

EE 577 - M2A1

Joseph Brownlee

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

A. Find the reluctances $\mathcal{R}_c$ and $\mathcal{R}_g$

$$\mathcal{R} = \frac{\ell}{\mu A}$$

$$\mathcal{R}_c = \frac{30 \text{ cm}}{\mu_0 70000 \cdot 9 \text{ cm}^2} = \frac{0.3 \text{ m}}{\pi \times 10^{-7} \cdot 70000 \cdot 0.0009 \text{ m}^2} = \mathbf{3,789} \left[\frac{\text{A}}{\text{Wb}} \right]$$

$$\mathcal{R}_g = \frac{0.050 \text{ cm}}{\mu_0 \cdot 9 \text{ cm}^2} = \frac{0.0005 \text{ m}}{\pi \times 10^{-7} \cdot 70000 \cdot 0.0009 \text{ m}^2} = \mathbf{442,097} \left[\frac{\text{A}}{\text{Wb}} \right]$$

B. Find the flux ϕ if the magnetic circuit is operating with $B_c = 1.0 \text{ T}$.

$$\phi = B_c A = 1 [\text{T}] \cdot 0.09 [\text{m}] = \mathbf{0.09 [\text{Tm}]}$$

C. Find the current i if the magnetic circuit is operating with $B_c = 1.0 \text{ T}$

$$\text{MMF} = \mathcal{F} = Ni = \phi \mathcal{R}$$

$$i = \frac{\phi \mathcal{R}}{N} = \frac{B_c A \mathcal{R}_{\text{eff}}}{N}$$

$$i = \frac{1 [\text{T}] \cdot 0.09 [\text{m}^2] (442,097 + 3,789) \left[\frac{\text{A}}{\text{Wb}} \right]}{500} = 80.259 \frac{\text{ATm}^2}{\text{Wb}}$$

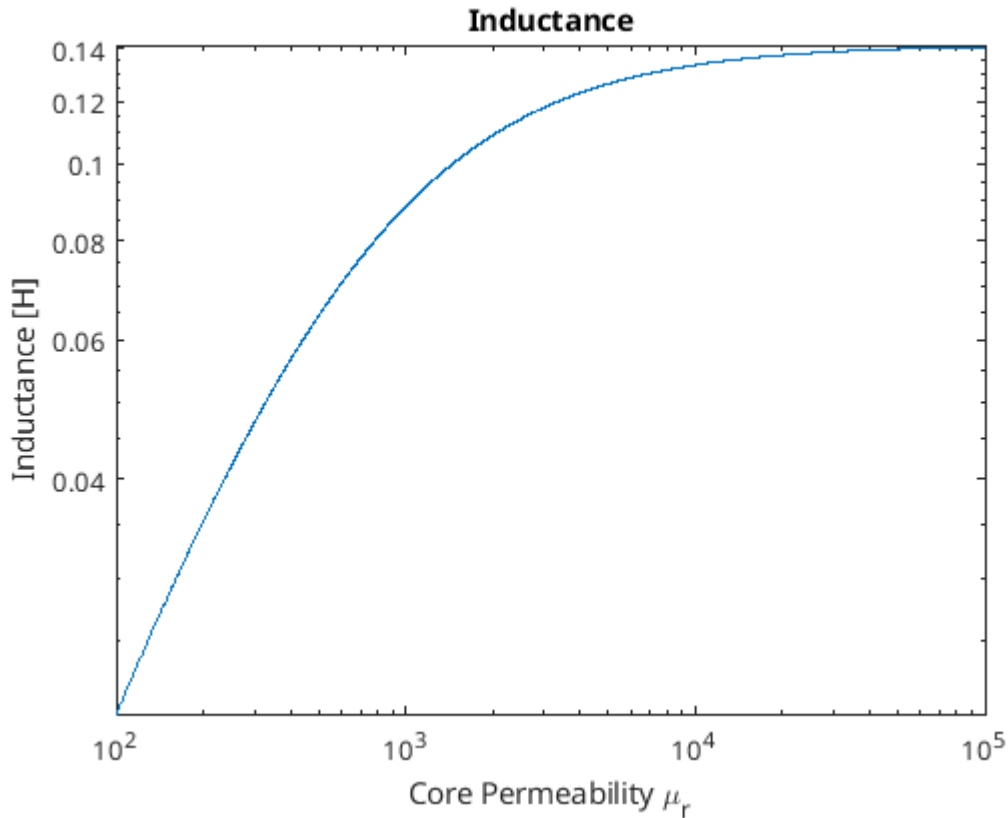
$$\mathbf{i = 80.259 \text{ A}}$$

D. Using MATLAB, plot the inductance of the magnetic circuit of the magnetic core shown as a function of core permeability over the range $100 \leq \mu_r \leq 100,000$.

$$H = \frac{Ni}{\ell_c}$$

$$B = \mu H$$

$$L = \frac{\lambda}{i} = \frac{N\phi}{i} = \frac{N \cdot BA}{i} = \frac{NA \frac{\mu Ni}{\ell_c}}{i} = \frac{\mu_{\text{eff}} N^2 A}{\ell} = \frac{N^2}{\mathcal{R}_{\text{eff}}}$$



The inductance reaches about 140 mH at large permeability.

Appendix: Matlab code and extra figure

```
% M2A1_D
% Using MATLAB, plot the inductance of the magnetic circuit
% of the magnetic core shown as a function of core permeability
% over the range  $100 \leq \mu_r \leq 100,000$ .
% Core properties
lc=30; %cm
lg=0.05; %cm   convert from cm to m
Ac=9; %cm^2
Ag=Ac;
N=500;
%%% calculations
mur = 100:100000;
u0=pi*10^(-7);
% reluctance
cm2m=100; %100^2 cm/cm^2
Rc=cm2m*lc./(u0*mur*Ac);
Rg=cm2m*lg./(u0*Ag);
% inductance
L=N^2./(Rc+Rg);
%%% plots
figure(2)
loglog(mur,Rc+Rg)
title("Reluctance")
xlabel("Core Permeability \mu_r")
figure(1)
loglog(mur,L)
title("Inductance")
ylabel("Inductance [H]")
xlabel("Core Permeability \mu_r")
```

