ELEC 435
Problem Set 8
Due: October 31, 2014

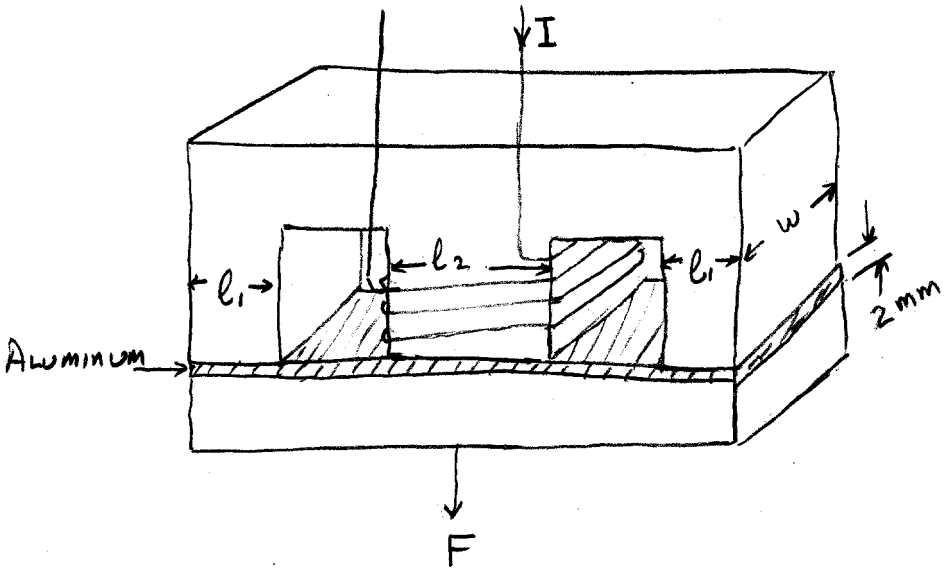
**Homework Problems.**

**H8.1** A solenoid coil consists of a single layer of 250 circular turns of wire with each turn having a 0.02 m radius. The axial length of the coil is 0.3 m. The coil is self-supporting, containing only air.

**(a)** Determine the inductance of the coil, assuming that the magnetic field intensity is uniform inside the coil and zero elsewhere.

**(b)** Find the stored energy in the magnetic field of the coil when the coil current is 18 A.

**H8.2** The device below is an electromagnet similar to those used in electric door locks. It consists of an "E" shaped core with a coil of 2000 turns, a 2 mm thick aluminum separator plate, and a rectangular pole piece. The dimensions are $l_1$ = 18 mm, $l_2$ = 36 mm, and $w$ = 36 mm. If the current in the coil is 1.5 A, what force is required to separate the two pieces. Assume that the permeability of the core and pole piece is infinite.




**H8.3** The electromagnet shown in the figure exhibits linear $\lambda$ vs. $i$ behavior until it abruptly saturates. The relation between $\lambda$, $i$, and $x$ is given by the equations

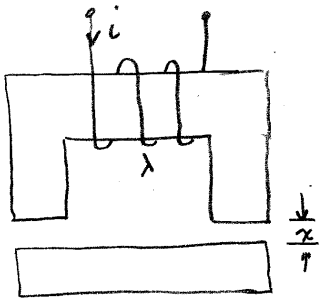
$$\lambda = \begin{cases} \frac{i}{x} & \text{for} \frac{i}{x} \leq 1 \\ 1 & \text{for} \frac{i}{x} > 1 \end{cases}$$

for $x$ in m, $i$ in A, and $\lambda$ in Wb-turns. (OK, it's not very realistic, but it makes the numbers simple.) These equations are valid for $0 < x \leq 1$.

**(a)** Sketch the magnetization ($\lambda$ vs. $i$) curves for $x = 1$, $x = 0.5$, and $x = 0.25$.

**(b)** Determine a formula for the electromagnetic force developed by this magnet.

**(c)** Sketch curves showing how force varies with $x$ for $i = 0.25, 0.5, \text{and} 1.0$ and force vs. $i$ for $x = 0.25, 0.5, \text{and} 1.0$.

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**Quiz Problems.**

**Q8.1** You are shopping at EPO when you come upon a large bin marked "Mystery Motors, $1 each." Unable to resist a bargain, you buy one, thinking you can use it in your 435 project. The only markings on the motor are "Acme Motors Inc." and "Model 37 Permanent Magnet DC Motor." Visiting Acme's Web site, you find that this model was discontinued 5 years ago and no information is available. Undaunted, you head to the lab to characterize the motor yourself. With an ohmmeter you measure an armature resistance of 7 Ω. Your project will use a 12 V battery, so you connect the motor to a 12 V power supply and find that its speed is 8000 rpm. With the motor connected to 6 V, the speed is 3900 rpm.

**(a)** Assuming that the internal friction of the motor is accurately modeled by Coulomb friction, what is the minimum voltage which will cause the motor to run?

**(b)** What will the motor's stall torque be at 12 V? How much current will it draw when stalled?

**(c)** What is the maximum mechanical power this motor can deliver at 12 V?

**(d)** Based on your measurements, you decide the motor is not powerful enough to drive your project, but that you can use it as a speed sensor. What will its output voltage be if the shaft is rotating at 2000 rpm?