Assignment - 01 (Solution)

Q.1) soln

we have given

Air gap flux $(\phi_g) = \phi = 0.5$ mwb

$\phi = 0.5 \times 10^{-3}$ wb

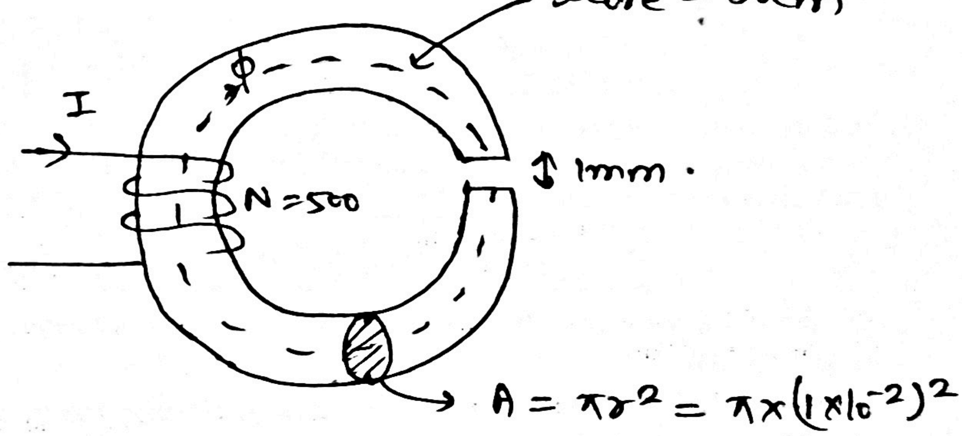
$\mu_r = 4000$

$l_{core} = 30cm = 30 \times 10^{-2}$ m

$l_g = 1mm = 1 \times 10^{-3}$ m

N = 500 turns.

diameter = 2cm



Current(I) = ?

$$\text{Flux density } (B) = \frac{\phi}{A} = \frac{0.5 \times 10^{-3}}{\pi \times 10^{-4}}$$

$$B = 1.5915\ T$$

$$\text{Total ampere turn} = \frac{B}{\mu_0} l_g + \frac{B}{\mu_0 \mu_r} l_{core}$$

$$NI = \frac{1.5915 \times 1 \times 10^{-3}}{4\pi \times 10^{-7}} + \frac{1.5915 \times 30 \times 10^{-2}}{4\pi \times 10^{-7} \times 4000}$$

or, $500 \times I = 1266 + 95 = 1361$

$\therefore I = \frac{1361}{500} = 2.72A$

current required $(I) = 2.72A$.

Q.2) soln-

we have given,

mean diameter $= 15cm = 15 \times 10^{-2} m$

cross sectional area $= 1.5cm^2 = 1.5 \times 10^{-4} m^2$

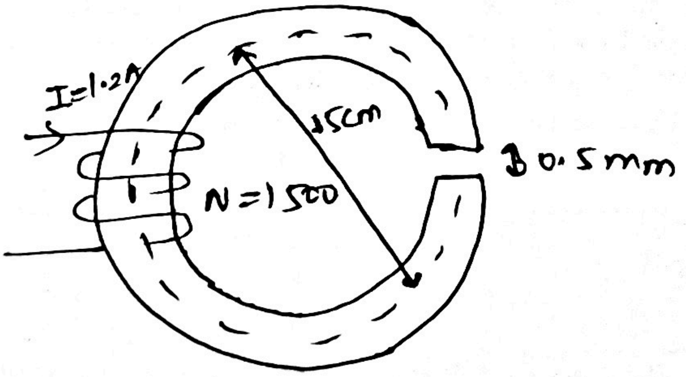
radial air gap$(l_g) = 0.5mm = 0.5 \times 10^{-3} m$

$N = 1500$

$I = 1.2A$

Air gap flux$(\phi_g) = 0.1 mwb = 0.1 \times 10^{-3} wb = \phi$

Relative permeability $(\mu_r) = ?$



length of iron core $(l_i) = \pi d - l_g$

$= \pi \times 15 \times 10^{-2} - 0.5 \times 10^{-3}$

$l_i = 0.4707 m$

$$B_g = \frac{\phi_g}{A} = \frac{0.1\times10^{-3}}{1.5\times10^{-4}} = 0.667\ T$$

$$\text{Total ampere turn} = \frac{B}{\mu_0} l_g + \frac{B}{\mu_0 \mu_r} l_i$$

$$NI = \frac{0.667}{4\pi\times10^{-7}} \times 0.5\times10^{-3} + \frac{0.667}{4\pi\times10^{-7}\times\mu_r} \times 0.4707$$

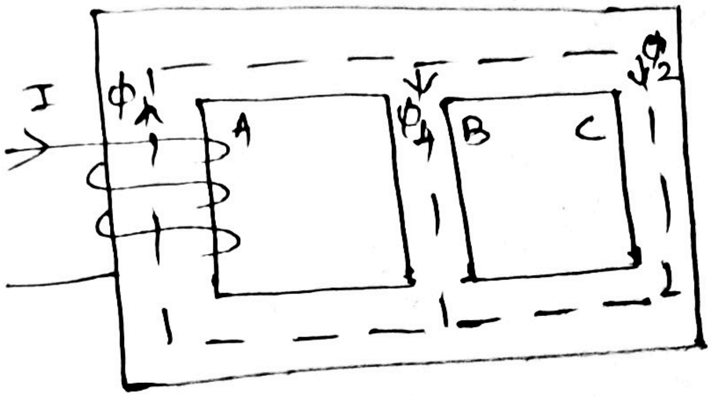
$$\text{or, } 1500\times1.2 = 265 + \frac{249965.68}{\mu_r}$$

$$\text{or, } 1535\,\mu_r = 249965.68$$

$$\therefore \mu_r = \frac{249965.68}{1535} = 162.8 = 163$$

Q.3) soln -

we have given



Mean length of section A(l) = 25cm
mean length of section B(l_1) = 15cm
mean length of section C(l_2) = 25cm

$\mu_r = 600$

$A = (2 \times 2)\ cm^2 = 4 \times 10^{-4} m^2$

$\phi_2 = 2 mwb$
$= 2 \times 10^{-3} wb$

$N = 500$

$I = ?$

As B and C are parallel,

$\phi_1 S_1 = \phi_2 S_2$

$\phi_1 \frac{l_1}{\mu_0 \mu_r A} = 2 \times 10^{-3} \times \frac{l_2}{\mu_0 \mu_r A}$

$\phi_1 \times \frac{15 \times 10^{-2}}{\cancel{4\pi \times 10^{-7} \times 600 \times 4 \times 10^{-4}}} = \frac{2 \times 10^{-3} \times 25 \times 10^{-2}}{\cancel{4\pi \times 10^{-7} \times 600 \times 4 \times 10^{-4}}}$

$$\phi_1 = \frac{2\times10^{-3} \times 25\times10^{-2}}{15\times10^{-2}}$$

$$= 3.33\times10^{-3}$$

$$\phi_1 = 3.33\times10^{-3}\ wb$$

$$\phi = \phi_1 + \phi_2 = 3.33\times10^{-3} + 2\times10^{-3} = 5.33\times10^{-3}\ wb$$

reluctance of A section $(S) = \frac{l}{\mu_0 \mu_r A}$

$$= \frac{25\times10^{-2}}{4\pi\times10^{-7}\times600\times4\times10^{-4}}$$

$$= 829352.44\ AT/wb$$

Reluctance of B section $(S_1) = \frac{l_1}{\mu_0 \mu_r A}$

$$= \frac{15\times10^{-2}}{4\pi\times10^{-7}\times600\times4\times10^{-4}}$$

$$= 497611.465\ AT/wb$$

Reluctance of C section $(S_2) = \frac{l_2}{\mu_0 \mu_r A}$

$$= \frac{25\times10^{-2}}{4\pi\times10^{-7}\times600\times4\times10^{-4}}$$

$$= 829352.44\ AT/wb$$

$$S_{eq} = S + S_1 \| S_2$$

$$= 829352.44 + [497611.465 \| 829352.44]$$

$$= 1140359.605$$

Total ampere-turn = ϕS_{eq}.

$NI = \phi S_{eq}$

or, $500 \times I = 5.33 \times 10^{-3} \times 1140359.605$

or, $I = \dfrac{5.33 \times 10^{-3} \times 1140359.605}{500}$

$\therefore I = 12.15$ A

Q.4) Soln-

we have given,

$l_{core} = 40cm = 40 \times 10^{-2} m$

$l_g = 0.05 cm = 0.05 \times 10^{-2} m$

$A = 12cm^2 = 12 \times 10^{-4} m^2$

$\mu_r = 4000$

$N = 400$

Fringing $= 5\% = 0.05$

Reluctance of core $(S_c) = \dfrac{40 \times 10^{-2}}{4\pi \times 10^{-7} \times 4000 \times 12 \times 10^{-4}}$

$S_c = 66314.55$ AT/wb

$A_g = 12 + 0.05 \times 12 = 12.6$

Reluctance of air gap

$$S_g = \frac{l_g}{\mu_0 A}$$

$$= \frac{0.05 \times 10^{-2}}{4\pi \times 10^{-7} \times 12.6 \times 10^{-4}}$$

$$S_g = 315783.6 \text{ AT/wb}$$

i) The total reluctance $(S) = S_c + S_g$

$$S = 66314.55 + 315783.6$$

$$S = 382098.16 \text{ AT/wb}$$

ii) Current required to produce a flux density of 0.5T in the air gap

$$B_g = 0.5T$$

$$\phi = B_g A_g$$

$$I = ?$$

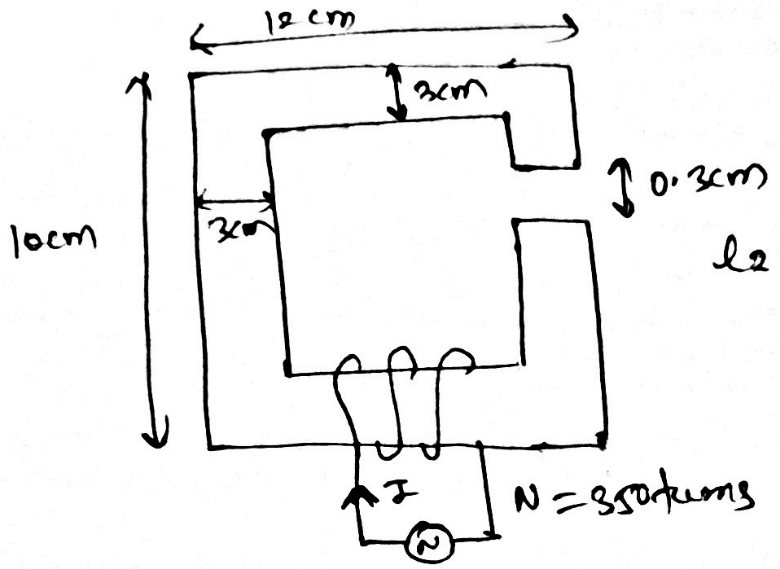
$$NI = \phi S_{eq} = B_g A_g \cdot S_{eq}$$

$$I = \frac{B_g A_g S_q}{N} = \frac{0.5 \times 12.6 \times 10^{-4} \times 382098.16}{400}$$

$$I = 0.602 \text{ A}$$

Q.5) Soln -

we have given,



$l_2 = l_g = 0.3cm = 0.3\times10^{-2} m$

$\mu_r = 1500$

$I = 4A$.

$l_1 = (12-1.5-1.5)\times2 + (10-1.5-1.5) + (10-1.5-1.5-0.3)$

$l_1 = 31.7 cm = 31.7\times10^{-2} m$.

i) Flux density $(B) = \frac{\phi}{A} =$

Total ampere turn $(NI) = \phi S_{eq}$

$350\times4 = \phi[S_1 + S_2]$ — ①

$S_1 = \frac{l_1}{\mu_0\mu_r A} = \frac{31.7\times10^{-2}}{4\pi\times10^{-7}\times1500\times3\times3\times10^{-4}}$

$S_1 = 186954.42$ AT/wb

$S_2 = \frac{l_2}{\mu_0 A} = \frac{0.3\times10^{-2}}{4\pi\times10^{-7}\times3\times3\times10^{-4}}$

$S_2 = 2653927.8$ AT/wb

From eqn (1)

$350 \times 4 = \phi\,(186954.47 + 2653927.8)$

$\phi = 4.9 \times 10^{-4}$ wb

Flux density $(B) = \frac{\phi}{A} = \frac{4.9 \times 10^{-4}}{9 \times 10^{-4}}$

$B = 0.54\,T$

ii) Inductance of coil $(L) = \frac{N\phi}{I}$

$= \frac{350 \times 4.9 \times 10^{-4}}{4}$

$L = 0.0428\ H.$