Problem Set - 1
Magnetic Circuits

1. Consider the toroidal core system shown in Fig. 1. The relative permeability of the core is 2000. The core has a square cross section.

   (a) Calculate the coil current required to produce a flux density of 1.2 T at the mean radius of toroid. (**Ans:** $i = 1.2$ A)

   (b) If 2-mm-wide air gap is made in the toroid, determine the new coil current required to maintain a core flux density of 1.2 T. (**Ans:** $i = 10.7445$ A)

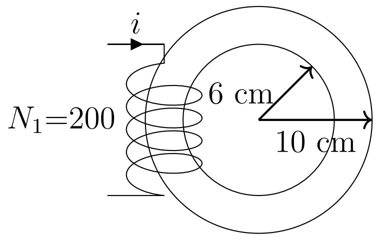

Figure 1

2. Consider the magnetic circuit shown in Fig. 2a. All dimensions are in cm. The depth of the core is 1 cm. The coil has 100 turns. The approximated $B - H$ curve of the core material is shown in Fig. 2b.

   (a) Find the current i in A required to produce a flux density of 0.5 T in the air gap. (**Ans:** $i = 8.555$ A)

   (b) If the current $i = 2A$, what will be the total flux in the core? (**Ans:** $\phi = 0.01169$ mWb)

   Neglect magnetic leakage and fringing.

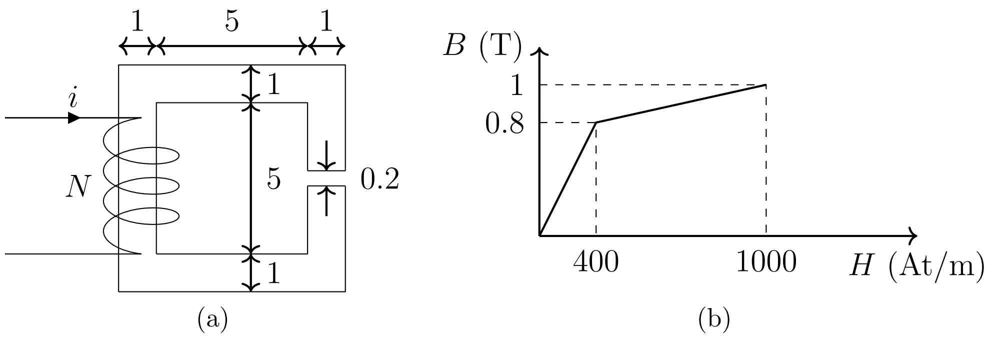

Figure 2

3. Consider the magnetic circuit shown in Fig. 3a. All dimensions are in cm. The depth of the core is 1 cm. The approximated $B - H$ curve of the core material is shown in Fig. 3b.

   (a) If $i_1 = 1$ A, calculate the value of of i_2 required to produce a flux density of 0.5 T in the core. (**Ans:** $i = -1.4$ A)

   (b) If $i_1 = 0.5$ A and $i_2 = 1.96$ A, calculate the total flux in the core. (**Ans:** $\phi = 0.1078$ mWb)

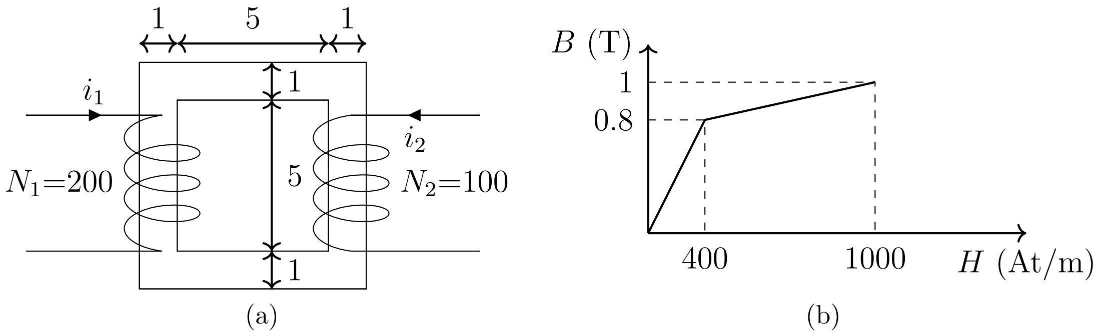

Figure 3

Neglect magnetic leakage.

4. An inductor is to be designed using a magnetic core of the form of that of Fig. 4. The core is of uniform cross-sectional area $A_c = 5\text{cm}^2$ and of mean length $l_c = 25\text{cm}$. Calculate the air-gap length l_g and the number of turns N such that the inductance is 14 mH so that the conductor can operate at peak current of 6 A without saturating. Assume that saturation occurs when the peak flux density in the core exceeds 1.7 T and that, below saturation, the core has a relative permeability$\mu_r = 3200$. (**Ans:** $l_g = 0.36$ mm; $N = 99$)

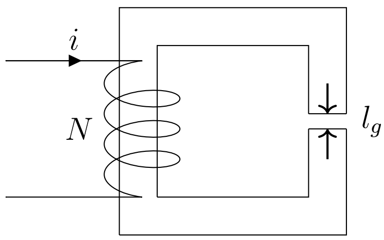

Figure 4

5. A coil wound on a magnetic core is excited by the following voltage sources.

   (a) 230 V, 50 Hz

   (b) 115 V, 25 Hz

   Compare the hysteresis losses and eddy current losses with these two different sources. For hysteresis loss consider $n = 2$. (**Ans:** $\dfrac{P_{h_{50}}}{P_{h_{25}}} = 2; \dfrac{P_{e_{50}}}{P_{e_{25}}} = 4$)

6. Power consumed by a three phase three wire load is measured by two wattmeter method. Determine the power factor of the load

   (a) If the two wattmeters read equal. (**Ans:** pf = 1)

   (b) If the one of them reads negative and half of the second wattmeter reading. (**Ans:** pf = 0.1890 leading/laggging)

   (c) If one of them reads zero.(**Ans:** pf = 0.5 leading/lagging)

7. A soft-iron toroid is concentric with a long straight conductor carrying a direct current I. If the relative permeability μ_r of soft-iron is 100, what is the ratio of the magnetic flux densities at two adjacent points located just inside and just outside the toroid? (**Ans:** $\dfrac{B_r}{B_x} = \dfrac{100 \times x}{r}$ where r and x are the distances between

the conductor and inside and the conductor and outside of the toroid respectively. $x < r$)

8. A coil wound on a magnetic core consumes a core loss of 200 W when it is excited by 230 V, 50 Hz supply. The core consumes 80 W when it is excited by 115 V, 25 Hz supply. Compute the hysteresis and eddy current loss at 50 Hz. Assume $n = 2$ for the hysteresis loss. (**Ans:** $P_h = 120$ W; $P_e = 80$ W)