



THE UNIVERSITY OF ZAMBIA

DEPARTMENT OF MECHANICAL ENGINEERING

NAME **: TWAAMBO CHOOPA**

COMPUTER NUMBER **: 2018207369**

SCHOOL **: MINES**

|

COURSE **: MEC 3102**

LAB NUMBER **: 01**

LECTURER **: MR. Munkombwe Boyd**

Q1 a) Amperes Law : States that the line integral of magnetic field intensity around a closed path is equal to the sum of the currents flowing through the surface bounded by the path.

b) Lorentz Law : This is the force exerted on a charged particle q moving with a velocity v through an electric field E and magnetic field B .

c) Faradays Laws : i) Whenever a conductor cuts across the magnetic field, an emf is induced in the conductor.

ii) The magnitude of induced emf in a coil is directly proportional to the rate of change of flux linkages.

d) Lenz's Law : The direction of induced current in a circuit is such that it creates its own magnetic field which opposes the original magnetic field.

Q4

$$F_1 = \frac{\mu_0 I_1 I_2 \cdot L}{2\pi d}$$

$$F_2 = \frac{\mu_0 I_2 I_3 \cdot L}{2\pi d}$$

$$F_1 = \frac{(2 \times 10^{-7}) (2 \times 5) (2.5)}{2\pi \times 2}$$

$$F_2 = \frac{(2 \times 10^{-7}) (5 \times 7) (2.5)}{(2\pi) (1)}$$

$$F_1 = \frac{(2 \times 10^{-7}) (5) (2.5)}{2}$$

$$F_2 = (2 \times 10^{-7}) (35) (2.5)$$

$$F_1 = (2 \times 10^{-7}) (5) (2.5)$$

$$F_2 = (2 \times 10^{-7}) (35) (2.5)$$

$$F_1 = (2 \times 10^{-7}) (12.5)$$

$$F_2 = (2 \times 10^{-7}) (87.5)$$

$$F_1 = 2.5 \times 10^{-6} \text{ N}$$

$$F_2 = 1.75 \times 10^{-5} \text{ N}$$

We take F_1 to be negative (goes into page) and F_2 to be positive (leaves page).

F_{net} is the sum of the two forces F_1 and F_2

$$F_{\text{net}} = F_2 - F_1$$

$$F_{\text{net}} = 1.75 \times 10^{-5} \text{ N} - 2.5 \times 10^{-6} \text{ N}$$

$$F_{\text{net}} = \underline{1.5 \times 10^{-5} \text{ N}}$$

Q5 C is located on the place where the direction of magnetic force from the two other in opposite direction. The possible location is at the ~~right~~^{left} of A or the right of B. Let the distance from C to wire A be X

$$F_{CA} = F_{CB}$$

$$\frac{\mu_0 I_a I_a l}{2\pi a_{ca}} = \frac{\mu_0 I_b I_b l}{2\pi a_{cb}}$$

$$= \frac{I_a}{a_{ca}} = \frac{I_b}{a_{cb}}$$

$$= \frac{1}{x} = \frac{2}{2+x}$$

$$= 2x = 2+x$$

$$\underline{x = 2\text{m}}$$

2 m to the left of wire A or 4 m of wire wire B

Q6

Vertical component of Earth's magnetic field $B = 40 \mu\text{T}$

$$\text{Speed } 140 \frac{\text{km}}{\text{hr}} \times \frac{1 \text{ hr}}{60 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ sec}} \times \frac{1000 \text{ m}}{1 \text{ km}} = \frac{140,000}{3600} = \frac{1400}{36} = \frac{350}{9} \text{ m/s}$$

Length = 1.5 m (No need to convert)

$$v = \frac{350}{9} \text{ m/s}, l = 1.5, B = 40 \times 10^{-6}$$

$$\mathcal{E} = Blv$$

$$\mathcal{E} = (40 \times 10^{-6}) \times (1.5) \times \left(\frac{350}{9}\right)$$

$$\mathcal{E} = 2.33 \times 10^{-3} \text{ V}$$

Q9 a) Mean Circumference $l = 600 \text{ mm} = 0.6 \text{ m}$

Number of turns $(N) = 200$

Current through coil $(I) = 4 \text{ A}$

Magnetic field strength $\Rightarrow H = \frac{NI}{l}$

$$H = \frac{NI}{l}$$

$$H = \frac{200 \times 4}{0.6}$$

$$H = \frac{800}{0.6}$$

$$H = 1333.33 \left[\frac{\text{AT}}{\text{m}} \right]$$

b) $B = \mu_0 H$ $\mu_0 = 4\pi \times 10^{-7} \frac{\text{H}}{\text{m}}$ (Permeability of free space)

$$B = (4\pi \times 10^{-7}) \times (1333.33)$$

$$B = 1.675516082 \times 10^{-3}$$

$$B = 1.676 \times 10^{-3} \text{ T}$$

$$B = 1675.51 \mu\text{T}$$

c) Area $= 500 \text{ mm}^2 = 500 \times 10^{-6} \text{ m}^2$

$$\Phi = BA$$

$$\Phi = (1675.51 \times 10^{-6}) \times (500 \times 10^{-6})$$

$$\Phi = \cancel{0.83775504}$$

$$\Phi = 0.8378 \times 10^{-6} \text{ Wb}$$

$$\Phi = 0.8378 \mu\text{Wb}$$

Q11

At saturation $B = \mu_0 H$

Using Ampere's circuital law $\int H \cdot ds = \mu_0 I$ --- (1)

According to ~~B-H~~ ~~curve~~, material is in saturation

$$\text{at } B = 1.28 \text{ mWb}$$

$$H = \frac{1}{\mu_0} \times 1.28 \times 10^{-3}$$

$$H = \frac{1.28 \times 10^{-3}}{4\pi \times 10^{-7}}$$

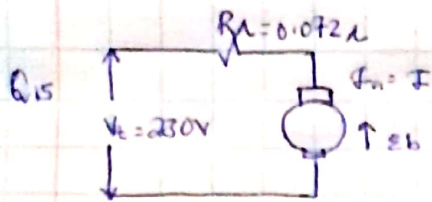
By Ampere's circuital law

$$\int H \cdot ds = \mu_0 I$$

$$\frac{1.28 \times 10^{-3}}{4\pi \times 10^{-7}} \int ds = 4\pi \times 10^{-7} \times I$$

$$\frac{1.28 \times 10^{-3}}{4\pi \times 10^{-7}} \times 200 \times 170 \times 440 \times 10^{-6} = 4\pi \times 10^{-7} I$$

$$\underline{\underline{I = 0.0423 \text{ mA}}}$$



Terminal Voltage, $V_t = 230\text{ V}$
 Armature resistance, $R_a = 0.072\ \Omega$

a) $I_a = I_f = I = 100\text{ amps}$
 Speed, $N_1 = 1200\text{ rev/min}$
 $R_a = R_f = 0.072\ \Omega$

DC device motor, $E_b = V_t - I_a(R_a + R_f)$, as field resistance is neglected.

$$E_b = E_{b1} = V_t - I_a R_a$$

$$E_{b1} = 230 - 100(0.072)$$

$$E_{b1} = 222.8\text{ V}$$

$$E_{b1} = \underline{223\text{ V}}$$

Armature torque of DC motor is

$$T_a = \frac{E_b I_a}{\left(\frac{2\pi}{60}\right) N} = \frac{E_b I_a}{\omega_m}$$

$$T_{a1} = \frac{E_{b1} I_{a1}}{\left(\frac{2\pi}{60}\right) N_1}$$

$$T_{a1} = \frac{230 \times 100 \times 60}{(2\pi)(1200)} = \underline{177.54\text{ Nm}}$$

Torque developed by motor is $T_{a1} = 177.54\text{ Nm}$

b) Given $R_a = R_{a2} = 0.072\ \Omega$

$$V_t = 230\text{ V}$$

$$\text{Torque, } T_{a2} = 300\text{ Nm}$$

DC device motor, $T_a \propto I_a^2$, we can write as $\frac{T_{a1}}{T_{a2}} = \frac{I_{a1}^2}{I_{a2}^2}$ - (1)

$$\frac{177.54}{300} = \frac{(100)^2}{I_{a2}^2}$$

$$\sqrt{\frac{I_{a2}^2 \cdot 177.54}{177.54}} = \sqrt{\frac{3000000}{177.54}}$$

$$I_{a2} = 129.990771 \Rightarrow \underline{130\text{ A}}$$

EMF of motor as

$$E_{b2} = V_t - I_{a2} R_{a2}$$

$$= 230 - 130 \times 0.072$$

$$= 220.64\text{ V} \Rightarrow \underline{221\text{ V}}$$

$$\text{As } \frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \times \frac{I_{a1}}{I_{a2}}$$

$$N_2 = \left(\frac{E_{b2}}{E_{b1}} \times \frac{I_{a1}}{I_{a2}} \right) N_1$$

$$N_2 = \left(\frac{221}{223} \times \frac{100}{130} \right) 1200$$

$$N_2 = \underline{914.8\text{ rev/min}}$$

Q18 We have $Z=4$, $P=6$, $f=4000$ Hz, $V_{in} = 150$ V, 10 hp, $s_{lip} = 3\%$ at rated power output
friction and windage loss = 200 W at tested speed.

a) Rotor speed (N_r) $N_s = 120f$

$$s = \frac{N_s - N_r}{N_s} = \frac{120 \times 4000}{6}$$

$$s N_s = N_s - N_r = \frac{48000}{6}$$

$$N_r = N_s - s N_s = 8000 \text{ rpm}$$

$$N_r = (1 - s) N_s$$

$$N_r = (1 - 0.03) \times 8000$$

$$N_r = 0.97 \times 8000$$

$$N_r = \underline{\underline{7760 \text{ rpm}}}$$

b) $f_r = s f_s =$

$$f_r = (0.03) \cdot (4000)$$

$$f_r = \underline{\underline{120 \text{ Hz}}}$$

c) Power crossing air gap

$$P_{out} = 10 \times 746 = 7460 \text{ watt}$$

$$P_{developed \text{ in motor}} = P_{out} + P_{losses (total)}$$

$$= 7460 + 200$$

$$= \underline{\underline{7660 \text{ watt}}}$$

$$P_{developed} = (1 - s) P_{air \text{ gap}}$$

$$P_{air \text{ gap}} = \frac{P_{developed}}{1 - s}$$

$$P_{air \text{ gap}} = \frac{7660}{(1 - 0.03)}$$

$$P_{air \text{ gap}} = \underline{\underline{7896.9 \text{ watt}}}$$

from stator = $P_{air \text{ gap}} - P_{losses} = P_{input}$
 P_{losses} for rotor or stator losses

d) $P_{cu \text{ - rotor}} = s P_{air \text{ gap}}$

$$= 0.03 \cdot (7896.9)$$

$$= \underline{\underline{236.9 \text{ watt}}}$$

e) $T_{out} = \frac{P_{out}}{\omega_r}$

$$= \frac{P_{out}}{\frac{2\pi N_r}{60}}$$

$$= \frac{(10 \times 746)}{\frac{2\pi (7760)}{60}}$$

$$= \frac{7460}{812.6253} = \underline{\underline{9.180 \text{ N.m}}}$$