**Homework 2**
**EE 306: Electromechanical Devices - Semester 161**

**Problem 1: (a)** A magnetic circuit as shown in Figure 1 has the following dimensions:

$$A_c = 16\ cm^2,\ l_c = 40\ cm,\ N = 350\ turns$$

The relative permeability of the core is 50000 and the air gap is 0.1 mm long. Assume that fringing in the air gap is negligible. The permeability of free space is $4\ \pi \times 10^{-7}$. The coil is connected to a voltage source and the current drawn is adjusted so that the magnetic flux density in the air gap is 1.5 T. Calculate the following:

1) The value of current
2) The magnetic flux in the air gap

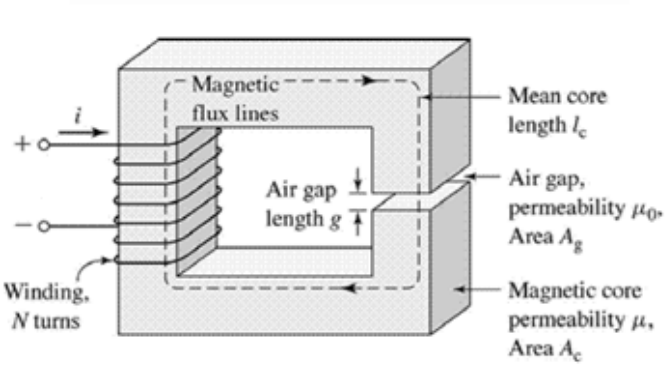


Figure 1

**(b)** Repeat **Part (a)** with the new length of air gap as 0.05 cm and assume 5% increase in effective cross section area for fringing effect.

**Problem 2:** Consider a magnetic circuit as shown in Figure 2. The core of the circuit is composed of cast steel and cast iron. Each material has a mean length of 20 cm. The cross section area of the core is 16 $cm^2$. The coil has 350 turns and it carries a current of 1.2 A. The relative permeability of the cast steel is 800 and that of cast iron is 250. Determine the following:

1) The flux in the core
2) The total flux linkage
3) The magnetic flux density B in the core

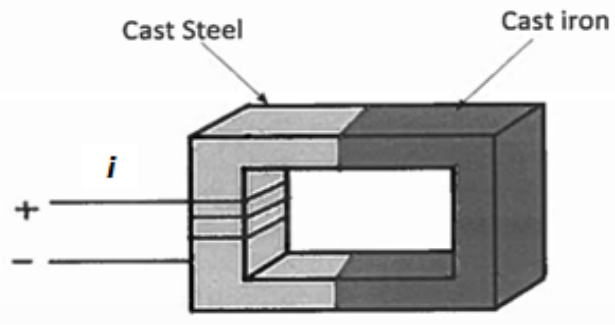


Figure 2

**Problem 3:** The magnetic circuit as shown in Figure 3 is composed of two different materials. The central leg is made up of ordinary iron plate while the rest of the core is made up of cast steel. The total number of turns in the coil is 500, and all legs have the same cross section area. The permeability of cast steel is $1.11 \times 10^{-3}$ Wb/A.t.m.

1) Draw the magnetic equivalent circuit
2) If the flux $\phi_2$ is 0.625 mWb:
   Find magnetic flux intensity $H_2$ and magnetomotive forces $F_1$ and $F_2$
3) If $\phi_1 = 0.906$ mWb:
   Find the total flux $\phi$, flux density $B_{left}$ and the corresponding $H_{left}$
4) Find total required magnetomotive force, $F_{total,}$ and the current needed
5) If the source voltage is 300 V, what would be the power consumed by the core?

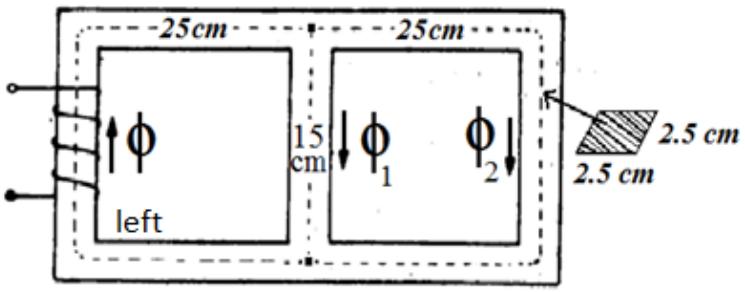


Figure 3

[Note: The permeability information of the central leg is not required for the solution]

**Problem 4: (a)** A magnetization curve of the typical ferromagnetic material is shown in Figure 4. Find the relative permeability of the material at:

1) $H = 250$ A-turns/m
2) $H = 500$ A-turns/m

**(b)** A square shaped magnetic core has been made with this material with a mean path length of 55 cm and a cross section area of 150 $cm^2$. If a coil of wire is wrapped around one leg of the core with 200 turns; find the following:

1) Current required to produce 0.012 Wb of flux in the core
2) The core's relative permeability at that current level
3) Reluctance

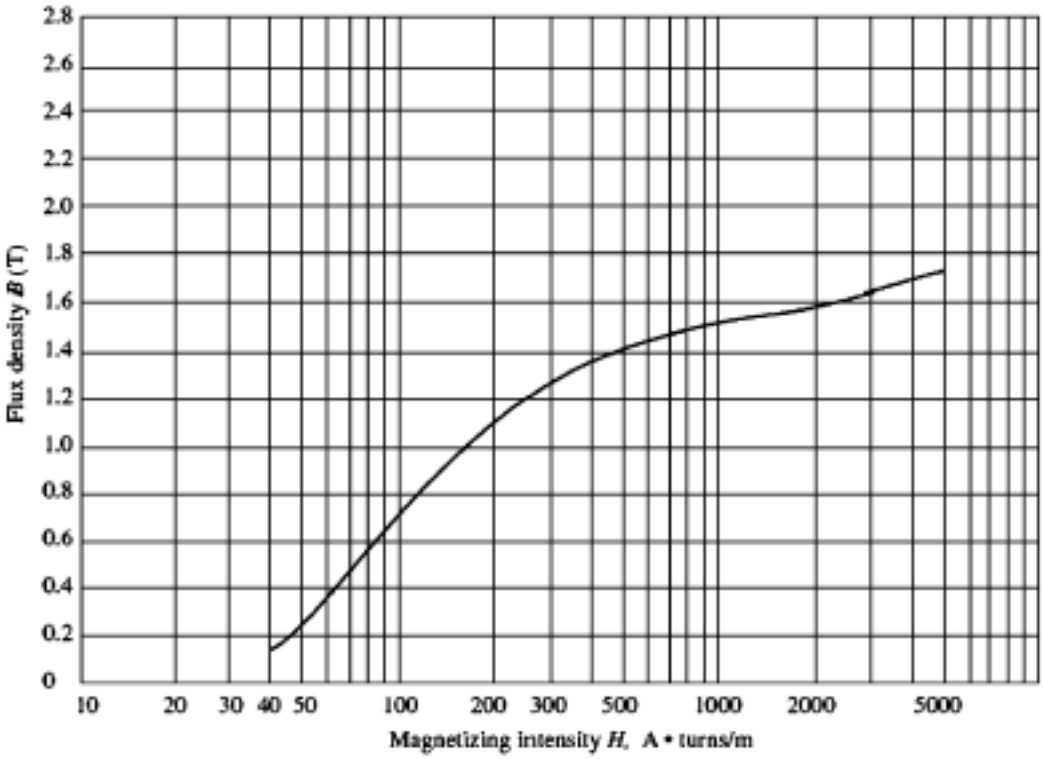


Figure 4

**Problem 5: (a)** The total iron loss in the core of a transformer having volume 0.16 $cm^3$ is 2170 W when excited at 50 Hz. The hysteresis loop of the core material, taken to some maximum flux density $B_{max}$, has an area of 9 $cm^2$ when drawn to scales of:

$$1 \text{ cm} = 0.1 \text{ Wb/m}^2 \text{ and } 1 \text{ cm} = 250 \text{ AT/m}$$

Calculate the hysteresis and eddy-current losses of the core in watts? You may use the following relation: [Iron losses = hysteresis losses + eddy-current losses]

**(b)** Repeat **Part (a),** if the same core of the transformer is excited to the same maximum flux density as in Part (a) but at the frequency of 60 Hz. Also, what will be total iron losses in the transformer core at 60 Hz?

Note: The value of $B_{max}$ is not required for both solutions.

**(c)** Find the hysteresis and eddy-current losses with the following parameters:

$$B_{max} = 1.3 \text{ Wb/m}^2, n = 2, Kh = 30, f = 50 \text{ Hz}$$

[Recall: Charles Steinmetz relation].

How can we reduce eddy-current losses (just state only two methods)?

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