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

$$F_1 = \frac{\mu_0 I_1 I_2}{2\pi d} . L \qquad F_2 = \frac{\mu_0 I_2 I_3}{2\pi d} . L$$

$$F_1 = \frac{(\cancel{4}^{2}\cancel{\pi}\times 10^{-7})(2\times 5)}{\cancel{2\pi}\times 2}(2.5) \qquad F_2 = \frac{(\cancel{4}^{2}\cancel{\pi}\times 10^{-7})(5\times 7)(2.5)}{(\cancel{2\pi})(1)}$$

$$F_1 = \frac{(2\times 10^{-7})(\cancel{10}^{5})(2.5)}{\cancel{2}} \qquad F_2 = (2\times 10^{-7})(35)(2.5)$$

$$F_1 = (2\times 10^{-7})(5)(2.5) \qquad F_2 = (2\times 10^{-7})(35)(2.5)$$

$$F_1 = (2\times 10^{-7})(12.5) \qquad F_2 = (2\times 10^{-7})(87.5)$$

$$F_1 = \underline{2.5\times 10^{-6}\ N} \qquad F_2 = \underline{1.75\times 10^{-5}\ N}$$

We take F_1 to be negative (goes into Page) and F_2 to be positive (leaves page).
Fnet as the sum of the two forces F_1 and F_2

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

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

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

T

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

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

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

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

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

$$= 2x = 2+x$$

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

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

Q6 Vertical component of earth's magnetic field $B = 40\,\mu T$

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

Length $= 1{\cdot}5\,m$ (No need to convert)

$u = \frac{350}{9}\,m/s$, $l = 1{\cdot}5$, $B = 40 \times 10^{-6}$

$\mathcal{E} = Blu$

$\mathcal{E} = (40 \times 10^{-6}) \times (1{\cdot}5) \times \left(\frac{350}{9}\right)$

$\mathcal{E} = 2{\cdot}33 \times 10^{-3}\,V$

Q9 a) Mean Circumference $l = 600mm = 0.6m$

Number of turns $(N) = 200$

Current through coil $(I) = 4A$

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

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

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

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

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

b) $B = \mu_0 H$ $\qquad \mu_0 = 4\pi \times 10^{-7}$ H/m (permeability of free space)

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

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

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

$$B = 1675.51 \ \mu T$$

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

$$\phi = BA$$

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

$$\phi = \cancel{0.83775804}$$

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

$$\phi = 0.8378 \ \mu Wb$$

Q11

At saturation $B = \mu_0 H$

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

According to B-H curve, material is in saturation

at $B = 1.28$ 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

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

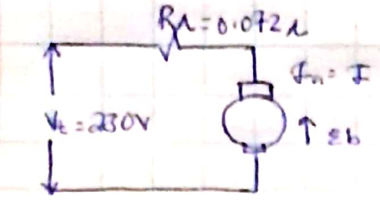
$$\frac{1.28 \times 10^{-3}}{4\pi \times 10^{-7}} \oint ds = 4\pi \times 10^{-7} \times I$$

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

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

Scanned with CamScanner

Q15



Terminal voltage, $V_t = 230\,V$

Armature resistance, $R_a = 0.072\,\Omega$

a) $I_{a_1} = I_a = I = 100$ amps

Speed, $N_1 = 1200$ rev/min

$R_a = R_{a_1} = 0.072\,\Omega$

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

$E_{b_1} = V_t - I_{a_1} R_a$

$E_{b_1} = 230 - 100(0.072)$

$E_{b_1} = 222.8\,V$

$E_{b_1} = \underline{223\,V}$

Armature torque of Dc motor is

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

$$T_{a_1} = \frac{E_{b_1} I_{a_1}}{\left(\frac{2\pi}{60}\right) N_1}$$

$$T_{a_1} = \frac{230 \times 100 \times 60}{(2)(\pi)(1200)} = \underline{177.54\,\text{nm}}$$

Torque developed by motor is $T_{a_1} = 177.54$ nm

b) Given $R_a = R_{a_2} = 0.072\,\Omega$

$V_t = 230V$

Torque, $T_{a_2} = 300$ nm

Dc device motor, $T_a \propto I_a^2$, we can write as $\frac{T_{a_1}}{T_{a_2}} = \frac{I_{a_1}^2}{I_{a_2}^2}$ - (Q)

$$\frac{177.54}{300} = \frac{(100)^2}{I_{a_2}^2}$$

$$\sqrt{\frac{I_{a_2}^2\, \cancel{177.54}}{\cancel{177.54}}} = \sqrt{\frac{3000000}{177.54}}$$

$I_{a_2} = 129.990771 \Rightarrow \underline{130\,A}$

Emf of motor is

$E_{b_2} = V_t - I_{a_2} R_{a_2}$

$= 230 - 130 \times 0.072$

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

As $\frac{N_2}{N_1} = \frac{E_{b_2}}{E_{b_1}} \times \frac{I_{a_1}}{I_{a_2}}$

$$N_2 = \left(\frac{E_{b_2}}{E_{b_1}} \times \frac{I_{a_1}}{I_{a_2}}\right) N_1$$

$$N_2 = \left(\frac{221}{223} \times \frac{100}{300}\right) 1200$$

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

Q18 We have 3-φ, P=6, f=400Hz, V_{line} = 150V, 10hp, slip = 3% at rated power output friction and windage loss = 200W at rated speed.

a) Rotor speed (N_r)

$S = \frac{N_s - N_r}{N_s}$

$SN_s = N_s - N_r$

$N_r = N_s - SN_s$

$N_r = (1-S)N_s$

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

$N_r = 0.97 \times 8000$

$N_r = \underline{7760\ rpm}$

$N_s = \frac{120f}{P}$

$= \frac{120 \times 400}{6}$

$= \frac{48000}{6}$

$= 8000\,rpm$

b) $f_r = Sf_s$

$f_r = (0.03)\cdot(400)$

$f_r = \underline{12Hz}$

c) Power crossing air gap

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

$P_{developed\ in\ motor} = P_{out} + P_{losses\,(f\&w)}$

$= 7460 + 200$

$= \underline{7660\ watt}$

$P_{developed} = (1-S)P_{airgap}$

$P_{airgap} = \frac{P_{developed}}{1-S}$

$P_{airgap} = \frac{7660}{(1-0.03)}$

$P_{airgap} = \underline{7896.9\ watt}$

from stator $= P_{airgap} - \underset{\substack{f\&w + rotor \\ losses \cdot losses}}{P_{losses}} = P_{output}$

d) $P_{cu\text{-}rotor} = S\,P_{airgap}$

$= 0.03\cdot(7896.9)$

$= \underline{236.9\ watt}$

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

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

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

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