EE24

BASIC ELECTRICAL ENGINEERING FOR CE

LECTURE NO. 1

Basic Principles of Electricity

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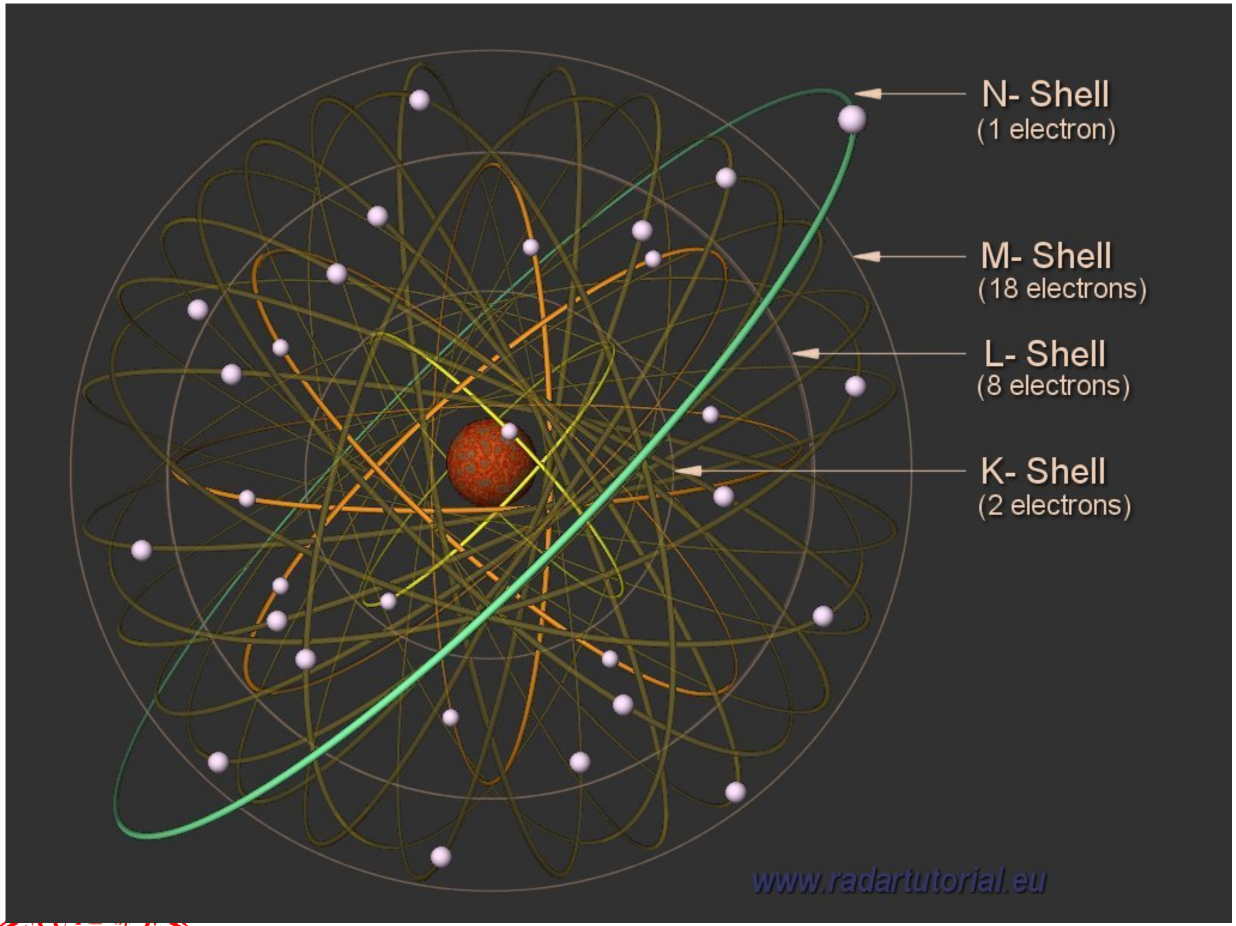
Basic Definitions

- **Matter** : anything that occupies space and has weight
- **Element** : a substance that cannot be decomposed any further by chemical action
- **Compound** : a combination of two or more elements
- **Molecule** : smallest particle that a compound can be reduced to before it breaks down into its elements
- **Atom** : smallest part that an element can be reduced to and still keeping the properties of the element
- **Valence electrons** : electrons found in the outermost shell or orbit of an atom.
- **Atomic Number** : represents the number of electrons or protons in an atom
- **Atomic Mass** : represents the sum of protons and neutrons of an atom

Structure of Matter



$N=2n^2$

N is the number of electrons on a given shell

n is the nth shell of an atom

Parts of An Atom

Name	Charge	Mass (kg)
PROTON	Positive	1.672 x 10^-27
ELECTRON	Negative	9.107 x 10^-31
NEUTRON	No Charge	1.672 x 10^-27

Element	# of Electrons	# of Protons	# of Neutrons	Valence Electron
COPPER	29	29	34	1
ALUMINUM	13	13	14	3
GERMANIUM	32	32	41	4

Electric Charge

A matter is said to be charged if it has **either an excess or deficit of electrons** from its normal values due to sharing.

❖ Coulomb (C) – unit of electric charge, which is equivalent to 6.25×10^{18} electrons or protons. Named after the French Physicist Charles A. Coulomb (1736-1806)

Potential Difference

- **Potential** – the capability of doing work

Any charge has the capability of doing work of moving another charge either by attraction or repulsion.

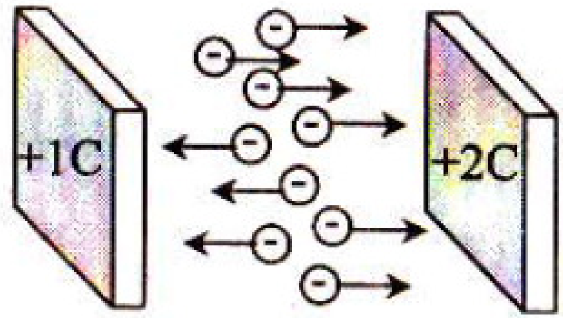
The net number of electrons moved in the direction of the positive charge plate depends upon the potential difference between two charges.

- **Volt** – unit of potential difference, which is equal to ONE Joule of Work per ONE Coulomb of Charge. Named after the Italian Physicist, Alessandro C. Volta (1754-1827)

Example

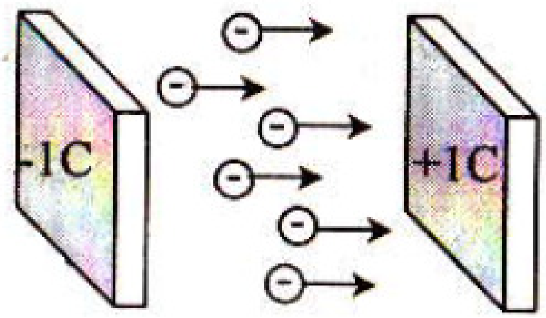
Example: Assume 1 C of charge can moved 3 electrons.

a.



6 electrons will be attracted by the +2 C plate and 3 electrons will be attracted by the +1 C plate, making a resultant motion of 3 electrons going towards the +2 C plate

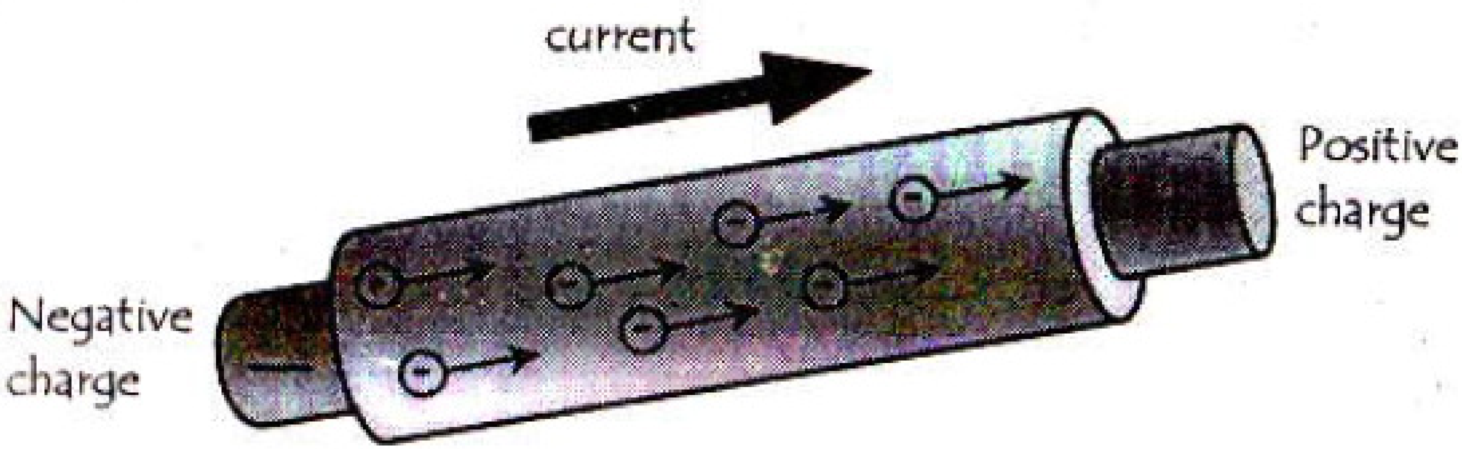
b.



3 electrons will be attracted by the +1 C plate and 3 electrons will be repelled by the –1 C plate, making a resultant motion of 6 electrons going towards the +1 C plate

Electric Current

When a potential difference between two charges forces a third change to move, the charge in motion is called an ELECTRIC CURRENT. It is the flow of electrons at given point and time.



❖ **Ampere (A)** – unit of charge flow equal to One Coulomb past a given point in One Second. Named after the French Physicist and mathematician Andre M. Ampere (1775-1836)

Resistance

Resistance is the opposition to the flow of electrons. The effect of resistance is that the conductor may become hot due to collisions of electrons and the work done by the applied force in producing the current.

❖ **Ohm (Ω)** – unit of resistance, named after German physicist George Ohm (1787-1854)

❖ **Siemens (S)** – unit of conductance which is the reciprocal of resistance

Nature of Resistance

$$R = \rho \frac{L}{A}$$

$$R = \rho \frac{V}{A^2}$$

$$R = \rho \frac{L^2}{V}$$

CM=d^2; 1000 mil = 1 inch; 1 MCM = 1000 CM

R = Resistance (Ohm)

A = Cross Sectional Area (m^2)

ρ = Resistivity (Ohm-Meter),

1.72x10^{-8} Ohm-Meter for Copper

10.37 Ohm-Circular Mil per Feet for Copper (Ω-CM/ft)

L = Length (Meter)

V = Volume (Cubic Meter)

Example #1

A rectangular carbon block has dimensions 1.0cm x 1.0cm x 50 cm. (i) What is the resistance measured between two square ends? (ii) between two opposing rectangular faces? Resistivity of carbon at 20C is $3.5x10^{-5}$ Ω-m.

ANSWER: (i) 0.175 Ω, (ii) 7×10^{-5} Ω

Example #2

Determine the resistance of a busbar made of copper if the length is 10 meters long and the cross-section is a 4x4 cm^2. Use 1.7241×10^{-8} Ω-m as copper resistivity.

ANSWER: (i) 1.078×10^{-4} Ω

Example #3

The substation bus bar is made up of 2 inches round copper bars 20 feet long. What is the resistance of each bar if resistivity is 1.724 x 10^-6 Ohm-Centimeter.

ANSWER: 5.185×10^{-5} Ohm

Example #4

A one-meter rod of 2 cm diameter is drawn until its resistance is 100 times the initial resistance. Its length afterward is?

ANSWER: 10 meters

Example #5

A conductor whose diameter is 0.175 inch has a resistance of 0.5 Ohm. The wire is drawn through a series if dies until its diameter is reduced to 0.08 inch. Assuming the specific resistance of the material remains constant, what is the resistance of the lengthened conductor?

ANSWER: 11.45 Ohm

Temperature and Resistance

$$\frac{R_1}{R_2} = \frac{T + t_1}{T + t_2}$$

$$R_2 = R_1\left(1 + \alpha_{t1}\Delta t\right)$$

$$\Delta t = t_2 - t_1$$

$$\alpha_{t1} = \frac{1}{T + t_1}$$

Material	ρ (Ω-CM / ft)	T (°C)	α at 20 °C
Silver	9.9	243	0.0038
Copper	10.37	234.5	0.00393
Aluminum	17	236	0.0039
Tungsten	33	202	0.0045
Zinc	36	250	0.0037

R_1 = initial resistance (ohm)
R_2 = final resistance (ohm)
T = inferred absolute temperature
= temperature when resistance of a given material is zero.
t_1 = initial temperature
t_2 = final temperature
Δ_t = change in temperature
α = temperature coefficient of resistance

Example #6

The resistance of copper wire at 30C is 50 Ohms. If the temperature coefficient of copper at 0C is 0.00427, what is the resistance at 100C?

ANSWER: 63.24 Ohms

Example #6

The resistance of a wire is 126.48 Ohms at 100C and 100 Ohms at 30C. Determine the temperature coefficient of copper at 0C.

ANSWER: 0.00427

Example #7

Two heating elements which is 500 Ohms and 250 Ohms are connected in series with temperature coefficients of 0.001 and 0.003 Ohms per ^{O}C, respectively ay 20^{O}C. Calculate the effective temperature coefficient of the combination.

ANSWER: 0.00167