EE 201.3 (Section 03)

(Instructor: Denard Lynch)

Midterm Examination

Tuesday, October 21, 2003

7:00 PM

Time Allowed: 2 Hours

Materials allowed: One 8½" X 11" sheet of notes, Calculators

Instructions:

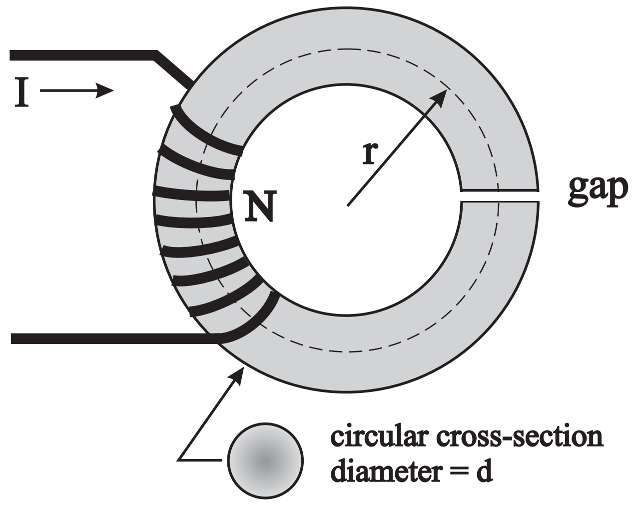
- **Answer all questions in the space provided (use page backs for rough work if necessary)**
- **State your assumptions; show all relevant work. Box, circle or otherwise highlight your answers.**
- **Put your <u>name</u> and <u>student number</u> on the cover page; put *only* your <u>student number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

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

Name:____

Student Number:__________________________________

1) Consider the magnetic circuit at right. The coil (N = 500 turns) is carrying a current of 2A. The ferromagnetic core is made of **cast steel**. The core has a circular cross-section with a diameter, **d = 2.5cm** and the flux produced follows an average path with radius, **r = 12cm**. There is a **1 mm gap** cut through the core.



(Refer to the B_H curves on the last page)

a) Find the flux density, **B** in the air gap (*consider fringing effects*).

[5]

(Note: Use the following table to assist with your calculations)

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

b) Once this flux is established, what is the force of attraction between the faces of the core in the air gap? (hint: $F = \frac{B_{gap}^2 A_{gap}}{2\mu_0}$)

[2]

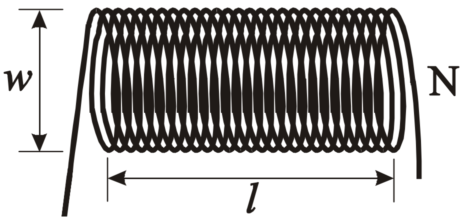
c) What is the inductance, L, of the coil at this current and flux level?

[2]

2) The air-core inductor shown in the figure consists of 250 turns of 26 gauge copper wire. It has a length, l = 3.8cm and a width, w = 3mm.

a) What is the inductance of the coil?

[2]



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

[1]

f = ________________________.

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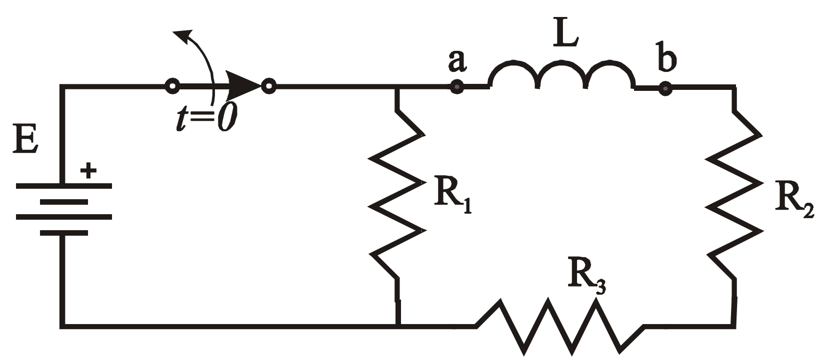
4) Consider the R – L circuit in the accompanying figure. The component values are as follows:

E = 12V **L = 0.5H**
R_1 = 680Ω **R_2 = 100Ω**
R_3 = 220Ω

The switch has been closed long enough so that steady state conditions have been reached.



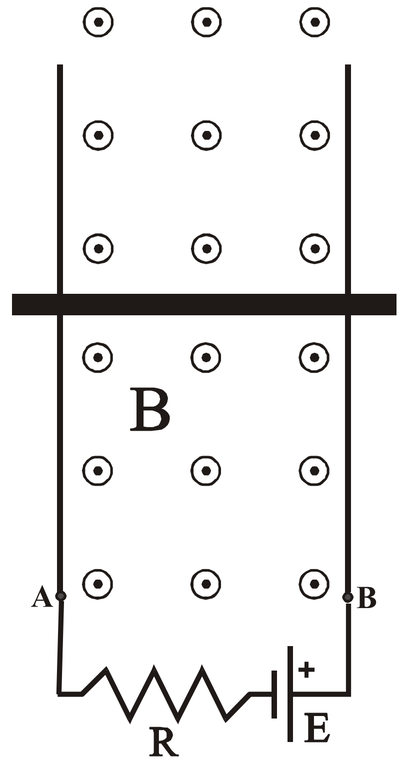
a) Give the expressions for the current through the inductor, $\boldsymbol{i_L}$, and the voltage across the inductor, $\boldsymbol{v_L}$, as a function of time (starting when the switch is opened).

[3]

b) What is the magnitude of the voltage across R_3 1msec after the switch is opened?

[2]

5) The linear system at right consists of a bar of mass, **m = 0.7kg** which is in contact with two rails which are **1.8meters** apart. The rails are perfectly ***vertical*** and a guide mechanism helps the bar maintain sufficient electrical contact with the rails without adding any external forces to the bar. The coefficient of static friction, μ between the bar and the rails is **0.18**. A magnetic field of density, **B = 0.6T** exists in the area of concern (perpendicular to the rails and out of the page as shown). A battery with a terminal voltage, **E = 12V** is connected through a **1 Ω** resistor to the rails at points **a** and **b** (positive). (Assume the bar and rails have no significant resistance.)



a) Calculate the magnitude and direction of an external force that would be required to initially hold the bar stationary.

[3]

b) Once the external force calculated in a) is removed, will the bar move and in which direction?

[1]

c) Once the system reaches "steady state", what is the velocity of the bar?

[3]

d) Once the system has reached a steady state, calculate the amount of both electrical and mechanical power generated and consumed in this system (sources and sinks) and show that energy is being conserved (i.e. sources and sinks of power are balanced)

[4]

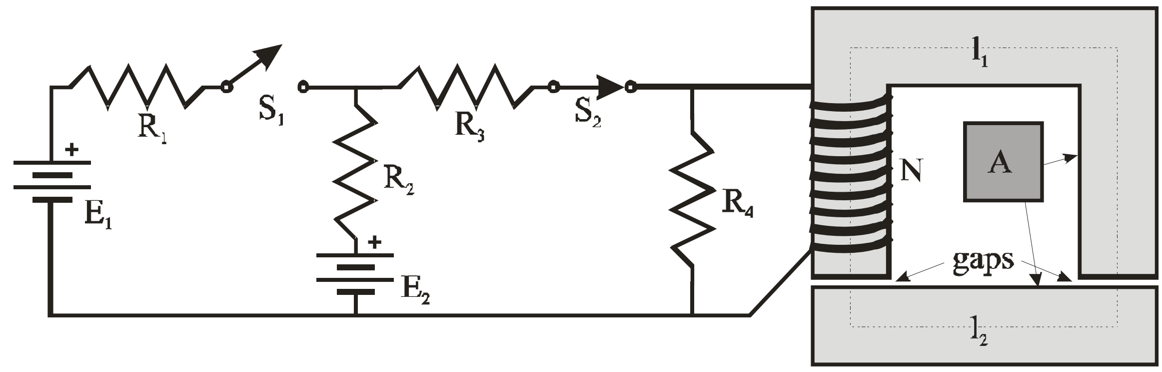
e) What is the overall efficiency of the system?

[2]

f) Is the system acting as a motor or generator?

[1]

6) Consider the R – L circuit show in the figure below:



The ferromagnetic material that makes up the core of the inductor has a relative permeability, μ_r = **1850** (assumed constant over the range if interest). The average path lengths are l_1 = **0.3m**, and l_2 = **0.12m** and the two gaps are filled with a paramagnetic film (i.e. μ_r= 1) **0.2mm** thick. The cross-sectional area of the core, **A**, is **2cm X 2cm** throughout.

The circuit component values are:

N = 250 turns	**E_1 = 12V**	**E_2 = 10V**	
R_1 = 4Ω	**R_2 = 5Ω**	**R_3 = 5Ω**	**R_4 = 100Ω**

The system has reached *steady state* with switch **S_1** *open* and **S_2** *closed* as shown.

a) What is the inductance of the coil? (Note: neglect any fringing effects.)

[3]

b) What is the current through the coil? (with switch **S_1** *open* and **S_2** *closed* as shown.)

[2]

Switch **S_1** is **closed** at time ***t = 0***.

c) What is the current through the coil once the system again reaches *steady state*?

[7]

continued on next page…

c) Give the expression for the current through the inductor and the voltage across the inductor as a function of time (starting at $t = 0$).

[3]

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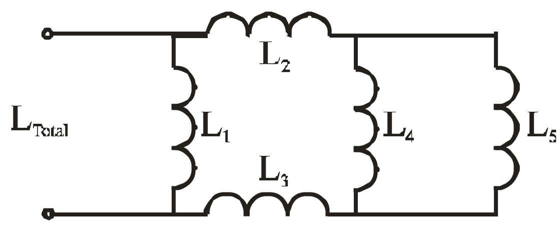
7) Calculate the total inductance, $\boldsymbol{L_{Total}}$ of the combination of inductors shown in the figure. The values of the components are as follows:

[3]

L_1 = 200mH **L_2 = 30mH**
L_3 = 100mH **L_4 = 100mH**
L_5 = 234mH



L_{Total} = ______________________

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8) What is the RMS value of the voltage of an AC source that will produce the same amount of heat in a resistive load as a 12V D.C. battery?

[1] ______________________________

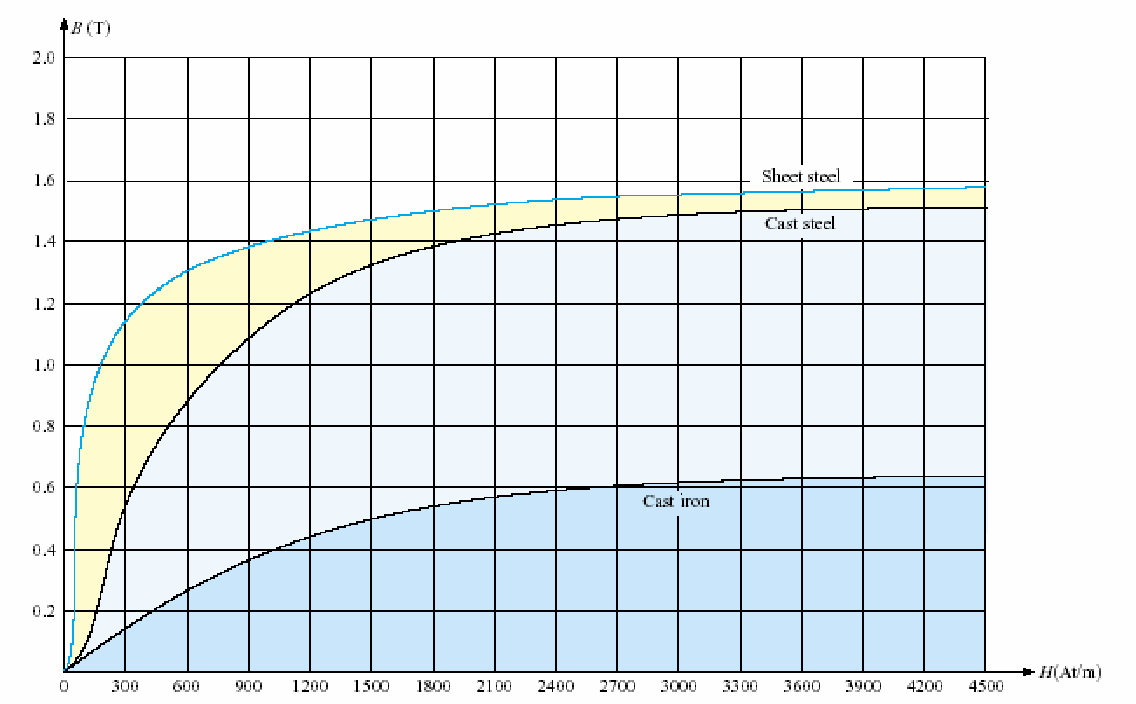

FIG. 11.23
Normal magnetization curve for three ferromagnetic materials.

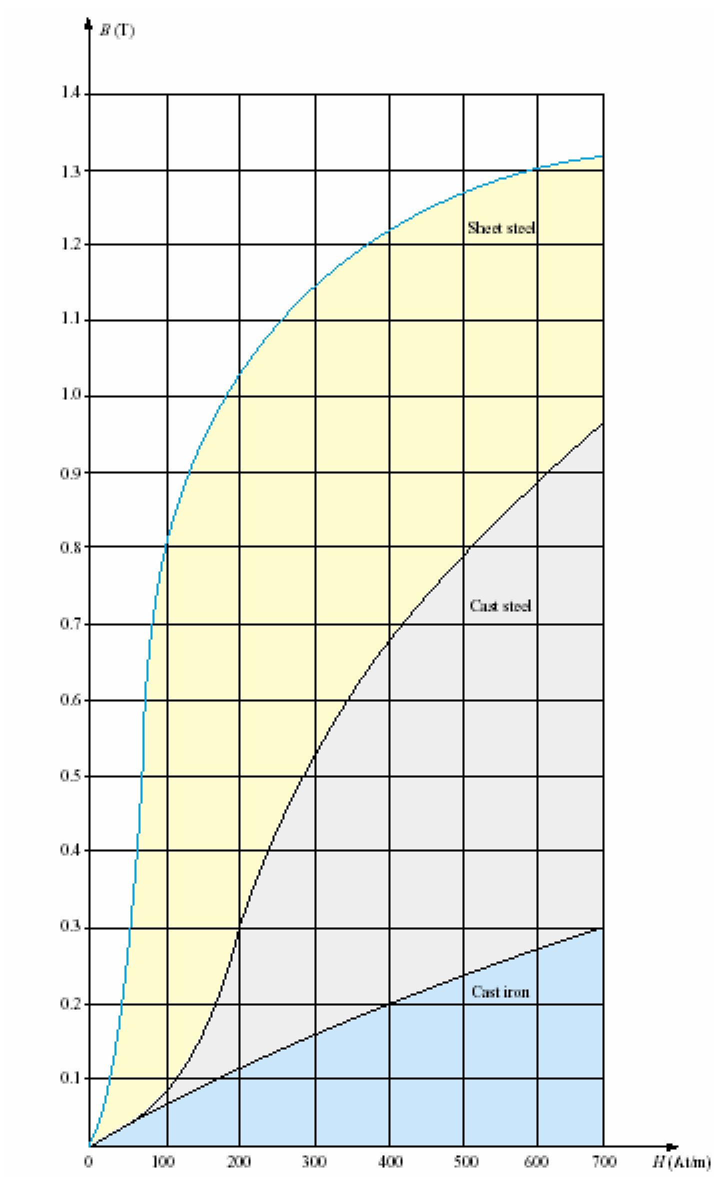

FIG. 11.24
Expanded view of Fig. 11.23 for the low magnetizing force region.

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