Unit-1

1.① **Voltage** :- The difference in potential energy of the charges is called the potential difference.
It is also known as voltage.
It is denoted by V.
It is expressed in terms of energy (w) per unit charge. i.e $V = \frac{W}{Q}$

energy(w) in joules (J)
charge (Q) in colombs (c)

② **Current** :- The rate of flow of electrons in conductive (or) semi conductive meterials

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

Q = charge of electrons in colombs
t = time in seconds.

③ **Energy** :- energy is the capacity for doing work.
energy is nothing but stored work.
Energy may exist in many forms such as mechanical, electrical, chemical and also so on.

④ **Power** :- rate of change of energy. If certain amount of energy is used over a certain length of time.

$$P = \frac{W}{t} = \frac{\text{energy}}{\text{time}} \quad \text{(or)} \quad P = \frac{dw}{dt} = \frac{dw}{dq} \times \frac{dq}{dt}$$

$$\boxed{P = V \times I}$$

① If 70J of energy is available for every 30C of charge what is the voltage

Solⁿ:-

$$V = \frac{W}{Q} = \frac{70}{30} = 2.33\ V$$

② Five coulombs of charge flow past a given point in a wire in 2 sec. How many amperes of current is flowing

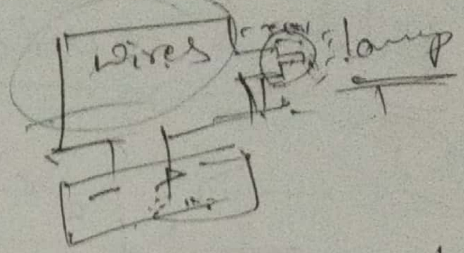
$$I = \frac{Q}{t} = \frac{5}{2} = 2.5\ Amp$$

③ what is the power in watts if energy equal to 50J is used in 2.5 sec

$$P = \frac{W}{t} = \frac{50}{2.5} = 20\ Watts.$$

Circuit :- electric

1) energy source → battery (or) generator
2) load → lamp (or) motor
3) connecting wires



combination of these three elements a simple circuit

→ A battery is connected to a lamp with two wires

→ A closed Circuit :- is defined as a circuit in which the current has a complete path to flow.

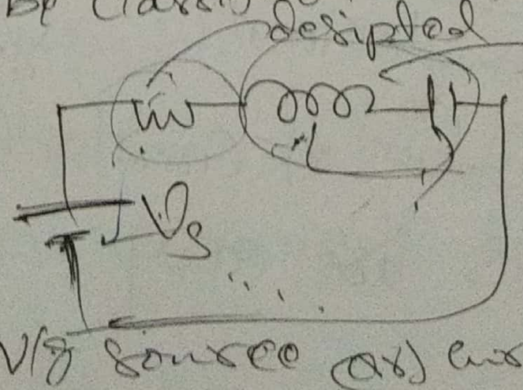
→ A Open Circuit :- when the current path is broken so that current can't flow, the circuit is called an open circuit.

→ electric network :- inter connection of two (or) more circuit elements (viz. V/g source, resistors, inductors & capacitors) is called an electric network

network elements may be classified into four groups

1) Active or passive :-

Active which is the source delevered the energy.



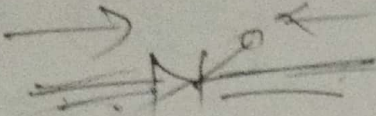
storage elements

V/g source (or) current source.

Passive R, L, C elements
→ desipated the energy.
→ stores the energy.

Bilateral & Unilateral:-

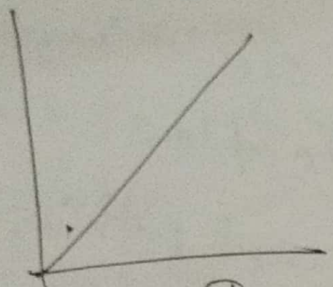
V-I



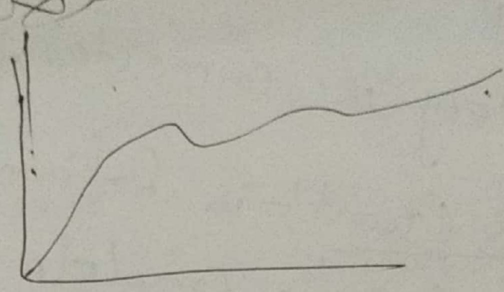
Both the directions → Bilateral. e
only one direction → unilateral.

Ex:-

Linear and Non linear Elements:-

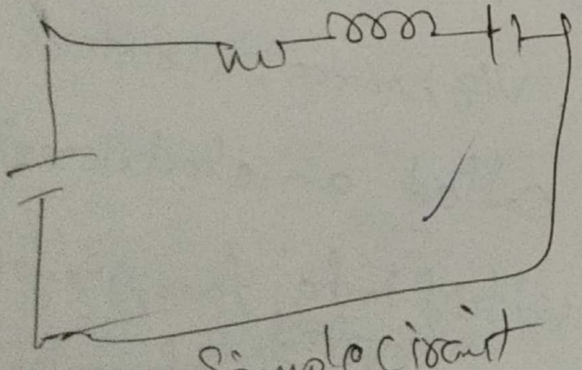


linear



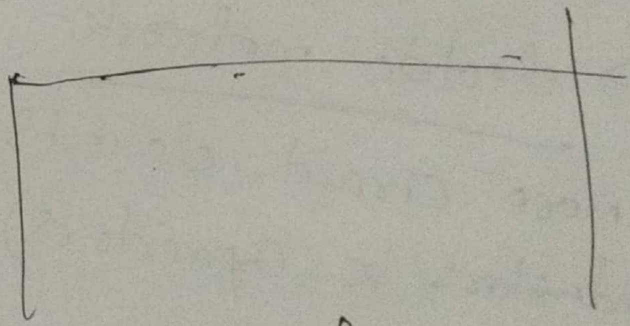
non linear.

Lumped & Distributed



a Simple circuit

So Calculation of circuit elements are easy.



For Long trm line

R — that is very complicated.
L, C not seperable.

network elements may be classified into four groups

(1) Active (or) Passive

(2) Unilateral (or) bilateral

(3) Linear (or) nonlinear

(4) Lumped (or) distributed

(1) Active and Passive:-

→ Energy sources (V & I sources) are active elements, capable of delivering power to some external device. → Passive elements are those which are capable only of receiving power. Inductors & capacitors are capable of storing a finite amount of energy, and return it later to an external element.

(2) Bilateral and Unilateral:-

In the bilateral element, the V/g & I (curr) relation is the same for current flowing in either direction. In contrast, a unilateral element has different relations b/w v/g & current for the two possible directions of current.

Example of unilateral element:- Vacuum diodes, silicon diodes & metal rectifiers.

Bilateral ele → R, L, C

(3) Linear & Nonlinear Elements:-

An element is said to be linear, if its v-i characteristic is at all times a straight line through the origin. $V \alpha I$ (or) $V = IR$.

the linear element (or) network is one which satisfies the principle of superposition. i.e the principle of homogeneity and additivity.

→ An element which does not satisfy the above principle is called a non linear element.

(4) Lumped and distributed:-

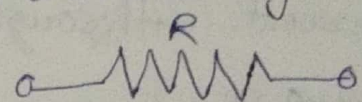
lumped elements are those elements which are very small in size and in which simultaneous actions takes place for any given cause at the same instant of time. Typical lumped elements are capacitors, resistors, inductors and transformers. generally the elements are considered as lumped when their size is very small compared to the wave length of the applied signal. Distributed elements on ~~the other hand~~, are those which are not electrically seperable for analytical purposes:

Ex:- a t/m line which has distributed resistance inductance & capacitance along its length may extend for hundreds of miles.

Resistance Parameters:-

when a current flows in a material, the free electrons move through the material and collide with other atoms these collisions cause the electrons to lose some of their energy. this loss of energy per unit charge is the drop in potential across the material.

→ the property of a material to restrict the flow of electrons is called resistance, denoted by R.

the Symbol for the resistor is 

the unit of resistance is ohm (Ω).

ohm:- It is defined as the resistance offered by the material when a current of one ampere flows b/w terminals with one volt applied across it.

According to ohm's Law, $I \propto V$, $I \propto \frac{1}{R}$

$$I = \frac{V}{R} \Rightarrow \boxed{V = IR} \Rightarrow \boxed{V = R\frac{dq}{dt}}$$

$$\text{Power } (P) = Vi = (iR)i = i^2R$$

$$\text{Energy } W = \int_0^t P\,dt = Pt = i^2Rt = \frac{V^2}{R}t$$

Example:- A 10Ω resistor is connected across a 12V battery How much current flows through the resistor

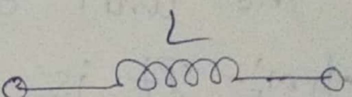
$$V = IR$$

$$I = \frac{V}{R} = \frac{12}{10} = 1.2\,A$$

Inductance Parameter:-

A wire of certain length, when twisted into a coil becomes a basic inductor. If current is made to pass through an inductor, an electromagnetic feild is formed. A change in the magnitude of the current, changes the electromagnetic field.

The unit of inductance is henry, denoted by H. By definition, the inductance is one henry when current through the coil, changing at the rate of one ampere per second, induced one volt across the coil.

the Symbol for inductance is 

$$v = L\frac{di}{dt} \Rightarrow di = \frac{1}{L} v\,dt$$

$$\int_0^t di = \frac{1}{L}\int_0^t v\,dt \Rightarrow i(t) - i(0) = \frac{1}{L}\int_0^t v\,dt$$

$$\boxed{i(t) = \frac{1}{L}\int_0^t v\,dt + i(0)}$$

The current in an inductor is dependent upon the integral of the v/g across its terminals and the initial current in the coil, $i(0)$

$$P = vi = L\,i\frac{di}{dt} \text{ Watts}$$

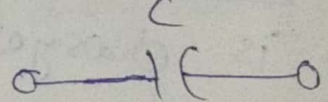
$$W = \int_0^t P\,dt = \int_0^t L\,i\frac{di}{dt}\,dt = L\int_0^t i\,di = \frac{Li^2}{2}$$

Example:- the current in a 2H inductor varies at a rate of 2 A/S. Find the v/g across the inductor and the energy stored in the magnetic field after 2S.

Sol:- $v = L\frac{di}{dt} = 2\times 4 = 8V$ $\quad W = \frac{1}{2}Li^2 = \frac{1}{2}\times 2\times (4)^2 = 16J.$

Capacitance Parameter:-

Any two conducting surfaces separated by an insulating medium exhibit the property of a capacitor. The conducting surfaces are called electrodes, and the insulating medium is called dielectric. A capacitor stores energy in the form of an electric field that is established by the opposite charges on the two electrodes. the electric field is represented by lines of force b/w the possitive and -ve charges, and is concentrated within the dielectric. the amount of charge per unit voltage that is capacitor can store is its capacitance denoted by C. the unit of capacitance is Farad. By def^n on Farad is the amount of capacitance when one coulomb of charge is stored with one volt across the plates.

The symbol for capacitance is 

A capacitor is said to have greater capacitance if it can store more charge per unit voltage & the capacitance is given by

$$C = \frac{Q}{V} \Rightarrow q = CV \Rightarrow \frac{dq}{dt} = C\frac{dv}{dt} \Rightarrow \boxed{i = C\frac{dv}{dt}}$$

$$dv = \frac{1}{C}\, i\, dt$$

$$\int_0^t dv = \frac{1}{C}\int_0^t i\,dt$$

$$v(t) - v(0) = \frac{1}{C}\int_0^t i\,dt$$

$$\boxed{v(t) = \frac{1}{C}\int_0^t i\,dt + v(0)}$$

the voltage in a capacitor is dependent upon the integral of the current through it. and initial voltage across it.

Power $P = vi = vC\frac{dv}{dt}$

Energy $W = \int_0^t P\,dt = \int_0^t vC\frac{dv}{dt}\,dt$

$$\boxed{W = \frac{1}{2}Cv^2}$$

Example:- A capacitor having a capacitance $2\mu F$ is charges to a voltage of 1000V. Calculate the stored energy in joules

Sol^n:- $W = \frac{1}{2}CV^2 = \frac{1}{2}\times 2\times 10^{-6}\times (1000)^2$

$= 1\ J$

V-I Relation of RLC element

	Volts(V)	Ampere	Power	Energy
Resistor(R)	$V = IR$	$I = \frac{V}{R}$	$P = I^2R$ (or) $\frac{V^2}{R}$	–
Inductor(L)	$V = L\frac{di}{dt}$	$I = \frac{1}{L}\int_0^t v\,dt$	$P = Li\frac{di}{dt}$	$W = \frac{1}{2}Li^2$
Capacitor(C)	$V = \frac{1}{C}\int_0^t i\,dt$	$i = C\frac{dv}{dt}$	$P = Cv\frac{dv}{dt}$	$W = \frac{1}{2}Cv^2$