ESc201, Lecture 2: Components and circuits

There would be no Laboratory this week.

Tutorial on Th, Aug. 01 will not be held, instead, the tutorial is being converted to a regular class in the same L20

Reference Books:

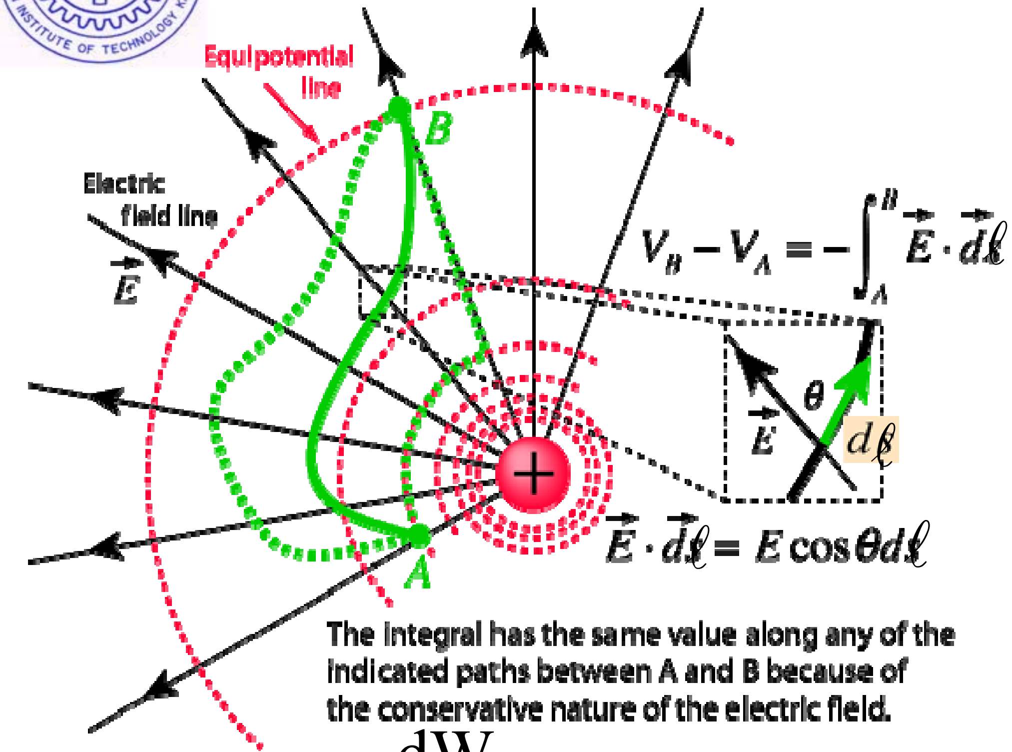
Foundations of Analog and Digital Electronic Circuits: Anant Agarwal and Jeffrey H. Lang, Dept. of EECS, MIT, Cambridge, MA, USA, Elsevier.

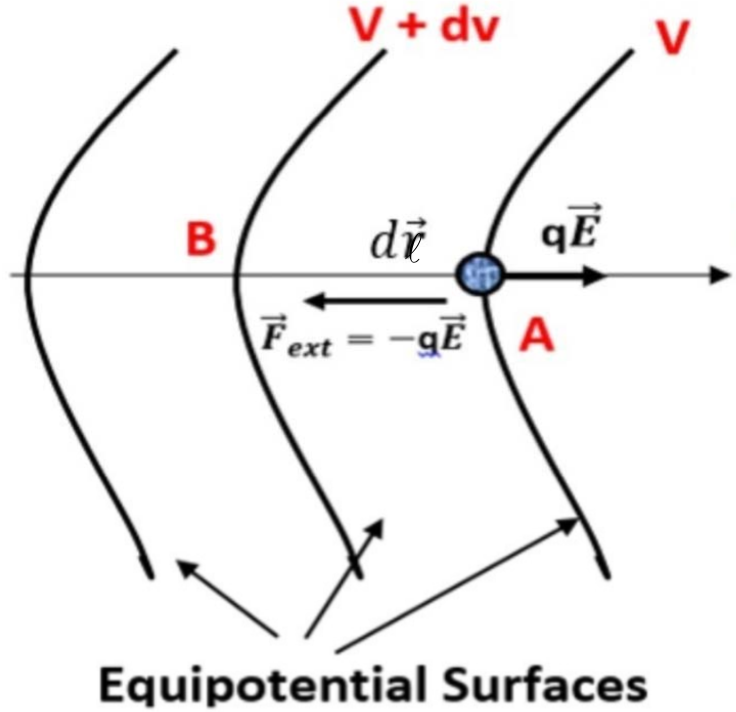
Engineering Circuit Analysis : W. Hayt, J. E. Kemmerly and S. M. Durbin, TATA McGraw Hill.

Digital Design : M. M. Mano, Ciletti, 4th edition, Pearson

Digital Principles and Applications: A.P. Malvino, D.P. Leach, 5th edition, Tata McGraw Hilll.

Potential (Voltage) difference.





$$\vec{F}_{ext} \bullet d\vec{\ell} = W = -q\vec{E} \bullet d\vec{\ell}$$

$$\frac{dW}{q} = -\vec{E} \bullet d\vec{\ell} = dV \qquad \text{or } \vec{E} = -\frac{dV}{d\vec{\ell}}$$

Voltage **(V_{AB})** ***(referred to as potential difference between A & B):***

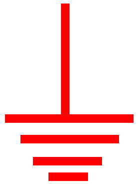
– Work done (or energy spent) to move a unit charge between these two points.

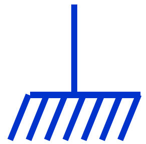
– (work done)/(unit charge) => 1 J/1 C = 1 V

If one of the points (say B) is at infinity then the potential is only V_A

Usual Reference nodes

- **Voltage is a *Scalar quantity: always measured with respect to* some reference. If not specified then it is infinity. But how is infinity obtained in a finite circuit?**
- **Ground (earth) is assumed to be an infinite conductor, all charges that goes to ground goes to infinity. Then take *ground to be (zero volt) Zero resistance* => *can absorb unlimited amount of* current without changing its potential**

Circuit symbol for ground 

Circuit symbol for body 

- **V_A being potential at A with respect to ground and V_{AB} the potential at A with respect to potential at B (All circuits must have a *reference point*)**
- **If the reference point is not explicitly shown, then any node can be taken as a reference point. (This is sometimes called body).** Small and portable appliances (cell-phones, ipods, etc.) do not have actual ground. They have something known as ***floating ground (also*** referred to as ***chassis ground)(body)***

Typically a line plate running at the periphery of the PCB. Floating ground apparatus are dangerous, since they may give electric shocks or get destroyed by electric electrostatic discharge (lightning) or in dry weather, as mentioned in Lec1.

– The equipments that you will be using in the lab will all have ***actual ground***

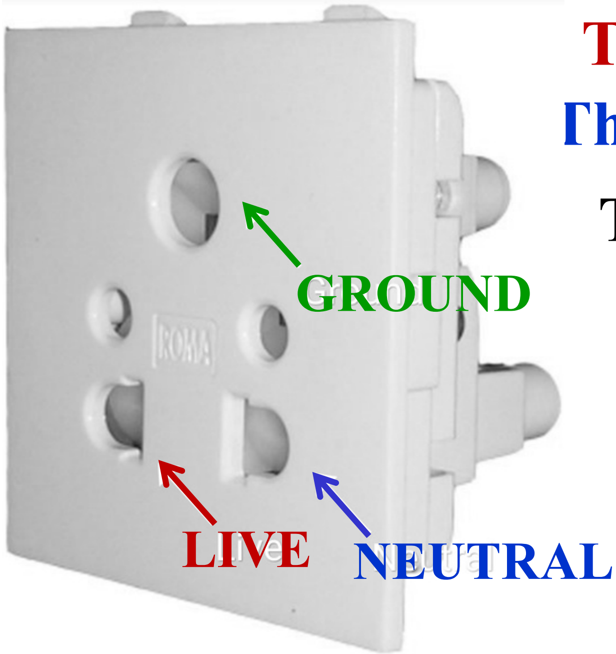
Actual Ground and Reference Ground:

• Power supply in your homes have a ground connection, so does all big electrical and electronic appliances

• 3-pin plugs: Live, Neutral, and Ground

• 2-pin: Only Live and Neutral (floating ground)

– Lightning arrester is a classic example of an actual ground



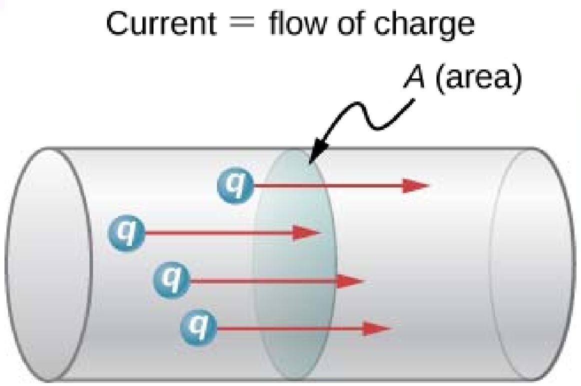
The LIVE wire is represented as BROWN.

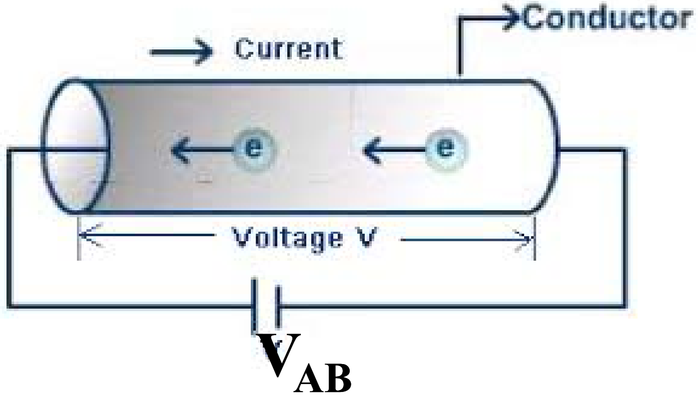
The NEUTRAL wire is represented as BLUE.

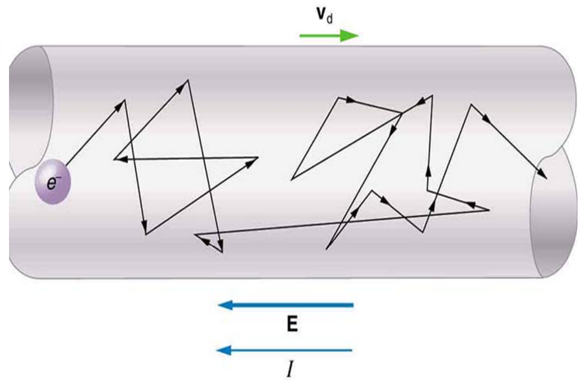
The EARTH wire is represented as GREEN & YELLOW

Current (Ampere)

UDas







- **By convention, positive direction of current is defined as the direction of flow of positive charges – Electrons flow opposite to the direction of current flow.**
- **For charges to flow between two points in a closed circuit, a potential difference must exist between these two points.**

Expressed as: $I = \Delta Q/\Delta t$ (1 Coulomb/ 1 sec = 1 Ampere)

– In the limit, as $\Delta t \rightarrow 0$, $I = dQ/dt$ (differential form)

If dQ/dt is constant => *direct current (dc)*

If dQ/dt exists but not constant at all time => *alternating current(ac)*

Note: 1 A of current implies about 10^{19} electrons flowing per second through a cross-sectional area.

How are current and voltage related?

The potential difference (voltage) across an ideal conductor is proportional to the current through it. i.e. V(t) = R.I(t) , where V(t) is the time dependent Voltage difference across the element and I(t) is the time dependent current through it.

This is a linear relationship.

The constant, R, *is called the resistance of the component and is measured in units of Ohm* (Ω).

Alternate form: I = GV, with G being the ***conductance of the resistor*** (G = 1/R)

– Current always flows from higher to lower potential

– The unit of **resistance is Ohm (Ω)**, while that of **conductance is Mho (℧)**.

Homogeneous linear functions: f(ax+bz)=af(x)+bf(z)

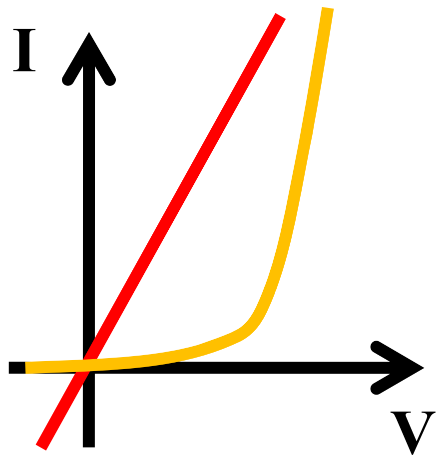
If y is x+a(x−z) then f(y) is f(x)+a(f(x)−f(z)).

OHM'S LAW

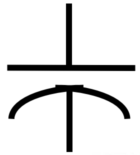
Georg Simon Ohm
1789-1854

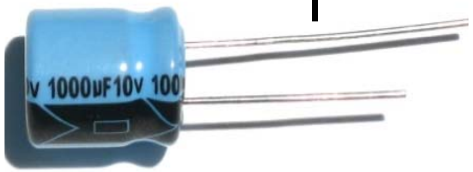
Circuit Symbol

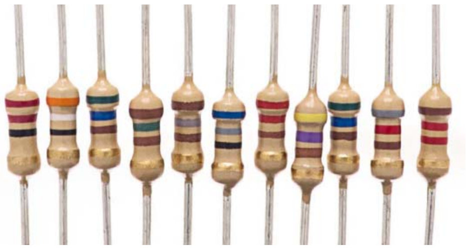
R

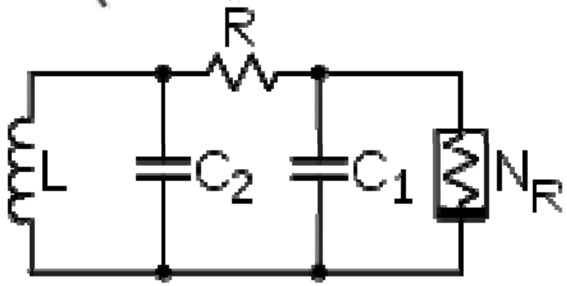


UDas



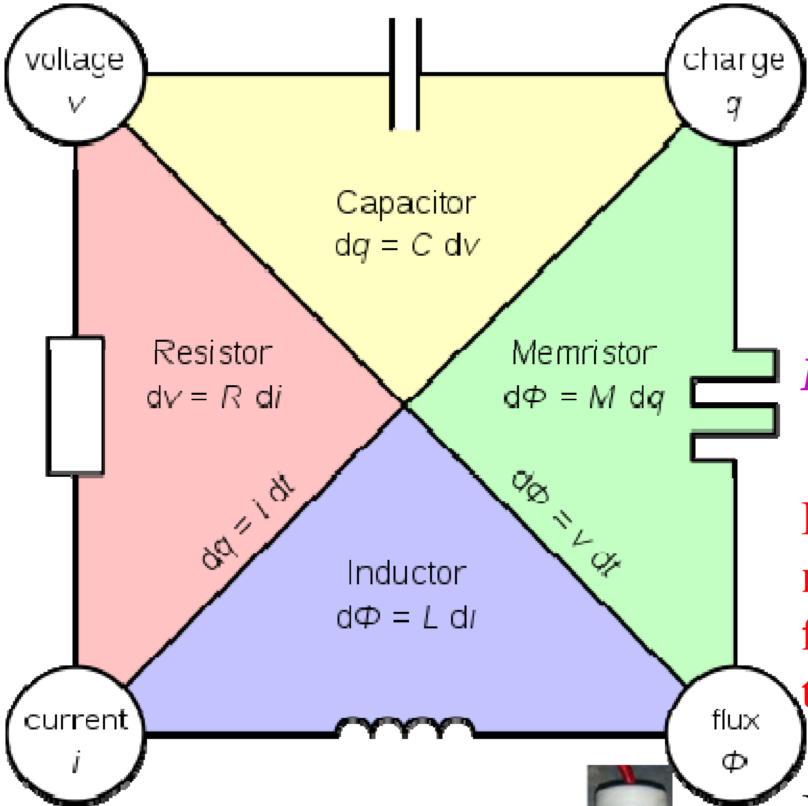






BBRoyGB

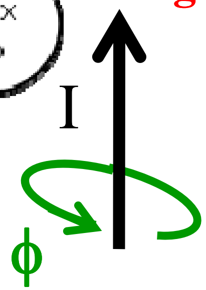
had a very G



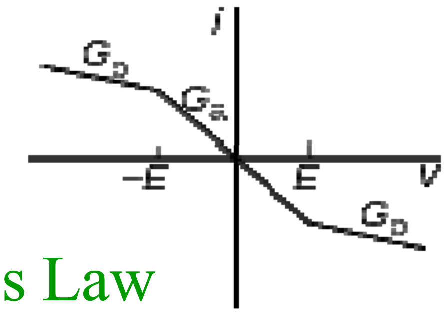
Memory resistor

1971 by circuit theorist Leon Chua

Resistance depends on how much electric charge has flowed in what direction through it in the past

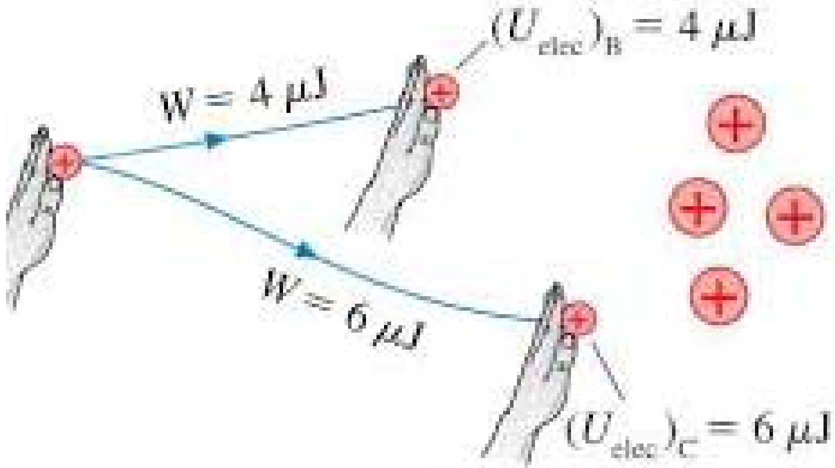


Ampere's Law



Work done/time – Power (P) [Watt]

The charge's electric potential energy at any point is equal to the amount of work done in moving it there from point A.



– **Defined as work done per unit time**

– **Thus,**

P = [(work done)/(unit charge)] x [(unit charge)/(unit time)] = voltage x current = VI

Unit of P is Joules/sec or Watt (W)

$$P(t) = \frac{dW}{dt} = \frac{dW}{dq}\frac{dq}{dt} = v(t)\,i(t)$$

$$W = \int_{t_1}^{t_2} P(t)\,dt$$

– **In an element, if the current flows from:**

• **lower to higher potential, then that element is *generating power i.e. Power (VI) is negative.***

• **higher to lower potential, then that element is *absorbing or dissipating power i.e. Power (VI) is positive.***

– **Within an electric circuit, the total power generated must equal the total power dissipated. No Creation or destruction of Energy.**