## Homework 1 – Magnetic Circuits

**Q.1.** The magnetic circuit seen in figure 1 is composed of a steel core B-H characteristics of which is given in the attached file. The geometric and electrical data are given as follows:
$g = 1$ mm, $l_1 = 20$ cm, $l_2 = 50$ cm, $N = 200$ turns, $A = 10$ cm$^2$, $\mu_0 = 4\pi 10^{-7}$ H/m
Neglect fringing and leakage.

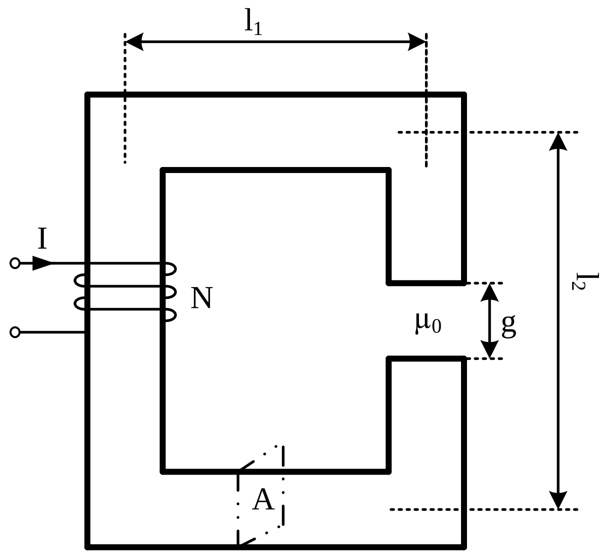


Figure 1: The Magnetic Circuit

For parts A, B and C, model the magnetic circuit, obtain its electrical equivalent circuit and obtain the set of equations which can be deduced from your model.

**Part A)** Suppose that the core is ***infinitely permeable***. Find the excitation current so that the flux density at the air gap is 0.63 Tesla.

**Part B)** Suppose that the B-H characteristics of the core is ***linear*** with relative permeability of 8000. Find the excitation current so that the flux density at the air gap is 0.63 Tesla.

**Part C)** Plot the B-H characteristics of steel given on the attachement. Find the excitation current so that the flux density at the air gap is 0.63 Tesla, by using the attached ***realistic B-H characteristics***.

**Part D)** For all three methods, find the excitation current so that the flux density at the air gap is 1.25 Tesla, this time.

**Part E)** Obtain the **relative permability vs magnetic field intensity** characteristics of the steel core and plot it on the same figure with the B-H characteristics. Mark the points in (C) and (D).

**Part F)** Comment on the results and compare the methods.

**Q.2.** You are asked to design an inductor as shown in Figure 2-a and the core is pre-selected.

$l_1$ = 15 cm, $l_2$ = 10 cm, A = 10 cm$^2$, $\mu_0 = 4\pi 10^{-7}$, $\mu_r$ = 1400, $B_{sat}$ = 0.8 Tesla

$B_{sat}$ is the point where the core starts to saturate.

**Part A)** Show that the inductance of this coil is as following, starting from the definition of inductance.

$$L = \frac{N^2 \mu_r \mu_0 A}{2l_1 + 2l_2}$$

**Part B)** The required inductance is 2 mH. How many turns should be wounded?

**Part C)** Find the maximum current that this inductor can withstand without saturating the core.

**Part D)** Find the stored energy with two different methods at the operating point in (C).

Now, you are given the same core with the same geometry, only there is an air gap (g = 3mm) this time as shown in Figure 2-b.

**Part E)** Derive the expression of inductance in this case.

**Part F)** How many turns should be wounded this time for L = 2 mH?

**Part G)** Find the maximum current that this inductor can withstand without saturating the core.

**Part H)** Find the stored energy at the operating point in (G).

**Part I)** Comment on the results, compare the two cases and discuss the effects of using an air gap.

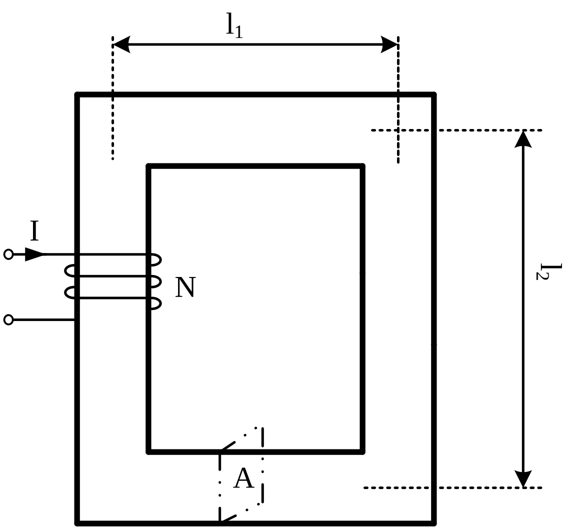


Figure 2-a: Inductor without Air Gap

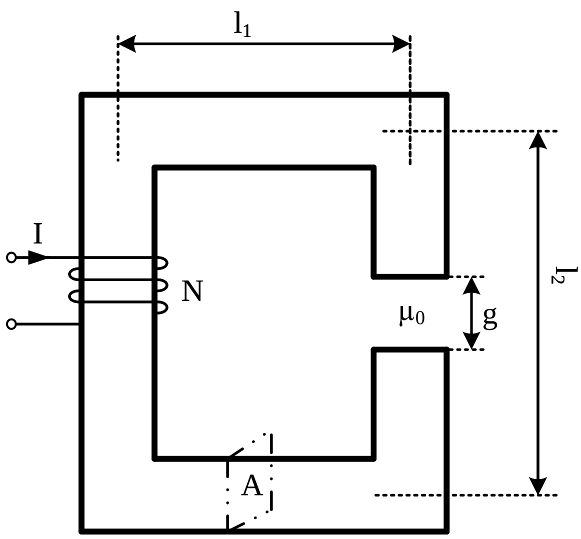


Figure 2-b: Inductor with Air Gap