Name:

Roll no. :

Test No:

Subject: Full test 1

1. (a) Nanomaterials can be defined as the materials possessing at minimum, one external dimension measuring 1-100nm. They can occur naturally or as a product of a reaction or be produced purposefully ~~though~~ through some synthesis techniques.
These material have different physical and chemical properties to make the more useful.

There are two main approaches ~~of~~ for nanomaterial synthesis
(i) Top down! Size reduction from bulk materials
(ii) Bottom up! material synthesis from atomic level.

Some common techniques are,

(i) Inert Gas Condensation!
→ Produces well defined grains with a narrow size distribution.
→ involves two steps, first is the evaporation of material and controlled condensation of evaporated atoms to produce desired particle size. Evaporation is done inside a chamber filled with inert gas like helium.

(ii) Chemical Vapour deposition!
Silicon atoms reaching the substrate are produced by chemical reaction between $SiCl_4$ & Hydrogen.

(iii) Sputtering
→ physical vapour decomposition process
→ High energy ions bombarded on a solid target to eject its atoms in vapour phase.

- reject atoms can be deposited in form of nano film on Cold Substrate
- slow deposition time and low temperature of Substrate helps in Preventing growth of nano Particles into large ones.

(iv) Electro deposition

→ it is a single step method

→ Large number of nano crystalline Structures have been made by this method.

1.(b)

$$\vec{P} = \frac{2}{\rho^2} \hat{a}_\rho \ nC/m^2$$

$$d\vec{P} = \varepsilon_0 \chi \, dE$$

inside the Conductor $[0 < r < a]$

as $P = 0$ Here, $\therefore \boxed{E = 0 \Rightarrow D = 0}$

in a region $[a < r < b]$

$$dE = \frac{1}{\varepsilon_0 \chi} \left(\frac{-4}{\rho^3}\right) . d\rho \quad . \quad \hat{a}_\rho$$

Integrating both sides.

$$\int dE = \frac{1}{\varepsilon_0 \chi} \int_a^b \frac{-4}{\rho^3} . d\rho \ \hat{a}_\rho = \frac{1}{\varepsilon_0 \chi} \left[\frac{-4}{\rho^2 (-2)}\right]_a^b$$

$$\vec{E} = \frac{2}{\varepsilon_0 \chi} \left(\frac{1}{b^2} - \frac{1}{a^2}\right) \hat{a}_\rho$$

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$$\vec{E} = \frac{2}{8.854\times10^{-12}(11.7-1)} \times \left[\frac{1}{(5\times10^{-3})^2} - \frac{1}{(10^{-4})^2}\right]\hat{a}_\rho$$

$$\cancel{\boxed{\vec{E} = -2.11\times10^{7}\,\hat{a}_\rho}\ V/m}$$

$$\cancel{\vec{D} = \varepsilon_0\varepsilon_r\vec{E} = 8.854\times10^{-12}\times11.7\,(-2.11\times10^{7})}$$

$$\cancel{\boxed{\vec{D} = -2.185\times10^{-3}\,\hat{a}_\rho\ C/m^2}}$$

for $r > b$

$$\vec{E} = \frac{1}{\varepsilon_0\chi}\int_b^{\infty} -\frac{4}{\rho^3}\cdot d\rho\ \hat{a}_\rho = \frac{1}{\varepsilon_0\chi}\left[\frac{-4}{(-2)\rho^2}\right]_b^{\rho}$$

$$\cancel{\vec{E} = \frac{2}{8.854\times10^{-12}(11.7-1)}\left(\frac{1}{r^2} - \frac{1}{b^2}\right)\hat{a}_\rho}$$

$$\cancel{\boxed{\vec{E} = 21.11\left[\frac{1}{r^2} - 40000\right]\hat{a}_\rho}\ V/m}$$

$$\cancel{D = \varepsilon_0\varepsilon_r\vec{E} = 8.854\times12.7\times10^{-12}\times21.11\left[\frac{1}{r^2} - 40000\right]\hat{a}_\rho}$$

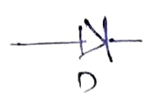
$$\cancel{\boxed{D = 2.373\times10^{-9}\left[\frac{1}{r^2} - 40000\right]\hat{a}_\rho}\ C/m^2}$$

(ii) $$\cancel{V_{ab} = -\int_b^a E\cdot d\rho = -\int_{5\times10^{-3}}^{7\times10^{-3}}(-2.11\times10^{7})\cdot d\rho}$$

$$\cancel{\boxed{V_{ab} = -84.4\ kV}}$$

1(c)

Constant Voltage diode model

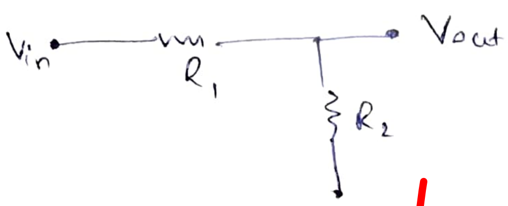


$\Rightarrow$ When D is ON $\Rightarrow$

$\Rightarrow$ When D is OFF $\Rightarrow$

(i)

Assuming Diode is OFF



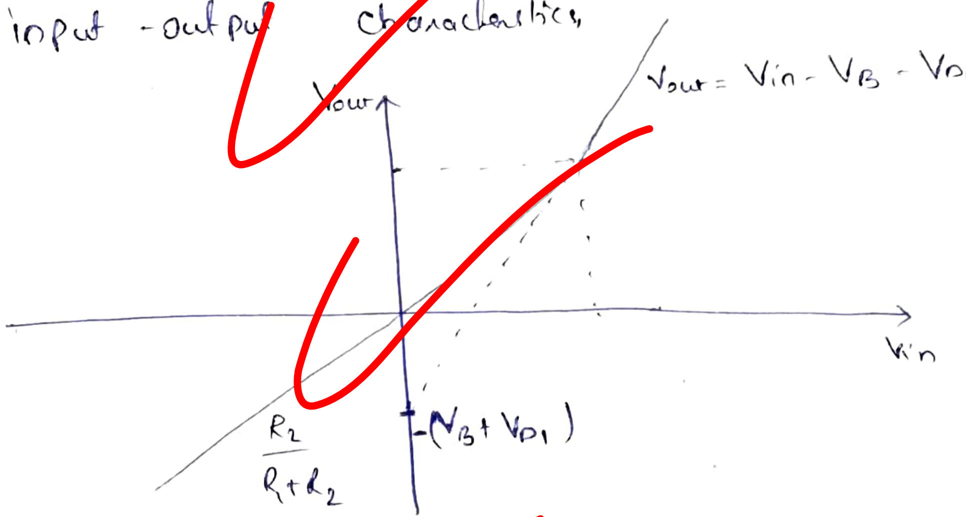
$$V_{out} = \frac{R_2}{R_1+R_2} \cdot V_{in}$$

So, when ~~$V_{out} >$~~ $V_{out} < V_{in} - V_B - V_{D1}$

Diode will turn ON $\Rightarrow$ i.e, $V_{in} > V_B + V_{D1}$

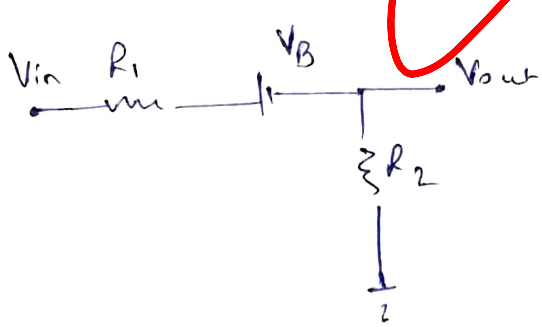
Hence output $\Rightarrow$ $V_{out} = V_{in} - V_B - V_{D1}$

input - output characteristics,



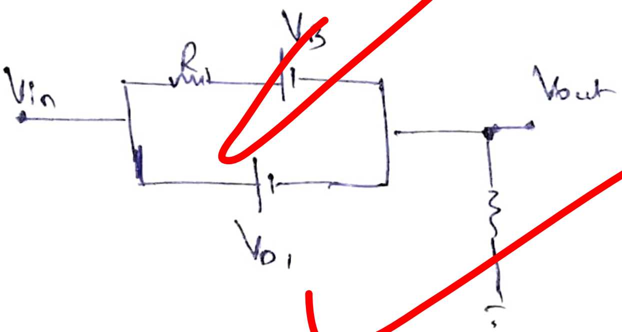
(ii)

When $D_1 \rightarrow$ is OFF



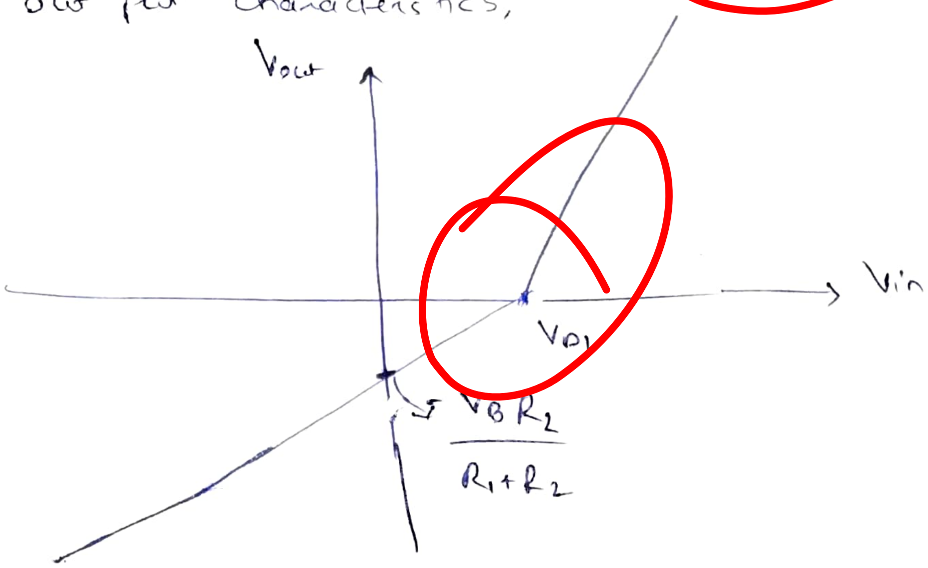
$$V_{out} = \left[\frac{V_{in} - V_B}{R_1 + R_2}\right] \times R_2$$

and when ~~Vin > V~~ Diode is ON, i.e, ($V_{in} > V_{01}$)



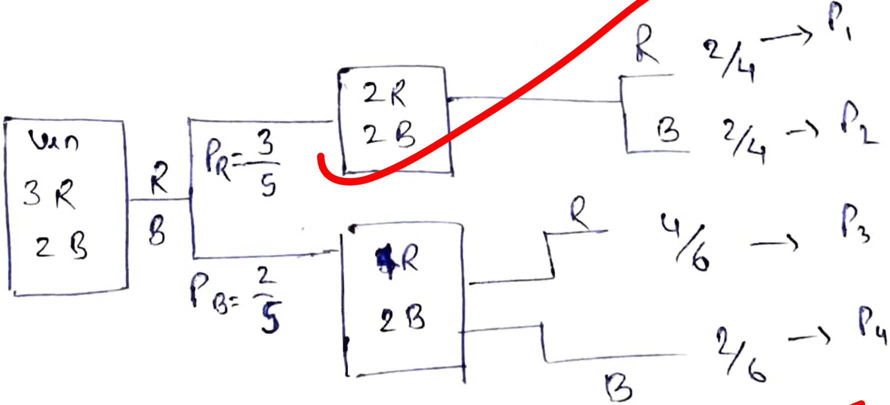
$V_{out} = V_{in} - V_{01}$

Input out put characteristics,



$\frac{V_B R_2}{R_1 + R_2}$

1(d)



(i) P(both balls drawn are red) = $\frac{3}{5} \times \frac{2}{4} = \frac{3}{10}$ Ans.

(ii) P(2nd balls is red then 1st ball was blue) → Using baye's theorem

$P(E)$ $P = \dfrac{P_3 \times P_B}{P_3 \times P_B + P_1 \times P_C} = \dfrac{\frac{4}{6} \times \frac{2}{5}}{\frac{4}{6} \times \frac{2}{5} + \frac{2}{4} \times \frac{3}{5}}$

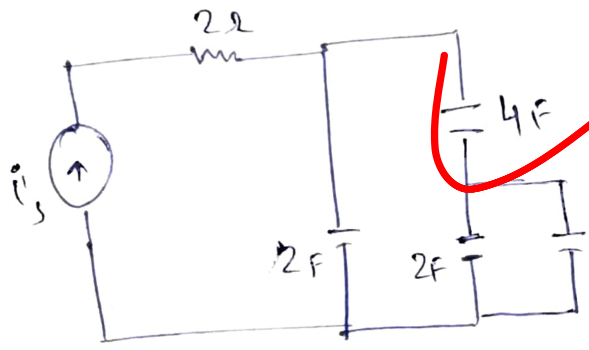
$= \dfrac{\frac{4}{15}}{\frac{4}{15} + \frac{3}{10}} = \dfrac{4}{15} \times \dfrac{30}{17}$

$\boxed{P = \dfrac{8}{17}}$ Ans.

1.(e) In series combination $\dfrac{1}{C_{eq}} = \dfrac{1}{C_a} + \dfrac{1}{C_b} + \dfrac{1}{C_c}$

In parallel combination $C_{eq} = C_a + C_b + C_c$

Using this and Redrawing the circuit



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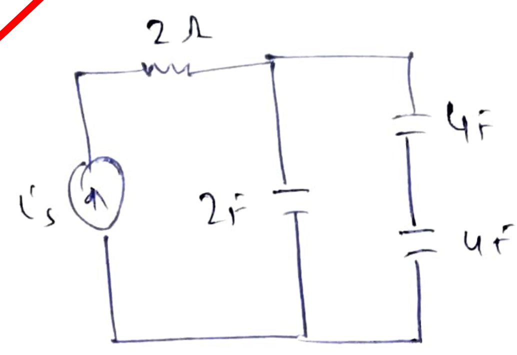

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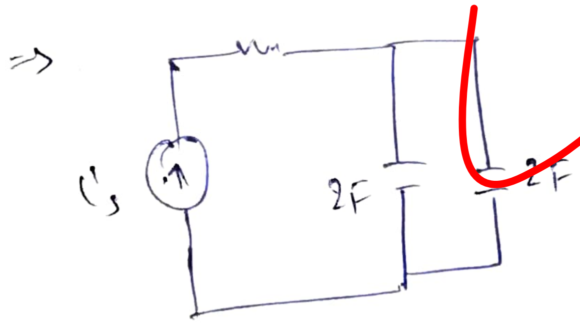

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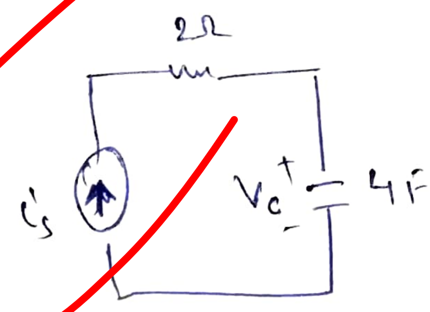
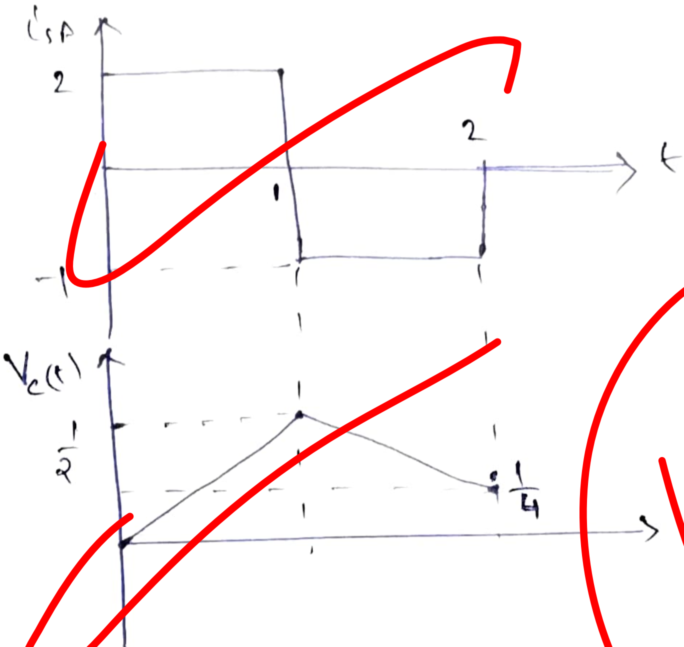


$C_{eq} = 4F$

As $\quad i_c = C\dfrac{dV}{dt} \quad \& \quad V_c = \dfrac{1}{C}\int i\,dt$

Hence, $V_c(t) = \dfrac{1}{C_{eq}} \int i_s\,dt = \dfrac{1}{4}\int i_s\,dt$

$$\cancel{= \frac{1}{4}\left\{ \int_0^1 2\,dt + \int_1^2 (-1)\,dt \right\}}$$



(ii) Energy dissipated in 2Ω resistor

$$E = \int_0^2 i_s^2 \times R\,dt$$

$$= \int_0^1 (2)^2 \times 2\,dt + \int_1^2 (-1)^2 \times 2\,dt$$

$$= 8\left[t\right]_0^1 + 2\left[t\right]_1^2$$

$$= (8-0) + 2(2-1)$$

$$\boxed{E = 10\ J}$$

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4.(a)(i)

Single precision form

S	BE	mantissa
1 bit	8 bit	23 bit

$\underbrace{1}_{\text{Sign } (\sigma)}\ \underbrace{100\ 1100}_{BE}\ \underbrace{1\ 011\ 1110\ 0010\ 0000\ 0000\ 0000}_{\text{mantissa}}$

Here Sign (σ) bit is $1 \rightarrow$ Hence it is a negative number.

$BE = 153$, ~~Actu~~ Actual Exponent $(AE) = BE - Bias$

$Bias = 2^{8-1} - 1 = 127$

~~Actua~~ $AE = e = 153 - 127 = 26$

~~mantissa $(\bar{x})$ = 0111~~

mantissa $(\bar{x}) = 1.011\ 1110\ 0010\ 0000\ 0000\ 0000$

shifting towards left by 11 bit

$= (1011\ 1110\ 0010) * 2^{-11}$

$= (3042) * 2^{-11}$

Decimal Representation $\sigma(\bar{x})2^{e}$

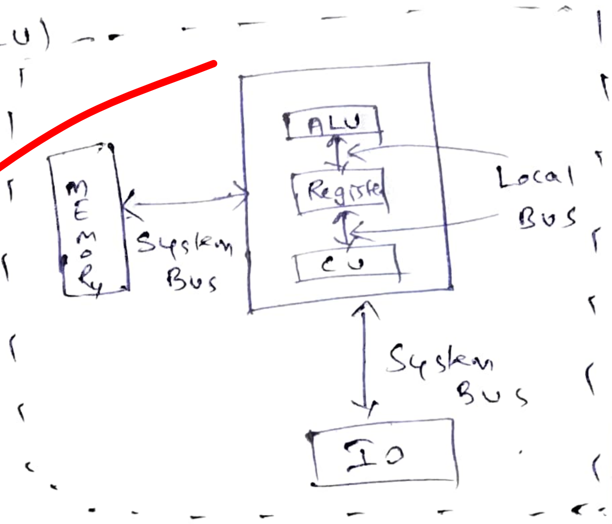
$-[3042] * 2^{-11} \times 2^{26}$

$\boxed{Ans \Rightarrow -(3042) * 2^{15}}$

4.(a)(ii) In Computer System the ~~Project~~ Processing System is a major block which is responsible for performing and Controlling the tasks by giving them appropriate signals.

Basic Processing System in a Computer Consists of 3 units

(i) Arithematic logical Unit (ALU)
(ii) Control Unit (CU)
(iii) Registers.



Computer System

Arithematic logical unit (ALU)

It performs all the mathematical and logical operations need to be performed for completion of task such addition, Subtraction, multiplication, division, AND, OR, XOR operations etc, Increment decrement, shifting operation with the help of accumulator Register.

Control unit (CU)

It is responsible for generating Control signals to fetch, Read, Write data to or from memory or IO device. It is like brain of Processing ~~&~~ unit and Controls the flow of data in the Computer System.

Registers → These are used for storage of data for temporarily purpose so that ALU operation can be performed on the data and then with the help of CU it is send to destination.

4.(b)(i) Phantom loading → It is the fictitious loading for testing the performance of appliance (energymeter) without actually loading to normal condition.

Advantages

→ The losses will be lesser during this loading compared to actual loading

→ Hence low cost will be there for testing

4.(b)(ii)

$K = 600 \text{ rev/kWh}$

Due to lag adjustment $\Delta = 86°$

with lag adjustment, $\Delta = 90°$,

$P = VI\cos\phi = 240 \times 10 \times 0.8 = 1920\,W = 1.92\,kW$

~~for 1hr, P(kWh) = 1.92 kWh~~

Hence, $\text{rev/hr} = 600 \times 1.92 = 1152$

$$\boxed{\text{Speed in rpm} = \frac{1152}{60} = 19.2 \text{ rpm}}$$

Now with lag adjustment $\Delta = 86^\circ$

(1) $P_m = VI \sin(\Delta - \phi)$

$P_m = 240 \times 10 \sin(86 - 0) = \cancel{2.394 \text{ kW}}$ [UPF $\Rightarrow \phi = 0^\circ$]

$\cancel{2.4} = 2.394$ kW

$P_T = VI \times \cos\phi = 240 \times 10 \times 1 = 2400$ kW

$\%\text{error} = \frac{P_m - P_T}{P_T} \times 100 = \frac{2.394 - 2.4}{2.4} \times 100$

$\boxed{\%\text{error} = -0.25\%}$

(2) $P_m = 240 \times 10 \left(\sin\left[86 - \cos^{-1} 0.5\right]\right) = 1.052$ kW

$P_T = 240 \times 10 \times 0.5 = 1.2$ kW

$\%\text{error} = \frac{1.052 - 1.2}{1.2} \times 100$

$\boxed{\%\text{error} = -12.33\%}$

1(b) (iii) 1.

$I_1 = 100 \pm 2$ A $\Rightarrow \varepsilon_1 = 2\%$

$I_2 = 200 \pm 5$ A $\Rightarrow \varepsilon_2 = 2.5\%$

Error

$\%\varepsilon_x = \left[\frac{I_1}{I_1 + I_2} \times \varepsilon_1 + \frac{I_2}{I_1 + I_2} \times \varepsilon_2\right]$

$= \left[\frac{100}{100 + 200} \times 2 + \frac{200}{100 + 200} \times 2.5\right] = \frac{7}{3}\%$

$I = I_1 + I_2 = 100 + 200 = 300$

$\frac{7}{3}\%$ of $I = \frac{7}{3} \times \frac{300}{100} = 7\ A$

$\therefore \boxed{I = (300 \pm 7)\ A}$

(2). As standard deviations,

$\sigma_1 = 2A, \quad \sigma_2 = 5$

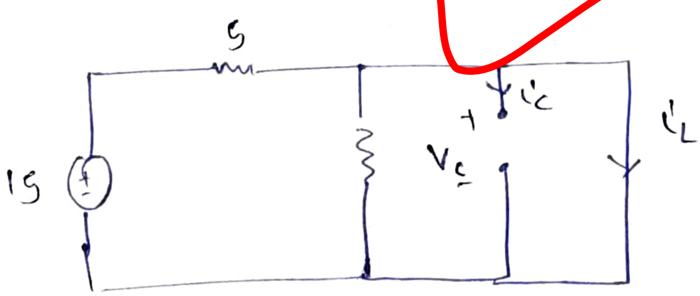
$$\sigma_x = \sqrt{\left(\frac{\partial I}{\partial I_1}\right)^2 \times \sigma_1^2 + \left(\frac{\partial I}{\partial I_2}\right)^2 \sigma_2^2} \qquad \left(\frac{\partial I}{\partial I_1} = \frac{\partial I}{\partial I_2} = 1\right)$$

$$= \sqrt{(1)^2 \times (2)^2 + (1)^2 \times (5)^2}$$

$\sigma_x = 5.385$

$\boxed{I = (300 \pm 5.385)\ A}$

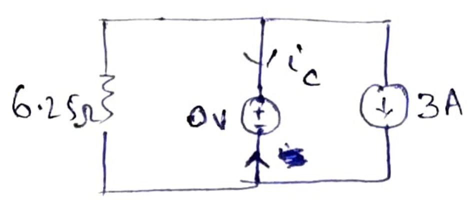
4.(c) (i) For $t < 0$, Circuit has achieved steady state hence capacitor behaves as open circuit and inductor behaves as short circuit



$i_L(0^-) = \frac{15}{5} = 3\ A$

$V_c(0^-) = 0\ V$

For $t \geq 0^+$



As inductor doesnot allow sudden change in current hence behaves as current source similarly, capacitor doesnot allow sudden change in voltage hence taken as voltage source.

$\therefore \boxed{V_c(0^+) = 0\ V}$

$\boxed{i_c(0^+) = -i_L(0^+) = -3\ A}$

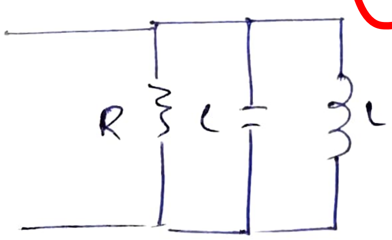
as,

$i_c = C\dfrac{dV}{dt} \Rightarrow i_c(0^+) = C\dfrac{dV(0^+)}{dt}$

$\left.\dfrac{dV_c}{dt}\right|_{t=0^+} = \dfrac{i_c(0^+)}{C} = \dfrac{-3}{10\times10^{-3}}$

$\boxed{\left.\dfrac{dV_c(t)}{dt}\right|_{t=0^+} = -300\ V/sec.}$

(ii) for $t>0$ circuit is



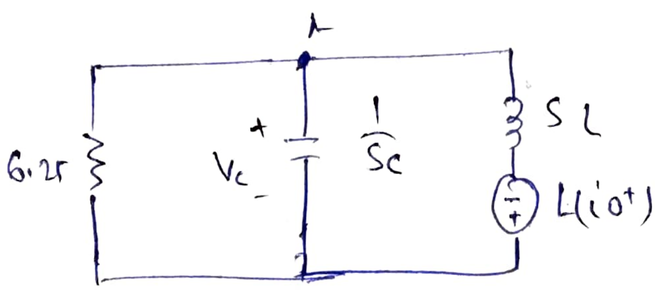
$R^2 = (6.25)^2 = 39.0625$

$4\dfrac{C}{L} = \dfrac{4\times10\times10^{-3}}{1} = \dfrac{1}{25}$

As, $\dfrac{1}{R^2} < 4\dfrac{C}{L}$

Hence, circuit is Under damped

(iii) for $t>0$, in laplace domain



$L i(0^+) = 1\times3 = 3\ V$

KCL at C,

$\dfrac{V_c}{6.25} + V_c SC + \dfrac{(V_c+3)}{S} = 0$

$V_c\left[\dfrac{1}{6.25} + \dfrac{S}{100} + \dfrac{1}{S}\right] = -\dfrac{3}{S}$

$$V_c\left(\frac{16\cancel{s} + s^2 + 100}{100\,\cancel{s}}\right) = -\frac{3}{\cancel{s}}$$

$$V_c = -\frac{300}{s^2+16s+100} = -\left[\frac{3}{(s+8)^2+6^2}\right] \times \frac{6}{6}$$

$\cancel{\&}$ Taking inverse laplace,

$$V_c(t) = -\frac{1}{2} e^{-8t} \sin 6t \times 100$$

$$\boxed{V_c(t) = -50\, e^{-8t} \sin 6t \text{ Volts.}}$$

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5.(a)
(i)

Cache memory is an extra memory which is used to store the image of some data present in main memory and secondary memory so that it can be accessed faster by CPU when needed, and there will be no need to access the main memory which may take longer time.

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Advantages

→ It makes the CPU works faster as it's access time is much lesser than main and secondary memory and hence CPU utilization is better.

→ It stores program that can be ~~used~~ executed in a short period of time.

(ii) Access time with miss

$$= (\text{Instruction}) \times \left\{ \left(\begin{array}{c}\text{instruction}\\ \text{miss rate}\end{array} \right) [CPI + \text{misspenalty}] + \left(1 - \begin{array}{c}\text{instruction}\\ \text{miss rate}\end{array} \right) [CPI] \right\}$$

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$$+ (\text{Data}) \times \left\{ \begin{array}{c}\text{Data}\\ \text{miss rate}\end{array} \left(CPI + \text{misspenalty} \right) + \left(1 - \begin{array}{c}\text{Data}\\ \text{miss rate}\end{array} \right) CPI \right\}$$

$$= 0.36 \times \left\{ \frac{2}{100} \times (2+40) + \left(1 - \frac{2}{100}\right) \times 2 \right\}$$

$$+ (1 - 0.36) \left\{ \frac{4}{100} \times (2+40) + \left(1 - \frac{4}{100}\right) \times 2 \right\}$$

$= 1.008 + 2.304 = 3.312$ cycles / ~~fast~~

Without a miss

$CPI = 2$ cycles

Hence,

machine will run $(3.312 - 2) = 1.312$ cycles faster with perfect Cache without a miss.

5.(b) For A, $(x, y, z) = (\cancel{\frac{L}{2}}\,\infty, \frac{L}{2}, \infty)$

Taking Reciprocal for miller indices,

$(h.\ k\ l) = (0 \cdot \frac{2}{1}\ \ 0)$ $[\frac{1}{\infty} = 0]$

$\therefore$ for A, multiplying by L

miller indices

$(h k l) = (0\ \ 2\ \ 0)$

For B interceptions

$(x, y, z) = (L, \frac{L}{2}, \frac{L}{2})$

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Taking Reciprocals

$= (\frac{1}{L}, \frac{2}{L}, \frac{2}{L})$

hence, miller indices for B

$(h\ k\ l) = (1\ \ 2\ \ 2)$

5.(c)

$\phi = 50°$,

$\beta = \tan^{-1}\left(\frac{\omega L}{R}\right) = \tan^{-1}\left(\frac{2\pi \times 50 \times 1200 \times 10^{-3}}{362}\right) = 4.96°$

$\theta_p = -45' = -0.75°$ $\qquad \sigma_p = \frac{0.8}{100}$

$\theta_c = 90' = 1.5°$ $\qquad \sigma_c = -\frac{0.2}{100}$

CT Ratio $= \frac{20}{1}$, PT Ratio $= \frac{100}{1}$

Here,

α ?

$\phi = \alpha + \beta + \theta_c + \theta_p$

$50° = \alpha + 4.96 + 1.5 + 0.75 \Rightarrow \alpha = 42.79°$

$P_{True} = \frac{\text{CT Ratio}}{1+\sigma_c} \times \frac{\text{PT Ratio}}{1+\sigma_p} \times \text{Wattmeter Reading} \times \frac{\cos\phi}{\cos\beta \cdot \cos\alpha}$

$= \frac{20}{\left[1 + \left(-\frac{0.2}{100}\right)\right]} \times \frac{100}{\left[1 + \frac{0.8}{100}\right]} \times 350 \times \frac{\cos 50}{\cos 4.96 \times \cos 42.79}$

$\boxed{P_{True} = 611.783 \text{ KW}}$

5(e) (i) For eigen value, forming characteristic equation

$$|C-\lambda I| = 0 \Rightarrow \begin{vmatrix} -\lambda & 0 & 0 & 1 \\ 1 & -\lambda & 0 & 0 \\ 0 & 1 & -\lambda & 0 \\ 0 & 0 & 1 & -\lambda \end{vmatrix} = 0$$

$$-\lambda \begin{vmatrix} -\lambda & 0 & 0 \\ 1 & -\lambda & 0 \\ 0 & 1 & -\lambda \end{vmatrix} - 1 \begin{vmatrix} 1 & -\lambda & 0 \\ 0 & 1 & -\lambda \\ 0 & 0 & 1 \end{vmatrix} = 0$$

$$-\lambda\left[-\lambda(\lambda^2)\right] - 1\left[1\right] = 0$$

$$\lambda^4 - 1 = 0$$

$$(\lambda^2-1)(\lambda^2+1) = 0 \Rightarrow (\lambda-1)(\lambda+1)(\lambda^2+1) = 0$$

$$\boxed{\text{eigenvalues} \Rightarrow 1, -1, i, -i}$$

(ii) By Cayley Hamilton theorem

$$C^4 - I = 0 \Rightarrow C^4 = I$$

$$\Rightarrow C^{-1}C^4 = C^{-1}I \Rightarrow C^3 = C^{-1}$$

$$[C^{2}]^2 = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix}$$

$$[C]^3 = [C]^{-1} = [C]^2[C] = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

$$C^{-1} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \end{bmatrix}$$

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(iv) $$[C^2]^{-1} = [C^{-1}]^2 = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix}$$

(iii)

$$|C| = 1 \times -1 \times 1 \times -1 = -1$$

$$|C+I| = \begin{bmatrix} 1 & 0 & 0 & 1 \\ 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 \end{bmatrix} = 1 \times \begin{vmatrix} 1 & 0 & 0 \\ 1 & 1 & 0 \\ 0 & 1 & 1 \end{vmatrix} - 1 \begin{vmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{vmatrix}$$

$$= 1 \times 1 - 1 \times 1 = 0$$

$$|C+2I| = \begin{bmatrix} 2 & 0 & 0 & 1 \\ 1 & 2 & 0 & 0 \\ 0 & 1 & 2 & 0 \\ 0 & 0 & 1 & 2 \end{bmatrix} = 2 \times \begin{bmatrix} 2 & 0 & 0 \\ 1 & 2 & 0 \\ 0 & 1 & 2 \end{bmatrix} - 1 \begin{bmatrix} 1 & 2 & 0 \\ 0 & 1 & 2 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= 2 \times [2 \times 2] - 1 \times [1]$$

$$= 7$$

6(a)
(i) Relaxation Oscillators are non sinusoidal oscillators so active component ~~are~~ employed in these oscillator works in non linear region while in case of sinusoidal oscillator active component employed works in linear region and the analysis is done in the frequency domain for sinusoidal oscillators.

In Nonlinear region for relaxation oscillator, it is like charging and discharging of capacitors while in linear region for sinusoidal oscillator it is like tank circuit ~~to~~ ~~Produ~~ to provide sinusoidal output.

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(ii) Here in given oscillator, gain $A = 1 + \frac{R_f}{R_i}$

feed back voltage $V_f = \beta V_o = \frac{Z_2}{Z_1+Z_2} V_o$

$Z_2 \Rightarrow$ Parallel combination of R and C

$Z_1 \rightarrow$ Series combination of R and C

$$\beta = \frac{\frac{R \times \frac{1}{sc}}{R+\frac{1}{sc}}}{\frac{R \times \frac{1}{sc}}{R+\frac{1}{sc}} + R + \frac{1}{sc}} = \frac{\frac{R}{scR+1}}{\frac{R}{scR+1} + R + \frac{1}{sc}} = \frac{scR}{scR + scR + 1 + Rsc[scR+1]}$$

$$\beta = \frac{SCR}{S^2R^2C^2 + 3SCR + 1} = \frac{RC}{SR^2C^2 + 3CR + \frac{1}{S}} = \frac{RC}{j\omega R^2C^2 + 3RC + \frac{1}{j\omega}}$$

for Sustained oscillation, ~~phase of~~ to satisfy Barkhausen Criteria ~~imaginary~~ imaginary part of $[A\beta]$ should be zero

$$\therefore \quad j\omega R^2C^2 - \frac{1}{\omega} = 0 \Rightarrow \omega^2 = \frac{1}{R^2C^2}$$

$$\boxed{\omega = \frac{1}{RC} \Rightarrow f = \frac{1}{2\pi RC}}$$

$$A\beta = \left(1 + \frac{R_f}{R_i}\right) \times \frac{\cancel{RC}}{3\cancel{RC}} = \left(1 + \frac{R_f}{R_i}\right) \times \frac{1}{3}$$

for $A\beta \geq 1$ (for Sustained oscillation)

$$\frac{1}{3}\left(1 + \frac{R_f}{R_i}\right) \geq 1 \Rightarrow \boxed{R_f > 2R_i}$$

necessary Condition on R_f & R_i

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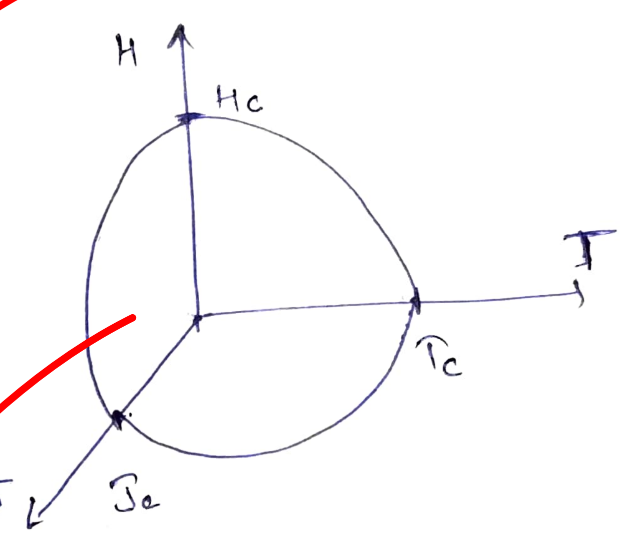
At resonance, phase shift is Zero degree, and by varying frequency below resonance then phase shift becomes positive and vice versa. So, by varying applied frequency phase shift requirement is achieved.

8.(b) (i)

Super Conductivity is defined by two features in a material, when a material posses zero resistivity and perfect diamagnetism then this condition is known as super conductivity and the material is known as super conductor.

Critical temperature, T_c, critical field H_c, and critical current density J_c all are inter related with each other by parabolic function.

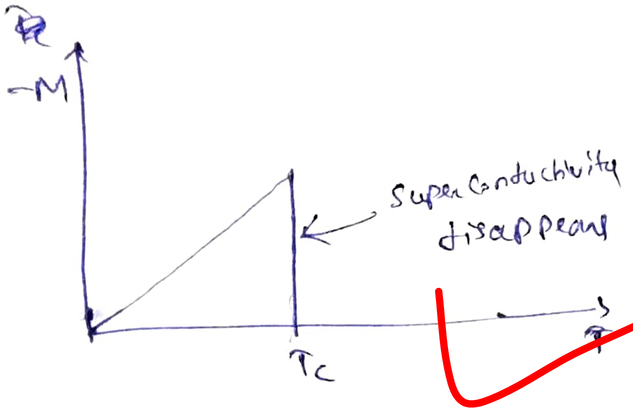
$$H_c = H_0\left[1 - \left(\frac{T}{T_c}\right)^2\right]$$



Type-I Super Conductors ⇒ When the ~~er~~ temperature (T) becomes greater than critical temperature (T_c) then super conductivity destroys abruptly, i.e, there is no mixed state in these super conductors. Eg ⇒ Hg, Zn etc.

Type II Super Conductors ⇒ When there exist a mixed state between super conductivity and normal state then they are known as Type II super conductor. ~~therefore~~ There super conductivity destroys gradually.

Eg ⇒ NbTi, Nb_3Sn etc.



Type-I

Type-II

b) (ii)

In a conductor,

$$\sigma = ne\mu = \frac{ne v_d}{E} \qquad [v_d = \mu E]$$

$\sigma \rightarrow$ conductivity
$\mu \rightarrow$ mobility
$v_d \rightarrow$ drift velocity

$$\frac{1}{1.54 \times 10^{-8}} = \frac{5.8 \times 10^{28} \times 1.6 \times 10^{-19} \times v_d}{1 \times 100}$$

$$\boxed{v_d = 0.6997 \text{ m/s} \simeq 0.7 \text{ m/s}}$$

$$\text{mobility } (\mu) = \frac{v_d}{E} = \frac{0.6997}{100} = 6.997 \times 10^{-3} \text{ m}^2/\text{Vs}$$

$$\boxed{\mu = 69.97 \text{ cm}^2/\text{Vsec.}}$$

As, $v_d = \frac{eE\tau}{m}$ $\qquad \tau \rightarrow$ Relaxation time.

$$0.6997 = \frac{1.6 \times 10^{-19} \times 100 \times \tau}{9.1 \times 10^{-31}}$$

$$\boxed{\tau = 3.98 \times 10^{-14} \text{ sec.}}$$

$$E_F = \frac{1}{2} m v_F^2$$

$$5.9\times10^{-19}\times 1.6 = \frac{1}{2}\times 9.1\times10^{-31}\times V_F^2$$

$$\boxed{V_F = 1390.7\ Km/sec}$$

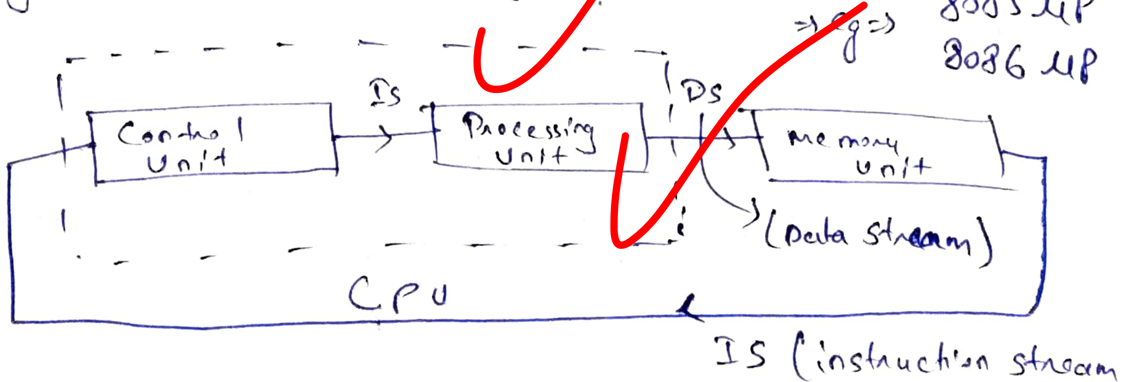
6.(c)
(i)

RISC Architecture	CISC Architecture
→ Supports more Registers	→ ~~less~~ Supports less register
→ less addressing modes	→ Supports ~~less~~ more addressing mod
→ Fixed length instruction	→ Variable length instruction
→ Supports successful pipelining	→ Unsuccessful pipelining
→ Here CPI = 1	→ Here CPI ≠ 1
→ It is a super computer	→ It is General purpose Computer
→ used in Real time applications	→ used in personal applications
→ Smaller instruction set	→ larger instruction set
eg ⇒ Motorola, ARM Processor	→ Intel Processor.

(ii) Flynn's Classification,

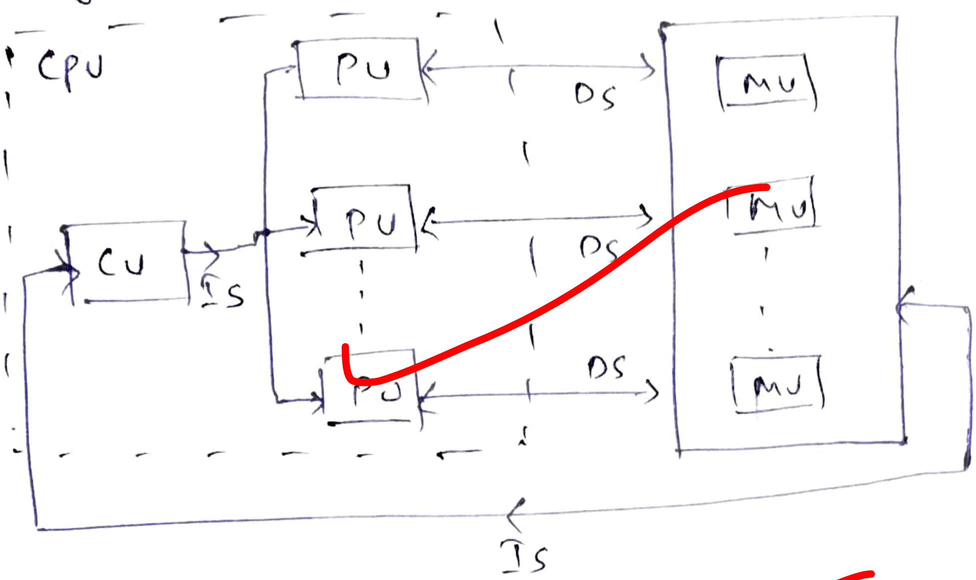
(1) Single ~~Sin~~ instruction Single data Stream

→ eg ⇒ 8085 μP
8086 μP



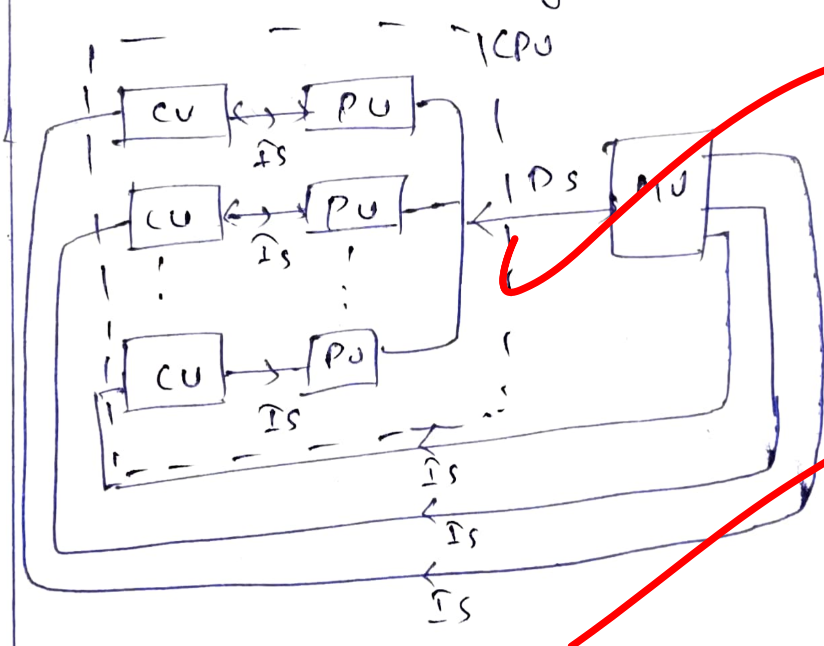
(II) Single instruction multiple data stream

CU → Control unit
PU → Processing unit
MU → memory unit



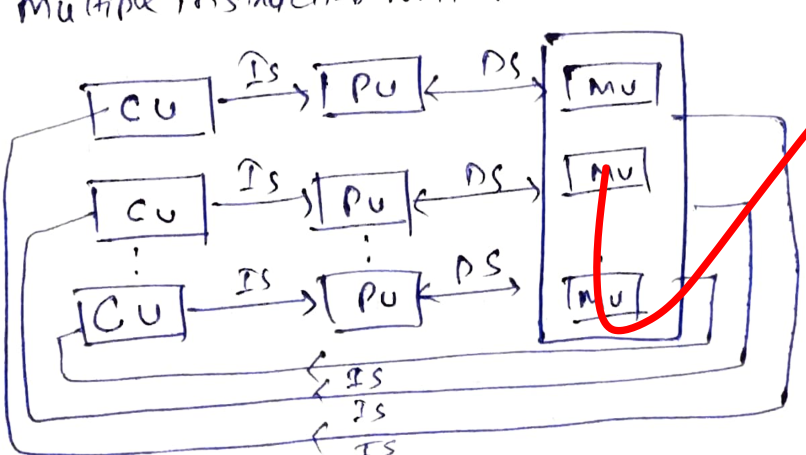
implemented as a array processor system design
eg ⇒ Sataran Processor

(III) Multiple instruction single data stream



eg ⇒ It is not used practically as contains multiprocessor but one is used at a time.

(IV) Multiple instruction multiple data stream



→ implemented as multiprocessor system design.
eg ⇒ Cray Processor
Cyber Processor.

6.(c)
(iii)

Gantt Chart (Time Quantum = 4)

	P_3	P_1	P_2	P_3	P_4	P_5	P_1	P_5

0 1 5 9 12 14 16 20 21 24

$P_3 : 6$

$P_3 : 2$, $P_1 : 5$, $P_2 : 3$, $P_4 : 2$, $P_5 : 7$

$P_3 : 1$, $P_1 : 1$, $P_2 : 3$, $P_4 : 2$, $P_5 : 7$

$P_3 : 1$, $P_1 : 1$, $P_4 : 2$, $P_5 : 7$

$P_4 : 2$, $P_1 : 1$, $P_5 : 7$

$P_1 : 1$, $P_5 : 3$

CT => Completion time

	AT	BT	CT	TAT	WT
P_1	2	5	21	19	14
P_2	4	3	12	8	5
P_3	1	6	14	13	7
P_4	2	2	16	14	12
P_5	3	7	24	21	14

$TAT = CT - AT$

$WT = TAT - BT$

$$\text{Average TAT} = \frac{19 + 8 + 13 + 14 + 21}{5}$$

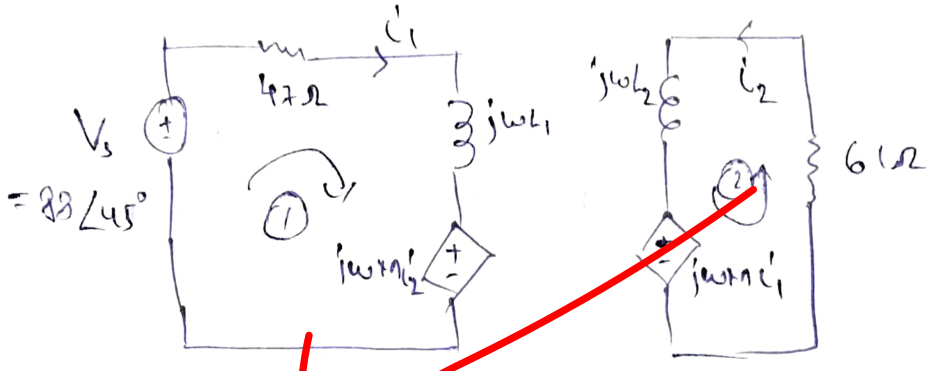
$$\boxed{(TAT)_{Avg.} = 15}$$

$$\text{Average WT} = \frac{14 + 5 + 7 + 12 + 14}{5}$$

$$\boxed{(WT)_{Avg.} = 10.4}$$

8.(a)
(i)

Converting the circuit in phasor domain



$L_1 = 18\,H, \quad L_2 = 27\,H, \quad M = 17\,H, \quad \omega = 6\ rad\,s^{-1}$

Applying KVL in loop ①

$$88\angle 45^\circ = (47 + j\,6\times 18)\,i_1 + j\times 6\times 17\, i_2$$

$$88\angle 45^\circ = (47 + j108)\,i_1 + j102\, i_2 \quad -①$$

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Applying KVL in loop ②

$$(61 + j\,6\times 27)\,i_2 + j6\times 17\, i_1 = 0$$

$$(61 + j162)\,i_2 + j102\, i_1 = 0 \quad -②$$

using ① & ②

$$88\angle 45^\circ = \left[(47 + j108) + j102\left(\frac{-j102}{61+j162}\right)\right] i_1$$

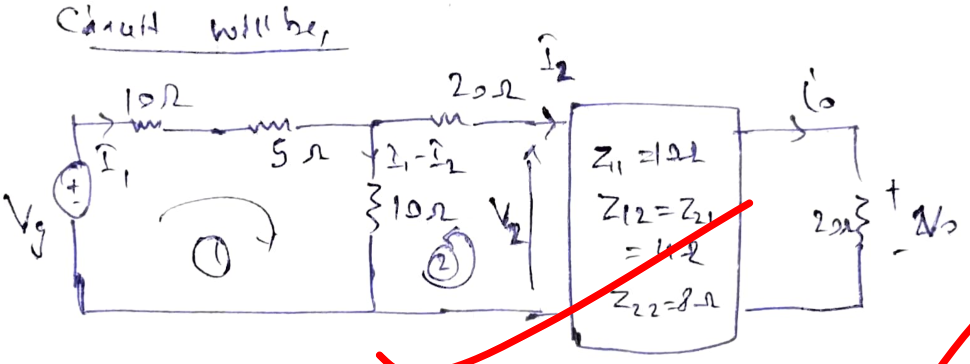
$$\boxed{i_1(t) = 1.028\angle 7.8^\circ\ A = 1.028\cos(6t + 7.8^\circ)\ A}$$

$$i_2 = \frac{-j102}{(61+j162)} \times i_1 = \frac{-j102}{61+j162} \times 1.028\angle 7.8$$

$$\boxed{i_2(t) = 0.6057\angle{-151.57} = 0.6057\cos[6t - 151.57^\circ]\ A}$$

8 (a)
(ii)

Circuit will be,



KVL in loop ①

$V_g = (10+5) I_1 + 10(I_1 - I_2) \Rightarrow V_g = 25 I_1 - 10 I_2$ — ①

By Z parameter

$V_2 = Z_{11} I_2 - i_o Z_{12} \Rightarrow V_2 = 10 I_2 - 4 i_o$ — ②

$V_o = Z_{21} I_2 - i_o Z_{22} \Rightarrow V_o = 4 I_2 - 8 i_o$ — ③

Apply KVL in loop ②

$V_2 = -20 I_2 + 10(I_1 - I_2) = +10 I_1 - 30 I_2$ — ④

Using ④ in ②

$+10 I_1 - 30 I_2 = 10 I_2 - 4 i_o \Rightarrow 40 I_2 = 4 i_o + 10 I_1$

$\Rightarrow 10 I_2 = i_o + 2.5 I_1$ — ⑤

Using ⑤ in ③

$V_o = \frac{4}{10}(i_o + 2.5 I_1) - 8 i_o = 0.4 i_o - 8 i_o + I_1$

$\cancel{I_1 = -0.5 V_o - 3.6 i_o}$ $\boxed{I_1 = V_o + 7.6 i_o}$ — ⑥

Using ⑥ & ⑤ in ①

$V_g = 25[V_o + 7.6 i_o] - i_o - 2.5(V_o + 7.6 i_o)$

$\boxed{V_g = 22.5 V_o + 170 i_o}$ — ⑦

Resulting two port matrix is by comparing

$$V_1 = AV_2 + BI_2 \Rightarrow V_g = 22.5 V_o + 170 i_o$$

$$I_1 = CV_2 + DI_2 \Rightarrow I_1 = V_o + 7.6 i_o$$

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 22.5 & 170 \\ 1 & 7.6 \end{bmatrix}$$

2. When $V_g = 10$,

$$10 = 22.5 V_o + 170 i_o \qquad \text{also } V_o = 20 i_o$$

$$10 = (22.5 \times 20 + 170) i_o$$

$$i_o = \frac{1}{62}$$

Power delivered to load $= i_o^2 \times R = \left(\frac{1}{62}\right)^2 \times 20$

~~$P = 5.203$ mW~~

$$\boxed{P = 5.203 \text{ mW}}$$

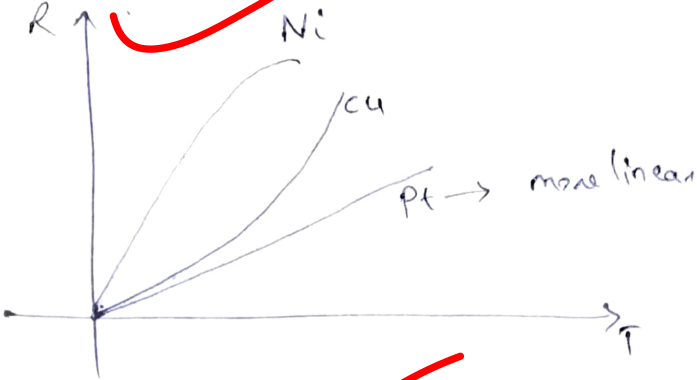
8.(b)
(i) **RTDs** are the components having Positive temperature Coefficient of Resistance,

Eg ⇒ Cu, Ni, Pt.

Here

$$R = R_0 [1 + \alpha \Delta T]$$

α ↳ temperature Coefficient.



While, Thermistors has both Positive and negative temperature coefficient but negative temperature Coefficient thermistors are most practically used in temperature control of CRT's, like electrical heaters, microovens etc.

→ Used in BJT for temperature compensation.

→ It has higher Sensitivity then RTD

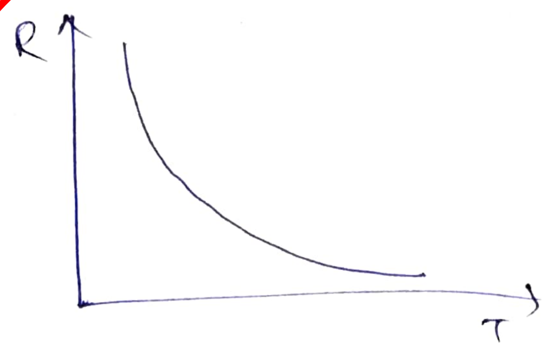
→ RTD are more linear then Thermistors

→ RTDs haven better stability

→ Thermistors are cheaper then RTDs

Now, For Negative temperature Coefficient Thermistor

$$\boxed{R = R_0\, e^{\beta\left[\frac{1}{T} - \frac{1}{T_0}\right]}}$$



β → temperature Coefficient

8(b) (ii)

On some materials when force is applied then there is dynamic voltage is developed across the material. This is known as piezo electric effect and material which show this effect are known as piezoelectric materials,

eg => Quartz crystal, $BaTiO_3$ etc.

For the expression of voltage,

when Pressure ~~force~~ is applied, electric field is produced proportional to applied force.

$$\therefore E \propto P$$

$$\frac{V}{t} \propto P \qquad E = \frac{V}{t}$$

$$\frac{V}{t} = gP \qquad [g \Rightarrow \text{Voltage sensitivity}]$$

$$\boxed{V = gtP}$$

[Here assumption is Pressure is dynamic not static]

in terms of force.

$$\boxed{V = \frac{d}{\varepsilon} \times t \times \frac{F}{A}}$$

$P = \frac{\text{Force}}{\text{Area}}$

and $g = \frac{d}{\varepsilon}$

d = Charge sensitivity

Numerical

$$\text{Stress} = P = \frac{\text{Force}}{\text{Area}} = \frac{5}{5 \times 5 \times 10^{-6}} = 0.2 \times 10^{6}\ N/m^2$$

$$\text{modulus of elasticity} = \frac{\text{Stress}}{\text{Strain}}$$

$$12\times10^{6} = \frac{0.2\times10^{6}}{Strain} \Rightarrow \boxed{Strain = 16.67\times10^{-3}}$$

Charge is given by

$$Q = dF = 150\times10^{-12}\times 5$$

$$\boxed{Q = 0.75\,nC = 750\,pC}$$

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Capacitance,

$$C = \frac{\varepsilon A}{d} = \frac{12.5\times10^{-9}\times(5\times5\times10^{-6})}{1.25\times10^{-3}}$$

$$\boxed{C = 250\,pF}$$

Q.C(i) Widemann Franz Law states that for conductor metal, its ratio of thermal conductivity to electrical conductivity is directly proportional to temperature,

i.e., $\frac{K}{\sigma} \propto T \Rightarrow \boxed{\frac{K}{\sigma} = LT}$

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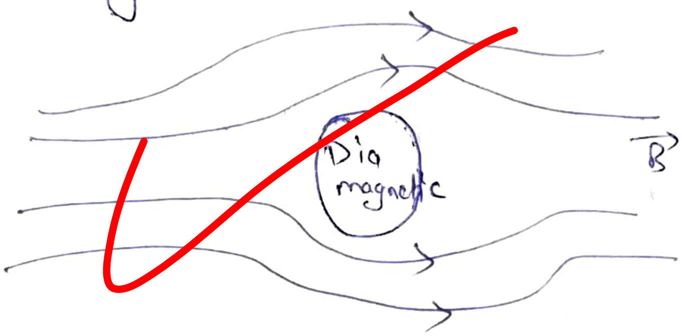
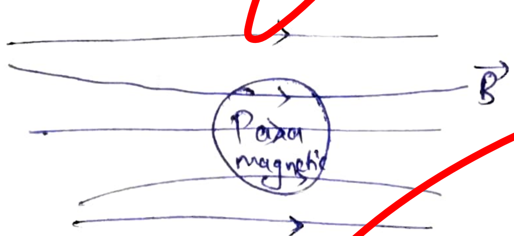
"L" is Lorentz no. $\boxed{L = 2.44\times10^{-8}\ W\Omega/K^{2}}$

Thermal conductivity of stainless steel is reduced as it contains additive which can be thought as impurities which will increase thermal scattering due to difference in materials. Hence plain carbon steel have greater thermal conductivity than for stainless steel.

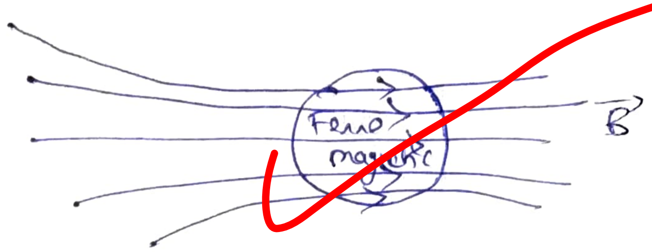
8(c)(ii) ~~Diag~~ Diamagnetism => When a material doesnot allow external magnetic field lines to pass through it then it is said to be diamagnetic material. It is due to full filled orbitals which contain both electron of opposite spin making the total magnetic moment zero.



Paramagnetism => Some of the orbitals are half empty then due to only electron which is having a particular direction of electron spin making a magnetic moment non zero & will give rise to paramagnetism. But consider the whole material due to randomness of magnetic moment it doesnot show spontaneous magnetization. Hence ~~uses~~ it allow some of ~~at~~ magnetic lines to pass throw it



Ferromagnetism => When there are many half filled orbitals hence there will be large magnetic moment which ~~gi~~ may give rise to spontaneous magnetization and it will attract ~~~~ magnetic field line to pass through it very strongly. This is Ferromagnetism



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8.(c)(iii)

$\rho = 8.90\ g/cm^3 \qquad Z = 58.71\ g/mol$

$\text{no. of atoms}/cm^3 = \frac{8.90}{58.71} \times 6.022 \times 10^{23} = 9.129 \times 10^{22}$

$\text{no. of atoms}/m^3 = 9.129 \times 10^{28}$

$1 \text{ bohr magneton} = \frac{eh}{4\pi m} = \frac{1.6 \times 10^{-19} \times 6.626 \times 10^{-34}}{4\pi \times 9.1 \times 10^{-31}}$

$= 9.27 \times 10^{-24}\ Am^2$

6

$\mu_m\ p_m = 0.6 \times 9.27 \times 10^{-24} = 5.562 \times 10^{-24}\ Am^2$

$M = \text{no. of atoms}/m^3 \times p_m = 9.129 \times 10^{28} \times 5.562 \times 10^{-24}$

$= 5.0775 \times 10^5\ A/m$

$\boxed{\text{Saturation magnetization} = M = 5.0775 \times 10^5\ A/m}$

$\text{Saturation flux density} = B = \mu_0 M = 4\pi \times 10^{-7} \times 5.0775 \times 10^5$

$\boxed{B = 0.638\ T}$