EE321 Exam 1
Spring 2009

Notes**: Write your name and ID on blue book. This part of exam will be recycled.**

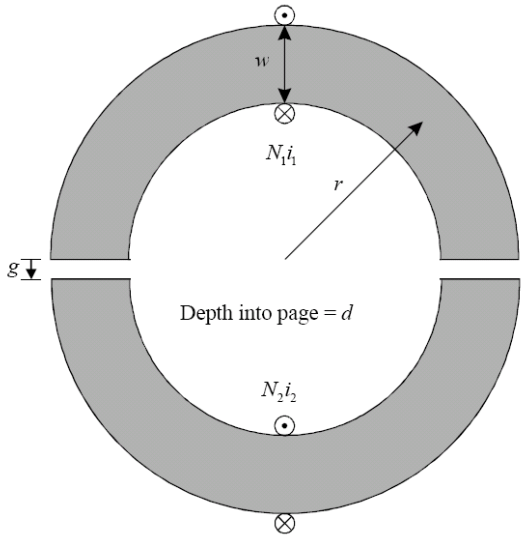
You must show work for credit, except for problem 6.

Achieving a score of 60% or above on this exam satisfies ABET Objective 1 and Objective 2.

Good luck !

1.) 10 pts. Consider a Cartesian coordinate system. Suppose there exists a uniform H-field with a +10 A/m component in the x-direction, a +20 A/m component in the y-direction, and a -5 A/m component in the z-direction. What is the magneto motive force drop between the starting point (5,2,1) (x, y, z) and the ending point (4,2,4).

For problems 2-3, consider the split toroid shown below. The cross section of the toroid is rectangular.



2.) 15 pts. The permeability of the magnetic material in the split toroid may be expressed

$$\mu_B(B) = \mu_0 \frac{5000}{1+|B|}$$

where μ_0 is the permeability of free space, $4\pi 10^{-7}$ H/m. Now suppose $g = 1$ mm, $r = 10$ cm, $w = 1$ cm, $d = 2$ cm, $N_1 = 100$, $N_2 = 20$, and $i_1 = 5$ A. If the flux linking the second winding is $\lambda_2 = 0.004$ Vs, what is the current i_2?. Hint $100 < i_2 < 200$.

3.) 20 pts. Assume that the relative permeability of the magnetic material in the toroid is constant and has a value μ_r. Derive an expression of the electromagnetic force on the lower half of the toroid. Your expression should be in terms of the following variables: w, d, r, N_1, N_2, i_1, i_2, g, μ_r, and μ_0. The desired result is symbolic – do not use the numbers from problem 2 !

4.) 15 pts. Consider a magnetic system with the following flux linkage equations

$$\lambda_1 = 2i_1 + 10\sin(4\theta_{rm})(1 - e^{-2i_1 - i_2})$$
$$\lambda_2 = 3i_2 + 5\sin(4\theta_{rm})(1 - e^{-2i_1 - i_2})$$

where $i_1 \geq 0$ and $i_2 \geq 0$. Derive an expression for co-energy.

[CONTINUED ON NEXT PAGE]

5.) 10 pts. Consider a variable reluctance stepper motor. The flux linkage equation may be expressed

$$\lambda_{as} = \frac{1}{1000}(5 + 4\cos(4\theta_{rm}))i_{as}$$

The winding resistance of the stepper motor is 5 Ohms, and the supply voltage for the stepper motor circuit is 10 V. There are 5 phases. 5a) What is the step length ? { 5 pts}. Neglecting semiconductor voltage drops, what is the holding torque ? { 5 pts}.

The following questions should be answered true or false. They are worth 1 pt. each. You do not need to show work.

6a) Ferrimagnetic materials have higher saturation flux densities then ferromagnetic materials.
6b) In an inductor, most of the energy is stored in the magnetic material.
6c) Magnetic saturation causes a magnetic field not to be conservative.
6d) The atoms in ferromagnetic materials have magnetic moments that are aligned in an anti-parallel fashion.
6e) Some stepper motors use permanent magnets
6f) Coenergy and field energy are equal in linear magnetic systems.
6g) The following system is magnetically linear

$$\lambda = \frac{1}{2+x}i$$

6h) Ohm's law is easier to break than Kirchoff's voltage law.
6i) Any set of flux linkage equations one might write possess the properties of a conservative field
6j) Multistack variable reluctance stepper motors are never built with just two phases.