Introduction

About Electrical Engineering: Branch of engineering concerned with design of electrical/electronic systems/processes.

Engineering: Discipline concerned with design of systems/processes:
- Electrical
- Mechanical
- Chemical
- Civil
- Aerospace
- Industrial
- Nuclear
- Biomedical
- Software

Electrical systems: manage energy (generation, transmission, distribution, consumption)
Electronic systems: manage information (gather, store, communicate, analyze)

Subdisciplines of Elec. Eng.:
- power
- electronics/microelectronics/photronics
- communications
- electromagnetics
- signal processing
- controls
- computers/microprocessors.
Circuits, Currents, Voltages

. **Electrical circuits**: Electrical components connected together

- **Switch**
- **Battery**
- **Headlights**

**Current**: Rate of flow of charges; charges flow due to electrical field or force (opposites attract)

**Battery**: Converts chemical energy to electrical energy

- Has two electrodes (cathode & anode) connected by electrolyte

- **Cathode**: Cathode & electrolyte react to consume electrons (reduction) causing it to be +vely charged.
- **Anode**: Anode & electrolyte react to produce electrons (oxidation) causing it to be -vely charged.

 enorme

This process sets an electric field from cathode to anode that opposes further reduction of cathode / oxidation of anode, as this means the charge transfer from anode to cathode.

When cathode & anode are connected through a circuit, the charges move from cathode to anode along the circuit, reducing the in-built emf; so reduction/oxidation process can resume, separating more charges available for flow. Chemical energy is consumed in such separation and converted to electrical energy.

**Voltage**: The in-built electric field (emf) is quantified in Volts, which is the energy required to move a unit charge against the in-built field from anode to cathode. **Volts = Joules / Coulomb**

**Fluid flow analogy**: current = fluid flow rate

- voltage = pressure
- resistance = constriction

Current (charge flow rate): proportional to voltage (energy/charge) inversely proportional to resistance.
Circuit, current, voltage

\[ i(t) = \frac{dq}{dt} \quad \Leftrightarrow \quad q(t) = \phi(t) + \int_{0}^{t} i(t) \, dt \]

\[ \text{dc/}ac \text{ current: constant/} \text{changing current that reverse direction periodically.} \]

\[ \text{dc} = \text{direct current} \]
\[ \text{ac} = \text{alternating current} \]

\[ q(t) = \begin{cases} 
0 & t < 0 \\
2 - 2e^{-10t} & t \geq 0 
\end{cases} \quad \Rightarrow \quad i(t) = \begin{cases} 
0 & t < 0 \\
200e^{-10t} & t \geq 0 
\end{cases} \]

\[ \text{Similary dc/}ac \text{ voltage: constant/periodically reversing voltage} \]

\[ V_{ab} = V_a - V_b \quad \Rightarrow \quad V_{ab} = -V_{ba} \]

\[ \text{power:} \quad \text{power} = \text{voltage} \cdot \text{current} \]

\[ \text{Joules} \quad \text{Coulomb} \quad \text{time} = \frac{\text{Joules}}{\text{time}} = \text{Watts} \]

\[ p = V \cdot i \]

\[ \text{Example:} \]

\[ p = 24 \quad p = (12) \cdot (-1) = -12 \quad p = (12) \cdot (-3) = -36 \]

\[ \text{Energy:} \quad W = \int_{t_0}^{t_1} p(t) \, dt \quad \text{suppose} \quad V(t) = 12, \quad i(t) = 2e^{-t} \]

\[ \Rightarrow \quad p(t) = 24e^{-t} \]

\[ W = \int_{0}^{\infty} 24e^{-t} \, dt = 24 \left[ -e^{-t} \right]_{t=0}^{\infty} = 24 \left[ 0 - (-1) \right] = 24. \]