EE 577 - M2A1

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

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

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

$\mathcal{R}_c = \frac{30\text{ cm}}{\mu_0 70000 \cdot 9\text{ cm}^2} = \frac{0.3\text{ m}}{\pi\times10^{-7}\cdot 70000\cdot 0.0009\text{ m}^2} = \mathbf{3,789}\left[\frac{\text{A}}{\text{Wb}}\right]$

$\mathcal{R}_g = \frac{0.050\text{ cm}}{\mu_0 \cdot 9\text{ cm}^2} = \frac{0.0005\text{ m}}{\pi\times10^{-7}\cdot 70000\cdot 0.0009\text{ m}^2} = \mathbf{442,097}\left[\frac{\text{A}}{\text{Wb}}\right]$

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

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

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

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

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

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

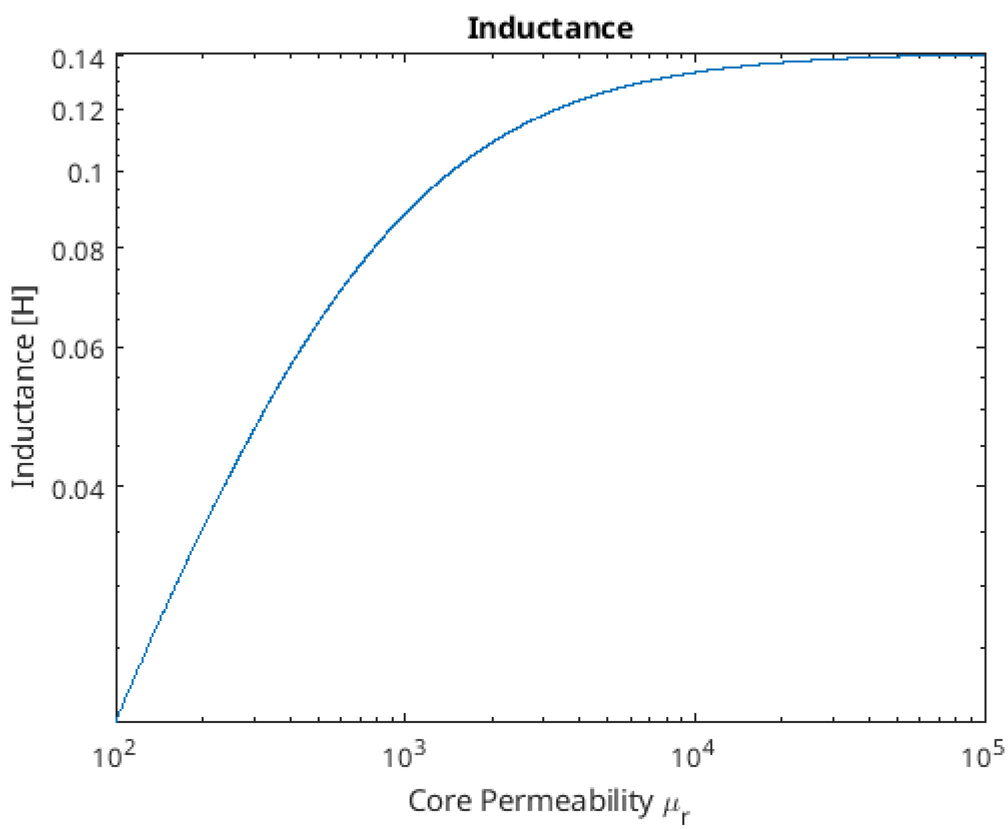
$\boldsymbol{i = 80.259\text{A}}$

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

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

$B = \mu H$

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



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}\leq100,000.
    % Core properties
    lc=30; %cm
    lg=0.05; %cm
    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")
```