EE 201.3

(Instructors: Lynch/Teng)

Midterm Examination

Tuesday, October 25, 2005

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: 100)**

2	3	4	5	6	Total
/15	/25	/15	/25	/20	/100

Name:____

Student Number:__________________________________

Some potentially useful constants/relationships:

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

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

Magnetic field, B, a distance d from a wire carrying current I: $B = \dfrac{\mu_o I}{2\pi d}$

Magnetic force of attraction: $F_{att} = \dfrac{B^2 A}{2\mu_o}$

1) Find the reluctance of a magnetic circuit if a magnetic flux $\Phi = 5.2\times10^{-4}$ Wb is established by an impressed mmf of 400 A-t.

[2]

2) Two long parallel conductors, separated by a distance a = 10 cm, carry currents in the same direction. If $I_1 = 5A$ and $I_2 = 8A$, what is the force per meter unit length exerted on each conductor by the other?

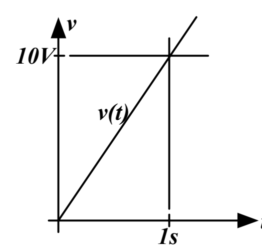
[4]

Do they attract or repel each other?

[1]

3) The voltage observe across a 1Henry inductor is shown in the diagram. Assuming the current through the inductor at $t = 0$ is 0A, what is the current through the inductor at $t = 1s$?

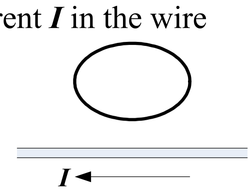
[4] i) 5A ii) 10A iii) 20A



4) What is the direction of induced current in the oval loop when the current ***I*** in the wire shown below the loop decreases rapidly to zero?

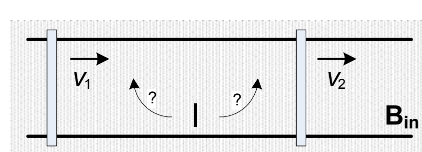
[2]

i) Clockwise ii) Counterclockwise



5) Two bars are moving toward right on two parallel rails. If $v_1 > v_2$, determine the direction of current in the loop (*before* the first bar catches the second bar) formed by the two bars and the rails between them.

i) Clockwise ii) Counterclockwise



[2]

6) A 30-turn circular coil of radius 4 cm and resistance 1Ω is place in a magnetic field directed perpendicular to the plane of the coil. The magnitude of the magnetic field varies in time according to the expression $B = 0.01t + 0.04t^2$. Calculate the induced *emf* in the coil at $t = 5$s

[5]

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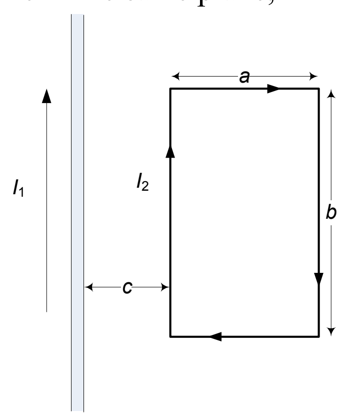
7) A rectangle loop and a long straight current-carrying conductor lie in the same plane, where the current in the wire, $I_1 = 10$A, the current in the loop, $I_2 = 5$A , $a = 10$ cm, $b = 20$ cm, and $c = 5$ cm. Find the magnitude and direction of the net force exerted on the rectangular loop by the magnetic field of the long straight conductor. (Hint, net force is *not* zero!)



[7]

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8) The current through a 100mH inductor over a period of time, *t*, is given by: $i_L(t) = (3 \times 10^{-3})t^2 A$. What is the voltage across the inductor at time $t = 10ms$?

[3]

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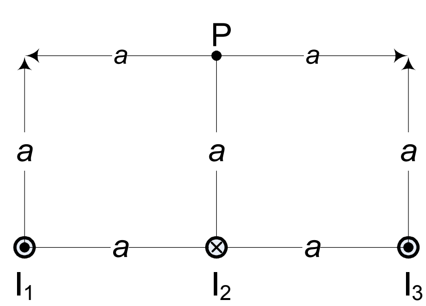
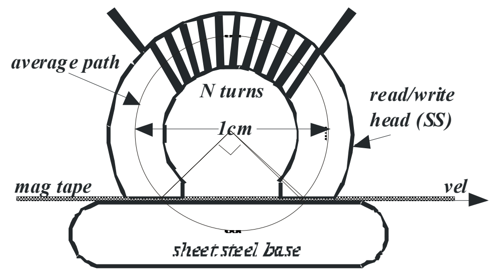
9) In the figure below, wire 1 carries a current $I_1 = 30$ mA, wire 2 carries a current $I_2 = 20$ mA, and wire 3 carries a current $I_3 = 40$ mA. Currents I_1 and I_3 are out of the page. Current I_2 is into the page.

Find the resultant magnetic field **B** at point P when $a = 10$ cm.



[10]

10) A magnetic read/write head is used to "imprint" data on a magnetic tape as it is moved between the head and a matching sheet steel base. The tape is made of a mylar strip 2 mils thick ***(.0508mm)*** impregnated with a ferrite material giving it a $\mu_r = 10$. The average path in this magnetic circuit is circular with a diameter of ***1cm***. 75% of the path is in the head and the other 25% is in the base (the thickness of the tape can be ignored in terms of determining the path length in the head and base). The effective cross-sectional area in the base is 3mm X 6mm, but it is only 3mm X 3mm everywhere else in the circuit including the interface between the head and the base (i.e. through the tape)



The system has been designed so that a drive current of 30mA is available to provide the field density of B = 1.3T needed to effectively magnetize the tape.

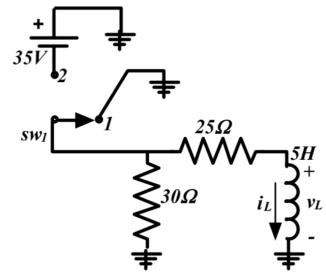
[10] **a)** How many turns are required in the head coil to supply the necessary magnetic field strength?

[5] **b)** How much *extra* force is required to pull the tape through the mechanism due only to the magnetic attraction at this flux density (1.3T) if the coefficient of friction, μ, is 0.05?

(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)		

11) Consider the R-L circuits shown in the figures to answer the following questions on transients. (Note the polarities indicated for i_L and v_L when answering.)



a) The switch, sw_1, has been in position 1for a long time. At $t = 0$, the switch is moved to position 2

i) What is the final, steady-state current, I_f, through the inductor after the switch is moved to position 2?

[2]

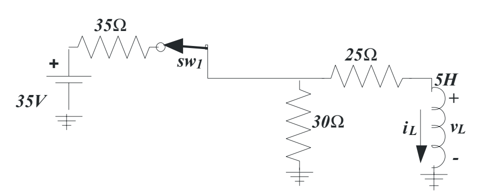
ii) What is the time constant, τ, of the charging circuit?

[3]

iii) What is the value of the current through the inductor 0.1s after the switch is moved to position 2?

[5]

b) The switch, sw_1, has been closed for a long time. At $t = 0$, the switch is opened.



i) What is the steady-state current, I_i , through the inductor *before* the switch is opened?

[2]

ii) What is the time constant, τ, of the R-L circuit *after* the switch is opened?

[3]

iii) Write the expression that gives the current through the inductor as a function of time after the switch is opened.

[5]

c) The current through an inductor is given by the expression:

$$i_L = 0.25 - 0.5e^{-4t} A \text{, } t \geq 0$$

i) What is the initial current (@ t = 0^+)

[1]

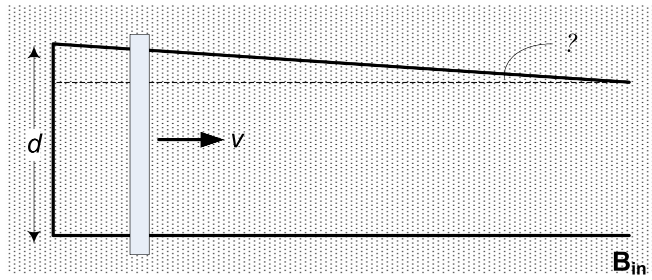
ii) What is the final current (@ t = ∞)

[1]

i) At what time after $t = 0$ will the current be 0A?

[3]

12) Consider the following bar & rail system in a magnetic field **B = 0.5T**. The bar is moving to right at a constant velocity **v = 1.0 m/s**. The two rails, **1m** apart (i.e. d = 1m), form an angle $\theta = 1°$.



a) Assume the bar is at rest at the left end at $t = 0$. Find the motional emf, **E** , between the rails as a function of time.

[15]

b) Assume the only resistance in the system is in the bar which has an internal resistance R/ℓ = 0.1Ω/m. Find the induced current at $t = 30$s.

[3]

c) Calculate the magnitude and direction of the force required to keep the bar moving at the constant velocity at $t = 30$s.

[2]

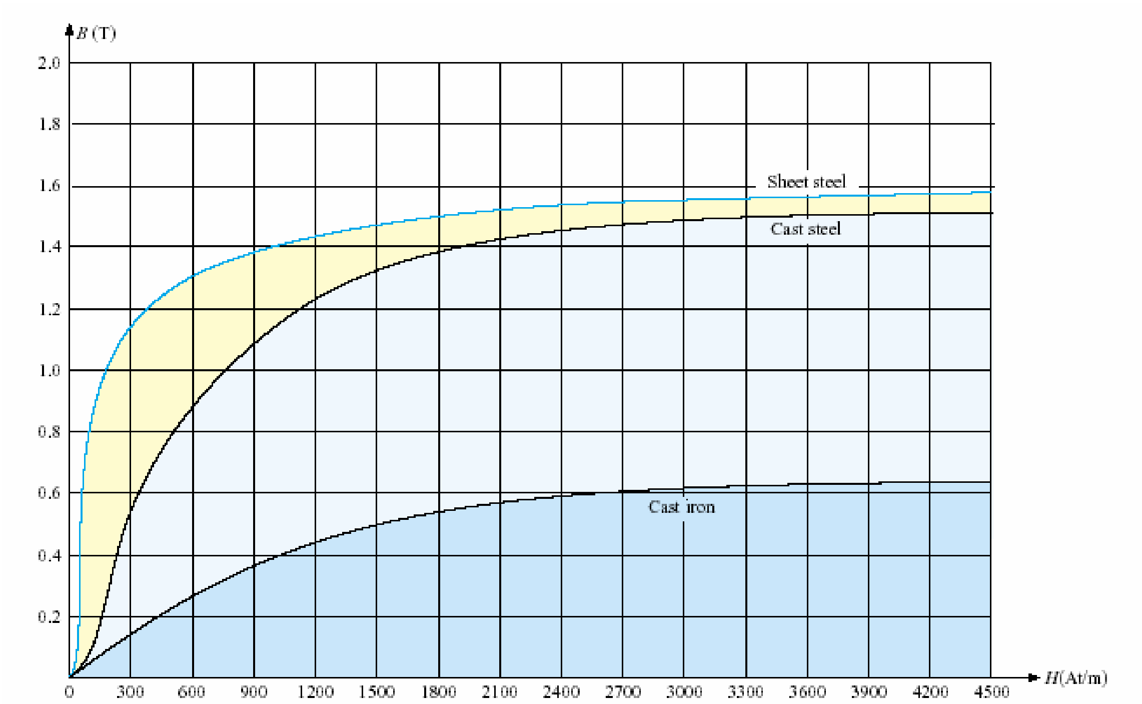


FIG. 11.23
Normal magnetization curve for three ferromagnetic materials.

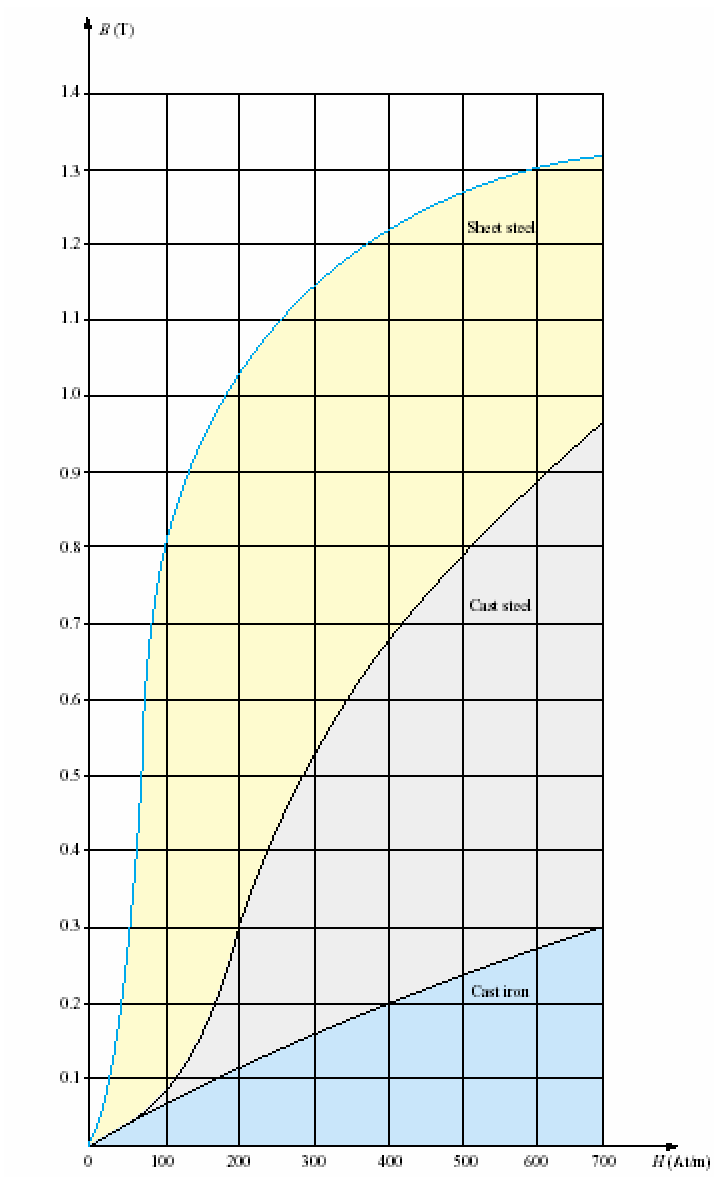


FIG. 11.24
Expanded view of Fig. 11.23 for the low magnetizing force region.

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