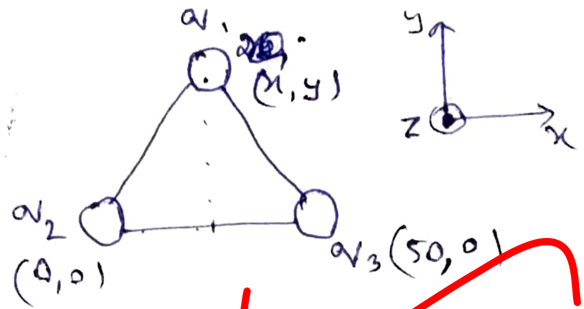
1.(a)



F_{13} = By Coulombic force of attraction

$$\vec{F}_{13} = \frac{1}{4\pi\varepsilon_0} \times \frac{q_1 q_3}{|R_{13}|^3} \vec{R_{13}}$$

Coordinates of q_1 $x = 25$ cm

$y = \sqrt{50^2 - 25^2} = 25\sqrt{3}$ cm

$\vec{R}_{13} = (50-25)\hat{a}_x + (0 - 25\sqrt{3})\hat{a}_y$

$\vec{R}_{13} = 25\hat{a}_x - 25\sqrt{3}\hat{a}_y$

$$\vec{F}_{13} = \frac{9\times10^9 \times 10^{-6} \times 0.5\times10^{-6}}{\left(\sqrt{25^2+(25\sqrt{3})^2}\right)^3 \times 10^{-6}} \times \left[25\hat{a}_x - 25\sqrt{3}\hat{a}_y\right]\times10^{-2}$$

~~$\vec{F}_{13} = 22.5\hat{a}_x - 38.97\hat{a}_y$~~ N $F_{13} = 9\times10^{-3}\hat{a}_x - 0.0156\hat{a}_y$ N

$$F_{23} = \frac{9\times10^9 \times (-10^{-6}) \times (0.5\times10^{-6})}{(50)^3 \times10^{-6} \times 100} \times 50\,\hat{a}_x \quad [R_{12} = 50\hat{a}_x]$$

$F_{23} = -0.018\,\hat{a}_x$ N

Net force $F = F_{13} + F_{23}$

$$F = 9\times10^{-3}\,\hat{a}_x \quad 0.0156\,\hat{a}_y - 0.018\,\hat{a}_x$$

$$\boxed{F = -\left[9\times10^{-3}\,\hat{a}_x + 15.6\times10^{-3}\,\hat{a}_y\right] N}$$

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$$\boxed{|F| = 18\times10^{-3}\ N}$$

1.(b) The Conventional Communication was done using analog signals, but they suffer from many losses like distortion, interference etc.

So, in modern Communication System digital Signals are used because it is having Several advantages over analog Communication System.

Advantages:

→ The effect of noise, distortion and interference is much less ~~as~~ ~~th~~ in digital System as they are less affected.

→ Digital Circuits are more reliable

→ Digital Circuit are easy to design and cheaper then analog Circuit

→ The Hardware implementation in digital Circuits is more flexible then analog Circuits.

→ Probability of error is reduced in digital circuit by using error detecting and error correcting codes.

→ Occurence of cross talks is very rare in digital communication.

→ The capacity of channel is effectively used by digital signals

→ Digital signal can be saved and retrieved more conveniently than analog signals.

→ Configuring process is easier for digital signals.

1.(c) Computer architecture ~~is~~ means that how the components in computer are present. Like the components CPU, IO and memory and ~~th~~ data how it is present which will define the term computer architecture.

There are different classification based on different parameters.

(I) Based on how program and data is store there are two types of computer ~~archi~~ architecture.

(a) Von neumann architecture: In this user program and data is stored in same memory. This can be used for multiple tasks on same platform.

(b) Harvard architecture In the the user Program is stored in Code memory Rom and data is Present in Volatile memory RAM. used for Specific task only.

Based on instruction set there is two type of architure.

(i) Complex Instruction set Computer (CISC)

(ii) Reduced Instruction set Computer (RISC)

Properties of Reduced instruction set Computer

(i) It support more Registers

(ii) It Supports less addressing modes

(iii) It Support Successfull pipelining

(iv) CPI =1 [Cycle per instruction]

(v) It supports fixed length instruction

(vi) It is a Super Computer

(vii) It is used in Real time application

(viii) It has expensive Processor

(ix) It has Hardwired Control unit

(x) It Contains Small Instruction Set

(xi) Eg:- Motorola Processor, ARM Processor.

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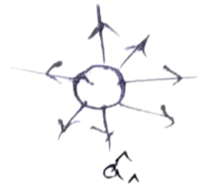
1.(i) Electric field due to a point charge is given by

$$\vec{E} = \frac{1}{4\pi\epsilon_0} \times \frac{Q}{r^2}\,\hat{a}_r$$



$$\vec{D} = \frac{Q}{4\pi r^2}\,\hat{a}_r$$

Taking Divergence,

$$\vec{\nabla}\cdot\vec{D} = \frac{1}{r^2}\cdot\frac{\partial}{\partial r}\left(D_r\, r^2\right)$$

[as only r component is present]

$$= \frac{1}{r^2}\cdot\frac{\partial}{\partial r}\left[\frac{Q}{4\pi \cancel{r^2}}\cdot \cancel{r^2}\right]$$

$$\boxed{\vec{\nabla}\cdot\vec{D} = 0}$$

Now, for line charge,

$$\vec{E} = \frac{\rho_l}{2\pi\epsilon\rho}\,\hat{a}_\rho$$

[$\rho_l \rightarrow$ line charge density]

$$\vec{D} = \frac{\rho_l}{2\pi\rho}\,\hat{a}_\rho$$

Taking Divergence.

$$\vec{\nabla}\cdot\vec{D} = \frac{1}{\rho}\cdot\frac{\partial}{\partial \rho}\left[\rho D_\rho\right]$$

[as only ρ component is present]

$$= \frac{1}{\rho}\,\frac{\partial}{\partial \rho}\left[\frac{\rho_l}{2\pi\cancel{\rho}}\cdot\cancel{\rho}\right]$$

Hence,
$$\boxed{\vec{\nabla}'\cdot\vec{D}' = 0}$$

So, for point charge and unifor line charge, divergence of flux density is zero for both.

1(e) $m(t) = A \sin \omega t$

$$\frac{S}{N_a} = \frac{\text{Power of Signal}}{\text{Power of Noise}}$$

$$\text{Power of Signal} = \frac{A^2}{2}$$

$$\text{Power of Noise} = \frac{\Delta^2}{12} \qquad [\Delta \to \text{Step size}]$$

$$\Delta = \frac{V_H - V_L}{\text{no. of levels}} = \frac{A-(-A)}{2^n} = \frac{2A}{2^n}$$

$$\frac{S}{N_Q} = \frac{A^2}{2} \times \frac{12 \times (2^n)^2}{(2A)^2} = \frac{A^2 \times 2^{2n} \times 12}{2 \times 4A^2}$$

$$= 1.5 \times 2^{2n}$$

In dB

$$\frac{S}{N_a} = 10\log(1.5 \cdot 2^{2n}) = 10\log(2^{2n}) + 10\log 1.5$$

$$= 6.02n + 1.7609$$

$$\boxed{\frac{S}{N_Q} \simeq (6n + 1.8)\ dB}$$

3(a) $E = -8xy\,\hat{a}_x - 4x^2\,\hat{a}_y + \hat{a}_z$ V/m

$$V_{AB} = -\int_B^A E\cdot dl$$

(i) $y = 3x^2 + z$, $z = x + 4$

$\therefore y = 3x^2 + x + 4$

$$\cancel{V_{AB} = -\left\{\int_1^2 -8x(3x^2+x+4)\,dx + \int_8^{18} -4x^2\,dy + \int_5^6 dz\right\}}$$

$$\cancel{= -\left\{-\frac{470}{3} - 4x^2 \times 10 + 1\right]}$$

$$\cancel{V_{AB} = \frac{467}{3} + 40x^2}$$

$dy = 6x\,dx + dz \Rightarrow dy = (6x+1)\,dx$

$dz = dx$

$$V_{AB} = -\left\{\int_1^2 -8x(3x^2+x+4)\,dx - \int_1^2 4x^2\cdot(6x+1)\cdot dx + \int_1^2 dz\right\}$$

$$= -\left[-\frac{470}{3} + \left(-\frac{298}{3}\right) + 1\right] = 255 \text{ Volt.}$$

$W = Q \cdot V_{AB}$

$= 6 \times 255$

$\Rightarrow \boxed{W = 1530\ J}$

(ii) At $B = (1, 8, 5)$ | at $A(2, 18, 6)$

$x = 1$ | $x = 2$

$y = 8x$ | $y = 9x$

$z = 5x$ | $z = 3x$

Using coordinate of x and y

$(1, 8)$ & $(2, 18)$

we get equation

$(y - 8) = \frac{18 - 8}{2 - 1}(x - 1) \Rightarrow 10x - y = 2$

$\Rightarrow y = 10x - 2$

$dy = 10\,dx$

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Now,

$$V_{AB} = -\left\{\int_1^2 -8x(10x-2) \cdot dx + \int_1^2 -4x^2 \cdot 10\,dx + \int_5^6 dz\right\}$$

$$V_{AB} = -\left[-\frac{488}{3} - \frac{280}{3} + 1\right] = 255 \text{ Volts.}$$

$\boxed{W = V_{AB} \times Q = 255 \times 6 = 1530\,J}$

Hence, work done remain same and it's independent of path selected.

3(b)

$$V = 2x^2y + 20z - \frac{4}{x^2+y^2}$$

$$\vec{E} = -\nabla . V$$

$$= -\left[\frac{\partial}{\partial x}V\,\hat{a}_x + \frac{\partial}{\partial y}V\,\hat{a}_y + \frac{\partial}{\partial z}V.\hat{a}_z\right]$$

$$= -\frac{\partial}{\partial x}\left(2x^2y + 20z - \frac{4}{x^2+y^2}\right)\hat{a}_x - \frac{\partial}{\partial y}\left(2x^2y + 20z - \frac{4}{x^2+y^2}\right)\hat{a}_y$$

$$-\frac{\partial}{\partial z}\left(2x^2 + 20z - \frac{4}{x^2+y^2}\right)\hat{a}_z$$

$$-2x^2\hat{a}_y$$

$$= -4xy + \left(\frac{-4\times 2x}{(x^2+y^2)^2}\right)\hat{a}_x + \left(\frac{-4\times 2y}{(x^2+y^2)^2}\right)\hat{a}_y - 20\hat{a}_z$$

$$= -4\times 6\times(-2.5) + \left(\frac{-4\times 2\times 6}{[6^2+(-2.5)^2]^2}\right)\hat{a}_x + \frac{-4\times 2\times(-2.5)}{(6^2+(-2.5)^2)^2}\hat{a}_y - 20\hat{a}_z$$

$$-2\times 6^2\times\hat{a}_y$$

$$\boxed{\vec{E} = 59.973\,\hat{a}_x - 71.989\,\hat{a}_y - 20\hat{a}_z} \text{ V/m}$$

$$\vec{D} = \varepsilon\vec{E}$$

$\vec{D} = \varepsilon_0 E$ (Assuming air as medium)

$$\vec{D} = 8.852\times 10^{-12}\left[59.973\,\hat{a}_x - 71.989\,\hat{a}_y - 20\hat{a}_z\right]$$

$$\boxed{\vec{D} = (0.531\,\hat{a}_x - 0.637\,\hat{a}_y - 0.177\,\hat{a}_z)\ \text{nC/m}^2}$$

Using Gauss divergence theorem,

$$\vec{\nabla}\cdot\vec{D} = \rho_v$$

$$\rho_v = \frac{\partial}{\partial x}D_x + \frac{\partial}{\partial y}D_y + \frac{\partial}{\partial z}D_z$$

$$\rho_v = \varepsilon_0\left[\frac{\partial}{\partial x}\left(-4xy - \frac{8x}{(x^2+y^2)^2}\right) + \frac{\partial}{\partial y}\left(-2x^2 - \frac{8y}{(x^2+y^2)^2}\right) + \frac{\partial}{\partial z}(-10)\right]$$

$$\rho_v = \varepsilon_0\left[-4y - \left(\frac{8(x^2+y^2)^2 - 8x \times 2(x^2+y^2)2x}{(x^2+y^2)^4}\right) - \left(\frac{8(x^2+y^2)^2 - 8y \times 2(x^2+y^2) \times 2y}{(x^2+y^2)^4}\right)\right]$$

$$\rho_v = \varepsilon_0\left[-4y - \left(\frac{8(x^2+y^2)^2 - 32x^2(x^2+y^2)}{(x^2+y^2)^4}\right) - \left(\frac{8(x^2+y^2)^2 - 32y^2(x^2+y^2)}{(x^2+y^2)^4}\right)\right]$$

$$= \varepsilon_0\left[-4\times 2.5 - \left(\frac{8\times(6^2+2.5^2)^2 - 32\times 6^2(6^2+2.5^2)}{(6^2+2.5^2)^4}\right) - \left(\frac{8\times(6^2+2.5^2) - 32\times 2.5^2(6^2+2.5^2)}{(6^2+2.5^2)^4}\right)\right]$$

$$= \varepsilon_0\left[10.0108 - 2.5458\times 10^{-3}\right]$$

$$\approx 10\,\varepsilon_0 = 10\times 8.854\times 10^{-12}\ C/m^3$$

$$\boxed{\rho_v = 88.54\ pC/m^3}$$

8(c)

$$\frac{S}{N} = \frac{\text{Preceived } (P_R)}{\text{Noise power}}$$

Noise power $= N_0 \times f = 2 \times 10^{-12} \times 10^4$

$$\frac{S}{N} = 5 \times 10^7 P_R \quad \text{--- (1)}$$

Channel attenuation 80dB

$P_T \Rightarrow$ Power transmitted

i.e., $10 \log\left(\frac{P_T}{P_R}\right) = 80 \Rightarrow P_T = 10^8 P_R$ --- (2)

(i) For DSBAM

$SNR = \frac{S}{N} = 50\,dB \Rightarrow 10\log\left(\frac{S}{N}\right) = 50$

$\Rightarrow \frac{S}{N} = 10^5$

Using (1)

$10^5 = 5 \times 10^7 P_R$

Using (2)

$$P_T = \frac{10^8 \times 10^5}{5 \times 10^7}$$

Power transmitted $\boxed{P_T = 200\,kW}$

$BW = 2 \times$ message signal $BW = 2 \times 10\,KHz$

$\boxed{BW = 20\,KHz}$

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(ii) Similarly for SSBAB

P_T remains same $\boxed{P_T = 200\,kW}$

$\boxed{BW = \text{message signal } BW = 10\,KHz}$

3(c) for Conventional AM, with $\mu = 0.8$

$$\eta = \frac{\mu^2}{2+\mu^2} = \frac{0.8^2}{0.8^2+2} = 0.242$$

$$10 \log\left(\frac{S}{N}\right) = \eta \times \cancel{\frac{5\times10^7 \times P_T}{10^8}} = 50\,dB \Rightarrow \frac{S}{N} = 10^5$$

$$10^5 = \eta \times \frac{5\times10^7\, P_T}{10^8}$$

$$10^5 = 0.242 \times \frac{P_T}{2}$$

$$\boxed{P_T = 826.44\ KW}$$

$$Bw = 2\times10\ KHz$$

$$\boxed{BW = 20\ KHz}$$

5(a)

from 2,

$$F^{-1}[(1+j\omega)\,X(\omega)] = A e^{-2t}\,u(t)$$

Taking fourier transform

$$(1+j\omega)\,X(\omega) = \frac{A}{2+j\omega}$$

$$X(\omega) = \frac{A}{(2+j\omega)} \times \frac{1}{(1+j\omega)} = A\left[\frac{1}{1+j\omega} - \frac{1}{2+j\omega}\right]$$

Taking inverse fourier transform

$$x(t) = A\left[e^{-t} - e^{-2t}\right] u(t)$$

Using Parseval theorem of energy

$$E = \frac{1}{2\pi}\int_{-\infty}^{\infty} |X(\omega)|^2\, d\omega = \frac{24\pi}{2\pi} = 12 \quad [\text{from } 3]$$

$$E = \int_{-\infty}^{\infty} x(t)^2 \cdot dt = \int_{-\infty}^{\infty} A^2\left[e^{-2t} - e^{-4t}\right] u(t) \cdot dt$$

$$= A^2 \int_0^{\infty}\left[e^{-2t} - e^{-4t}\right] dt$$

$$= A^2\left[\frac{e^{-2t}}{-2} + \frac{e^{-4t}}{4}\right]_0^{\infty} = A^2\left[\frac{1}{2} - \frac{1}{4}\right] = \frac{A^2}{4}$$

$$\therefore \frac{A^2}{4} = 12 \Rightarrow A = \pm 4\sqrt{3}$$

from 1, $x(t)$ is Real and negative, So, $A = -4\sqrt{3}$

$$\therefore \boxed{x(t) = -4\sqrt{3}\left[e^{-t} - e^{-2t}\right] u(t)}$$

5(b)

In moving coil meter,

$$T = NIBA = K\theta \quad -①$$

Now, $I = \frac{V}{R} = \frac{100 \times 10^{-3}}{20} = 5\,mA$

Now, using ①

$$100 \times 5 \times 10^{-3} \times B \times (30 \times 25) \times 10^{-6} = 0.375 \times 10^{-6} \times 120$$

$$B \times 3.75 \times 10^{-4} = 0.375 \times 10^{-6} \times 120$$

$$\boxed{B = 0.12\ Tesla} \longrightarrow \text{flux density in air gap,}$$

Now, $R_{coil} = 0.3 \times R_m = 0.3 \times 20 = 6\,\Omega$

$$R_{coil} = \frac{\rho l}{A}$$

$l = N \times$ Perimeter of coil

$$= 100 \times 2 \times [30 + 25] \times 10^{-3} = 11\,m$$

$$6 = \frac{1.7 \times 10^{-8} \times 11}{A} \Rightarrow A = 3.11667 \times 10^{-8}\,m^2$$

$$A = \frac{\pi D^2}{4} = 3.11667 \times 10^{-8}\,m^2$$

$$\boxed{\begin{aligned} D &= 0.1992\ mm \\ D &\simeq 0.2\ mm \end{aligned}} \longrightarrow \text{diameter of copper wire of coil.}$$

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5(c)

$$P_{input} = \frac{P_{out}}{\eta} = \frac{11.2}{0.88} = 12.7273 \text{ KW}$$

$$P_{input} = \sqrt{3} \times V_L I_L \times \cos\phi$$

$$12.7273 \times 10^3 = \sqrt{3} \times 220 \times 38 \times \cos\phi$$

$$\boxed{\text{Power factor of motor } [\cos\phi] = 0.8789 \text{ lagging}}$$

When power is measured in 3ϕ circuit using two wattmeters then power measured by two wattmeter are,

$$\cancel{w_1 = \frac{P_{in}}{3} \cos(\phi + 30^\circ)} \qquad \cancel{w_2 = \frac{P_{in}}{3} \cos(\phi - 30^\circ)}$$

$\frac{P_{in}}{3}$ ↳ single phase power,

$$W_1 = V_L I_L \cos(\phi + 30^\circ) \qquad W_2 = V_L I_L \cos(\phi - 30^\circ)$$

$$\phi = \cos^{-1}(0.8789) = 28.49^\circ$$

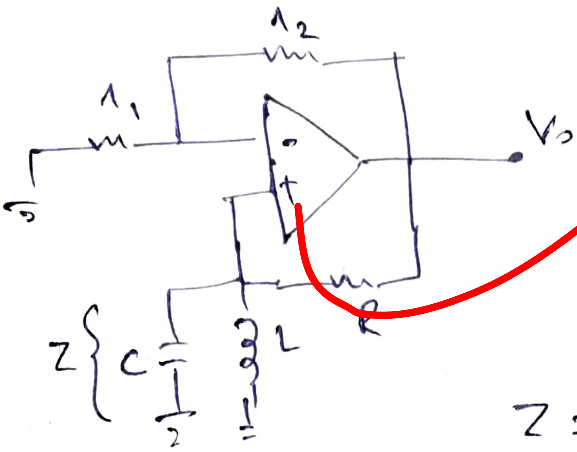
$$W_1 = 220 \times 38 \times \cos(28.49 + 30^\circ) \qquad W_2 = 220 \times 38 \cos(28.49 - 30)$$

$$\boxed{W_1 = 4.37 \text{ KW}} \qquad \boxed{W_2 = 8.357 \text{ KW}}$$

5.(a)

In this,

gain $A = -\dfrac{R_2}{R_1}$



$\beta = \dfrac{Z}{Z+R}$

$$Z = \frac{j\omega L \times \frac{1}{j\omega C}}{j\omega L + \frac{1}{j\omega C}} = \frac{\frac{L}{C}}{j\left[\omega L - \frac{1}{\omega C}\right]}$$

$$Z = -j\frac{L}{C} \times \frac{\omega C}{[\omega^2 LC - 1]} = \frac{-j\omega L}{(\omega^2 LC - 1)}$$

Now,

$$\beta = \frac{\frac{-j\omega L}{(\omega^2 LC - 1)}}{\frac{-j\omega L}{(\omega^2 LC-1)} + R} = \frac{-j\omega L}{(\omega^2 LC - 1)R - j\omega L}$$

$$\beta = \frac{1}{1 - \frac{R(\omega^2 LC - 1)}{j\omega L}}$$

for sustained oscillation, $|A\beta| = 1$

& imaginary part should be zero,

$$\therefore \frac{R(\omega^2 LC - 1)}{\omega L} = 0$$

$\omega^2 LC - 1 = 0 \Rightarrow \boxed{\omega_0 = \dfrac{1}{\sqrt{LC}}}$ ← frequency of oscillation,

$$|A\beta| = \left|\frac{R_2}{R_1} \times 1\right| = 1 \qquad \therefore [\beta = 1]$$

$\therefore \boxed{R_2 = R_1} \rightarrow$ Condition for oscillations to start.

5(e) (i) Hysteresis loss is given by Area of BH Curve,

Area of parallelogram = $b \times h$

$b = 400$ KA/m , $h = 2$ wb/m^2

$$\boxed{\begin{aligned} \text{Hysteresis loss}\,|\,\text{cycle} &= 400 \times 10^3 \times 2 \\ &= 800 \times 10^3 \text{ watts/cycle.} \end{aligned}}$$

(ii) $(BH)_{max}$ Product $= B_{max} \cdot H_{max}$

$= [200 - (-200)] \times 10^3 \times 1$

$= \underline{\underline{400 \times 10^3}}$

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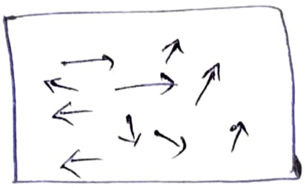
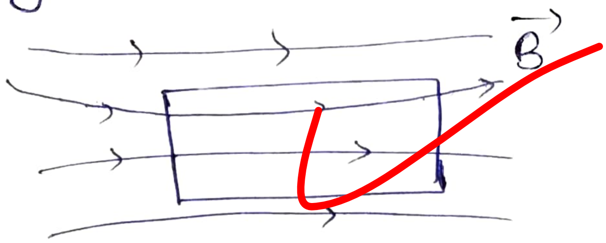
6(a) Magnetic materials are classified on the basis of domains present inside the magnetic materials.

(i) Paramagnetic material



In these type of material the magnetic domain are randomly oriented, so when no external magnetic field is present they shows have net zero magnetic moment hence, they do not show spontaneous magnetization. They have small positive susceptibility and magnetic permeability slightly greater than 1

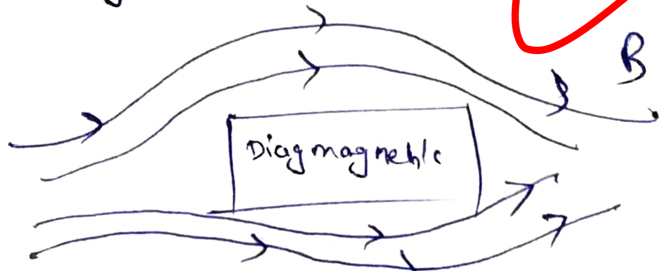


Some of magnetic lines pass through paramagnetic material

Eg => Aluminium, Calcium, Lithium etc.

(ii) Diamagnetic materials

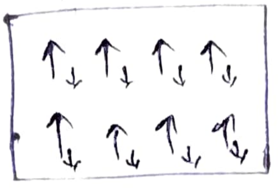
In this no domain is present i.e, net magnetic moment is zero. But when external field is applied there is magnetic moment is opposite direction so magnetic field lines doesnot pass thorught



They have permeability less then one and Succespahability small negative. In perfect diagmagnetic material permeability is zero.

Eg⇒ Bismuth, Copper diagmond etc.

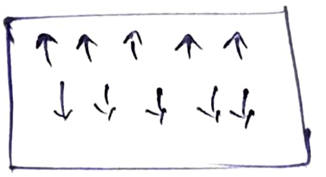
(iii) Ferri magnetic materials:



In these materials domains are present in opposite direction but one domain dominates over the other which is in opposite direction. So they show spontaneous magnetization. They have High permeability. The have high susceptability.

Eg⇒ ~~Fe_3O_8~~ $M_3Fe_5O_{12}$, $MnFe_2O_3$ [M is metal]

(iv) Antiferro magnetic materials



The have antiparallel ~~dip.~~ domains.

Hence no spontaneous magnetization.

They also have high permeability and susceptability.

Eg MnO, MnO_2, FeO etc.

They remain antiferro magnetic till Neel's temperature. above which they become paramagnetic materials.

Ferromagnetic materials

↑ ↑ ↑↑

→ They have net magnetic moment in absence of field. Hence they show spontaneous magnetization

→ They have high permeability [$\mu_r >> 1$]

→ highly positive susceptability

→ Due to thes properties they show ~~ale~~ retentivity and coercivity

→ The highly attract the magnetic field lines to pass through them

↑ Ferromagnetic / Antiferromagnetic / Ferrimagnetic.

→ They remain ferromagnetic till Curie temperature above which they become paramagnetic materials.

Eg → Iron, Cobalt, Nickel etc.

→ Due to retentivity and coercivity they posses some losses when alternating field is applied to them, i.e, Hysteresis and Eddy current losses.

Numerical!

$\mu = 4.61\,\mu_0 = \mu_r\,\mu_0$

$\Rightarrow \mu_r = 4.61$

(i) $\chi_m = \mu_r - 1 = 4.61 - 1 = 3.61$

(ii) $\vec{H}$

$\vec{B} = \mu \vec{H} \Rightarrow 10\,e^{-y}\,\hat{a}_z = 4.61\,\mu_0\,\vec{H}$

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$$\boxed{\vec{H} = \frac{10\,e^{-y}}{4.61\,\mu_0} = 1.7262\times10^{6}\,e^{-y}\,\hat{a}_z \;\; A/m}$$

(iii) $\chi_m = \dfrac{\vec{M}}{\vec{H}} \Rightarrow \vec{M} = 3.61 \times 1.7262\times10^{6}\,e^{-y}\,\hat{a}_z$

$$\boxed{\vec{M} = 6.23\times10^{6}\,e^{-y}\,\hat{a}_z}$$

6.(b) Trigonometric fourier series

$$x(t) = a_0 + \sum_{n=1}^{\infty}\left[a_n \cos n\omega_0 t + b_n \sin n\omega_0 t\right] \quad \text{—(1)}$$

$$a_0 = \frac{1}{T_0}\int_{T_0} x(t)\,.dt$$

$T_0 = \pi$ $\qquad \omega_0 = \dfrac{2\pi}{T_0} = \dfrac{2\pi}{\pi} = 2$

$$a_0 = \frac{1}{\pi}\int_0^{\pi} e^{-t/2}\cdot dt = 0.50428$$

$$\simeq \underline{\underline{0.504}}$$

$$a_n = \frac{2}{T_0}\int_{T_0} x(t)\cdot \cos n\omega_0 t \; dt$$

$$= \frac{2}{\pi}\int_0^{\pi} e^{-t/2}\cdot \cos 2nt \; dt$$

$$= \cancel{\frac{2}{\pi}\left[\frac{e^{-t/2}}{\sqrt{(\frac{1}{2})^2+}}\right.} = \frac{2}{\pi}\left[\frac{e^{-t/2}}{(\frac{1}{2})^2+(2n)^2}\left[-\frac{1}{2}\cdot \cos 2nt + 2n\sin 2nt\right]\right]_0^{\pi}$$

$$= \frac{2}{\pi}\left\{\frac{e^{-\pi/2}}{0.25+4n^2}\left(-0.5\cos 2n\pi + 2n\cdot \sin 2n\pi\right) - \frac{1}{(\frac{1}{2})^2+4n^2}\left(-0.5\times 1 + 0\right)\right]$$

$$a_n = \frac{2}{\pi}\left[\frac{e^{-\pi/2}(-0.5)+0.5}{0.25+4n^2}\right]$$

$$\boxed{a_n = \frac{0.252}{0.25+4n^2}}$$

$$b_n = \frac{2}{T_0}\int_{T_0} x(t)\;\sin n\omega_0 t \; dt$$

$$= \frac{2}{\pi}\int_0^{\pi} e^{-t/2}\cdot \sin 2nt \; dt$$

$$= \frac{2}{\pi}\left[\frac{e^{-t/2}}{0.25+4n^2}\left(-0.5\times \sin 2nt - 2n\cdot\cos 2nt\right)\right]_0^{\pi}$$

$$= \frac{2}{\pi}\left[\frac{e^{-\pi/2}}{0.25+4n^2}(0-2n) - \frac{1}{0.25+4n^2}(0-2n)\right]$$

$$= \frac{2}{\pi}\left[\frac{2n\left(1-e^{-\pi/2}\right)}{0.25+4n^2}\right] \Rightarrow \boxed{\frac{1.008\,n}{0.25+4n^2} = b_n}$$

Now using ①

$$\boxed{x(t) = 0.50428 + \sum_{n=1}^{\infty}\left[\frac{0.2521}{0.25+4n^2}\cos 2nt + \frac{1.008n}{0.25+4n^2}\sin 2nt\right]}$$

(ii) For this,

$$C_n = \frac{1}{2}\left[a_n - j b_n\right] = \frac{1}{2}\left[\frac{0.2521 - j1.008n}{0.25+4n^2}\right]$$

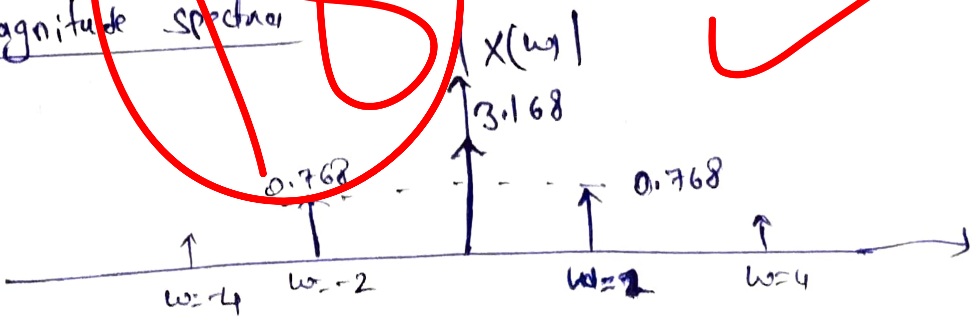
Fourier transform of $x(t)$

$$x(t) \rightleftharpoons X(\omega)$$

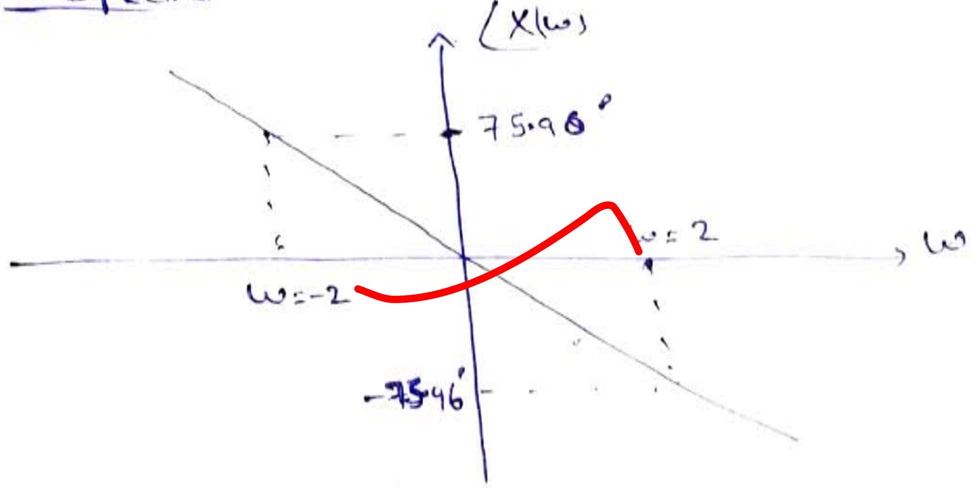
$$x(\omega) = 2\pi \sum_{n=-\infty}^{\infty} C_n\,\delta(\omega - n\omega_0)$$

$$= 2\pi \sum_{n=-\infty}^{\infty} \frac{1}{2}\left[\frac{0.2521 - j1.008n}{0.25+4n^2}\right] \times \delta(\omega - 2n)$$

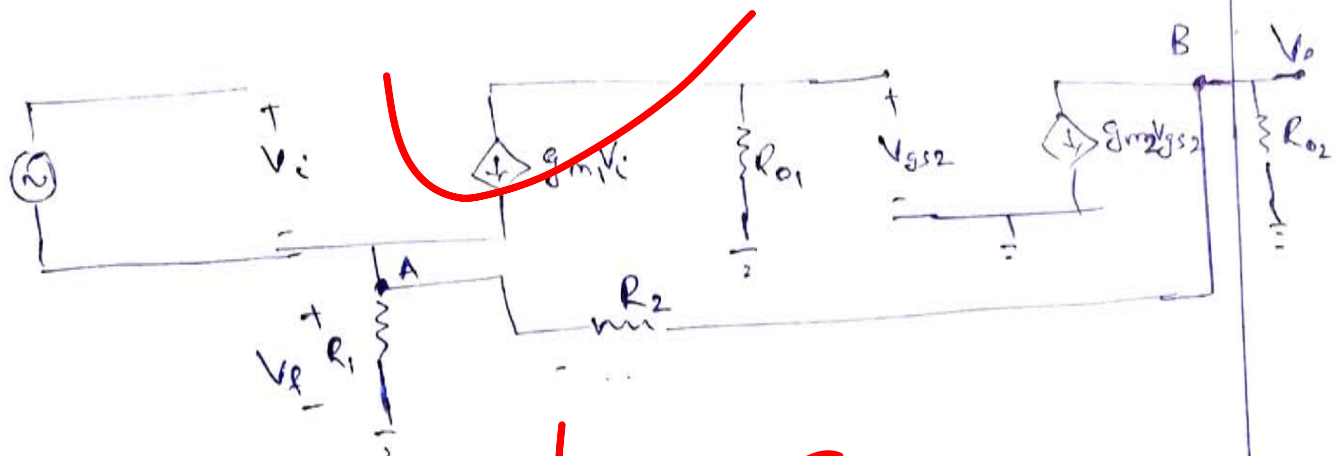
Magnitude spectrum



phase spectra



6(c) Drawing AC equivalent of given circuit



$$\beta = \frac{V_f}{V_o} = V_o \times \frac{R_1}{R_1+R_2} \times \frac{1}{V_o} = \frac{R_1}{R_1+R_2}$$

(i)

$$\boxed{\beta = \frac{R_1}{R_1+R_2}}$$

KCL at node A

$$-g_{m_1}V_i + \frac{V_f}{R_1} + \frac{V_f - V_o}{R_2} = 0 \Rightarrow -g_{m_1}V_i + V_o\left[\frac{\beta}{R_1} + \frac{\beta}{R_2} - \frac{1}{R_2}\right] = 0 \quad \text{—(1)}$$

Now Calculating open loop gain A [i.e, without feed back]

KCL at B,

$$g_{m2} V_{gs2} + \frac{V_o}{R_{o2}} = 0$$

$$\left[\because V_{gs2} = -g_{m1} R_{o1} V_i\right]$$

$$-g_{m1} g_{m2} R_{o1} V_i + \frac{V_o}{R_{o2}} = 0$$

$$\therefore \boxed{A = \frac{V_o}{V_i} = g_{m1} g_{m2} R_{D1} R_{D2}} \quad -(1)$$

Closed loop gain.

$$A_f = \frac{A}{1+A\beta} = \frac{g_{m1} g_{m2} R_{D1} R_{D2}}{1+ g_{m1} g_{m2} R_{D1} R_{D2} \beta}$$

$$A_f \approx \frac{1}{\beta} \quad \left[g_{m1} g_{m2} R_{D1} R_{D2} \beta >> 1\right]$$

(ii) $$A_f = \frac{R_1 + R_2}{R_1} = 1 + \frac{R_2}{R_1} = 10 \quad (2)$$

$$\therefore \boxed{\frac{R_2}{R_1} = 9}$$

So, if $\boxed{\begin{array}{l} R_1 = 1\,K\Omega \\ R_2 = 9K\Omega \end{array}}$

(iii) $$\boxed{A\beta = g_{m1} g_{m2} R_{D1} R_{D2} \times \frac{R_1}{R_1+R_2}} \quad -(3)$$

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(iv) Using (3)

$A\beta = 4 \times 4 \times 10^{-6} \times 10 \times 10 \times 10^{6} \times 0.1$

$\left[\text{Taking } \frac{1}{\beta} = 10\right]$

$A\beta = 160$

$A = 4 \times 4 \times 10 \times 10$ (using (1))

$\boxed{A = 1600 \text{ V/V}}$

$A_f = \frac{A}{1 + A\beta} = \frac{1600}{1+160}$

$\boxed{A_f = 9.938 \approx 10 \text{ V/V}}$

7.(a)(i) *Magnetic anisotropy means that a magnetic material can have different magnetic properties ~~&~~ in different direction, i.e, its magnetic properties are becoming direction dependent.

So, it can be easier to magnetize in one direction and may be harder to magnetize in another direction.

The magnetic anisotropy can be caused in a material due to combination of many factors.

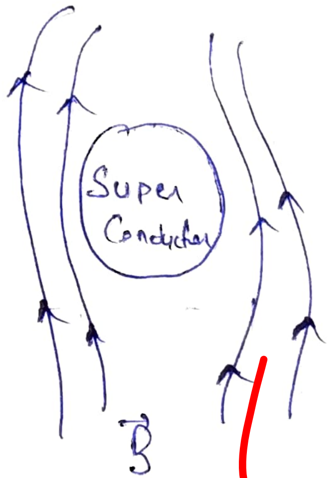
eg ⇒ atomic structure of crystal may introduce preferential directions for magnetization.

⇒ when particles are not perfectly spherical, the ~~deg~~ demagnetizing field will not be equal for all directions

⇒ Tension may also alter the magnetic behaviour leading to magnetic anisotropy

For most magnetically anisotropic materials, there are two easiest directions to magnetizing the material which are 180° rotation apart. These are known as easy axis. It is basically favorable direction for spontaneous magnetization.

7.(a)(ii) In Super Conductor, they show perfect diamagnetism. So, it repels all the magnetic field lines to go out of the Super Conductor material. This is Known as Meisneer's effect.



⇒ Inside the Super Conductor there is no magnetic field lines passing through i.e, it is showing Perfect diagmagnetism,

⇒ $B = 0$ (in side Super Conductor)

$B = \mu_0 (H + M) = 0 \Rightarrow H = -M$

$\Rightarrow \chi = \frac{M}{H} = -1$

$\chi = \mu_r - 1 = -1$

$\mu_r = -1 + 1 = 0$

$\boxed{\mu_r = 0}$ → This is condution for Perfect diagmagnetism,

i.e, meisneer effect in Super Conductor.

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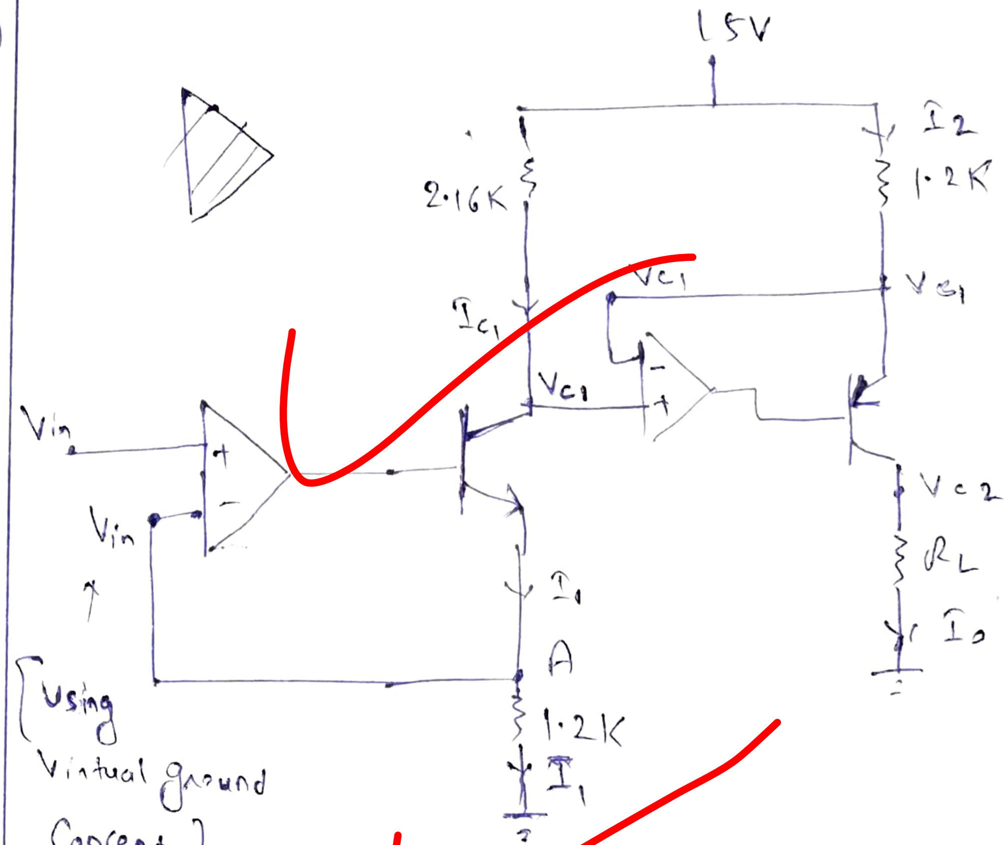
7(b)(i)



[Using Virtual ground Concept]

$V_A = 5V$, $\quad I_1 = \frac{5}{1.2} = 4.1667\,mA$

$I_{C_1} \simeq I_1 = 4.1667\,mA$

$V_{C_1} = 15 - 2.16 = 5.9999 \simeq 6V$

$V_{E_1} = V_A = 5V$, $\quad V_{CE_1} = 6 - 5 = 1$

$I_2 = \frac{15 - V_{C_1}}{1.2} = 7.5\,mA$

$\boxed{I_2 \simeq I_o = 7.5\,mA}$

Now for max R_L, $V_{CE_2\,sat} = 0.3 \Rightarrow V_{EC} = -0.3$

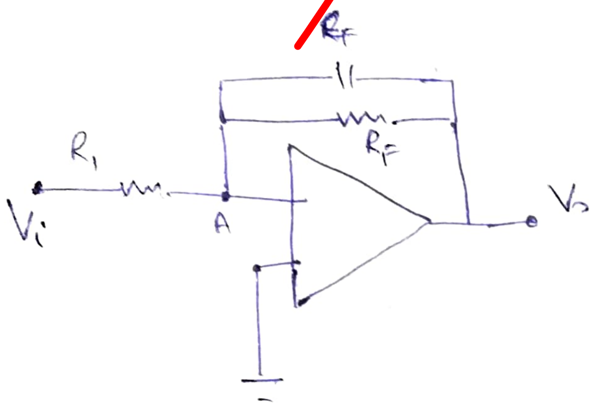
$V_{C_1} - V_{C_2} = -0.3 \Rightarrow V_{C_2} = 6 + 0.3 = \cancel{5.7V}$

$= 6.3V$

$$R_{Lmax} = \frac{V_{c2}}{I_o} = \frac{\cancel{5.7}\ 6.3}{7.5}\ K\Omega$$

$$\boxed{R_{Lmax} = 840\ \Omega}$$

7(b) (ii)



~~KCL at A~~ $[V_A = 0]$

$\downarrow$

By Virtual ground Concept

KCL at A

$$\frac{0-V_i}{R_1} + \frac{0-V_o}{R_F} + (0-V_o)\, sC_F = 0$$

$$-\frac{V_i}{R_1} = V_o\left[\frac{1}{R_F} + sC_F\right] \Rightarrow \frac{V_o}{V_i} = -\frac{R_F}{R_1} \times \frac{1}{(1+sR_FC_F)} \quad \text{— (1)}$$

True integration will take place, when

$$\boxed{|sR_FC_F| >> 1}$$

$$\cancel{\omega = \frac{1}{\sqrt{R_FC_F}}} \qquad \omega \geq \frac{1}{R_FC_F} = \frac{1}{1.4\times10^{6}\times10\times10^{-9}}$$

$$f \geq \frac{\omega}{2\pi} = \frac{71.428}{2\pi} = 11.37\ Hz$$

$$\boxed{f \geq 11.37\ Hz}$$

DC gain

$$\left|\frac{V_o}{V_i}\right| = \frac{R_F}{R_1}\frac{1}{\sqrt{1+\omega^2R_F^2C_F^2}} = \frac{1.4\times10^6}{100\times10^3}\times\frac{1}{\sqrt{1+1^2}}$$

$$\boxed{\left|\frac{V_o}{V_i}\right| = 9.899 \simeq 9.9}$$

When $V_i = 7\sin\omega t$ $\quad [\omega = 2\pi\times10\times10^3]$

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Using (1)

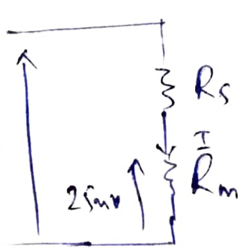
$$\left|\frac{V_o}{V_i}\right| = \left|\frac{1.4\times10^6}{100\times10^3}\times\frac{1}{\sqrt{1+(2\pi\times10\times10^3\times1.4\times10^6\times1\times10^{-9})^2}}\right|$$

$$\left|\frac{V_o}{V_i}\right| = 0.0159$$

$$V_o = 0.0159\times7$$

$$\boxed{\text{Peak value of output voltage} = 0.1114 \text{ Volts.}}$$

7.(c)(i) Series multiplier Resistance, (R_s)



$$I = \frac{25\,mV}{R_m} = \frac{25\times10^{-3}}{25} = 1\,mA$$

$$10 = I(R_s+R_m)$$

$$10 = 1\,mA\,(R_s+25)$$

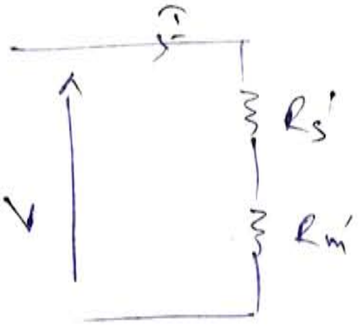
$$\Rightarrow \boxed{R_s = 9975\,\Omega}$$

Now due to 10°C rise in temperature,

$$R_s' = [1+\alpha_1 \Delta T] \times R_s = 9975[1+15\times10^{-5}\times 10]$$

$$= 9989.9625\,\Omega$$

$$R_m' = [1+\alpha_2 \Delta T] R_m = (1+0.004\times 10)\,25 = 26\,\Omega$$



$$\Rightarrow V = I(R_s' + R_m')$$

$$= 1\times10^{-3}[9989.9625 + 26]$$

$$V = 10.0159 \text{ Volt} \leftarrow \text{measured}$$

$$\%\,\text{error} = \frac{V_{measured} - V_{True}}{V_{True}} \times 100$$

$$= \frac{10.0159 - 10}{10} \times 100$$

$$\boxed{\%\,\text{error} = 0.159625\,\% \simeq 0.16\,\%}$$

7(c)(ii) $$\text{kWh consumed} = \frac{230\times4\times1.0}{1000}\times 6 = 5.52\ \text{kWh}$$

$$\text{meter Constant } K = \frac{\text{Revolution}}{\text{kWh Consumed}} = \frac{2208}{5.52}$$

$$\boxed{K = 400\ \text{revolutions/kWh}}$$

When no. of revolution = 1472

$$\text{Kwh Consumed} = \frac{\text{Revolutions}}{K} = \frac{1472}{400} = 3.68 \text{ Kwh}$$

$$\text{Kwh Consumed} = \frac{V I \times \text{Power factor} \times \text{time}}{1000}$$

$$3.68 = \frac{230 \times 5 \times \text{Power factor} \times 4}{1000}$$

$$\boxed{\text{Power factor} = 0.8}$$

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