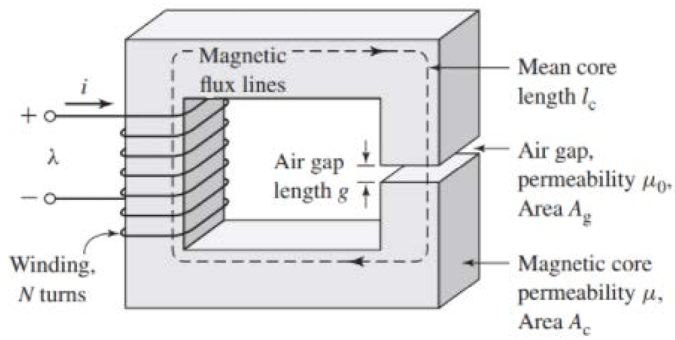
EENG577 M2-A1 Assignment KEY

Source: Ex1.1 Fitzgerald & Kingsley. 7th Edition

Problem-I

Consider the magnetic circuit shown with dimensions $A_c = A_g = 9\ cm^2$, $g = 0.050$ cm, $l_c = 30$ cm, and $N = 500$ turns. Assume the value $\mu_r = 70{,}000$ for core material.



a) Find the reluctances R_c and R_g
b) Find the flux φ if the magnetic circuit is operating with $B_c = 1.0$ T and (c) the current i.
c) Find the current I if the magnetic circuit is operating with $B_c = 1.0$ T
d) Using MATLAB, plot the inductance of the magnetic circuit of the magnetic core shown as a function of core permeability over the range $100 \le \mu_r \le 100{,}000$.

EXAMPLE 1.1

The magnetic circuit shown in Fig. 1.2 has dimensions $A_c = A_g = 9\ \text{cm}^2$, $g = 0.050$ cm, $l_c = 30$ cm, and $N = 500$ turns. Assume the value $\mu_r = 70{,}000$ for core material. (a) Find the reluctances $\mathcal{R}_c$ and $\mathcal{R}_g$. For the condition that the magnetic circuit is operating with $B_c = 1.0$ T, find (b) the flux ϕ and (c) the current i.

■ Solution

a. The reluctances can be found from Eqs. 1.13 and 1.14:

$$\mathcal{R}_c = \frac{l_c}{\mu_r \mu_0 A_c} = \frac{0.3}{70,000\,(4\pi \times 10^{-7})(9 \times 10^{-4})} = 3.79 \times 10^3\ \frac{\text{A} \cdot \text{turns}}{\text{Wb}}$$

$$\mathcal{R}_g = \frac{g}{\mu_0 A_g} = \frac{5 \times 10^{-4}}{(4\pi \times 10^{-7})(9 \times 10^{-4})} = 4.42 \times 10^5\ \frac{\text{A} \cdot \text{turns}}{\text{Wb}}$$

b. From Eq. 1.4,

$$\phi = B_c A_c = 1.0(9 \times 10^{-4}) = 9 \times 10^{-4}\ \text{Wb}$$

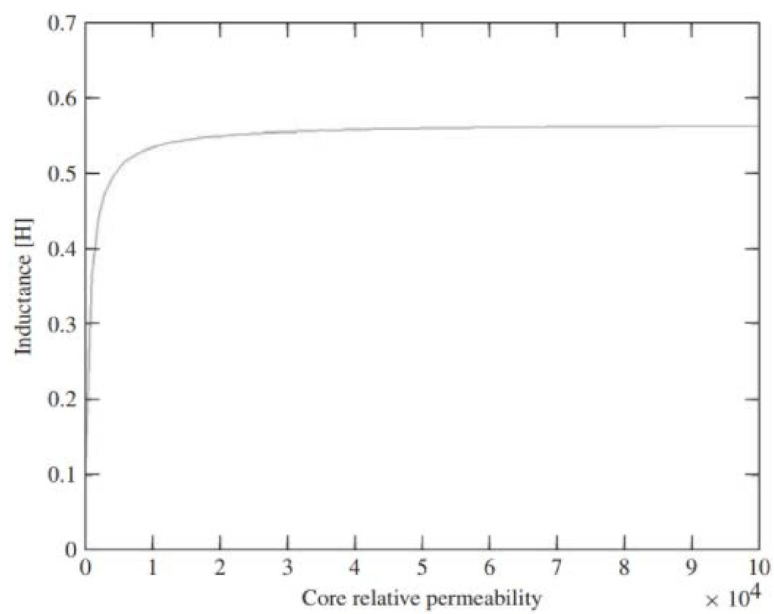
c. From Eqs. 1.6 and 1.15,

$$i = \frac{\mathcal{F}}{N} = \frac{\phi(\mathcal{R}_c + \mathcal{R}_g)}{N} = \frac{9 \times 10^{-4}(4.46 \times 10^5)}{500} = 0.80\ \text{A}$$

d) MATLAB script:

```
clc
clear

% Permeability of free space
mu0 = pi*4.e-7;

%All dimensions expressed in meters
Ac = 9e-4; Ag = 9e-4; g = 5e-4; lc = 0.3;
N = 500;

%Reluctance of air gap
Rg = g/(mu0*Ag);

mur = 1:100:100000;
Rc = lc./(mur*mu0*Ac);
Rtot = Rg+Rc;
L = N^2./Rtot;

plot(mur,L)
xlabel('Core relative permeability')
ylabel('Inductance [H]')
```

The resultant plot is shown. Note that the figure clearly confirms that, for the magnetic circuit of this example, the inductance is quite insensitive to relative permeability



MATLAB plot of inductance vs. relative permeability