



# Introduction

## Electrical & Electronic Circuits and Elements

Embedded Systems & Embedded Programming

# Fundamentals of Electricity

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❖ **Electricity** is briefly defined as the flow of **electric charges**

❖ **Electric charge (Q)**

- Is a fundamental property of matters, like mass
- Causes matters to experience a force when they are placed in an electromagnetic field
- The smallest amount of charge that exists is the charge carried by an electron ( $1.602 \times 10^{-19} \text{ C}$ )
- Is measured in coulombs (C)
  - The coulomb is defined as the **quantity of charge** that flows through the cross section of an electrical conductor carrying one **ampere** for one **second**.  $1 \text{ C} = 6.241 \times 10^{18}$  charges
- Exists in **positive** (+) or **negative** (-) forms

# Fundamentals of Electricity (Charge)

❖ Charges are carried by electrons and protons

➤  $q_e = -1.602 \times 10^{-19} \text{ C}$  and  $q_p = +1.602 \times 10^{-19} \text{ C}$

❖ Electrostatic force (**Coulomb's law**)

➤ Is the force that operates between charges

➤ Opposites attract and likes repel

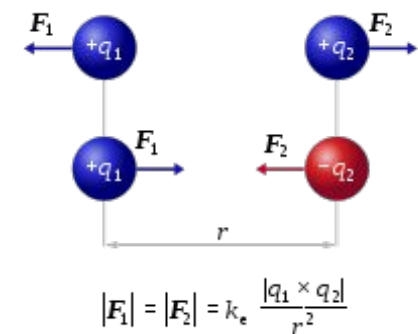
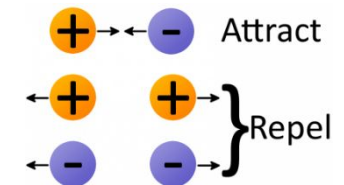
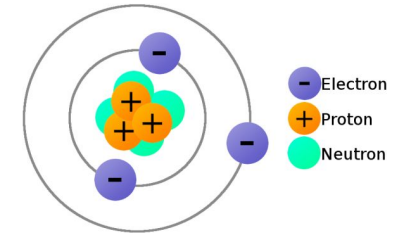
■ e.g. electrons will push away other electrons and be attracted to protons

➤ The amount of the force depends on how far they are from each other

➤ The closer two charges get, the greater the force becomes

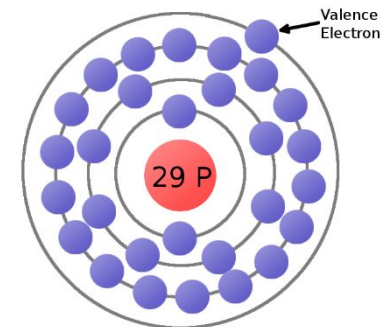
➤ Is one of those forces that hold atoms together

➤ But it can also make electrons (and charges) flow!!

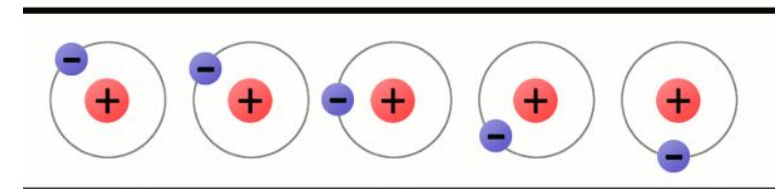


# Fundamentals of Electricity (Charge Flow)

- ❖ The outermost electrons of an atom are called the **valence** electrons
- ❖ **Valence** electrons require the least amount of force to be freed from an atom
- ❖ By applying enough electrostatic force on a valence electron we can free it
  - Pushing it with another negative charge
  - Attracting it with a positive charge
- ❖ A free electron in the space between atoms
  - Eventually finds a new atom to latch on to
  - And its negative charge ejects another valence electron from the atom
  - This chain effect creates the flow of electrons (charges)
  - And the flow of charges is **CURRENT**



The Bohr model of an atom of copper



# Fundamentals of Electricity (Conductivity)

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- ❖ Some types of atoms are better than others at releasing their electrons
- ❖ Conductivity measures how tightly bound an electron is to an atom
- ❖ Conductors
  - Elements with high conductivity, which have very mobile electrons
  - Metals like copper, silver, and gold etc.
- ❖ Insulators
  - Elements with low conductivity that prevent the flow of electrons
  - Popular insulators include glass, rubber, plastic, and air
- ❖ Semiconductors
  - Have a conductivity between conductors and insulators
  - Let electrons flow under certain conditions



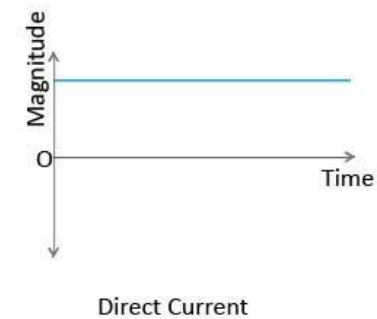
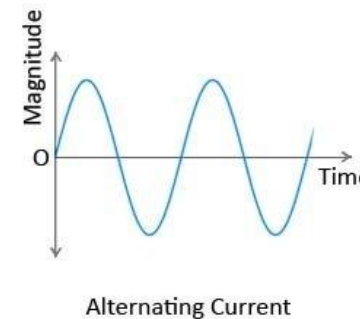
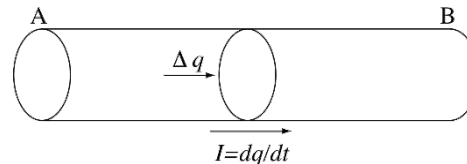
[What is Electric Charge and How Electricity Works](#)

# Fundamentals of Electricity (Current)

- ❖ In order to flow charges, current, a circuit is required
- ❖ A circuit is a closed, never-ending loop of conductive material
- ❖ Current is defined as the rate of flow of charges through a predetermined area of a conductor (Amount of charge per second)
- ❖ Current unit is **ampere** or **C/sec**
- ❖ Can be measured by Multimeters (series connected)
- ❖ It can be in AC (Alternating Current) or DC (Direct Current) forms
  - DC current has a constant value
  - AC current has a value that changes sinusoidally



[Basic Electricity - What is an amp?](#)

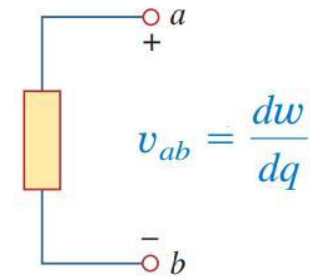




# Fundamentals of Electricity (Voltage)

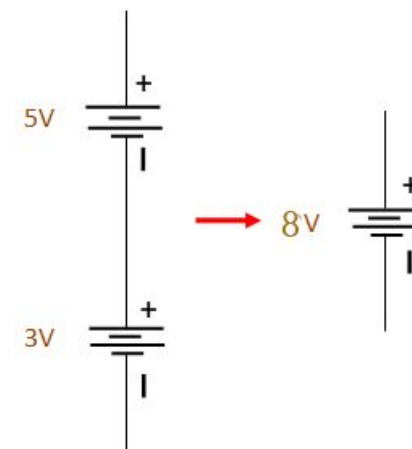
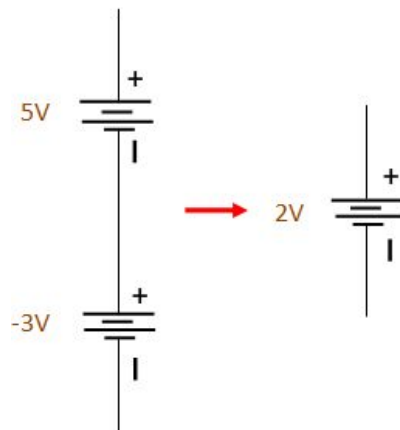
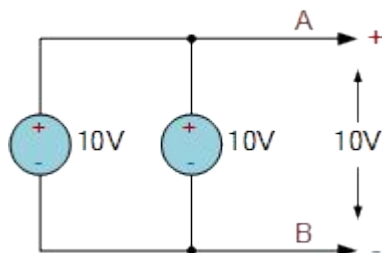
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- ❖ Moving charge in a direction between two points in a circuit, takes some energy
- ❖ **Voltage** (potential difference) is the energy required to move a unit charge through an element
  - Measured in **volts (V)** or **joule (J) / coulomb (C)**
- ❖ A **voltage source** raises the electrical potential of the charged particles
  - So charges can move in the circuit
- ❖ A constant voltage is called a **DC voltage** and is represented by **V**
- ❖ A sinusoidally time-varying voltage is called an **AC voltage** and is represented by **v**
- ❖ Voltage is always relative
  - Is measured between two points
  - A point in the circuit should be used as **reference voltage** (like ground; **GND**)



# Fundamentals of Electricity (Voltage)

- ❖ It can be measured by multimeters and oscilloscopes (parallel connected)
- ❖ Series connection of voltage sources
- ❖ Parallel connection of voltage sources
- ❖ Polarities matter



[Basic Electricity - What is voltage?](#)



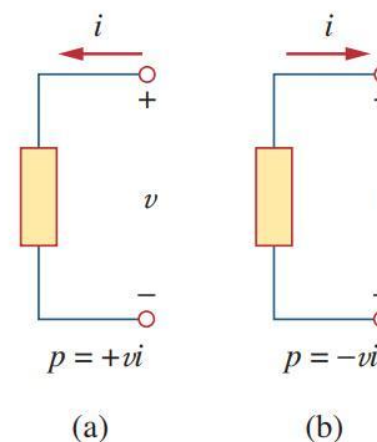
# Fundamentals of Electricity (Power)

- ❖ Power is the time rate of generating or consuming energy
- ❖ Measured in **watts (W)** or **joules (J) / seconds (s)**

$$p = \frac{dw}{dt}$$

$$p = \frac{dw}{dt} = \frac{dw}{dq} \cdot \frac{dq}{dt} = vi$$

$$p = vi$$



Reference polarities for power using the passive sign convention: (a) absorbing power, (b) supplying power.



[Basic Electricity - Power and watts](#)

# Fundamentals of Electricity

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## ❖ Some useful links

- [What is Electricity?](#)
- [Coulomb's Law | Electronics Basics](#)
- [Electric Field | Electronics Basics](#)
- [Electric Potential and Electric Potential Difference \(Voltage\) | Electronics Basics](#)
- [Electric Circuits: Basics of the voltage and current laws](#)
- [Battery Energy and Power](#)