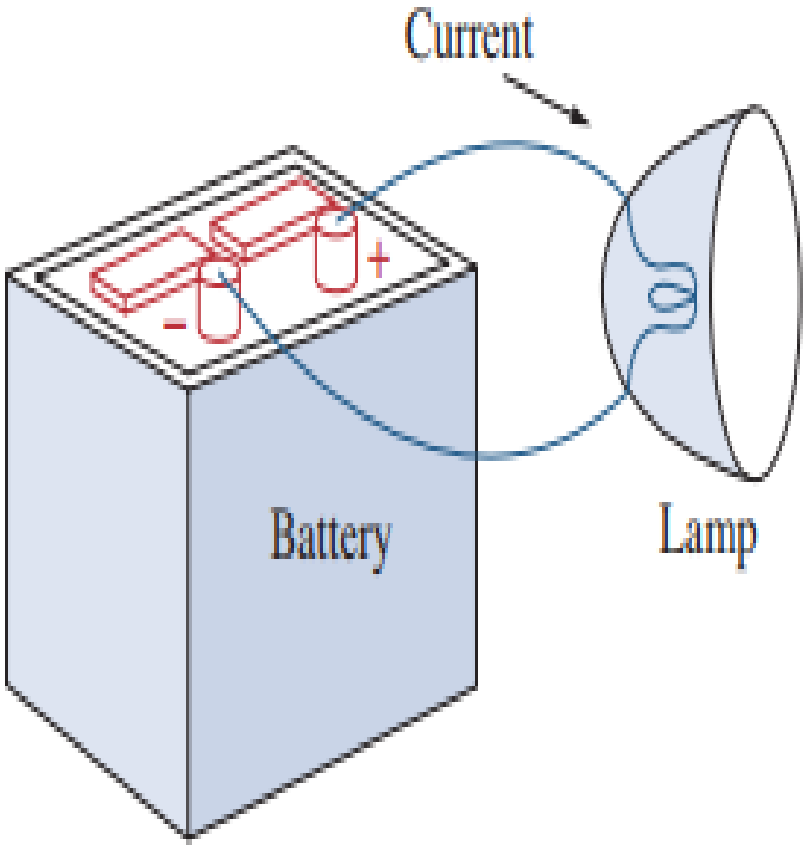
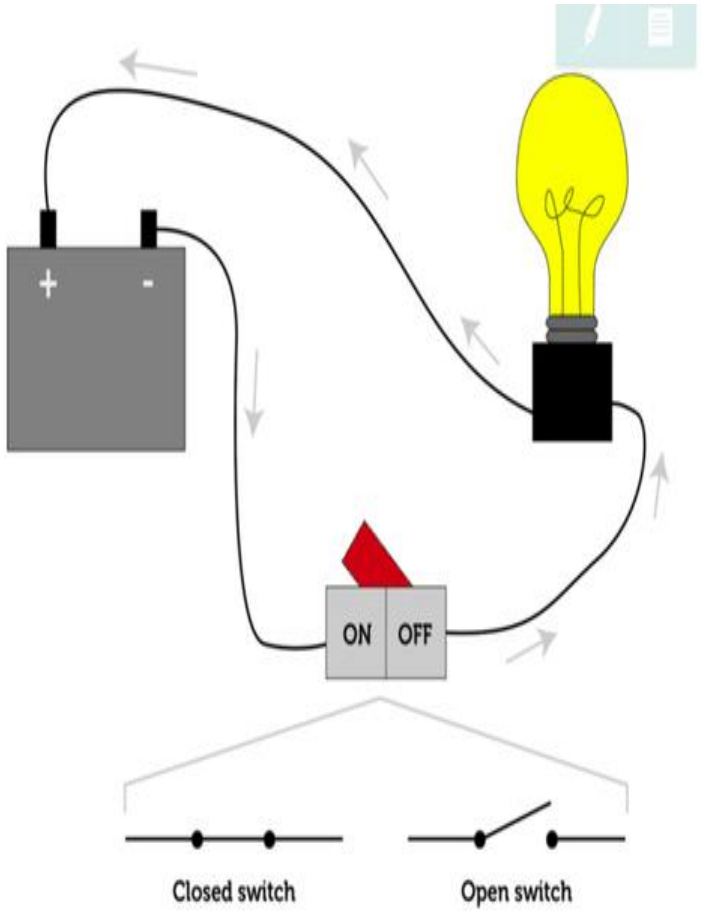
UNIT 1: DC CIRCUITS

Lecture 1

Prepared By:
Krishan Arora
Assistant Professor and Head

Electrical Circuit





Charge and Current

- Charge: Charge is an electrical property of the atomic particles of a matter.

  S.I Unit: Coulomb (C)

  Symbol: Q

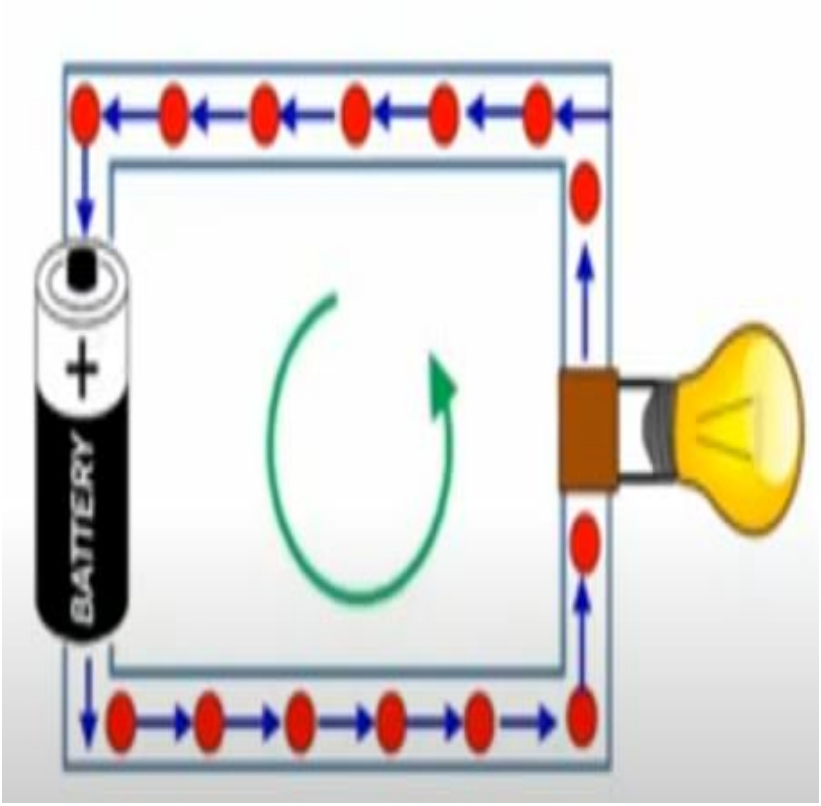
- Current: Rate of change of charge.

OR

Continuous flow of electrons in an electrical circuit.

S.I Unit: Ampere (A)

Symbol: I



Charge and Current

- Mathematically,

$$I = \frac{dQ}{dt} \; or \; Q = \int_{t_0}^{t} I.dt$$

Or, in simple terms:

$$I = \frac{Q}{T}$$

So, 1 Ampere = 1 coulomb/ 1 second.

QUICK QUIZ (Poll 1)

1 Coulomb is same as:

A. Watt /sec
B. Ampere/sec
C. Joule-sec
D. Ampere-sec

QUICK QUIZ (Poll 2)

Example: The total charge entering a terminal is given by $q(t)=5t\sin 4\pi t$ mC. Calculate the current at $t=0.5$s

A.31.42A
B.31.42mA
C.62.8mA
D.62.8A

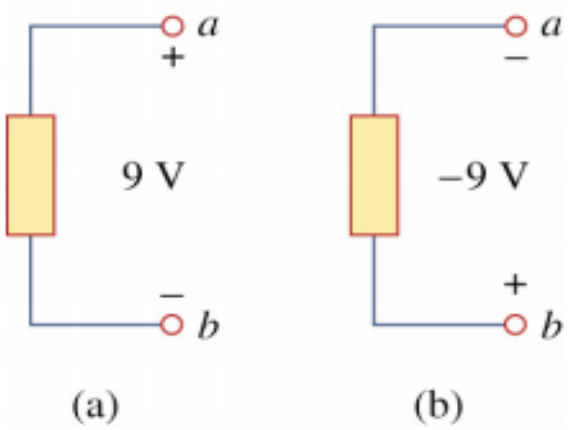
Explanation

$$i(t) = \frac{dq(t)}{dt} = \frac{d}{dt}(5t\sin 4\pi t) = (5\sin 4\pi t + 20\pi t\cos 4\pi t)\text{mA}$$

$$i(0.5) = 5\sin 2\pi + 10\pi\cos 2\pi = 31.42\text{mA}$$

Voltage

- To move an electron from point *a* to point *b*, external electromotive force (emf), typically a battery, is needed
- The voltage v_{ab} between two points *a* and *b* is the energy needed to move a unit charge from *a* to *b*
- Mathematically, $v_{ab} \triangleq \frac{dw}{dq}$
- 1 volt = 1 joule / coulomb
- Two equivalent representations:
  - Point *a* is v_{ab}=+9V above point *b*
  - Point *b* is v_{ba}=-9V above point *a*
  - In general, v_{ab}= -v_{ba}



Power and Energy

- Power: Rate at which the work is done.

OR

Time rate of absorbing or supplying energy

S.I Unit: Watts (W)

Symbol: P

Mathematically,

$$P = \frac{dW}{dt} = \frac{dW}{dq} \cdot \frac{dq}{dt} = V.I$$

Implies, $\boxed{P = V.I}$

Power and Energy

- Energy: Capacity of doing work.

  S.I Unit: Joules(J)

  Symbol: E

QUICK QUIZ (Poll 3)

Calculate the current ratings of 100 Watt incandescent bulb and 15 Watt LED lamp operated with the domestic supply of 220 Volt?

A. Bulb = 0.068 A and LED = 0.45 A
B. Bulb = 0.45 A and LED = 0.068 A
C. Bulb =0.50 A and LED = 0.068 A
D. Bulb = 0.50 and LED = 0.68 A

QUICK QUIZ (Poll 4)

From the previous question, it can be inferred that:

A. LED consumes 5 times more current than Bulb.
B. Bulb consumes 5 times more current than LED..
C. LED consumes 6.6 times more current than Bulb.
D. Bulb consumes 6.6 times more current than LED.

Network Components

- Passive elements: not capable of generating energy
  - e.g., resistors, capacitors, and inductors
- Active elements: capable of generating energy
  - e.g., generators, batteries, and operational amplifiers

Active

Battery

Transistor, Op-amp, etc

Passive

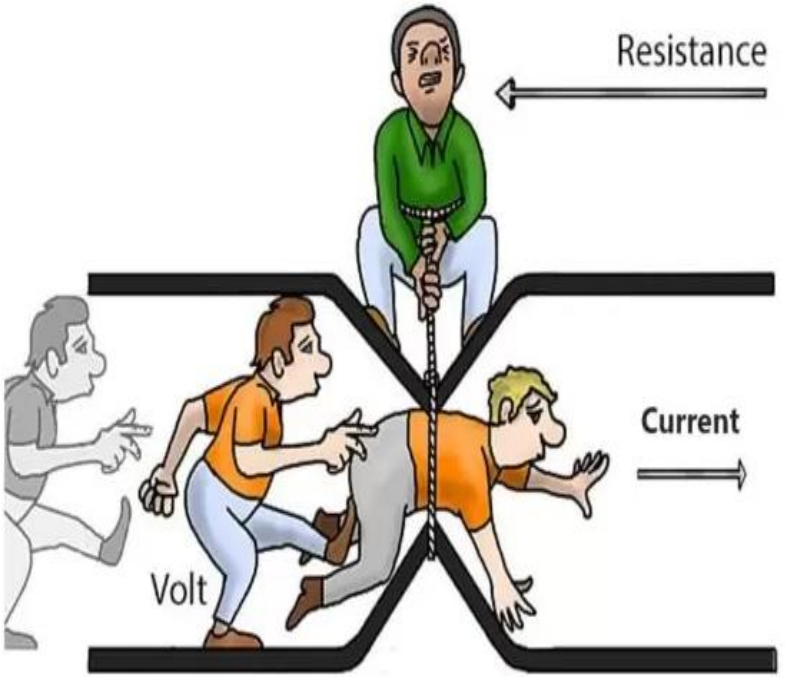
Resistance (R)
Capacitance (C)
Inductance (L)

Resistance

- Resistance: It is an opposition to the flow of current.

  S.I Unit: Ohm (Ω)

  Symbol: R



Capacitance

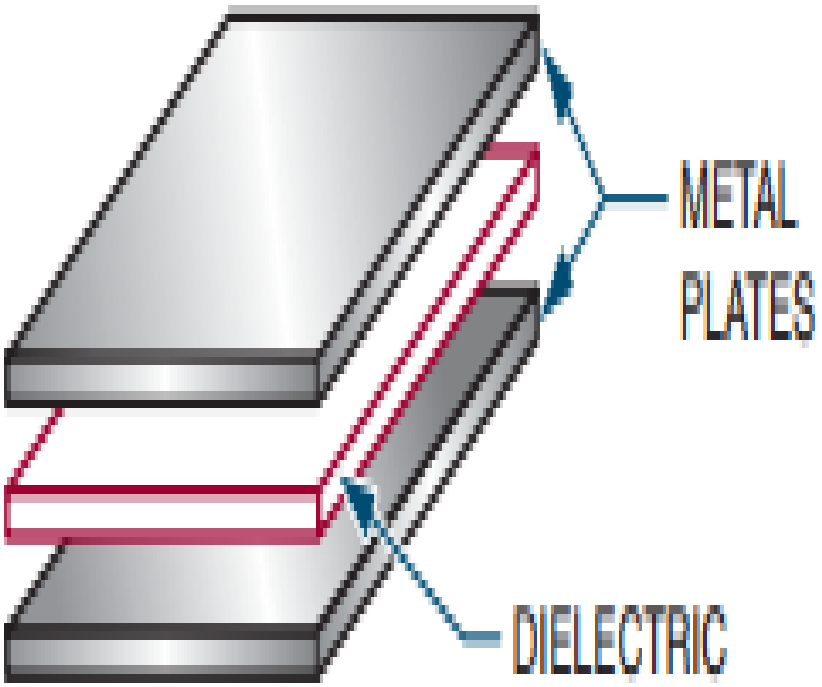
- Capacitance is the ability of a device to store electrical energy in an electrostatic field.
- A capacitor is a device that stores energy in the form of an electrical field..
- A capacitor is made of two conductors separated by a dielectric.

S.I Unit: Farad (F)

Symbol: C

Two important Properties:

1. No current flows through the capacitor, if the voltage remains constant.
2. Voltage across a capacitor cannot change instantaneously.



Inductance

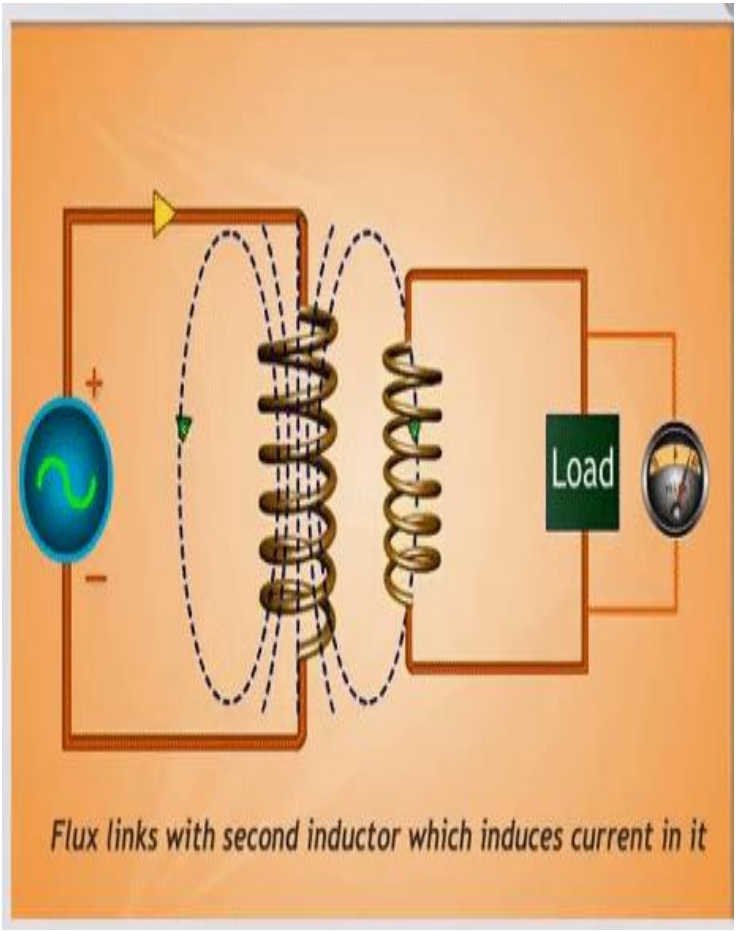
- Inductance is the characteristic of an electrical conductor that opposes a change in current flow.
- An inductor is a device that stores energy in a magnetic field.
- When a current flows through a conductor, magnetic field builds up around the conductor. This field contains energy and is the foundation for inductance

  S.I Unit: Henry (H)

  Symbol: L

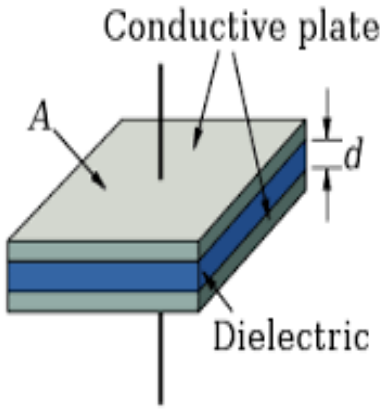
Two important Properties:

1. No voltage appears across an inductor, if the current through it remains constant.
2. The current through an inductor cannot change instantaneously.

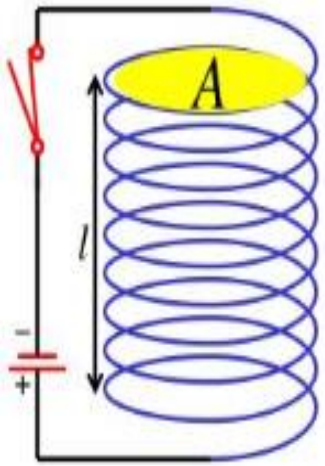


Capacitance and Inductance

- $Q = CV$
- $I = \frac{dQ}{dt} = \frac{d\ CV}{dt} = C\frac{dV}{dt}$
- $E = \frac{1}{2}CV^2$
- $C = \frac{A\in}{d}$



- $V = L\frac{dI}{dt}$
- $E = \frac{1}{2}LI^2$
- $L = \frac{\mu N^2 A}{L}$



QUICK QUIZ (Poll 5)

Identify the passive element

A. Battery
B. Transformer
C. Transistor
D. OP-amp
E. None of these

QUICK QUIZ (Poll 6)

Find the value of capacitance if the value of voltage increases linearly from 0 to 100 V in 0.1 s causing a current flow of 5 mA?

A. 10 μF

B. 5 F

C. 10 F

D. 5 μF