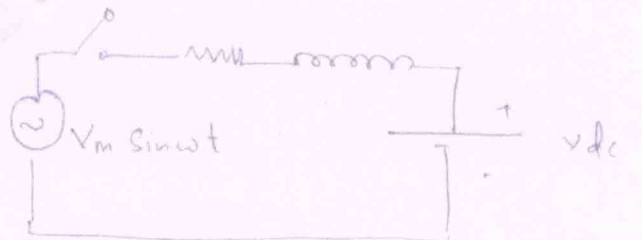
Q1



(a) STEADY STATE CURRENT

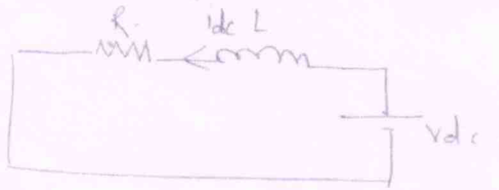
By Superposition, considering only AC Source

At steady state,

$$i_{ac} = \frac{V_m \sin(\omega t - \phi)}{\sqrt{\omega^2 L^2 + R^2}}$$

where $\phi = \tan^{-1}\left(\frac{\omega L}{R}\right)$ 1 mark

Considering only DC Source,



At steady state, inductor acts as short circuit for DC

$$i_{dc} = \frac{+V_{dc}}{R}$$ 1 mark

Net current at steady state

$$i = i_{ac} - i_{dc} = \boxed{\frac{V_m \sin(\omega t - \phi)}{\sqrt{\omega^2 L^2 + R^2}} - \frac{V_{dc}}{R}}$$ 1 mark

(b) for $t > 0$,

$$i(t) = \frac{V_m \sin(\omega t - \phi)}{\sqrt{\omega^2 L^2 + R^2}} - \frac{V_{dc}}{R} + ke^{-t/\tau} \quad (\tau = L/R).$$

1 mark

at $t = 0$, $i = 0$

$$0 = \frac{V_m \sin(-\phi)}{\sqrt{\omega^2 L^2 + R^2}} - \frac{V_{dc}}{R} + k$$

$$k = \frac{V_m}{\sqrt{R^2 + \omega^2 L^2}} \sin\phi + \frac{V_{dc}}{R} \quad \boxed{1 \text{ mark}}$$

$$\boxed{i(t) = \frac{V_m}{\sqrt{R^2 + \omega^2 L^2}} \sin(\omega t - \phi) - \frac{V_{dc}}{R} + \left[\frac{V_m}{\sqrt{R^2 + \omega^2 L^2}} + \frac{V_{dc}}{R}\right] e^{-Rt/L}}$$

Q2.

$$\overline{I}_{in} = \frac{\overline{V}_o}{4} + \cancel{\frac{\overline{V}_o}{4j}} - \cancel{\frac{\overline{V}_o}{4j}}$$

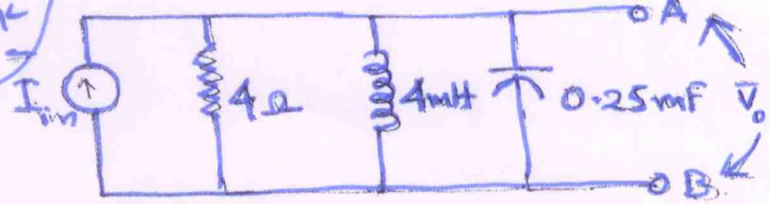
1 mark

$4mH = 4 \times 10^{-3} \times 1000\,\Omega = 4\,\Omega$

$0{\cdot}2mF = \dfrac{1}{1000 \times 0{\cdot}25 \times 10^{-3}} = 4\,\Omega$

$$= \frac{\overline{V}_o}{4}$$

2 mark



$$\overline{V}_o = 4\,\overline{I}_{in}$$

$$= \cancel{4}\cdot 2\angle 45^\circ = 8\angle 45^\circ$$

$$v_o = 8\sqrt{2}\cos(1000t + 45^\circ).$$

$$= 11{\cdot}313\cos(1000t + 45^\circ).$$

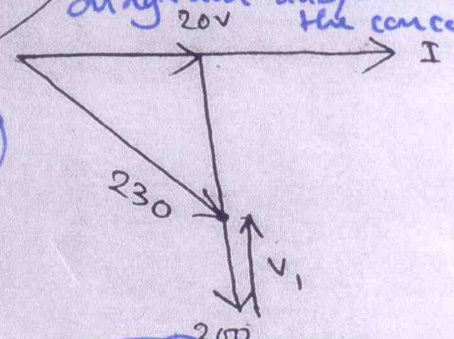
$$Z_{th} = 4 + j0 = 4\angle 0^\circ.$$

2 mark.

Q3.

Taking the current as the reference phasor, the ~~se~~ phasor diagram of the circuit is ~~##~~ shown in the figure assuming V_1 to be the voltage drop across the inductor.

2 marks for drawing the phasor diagram and/or understanding the concept.



$$\therefore (230)^2 = (200 - V_1)^2 + 20^2$$

$$\text{or, } V_1^2 - 400V_1 - 12500 = 0$$

1 mark

$$\therefore V_1 = 429.12,\ -29.12.$$

Negative of V_1 means it is lagging I by an angle 90^0 which is not possible for an inductor, hence this negative value is discarded.

2 marks for taking the decision of +ve/-ve

$$\therefore V_1 = 429.12\,V$$

$$\therefore I = \frac{429.12}{100} = 4.29\,A.$$

If no reasoning is provided why the +ve value is considered deduct 1 mark

Q4. Time period of p is 5ms, therfore $f = 200\,Hz$

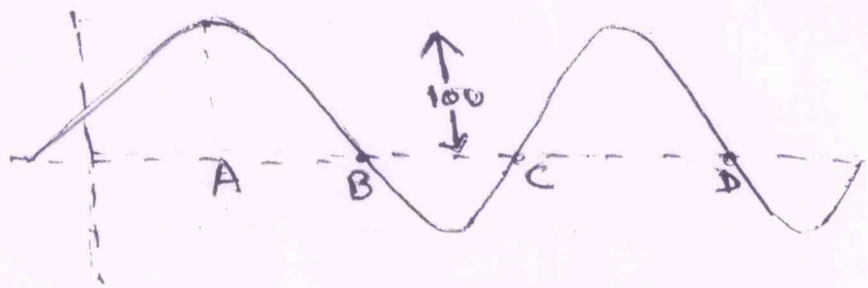
Frequency of the source is therefore $\frac{200}{2}\,Hz = 100\,Hz$.

1 mark.

Let the equation of the instantaneous power is:

$$p = X\sin\omega t + y \text{ ------ (1)}$$

$$\omega = 2\pi f = 2\times\pi\, 200 = 1256.637$$



$AD = AB + BC + CD = 5ms$

or, $2AB + BC = 5ms$

or, $2AB = (5 - 1.666)ms$ or, $AB = 1.667\,ms$

Considering (1), P_{max} will occur at $\omega t = \pi/2$ or $t = 1.25\,ms$

$\therefore 100 = x + y$ --- (2)

$p = 0$ will be at $t = (1.25 + 1.667)ms = 2.917\,ms$

$\therefore 0 = X\sin(1256.637 \times 2.917 \times 10^{-3}) + y$

or, $0 = -0.5x + y$ --- (3)

Solving (2) and (3), $X = 66.67$, $y = 33.33$

$\therefore$ The average value of the waveform = power = 33.33 watt.

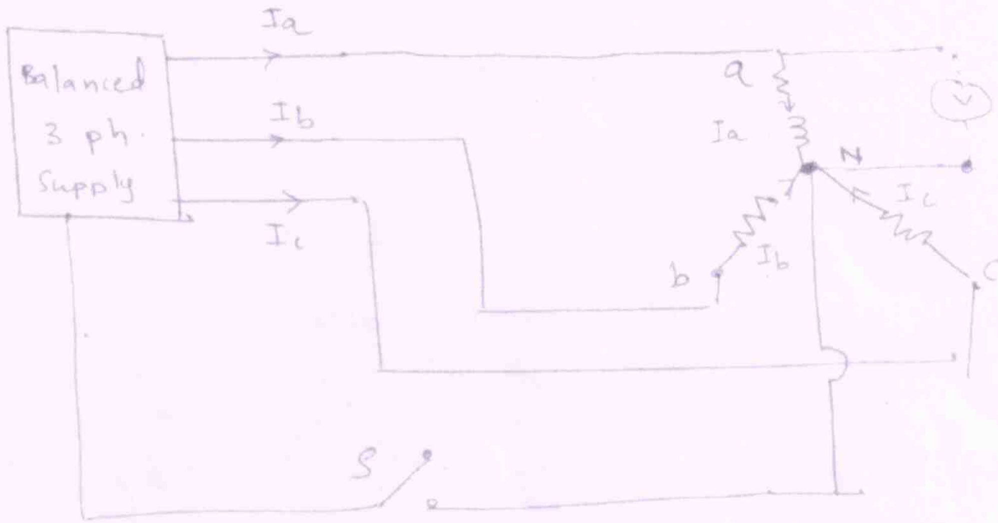
4 marks

Now $\phi = 1.667 \times \frac{360}{10} = 59.97 \simeq 60^\circ$

$VI\cos\phi = 33.33 \Rightarrow VI = \frac{33.33}{0.5}$

Reactive power = $VI\sin\phi = 60.66\sin 60^\circ = 57.27\,VAR$

(Q.5)



(1) S is closed $\Rightarrow$ Load nuetral is at same potential as supply nuetral.

Balanced voltages appear across load

$$V_{an} = \frac{400}{\sqrt{3}} = 230.9\ V.$$

$$\boxed{V_{an} = 230.9 \angle 0^{\circ}, \quad V_{Bn} = 230.9 \angle -120 \quad \& \quad V_{cn} = 230.9 \angle 120}$$

1 mark

$$I_N = I_a + I_b + I_c$$

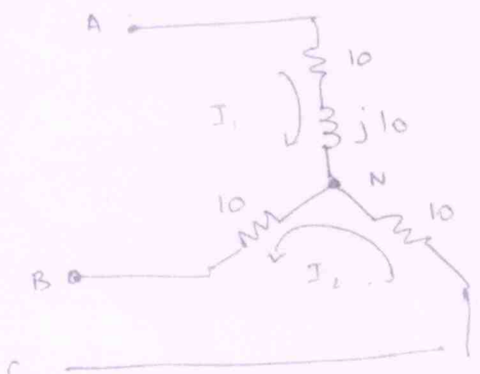
$$= \frac{V_{an}}{10+j10} + \frac{V_{BN}}{10} + \frac{V_{CN}}{10}$$

$$\boxed{I_N = 16.33 \angle -135}$$ $\leftarrow$ 1 mark

5) 2. (2) 'S' is open

⇒ Load and supply nuetrals are not connected

⇒ Load phase - nuetral voltages are NOT balanced



$V_{AB} = \bar{I}_1 (10 + j10) + (I_1 + \bar{I}_2) 10 = 400 \angle 0$

$V_{CB} = 10 \bar{I}_2 + (\bar{I}_1 + \bar{I}_2) 10 = -400 \angle -120$

Solving,

$$2 I_1 (10 + j10) + 20 \bar{I}_1 + \cancel{20 \bar{I}_2} - \cancel{20 I_2} - 10 I_1 = 800 \angle 0 + 400 \angle -120$$

$$30 I_1 + j I_1 (20) = 800 \angle 0 + 400 \angle -120$$

$$I_1 = \frac{800 \angle 0 + 400 \angle -120}{30 + j20}$$

$$= 19.21 \angle -63.69 \text{ A}$$

2 marks (steps)

and $V_1 = I_1 (10 + j10)$

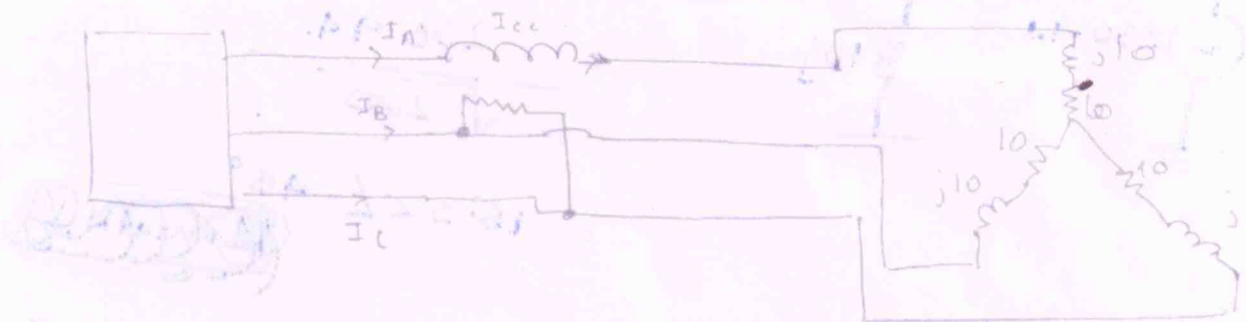
$= \boxed{271.63 \text{ V}}$ ← 1 mark

(Q 6)

The reading of Wattmeter is

$(I_a)(V_{BC})\cos(\theta)$

angle betw I_a & V_{BC}



(2 marks)

$\theta = 90 - \phi$

$W = I_A V_{BC} \cos(90-\phi)$

$= I_A V_{BC} \sin\phi$

$= \sqrt{3}\, V_{ph}\, I_{ph} \sin\phi$

$\tan\phi = \frac{10}{10} = 1$ $\boxed{\text{2 marks}}$

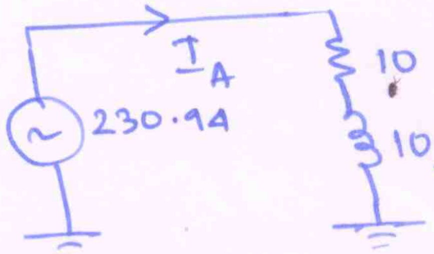
$\sin\phi = 1/\sqrt{2}$

$|I| = \frac{230.94}{\sqrt{10^2+10^2}} = 16.32$ $\boxed{\text{1 mark.}}$

$W = \sqrt{3} \times 230.94 \times 16.32 \times \sin(45)$

$\boxed{= 4615.99}$ ← $\boxed{\text{1 mark.}}$

Per phase equivalent ckt:



$$I_A = \frac{230.94}{\sqrt{10^2+10^2}\angle 45^\circ}$$

$$= \frac{230.94.}{\sqrt{200}}$$

$$= 16.32\angle -45^\circ$$ ~~1 mark~~

$\therefore$ Power $= \sqrt{3} \times 400 \times 16.32 \times \cos 45$ $\boxed{\text{1 mark.}}$

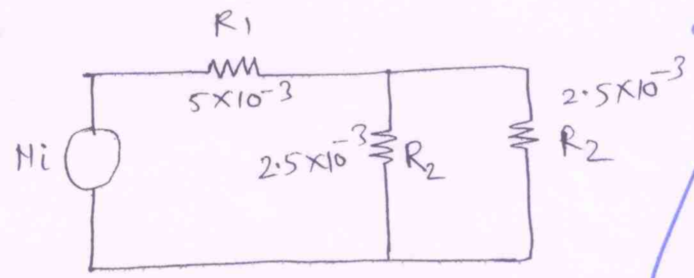
$= 7995.13$ W.

Reactive $= \sqrt{3} \times 400 \times 16.32 \times \sin 45^\circ$ $\boxed{\text{1 mark.}}$

$= 7995.13$ W

$= \sqrt{3} \times 4615.99$

Q7.



$$R_1 = \frac{24\times10^{-2}}{\mu\times12\times10^{-4}}$$

$$\phi = \frac{MMF}{R}$$

1 mark.

$$R_2 = \frac{72\times10^{-2}}{\mu\times6\times10^{-4}}$$

mmf required for R_1 $= \dfrac{24\times10^{-2}}{\mu\times12\times10^{-4}} \times 5\times10^{-3}$ 1 mark

mmf required for R_2 $= \dfrac{72\times10^{-2}}{\mu\times6\times10^{-4}} \times 2.5\times10^{-3}$

$$\frac{24\times5\times10^{-5}}{\mu\times12\times10^{-4}} + \frac{72\times2.5\times10^{-5}}{\mu\times6\times10^{-4}} = 750\times0.5$$

$$\frac{1}{\mu} + \frac{72\times25}{\mu\times600} = 375$$

3 marks

$$\frac{1}{\mu}[1+3] = 375$$

$$\frac{4}{\mu} = 375$$

$$\mu = \frac{4}{375} \cong 0.01066$$

$$\mu_0\mu_r = \frac{4}{375}$$

$$\mu_r = \frac{4}{375\times4\pi\times10^{-7}} = 8488.26$$

For calculation mistake deduct 1 mark.