1. In the magnetic circuit of Fig. 1, the coil F2 is supplying 500 AT in the direction indicated. Find the AT that the coil F1 must provide to produce a flux of 4 mWb in the airgap. The relative permeability of the core is 4500.

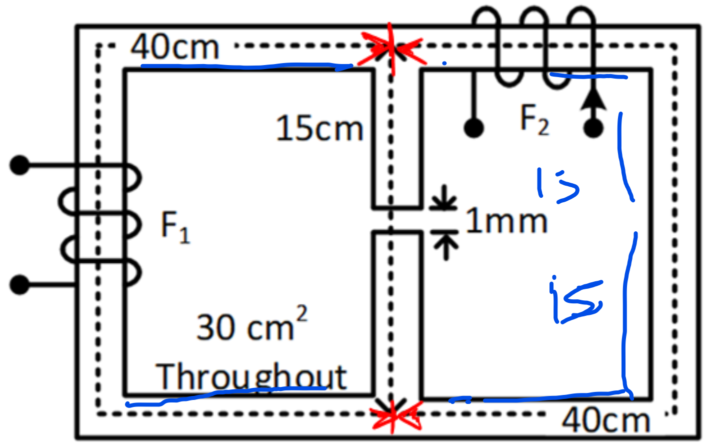

Figure 1

Q1

Reluctance of 40 cm long core $= \frac{l}{\mu_0 \mu_r A} = \frac{40 \times 10^{-2}}{4\pi \times 10^{-7} \times 4500 \times 30 \times 10^{-4}}$

$\therefore R_1 = R_2 = 23.58 \times 10^3$

Reluctance of airgap $= \frac{1 \times 10^{-3}}{4\pi \times 10^{-7} \times 30 \times 10^{-4}} = 265 \times 10^3 = R_4$

Reluctance of central limb $= \frac{(15 - 0.1) \times 10^{-2}}{4\pi \times 10^{-7} \times 4500 \times 30 \times 10^{-4}} = 8.78 \times 10^3 = R_3$

Now, flux in the airgap is 4 mWb

$\therefore$ MMF drop in central limb $= \phi (R_3 + R_4)$

$= 4 \times 10^{-3} (8.78 + 265) \times 10^3$

$= 1095.12$ AT

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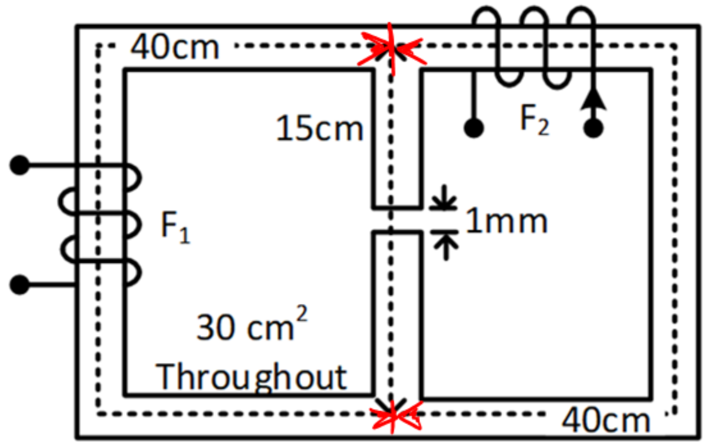
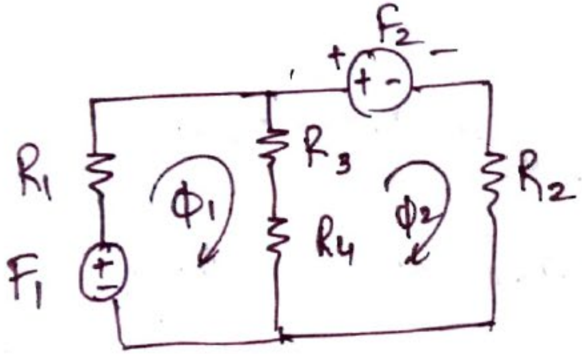


Figure 1



→ Need to find $\underline{\underline{F_1}}$, $\{F_2$ is known$\}$.

$$F_1 - \Phi_1 R_1 - (\Phi_1 - \Phi_2)(R_3 + R_4) = 0 \quad \cdots \quad (1)$$

and

$$0 - (\Phi_2 - \Phi_1)(R_3 + R_4) - F_2 - \Phi_2 R_2 = 0 \quad \cdots \quad (2)$$

$$\Phi_1(R_1 + R_3 + R_4) - \Phi_2(R_3 + R_4) = F_1$$

$$-\Phi_1(R_3 + R_4) + \Phi_2(R_2 + R_3 + R_4) = -F_2$$

solve to get Φ_1, Φ_2, and F_1.

$\Phi_1 = 28.98$ mWb, $\Phi_2 = 25$ mWb, $F_1 = 1778$ AT

2. For the magnetic circuit shown in Fig. 2, the points of magnetization curve are as follows:

H (AT/m)	200	400	500	600	800	1000	1400
B (T)	0.46	0.87	0.98	1.08	1.23	1.33	1.48

Calculate the exciting current required to create a flux of 0.25 mWb in the airgap. What is the flux in the central limb?

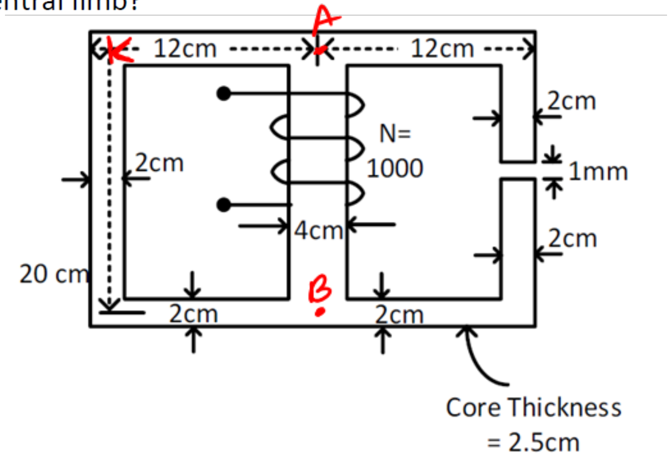
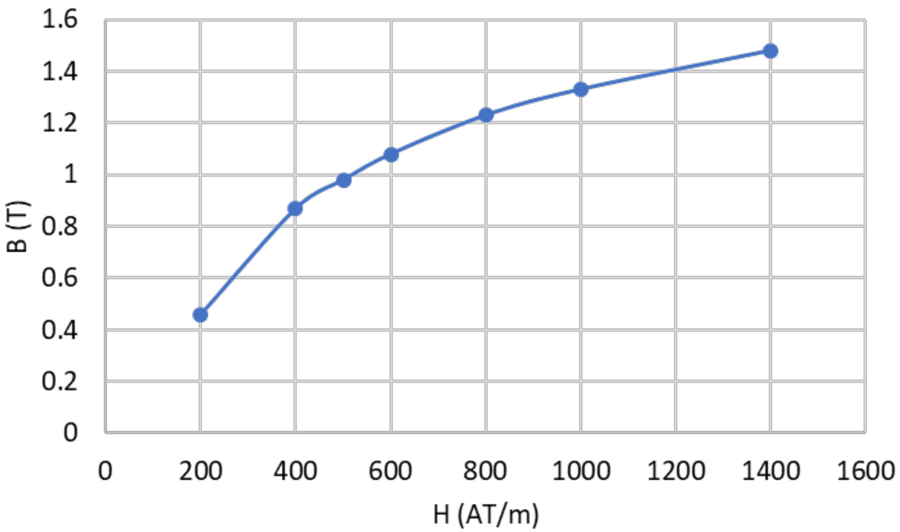


Figure 2



Reluctance of airgap $= \dfrac{1\times10^{-3}}{4\pi\times10^{-7}\times2\times2.5\times10^{-4}} = 15.9\times10^{5}$

flux through this airgap is ~~0.23~~ 0.25 mWb.

$\Rightarrow$ ~~AT~~ AT required $= 0.25\times10^{-3}\times15.9\times10^{5}$

≈ 398 AT $= F_g$

length of right limb $l_{AB} = 12+12+20-0.1$ cm

$\doteq 43.9$ cm

flux density in Right limb $= \dfrac{0.25\times10^{-3}}{2\times2.5\times10^{-4}} = 0.5$ Wb/m^2

Corresponding H (from B-H curve data) $\simeq 220$ AT/m

$\therefore$ 'AT' required $F_{AB} = 220\times$ length of limb

$= 220\times0.439 \doteq 96.58$

≈ 97 AT.

$\therefore$ Total 'AT' required for Right limb

$= 97+398 = 495$ AT

2. For the magnetic circuit shown in Fig. 2, the points of magnetization curve are as follows:

H (AT/m)	200	400	500	600	800	1000	1400
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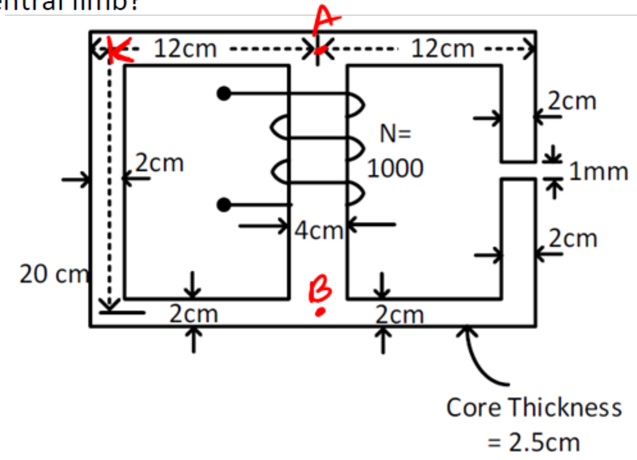
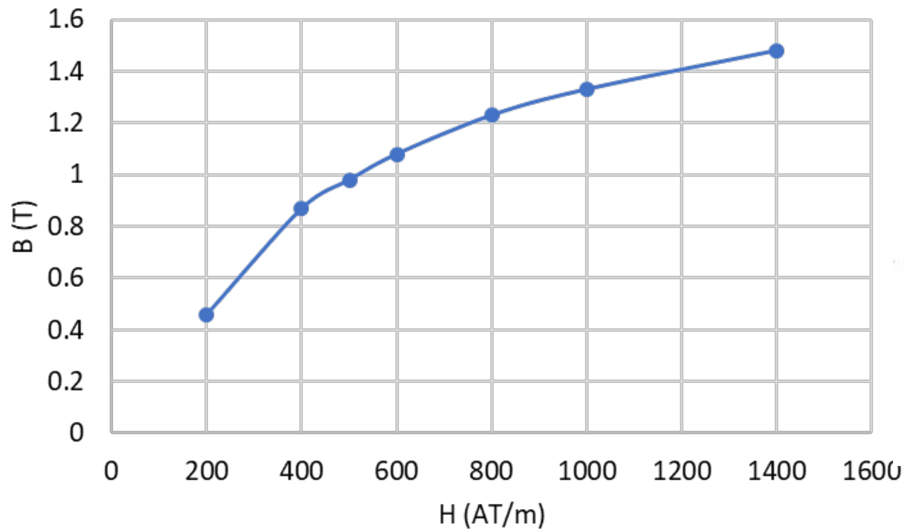
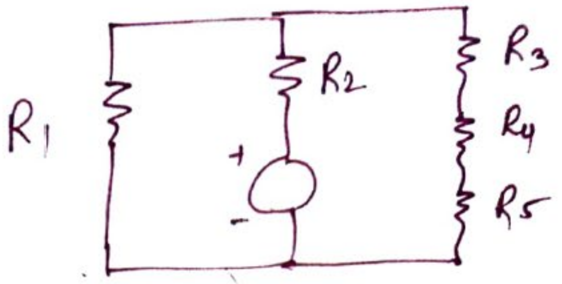


Figure 2



'R_1' is in parallel with ($R_3 + R_4 + R_5$)



$\Rightarrow$ 'AT' required to create a flux of 0.25 mWb in the airgap (also in the right limb) = 'AT' across R_1

$\therefore$ Length of left limb = $12 + 12 + 20 = 44$ cm

$\therefore$ H in left limb $= \frac{495}{0.44} = 1125$ AT/m

$\rightarrow$ $B \cong 1.38$ Wb/m^2 (from BH curve)

$\therefore$ ϕ (flux) in Left limb $= 1.38 \times 2 \times 2.5 \times 10^{-4} = 0.69$ mWb

2. For the magnetic circuit shown in Fig. 2, the points of magnetization curve are as follows:

H (AT/m)	200	400	500	600	800	1000	1400
B (T)	0.46	0.87	0.98	1.08	1.23	1.33	1.48

Calculate the exciting current required to create a flux of 0.25 mWb in the airgap. What is the flux in the central limb?

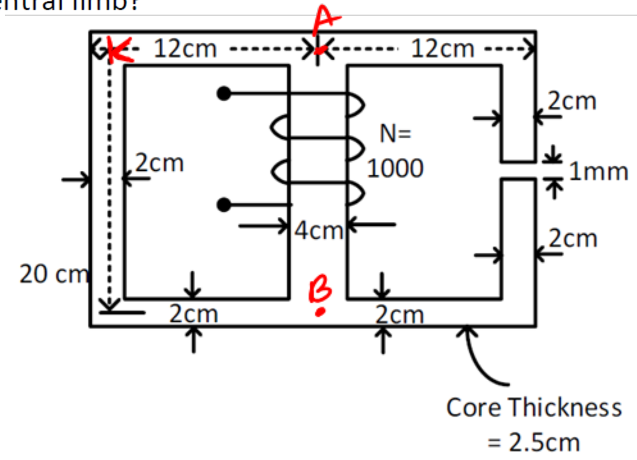
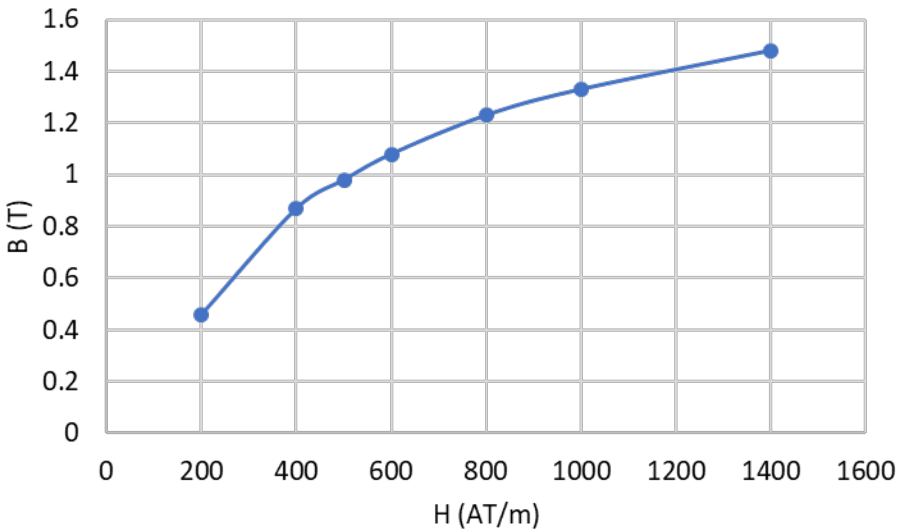


Figure 2



$\therefore$ ϕ (flux) in Left limb $= 1.38 \times 2 \times 2.5 \times 10^{-4} = 0.69$ mWb

$\therefore$ ϕ in central limb $= 0.69 + 0.25 = \cancel{0.00094 = 0.}$
$= 0.94$ mWb.

$\therefore$ 'B' in central limb $= \dfrac{0.94 \times 10^{-3}}{4 \times 2.5 \times 10^{-4}} = 0.94$ T

$\therefore$ 'H' (from BH curve) $\rightarrow$ 450 AT/m

$\therefore$ AT required $= 450$ AT/m $\times$ length of central limb
$= 450 \times 0.2 = 90$ AT

$\therefore$ Total AT $= 90 + 494 = 584$ AT

$\therefore$ Exciting Coil current $= \dfrac{584}{1000} = 0.584$ A

3. A 4-Pole, 50 Hz, 3 phase induction motor delivers full load torque at 1460 rpm. The speed of the stator field relative to the rotor is ___40___ rpm and of the rotor field relative to the rotor is ___40___ rpm.

$N_s \rightarrow 1500$ rpm

$N \rightarrow 1460$ rpm

4. A 3 phase, 400 V, 1460 rpm, 50 Hz, 100 HP, 4-pole induction motor is to be operated from 3 phase, 40 Hz supply. In order to maintain the airgap flux constant, the value of the supply voltage should be ___320___. This control technique is known as ___V/f___ control.

reduced to $\frac{40}{50} \times 400$

5. If the electromotive force in the stator of an 8 pole induction motor has a frequency of 50 Hz, and that in the rotor 1.5 Hz, at what speed is the motor running and what is the slip?

$N_s = \frac{120f}{P} = 750$ rpm ,

* slip frequency, $f_s = S \cdot f$

$\Rightarrow S = \frac{1.5}{50} = 0.03$

$\Downarrow$ 3%

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

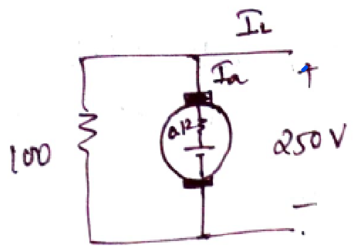
$\Rightarrow N = N_s(1-s)$

$= 750(0.97)$

$= 727.5$ rpm

6. A shunt machine, connected to 250 V mains, has an armature resistance (including brushes) of 0.12 ohm, and the resistance of the field circuit is 100 ohm. Find the ratio of the speed as a generator to the speed as a motor, the line current in each case being 80 A. (1.08)

Q6.



$R_a = 0.12\,\Omega$ $\quad R_f = 100\,\Omega$

$I_L = 80\,A$

Motor: $\quad I_f$ = field current = $\frac{250}{100} = 2.5\,A$

$(I_L = I_a + I_f)$ $\quad \therefore I_a = 80 - 2.5\,A = 77.5\,A$

$\therefore E_b = 250 - I_a \cdot R_a = 250 - 77.5 \times 0.12$

$= 240.7\,V$

Generator: $\quad$ field current $= 2.5\,A$

$(I_a = I_L + I_f)$ $\quad \therefore I_a = I_L + I_f = 82.5\,A$

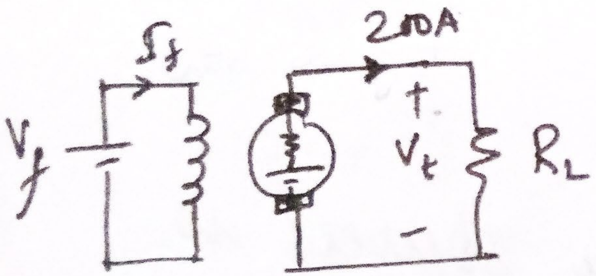
$\therefore E_g = 250 + I_a R_a = 250 + 82.5 \times 0.12$

$= 259.9$

Now, since field current is same for both cases,

$$\frac{N_{generator}}{N_{motor}} = \frac{E_g}{E_b} = \frac{259.9}{240.7} \approx 1.079$$

7. A separately excited generator, when running at 1200 rpm, supplies 200 A at 125 V to a circuit of constant resistance. What will be the current when the speed is dropped to 1000 rpm if the field current is unaltered? Armature resistance: 0.04 ohm, total drop at brushes: 2 V, ignore the effect or armature reaction. (166)



→ At 1200rpm. $V_t = 125V$, $I_a = 200A$

$\therefore R_L = \frac{125}{200} = 0.625\,\Omega$

Also, $E = V_t + \text{Brush drop} + I_a R_a$

$= 125 + 2 + 200\times 0.04 = 135\,V.$

Now, field is unchanged & speed is dropped to 1000rpm.

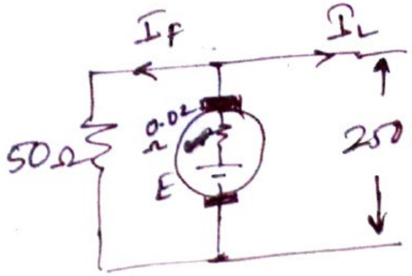
using $E = k\phi\omega$, we get, $\frac{E_2}{E_1} = \frac{N_2}{N_1}$ N: rpm.

$\therefore E_2 = 135\times\frac{1000}{1200} = 112.5\,V.$

$$\therefore I_a\Big|_{case2} = \frac{E_2 - \overset{\text{brushdrop}}{2V}}{\underbrace{0.625}_{R_L} + \underbrace{0.04}_{R_a}} = \frac{112.5-2}{0.665} = 166.2\,A$$

8. A shunt generator delivers 50 kW at 250 V and 400 rpm. The armature and field resistance are 0.02 ohm and 50 ohm, respectively. Calculate the speed of the machine running as a shunt motor and taking 50 kW input at 250 V. Allow 1 V per brush for contact drop and neglect armature reaction. (382 rpm)

Q8.



$R_a = 0.02\,\Omega$, $R_f = 50\,\Omega$

At 400 rpm, $P_{out} = 50$ kW,
$V_{out} = 250$ V

$I_f = 5A$,

$I_L = \dfrac{50000\text{ W}}{250\text{ V}} = 200$ A

In generating mode,

$I_a = I_L + I_f = 205$ A

$\therefore E_g = 250 + \underbrace{(2\text{ V})}_{\text{brush drop}} + \underbrace{205 \times 0.02}_{I_a \cdot R_a} = 256.1$ V

In motoring mode,

$I_a = I_L - I_f = 195$ A

$\therefore E_b = 250 - 2\text{V} - 195 \times 0.02 = 244.1$ V

Since I_f is same in both modes,

$\dfrac{N_{motor}}{N_{generator}} = \dfrac{E_b}{E_g} = \dfrac{244.1}{256.1}$

$\Rightarrow N_{motor} = \dfrac{244.1}{256.1} \times 400 = 381$ rpm.

9. A separately excited DC motor rotates at 1200 rpm when armature terminal voltage is 200 V and armature current is 1 A. The armature resistance is 1 ohm, field winding voltage is 100 V, and the field winding resistance is 100 ohm. Now, the motor is required to rotate at 1250 rpm, with armature current of 1 A, but the armature terminal voltage cannot be increased beyond 200 V. How to achieve the required speed? Give relevant details.

We know that, $E = k\phi\omega$ & $\phi \propto V_{field}$.

$$\therefore \frac{E_1}{\phi_1 \omega_1} = \frac{E_2}{\phi_2 \omega_2} \quad \text{or} \quad \frac{E_1}{V_{f_1} N_1} = \frac{E_2}{V_{f_2} N_2}.$$

Since E remains unchanged at 1200 & 1250 rpm, field voltage has to be reduced to increase the speed.

$$\therefore V_{f_2} = \frac{N_1 \cdot V_{f_1}}{N_2} = \frac{1200}{1250} \times 100 = \underline{\underline{96V}}.$$