EE 201.3 (Section 03)

(Instructor: Denard Lynch)

Midterm Examination

Tuesday, October 26, 2004

7:00 PM

Time Allowed: 2 Hours

Materials allowed: One 8½" X 11" formula sheet, Calculators

Instructions:

- **Answer all questions in the space provided (use page backs for rough work if necessary)**
- **State your assumptions; show all relevant work. Box, circle, or otherwise highlight your answers.**
- **Put your name and student number on the cover page; put *only* your student number on all remaining pages.**
- **Weighting for each question is indicated in the left margin (Total marks: 50)**

1	2	3	4	5	6	Total
/	/	/	/	/		/

Name:____

Student Number:__________________________________

1) State Ohm's Law for Magnetic circuits: ________________________________

[1]

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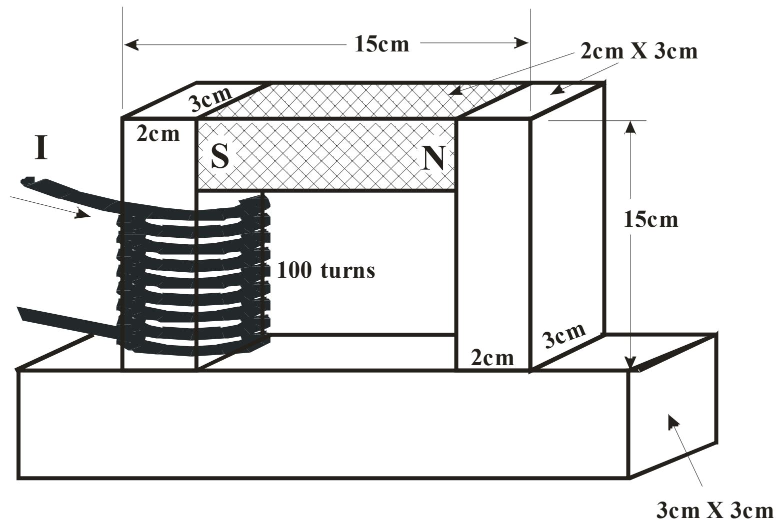
2) The magnet shown in the figure is used to pick up sheet steel bars and place them on a conveyor for milling.

The centre section is a permanent magnet that provides an mmf of 500A-t, and has an internal reluctance of 250,000 A-t/Wb (which can be assumed constant). The end sections are the same 2cm x 3cm. cross section as the permanent magnet, and are made out of cast steel. One of the legs has a coil of 100 turns wound in the direction shown.



Note: $F = \dfrac{B_{gap}^2 A_{gap}}{2\mu_0}$

Assume there is no gap between the magnet and the bar. (B-H curves are on the last page)

Answer the following questions about this magnet system:

a) Draw the electric equivalent of the magnetic circuit.

[2]

b) What is the minimum flux that must be flowing in the magnet if it is to hold up a bar with a mass of 50Kg?

[2]

(Note: You may use the following table to assist with your calculations)

Leg	Φ (Wb)	A (m^2)	B (T)	H (At/m)	L (m)	Hl (At)		

c) Assuming *no current* flowing in the coil, will the permanent magnet generate enough flux in this circuit to hold up the bar?

[4]

d) What is the magnitude and direction of the current required in the coil at the point when the bar will drop?

[4]

e) What is the inductance of the coil at the point where the bar just "lets go"?

[2]

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3) What is the period of a sinusoidal waveform that completes 360 cycles in 42msec?

[1]

T = ________________________.

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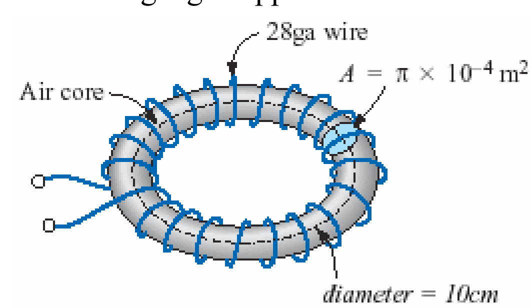
4) The 12.5μH air-core inductor shown in the figure consists of 28 gauge copper wire. The toroid has a diameter of 10cm and a cross-sectional area of π X $10^{-4}$$m^2$.



a) How many turns are in the coil?

[3]

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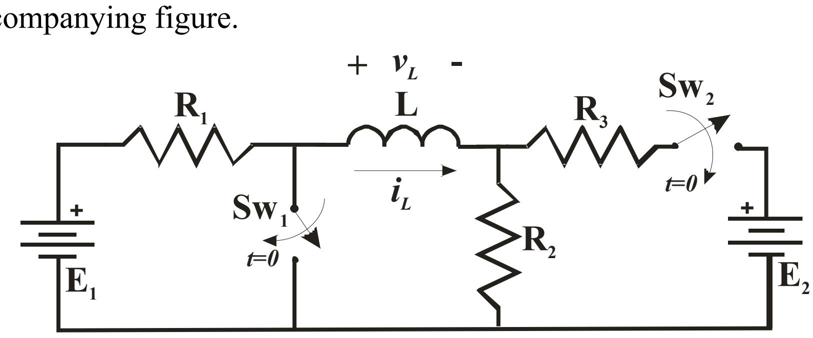
5) Consider the R – L circuit in the accompanying figure. *(Note the defined polarity of v_L and direction of i_L)*



Assume that the system has reached steady-state before both the switches, Sw_1 and Sw_2, are closed at exactly the same time.

Answer the questions below given the following circuit parameters:

E_1=10V, E_2=12V, $R_1$100Ω, R_2=33Ω, R_3=470Ω, and L=0.3H

a) Find v_L and i_L *before* the switches are closed.

[2]

b) How much energy is stored in the inductor *before* the switches are closed?

[1]

<u>Answer the remaining questions assuming the switches are closed at t = 0.</u>

c) What is the time constant, τ, in the R-L circuit *after* the switches are closed?

[2]

d) What will the final steady-state current be through the inductor?

[2]

e) Write the expression and graph the waveform for the current i_L as a function of time.

[3]

f) Find the expression and graph the waveform for the voltage, v_L as a function of time.

[3]

g) At what time will $i_L = 0$?

[3]

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6) If we consider fringing effects, the *effective area* at air gap 1mm long in a circular cross-section with a diameter of 2cm is:

[1]

i)3.80 X 10^{-3} ii) 3.14 X 10^{-4} iii) 3.80 X 10^{-4} iv) 1.39 X 10^{-3}

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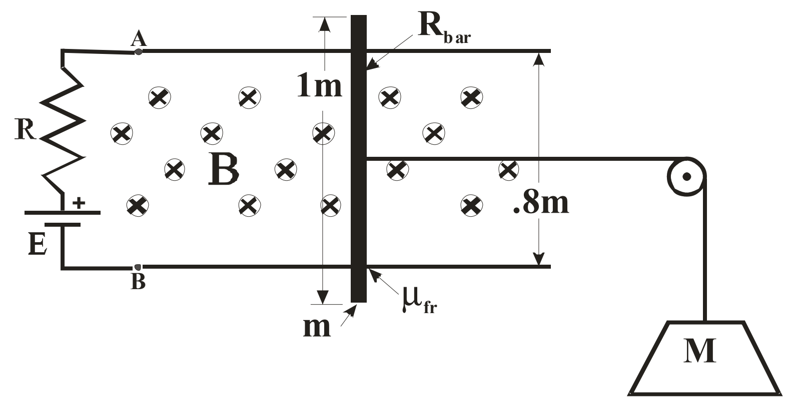
7) Consider the following Bar & Rail system attached to a voltage source and mass as shown in a magnetic field of density, B. The system consists of a **1m long** bar of mass, **m = 10.0kg** which is in contact with two rails which are **0.8meters** apart. The bar is connected to a mass **m = 5kg** through a cable and pulley so that the mass can travel vertically. The coefficient of static friction, μ_{fr} between the bar and the rails is **0.3**. A battery with a terminal voltage, **E = 24V** is connected through a resistor, **R**, to the rails at points **A** and **B**. The resistance of the bar, **R_{bar} = 0.1Ω.**



a) Assuming the bar is at rest, what is the *direction* of the magnetic force acting on the bar? (left or right or up or down)

[1]

<u>Assume the system has reach steady state for the remaining questions.</u>

b) The bar is moving to the right with a velocity of 34 m/s. What flux density, B, is present if a motional *emf* of 30V is observed *in the bar*?

[1]

c) With this flux density, how much current is flowing in the bar and what is its direction (*up* or *down* through the bar)?

[2]

[2] d) What is the value of the external resistor, R?

[2] e) What is V_{AB}?

[1] f) Is the bar & Rail system acting as a *motor* or *generator*?

[1] g) What is the total power into the system (in Watts) and what is the source?

[1] h) What is the useful power out of the system and where does it go?

[1] i) What is the efficiency, η, of the whole system?

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8) What is the voltage across a 100mH inductor if the current through it is charging at a rate of 1mA/μs.

[1] i) 0V ii) 1V iii) 100V

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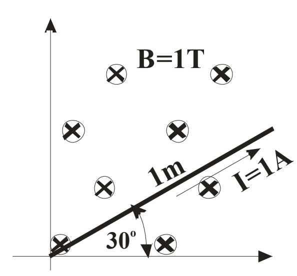
9) What is the magnitude of the force on the wire shown in the diagram if it is carry a current of 1A?

[1]
i) 1N
ii) 0.5 N
iii) 0.87 N



Some potentially useful constants:

Acceleration of gravity: $g = 9.81\ m/s^2$

Permeability of free space: $\mu_o = 4\pi \times 10^{-7}$ Wb/At-m

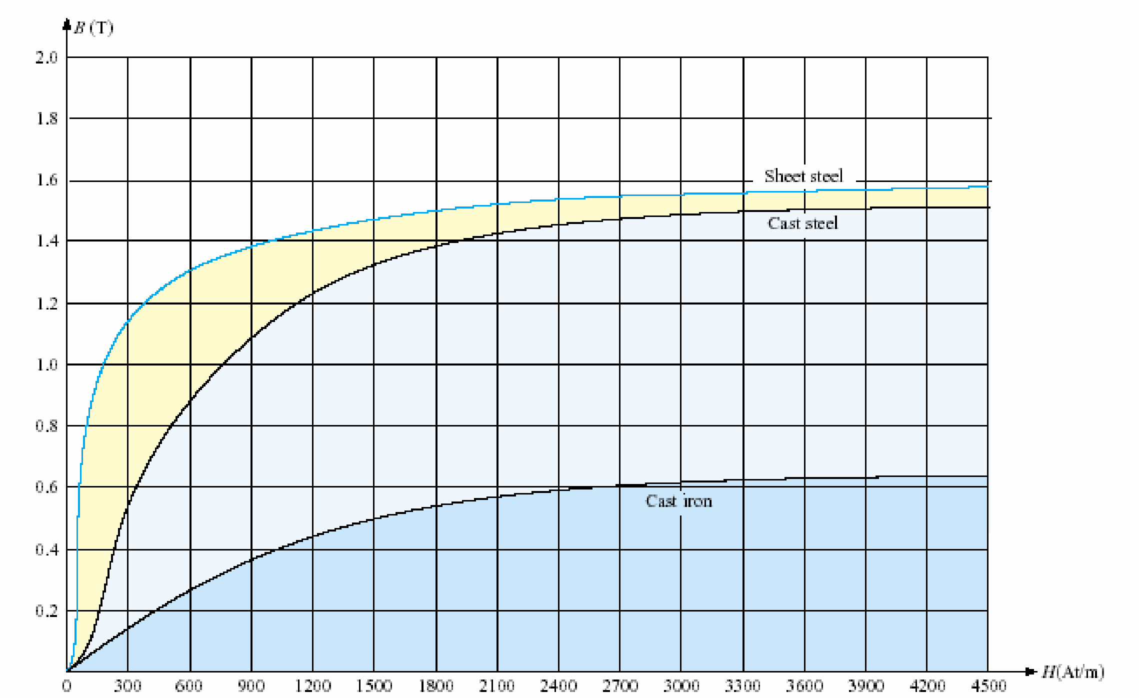


FIG. 11.23
Normal magnetization curve for three ferromagnetic materials.

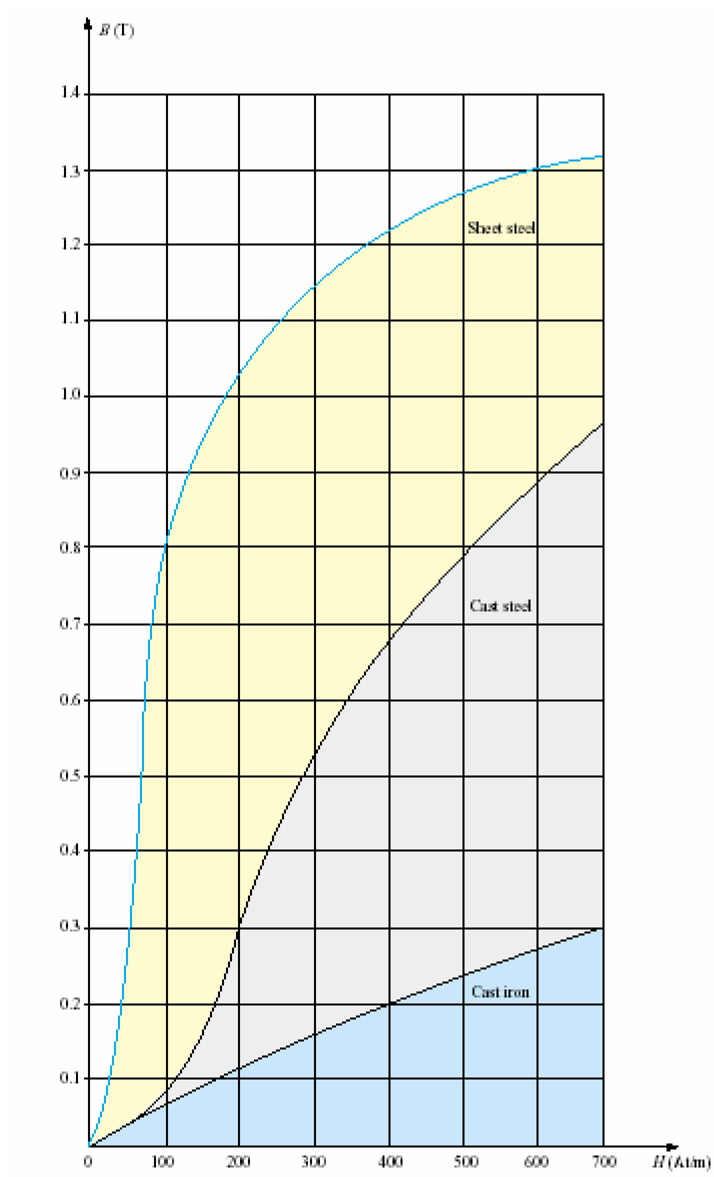


FIG. 11.24
Expanded view of Fig. 11.23 for the low magnetizing force region.

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