ELEC 342: Electromechanical Energy Conversion and Transmission

Homework 2

Solution of the Assignments

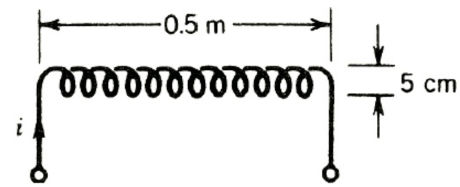
Assignments

P 1.1):

The long solenoid coil shown in Fig. has 250 turns. As its length is much greater than its diameter, the field inside the coil may be considered uniform. Neglect the field outside.

(a) Determine the field intensity (H) and flux density (B) inside the solenoid ($i = 100$ A).

(b) Determine the inductance of the solenoid coil.



Solution:

(a) $$H = \frac{Ni}{l} = \frac{250 \times 100}{0.5} = 50{,}000 \text{ At/m.}$$

$$B = \mu_0 H = 4\pi 10^{-7} \times 50{,}000 = 0.062832 \text{ T}$$

(b) $$L = \frac{N\phi}{i} = \frac{NB\pi r^2}{i} = \frac{N\pi r^2 \mu_0 \frac{Ni}{l}}{i} = \frac{N^2 \mu_0 \pi r^2}{l}$$

$$= \frac{250^2 \times 4\pi 10^{-7} \times 3.1416 \times (2.5 \times 10^{-2})^2}{0.5} \text{ H}$$

$$= 308.43 \, \mu\text{H}$$

P 1.4):

Two coils are wound on a toroidal core as shown in Fig. P1.4. The core is made of silicon sheet steel and has a square cross section. The coil currents are $i_1 = 0.28$ A and $i_2 = 0.56$ A.

(a) Determine the flux density at the mean radius of the core.

(b) Assuming constant flux density (same as at the mean radius) over the cross section of the core, determine the flux in the core.

(c) Determine the relative permeability, μ_r, of the core.

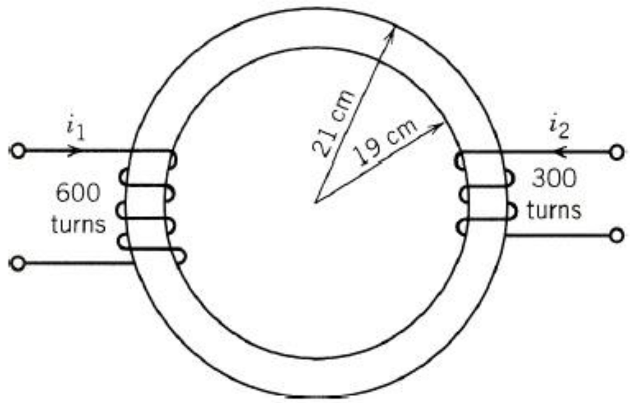


FIGURE P1.4

Solution:

(a) The two mmfs aid each other.

$$F = 600 \times 0.28 + 300 \times 0.56 = 336 \text{ At}.$$

$$H = \frac{336}{2\pi \times 20 \times 10^{-2}} = 267.38 \text{ At/m}.$$

$$B = 1.14 \text{ T} \rightarrow \text{from Fig. 1.7}$$

(b) $\Phi = 1.14 \times 2 \times 2 \times 10^{-4} = 0.000456 \text{ Wb}.$

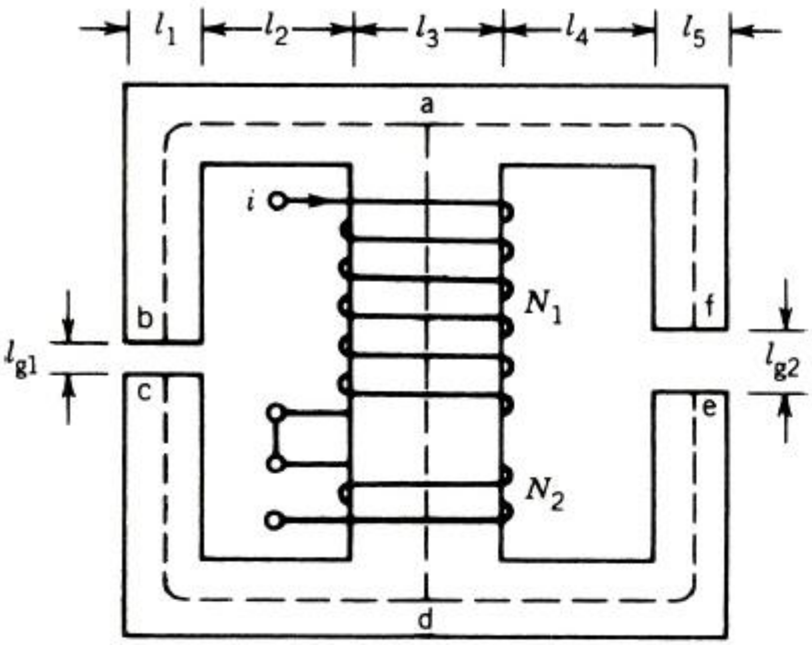
(c)
$$\mu_r = \frac{B}{\mu_0 H}$$

$$= \frac{1.14}{4\pi \times 10^{-7} \times 267.38}$$

$$= 3393$$

P 1.5):

The magnetic circuit of Fig. P1.5 provides flux in the two air gaps. The coils ($N_1 = 700$, $N_2 = 200$) are connected in series and carry a current of 0.5 ampere. Neglect leakage flux, reluctance of the iron (i.e., infinite permeability), and fringing at the air gaps. Determine the flux and flux density in the air gaps.

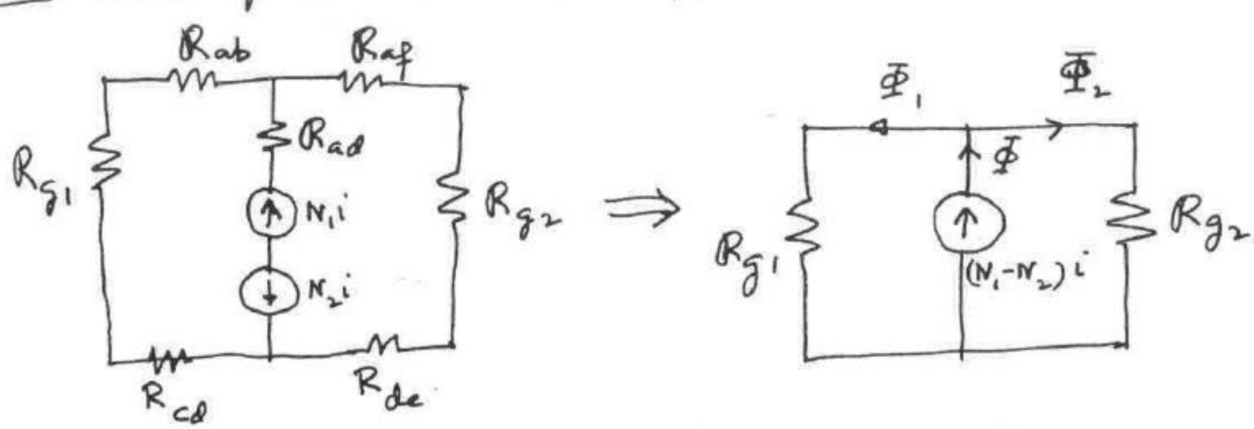


$l_{g1} = 0.05$ cm, $l_{g2} = 0.1$ cm
$l_1 = l_2 = l_4 = l_5 = 2.5$ cm
$l_3 = 5$ cm
depth of core = 2.5 cm

FIGURE P1.5

Solution:

$\boxed{1.5}$ MMFs of the two coils oppose each other.



$$A_{g1} = A_{g2} = 2.5 \times 2.5 \times 10^{-4} = 6.25 \times 10^{-4}\ m^2$$

$$\mathcal{R}_{g1} = \frac{0.05 \times 10^{-2}}{4\pi 10^{-7} \times 6.25 \times 10^{-4}} = 0.637 \times 10^{6}\ At/Wb.$$

$$\mathcal{R}_{g2} = \frac{0.1 \times 10^{-2}}{4\pi 10^{-7} \times 6.25 \times 10^{-4}} = 1.274 \times 10^{6}\ At/Wb$$

$$\Phi_1 = \frac{(700-200)\,0.5}{0.637 \times 10^{6}} = 0.392 \times 10^{-3}\ Wb.$$

$$\Phi_2 = \frac{500 \times 0.5}{1.274 \times 10^{6}} = 0.196 \times 10^{-3}\ Wb$$

$$\Phi = \Phi_1 + \Phi_2 = 0.588 \times 10^{-3}\ Wb$$

$$B_{g1} = \frac{0.392 \times 10^{-3}}{6.25 \times 10^{-4}} = 0.627\ Wb/m^2$$

$$B_{g2} = \frac{0.196 \times 10^{-3}}{6.25 \times 10^{-4}} = 0.3135\ Wb/m^2$$

P 1.11):

The magnetic circuit of Fig. P1.11 has a core of relative permeability $\mu_r = 2000$. The depth of the core is 5 cm. The coil has 400 turns and carries a current of 1.5 A.

(a) Draw the magnetic equivalent circuit.

(b) Find the flux and the flux density in the core.

(c) Determine the inductance of the coil.

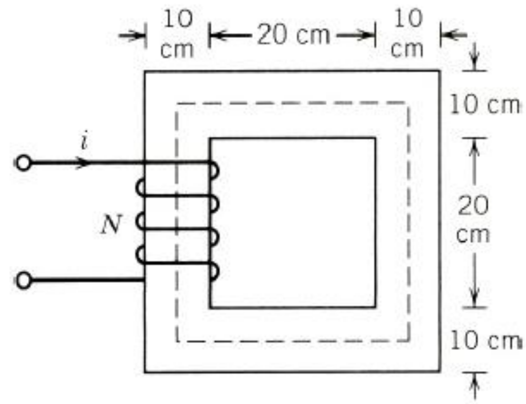


FIGURE P1.11

Solution:

(a)

(b) Mean length $l_c = 4 \times 30 = 120$ cm.

$$R_c = \frac{l_c}{\mu_c A_c} = \frac{120 \times 10^{-2}}{2000 \times 4\pi \times 10^{-7} \times 10 \times 5 \times 10^{-4}} = 95.49 \times 10^{3} \text{ At/Wb.}$$

$$\Phi = \frac{400 \times 1.5}{95.49 \times 10^{3}} = 6.2832 \times 10^{-3} \text{ Wb.}$$

$$B = \frac{6.2832 \times 10^{-3}}{10 \times 5 \times 10^{-4}} = 1.257 \text{ T.}$$

(c) $$L = \frac{N^2}{R_c} = \frac{400^2}{95.49 \times 10^{3}} = 1.6756 \text{ H.}$$