Q1. $\omega L_m = 50\pi \quad \therefore \; 2\cancel{\pi} f L_m = 50\cancel{\pi}$

$\therefore \; L_m = \frac{50}{100} = 0.5\,H$ 1 mark

$100 = 0.5 \frac{di}{dt}$ or, $di = \frac{100}{0.5} dt$

or $di = 200\,dt$ (3 marks)

$\therefore \; 10 = 200\,dt$ or, $dt = \frac{10}{200}$ s

$= 50$ ms

$\therefore$ The magnetic ckt will saturate at

$(10+50)$ ms or 60 ms 1 mark

1 mark

$\therefore V_1 = V_2 = 0$ after 60 ms 1 mark

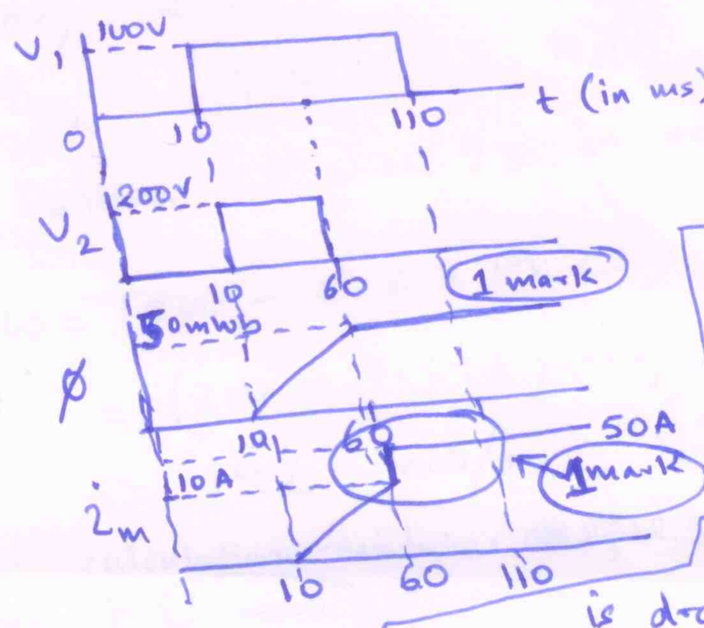
From 10ms to 60ms, $V_2 = 200V$

$V_1 = 100 \frac{d\phi}{dt} \quad \therefore \; d\phi = \frac{100}{100} dt$.

$\therefore \; d\phi$ (at 60 ms) $= \frac{100}{100} \times 50$ mWb. 1 mark

$= 50$ mWb.

$\therefore$



Hence $V_1 = 0$ after 60 ms. (not to be considered for grading.)

If the diagram is drawn without any markings and the nature is correct allot (3 marks)

Q2. $V = 200\,V \quad \therefore E_{b(\text{rated})} = 200 - 50 \times 0.4$

$$= (200 - 20)\,V$$

$$= 180\,V$$

$$\therefore \quad 180 = K_e \phi \omega$$

$$\therefore K_e \phi = \frac{180}{180} = 1. \quad \text{1 mark.}$$

$$\therefore \quad \omega = \frac{V.}{K_e\phi} - \frac{R_a}{(K_e\phi)^2} . T$$

$$= 200 - 0.4T \quad \text{.....(1)} \quad \text{4 marks}$$

From the load.

$$\omega_L = 250 - 3T_L .$$

At steady state, $\omega = \omega_L$ and

$T = T_L$

$$\therefore \quad 200 - 0.4T = 250 - 3T \quad \text{4 marks}$$

or, $2.6T = 50$

or, $T = 19.23$ Nm

Putting $T = 19.23$ in eq (1)

$$\omega = (200 - 0.4 \times 19.23) \text{ rad/s.}$$

$$= (200 - 7.692) \text{ rad/s}$$

$$= 192 \text{ rad/s.} \quad \text{1 mark}$$

For calculation mistakes deduct 1 mark.

Q3.

$$E_{b(\text{rated})} = 250 - 20 \times 0.2$$
$$= 246 = K_e\phi\, 100$$

$\therefore\ K_e\phi = 2.46.$ 1 mark

a) At no load, $I_a = 0$

$\therefore\ 250 = E_b = K_e\phi\,\omega = 2.46\,\omega$ 2 marks

$\therefore$ No load speed, $= \dfrac{250}{2.46}$ rad/sec.

$= 101.62$ rad/sec.

b) As the m/c is developing 1/2 the rated torque, $I_a = 10A$. 2 marks

$\therefore\ E_b = 125 - 10 \times 0.2 = 123 = 2.46\,\omega$

$\therefore\ \omega = 50$ rad/sec. 2 marks

c) Half the rated torque of the m/c

$= 10 \times 2.46$ Nm $= 24.6$ Nm.

$K_e\phi' = \dfrac{2.46}{2} = 1.23$ 3 marks

Now $I_a K_e\phi' = 24.6$ or $I_a = \dfrac{24.6}{1.23}$ 2 marks

$= 20A$

$\therefore\ E_b = 250 - 20 \times 0.2 = 246 = K_e\phi'\omega$

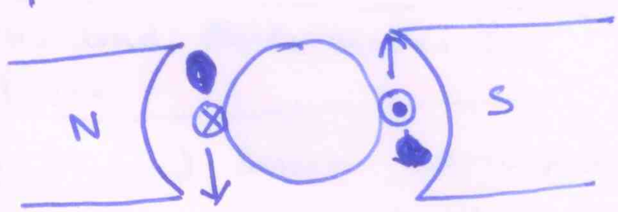
$\therefore\ \omega = \dfrac{246}{1.23} = 200$ rad/second.

3 marks

Q4. i) As the +ve plate of the battery is receiving current, power is absorbed by the source. Hence the d.c.m/c is operating as generator

(1 mark)

no explantion is required.

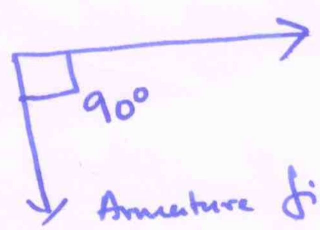


1 mark if the answer is correct

ii) With the current distribution shown, the torque experienced tries to rotate it in anti clockwise direction. As a generator therefore it has to be rotated in opposition to this torque. Hence it rotates in clockwise direction

1 mark if some explanation is given.

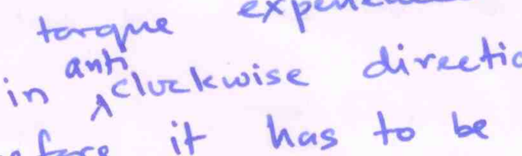
(iii)



0.5 mark for showing correct orientation

0.5 mark for mentioning 90°

(iv)



2 marks for showing any one of the flux lines.

As the magnetic material is operated at the knee point of the B-H, it is almost saturated, hence no further increment in flux is possible, but decrement is possible in the regions marked as R_2

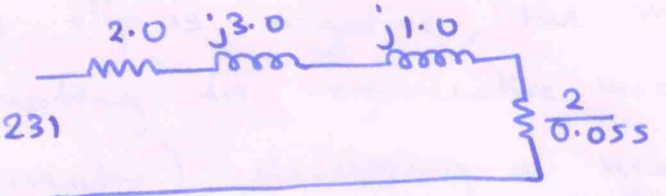
2 marks for the reasoning.

Q5. Star connected m/c.

Per phase voltage $= \frac{400}{\sqrt{3}} V \simeq 231V$

Synchronous speed $= 1000$ rpm $= 104.72$ rad/sec.

$\therefore \quad S_{fl} = \frac{1000-945}{1000} = 0.055$



1 mark

$\therefore$ Rated current $= \frac{231}{\sqrt{38.36^2+16}} A = \frac{231}{38.56} A$

$= 5.99 \simeq 6A$

$\therefore \quad T_{rated} = \frac{3}{104.72} \; 36 \times \frac{2}{0.055} \; Nm = 37.50$ Nm. 1 mark.

$T_L = \frac{1}{4} \times 37.50$ Nm $= 9.37$ Nm. 1 mark

Per phase voltage applied $= \frac{200}{\sqrt{3}} = 115.47$

$T = \frac{3.}{104.72} \cdot \frac{115.47^2}{\left(2+\frac{2}{s}\right)^2+16} \cdot \frac{2}{s} = 9.37$ 3 marks

Solving, $S = 14.31, \; 0.07 \leftarrow$ 2 marks (for accepting the right s)

Therefore, the acceptable value is 0.07.

$\therefore$ Speed of the motor is $(1-0.07) \times 1000$ rpm

$= 930$ rpm 1 mark.

Current drawn by the motor $= \frac{115.47}{\sqrt{\left(2+\frac{2}{0.07}\right)^2+16}}$

$= \frac{115.47}{\sqrt{950.61}} A = 3.74 A$ 1 mark.

Deduct 1 mark for calculation mistake

Deduct 3 marks if 400V is taken instead of 115V.

Q6 Synchronous speed of the m/c 1500 rpm
$= 157.07$ rad/s

The speed of the m/c is 1530 rpm

$$\therefore \quad S = \frac{1500 - 1530}{1500} = -0.02$$ 3 marks.

As slip is negative, the machine is operating in regenerative mode (as a generator) developing a negative torque

Current drawn by the machine in each phase.

$$I = \frac{400}{\sqrt{1^2 + \left(\frac{2}{-0.02}\right)^2}} = \frac{400}{\sqrt{1 + 10{,}000}} = 4\text{A}$$ 2 marks

$$\therefore \text{Torque} = \frac{3}{\omega_s} \cdot I_2^2 \times \frac{2}{-0.02}$$

$$= \frac{3}{157.07} \times 16 * \frac{2}{-0.02} \text{ Nm}$$

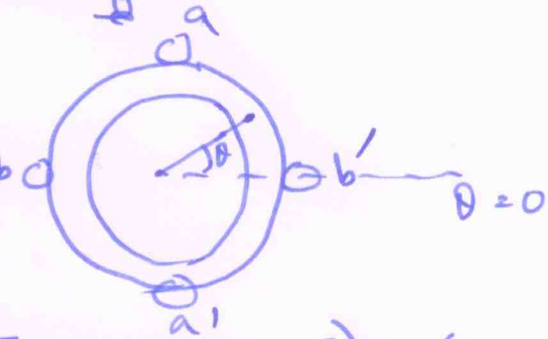
$$= -30.55 \text{ Nm}.$$ 5 marks

Deduct 3 marks if $\frac{400}{\sqrt{3}}$ is taken instead of 400V

If slip is determined to be +ve i.e +0.02 and torque is obtained as +30.55 Nm no credit will be awarded.

Q7. The resultant ~~mag~~ MMF at any angle θ

$$F_{res} = F_a \cos\theta + F_b \cos(\theta + 90^\circ)$$



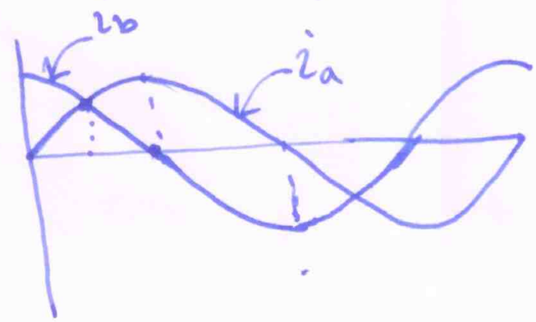
$$= F_m \sin\omega t \cos\theta + F_m \sin(\omega t + 90^\circ)\cos(\theta + 90^\circ)$$

$$= F_m \sin\omega t \cos\theta + F_m \cos\omega t(-\sin\theta)$$

$$= F_m(\sin\omega t \cos\theta - \cos\omega t \sin\theta)$$

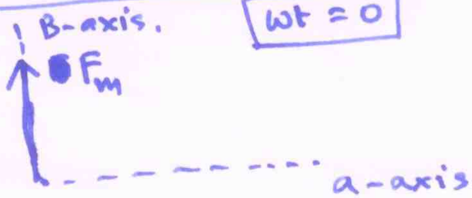
$$= F_m \sin(\omega t - \theta)$$

4 marks



Graphical derivation.

$\boxed{\omega t = 0}$



$\omega t = 45^\circ$

$i_a = I_m/\sqrt{2}$

$i_b = \dfrac{I_m}{\sqrt{2}}$

At $\omega t = 90^\circ$

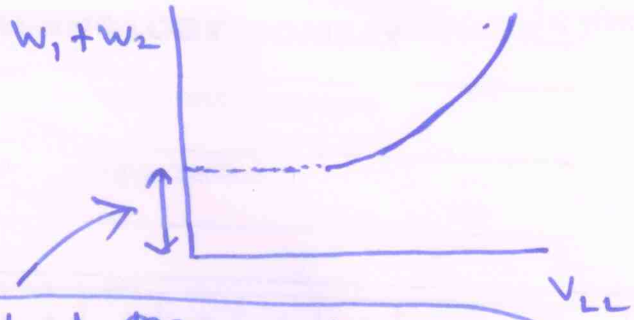
$i_a = I_m \Rightarrow F_m$

$i_b = 0$.

4 marks

i) Magnitude is F_m and it is constant and does not vary with time ii) Rotating clockwisely in a continuous fashion. 2 marks

Q8.



no load ~~losses~~, mechanical losses.

No load losses corresponds to Iron loss + no load mechanical losses.

Iron loss $\propto$ flux $\propto$ Voltage.

Hence $V_{LL} \to 0$, $W_1 + W_2$ will represent the no load mechanical losses.

Note: the speed has almost remained same in the experiment

Give full credit if it is explained without actually showing the extrapolation of the curve

or

if it is mentioned $W_1 + W_2$ as. $V_{LL} \to 0$.

7 marks

No part marking for this question.