IC FABRICATION

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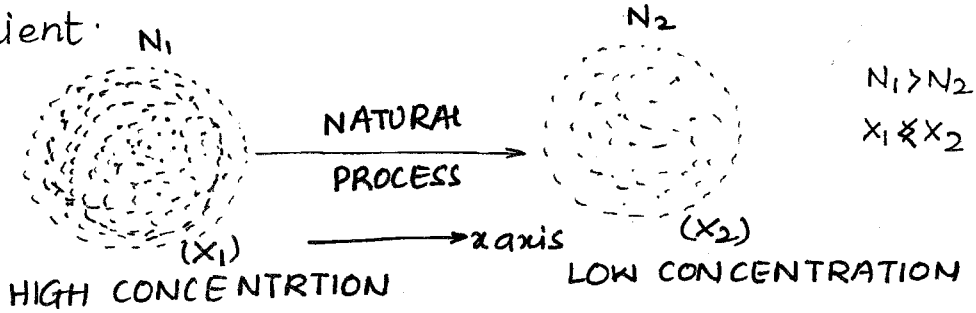
*NPTEL → Prof. Nandita Dasgupta. (VLSI Fabrication).
* SK Gandhi
* oxidation, Ion Implantation diffusion → numericals.

* **DOPING:**

i) Diffusion.
ii) Ion Implantation.
iii) Epitaxy

i) DIFFUSION:

* Diffusion means movement of material under concentration gradient.



* As

$$J = -D\frac{dn}{dx}$$ ← FICKS 1st Law of Diffusion.

Hence -ve sign.

D = diffusion const.
J = Flux (always +ve). (we always say that flux is +ve).

$\frac{dn}{dx}$ = Concentration gradient

$$\frac{dN}{dx} = \frac{N_2 - N_1}{x_2 - x_1}$$ ← -ve quantity

* FICKS IInd LAW OF DIFFUSION:

* Ficks 2nd law of diffusion states that:

$$\nabla \cdot J = -\frac{\partial \rho_v}{\partial t}$$

$$\nabla = i\frac{\partial}{\partial x} + j\frac{\partial}{\partial y} + k\frac{\partial}{\partial z}$$

* For one dimension we get:

$$\frac{\partial J}{\partial x} = -\frac{\partial N}{\partial t}$$

$$J = -D\frac{\partial N}{\partial x} \quad \text{---(i)}$$

$$\frac{\partial J}{\partial x} = -\frac{\partial N}{\partial t} \quad \text{---(ii)}$$

diff. eqn(i) w.r.t x we get:-

$$\frac{\partial J}{\partial x} = -D\frac{\partial^2 N}{\partial x^2}$$

from eqn (ii) we get:-

$$\frac{-\partial N}{\partial t} = -D\frac{\partial^2 N}{\partial x^2}$$

$$\boxed{D\frac{\partial^2 N}{\partial x^2} = \frac{\partial N}{\partial t}} \leftarrow \text{wave Equation}$$

N : Concentration.
x : space.
t : time

* N is a func^n of Both space and time.

$$\boxed{N = f(x, t)}$$

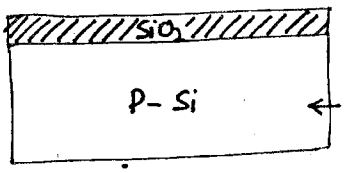
* TYPES OF DIFFUSION:-

i) Predeposition / Infinite source Diffusion.
ii) Drive in / Limited source diffusion.

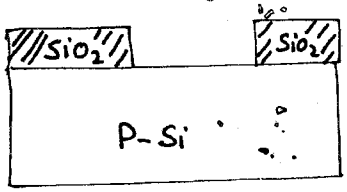
i) Predeposition / Infinite Source Diffusion:-

Diode Formation

a) Take P substrate.



b) open a window using lithography + Etching



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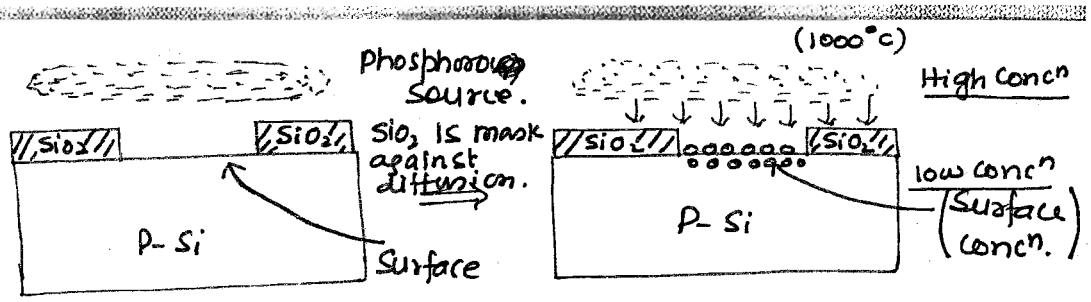
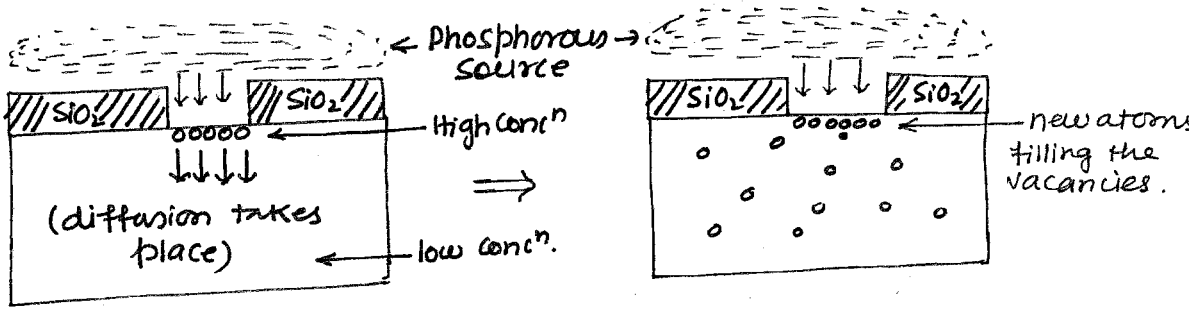
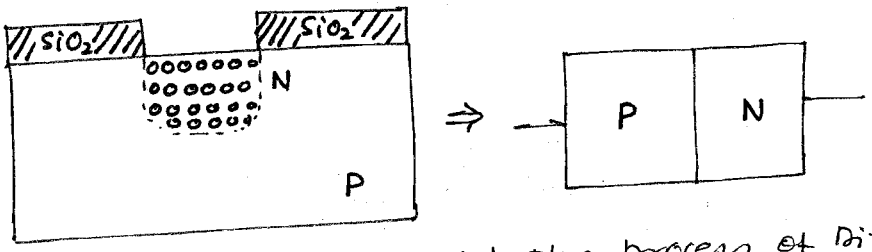


(4)



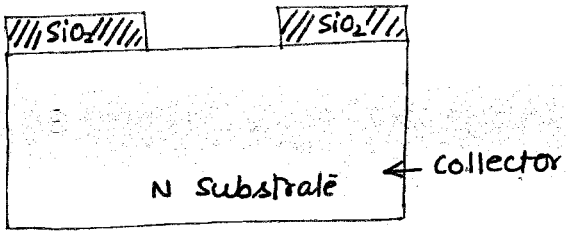
5) Finally,



* Diffusion occurs at 1000°c and to stop the process of diffusion decrease the temperature.

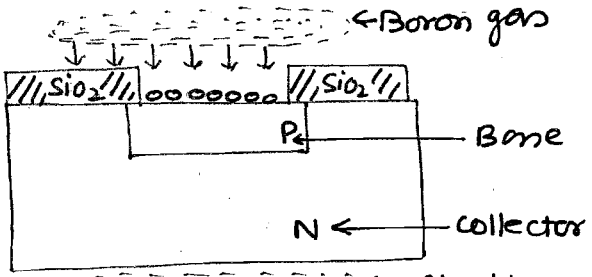
* BJT FORMATION (NPN):

1) Take N substrate

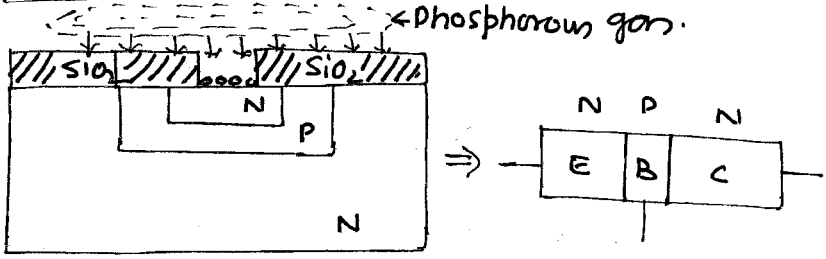


Note:-
* Contacts are also to be connected.

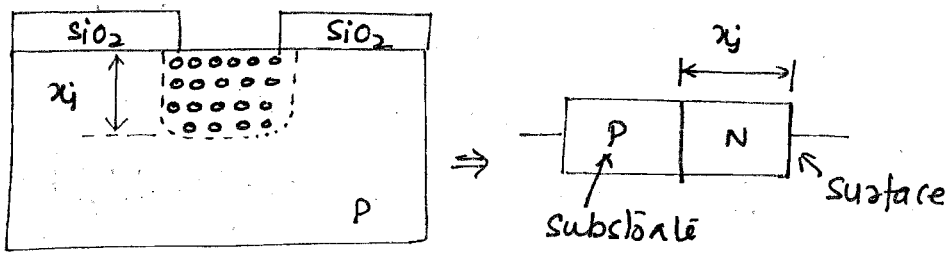
2)



3)



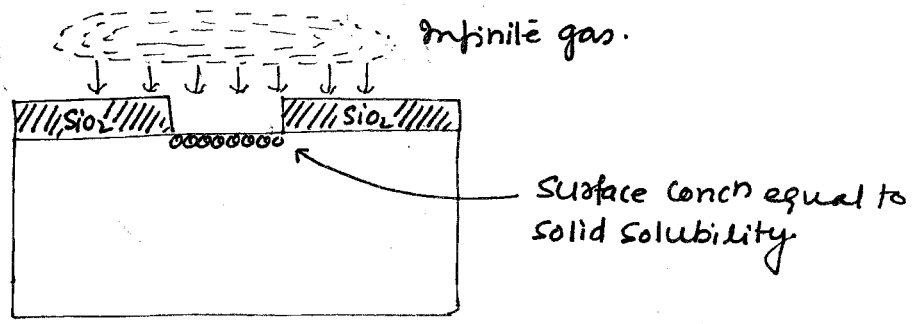
* **Parameters of Diffusion:**
  - Junction Depth.
  - Doping Profile.
  - Surface concentration.

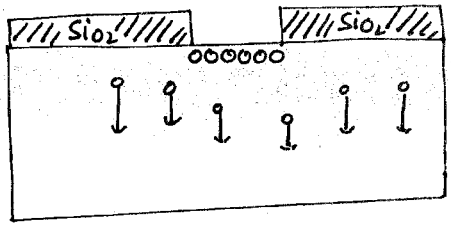


x_j: Junction Depth ie distance from surface where junction forms.

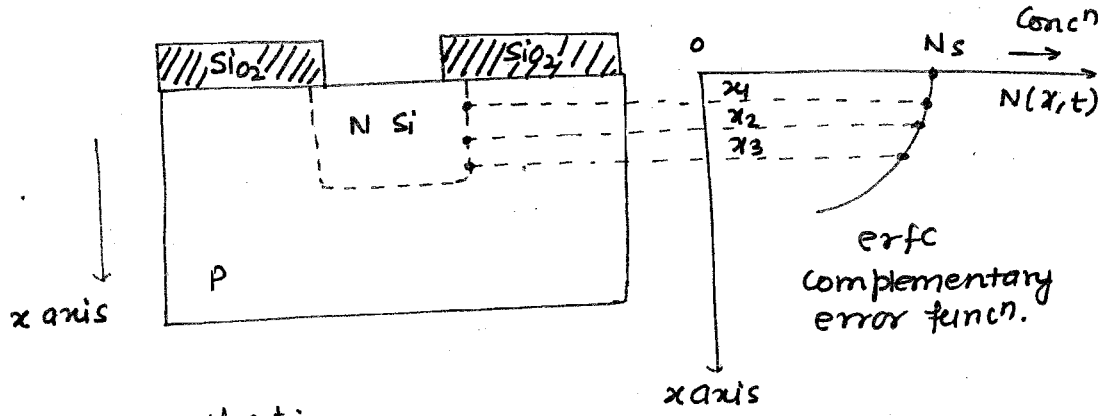
* **Surface Concn in Predeposition:**

* Solubility is a funcn of Temp.
* Surface Concn is always constant ie the vacancies created at surface remain const.





* DOPING PROFILE:



We know that:

$$D\frac{\partial^2 N}{\partial x^2} = \frac{\partial N}{\partial t}$$ ← Partial differential equation.

$N(x,t)\big|_{x=\infty} = 0$

$N(x,t)\big|_{x=0} = N_s$ ← Surface conc^n.

$N(x,t)\big|_{t=0} = 0$ ← Boundary conditions

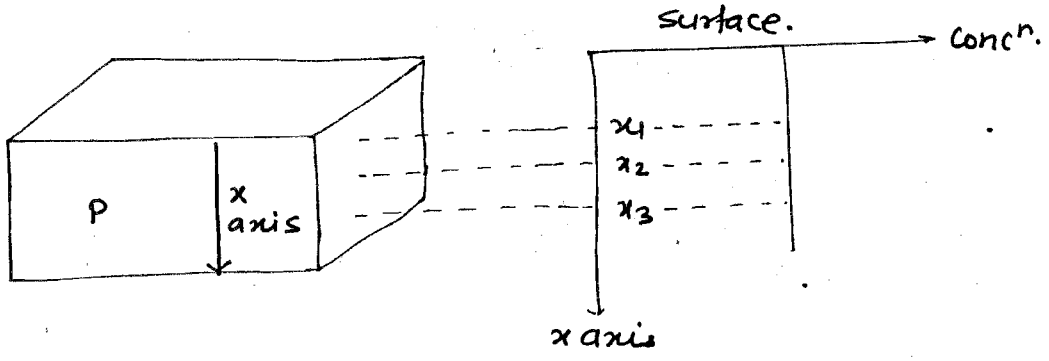
* Solution for the Partial differential equation is given as:

$$N(x,t) = N_s \operatorname{erfc}\left(x/2\sqrt{Dt}\right).$$

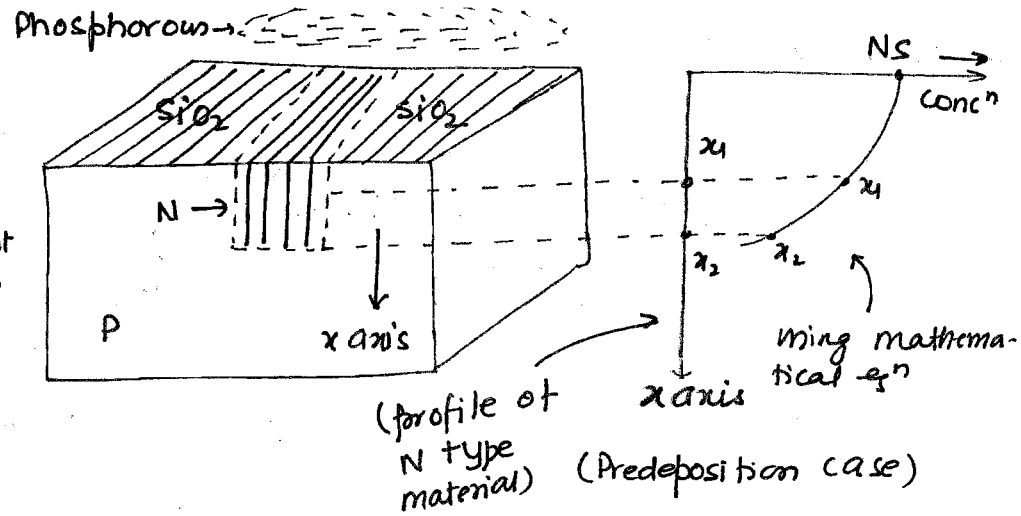
t: time.

* EPITAXY is method of UNIFORM DOPING:

Note:



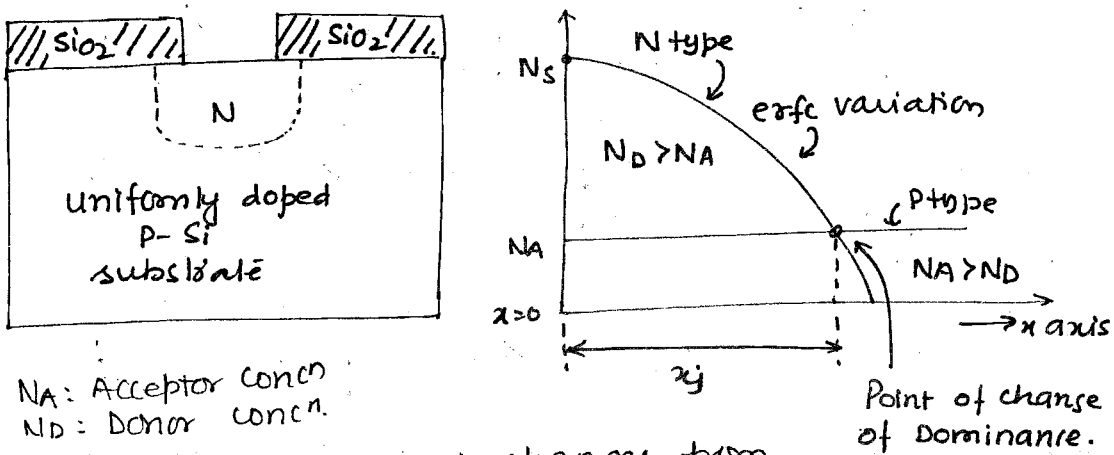
UNIFORMLY DOPED SUBSTRATE.



* at constant temp.
* N_S is constant at given temp.

*Junction Depth:

* Consider a uniformly doped P type substrate.
* Assume N type diffusion has been done



N_A: Acceptor conc^n
N_D: Donor conc^n.

* Junc^n forms when material changes from N type to P type and vice versa.
* At the junc^n ie $\boxed{x = x_j}$ ← Point of intersection of curves.

$$\boxed{N_A = N(x, t)}$$

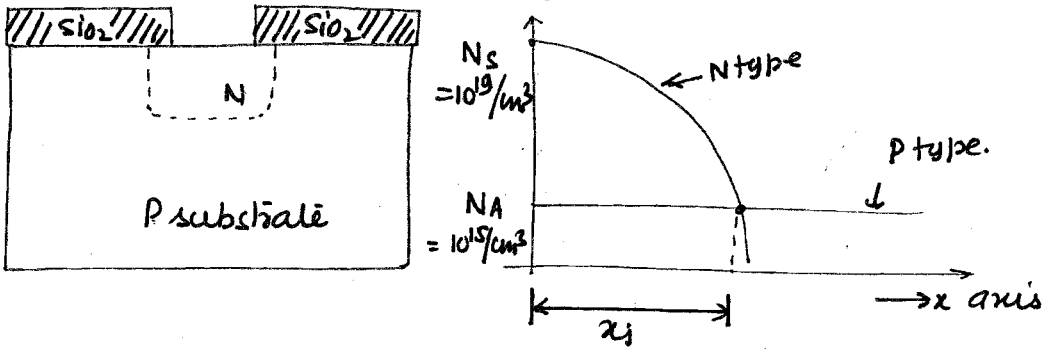
So, $$\boxed{N_A = N_s \operatorname{erfc}\left(\frac{x}{2\sqrt{Dt}}\right) = N(x, t).}$$

Q1) Phosphorous is diffused into uniformly doped P type subs. trati with background conc^n of $10^{15}/cm^3$ at T = 1100°c. The diffusion constant at this temp is 10^{-12} cm^2/sec; solid solubility of phosphorous and silicon is $10^{19}/cm^3$ at 1100°c. Assume predeposition time of 1 hour & find the junc^n Depth?

erfc of 2.75 = 10^{-4}

erfc (2.75) = 10^{-4}.

Soln:-



* At the junction:-

$$N_A = N(x,t) = N_S \, erfc\left(x_j / 2\sqrt{Dt}\right)$$

$$10^{15} = 10^{19} \, erfc\left(x_j / 2\sqrt{Dt}\right)$$

$$10^{-4} = erfc\left(x_j / 2\sqrt{Dt}\right).$$

So, $$2.75 = \frac{x_j}{2\sqrt{Dt}}$$

or $$x_j = 2.75 \times 2 \times \sqrt{10^{-12}\ cm^2/sec \times 3600\ sec}$$

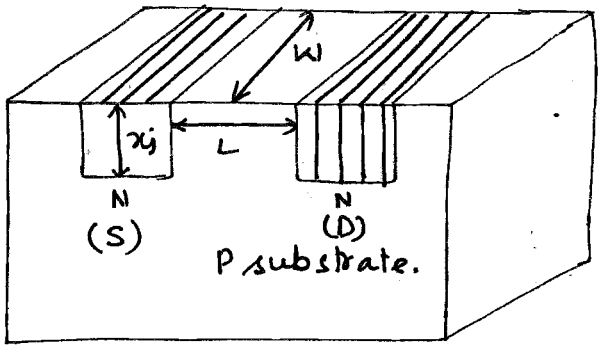
$$\boxed{x_j = 3.3\ \mu m}$$

Note:-

L: channel length.

W: channel width

x_j: junc^n depth.



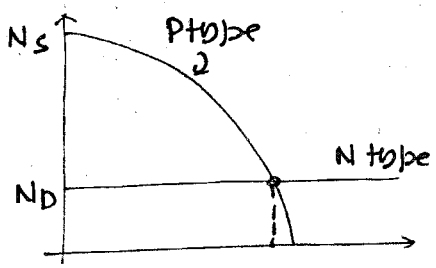
(N MOS)

Note:-

* Junc^n depth is decided during Diffusion process
* W/L Ratio decided during Lithography process. (Mask lithography)
* x_j is important parameter in MOSFET fabrication.

Q2) Boron is diffused into an n type sc with back ground concn of $10^{14}/cm^3$. The predeposition is carried out for 2 hrs. Assume diffusion const of 5×10^{-13} : solid solubility of $10^{20}/cm^3$. Find the junction depth.

$erfc(3.45) = 10^{-6}$.



Soln:. $N_S erfc(x_j/2\sqrt{Dt}) = N_D$

$10^{14} = 10^{20} erfc(x_j/2\sqrt{Dt})$

$10^{-6} = erfc(x_j/2\sqrt{Dt})$

So, $\boxed{\frac{x_j}{2\sqrt{Dt}} = 3.45}$ *** ← in Prelims.

$x_j = 2 \times 3.45 \times \sqrt{5 \times 10^{-13} \times 2 \times 3600}$

$x_j = 60 \times 10^{-6} \times 2 \times 3.45$

$\boxed{x_j = 414 \times 10^{-6} \text{ cm.} = 4.14 \mu m.}$

Note (Prelims) :.

$erfc(3.45) = 10^{-6} \Rightarrow erfc^{-1}(10^{-6}) = 3.45$

$erfc(2.75) = 10^{-4} \Rightarrow erfc^{-1}(10^{-4}) = 2.75$

} Constant value.

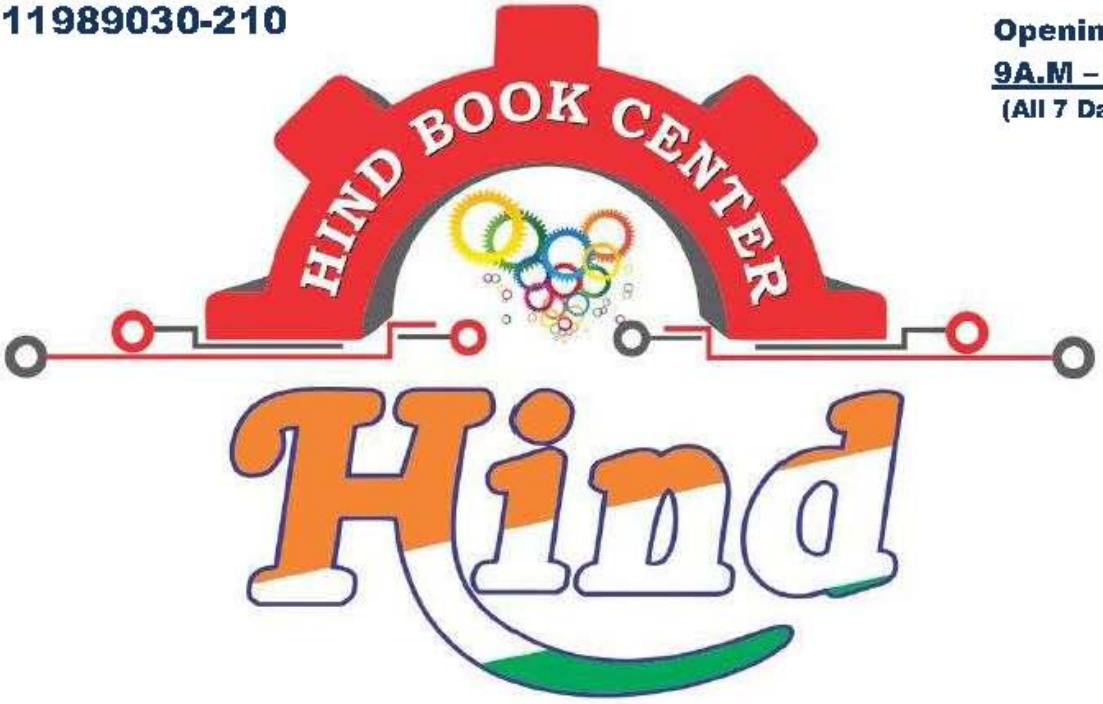
Now, $N_A = N_S erfc(x_j/2\sqrt{Dt})$

$\left(\frac{N_A}{N_S}\right) = erfc(x_j/2\sqrt{Dt})$

$erfc^{-1}(N_A/N_S) = \text{constant} = \frac{x_j}{2\sqrt{Dt}} = K.$

So, $x_j = 2\sqrt{Dt} \times K.$

$\boxed{x_j \propto \sqrt{t}}$



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ADVANCE COMMUNICATION

By-Urvashi Maim

Satellite Communication (facultycomm@gmail.com)

link design. ✓ facultyadvancecomm@gmail.com
optical Communication

*Syllabus:

i) optical communication. → John M Senior (3rd Edition)
ii) Cellular Communication → Rappaport
iii) Data Communication. → Forouzan
iv) Satellite Communication → Pratt.

PRELIMS

1) OC — 1 (Jh)
2) CC — 1 (Jh)
3) DC — 6→5 (Jh), 1 (N)
4) SC — 2→1 (Jh), 1 (N)

MAINS (85 marks)

40 marks → 10M, 10M } Basics; 20M } link design.
20 Marks → link design.

25 marks → 15m (link design); 10m (free space loss).

*OPTICAL FIBRE COMMUNICATION:.

→ Comm^n is whatever sent by Tx is retrieved by Rx and can be understood at Rx end.

dealing with light.

- Visible Region
  - made up of VIBGYOR
  - *(Bandwidth is less hence data comm^n not possible
  - * Since light is visible so security is less. The changes 0 to 1 are visible
- UV Region
  - not preffered because UV rays are absorbed by the solid. Hence attenuation occurs.
  - *need of ampl^r
- IR Region → not visible to normal eyes. Hence Security is high. (Information is not leaked)
  - * Band width is also high.
  - *IR waves are not absorbed by the solid material. Hence attenuation is less. Need of ampl^r, repeaters are less.
  - * Design of link is not costly

*FIBER:.

* behaves a transmission waveguide.

made up of

- SILICA (dielectric)
- PLASTIC (dielectric)

EMI → Electromagnetic Induction.

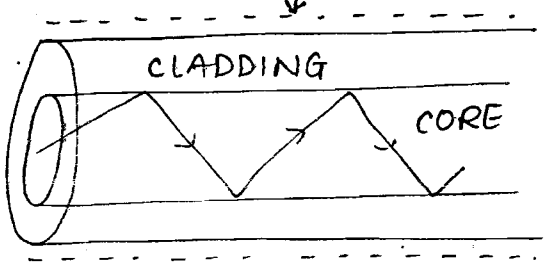
RFI → Radio frequency Interference.

* due to dielectric behaviour EMI, RFI is less. Hence CROSS TALK is low.
* Noise ↓ (Interference ↓) → Note:. optical cables doesn't radiate the energy and also doesn't allow external signal from entering into the fiber
* Signal Fidelity ↑ (High)
* can be transmitted to long distance hence Range ↑.

Note:. (why light source can't be sent through free space?)

* In free space, dust particles, water particles will be present hence Fading occurs and hence the strength ↓. Hence light is not sent through unguided media.

BUFFER & JACKET



* Core & cladding are both made of silica.
* Light propagates by principle of TIR.

*cladding is made up of silica. since if air is present losses will be high and information is lost.

Note :. (Advantages of using optical fiber cable (OFC))

1) Bandwidth:

Range is 10^{13} Hz to 10^{15} Hz

Bandwidth = $f_H - f_L$

$= 10^{15} - 10^{13}$

Information carrying capacity is High. → $BW \cong 10^{15}$ Hz

* Channel capacity is

$C = BW \log_2(1+S/N)$

C ↑ BW ↑.

SHANNON THEOREM.

* BW attainable is of 40 Gbps in passive optical network. (PON)

2) security:

* IR rays are used.
* not visible to naked eyes. hence signal cannot be tracked.

3) less distortion & attenuation :.

* Attenuation in fiber is of Range 0.5 dB/Km due to the dielectric used.
  - → doesn't allow anything to go out or come in.
  - → dielectric doesn't absorb anything and hence amplification requirement is ↓.

4) Amplification ↓ :.

* ampl^r & Repeater requirement is less.
* Ampl^r amplifies the Signal & Noise also.

* In

Amplifier → S↑ N↑ SNR const.

Repeater → 3R → SNR is boosted
(Signal is amplified whereas Noise is not amplified)

(can advance or delay)
- Retime
- Reshape
- Regenerate

→ Increase Tx Range.

* In Satellite Comm^n and digital comm^n we mostly use Repeaters.

5) Transmission Range ↑ (very high):

* due to Repeater being used Tx Range is very high.

Note: (ICT Based - GS point of View):-

* NOFN (National optical fiber network)
  - 2.5 lakh gram panchayat to be linked using Broadband Connectivity. The speed is 100Mbps.
* 1st phase → 1 lakh gram panchayat connected and later name changed to BHARAT NET.
* In optical fibers → dielectric (RFI/EFI ↓) hence instead of laying down, we are installing the cables on power towers along with the power cables.

Note:-

* OFN are not preferred in hilly areas due to the terrain.
* Hilly areas are prone to landslides, weather conditions etc hence if OFN is installed then they are likely to get disturbed.
* Also laying down of OFN in hilly areas is difficult as digging and laying them down is difficult.
* Instead of OFN, microwave links (μw ave Comm^n) is preferred in Hilly areas.

*OPTICAL FIBER COMMUNICATION:.

*In this the signal is in the form of light pulses which is guided through dielectric waveguide made up of "SILICA OR PLASTIC".

*The Transmission of Signal takes place through TOTAL INTERNAL REFLECTION (TIR)

*Why OFC is Preferred?

i) enormous Bandwidth, the frequency range of light signal is from 10^{13} Hz to 10^{15} Hz normally. Hence the Bandwidth is very high.

SHANNON CHANNEL CAPACITY	$C = BW \log_2(1+S/N)$	$C \propto BW$

*C = Channel capacity (Bits/sec)

Hence the information carrying Rate is very high

ii) Electrical Isolation:.

*optical fibre is dielectric transmission waveguide and doesnot conduct or radiate and it doesnot allow other electrical signals to interfere. Hence there is less interference like ELECTROMAGNETIC INDUCTION & RADIO FREQUENCY INTERFERENCE.

*So chances of CROSS TALK is less

ii) less Transmission loss:.

*The fiber is fabricated with less loss ie around 0.2 dB/Km. Hence attenuation is less so less no. of REPEATERS are required. Hence Overall cost is reduced.

iv) SECURITY:-

*IR rays are preferred which are not visible and not also absorbed by the material. Hence chances of Radiation is less. Hence more security.

*Due to less losses the Transmission Range is very high.

*Due to these above advantages we are using OFC in

i) PON (Passive optical Networks) (window 1 used)
ii) Bharat net (Gram Panchayats Connectivity).

*No signal amplification, no Repeaters are used. Hence called as Passive.
* Range is limited (20Km – 40Gbps).

iii) Submarine cables are used in an around chennai port, Kanya Kumari, ernakulam port to make Connectivity to the outside world. Repeaters are used at every 50Km.

Note:.
*Transmission window Range is selected to find such that what wavelength of light can be sent so that the attenuation will be less and Requirement of Repeaters is less. (To find Range of wavelength so that attenuation is less)

Note:.
*In window 3 we have designed EDFA (Erbium Doped Fiber Ampl^r)
↳ EDFA can ~~beside~~:
↳ work as Repeaters also.

Note:.
* A TRANSMISSION WINDOW is the range of the wavelength at which attenuation is low.
*In OFC, WINDOW 3 ranging from 1500 nm to 1600 nm is most preferred because it has low attenuation, less dispersion & high transmission Range & data rate. supports wavelength

division multiplexing & EDFA (Erbium Doped Fiber Ampl^r) can be used.

*WINDOW 1 (800 nm - 900nm):-

* LED is used as source so high dispersion, high loss and used for short distance communication.

*WINDOW 2 (1260 nm to 1360 nm):-

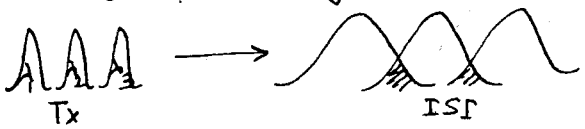
i) Laser in single mode is used

ii) dispersion is negligible

iii) High Tx Range.

But it doesn't support multiplexing efficiently

Note:.



*LED (Light emitting diode) is:.

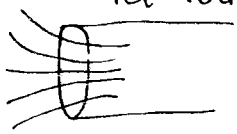
a) Non monochromatic (having multiple wavelength)

b) Non coherent.

Hence it is highly dispersive in nature. Due to these limitations LED is generally not preferred for long distance comm^n using optical fibres.

* Also, due to non-monochromatic & non coherent nature there is Inter symbol interference and original information can't be Retrieved back at the Rx side.

Note:. let 10GHz (BW)



* one telephone caller needs 64 KHz BW for peforming calling information. Hence if there is no wavelength division multiplexing the remaining BW is wasted.

*Now suppose if we are doing wavelength division multiplexing then multiple users can use the same 10GHz BW simultaneously and no. of users can be given as:.

$64\times10^3 \times n = 10\times10^9$

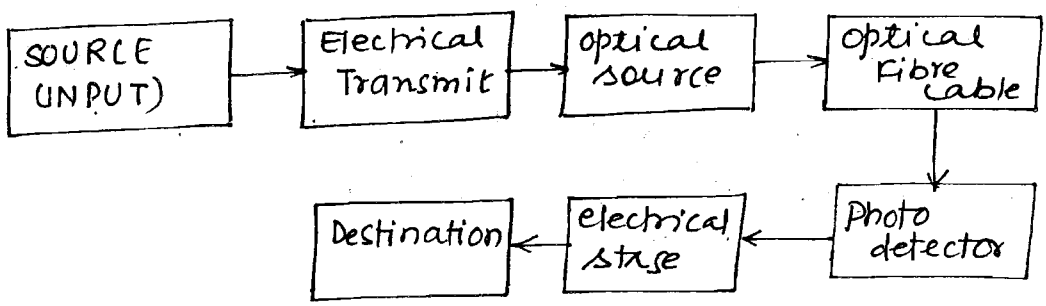
$n = 10^6 \times 0.15625$

$= 156.25\times10^3$ users

{ Wavelength division multiplexing uses light of different colours to be multiplexed }

Note :-

*OPTICAL FIBRE SYSTEM :-



* Optical source :-

*It does Electrical to optical conversion and provides maxm coupling of the signal in the form of light pulses with the Fiber and the coupling is done with the help of mechanical Interfaces like LENS OR PRISM.

*These are of two types LED & LASER.

*optical Cable transmit the light pulse through "Total Internal Reflection".

Reciever :-

* The Photodetectors like Avalanche Photodiode, PIN DIODE & photo transistors do optical to electrical conversion so that information can be retrieved.

*** Note :-

*OPTICAL SOURCE operates in FORWARD BIAS mode whereas PHOTO DETECTORS operate in REVERSE BIAS mode.

*RAY THEORY & BASIC CONCEPTS OF OFC:

Wave nature taken when → Light → Wave → Tx channel → optical fibre (TIR)

Light → Particle (flowing in the form of packets of Photons).

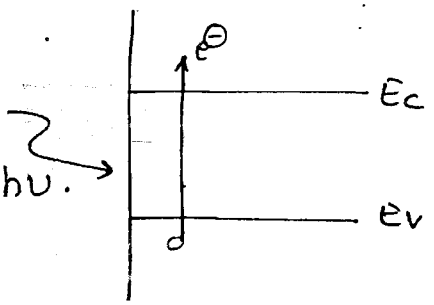
Generation & Recieving of the light we take particle nature. → (LED, LASERS ← for Generation; APD, PIN diode, Photodiode) For Detection

* LIGHT has DUAL NATURE which defines its generation in the form of PHOTONS ie PARTICLE NATURE and the other is how does the light travel in any medium ie WAVE NATURE.

* The working of the OPTICAL SOURCE & PHOTODETECTORS is defined by PARTICLE NATURE in which the energy of the PHOTON is given by

$$E = h\upsilon = \frac{hc}{\lambda}$$

$$E(eV) = \frac{1.2406}{\lambda(\mu m)}$$



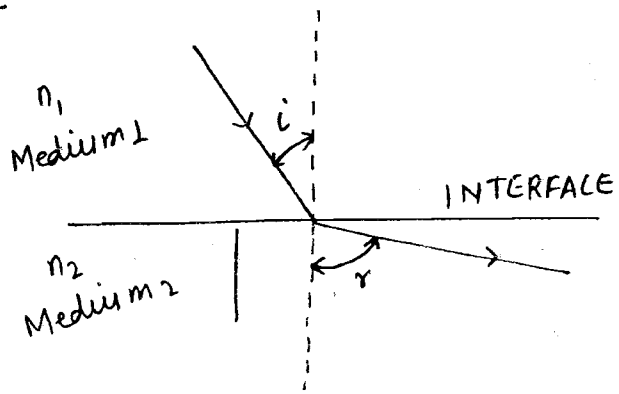
* The total Internal Reflection is based on WAVE NATURE & is defined with the help of SNELL'S LAW.

ote:

$$RI = \frac{c}{v}$$

c ← Velocity of light in free space

v ← Velocity of light in any medium



$$n_1 \sin i = n_2 \sin r$$

SNELL'S LAW.

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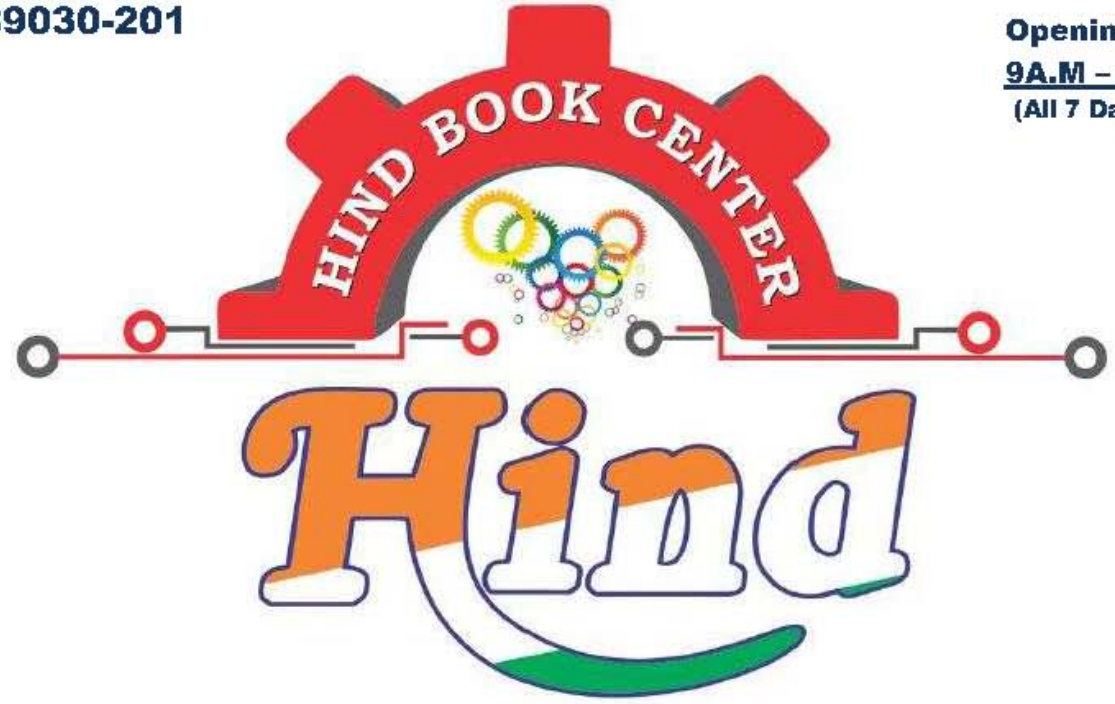

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ELECTRONICS ENGINEERING

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ANALOG ELECTRONICS

By-Ifteqar Ahamad SIR

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* DEFINITION OF ANALOG CIRCUIT:.

* A ckt which consists of atleast one electronic device as the major components then that ckt will be Electronic circuit
  i) Ampl^r.
  ii) Rectifier.
  iii) Oscillator.

* ckts can be of 3 types
  i) Analog ckt (Input also analog and output also analog)
  ii) Digital ckt (Input Digital & Output also digital)
  iii) Mixed Electronic ckt (A to D Convertor, D to A Converter).

* ANALOG ELECTRONIC CKT:.

* An Electronic ckt which performs processing of Analog signals or a ckt in which Input and output are Analog signals. Such ckt are called Analog Electronic ckt.

  i) Amplifier.
  ii) Rectifier; etc

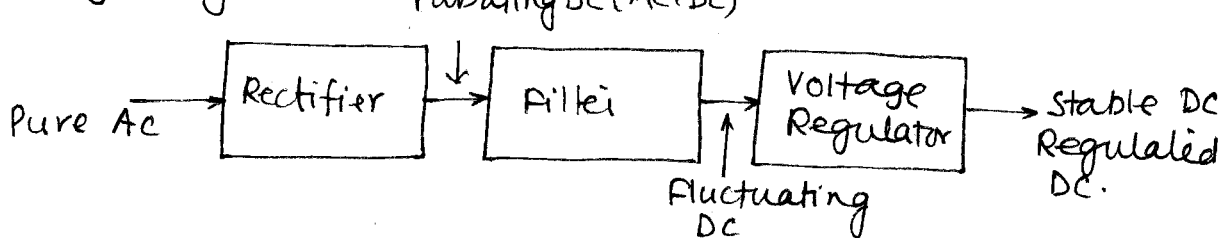
* Real time signals are Analog Signals; hence Analog ckts (usage) ← despite of Digital Era why use Analog ckts.

* Advantages of Analog circuits are:.
  i) Most of the Real time signals are Analog in nature & hence they can be directly processed in Analog circuit. But digital processing requires A to D & D to A Conversion which increases complexity and signal Accuracy is also lost; due to Quantisation Errors.
  ii) Analog ckt can process signals having higher power level also. Digital ckts fails for processing high power supply. Digital ckts often work in mw range.

* Note:. Ic's works on DC power supply. They won't work on AC power.

* DC POWER SUPPLY:.

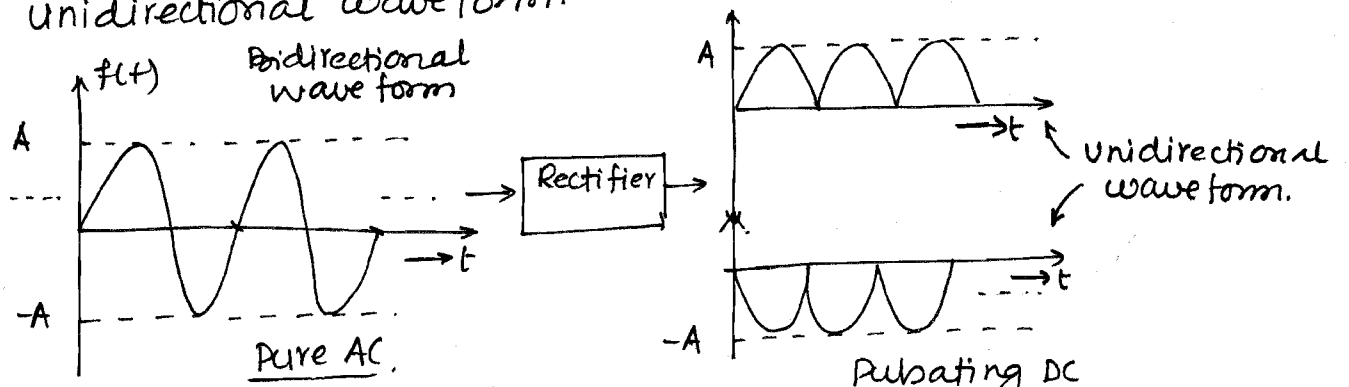
* It converts AC power into DC Power.
* A Regulated power supply consits of a Rectifier, Filter and a Voltage Regulator



* AC to DC conversion is needed because majority of Electronic Devices and appliances operate on DC power.

* RECTIFIER CIRCUIT :-

* An Electronic circuit which converts Pure AC into pulsating DC or a ckt which converts bidirectional waveform into a unidirectional waveform.



Pure AC.

Properties :-

i) Periodic variation
ii) Bidirectional variation (both in +ve & -ve values)
iii) Avg. value = 0 (DC value).
iv) It has single frequency component. (Sinusoidal).

* Triangular & Square wave are also called as AC signals but not pure AC as they also have Harmonics. But AC (Pure AC) should have single freqn component.

Pulsating DC

Properties :-

i) Periodic variation.
ii) Unidirectional variation.
iii) Non Zero Avg, hence DC value will be present.
iv) It has Harmonics.

* Time varying signals have AC components.

Note :-

* Periodic variation indicates presence of AC component that varies with time
* Non Zero Average indicates presence of DC component
* Hence Pulsating DC is a combination of AC & DC components.
* Rectifier converts Pure AC into Pulsating DC.

*Note:.

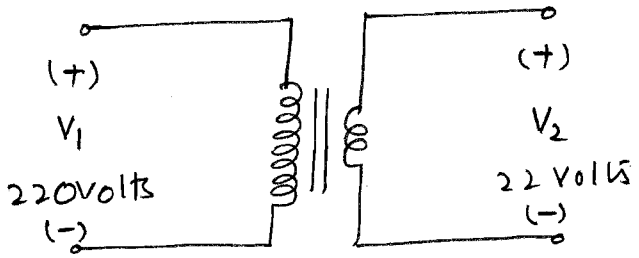
RECTIFIER

- **Low Voltage Rectifier**
  - DC output voltage is a few volt to a few 10's of volts
  - It consists of Diodes
    - **Half wave Rectifier**
    - **Full wave Rectifier**
      - Center Tapped Full wave Rectifier
      - Bridge Full wave Rectifier.
- **High Voltage Rectifier**
  - It consists of SCR
  - mainly studied by Electrical Engg in Power Electronics

*Note:.

* In low voltage Rectifiers, step down Transformer is used to reduce the strength of AC voltage

$$\frac{V_1}{V_2} = \frac{N_1}{N_2}$$



$N_1 : N_2$

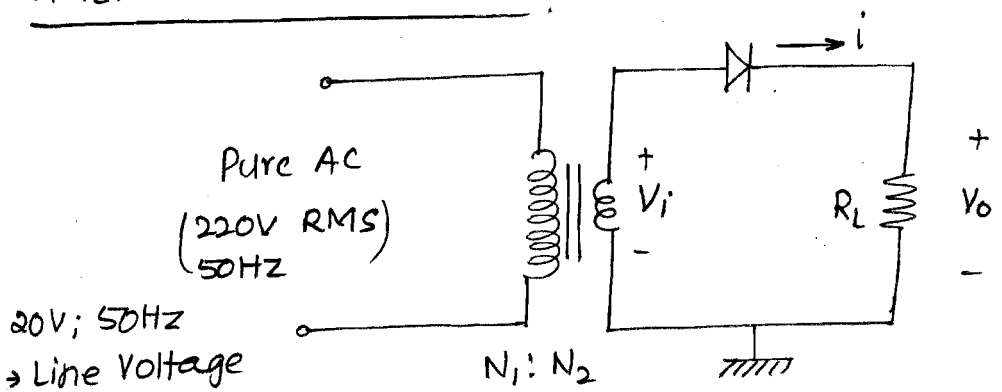
10 : 1

* Step Down Transformer is needed :.

i) to get low DC voltage from Rectifier.

ii) to protect Diodes which have smaller breakdown voltages.

HALF WAVE RECTIFIER:



* Vi : Pure AC voltage having smaller RMS value.

Mathematically,

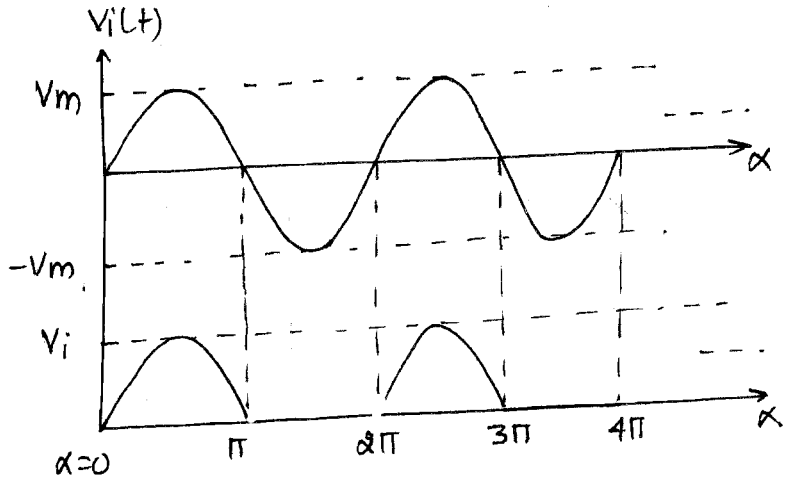
$$v_i(t) = V_m \sin\omega_0 t = V_m \sin\alpha.$$

V_m: Peak value.

$\frac{V_m}{\sqrt{2}}$: RMS value.

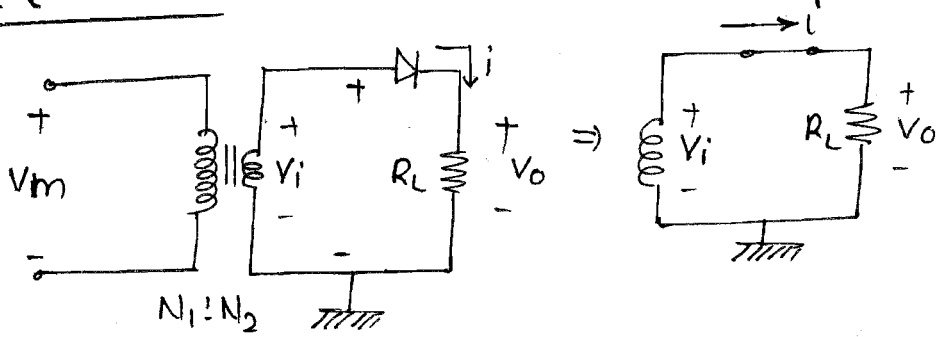
$314\ rad/sec = \omega_0 = 2\pi f_0$

$50Hz = f_0$: line frequency ie freqⁿ of AC supply (50Hz).



Analysis:

CASE I ($0 < \alpha < \pi$) :

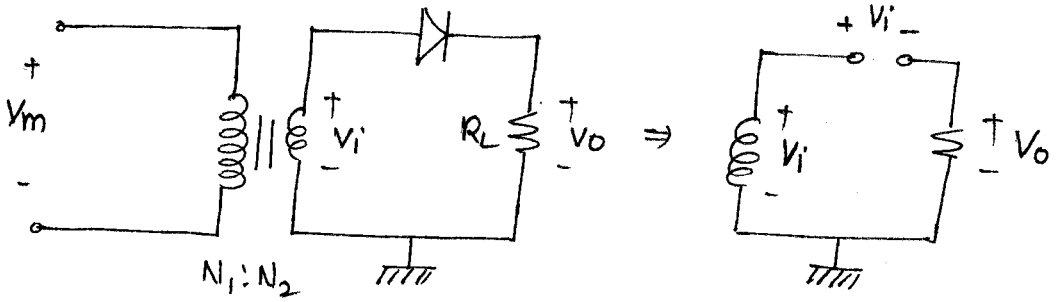


i) V_i is +ve

ii) Diode is in forward Bias ⇒ short ckt

iii) $\boxed{V_o \cong V_i}$

CASE ($\pi < \alpha < 2\pi$) :-



* Input voltage appears fully accross diode which is acting as open ckt

i) V_i become -ve

ii) Diode is in Reverse Biased ⇒ open circuit

iii) $\boxed{V_o = 0}$

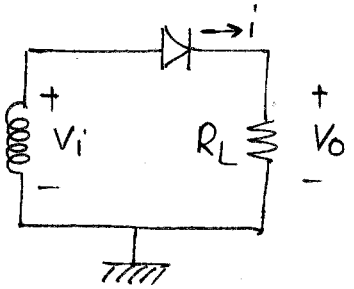
* Analysis of Hay wave Rectifier :-

i) Instantaneous output current (i) :-

a) $0 < \alpha < \pi$ [Diode is in FB ≡ R_F (few Ω)] :-

R_f = Bulk Resistance of Diode
(Inteinal Resistance of Diode).

* R_F : Inteinal Resistance of Diode; we name technically as Bulk Resistance.



* KVL in Secondary ckt :-

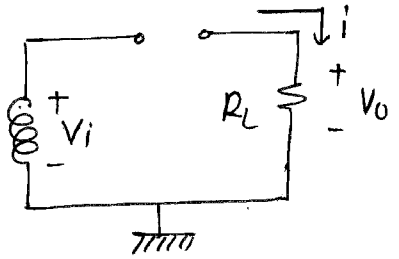
$-V_i + i \cdot R_F + i R_L = 0$

$$\boxed{i = \frac{V_i}{R_F + R_L} = \frac{V_m \sin\alpha}{R_F + R_L}}$$

$$\boxed{i = I_m \sin\alpha} \; ; \; \boxed{I_m = \frac{V_m}{R_F + R_L}}$$

i) $\pi < \alpha < 2\pi$ (Diode is in RB) :.

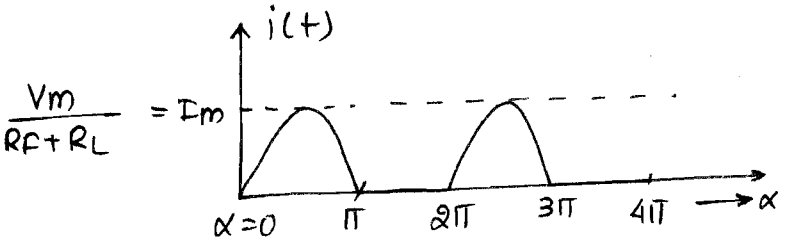
* If a diode is in RB, it passes a negligible current equal to Reverse saturation current.
* Reverse saturation current = nA (Si)
  uA (Ge).



$i \cong 0$

Hence

$$i = I_m \sin\alpha \quad ; \quad 0 < \alpha < \pi$$
$$\cong 0 \quad ; \quad \pi < \alpha < 2\pi$$



NOTE

ii) DC output current (I_{DC}) :.

I_{DC} = Average value of Instantaneous current "i".

Mathematically

$$I_{DC} = \frac{\text{Area}}{\text{Time Period}}$$

$$I_{DC} = \frac{1}{2\pi}\int_0^{2\pi} i\, d\alpha = \frac{1}{2\pi}\int_0^{\pi} I_m \sin\alpha\, d\alpha + 0.$$

$$= \frac{I_m}{2\pi}\left[-\cos\alpha\right]_0^{\pi} = -\frac{I_m}{2\pi}\left[-1-1\right]$$

$$I_{DC} = +\frac{I_m}{2\pi}\left[1+1\right]$$

***

$$I_{DC} = \frac{I_m}{\pi}\ A$$

iii) RMS output current (I_{RMS}):-

I_{RMS} = RMS value of instantaneous current "i".

Mathematically,

$$I_{RMS} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} i^2 d\alpha}.$$

$$I_{RMS} = \sqrt{\frac{1}{2\pi}\int_0^{\pi} I_m^2 \sin^2\alpha \, d\alpha}.$$

$$= \sqrt{\frac{1}{2\pi}\times\frac{I_m^2}{2}\left[\int_0^{\pi} d\alpha - \int_0^{\pi} \cos 2\alpha \, d\alpha\right]}.$$

$$= \sqrt{\frac{I_m^2}{2\pi\times 2}\left[\pi\right]}$$

$$= \sqrt{\frac{I_m^2}{4}}$$

***

$$\boxed{I_{RMS} = \frac{I_m}{2} A.}$$

iv) RMS value of AC component (I'_{RMS}):-

*output current of Rectifier is a pulsating DC ie (AC+DC).

$$\boxed{i = \text{AC Component} + \text{DC Component}}$$

$$i = i' + I_{DC}$$

$$\boxed{i' = i - I_{DC}} \leftarrow \text{AC component.}$$

I'_{RMS} = RMS value of i'.

$$= \sqrt{\frac{1}{2\pi}\int_0^{2\pi} (i')^2 d\alpha}$$

$$(I'_{RMS})^2 = \frac{1}{2\pi}\int_0^{2\pi}(i - I_{DC})^2 d\alpha = \frac{1}{2\pi}\int_0^{2\pi} i^2 d\alpha + \frac{1}{2\pi}\int_0^{2\pi} I_{DC}^2 d\alpha - \frac{1\times 2}{2\pi}\int_0^{2\pi} I_{DC}\cdot i \, d\alpha$$

$$(I'_{RMS})^2 = \frac{1}{2\pi}\int_0^{2\pi} i^2 d\alpha + \frac{1}{2\pi}\int_0^{2\pi} I_{DC}^2 d\alpha - \frac{2}{2\pi}\int_0^{2\pi} I_{DC}\, i\, d\alpha$$

$$= \underbrace{\frac{1}{2\pi}\int_0^{2\pi} i^2 d\alpha}_{I'^2_{RMS}} + \frac{1}{2\pi} I_{DC}^2 (2\pi) - \underbrace{\frac{2I_{DC}}{2\pi}\int_0^{2\pi} i\, d\alpha}_{I_{DC}}$$

$$(I'_{RMS})^2 = I'^2_{RMS} + I_{DC}^2 - 2I_{DC}^2$$

$$\boxed{(I'_{RMS}) = \sqrt{I'^2_{RMS} - I_{DC}^2}}$$

← An AC Ammeter Connected in series with R_L will record I'_{RMS}. Therefore I'_{RMS} is also known as Reading of AC Ammeter.

Note :-

* I_{DC} is reading of DC Ammeter.

) RIPPLE FACTOR (γ) :-

* The unwanted AC component which is present in the O/P of the Rectifier is known as Ripple.
* Ripple factor is a measure of the amount of AC component

Mathematically,

$$\boxed{r = \frac{\text{RMS value of AC component}}{\text{DC component}}}$$

$$\boxed{r = \frac{I'_{RMS}}{I_{DC}} = \frac{V'_{RMS}}{V_{DC}}}$$

As AC component is unwanted, Ripple factor should be smaller, and Ideally should be zero.

* Analysis :-

$$\boxed{r = \frac{I'_{RMS}}{I_{DC}} = \frac{\sqrt{I'^2_{RMS} - I_{DC}^2}}{I_{DC}} = \sqrt{\left(\frac{I'_{RMS}}{I_{DC}}\right)^2 - 1}}$$

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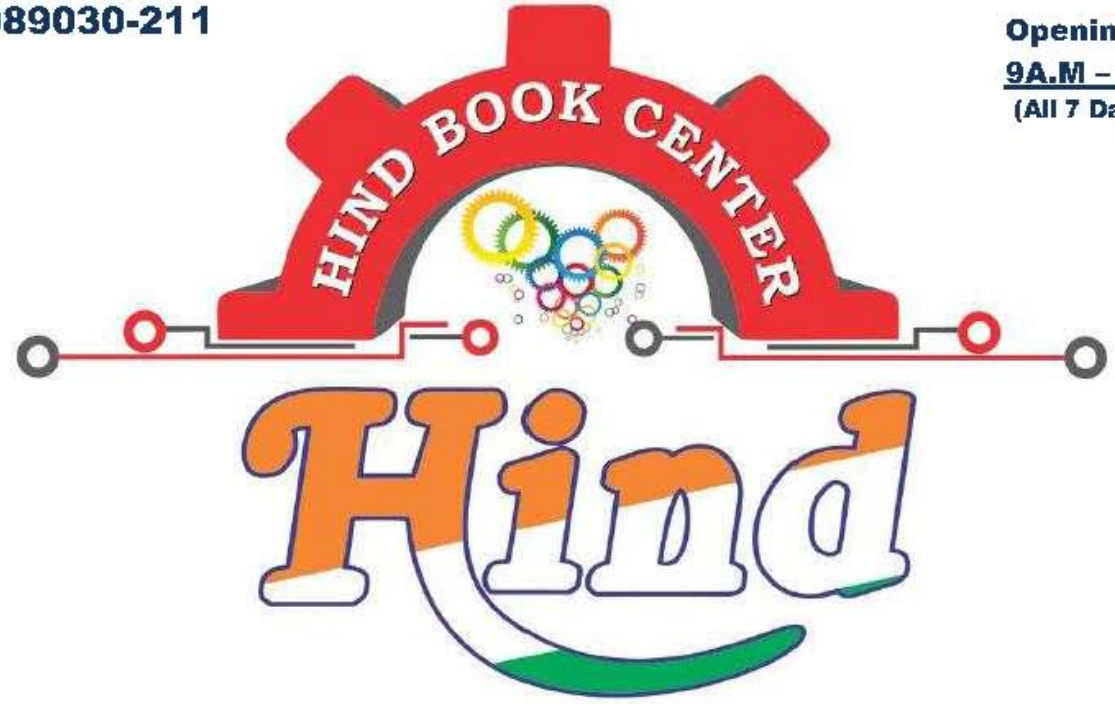

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Basic Electrical

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SYLLABUS:-

1) Transformers.
2) DC Machines. → Generator. / → Motor.
3) Induction machines → Motor. / → Generator.
4) Synchronous Machines → Motor. / → Generator.
5) Power Sources → Thermal. / → Nuclear. / → Hydro. / → Solar. / → Wind. / → Batteries.

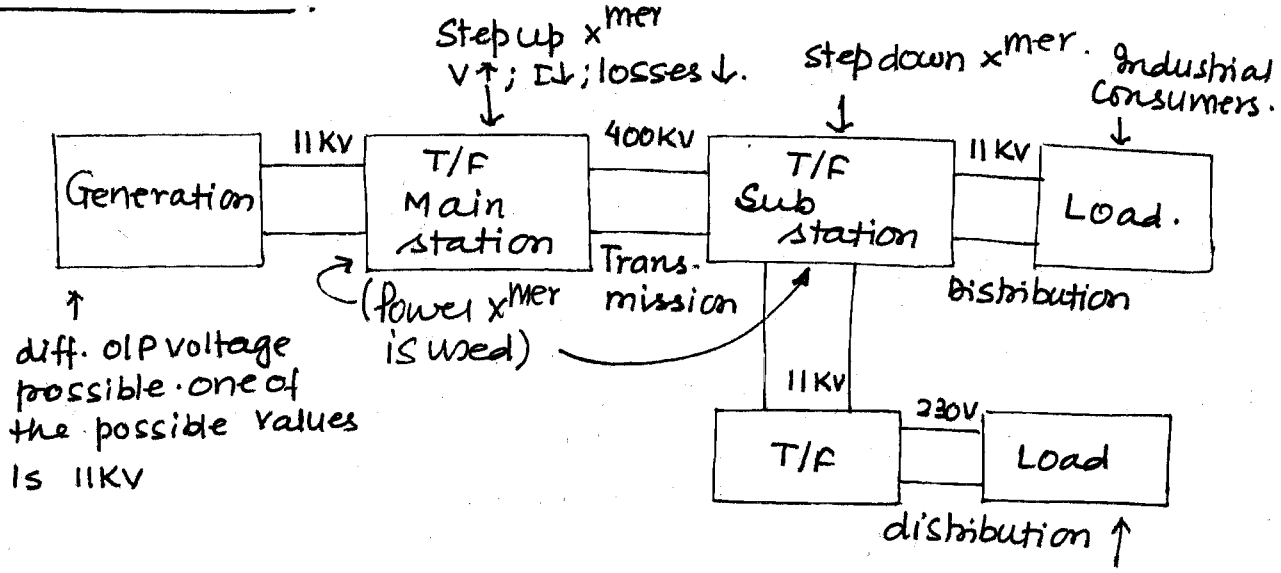
Books:-

1) Electrical Technology
   → Volume II
   C.B.L. THERAJA.

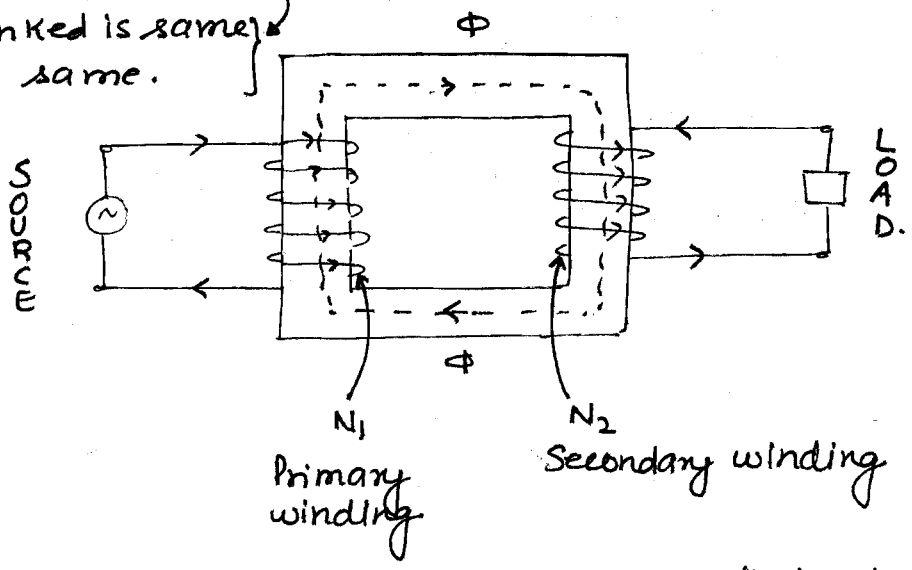
2) Electric Machines.
   → Ashfaq Hussain.

* Homework.
* Work book.
* Theory Book.

* TRANSFORMERS:



* No Rotating parts.
* x^mer is static Device
* Power linked is same
* Freq^n is same.



* Based on no. of turns ; x^mer is classified as:.

1) $N_1 > N_2$ ← Step Down x^mer.
2) $N_1 < N_2$ ← step up x^mer.
3) $N_1 = N_2$ ← Isolation x^mer.

Note:.

* Transformer is a static Device which consists of 2 or more than 2 electric circuits interlinked by common magnetic flux for the purpose of Transforming Power from 1 CKt to other CKt without changing any frequency and power.
* Transformer works based on the principle of FARADAY's LAW of ELECTROMAGNETIC INDUCTION (Mutal Inductance).

*In the xmer with respect to external ckt no energy conversion is present but with respect to internal ckt electrical energy is converted to magnetic field. and the magnetic field is converted to electrical energy.

*In the xmer Primary and Secondary winding are Electrically Isolated but are magnetically connected together.

*With respect to no. of turns ; xmers are classified as:.

i) $N_1 > N_2$ ← step Down xmer.

ii) $N_1 < N_2$ ← step up xmer.

iii) $N_1 = N_2$ ← Isolation xmer.

*Applications of xmer:.

1) To change the level of Voltage
2) To xfer maximum power from source to load (Impedance matching xmer).
3) To separate Dc component in the AC system (Isolation xmer).

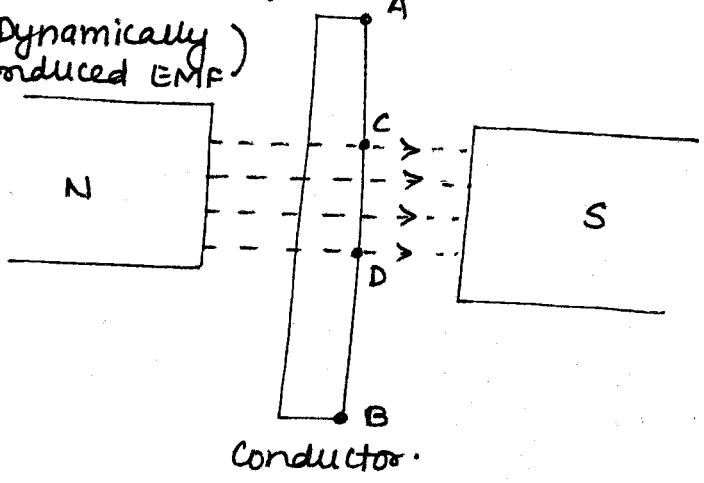
Note:.
*when distorted Sinusoidal waveform (consisting of Dc values and harmonics) are given to the xmer, then the xmer allows only the AC components and doesn't pass the Dc component. Hence it separates AC & Dc part. When separating of AC & DC is the only purpose then Isolation xmer ($N_1 = N_2$) is used.

*Note:.
*Essential Requirements to obtain Induced voltage are :-
i) Conductor
ii) Magnetic Field.
iii) Relative speed between Conductor and magnetic field. (either with respect to space or time).

*Note:.
*If the field is Constant (directed from North to South Pole of Permanent magnet) and if the Conductor is held Const (Stationary → No Relative motion) then NO EMF is Induced in the Conductor.

*Analysis:- (when conductor is Rotating.)

CASE I (Dynamically Induced EMF)



*EMF Induced in the conductor when it is being rotated in the steady magnetic field is called as DYNAMICALLY INDUCED EMF.

Eg: GENERATOR:

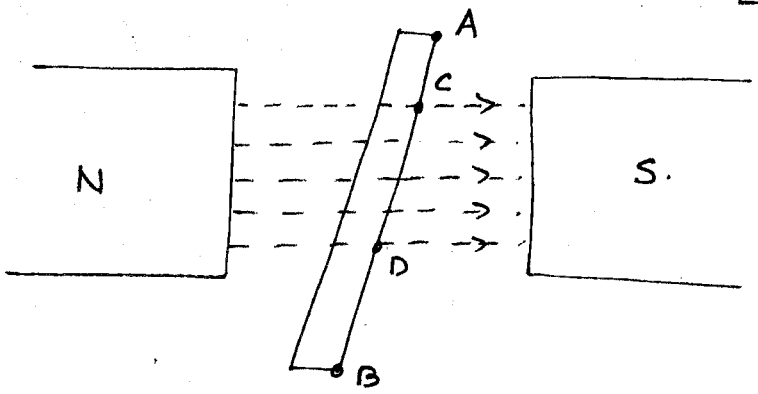
*FARADAY'S 1st LAW:-

*when conductor cuts the MAGNETIC LINES OF FORCE an EMF is Induced in the conductor

*FARADAY'S 2nd LAW:-

*EMF Induced in the conductor is directly proportional to RATE OF CHANGE OF FLUX.

$$e \propto \frac{d\phi}{dt}$$



$$e = BlV \sin\theta$$

B = Flux Density

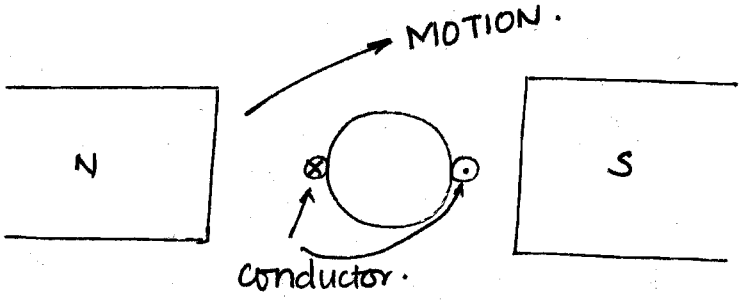
l = Active length of Conductor (CD)

V = linear Velocity of Conductor.

θ = Phase displacement b/w Conductor & mag

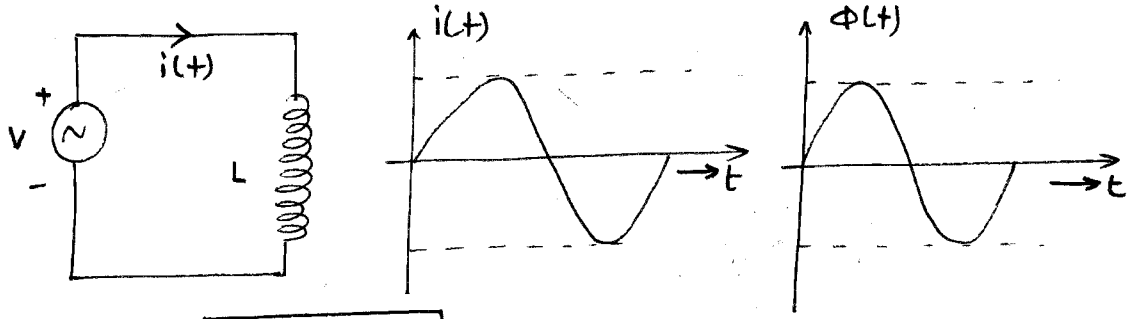
* Direction of Dynamically Induced EMF is obtained by using Fleming's RIGHT HAND RULE.

1) THUMB Indicates direction of MOTION.
2) FORE FINGER Indicates the direction of FLUX.
3) MIDDLE FINGER Indicates direction of INDUCED VOLTAGE (Induced current).



CASE 2 (Statically Induced EMF):

* EMF Induced in the conductor when it is subjected to TIME VARYING FLUX is called as STATICALLY INDUCED EMF.
* Direction of Statically Induced EMF is obtained by using LENZ LAW.



$e \propto d\Phi/dt$

$e = -N\frac{d\Phi}{dt}$

Lenz Law

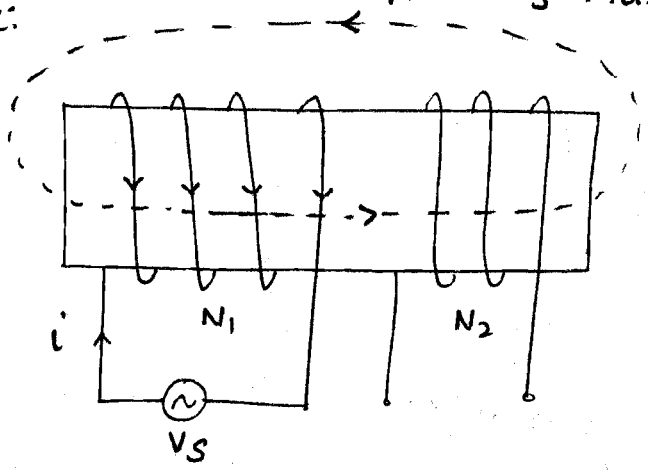
$V \rightarrow i \rightarrow \Phi \rightarrow e$

Lenz Law.

{ Induced EMF always oppose its cause due to which it is produced. }

* Analysis:-

Φ ← mag. flux forms closed path.



$$e_1 \propto \frac{d\Phi}{dt}$$

$$e_1 = -N_1 \frac{d\Phi}{dt}$$

$$= -N_1 \frac{d\Phi}{di} \times \frac{di}{dt} \quad \left[L = \frac{N\Phi}{i}\right]$$

$$\boxed{e_1 = -L_1 \frac{di}{dt}}$$ ← SELF INDUCED EMF.

$$e_2 \propto \frac{d\Phi}{dt}$$

$$e_2 = -N_2 \frac{d\Phi}{dt}$$

Current of 1st & no. of turns of 2nd →

$$= -N_2 \frac{d\Phi}{di} \times \frac{di}{dt} \quad \left[M = \frac{N_2\Phi}{i}\right]$$

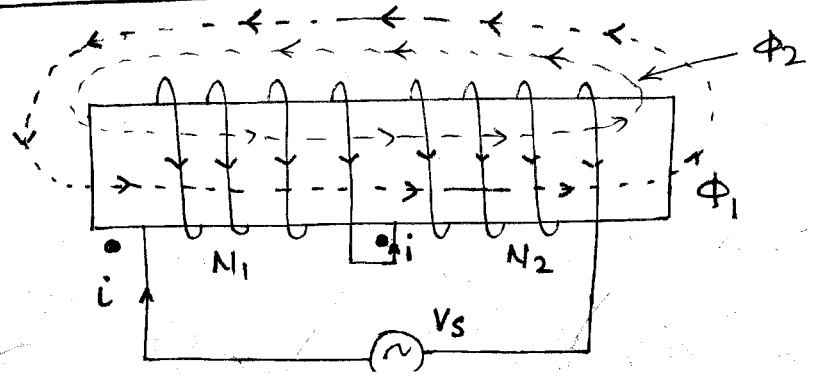
$$\boxed{e_2 = -M \frac{di}{dt}}$$ ← MUTUAL INDUCED EMF.

* MAGNETIC COUPLING:-

CASE 1 :-

↓

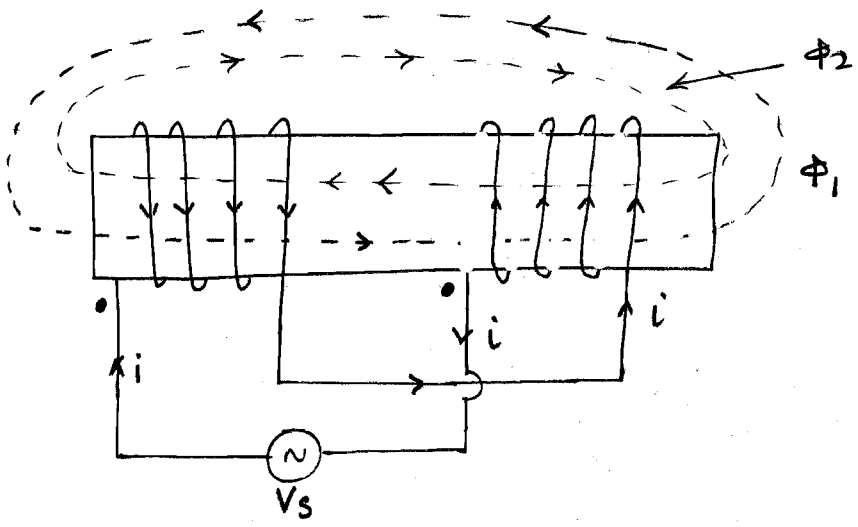
+ve mag. coupling.



CASE 2 :.

↓

-ve mag. coupling



Note:.

*) When Flux of the 2 Inductors are completing closed Path in the same direction then it is called as +VE MAGNETIC COUPLING.

OR

When the current is either entering or leaving at both DOTTED TERMINALS then it is called as +VE MAGNETIC COUPLING.

* When Flux of the 2 Inductors are completing closed Path in the opposite direction then it is called as -VE MAGNETIC COUPLING.

OR.

When one current is entering and other current is leaving at dotted terminal then it is called -VE MAGNETIC COUPLING.

Note:.

*In the xmer to maintain CONSTANT INDUCED VOLTAGE -ve MAGNETIC COUPLING is preferred.

* CLASSIFICATION OF TRANSFORMERS:

1) With Respect to Conliuction:

a) CORE TYPE XMER.
b) SHELL TYPE XMER.

2) With Respect to no. of windings:

a) SINGLE WINDING XMER (AUTOTRANSFORMER).
b) TWO WINDING XMER.
c) THREE WINDING XMER.

3) With Respect to no. of Phases:

a) SINGLE PHASE XMER
b) THREE PHASE XMER

4) With Respect to operating Frequency:

a) AUDIO FREQUENCY XMER
b) POWER FREQUENCY XMER

5) With Respect to Power System Appln:

a) DISTRIBUTION XMER.
b) POWER XMER.

6) With Respect to Measurement Appln:

a) CURRENT XMER.
b) POTENTIAL XMER.

7) With Respect to Electronic Appln:

a) IMPEDANCE MATCHING XMER.
b) ISOLATION XMER.
c) PULSE XMER.

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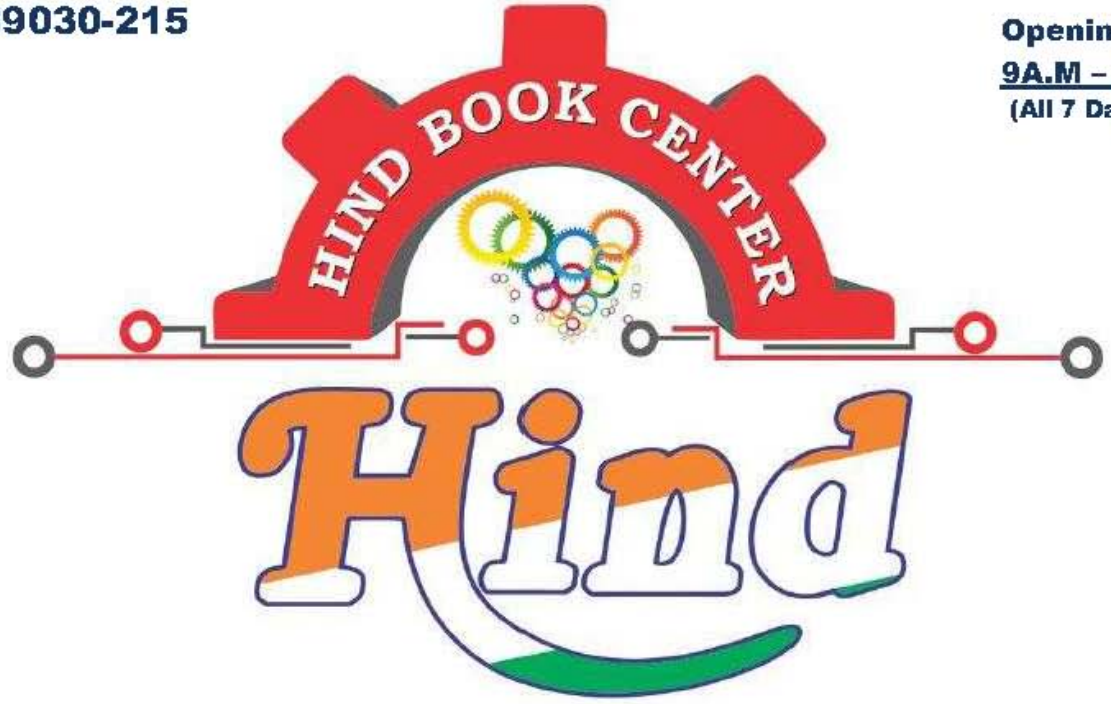

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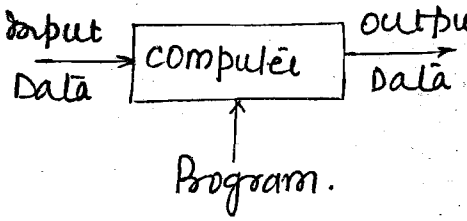
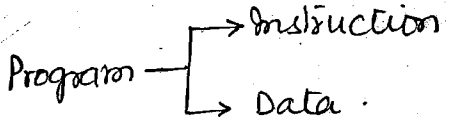
*COMPUTER:

*It is a computational device used to process the data under the control of a Program. so computer system functionality is program execution.



PROGRAM:

*Program is a sequence of instructions alongwith a Data.



*INSTRUCTION:

*It is a Binary code which is designed inside the processor to perform some task.

← The processor knows the meaning of a Binary code which is fed to it

Binary code - Bind with - operation.

For eg:.

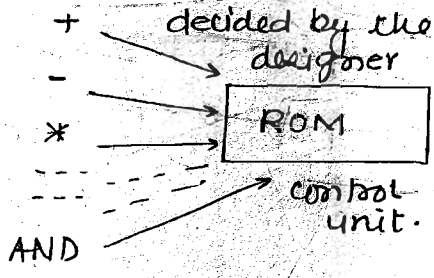
If CPU supports 8 operation then OPCODE size is specified as

$$\log_2^8 = 3 \text{ bit}$$

Binary code
000
001
010

111

operation



DATA:-

*Data is a binary code which is associated with a value based on the format

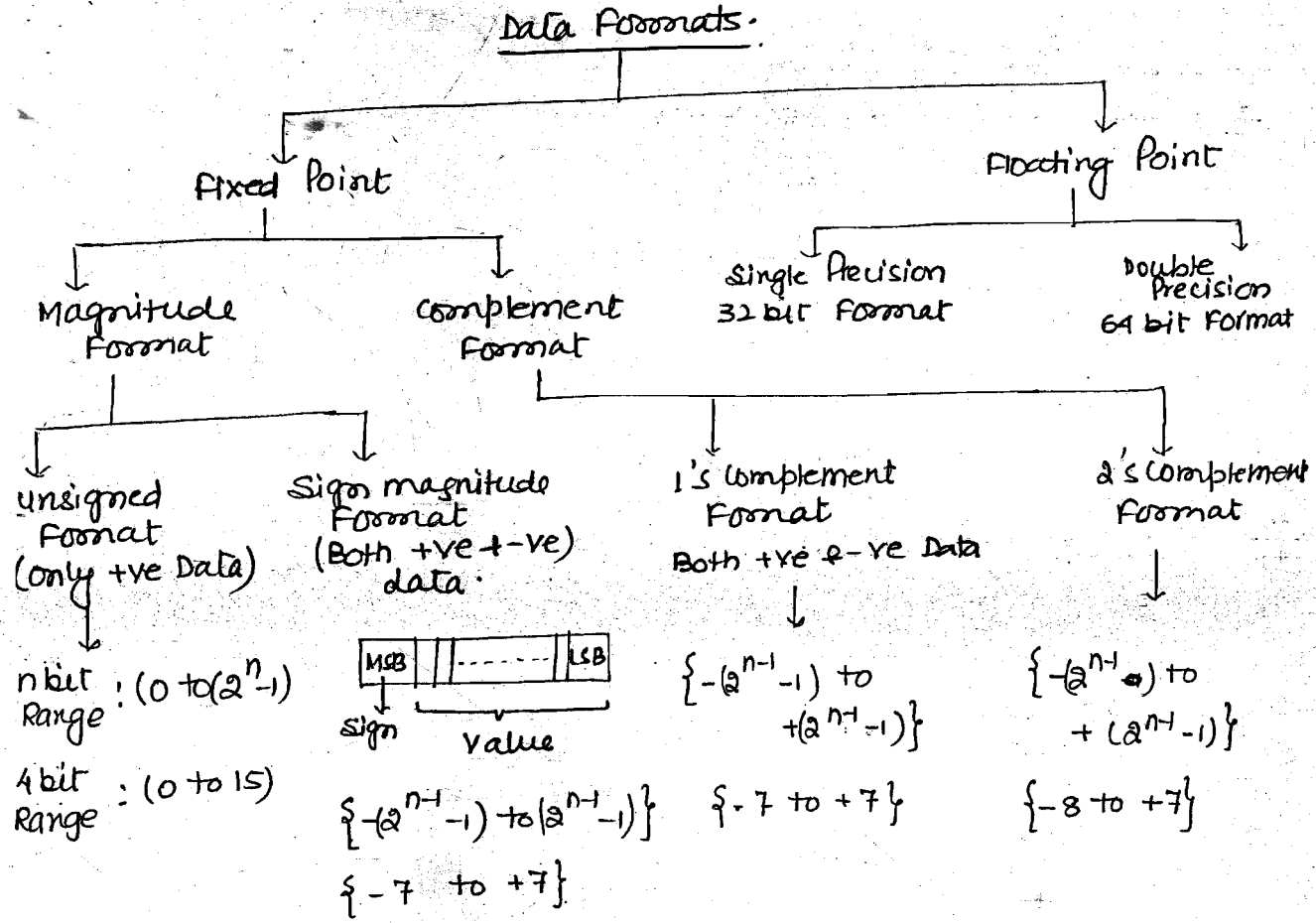
Binary code	- Bind with	- Value

$101 \longrightarrow 5$

$(101)_2 = 1\times2^2 + 0\times2^1 + 1\times2^0$

$= 5$

* Different data format used in the computer systems Design is as follows:-



4 Bit Binary	Unsigned Data	Sign magnitude Data	1's Comple-ment Data	2's Comple-ment Data
0000	0	+0	+0	+0
0001	1	+1	+1	+1
0010	2	+2	+2	+2
0011	3	+3	+3	+3
0100	4	+4	+4	+4
0101	5	+5	+5	+5
0110	6	+6	+6	+6
0111	7	+7	+7	+7
1000	8	-0	-7	-8
1001	9	-1	-6	-7
1010	10	-2	-5	-6
1011	11	-3	-4	-5
1100	12	-4	-3	-4
1101	13	-5	-2	-3
1110	14	-6	-1	-2
1111	15	-7	-0	-1
		(Not in use)		

1000 = -7
1000 = 0111 (7)

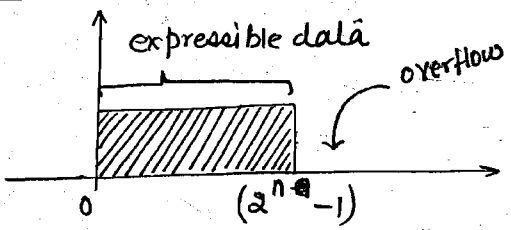
1000 = (-8)
1000 = 1000 (8)

1001 = -6
1001 = 0110 (6)

1001 = (-7)
1001 = 0111

(1's complement) (2's complement)

Note(Unsigned data):-



*carry flag is used in the processor design to indicate the Range exceeding condition of unsigned arithmetic ie

n bit + n bit = (n+1) bit

1 bit storage space
1 flip flop.
Flag → carry flag

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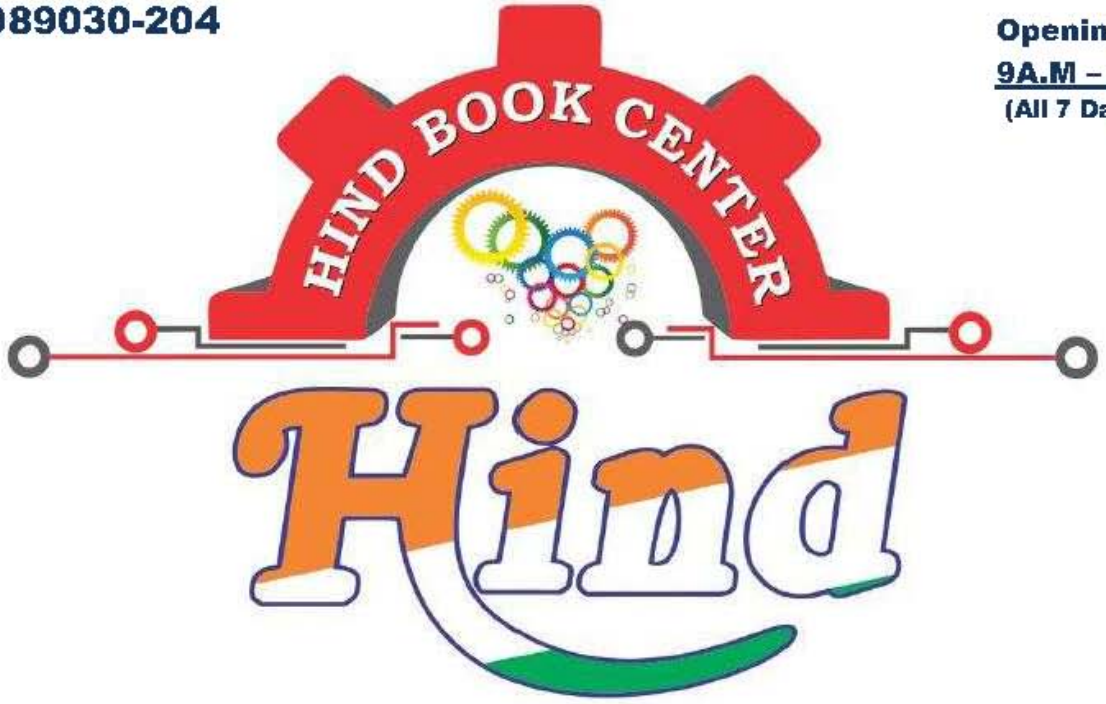

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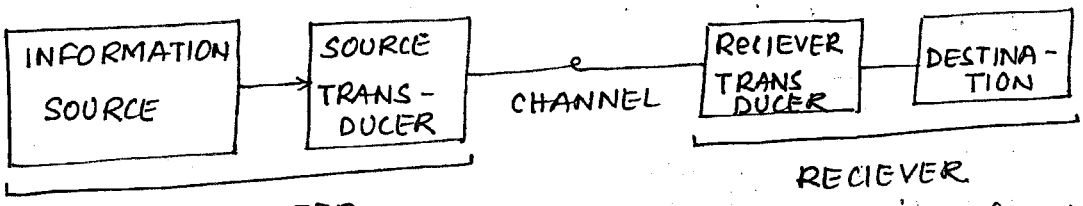
* COMMUNICATION:.

* It is the process of transmitting information from source to Reciever.

* BASIC BLOCK DIAGRAM OF COMMN SYSTEM:.

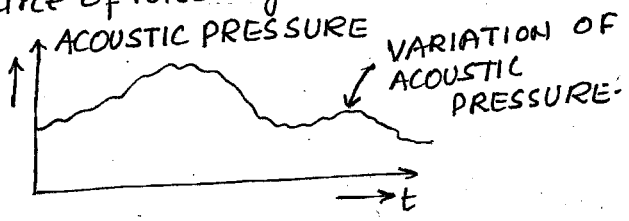


WIRED COMMN SYSTEM → Preferred for short distance

* NOTE:.

i) VOICE SIGNAL:→ Vocal cord is source of Voice Signal.

Range: 300Hz to 3.5 KHz



ii) AUDIO SIGNAL:.

Range: 20Hz to 20KHz.

iii) VIDEO SIGNAL:.

Range: 0 to 4.5MHz

* VOICE SIGNAL is a subset of Audio Signal
* Whatever sound that we can hear is the source of Audio Signal.
* VIDEO SIGNAL → variation of light intensity with time.

Note:.

* Information source is the source of the information.
* Source Transducer converts physical signal into electrical equivalent.

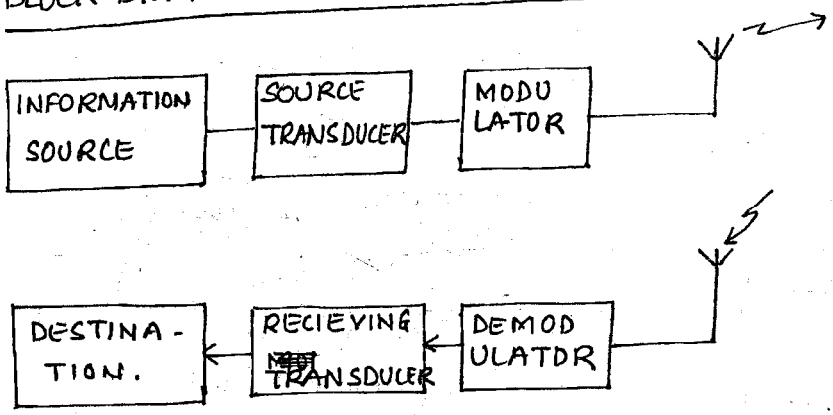
Eg MIC, MICROPHONE.

* Wired communication system is preferred for short distance communication only
* For long distance comm^n wireless transmission is preferred in which signal propagates through free space.

*Recieving Transducer converts Electrical signal into Physical equivalent.

Ex: LOUDSPEAKER.

*BLOCK DIAGRAM OF WIRELESS COMM^N SYSTEM:



*Long distance communication cannot be done without modulation.

* Generally without modulation, long distance communication through free space is not possible

*NEED FOR MODULATION:

i) Reducing Antenna Height

*For faithful Radiation the height of Antenna should be

$$h_t = \lambda/4 \quad ; \quad \lambda = v/f \Rightarrow \boxed{h_t = \frac{c}{4f}}$$

* Faithful Radiation means that the Properties of the Transmitting signal should not change.

Analysis:

let $f_1 = 15\ KHz$ → 15KHz → MOD. → 1MHz → $f_2 = 1\ MHz$

$$h_t = \frac{c}{4f} = \frac{3\times10^8}{4\times15\times10^3}$$

Practically not possible. → $h_t = 5\ Km$

$$h_t = \frac{c}{4f} = \frac{3\times10^8}{4\times10^6}$$

$h_t = 75$ mehre

↑ Practically can be implemented.

Note:-

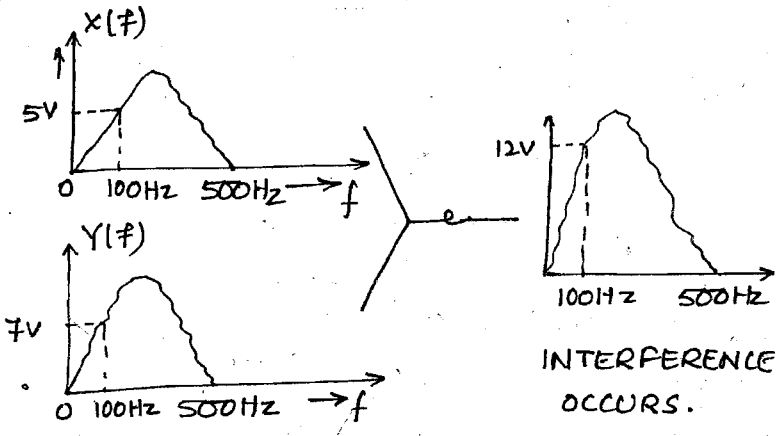
* For faithful Radiation of a Signal, Antenna Height should be atleast of $\lambda/4$.
* Transmitting Antenna converts ELECTRICAL SIGNAL INTO ELECTRO MAGNETIC and resulting signal propagates with light velocity.
* MODULATION is the process of increasing frequency of the signal to reduce Antenna height requirements.

ii) MULTIPLEXING:-

* Generally without modulation, multiplexing is not possible.
* MULTIPLEXING is the process of transmitting multiple no. of signals through a common channel.
* Generally without modulation, multiplexing is not possible.

$x(t) \longleftrightarrow X(f)$

$y(t) \longleftrightarrow Y(f)$



Note:-

* Due to interference only the interfered signal will be obtained and the original signal is lost in the process.
* Interference process is IRREVERSIBLE. once it occurs, it can't be Reversed ie individual signal can't be obtained back.
* During interference individual frequency components of the original signals are added.
* Due to interference, Multiplexing is failed.
* To avoid this, ~~reverse~~ modulation of original signal is done with different carrier frequencies, so that when multiplexed original signal is not lost.

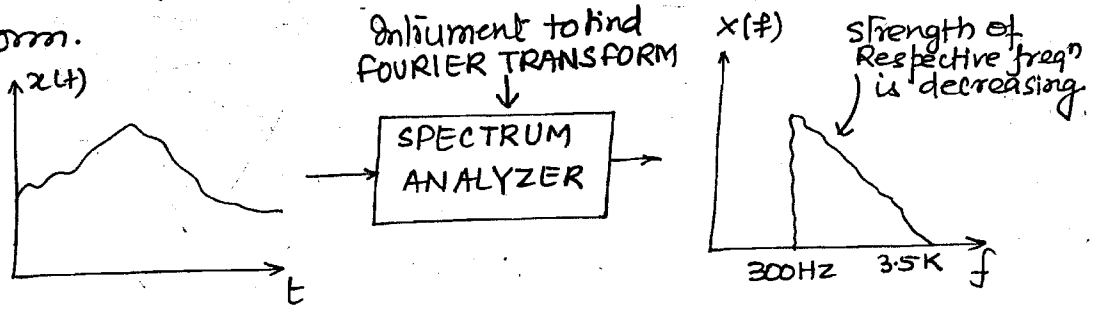
* FOURIER TRANSFORM:

* used to convert time domain signal $x(t)$ to frequency domain signal $X(f)$

$$x(t) \longleftrightarrow X(f)$$

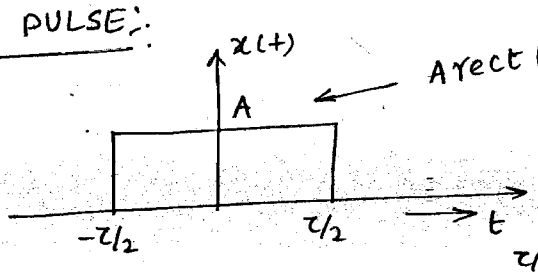
$$X(f) = \int_{-\infty}^{\infty} x(t)\, e^{-j2\pi ft}\, dt$$

* To obtain the frequencies present in $x(t)$ we do its Fourier Transform.



* FOURIER TRANSFORM is basically used to find Frequencies presented in the given TIME DOMAIN SIGNAL.

* RECTANGULAR PULSE:



$$X(f) = \int_{-\infty}^{\infty} x(t) e^{-j2\pi ft}\, dt = \int_{-\tau/2}^{\tau/2} A\, e^{-j2\pi ft}\, dt$$

$$= A \left. \frac{e^{-j2\pi ft}}{-j2\pi f} \right|_{-\tau/2}^{\tau/2}$$

$$= \frac{-A}{j2\pi f} \left\{ e^{-j2\pi f\tau/2} - e^{+j2\pi f\tau/2} \right\}$$

$$= \frac{A}{\pi f} \left\{ \frac{e^{j\pi f\tau} - e^{-j\pi f\tau}}{2j} \right\}$$

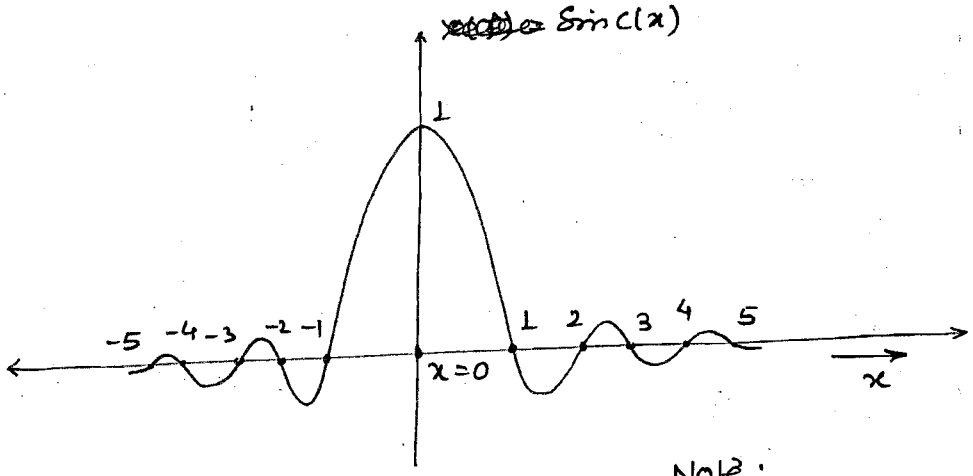
$$X(f) = \frac{A}{\pi f} \sin(\pi f \tau)$$

Note:

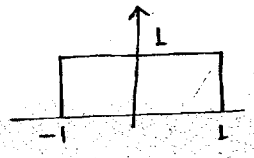
$$Sa(x) = \frac{\sin x}{x}$$

$$\text{sinc}(x) = \frac{\sin \pi x}{\pi x}$$

$$\text{sinc}(x) = 1 \; ; \; x = 0$$
$$= 0 \; ; \; x = \pm 1, \pm 2 \cdots$$



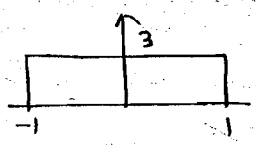
Note:



$\leftrightarrow 2\,\text{sinc}(2f)$

Now, $X(f) = \frac{A}{\pi f} \sin \pi f \tau$

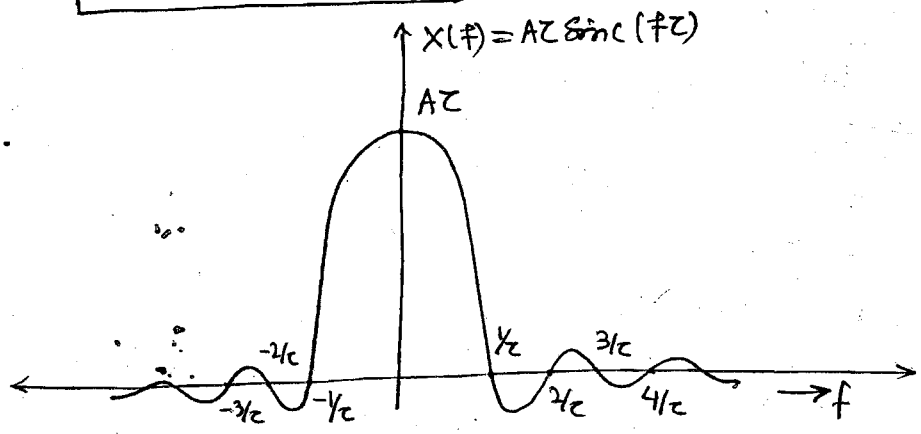
$= A \times \frac{\sin \pi f \tau}{\pi f \tau} \times \tau$

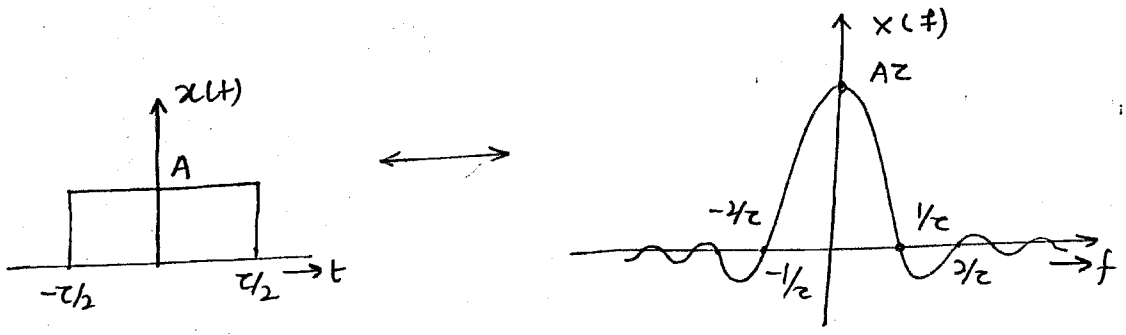


$\leftrightarrow 6\,\text{sinc}(2f)$

***

$$X(f) = A\tau \,\text{sinc}(f\tau)$$





Note:-

* Practically only the +ve frequency exists.
* X(f) contains all possible frequency from 0 to ∞.
* Bandwidth of x(t) is given as:-

$$BW = (\text{Highest +ve Frequency}) - (\text{Lowest +ve frequency})$$

$BW = \infty - 0 = \infty$ ← of Rectangular Pulse (Ideal Bandwidth).

* Always for faithful transmission:-

Bandwidth of channel $\geq$ Bandwidth of Signal ← So that Attenuation doesn't occur.

Note (Bandwidth of some Practical channels)

FINITE BAND WIDTH.

i) COAXIAL CABLE → 0 - 600 MHZ. ← depends on material by which it is made. If material is not good then Bandwidth will be reduced.

ii) PARALLEL WIRE → 0 - 200 MHZ

iii) OPTICAL FIBRE CABLE → FEW GHZ

* Bandwidth of channel also depends on its physical dimension.

* Every channel (wired) has FINITE BANDWIDTH. Hence the BW of x(f) has to be reduced.

*** BW of FREE SPACE is ∞. Since it is having ∞ BW hence x(f) can be sent to free space but generally not done since in free space there are various frequencies available and then x(f) will get interfered with all those frequencies and will get lost in the process.

Note:

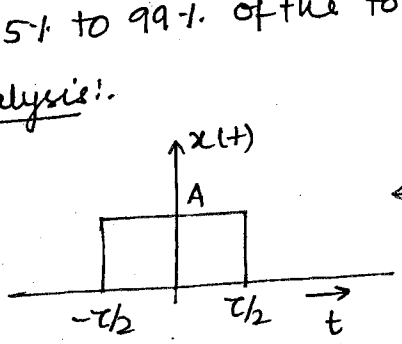
*For Proper Transmission of above signal, channel Bandwidth of ∞ is required.

*But BW offered by Practical channel will be finite only, so that before Transmission above signal should be BANDLIMITED by using "BANDLIMITING PROCESS".

* only those frequency component which contain 95 to 99 %. of the Energy / Power (total) are kept and rest are discarded during the Bandlimiting Process.

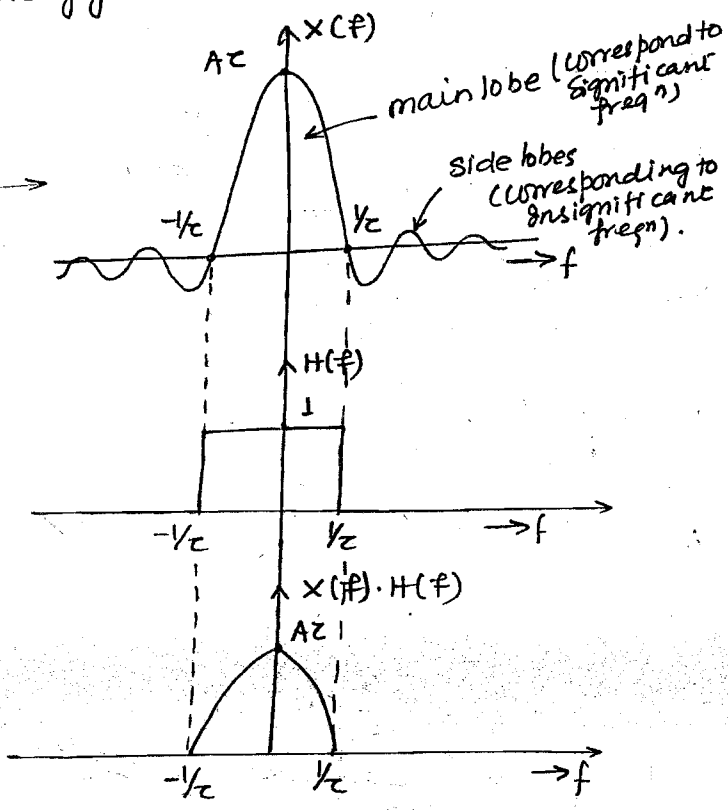
* Significant frequency are those frequencies which contain 95% to 99 %. of the total energy.

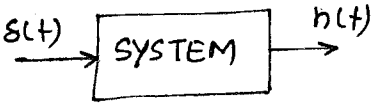
Analysis:



$$E = \int_{-\infty}^{\infty} x^2(t)\,dt = A^2\tau$$

Also, $$E = \int_{-\infty}^{\infty} |X(f)|^2\,df$$



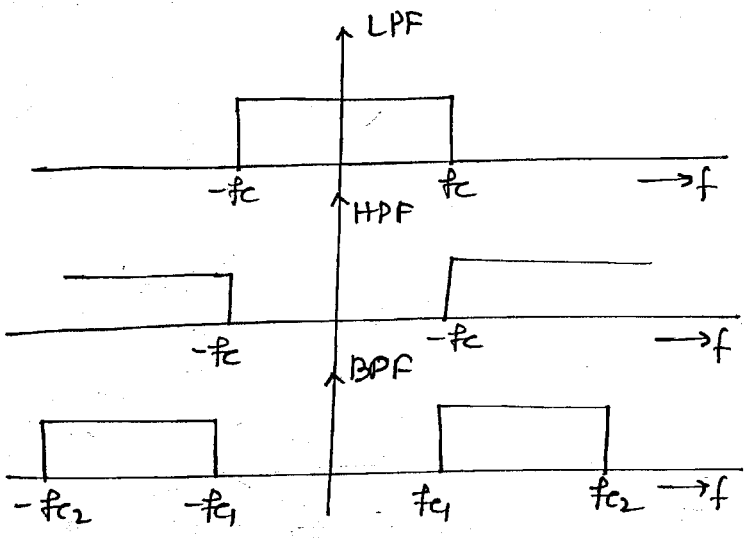


$h(t) \longleftrightarrow H(f)$

BW = $1/\tau$

* In Filter Analysis, we take -ve frequency into ~~Consideration~~ Consideration but in reality they donot exist.

Note:.



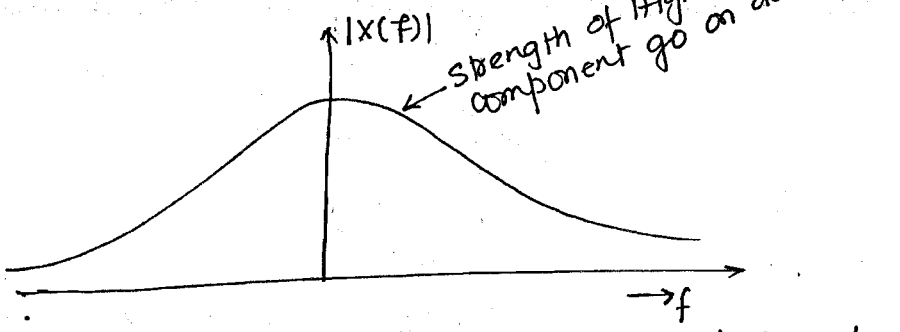
Note:.

* In Practical cases only the significant frequencies are to be transmitted. We don't transmit insignificant frequency.
* To Band limit a signal, significant frequencies only should be retained and insignificant frequencies should be eliminated.
* SIGNIFICANT FREQUENCY CONTAINS 95% to 99% of total strength of signal

*Analysis:.

$$x(t) = e^{-t}u(t) \longleftrightarrow X(f) = \frac{1}{a+j2\pi f} = \frac{1}{1+j2\pi f}$$

$$|X(f)| = \frac{1}{\sqrt{1+4\pi^2 f^2}}$$



* Strength of any Naturally generated signal always decreases as frequency increases.
* Naturally occurs; no mathematical proof.

Transfer Func^{n} model only for LTI system.

UNIT I :

i) BDR } Graphical
ii) SFG }
iii) Electrical network } Physical
iv) Mechanical System }
v) Integro differential Equation } mathematical
vi) Algebraic Equations

} ⇒ Transfer Function.

Analysis of Control System using Transfer function model

- Response Analysis (done for stable system).
  - Time Domain (2)
  - Freq^{n} domain (5)
- Stability Analysis (for any system).
  - Time domain (3) (4)
  - Freq^{n} domain (5).

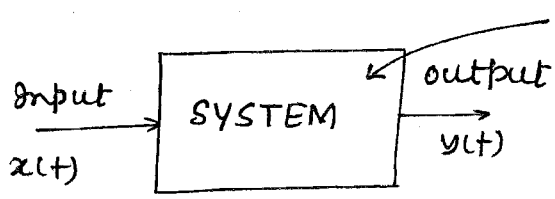
UNIT 6 : (Controller & Compensators)
↳ Redesigning of Control systems.

UNIT 7 :
State model approach. (for any system).

SYSTEM:-

*System is a means of Transforming a signal.

*Signal is one which carries Information.

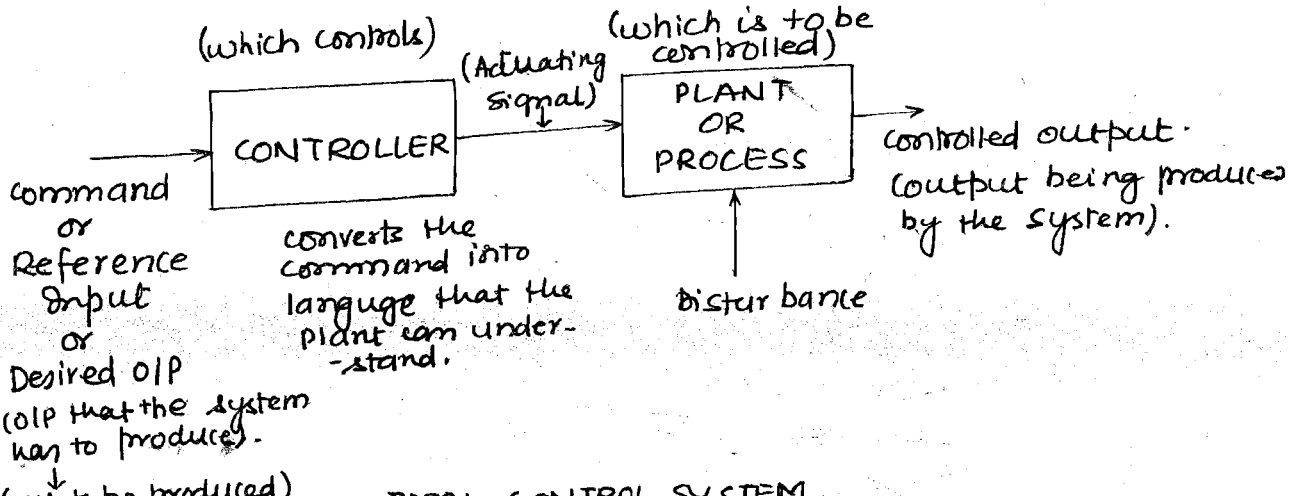


*control system gives specific output (demanded output). or desired output or deterministic output.

Note:-

*control system is that means by which any quantity of Interest is maintained or altered according to desired manner.

*Block Diagram of control system:-



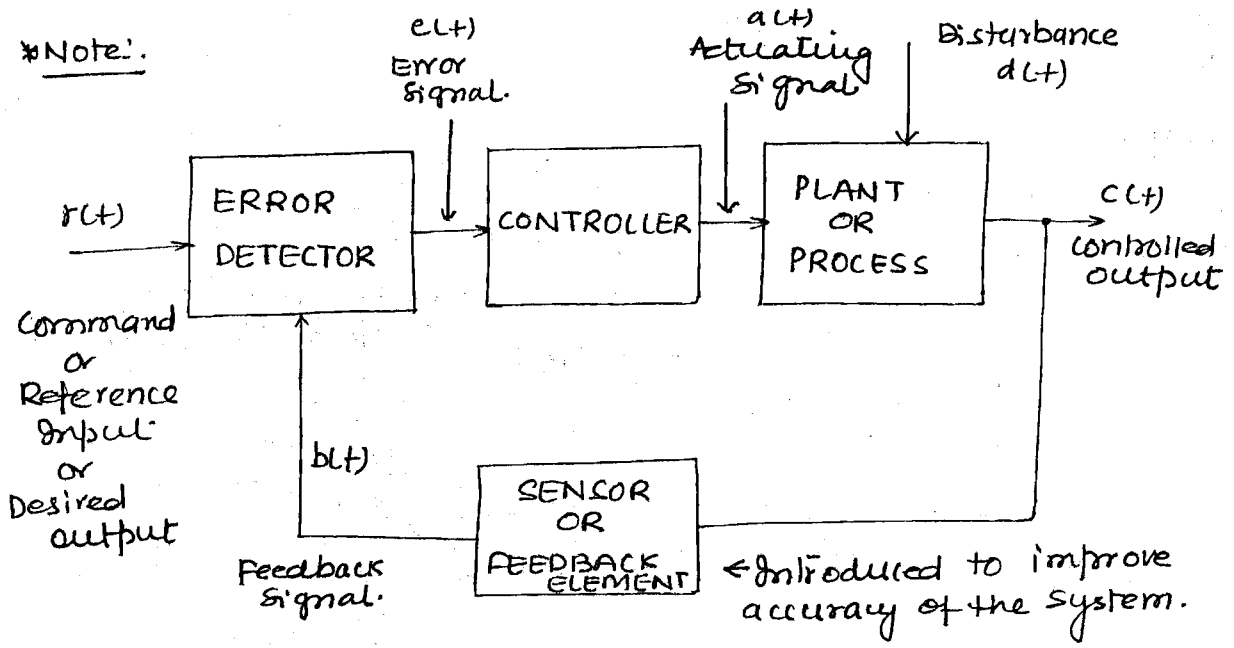
IDEAL CONTROL SYSTEM

Note:-

*Objective of any control system is to ensure that the controlled output becomes same as the command; or desired output.

*This state of the system is called as STEADY STATE.

*Note:-



Note:-

* If any disturbance occurs then the output of the control system differs from set value. To Restore the controlled output to its original value; the control system is modified as shown in above figure.

* Error Detector produces error signal with the help of sensor as the difference between desired output and actual output; which is suppressed by the controller by modifying the output of the Plant. Hence the effect of disturbance associated with the plant disappears from the total output. However, disturbance associated with other parts of the control system still continues in the output of the system which is unavoidable. Hence any practical system can reach the steady state with 100% desired output only at $t = \infty$.

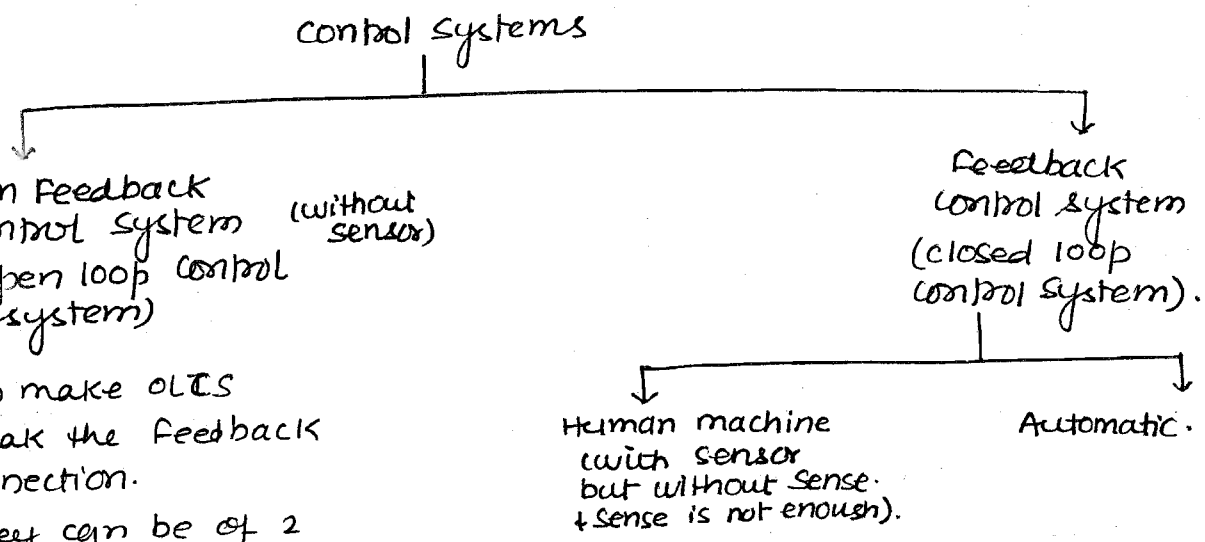
* $e(t) = 0$; hence rate of change of actuating signal is zero.

$$\frac{d}{dt} a(t) = 0 \Rightarrow d(t) = K.$$

Hence output becomes constant.

* Feedback in control system is introduced mainly to improve its accuracy but it also has impact on Gain, Bandwidth ; speed ; sensitivity ; stability etc.

* Classification of control systems:-



* To make OLCS break the feedback connection.

* They can be of 2 types:-

i) with sensor but without sense { used in Real time → Automobile → speedometer doesn't interact with Brakes. ↳ Gap is present since the sense is not enough to drive the process }.

ii) without sensor.

* Differences between performance of open & closed loop control system:-

OPEN LOOP CONTROL SYSTEM	CLOSED LOOP CONTROL SYSTEM
i) Behaviour of open loop system does not change though it's output changes. Hence the open loop system is not accurate.	i) Behaviour of closed loop system does change, if its output changes. Hence closed loop system is accurate.
ii) In open loop system sense is not present/complete, but usually sensor is present not compulsorily.	ii) In closed loop system sence is always present/complete either manually or automatically
iii) Time constant of open loop system is larger due to which the Transients takes large time to die-out. Hence open loop system is slow.	iii) Time constant of closed loop system is small due to which transients dies out rapidly. Hence closed loop system is faster.
iv) The effect of external disturbance and internal parameter variation is more in open loop system. ie open loop system is more sensitive.	iv) The effect of external disturbance and internal parameter variations is less in closed loop system ie closed loop system is less sensitive.

v) Open loop system is simple & economical.

vi) Open loop system is usually stable but cannot be stabilised if becomes unstable.

v) Closed loop system is complex and expensive.

vi) Closed loop system can become unstable but can be stabalised.

Note:

* Control systems have to stable whether they are:.
  i) Linear or non linear
  ii) time variant or invariant
  iii) Static or Dynamic etc.

} Control systems has to be stable whether it may be any of the diff. systems. (L, NL, TV, TI etc).

* Stability is necessary in control system since in that condition only we can obtain steady state in which output follows input.

Note:

* No Feedback gaurantees stability or unstability, -ve F/B always gaurantees better stability than +ve F/B.
* Inspite of presence of -ve feedback control system can still become unstable due to HIGH OPEN LOOP GAIN; HIGH TYPE NUMBER; HIGH SENSITIVITY; HIGH TRANSPORTATION DELAY or LAG PHASE.

i) high open loop gain
ii) high type number.
iii) high sensitivity.
iv) High transportation delay or Lag phase.

* Differences blw the Performance of -ve & +ve Feedback closed loop system:

Performance Criteria	-ve F/B	+ve F/B
i) Gain → Product const	↓	↑
ii) BW	↑	↓
iii) Time Constant	↓	↑
iv) Speed.	↑	↓
v) Sensitivity	↓	↑
vi) Stability.	↑	↓

Note!:

To analyse the control systems we have 2 standard models. They are:

1) Transfer function model.
2) State model. (latest model 1960).

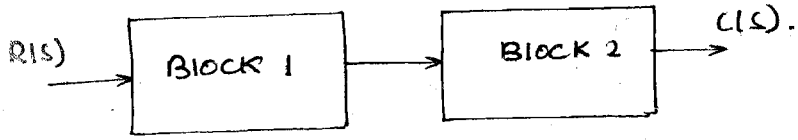
*Transfer function:
Ratio of laplace xform of the output and input with initial conditions zero.

*BLOCK DIAGRAM REPRESENTATION!:

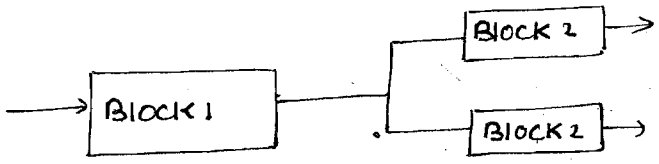
Standard Topologies!:

i) Series / cascade connection
ii) Parallel / Feed forward connection.
iii) closed loop / feedback / canonical connection.

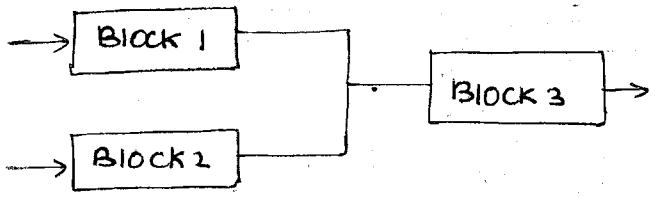
i) series / cascade connection:



one to one.

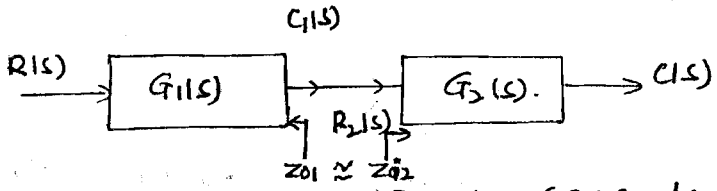


one to many



Many to one.

Note:-



✓i) $R_2(s) = C_1(s)$ → Non interactive cascade (no loading effect).

×ii) $R_2(s) \neq C_1(s)$ → Interactive cascade (not possible to find TF by BDR but can be found out by electrical network representation

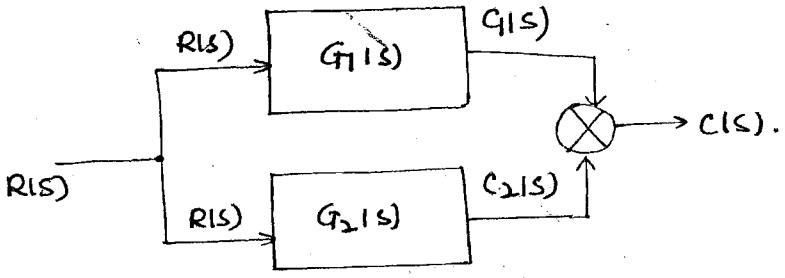
$$C(s) = G_2(s) R_2(s)$$

$$C_1(s) = R(s) G_1(s).$$

$$C(s) = G_2(s) \cdot G_1(s) R(s)$$

$$\boxed{\frac{C(s)}{R(s)} = G_1(s) \cdot G_2(s)}$$

ii) Parallel connection (Topology) :-

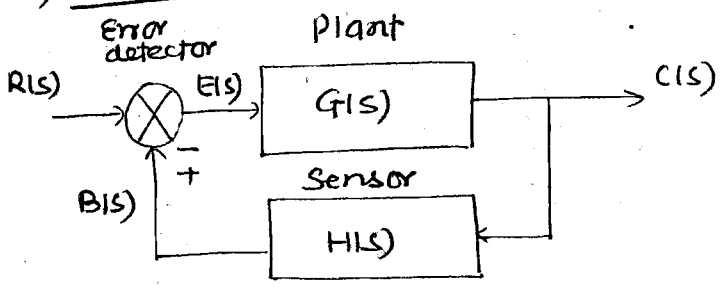


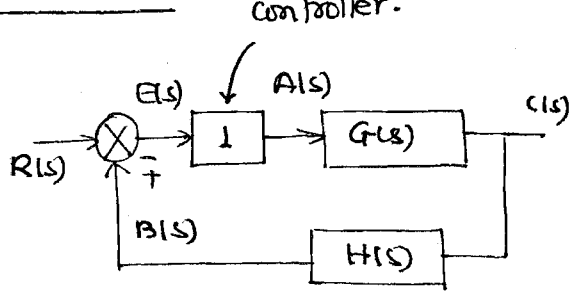
$$C(s) = C_1(s) + C_2(s)$$

$$= R G_1(s) + R G_2(s)$$

$$\boxed{\frac{C(s)}{R(s)} = G_1(s) + G_2(s)}$$

iii) Feedback / closed loop / canonical connection :-





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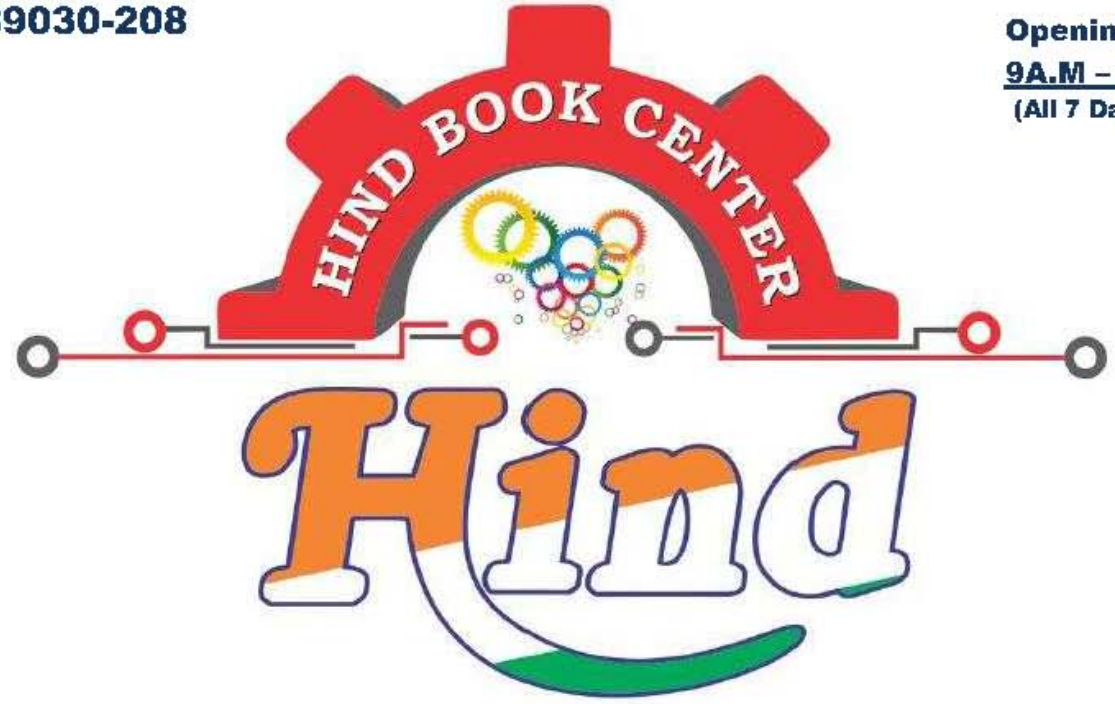

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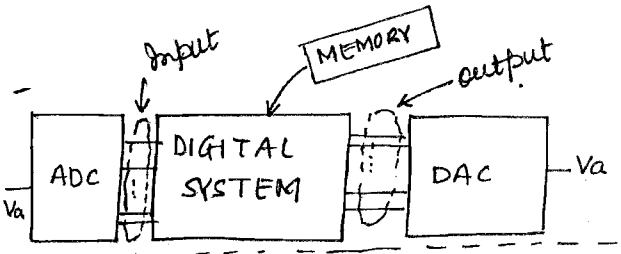


µP → ALU → Adder & Sub
DSP → Control unit → Decoder or MUX
µC → Registers & Counters → FLIP FLOPS
} LOGIC GATES → BJT OR MOSFET OR DIODES

FPGA → Field Programmable Gate Array.
↓
The place where we use the device

SYLLABUS :.

I) Basics
- → Boolean Algebra.
- → Logic Gates.
- → K MAP
- → Number systems; Codes and Data Representation.

II) Combinational circuits :.

i) Arithmetic circuits
- → HA, FA, HS, FS
- → Parallel Adder
- → Look Ahead carry Adder.
- → BCD Adder.
- → 2's complement Adder ckt

** ii) MULTIPLEXER (Every Gate & IES paper)...
iii) DEMUX
iv) DECODER
v) ENCODER
vi) COMPARATOR
vii) CODE CONVERTOR
viii) PARITY GENERATORS/CHECKERS

III) Sequential circuits :.
- i) Flip Flops.
- ii) Registers.
- iii) Counters.
- iv) State Machines
  - → Mealy
  - → Moore

Newly Added in GATE

IV) ADC's & DAC's.

V) LOGIC FAMILIES :.
- i) RTL
- ii) DCTL
- iii) IIL
- iv) DTL
- v) HTL
- vi) TTL
- vii) ECL

} BJT Based. ← Not included in GATE.

- i) NMOS
- ii) PMOS
- iii) CMOS

} FET Based. (Mainly GATE).

VI) Basics of Semiconductor Memories.
- i) RAM.
- ii) ROM.
- iii) PAL, PLA
- iv) PROM.

*Preperation Strategy:-

i) Class Notes.

ii) Practising Previous Papers.

- GATE
  - ECE
  - EE
  - IN
  - CSE
- IES.
  - ECE
  - EEE

iii) Reference Books:-

- M. Mano
- Roth.
- Jaub & schilling (ADC & DAC, logic families).

*BOOLEAN ALGEBRA:

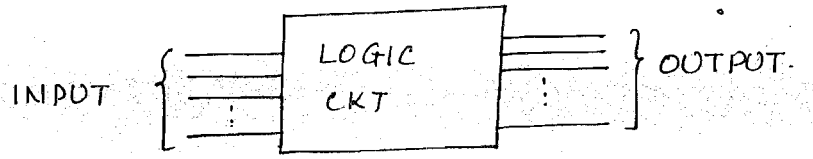
* Introduced in 1854 by GEORGE BOOLE.
* No xtor we available that time, hence designed with help of
  i) VENN DIAGRAM
  ii) SWITCHES → OFF (LOGIC 0), ON (LOGIC 1)

* Boolean Algebra only handles "0 and 1".

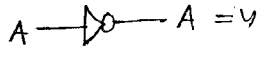
A, B, C } VARIABLES → 0, 1 } Boolean Algebra

* To minimize logical expressions following methods are used
  i) Boolean Algebra (1, 2, 3 variables max^m)
  ii) K Map (2, 3, 4, 5 variables at max^m)
  iii) Quine Mc'cluskey or TABULATION METHOD (Any no. of variables)
* Boolean Algebra is used when o/p is either "0 or 1"
  K Map is used when o/p is either "0, 1 or x"

*THEOREMS IN BOOLEAN ALGEBRA:



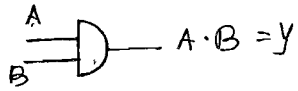
i) NOT:



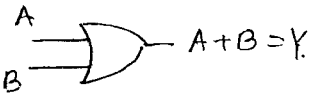
* Note:

$\bar{\bar{A}} = A$ ← NOT operation Relation.

ii) AND:



iii) OR:



AND OPERATION

$0 \cdot 0 = 0$
$0 \cdot 1 = 0$
$1 \cdot 0 = 0$
$1 \cdot 1 = 0$

$A \cdot A = A$
$A \cdot 0 = 0$
$A \cdot 1 = A$
$A \cdot \bar{A} = 0$

← AND-OPERATION THEOREM

OR OPERATION :.

$0+0 = 0$
$0+1 = 1$
$1+0 = 1$
$1+1 = 1$

OR-OPERATION THEOREM

$A+0 = A$
$A+A = A$
$A+1 = 1$
$A+\bar{A} = 1$

Q1) Minimize logic expression :.

$Y = AB + A\bar{B}$

Soln :. $Y = AB + A\bar{B}$

$Y = A(B+\bar{B})$

$\boxed{Y = A}$

Q2) To implement logical exp; $Y = AB + A\bar{B}C + A\bar{B}\bar{C}$; min^m no. of 2 input NAND Gates

a) 0 b) 1 c) 2 d) 3

Soln :. $\boxed{Y = AB + A\bar{B}C + A\bar{B}\bar{C}}$ ← SOP FORM

$= AB + A\bar{B}(C+\bar{C})$

$= AB + A\bar{B}$

$= A(B+\bar{B})$

$\boxed{Y = A}$ ← NO Gates Required

Q3) Minimize logic expression ; $y = (A+B)(A+C)$

Soln :. $\boxed{Y = (A+B)(A+C)}$ ← POS FORM.

$Y = A \cdot A + A \cdot C + A \cdot B + B \cdot C$

$Y = A + AC + AB + BC$

$Y = A(1 + C + B) + BC$

$\boxed{Y = A + BC}$ ← SOP FORM

Analysis :-

$(A+B)\cdot(A+C)$ → 3 variables.

SAME LITERALS

$$(A+B)(A+C) = A+BC$$

Q4) Minimize ; $(x+y)(x+\bar{y})(\bar{x}+y)$

Soln :- $(x+y\cdot\bar{y})(\bar{x}+y)$

$= x(\bar{x}+y)$

$= xy$

Q5) Minimize ; $(x+y+z)(x+y+\bar{z})$

Soln :- $(x+y+z)(x+y+\bar{z})$

$(x+y)+z\cdot\bar{z}$

$(x+y)$

Q6) Minimize

$Y = (A+B)(A+\bar{B})(\bar{A}+B)(\bar{A}+\bar{B})$

Soln :- $(A+B\cdot\bar{B})(\bar{A}+B\cdot\bar{B})$

$A\cdot\bar{A}$

$= 0.$

Q7) Minimize ; $y = A+\bar{A}B$

Soln :- $y = A+\bar{A}B$

$= (A+\bar{A})(A+B)$

$y = (A+B)$

Note :-

$(A+B)(A+C) = A+BC$

$(A+BC) = (A+B)(A+C)$ ← DISTRIBUTION THEOREM.

$(1+2\cdot3)\quad(1+2)\ (1+3).$

Q8) Minimize ;

i) $A+\bar{A}B \rightarrow (A+\bar{A})(A+B) = (A+B)$

ii) $A+\bar{A}\bar{B} \rightarrow (A+\bar{A})(A+\bar{B}) = (A+\bar{B})$

iii) $\bar{A}+AB \rightarrow (\bar{A}+A)(\bar{A}+B) = (\bar{A}+B)$

iv) $\bar{A}+A\bar{B} \rightarrow (\bar{A}+A)(\bar{A}+\bar{B}) = (\bar{A}+\bar{B})$

Q9) Minimum no. of logic gates required for $y = AB+\bar{A}C+A\bar{B}$

Soln :- $y = AB+\bar{A}C+A\bar{B}$

$= A(B+\bar{B})+\bar{A}C$ ∵

$= A+\bar{A}C$

$= (A+\bar{A})(A+C)$ ∴

$y = A+C$

Note :- The precedence order of the LOGIC SYMBOLS is :-

( ) > NOT > AND > OR → SOP

( ) > NOT > OR > AND ← POS.

Q10) Minimize ; $y = A\bar{B} + \bar{A}C + BC$

Soln:. $y = A\bar{B} + \bar{A}C + BC$

Note:. 3 variable Available

↳ Repeated Twice
↳ Complement on $A + \bar{A}$

$$\boxed{Y = A\bar{B} + \bar{A}C + BC = A\bar{B} + \bar{A}C}$$

$$\boxed{(A\bar{B} + \bar{A}C + BC) = (A\bar{B} + \bar{A}C)}$$ ← CONSENSUS THEOREM.

Q11) Minimize logical expression:.

i) $\bar{A}B + AC + BC = \bar{A}B + AC$
ii) $A\bar{B} + AC + BC = A\bar{B} + BC$
iii) $AB + AC + B\bar{C} = AC + B\bar{C}$

} ← SOP FORM.

POS FORM {
iv) $(A+B)(\bar{A}+C)(B+C) = (A+B)(\bar{A}+C)$
v) $(A+B)(A+C)(B+\bar{C}) = (A+C)(B+\bar{C})$
}

vi) $A\bar{B} + \bar{A}C + \bar{B}C = A\bar{B} + \bar{A}C$

vii) $\bar{A}\bar{B} + \bar{A}\bar{C} + B\bar{C} = \bar{A}\bar{B} + B\bar{C}$

Note:.
*check those literals where $A + \bar{A}$ are present ie one Literal A is uncomplemented and $\bar{A}$ is complemented.

*Analysis:.

$$(A+B)(\bar{A}+C) = A\cdot\bar{A} + AC + \bar{A}B + BC$$
$$= AC + \bar{A}B$$

$$\boxed{(A+B)(\bar{A}+C) = AC + \bar{A}B}$$ ← TRANSPOSITION THEOREM.

Q12) Minimize; $y = (A+B)(\bar{A}+\bar{B})$

Soln:. $y = (A+B)(\bar{A}+\bar{B})$

$$\boxed{Y = A\bar{B} + \bar{A}B = A \oplus B}$$

Q13) Minimize ; $y = (A+\bar{B})(\bar{A}+B)$

Soln:. $y = (A+\bar{B})(\bar{A}+B)$

$$\boxed{Y = AB + \bar{A}\bar{B} = A \odot B}$$

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Books:-

1) Semiconductor Physics and Devices
— DONALD NEAMEN.

2) GATE
- Basics
- Diode
- **FET

} Solved Examples of Donald Neamen.

*CLASSIFICATION OF TEMPERATURE (T):-

* Divided into three parts:-
  1) ABSOLUTE TEMPERATURE (0K = -273°c)
  2) ROOM TEMPERATURE (300K = 27°c)
  3) AMBIENT TEMPERATURE (T_A) (290K = 17°c)

** $^0K = K$ (old Notation → New Notation)

* Absolute Temperature is Practically not Possible. It is only the Reference Temperature, and never used in Reality.
* Absolute Temperature is just a Reference temperature
* At Room temperature, all properties of Semiconductor Devices are maxm at Room temperature.
* All Properties of Comm systems are taken at the Ambient Temp. ie 290K or 17°c.
** TEMPERATURE in KELVIN = TEMPERATURE in °c + 273

*THERMAL VOLTAGE (V_T) :-

* Also called as the "VOLT EQUIVALENT OF TEMPERATURE".
* Most of S.C devices properties changes with temperature.
* Mathematically,

** $$V_T = \frac{\bar{K}T}{q} \text{ volts}$$

Where, T = Temperature in Kelvin
q = Magnitude of charge (1.6×10^{-19} C)
$\bar{K} = 1.381 \times 10^{-23}$ J/°K

Also, $V_T = \frac{T}{11600}$ volts

Hence,

i) At $T = 0K \Rightarrow V_T = 0$ volts

ii) At $T = 300K \Rightarrow V_T = \frac{300}{11600}$

** $V_T = 0.02568$ volts
$= 26$ mV.

Note :-

1) For a large variation in Temperature, the variation in the Thermal voltage is negligible.

* BOLTZMANN CONSTANT :-

$\bar{K} = 1.381 \times 10^{-23}$ J/°K

$K = 8.62 \times 10^{-5}$ eV/°K

Hence, ** $\bar{K} = 1.6 \times 10^{-19}$ K

Hence, $V_T = \frac{\bar{K}T}{q} = \frac{q \times K T}{q}$

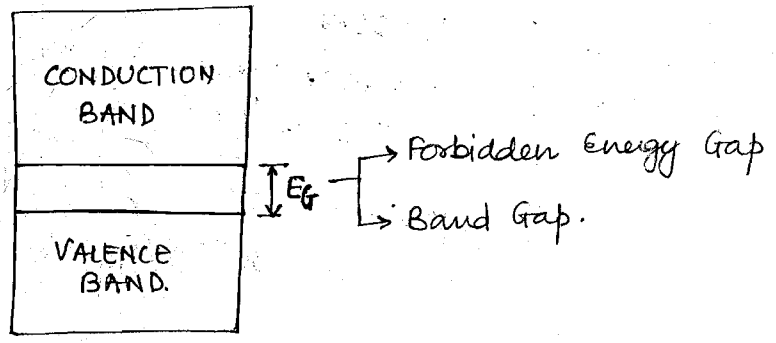
** $V_T = KT = \frac{\bar{K}T}{q}$

↳ Numerically equal values.

* ENERGY GAP (E_G or E_g) :-

* Gap between Valence Band and Conduction Band is called as Energy Gap.

* Band diagram of Semiconductor (SC) is given as :-



*

	E_{G0}	E_{G300}
Ge	0.782 eV	0.72 eV
Si	1.21 eV	1.1 eV

** * Energy Gap decreases with Temperature in a semiconductor. Mathematically,

** $$E_G \propto \frac{1}{Temp}$$

* To calculate E_G at different temp we can use:

** $$E_G(T) = E_{G0} - \beta_0 T \ (eV)$$

β_0 = material constant (eV/°K)

* For Germanium:

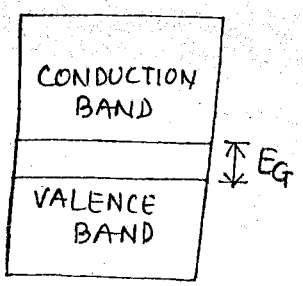
$$E_G(T) = 0.782 - 2.33 \times 10^{-4} T \ (eV)$$

* For Silicon:

$$E_G(T) = 1.21 - 3.6 \times 10^{-4} T \ (eV)$$

* For a semiconductor, Energy Gap is small

** $$E_G \leq 1.5eV$$



Note:

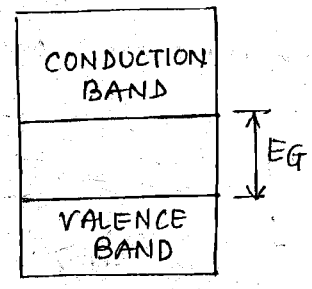
1) Semiconductors are BIPOLAR
2) Semiconductor can contribute DIFFUSION CURRENT.
3) Semiconductor has NTC of RESISTANCE

** $$T \uparrow \ R \downarrow$$

*Note:-

* For Insulators, the Energy Gap is large

↳** $E_G > 5eV$



* Insulators are Bad conductors of current, and their Conductivity is negligible.
* For Ideal Insulator, Conductivity is zero.

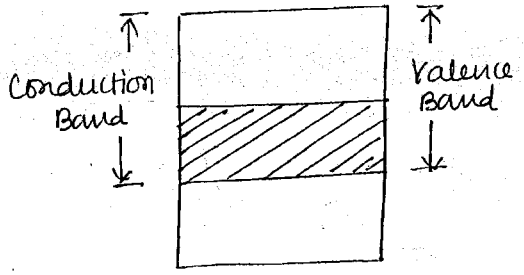
Note:-

1) If Energy Gap is small, less amount of additional energy is required for the $e^{\ominus}$ to jump from "VALENCE BAND" to "CONDUCTION BAND"

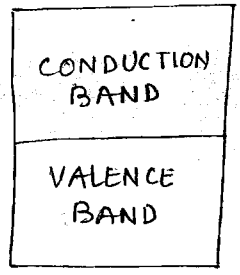
* For Metals (Conductors):-

↳ $E_G = 0\,eV$ ← Practically negligible value.

↳ (Non Zero Energy Gap)



(at T = 300K)



(at T = 0K)

* For metals, the conductors ~~and~~ the Conduction Band and Valence Band overlap each other and the overlapping increases with Temp.
* Conductivity is very large in Conductors
* Only DRIFT CURRENT flows in Conductor
* Conductors are unipolar, current carried only ~~in~~ by $e^{\ominus}$.
* PTC of Resistance:-** $T \uparrow R \uparrow$ ← Exclusive Property of Metals.

Definition of Semiconductor :-

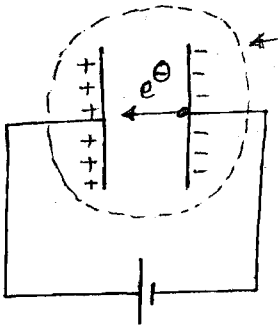
* Semiconductors are the elements whose conductivity lies in between in the conductivity of an insulators and the conductivity of a metal.

* ELECTRON VOLT (eV) :-

* Electron volt is a unit of ENERGY
* Very small unit of Energy (almost fraction of unit of Energy ie Joule).
* Electron volt is the unit of ENERGY in Electronics
** * 1 eV is defined as the energy gained by the electron (e^-) in moving through a potential difference of 1V.

Note :-

* Air is a perfect insulator, the Best insulator.



Note :-

* $e^\ominus$ cannot move through air, hence air in the glass has been removed.
* $e^\ominus$ can move through Vacuum
  - for eg → Vacuum Tubes

Mathematically

$$1\,eV = |q| \times \text{Potential difference}$$

$$= 1.6\times10^{-19}\,C \times 1\,V$$

** $$= 1.6\times10^{-19}\,C.V$$

Or $$\boxed{1eV = 1.6\times10^{-19}\ \text{Joules} = 1.6\times10^{-19}\ \text{Coulomb-Volt}}$$

Note :-

* Electron volt is the Kinetic Energy Gained by the $e^\ominus$ or the Potential energy lost by the $e^\ominus$.

Mathematically,

** Kinetic Energy $= \frac{1}{2} mv^2$

m = mass of $e^{\ominus}$
$= 9.1 \times 10^{-31}$ Kg

** Potential Energy $= q \times V$

V = Potential difference

By definition:-

KE gained = PE lost

$\frac{1}{2} mv^2 = qV$.

** Velocity of $e^{\ominus}$, $v = \sqrt{\frac{2qV}{m}}$ m/s

* ELECTRIC FIELD INTENSITY ($\mathcal{E}$ or E) :-

* Also called Field Intensity
* Also called as Field Gradient
* Also called as Field.

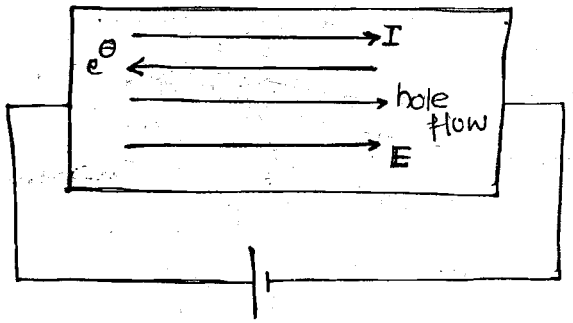
* Mathematically,

** $\mathcal{E}_0 = -\frac{dV}{dx}$ Volt/metre

Also, **

$|\mathcal{E}_0| = \frac{\text{magnitude of voltage Existing}}{\text{distance or space}}$

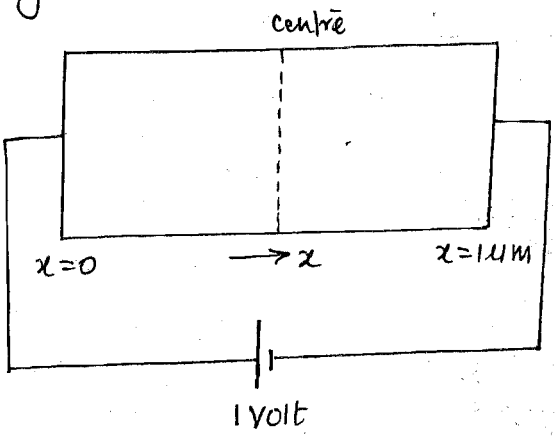
Note :-



* Field is always directed from +ve of the Battery to the -ve of the battery.
* Field is directed from "higher potential to lower potential".

Q1) Considering a uniform semiconductor Bar (Rectangular shape) calculate the field at the centre of the bar?

* specially designed question for Gate (donot change the values)



Soln:- At the centre of the Bar:-

$x = 0.5\mu m$

$V = 0.5\ V.$

Hence.

$$|E| = \frac{|V_c|}{x_c}$$

$$E = \frac{0.5\ V}{0.5\mu m}$$

$$\boxed{E = 1 \times 10^6\ V/m}$$

* MOBILITY OF CHARGE CARRIERS (μ):-

* Mobility of charge carrier is the ability of the charge carrier to move from one place to another ie how fast the charge carrier can move from one place to another.

* MOBILITY is defined:-

** $$\boxed{\mu = \frac{\text{drift velocity}}{\text{field intensity}}}$$

* Also, ** $$\boxed{\mu = \frac{v_d}{E}}$$ → Unit $m^2/Vsec$ or $cm^2/Vsec$

* MOBILITY denotes how quick is the $e^\ominus$ or the hole in moving from one place to another place.

** * DRIFT VELOCITY is the velocity of charge carrier under FIELD INTENSITY

** * DRIFT VELOCITY is the average velocity of charge carriers.

** $$\boxed{v_{drift} = \frac{v_{max} + v_{min}}{2}}$$

* electron mobility = $\mu_e = \mu_n$
Hole mobility = $\mu_h = \mu_p$

**

	GERMANIUM	SILICON
μ_n	3800 $cm^2/Vsec$	1300 $cm^2/Vsec$
μ_p	1800 $cm^2/Vsec$	500 $cm^2/Vsec$

*

$\frac{\mu_n}{\mu_p} = 2.1$ (for Ge)

$\frac{\mu_n}{\mu_p} = 2.6$ (for Si)

*Note's.

**1) $e^{\ominus}$ mobility (μ_n) is always greater than hole mobility (μ_p) and therefore the $e^{\ominus}$ can travel faster and also contributes more current when compared to the hole.

**2) For higher conductivity and larger currents, Ge devices must be preferred.

Ge → Large conductivity (due to larger mobilities)
Ge → Relatively more suitable for high frequency application (Large Gain Bandwidth Product)

3) Both Ge and Si have smaller switching times and Ge has larger leakage currents as compared to Si.

Si → Relatively high speed Applications (due to smaller leakage currents)
Si → High Power applications.

**4) Switching times are small in Ge and Si. Also,

$f = \frac{1}{t}$; t = switching times

Hence, both Si and Ge can work at high frequency, but Ge is preferred over Si, since Ge has larger "GAIN BANDWIDTH PRODUCT"

Books Preferred:

Electrical & Electronic measurement by AK SAWNEY.
- i) Instrumentation part
  - → Error Analysis
  - → Transducer
- ii) Electrical Measurements (I, V, Power, Energy R, L, C, F, Q)

iii) Electronic Measurement
- → Digital Voltmeter
- → CRO.

Electronic Instrumentation by H S KALSI / HELFRIC & COOPER.

*Ways of framing Questions:

60+ to 70 questions.

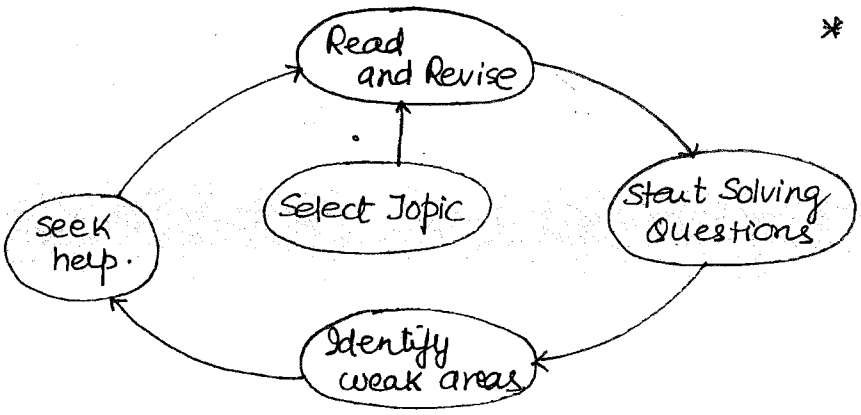
i) Single Stand Alone Standard (SSSQ) (N/T).

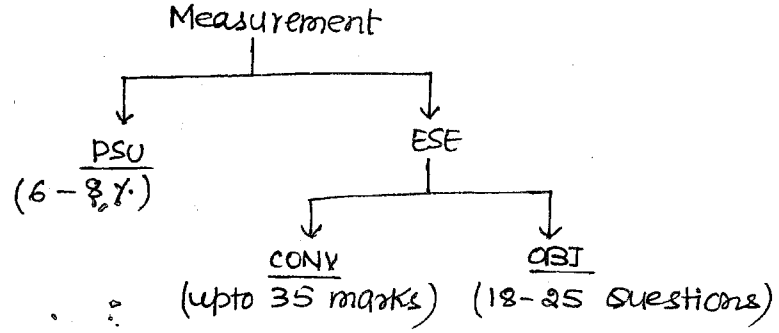
ii) Combination of options (COOP) (T).
based on Advantages, disadvantages, characteristics, properties application, utility.

iii) ~~Match~~ Matching list Questions (MLQ). (T)
Material from which manufactured, Range, Proportionality utility, application, Definitions.

iv) Assertion and Reason Questions (ARQ) (T).
Hence, thus, because.

*ECE Questions.
*EE Questions.
*IN Questions.





*INTRODUCTION TO MEASUREMENTS:

* Measurement is a process of comparision between a standard and an unknown resulting in knowing the mag. of unknown in terms of the standard.

* Instrument is a device which is used for this comparision.

Note:

* less power consumption in the instrument higher the Accuracy

* The two essential characteristics of an instrument are:

a) its operational power consumptions should be negligible
It is an Indicator of Accuracy

b) The instrument should not change the Ambient / Initial conditions of the circuit in which it has been introduced.
- It is an Indicator of Sensitivity.

*Note:

*** * Where ACCURACY is defined as the CLOSENESS with which the measured value approaches the true value.

* SENSITIVITY is defined as the Rate of change of output with respect to the input.

Mathematically

*** $$\text{Sensitivity} = \frac{\text{output}}{\text{input}}$$

3-4 Questions in ESE/PSU.

*ERROR ANALYSIS:

TOPICS:

i) Introduction (*** classification of errors, objectives). etc.
ii) Limiting errors
iii) Combination of Quantity
iv) Known Errors (conv. portion).
v) Statistical analysis of Data.
vi) Uncertainty Analysis.

*INTRODUCTION:

* The Accuracy of an Instrument or a measurement system is always specified in terms of its error. It is defined as the DEVIATION of the measured value from True value.

* Mathematically

$$\text{ERROR} = \text{Measured value} - \text{True value}$$

* ERROR is expressed in terms of units, it is the ABSOLUTE ERROR, and when expressed as a % it is a RELATIVE ERROR.

* In Industry, error analysis is done to minimize the error and to find this we have to classify the errors.

* Errors are classified on the basis on their

a) source
b) mode of propagation
c) Probability of occurence
d) magnitude

as
a) Gross Errors. (NPCR) → {Not (Permanent, constant or Repetitive).
b) Systematic Error.
c) Random Error.

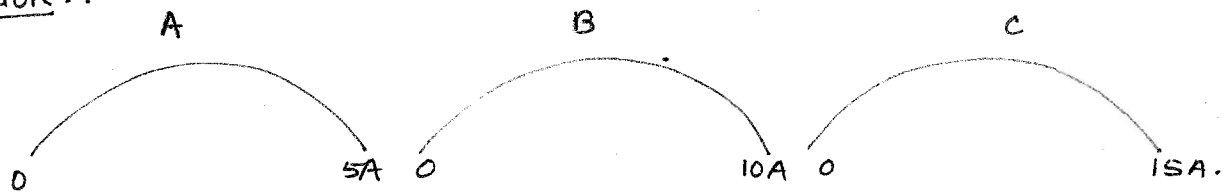
ERRORS

GROSS ERROR
* due to Human Factors
* Carelessness of Human
* improper/inexpeiencedUse. (connection of Ammeter or Voltmeter in Series or parallel).

SYSTEMATIC ERROR
* All Instrument Related Error (due to use of substandard material used error in inside the Instrument).

RANDOM ERRORS.

Note!.



$S_V = \frac{180^\circ}{5}$

$= 36^\circ/A.$

$= 1/36^{th}$ of 1A

(more sensitive) to current measurement

→ Introduces small error.

$S_V = \frac{180^\circ}{10}$

$= 18^\circ/A.$

$= 1/18^{th}$ of 1A

*An experienced person will use meter C whereas expeienced person will use meter A for the measurement.

↓

leading to GROSS ERROR by Amateur Person.

$S_V = \frac{180^\circ}{15A}$

$= 12^\circ/A.$

$= 1/12^{th}$ of 1A.

(less sensitive) to current measurement

→ Introduces large error

ERRORS

GROSS ERROR.

SYSTEMATIC ERROR

All Instrument related Error

Observational Errors

* occur due to improper observational methodology
* Eg:. ERROR due to PARALLAX.
* It is NPCR Not (Permanent constanst, Repetitive)
* can be minimised by carefulness.

Instrumental Error.

* Source is the Instrument and error getting spread inside the Instrument only
* Due to substandard material or Design.
* This type of Error is PCR. (Perrnanent, Const, Repetitive.)

Environmental Error

* Due to external factors such as stray EM fields temp. etc.
* This type of error is NPCR. (Non(Permanent const, Repetitive)

RANDOM ERRORS

* occur due to unknown causes.
* They are very small magnitude error.
* They can be known after taking Repetitive Reading
* can be compensated/ calculated by statistical methods such as MEAN STANDARD DEVIATION.

Can be minimised by statistical methods.

*The analysis of Systematic Error is an Indicator of the ACCURACY of an Instrument, where as the analysis of Random Errors is an Indicators of the Instruments PRECISION, there :.

** PRECISION :. It is defined as the ability of an Instrument to give the same reading when repeat measurements are made for a given value of the parameter under measurement.

OR.

PRECISION is the measure of Repetability or Reproducibility of an Instrument.

Note:.

* A Highly Precise Instrument need not necessarily be Accurate but a highly accurate Instrument is assumed to be precise.

*The two Important Indicators of Precision are :.

a) Conformity to Truth
b) Number of Significant digits in measurement.

Note :.

*Higher the number of the Significant digits, higher will be the Precision taken under the same units.

For Eg :.

180 V ← Significant digits upto 4

deviation upto 0.1 V → 180.0 V ← comparatively less precision.

deviation upto 0.01 V → 180.00 V ← High Precision

0.000180 MV ← units are different.

Significant digits upto 5.

SYLLABUS :-

THEORY PROBLEMS PROBLEMS

1) Static Electromagnetic Fields. (Hayt and Buck); Sadiku ; Schaum Series
2) Time Varying fields → Electro-Magnetic waves. (JORDAN BALMAIN).
3) Transmission Lines → Voltage and current waves. (JOHN D RYDER).
4) Waveguides (JORDAN BALMAIN).
5) Antennas and Radiated waves. (JORDAN BALMAIN).

Methodology of Preperation :-

1) Concepts / Theory / Fundamentals.
2) Application / Questioning style.
3) Beyond classroom
   ↳ Previous Papers → EC (Gate / ESE).
   ↳ EE (Gate / ESE).

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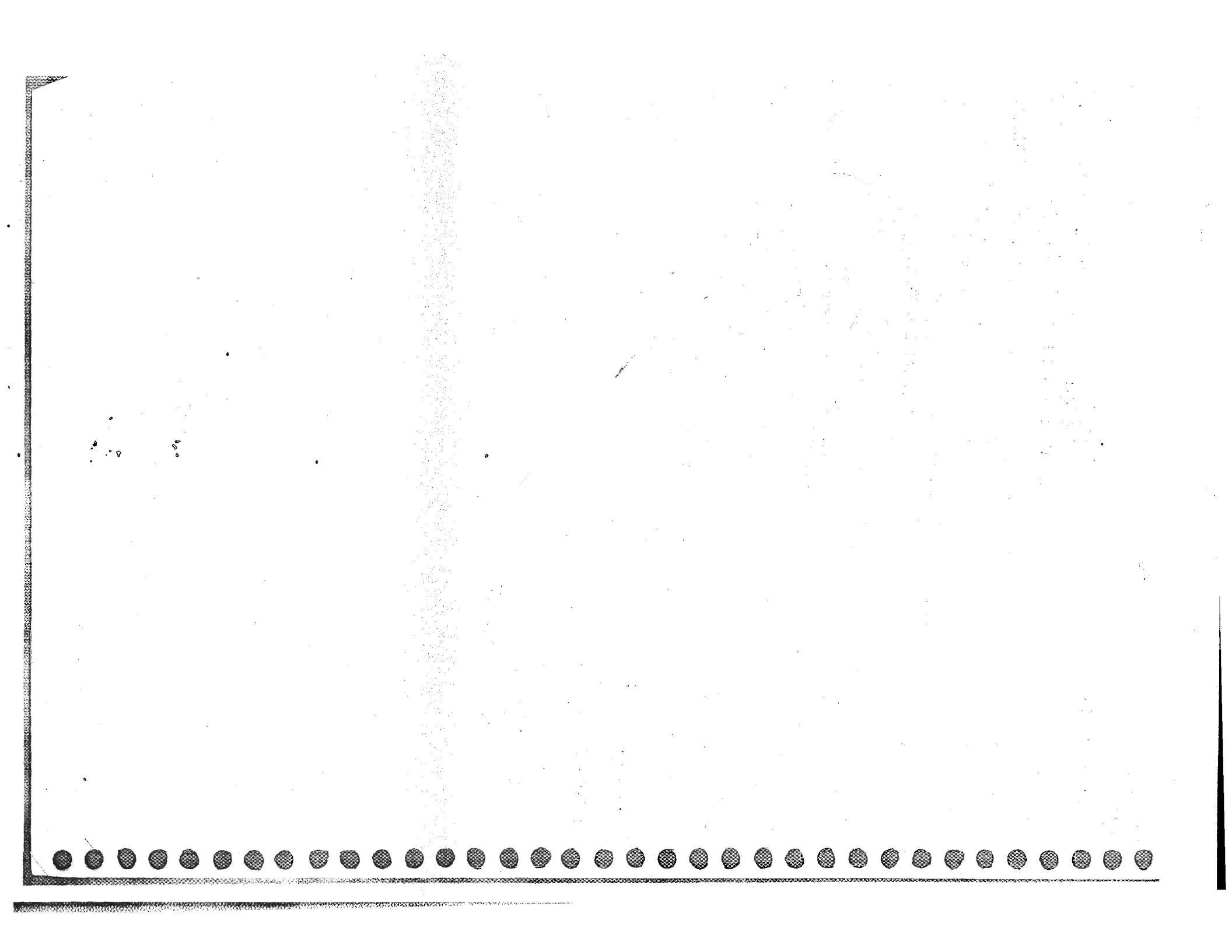
VSR suresh.

TEXT BOOK :-

1) HAYT & BUCK.
2) SADIKU.
3) JOHN D RYDER.
4) JORDAN BALMAIN.

SESSION 1 :-

1. Vector calculus.
   * Vector function
   * Density / Intensity func^n
2. Co-ordinate Systems
   * dl, ds, dv
   * (·) Dot
   * (×) Cross.

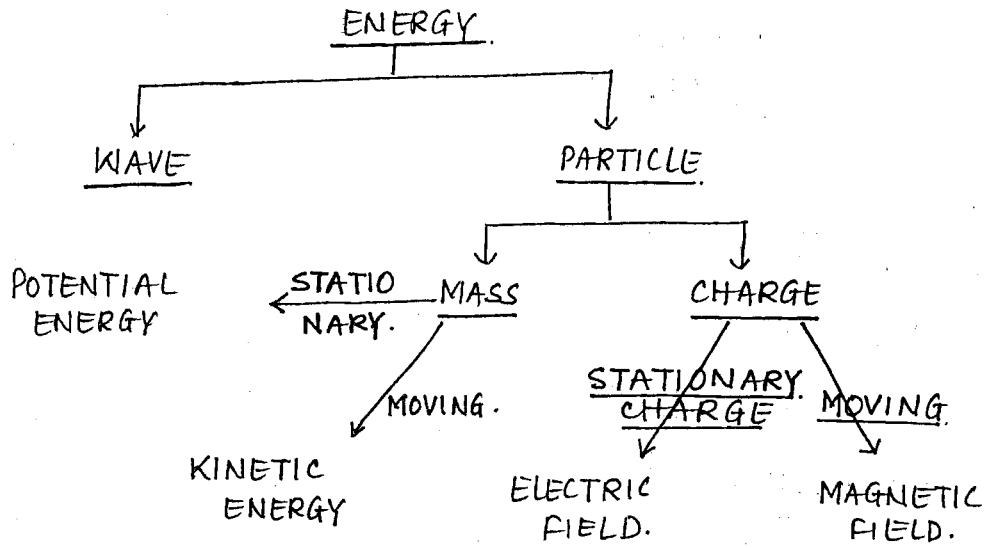


STATIC ELECTRO-MAGNETIC FIELDS

SESSION 1

*DEFINITION OF FIELD:-

*Everything in this world is ENERGY.



ELECTRIC FIELD:-

*Electric field is a format of energy that is all around a charge and influences similar charges nearby

Note:- Electric field cannot be seen but can be felt by a test charge when brought in its vicinity.

MAGNETIC FIELD:-

*Magnetic field is a format of energy that is all around a moving charge and influences similar moving charges nearby

Note:- Magnetic field cannot be seen but can be felt by another moving charge.

Note:-

1) Stationary charge → (CAUSE) VOLTAGE (D.C voltage) → ELECTRIC FIELD (EFFECT)

Note:-

*When voltages are given to the conductors, materials then the effect is seen in the free space.

*Voltages to conductors, materials (2D).
↳ effects the outer space (free space) (3D).

Note:- As in Antennas, where voltages and currents are given to the conductors and they start radiating signals in 3D space

2) Moving charge ⟶ DC CURRENT

↓

CAUSE

↓

MAGNETIC FIELD. (EFFECT)

Note:.

* When current is given to the conductor, materials it will give the cause in the free space and that is 3D space.
* Current or voltage given to Antenna hence felt in free space.

VECTOR CALCULUS:.

*It is the study of DIRECTIONAL INTEGRATIONS and DIRECTIONAL DERIVATIVES in 3 DIMENSIONAL SPACE.

DIRECTIONAL INTEGRATION:.

*It is calculation of the total effect of any phenomenon in a given direction in a given region.

*This can be implemented over a line, over a surface or over a volume. ie

$\int dl$ ⟶ line integral.

$\iint dS$ ⟶ surface integral.

$\iiint dV$ ⟶ volume integral.

DIRECTIONAL DERIVATIVE:.

* Directional derivative is the study of RATE OF CHANGE of any phenomenon in a given direction in a given region.
* Helps in the study of Rate of flow.
* Helps in understanding the nature of variation of any phenomenon.
* DEL OPERATOR is used for study of spatial variations in 3D of space. It is a vector operator.

Mathematically,

$$\nabla = \frac{\partial}{\partial x} a_x + \frac{\partial}{\partial y} a_y + \frac{\partial}{\partial z} a_z$$

← derivation along with the directions.

** It can be used to study the Rate of change of:

1) Scalar Quantities.
2) Vector Quantities.

* Examples are:

1) $f(x,y,z) = 4x^2y - 5z^3$ ← Scalar Quantity.

2) $\bar{A}(x,y,z)(x,y,z) = 4x^2y\,a_x + 7y\,a_y + 12xz\,a_z$ ← Vector Quantity.

Mag. depends on (x, y, z) — direction depends on (x, y, z)

3) $A(x)(y) = 4x^2\,a_y$ ← mag. depends on x. direction depends on y.

* **GRADIENT:**

* ∇ → operated on scalar function ie ∇f

** Gradient of Scalar → Result is Vector function

* **DIVERGENCE AND CURL:**

* ∇ operated on Vector function is called as:

1) Divergence → Dot product
2) Curl → Cross Product.

* Divergence of Vector given as $\nabla \cdot \vec{A}$. The Result is a Scalar.

* curl of Vector given as $\nabla \times \vec{A}$. The Result is Vector.

Mathematically,

** 1) $\nabla \cdot \vec{A}$ = Divergence of Vector (Dot product)
Result of operation is SCALAR.

** 2) $\nabla \times \vec{A}$ = cross product
= curl of Vector
Result of operation is Vector.

Note :-

* $\boxed{\nabla \cdot \nabla = \nabla^2 = \text{second order derivative.}}$ ← called as SCALAR LAPLACIAN operator.

Vector Identity :-

1) $\boxed{\nabla \times \nabla f = \nabla \times (\nabla f) = 0}$

$\boxed{\text{curl of Gradient of Scalar} = 0}$

2) $\boxed{\nabla \cdot (\nabla \times A) = 0}$

$\boxed{\text{Divergence of curl of Vector} = 0}$

Note :-

$A \times B = C$

$C \perp (A \text{ \& } B)$

Hence, $A \times C = |A||C| \sin 90^\circ \hat{n}$

$= |A||C| \hat{n}$

$A \cdot C = AC \cos 90^\circ$

$= 0.$

So, $\boxed{A \cdot (A \times B) = 0. \Rightarrow \nabla \cdot (\nabla \times A) = 0.}$

Note :-

$A \times B = |A||B| \sin\theta \hat{n}.$

$A \cdot B = |A||B| \cos\theta$

* $\nabla \times \nabla = 0$; since both are same vectors and moving in same direction as like $A \times A$. Hence,

$\nabla \times \nabla = |\nabla||\nabla| \sin 0 \hat{n} = 0$

So, $(\nabla \times \nabla f) = 0$

~~* Also, $\nabla \times \nabla \neq 0$; since both are same vector and moving in same direction.~~

* $\nabla \times A$ results in a vector $\perp^r$ to both ∇ and A. Hence

$\nabla \cdot (\nabla \times A) = \nabla \cdot B$

$B = (\nabla \times A)$ and $B \perp A$

$B \perp \nabla.$

So, $\nabla \cdot B = |\nabla||B| \cos 90^\circ$

$= 0.$

3) $\boxed{\nabla \times (\nabla \times A) = \nabla(\nabla \cdot A) - \nabla^2 A}$

Note :-

1. $\nabla \times (\nabla \cdot A)$
2. $\nabla (\nabla \times A)$

→ not allowed. { since curl of Scalar is not allowed. Also, ~~Divergence~~ Gradient of Vector is not allowed.

3. $\nabla (\nabla \cdot A) = \nabla^2 A$

*OUTFLOW & DIVERGENCE OF VECTOR FUNCTION:-

*Consider a cause or a source, having some effects radially outward from the cause. for all such phenomenon the STRENGTH decreases as the AREA OF EXPANSION increases; such that:-

"The TOTAL OUTFLOW, through any enclosing surface is always a CONSTANT, and this constant depends on the central cause"

*The strength represents a DENSITY VECTOR FUNCTION or closeness of the lines; and mathematically

$$\text{strength} = \frac{\text{Constant}}{\text{Area}} = \frac{\text{cause}}{\text{Area}}$$

Constant $\propto$ Cause

*If a cause is of Q coulombs of charge, the effect represents, the Physical attractive or repulsive force on any charge nearby. This is called as Electric flux or electric field.

CAUSE OR SOURCE : Q

EFFECT : Electric Force/ Field/ Flux (ψ_e)

STRENTH OF EFFECT :- Electric flux Density ($\vec{D}$)

*The strength is ~~called~~ called as Electric flux Density ($\vec{D}$) such that:-

$$\oint_{\text{closed}} \vec{D} \cdot d\vec{s} = \psi_e \text{ (total)} \propto Q.$$

Note:- The effect around the charge (Q) is called as Electric field and can be felt by test charge and is not visible.

$$\oint_{\text{closed}} \vec{D} \cdot d\vec{s} = Q. \leftarrow \text{GAUSS LAW IN INTEGRAL FORM.}$$

Note:-

*If the surface is not completely enclosing, the effects are Partial ie ~~$\oint \vec{D} \cdot d\vec{s}$~~

$$\iint_{\text{open}} D \cdot ds = \psi_e \neq Q$$

$\leftarrow$ flux Passing through the surface (open), only through that open surface and this is not GAUSS LAW.

* Every closed surface is identified with a finite volume enclosed.

1) $4\pi r^2 \xrightarrow{\text{sphere}} \frac{4}{3}\pi r^3$

2) $2\pi rh \xrightarrow{\text{cylinder}} \pi r^2 h$

3) $6a^2 \xrightarrow{\text{cube}} a^3$

4) $\pi r^2 \xrightarrow{\text{circle}}$ volume not defined.

* Mathematically,

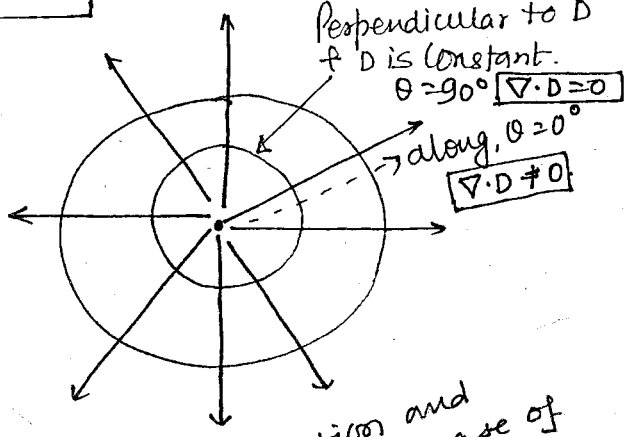
$$\boxed{\text{Strength of field, } \vec{D} = \frac{dQ}{ds}} \leftarrow \text{Coulombs/m}^2.$$

* $\frac{dQ}{dv} = \frac{d}{dl}\left(\frac{dQ}{ds}\right)$

so, $\frac{dQ}{dv} = \frac{d}{dl}\left(\frac{dQ}{ds}\right) = \nabla \cdot D$

$\rho_v = \nabla \cdot D$

so, $\boxed{\nabla \cdot D = \rho_v}$ ← GAUSS LAW in point form



Divergence at any point depends on the volume charge density

* The DOT (·) operation in derivative signifies the directional derivative in the vector direction.

Note!:

* Rate of change of strength depends on charge density. ($\nabla \cdot D = \rho_v$)

(D) ← ELECTRIC FLUX (ρ_v)

* $\boxed{\nabla \cdot D = |\nabla||D|\cos\theta}$

* The significance of Dot product is that, to understand the Rate of change of D, we have to read it along D. The surface given above are ⊥ to D. Hence $\theta = 90° \Rightarrow \nabla \cdot D = 0$

Note Cause: Q → Effect = D or E.

* $\nabla \cdot D$ → Represents rate of change of effect
  * helps in understanding the cause.
  * by finding ρ_v, charge stored in the volume helps in understanding the charge, Q.

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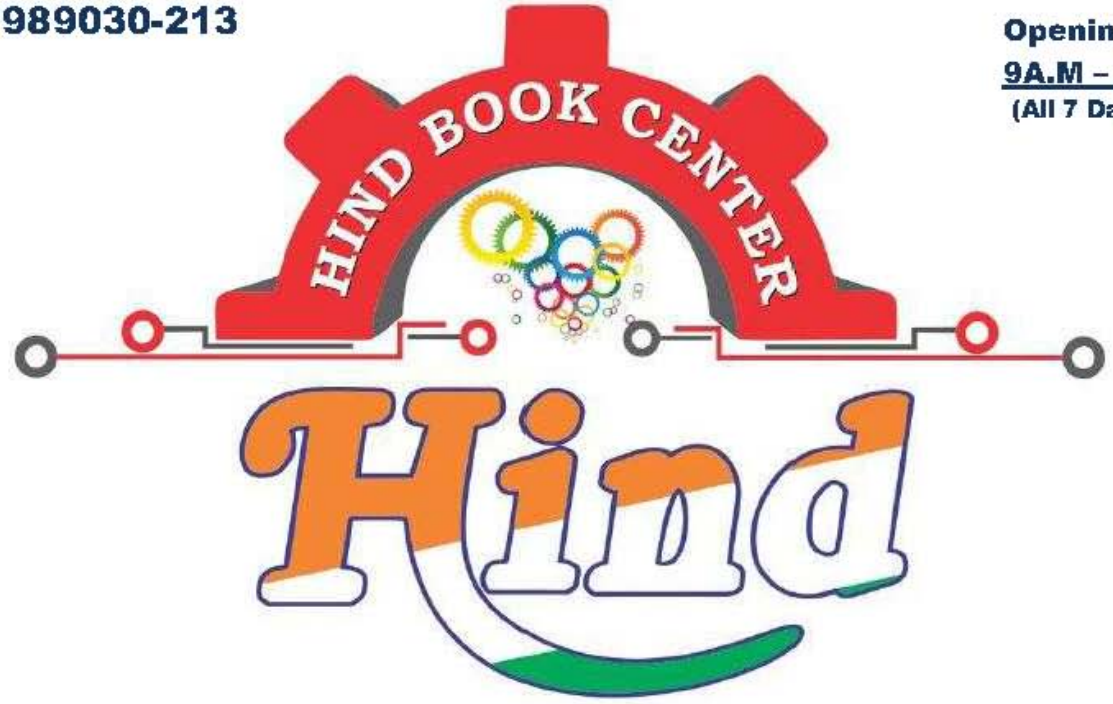

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MICROPROCESSOR:.

i) 8085. (Gate – in detail) → 2M/3M GATE → 20 Marks to 40 Marks IES.
ii) 8086.
iii) 8051.

Note:.

** IAS/IPS
ELECTRICAL OPTIONAL (MAINS)
↓
ECE + EEE

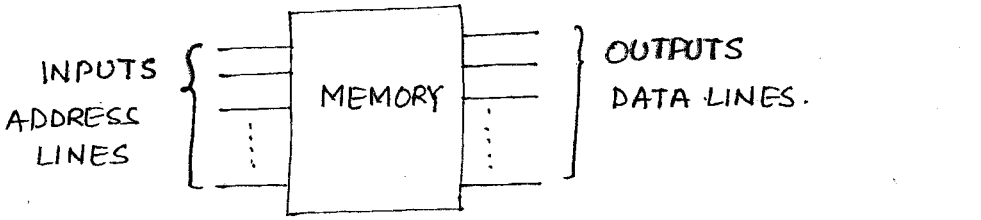
** BEFORE 2011
IAS PRELIMS ELECTRICAL GATE STANDARD (OBJECTIVE).

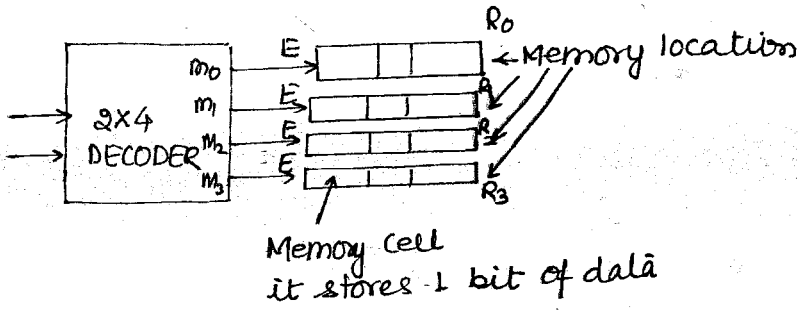
8085 SYLLABUS:.

i) Memories.]
ii) 8085 Basics.] 1Marks GATE
iii) Instruction set]
iv) Programming] ** 2MARKS GATE
v) Interfacing]

*MEMORIES:.

*Used for storage.





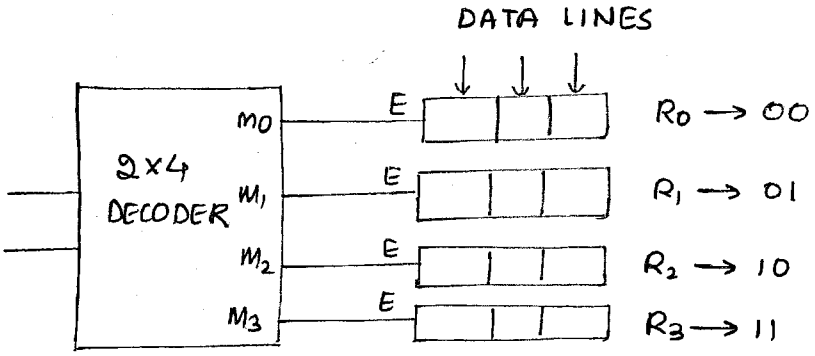
Note:.

* By giving input 00, m_0 will get selected hence the address of R_0 is 00.
* By giving input 01, m_1 will get selected hence the address of R_1 is 01.

MEMORY LOCATION	ADDRESS
R_0	00
R_1	01
R_2	10
R_3	11

* ADDRESS:.

*ADDRESS is a binary code which enables a particular location



*In order to store data in memory the following sequence has to be followed:.

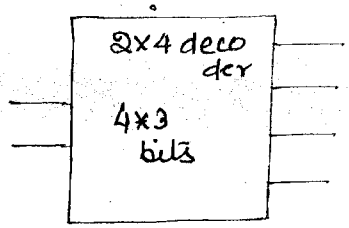
i) Select the location by giving an appropriate address.

ii) give the data through the Data lines.

*SIZE OF

*Size of Memory is measured in bits and is equal to NO. of memory locations multiplied with NO. of bits/location

Memory size = NO. of memory location x NO. of bits/location

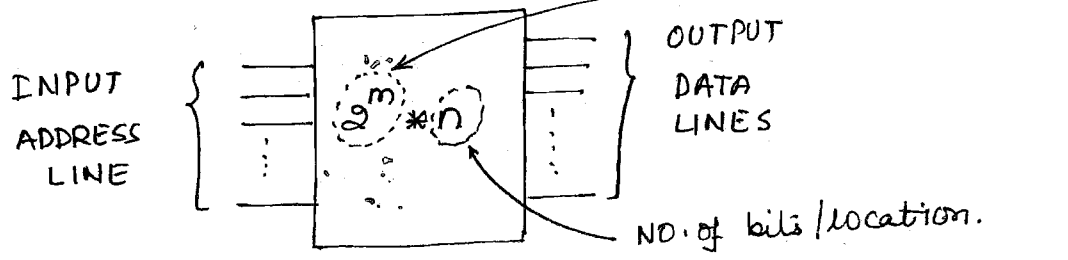


4 → locations.

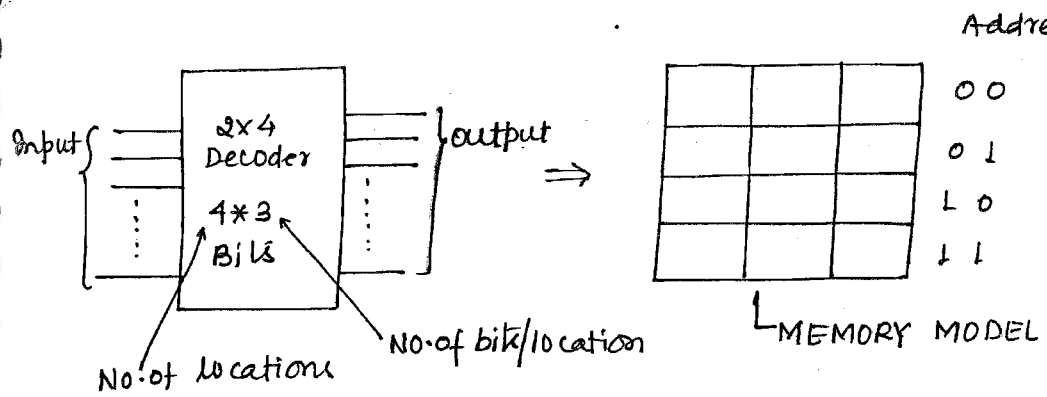
3 → bits/location.

*For m address lines, no. of location is 2^m.

* NO. of data lines = NO. of bits/location.



* MODEL OF MEMORY:.



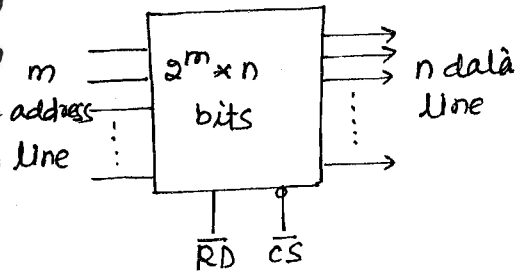
* Two types of Memory:.

i) Read only Memory (ROM)

ii) Read/write Memory (RWM)

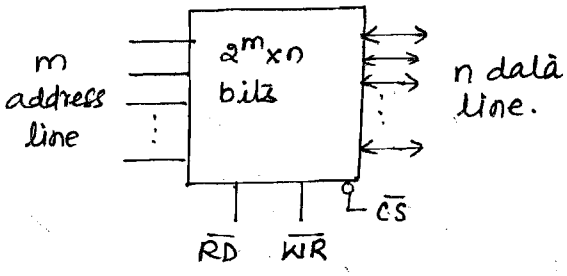
↳ commercially called RAM.

READ ONLY MEMORY:.



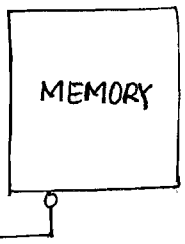
* Unidirectional data line to only Read data.

RANDOM ACCESS MEMORY

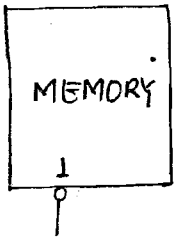


* Bidirectional data line to Read and write data

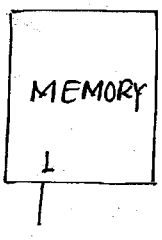
Note:.



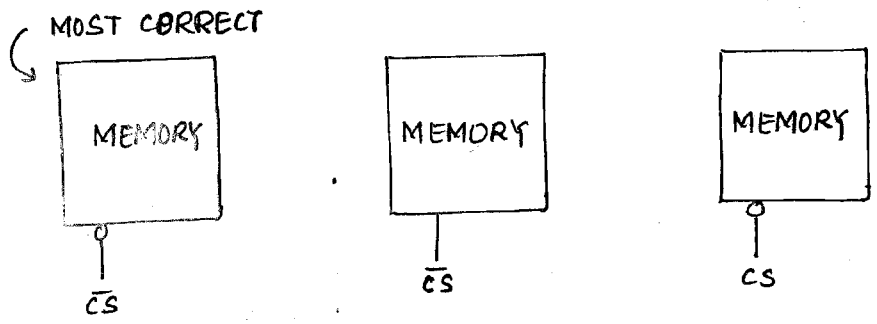
$\overline{CS}$ CHIP SELECT (ENABLE PIN)



$\overline{CS} = 0$ ACTIVE LOW



CS = 1 ACTIVE HIGH

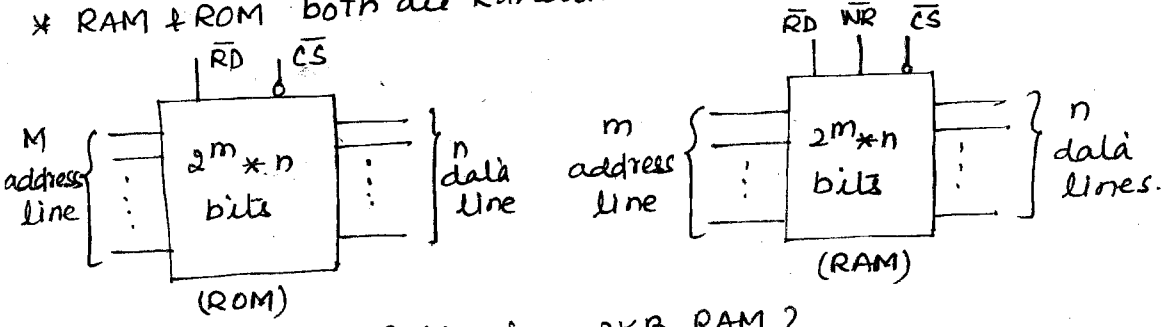


*Note!.
*All are 3 possible ways of Representing CHIP SELECT.

*RAM
*Random Access V/S Serial Access!.

*In Random access we directly give the address and reach the location where data is stored, but in serial access to reach some location we have to go serially

* RAM & ROM both are Random Access.



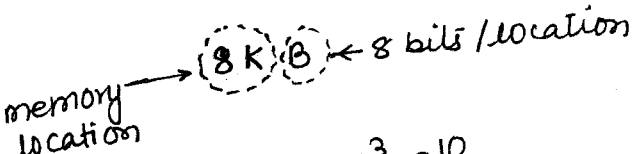
Q1) Construct 8 KB RAM using 2KB RAM ?

Soln:. KILO $\rightarrow 2^{10}$ Bits ; MEGA $\rightarrow 2^{20}$ Bits ; GIGA $\rightarrow 2^{30}$ Bits.

* Requirement is 8 KB

B : Bytes

8 bits make a Byte



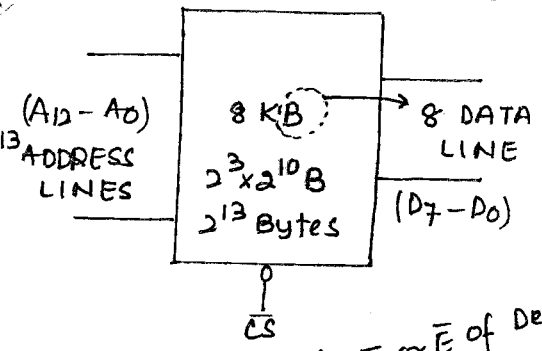
$8K \rightarrow 2^3 \times 2^{10}$

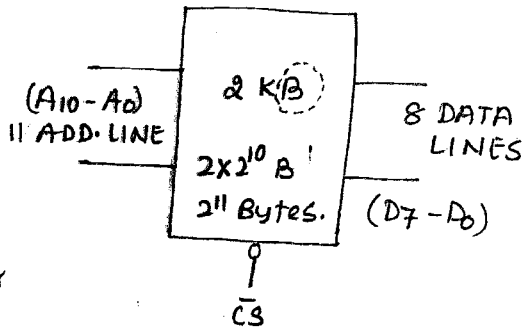
$= 2^{13} = 2^m.$

$\boxed{m = 13}$ ← Address lines.

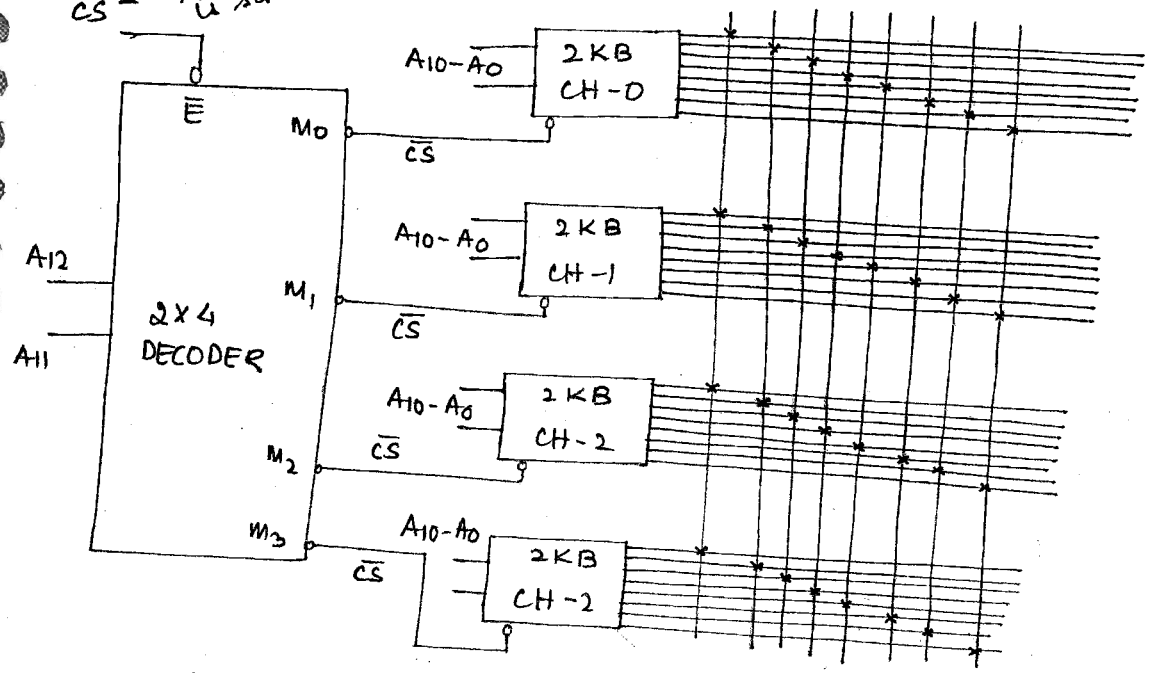
$\boxed{\text{data lines} = 8}$

B → Bytes ie 8 bits





$\overline{CS}$ ← of 8 KB RAM is same as $\overline{CS}$ or $\overline{E}$ of Decoder



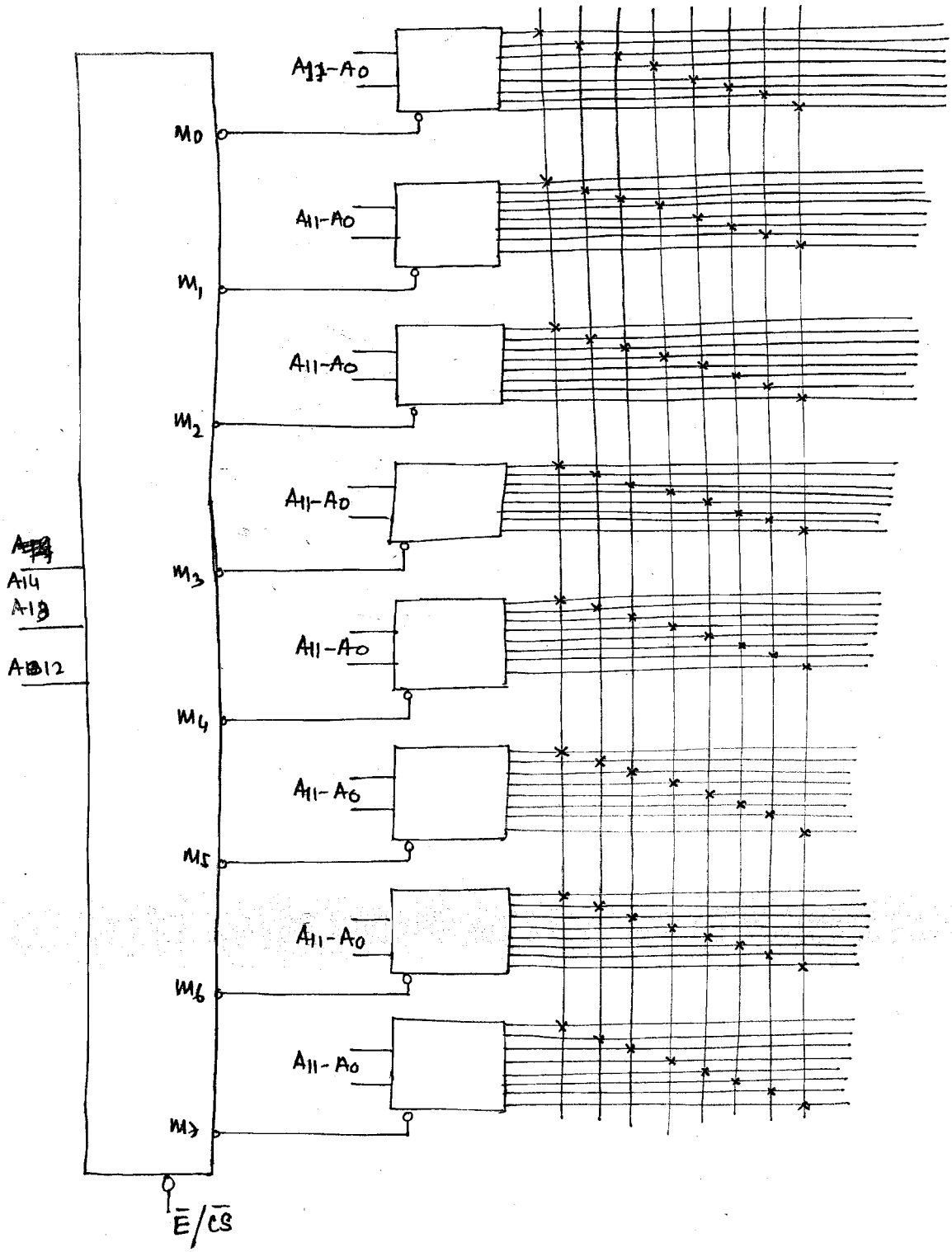
Note:

		2KB RAM										
A_{12}	A_{11}	A_{10}	A_9	A_8	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0
0	0	CHIP 0										
0	1	CHIP 1										
1	0	CHIP 2										
1	1	CHIP 3										

Q2) Construct 32 KB RAM using 4 KB ROM.

Soln:

32 KB ROM	4 KB ROM
$2^5 \times 2^{10}$ Bytes	$2^2 \times 2^{10}$ Bytes
Address lines = 15	Address line = 12.
Data line = 8	Data line = 8.


A11-A0
M0
A11-A0
M1
A11-A0
M2
A11-A0
M3
A14
A13
A12
A11-A0
M4
A11-A0
M5
A11-A0
M6
A11-A0
M7
Ē/C̄S̄

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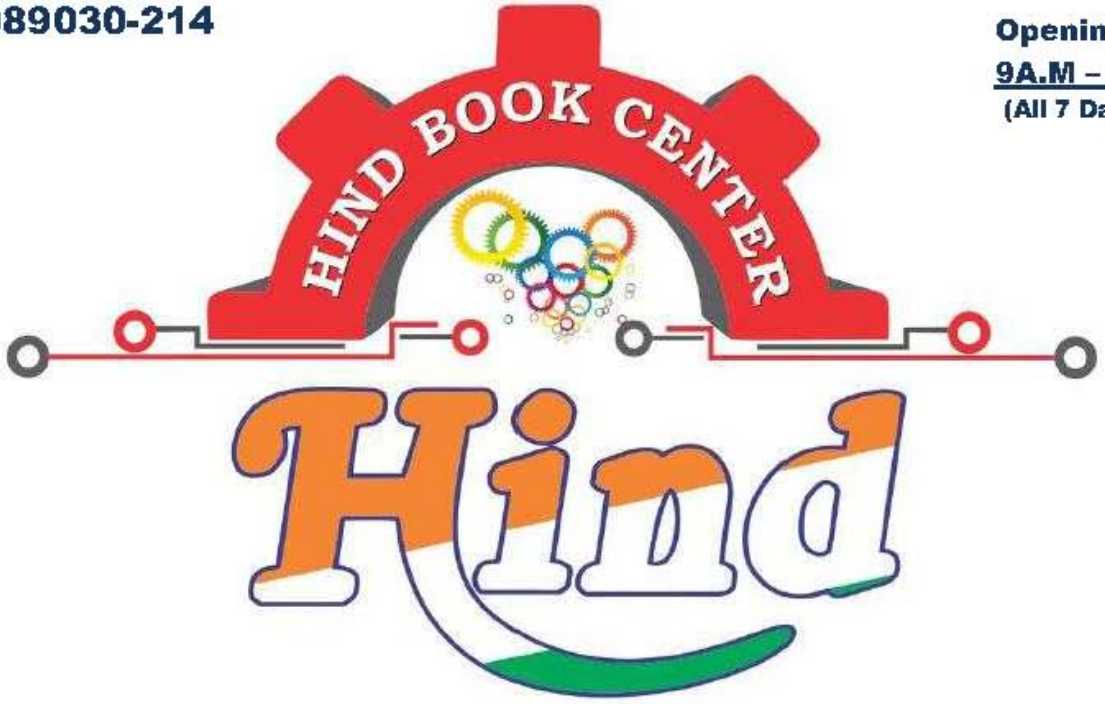

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CRYSTAL STRUCTURE

1) Atomic Arrangement in Solids.
2) Cubic Crystal system.
3) Miller Indices.
4) Bravais crystal structure.
5) Structural Imperfections.

* ATOMIC ARRANGEMENT IN SOLIDS:

CRYSTAL: It is a solid material in which Atomic or molecular arrangement is Periodic

* This Property of Crystal is known as CRYSTALLINITY.

*

SINGLE CRYSTAL MATERIAL:

* If material is having only one type of Periodical Arrangement then material is called single crystal.
* These materials are ANISOTROPIC MATERIALS. For Eg QUARTZ.

POLYCRYSTALLINE MATERIAL:

* These materials are divided into no. of small regions. These regions are called GRAINS.
* within each grain atomic or molecular arrangement is PERIODIC but this arrangement varies from one grain to the other.
  For Eg POLYCRYSTALLINE SILICON.
* These materials are Isotropic materials. ← Property depends on direction.

Note: (Anisotropic & Isotropic material):-

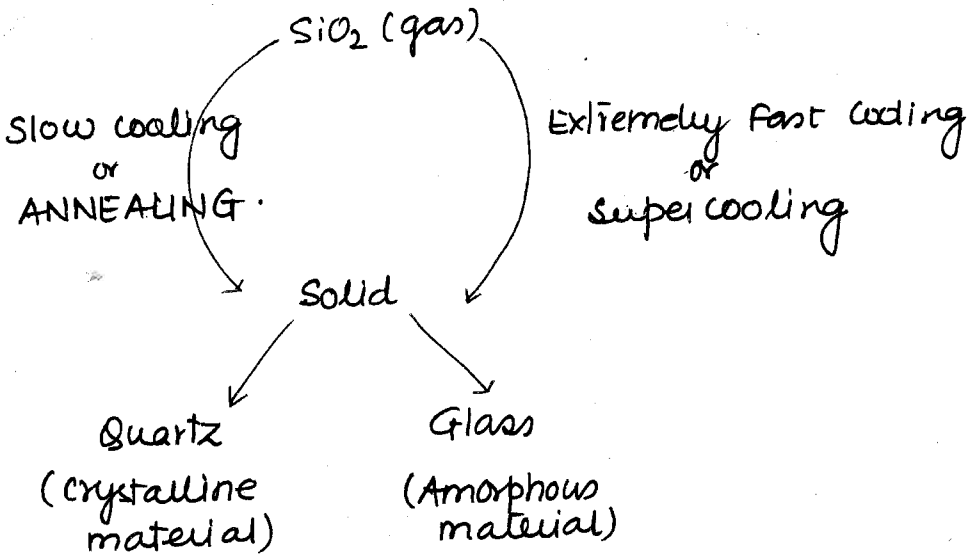
ANISOTROPIC MATERIAL:

A material is called ANISOTROPIC if properties of material depends on the direction in which they are measured.

ISOTROPIC MATERIAL:

* A material is called ISOTROPIC if properties of material are direction Independent.

*AMORPHOUS MATERIAL:



*When Atoms or molecules are not given opportunity to arrange in regular or periodic manner, an AMORPHOUS MATERIAL may be formed.

For Eg:- supercooled state of SiO_2 is known as GLASS. (AMORPHOUS MATERIAL).

*whereas on ANNEALING, SiO_2 may crystallize into QUARTZ. (CRYSTALLINE MATERIAL).

: In other cases, molecules may be extremely long and irregular in shape so that periodical arrangement may not be obtained as in the case of POLYMERS.

: EPITAXIAL PROCESS:

*The process of growth of a layer of silicon on a substrate is known as EPITAXIAL PROCESS.

1) In a Si Crystal, arrangement of atoms repeats periodically. This material can be classified as:.

a) Epitaxial & Amorphous.
b) Polycrystalline & Amorphous.
c) Single Crystal & Amorphous (material can't be both).
d) Epitaxial & Single Crystal.

CRYSTAL SYSTEM:-

1) UNIT CELL:-

*It is defined as the minimum Area cell in TWO dimension & the minm volume cell in 3-dimension, by repeatition of which a crystal may be formed.

2) PARAMETERS OF UNIT CELL:-

a) CELL DIMENSION
b) Angle between axis
c) no. of atoms per unit cell.
d) Co-ordination number.
e) Atomic Packing factor (APF).

Mathematically:-

$$APF = \frac{\text{Total Atomic Volume}}{\text{Vol. of unit cell.}}$$

$$APF = \frac{\text{No. of atoms per unit cell} \times \text{atomic Vol.}}{\text{Vol. of unit cell.}}$$

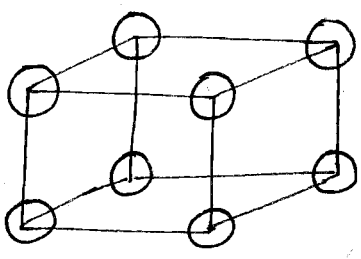
*Co-ordination number:-

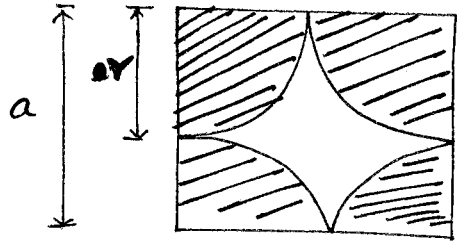
*The no. of atoms which are in physical contact with a particular atoms in a crystal structure, is known as CO-ORDINATION NUMBER.

*CUBIC CRYSTAL SYSTEM:-

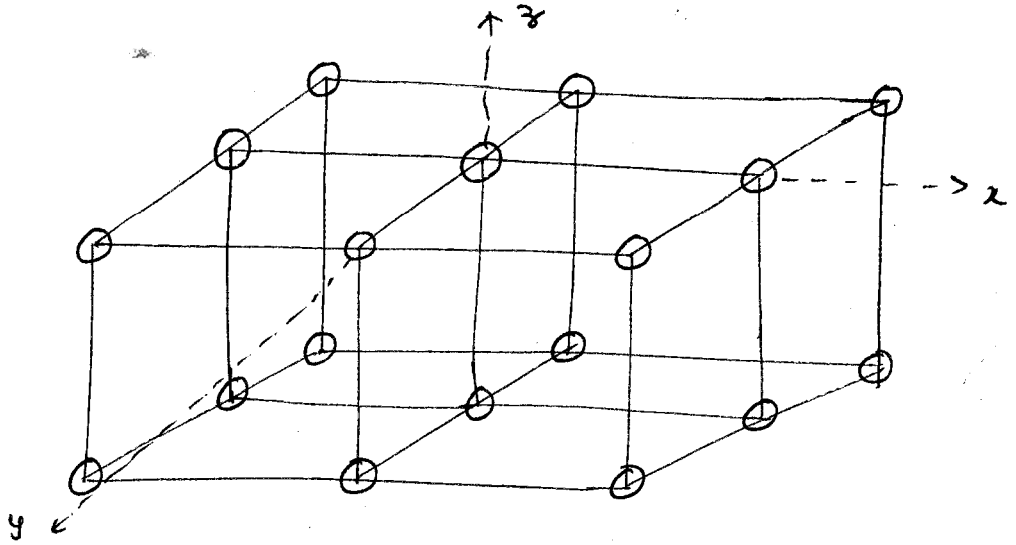
1) SIMPLE CUBIC:-

*In Simple cubic there are 8 corner atoms.
*Atoms are in physical contact along EDGE of the cube.





$a = 2r$



No. of atoms per unit cell = $8 \times \frac{1}{8} = 1$

$$APF = \frac{1 \times \frac{4}{3}\pi r^3}{a^3} = 0.52 \quad ; \quad a = 2r$$

Co-ordination number = 6. ← 8 atoms in contact in each direction.

* For Eg:.
  i) Manganese
  ii) Flourspar etc.

) Body centered cubic (BCC) :-

* In BCC there are 8 corner atoms and 1 Body centered atom.
* Atoms are in Physical contact along Body diagonal.

*Content:-

**1) Basics
2) Steady state AC circuits (Resonance)
3) Network Theorems
**4) Transient Analysis ← Very important
**5) Two Port Network
6) Filters
7) Magnetic coupled circuits } only memory Based Questions are asked. Don't waste much time on Revision.
8) Graph Theory

*Books:-

1) Fundamentals of Electric circuits - Alexander & Sadiku.
2) Engg. ckt Analysis - Hayt & Kemmerly
3) Network Analysis - Van Valkenburg
(Transients & Two Port)
↳ In Conventional.

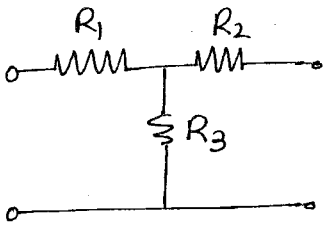
*Horne work
*Work Book
*Previous Papers (Gate) → EC. → EE. → IN.

IES → EC, EE
↓ ↓
Memory, Problems (Num + Theory)

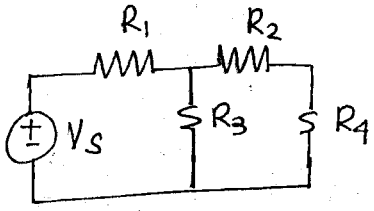
*CAS → obj (Made Easy book), Conventional

*Previous PSU papers.
*Test Series → old, new.

*Network & circuit:



T Network
↳ Comb^n of element
↳ may or may not be closed



N/w or circuit
↳ Comb^n of element
↳ necessary cond^n is closed path.

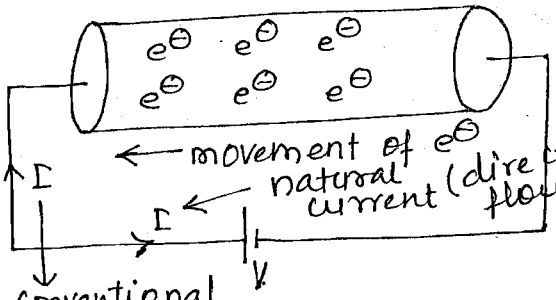
*All circuits are considered as networks but all networks cannot be considered as circuits.

*Network is a comb^n of elements, it may or may not consists of closed path.

*circuit is also a comb^n of elements and it should consist of closed path.

*Charge (Q), I, V, P, W:

$$q = -1.602 \times 10^{-19} C$$



$$I = \frac{da}{dt}$$ → unit is coulomb/sec or Ampere.

Mag. of conventional current = Mag. of Natural current

$$I = \frac{dQ}{dt}$$

$$Q = \int_{-\infty}^{t} I\,dt$$

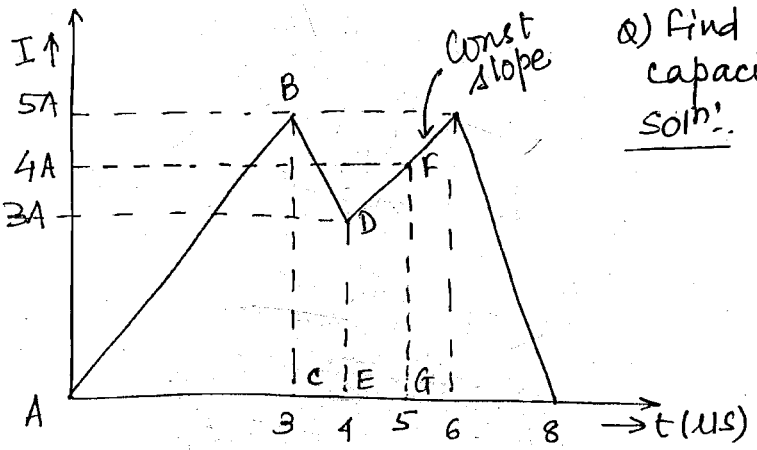
$$Q = \int_{-\infty}^{t} I\,dt = \int_{-\infty}^{0} I\,dt + \int_{0}^{t} I\,dt$$

$$Q = Q_0 + \int_{0}^{t} I\,dt$$

Q_0 → Initial charge

Note:
*In circuit Theory we only consider the "conventional current" and not the "Natural current"

*KCL and KVL are based on the "CONVENTIONAL CURRENT"



Q) Find charge aquired by the capacitor in 5μs

Soln:- 0-3μs (Region ABC)

$Q = \int I\,dt$ = Area under current time curve

$= \frac{1}{2} \times 3 \times 5 = 7.5$

(3μs-4μs) (Region BCDE)

⇒ Trapezoidal shape

$= \frac{1}{2}$ (sum of two heights) × (distance b/w two heights)

$= \frac{1}{2} \times (5+3) \times 1 = 4$

(4μs-5μs) (Region DFGE)

⇒ Trapezoidal shape

$= \frac{1}{2} \times (3+4) \times 1 = 3.5$

So total Area = 7.5+4+3.5

= 15μC

* To move an $e^{\ominus}$ from one place to another we require an external force called as EMF. So, mathematically ↳ "Electromotive force"

$$V = \frac{dW}{dQ} \text{ (Joules/C) or Volts}$$

* Time Rate of change of work is called Power.

Mathematically,

$$P = \frac{dW}{dt} \text{ (Joules/sec) or Watt}$$

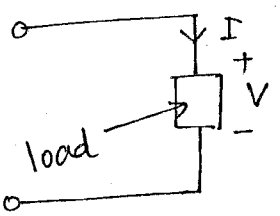
$$\Rightarrow P = \frac{dW}{dQ} \times \frac{dQ}{dt}$$

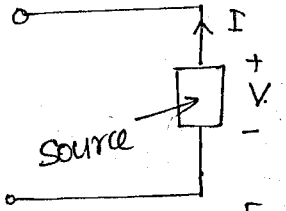
$$P = VI = I^2R = \frac{V^2}{R}$$

Also, $G = \frac{1}{R}$ = Conductance

Hence, $P = I^2/G = V^2G$

*Note :-





of element

* Current entering at the +ve terminal of the element
* Absorbing Power
* Acts as load.

or current leaving from the +ve terminal of the element

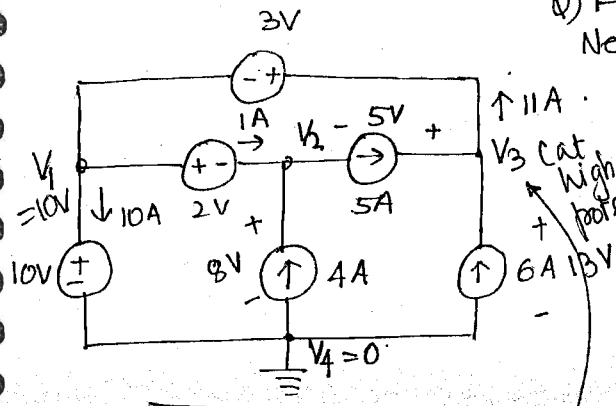
* Current entering at the −ve terminal of the element
* Delivering Power
* Acts as source

} of element

* When the current is Entering at the "+ve terminal", the element is "Absorbing Power"

* When the current is leaving from the "+ve terminal" the element is "Delivering Power".

Q) Find Power of each element of the Network shown:-



Soln:-

$P_{10} = 10V \times 10A = 100$ watts (Absor)

$P_4 = (-2+10) \times 4 = 32$ watts (delivering)

$P_5 = (-2-3) \times 5A = -25$ watts. (delivering)

$P_6 = (+3+10) \times 6A = 78$ watts (delivering)

$P_2 = 2V \times 1A = 2W$ (absorbing)

$P_3 = 11A \times 3V = 33$ watts (absorbing)

$V_1 - V_2 = 2$

$\Rightarrow V_2 = V_1 - 2 = 8V$

$V_3 - V_1 = 3V$

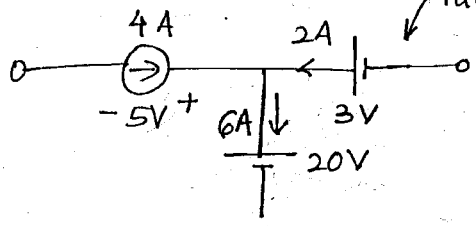
$V_3 = 3 + V_1 = 13V$

$P_4 = 4A \times 8V = 32$ Watts.
$P_6 = 13V \times 6A = 78$ watts.
$P_5 = 5A \times 5V = 25$ watts.
} Delivering Power

$P_{10} = 10V \times 10A = 100$ Watts
$P_2 = 2V \times 1A = 2$ watts
$P_3 = 11A \times 3V = 33$ watts
} Absorbing Power.

*Note :-

$(P_T)_{absorb} = (P_T)_{delivered}$ ← Satisfies for all networks.



Part of Network given.

Q) Find total power absorbed of fig. shown:.

soln:. $P_{20} = 20V \times 6A$
$= 120$ watts (A)

$P_4 = 5V \times 4A = 20$ watts (D)

$P_3 = 3V \times 2A = 6$ watts. (D)

also, $P_4 = -20$ watts (Absorbing)

$P_3 = -6$ watts (Absorbing).

so, total power absorbing $= 120 - 20 - 6 = 94$ watts (Absorbing)

* Note:-

* when only any part of Network is given we have to follow above steps to calculate total Absorbing or Delivering power.

* Power is always positive, in real time power is never considered to be as -ve and the same is valid for voltage also. For eg

Bulb → 40W (we donot say -40watt Bulb since it is absorbing Power)

Battery → +12°V (we donot say -12 V Battery which is source and it delivers power)

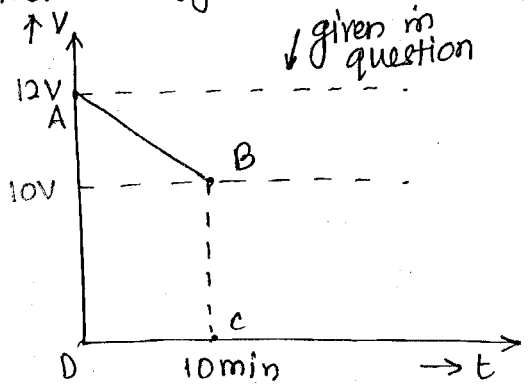
* Energy:-

* capacity to do any work is called as Energy

$$W = \int_0^t P\,dt$$

→ unit watt-sec or Joules.

Q) A fully charged mobile phone is good for 10 min talk time. During talk time battery delivers a const. current of 2A. Find Energy of the Battery during talk time?



↓ given in question

Soln:- * calculations for energy, time should always be in seconds.

Area of ABCD = $\frac{1}{2}$ × (Sum of 2 heights × dist. b/w 2 heights)

$= \frac{1}{2} \times (12+10) \times 600$

$\boxed{VxI = 6600}$

So, $\boxed{W = VIt} \Rightarrow \boxed{W = Pxt}$

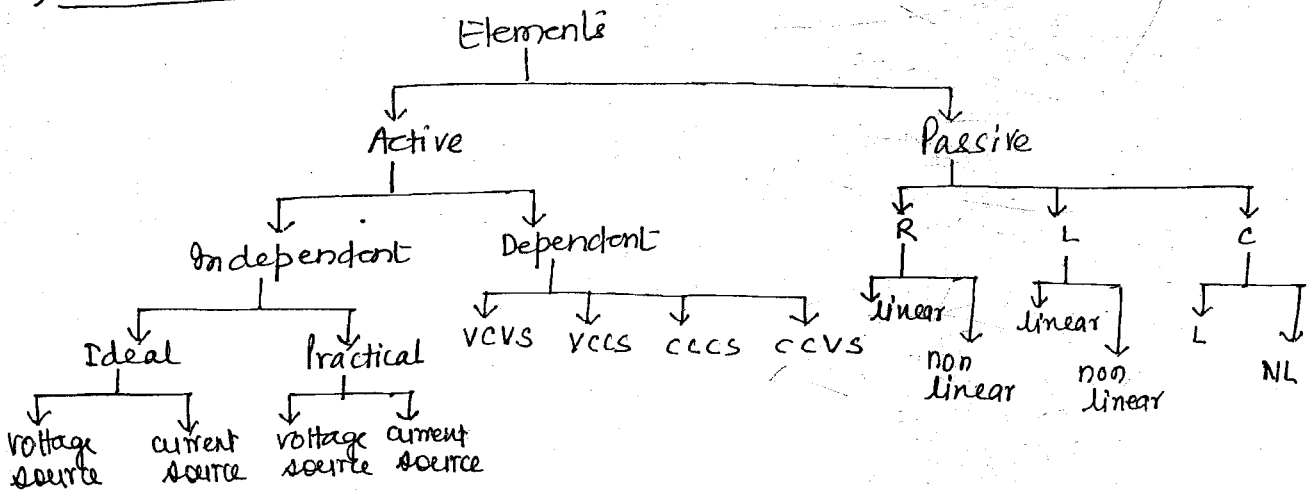
$W = 6600 \times 2A$

$\boxed{W = 13.2\ KJ}$

* CLASSIFICATION OF ELEMENTS:-

1) Active & Passive elements
2) Linear & Non linear elements
3) Unidirectional & Bi directional elements
4) Time variant & Invariant elements
5) Lumped & Distributed elements.

1) Active & Passive Elements:-



*ACTIVE ELEMENT:

*When the Element is capable of Delivering Energy Independently for long time (approx infinite time), then "ACTIVE ELEMENT"

OR

When the Element is having properly of Internal amplification then it is called as "ACTIVE ELEMENT"

*Examples:

1) Voltage source. } Independent sources.
2) current source. }
3) Transistor, & } Dependent sources.
4) OP-AMP

Note:

*when the 'c' is connected to DC, the capacitor is charging and while discharging it delivers energy independently, and that energy delivered to the ckt depends on the time Constant of the ckt, whereas the ACTIVE ELEMENT delivers energy independently.

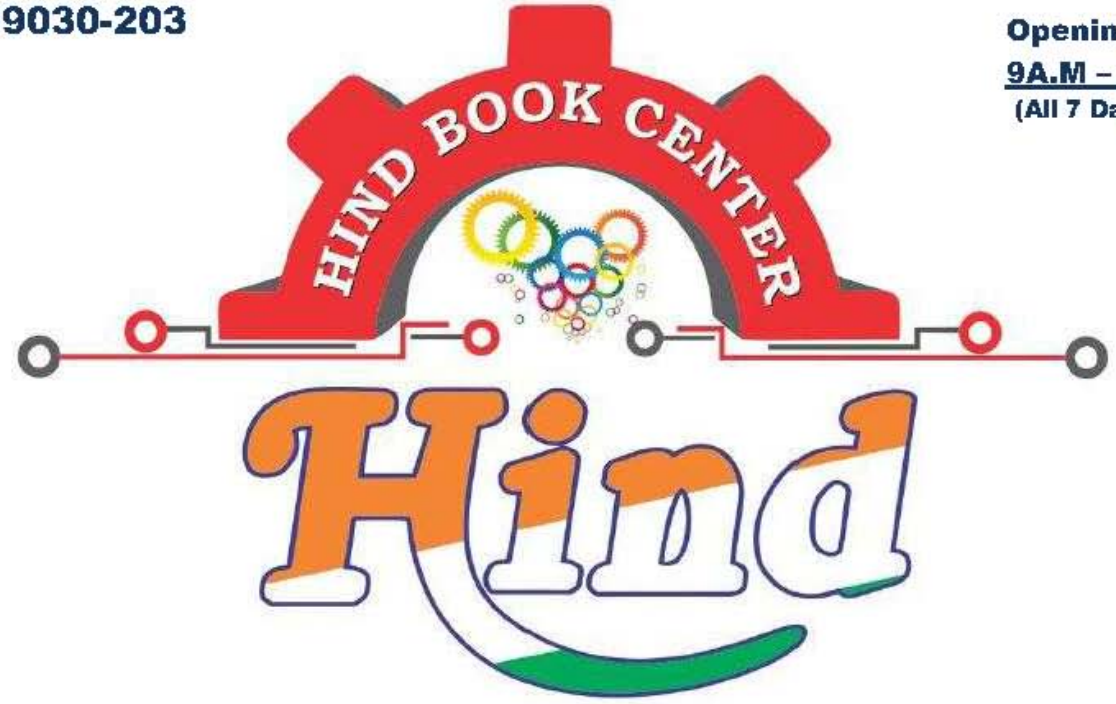
* During discharging capacitor can deliver energy independently for short time (depends on its time const) and capacitor is not having the properly of Internal Amplification. Hence capacitor is not an "ACTIVE ELEMENT".

*PASSIVE ELEMENT:

*when the Element is not capable of delivering energy Independently then it is called as "PASSIVE ELEMENT"

*Examples:

1) Resistor
2) Bulb
3) Transformer *** $(V_1 I_1 = V_2 I_2)$ → *** Internal power = External power.
   ↳ step up or step down the voltage, but no power is stepped up or stepped down Hence no Internal amplification



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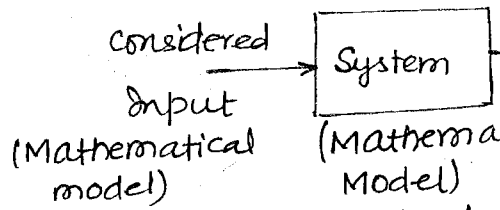
Signal & System

By-Vishnu Sir

*WHY SIGNALS AND SYSTEMS:.

* To ensure suitable working of the system to be designed before its actual designing. This is done by providing a Signal to ensure the response.
* And by mathematical tool these can be done.
* Considering the system as mathematical Model and also considering the input as mathematical. The desired System can be designed.

* To find the expression of the Response we study Signal & System.



* Mathematical tools used for find the Response of the System in more efficient way with less effort are:.
  - i) Fourier Series.
  - ii) Fourier Transforms.
  - iii) Laplace Transforms.
  - iv) Z Transforms.

  } used to minimize the effort in designing of the system.

Note:.

* Information (Signal) can exist in only two ways:.
  - i) Continuous Time signal.
  - ii) Discrete Time Signal. (if samples are taken at very close intervals then only information can be Retrieved back).

* Sampling Theorem provides guidelines to convert Continuous Time signals into Equivalent Discrete Time Signals.

SIGNALS :-

* Any entity having associated information with it is defined as SIGNAL.
* Signal here means voltage and current signals where both are functions of time.

$v(t)$ or $i(t)$ $\Big\}$ $f(t)$ ← 1 DIMENSIONAL SIGNAL

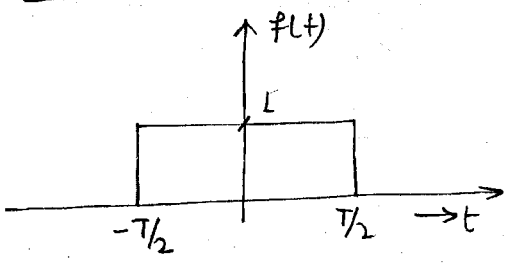
* Signals need not always be function of time.
* Signals also can be function of space having different intensity level.

Photo Picture → $f(x, y)$. ← 2 DIMENSIONAL SIGNALS (signal independent of time)

* Also the moving picture (Video signal) which is made up of various still frame is also a signal which is funcⁿ of space & time.

Hence Video = $f(x, y, t)$. ← 3 DIMENSIONAL SIGNAL (space, time)

* A signal may be function of n variable. These signals are called as N DIMENSIONAL SIGNALS. ↘ need not always be time always.
* Signals can be represented mathematically or graphically. Analysis of signals can be done easily when graphical format is considered.
* RECTANGULAR PULSE :-

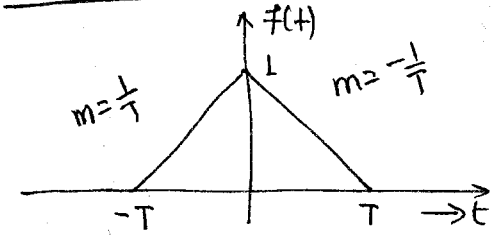


$f(t) = 1 \; ; \; -T/2 \le t \le T/2$

$0 \; ;$ otherwise.

* Any signal having short duration or existing for short duration is called a Pulse.

* TRIANGULAR PULSE :-



$f(t) = f_1(t) = m_1 t + c_1$

$f_1(t) = \frac{1}{T} t + 1 \; ; \; -T \le t \le 0$

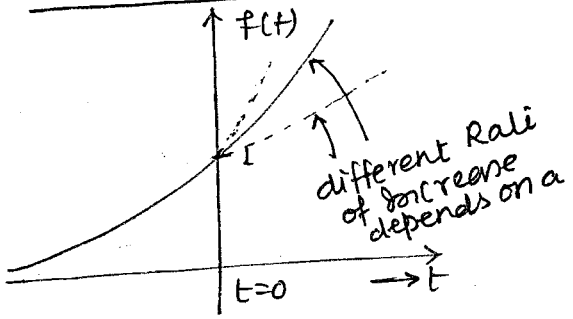
$f(t) = f_2(t) = m_2(t) + c_2$

$f_2(t) = \frac{-1}{T} t + 1 \quad 0 \le t \le T$

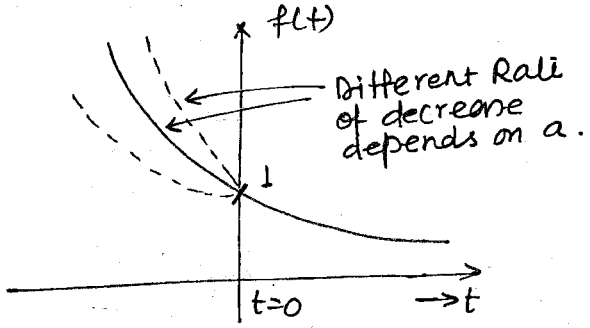
So, for Triangular Pulse:-

$$f(t) = \begin{cases} f_1(t) = \frac{1}{T}t + 1 & ; -T \le t \le 0 \\ f_2(t) = -\frac{1}{T}t + 1 & ; 0 \le t \le T \\ 0 & ; \text{otherwise.} \end{cases}$$

* EXPONENTIAL SIGNALS:-



$f(t) = e^{at}$

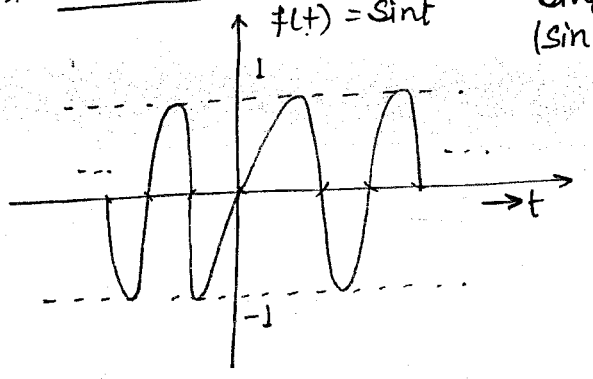


$f(t) = e^{-at}$

a = Scaling factor (deciding Rate of Increase or Decrease).

* a is also called as the Time Const as they decide Rate of Rise and decrease.

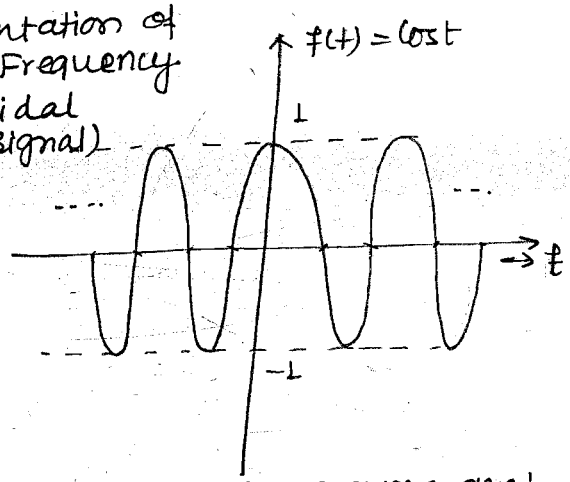
* SINUSOIDAL SIGNALS:-



* Zero cross over are:-

$t = \pm n\pi$

* Representation of Single Frequency (sinusoidal signal)

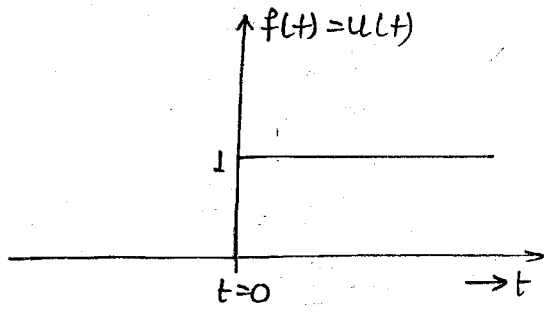


* Zero cross overs are:-

$t = \pm (2n+1)\pi/2$

* The instance of time where signals oscillating b/w +ve and -ve values cross 0 value are defined as ZERO CROSS OVER of such oscillating signals.

* UNIT STEP SIGNAL:.



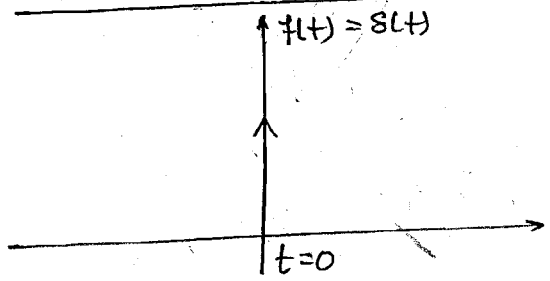
$$f(t) = 1 \; ; \; t > 0$$
$$0 \; ; \; t < 0.$$

$$f(t) = u(t) = 1 \; ; \; t \geq 0.$$
$$0 \; ; \; t < 0.$$

COMPROMISED DEFINITION

$u(t) = 1 \; ; \; t = 0.$

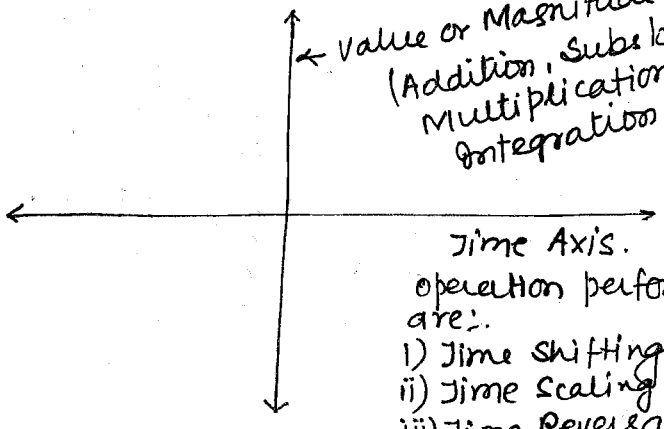
* IMPULSE FUNCTION:.



$$f(t) = \delta(t) = 0 \; ; \; t \neq 0$$
$$\neq 0 \; ; \; t = 0$$
$$\int_{-\infty}^{\infty} \delta(t)\,dt = 1$$

* Impulse Impacts can be measurable or unmeasurable. Analysis is done only for measurable Impacts.
* Hence to analyse the Impulse signal it has to be measurable and for that its Area should be equal to Unity.
* The magnitude of $\delta(t)$ is ∞ at $t=0$ and hence unmanageable so to manage them indirectly its Area is made equal to 1.

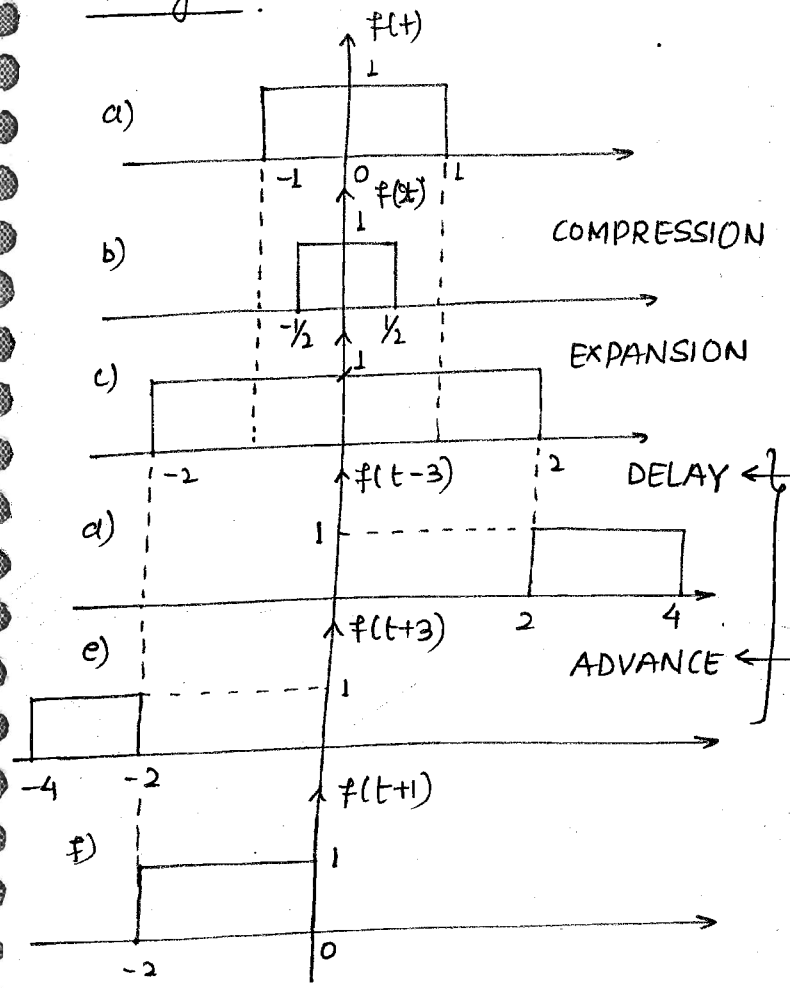
Note :.



operation performed on Time Axis are:.

i) Time Shifting.
ii) Time Scaling.
iii) Time Reversal.

*Analysis :-



*Note :-

* Scaling operation is also known as DIVIDE By "a" operation.
* Delay operation is also known as ADD "to" operation.
* Advance operation is also known as SUBTRACT "to" operation.

a) $f(t) = 1 \; ; \; -1 \le t \le 1$
$\quad\quad 0 \; ; \; \text{otherwise}$

b) $f(2t) = 1 \; ; \; -1 \le 2t \le 1$
$\quad\quad 0 \; ; \; \text{otherwise}$

$f(2t) = 1 \; ; \; -\frac{1}{2} \le t \le \frac{1}{2}$
$\quad\quad 0 \; ; \; \text{otherwise.}$

c) $f(\frac{1}{2}t) = 1 \; ; \; -1 \le t/2 \le 1$
$\quad\quad 0 \; ; \; \text{otherwise}$

$f(t/2) = 1 \; ; \; -2 \le t \le 2$
$\quad\quad 0 \; ; \; \text{otherwise.}$

Note :-

$t \rightarrow at$

$f(t) \xrightarrow{t \rightarrow at} f(at)$

$a > 1 \rightarrow$ COMPRESSION
$a < 1 \rightarrow$ EXPANSION

a = SCALING FACTOR.

d) $f(t-3) = 1 \; ; \; -1 \le t-3 \le 1$
$= 0 \; ;$ otherwise

$f(t-3) = 1 \; ; \; 2 \le t \le 4$
$0 \; ;$ otherwise

e) $f(t+3) = 1 \; ; \; -1 \le t+3 \le 1$
$0 \; ;$ otherwise

$f(t+3) = 1 \; ; \; -4 \le t \le -2$
$0 \; ;$ otherwise

f) $f(t+1) = 1 \; ; \; -1 \le t+1 \le 1$
$= 0 \; ;$ otherwise

$f(t+1) = 1 \; ; \; -2 \le t \le 0$
$0 \; ;$ otherwise

*Note :-

i) $t \rightarrow t - t_0 \rightarrow$ delay or Right shift

ii) $t \rightarrow t + t_0 \rightarrow$ Advance or left shift.