities in electrical circuits
- Voltage (V)
- Current (I)
- Resistance (R)

$$V = I \times R$$

Voltage = Current x Resistance

In scientific units: Volts = Amperes x Ohms

Think of the voltage as the FORCE that is DRIVING the total electrical flow rate (current), *against* the resistance encountered in a portion of an electrical circuit.

In scientific units: Volts = Amperes x Ohms

Alessandro Volta
1745 - 1827

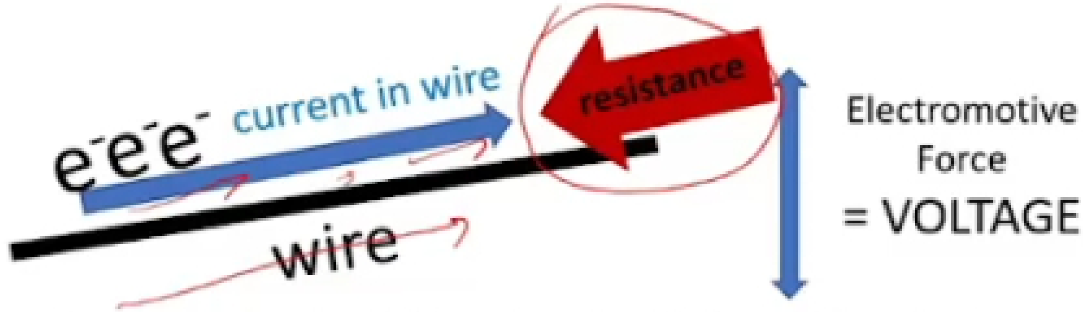
Andre-Marie Ampere
1775 - 1836

Georg Simon Ohm
17889 - 1854

Ohm discovered the merger

Voltage = (electrical) Current x (electrical) Resistance

Compare to pushing or cycling a bike up a hill



1) The force is your capacity for work to push or cycle the bike (or to 'drive' it); **that is like the Voltage in a circuit.**

2) The **resistance** is like the friction force on the tyres, the stiffness of the bike components, and the steepness of the hill; **all these factors work together to determine the rate of progress for a given force.**

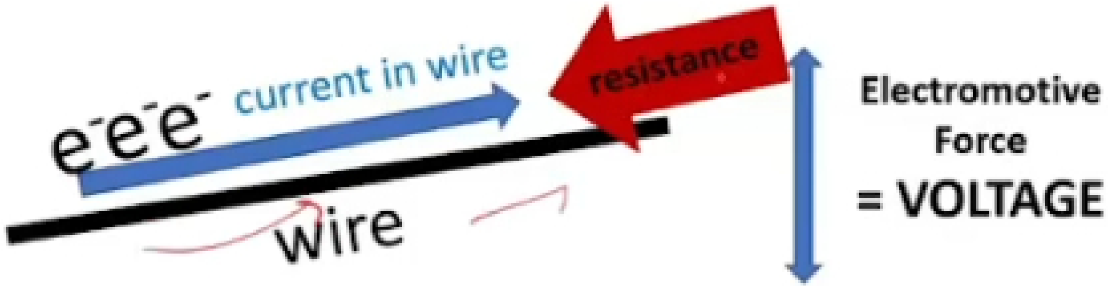
3) **The rate of progress (up the hill) – is similar to the "current" in a circuit**, which measures the total passage of electricity in a given time through a particular point.

Ohm’s Law

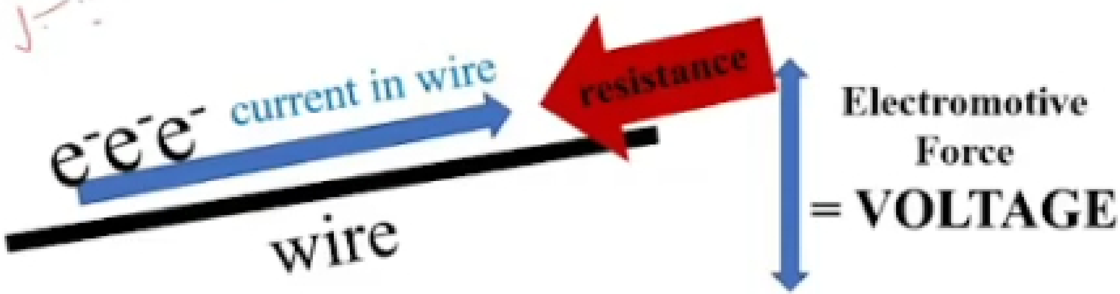
$$V = I \times R$$

$$\textit{Voltage} = \textit{Current} \times \textit{Resistance}$$

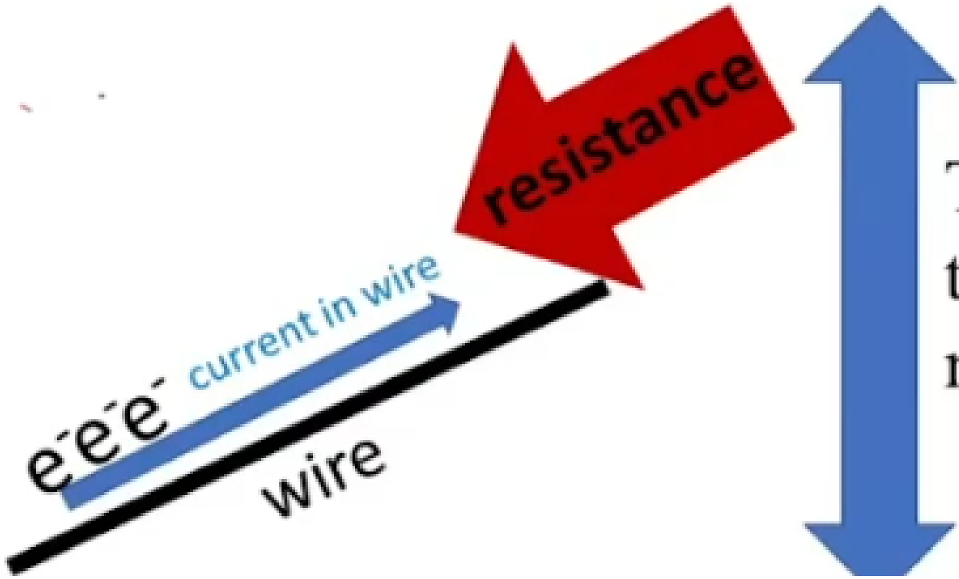
e^- = an electron, the basic physical unit of a current.



Suppose a wire has twice the resistance



Doubling the resistance of the circuit wire will mean twice the electromotive force (voltage) required to drive the same current through the circuit.



The greater the electrical resistance, the greater the applied voltage V needs to be to drive the same current I

Ohm's Law in practice

- A wire is a fixed material, so:
- Usually, the resistance of a wire does not vary
- So the value of 'R' in the equation V = I x R is fixed in practice.
- What is varied is the Voltage, V
- As the Voltage is increased, the current increases

V = I x R
Voltage = Current x Resistance
In scientific units:
Volts = Amperes x Ohms

Volts / Ohms = Amperes

Rearranging the equation to **express** the fact that ***voltage drives the change in current:***

Divide both sides by the 'constant' resistance:
V / R = I x R / R = I
Voltage / Resistance = Current

Kirchhoff’s Law

- Kirchhoff’s Voltage Law (KVL)
- Kirchhoff’s Current Law (KCL)