

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: $g = 9.81 \text{ m/s}^2$

Permeability of free space: $\mu_0 = 4\pi \times 10^{-7} \text{ Wb/At-m}$

Magnetic field, B , a distance d from a wire carrying current I : $B = \frac{\mu_0 I}{2\pi d}$

Magnetic force of attraction: $F_{att} = \frac{B^2 A}{2\mu_0}$

- 1) Find the reluctance of a magnetic circuit if a magnetic flux $\Phi = 5.2 \times 10^{-4} \text{ Wb}$ is established by an impressed mmf of 400 A-t.

[2]

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

[4]

Do they attract or repel each other?

[1]

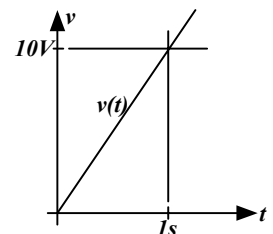
- 3) The voltage observe across a 1Henry inductor is shown in the diagram. Assuming the current through the inductor at $t = 0$ is 0A, what is the current through the inductor at $t = 1s$?

[4]

i) 5A

ii) 10A

iii) 20A

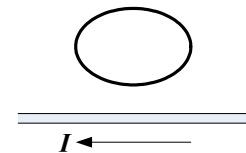


- 4) What is the direction of induced current in the oval loop when the current I in the wire shown below the loop decreases rapidly to zero?

[2]

i) Clockwise

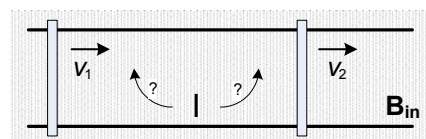
ii) Counterclockwise



- 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

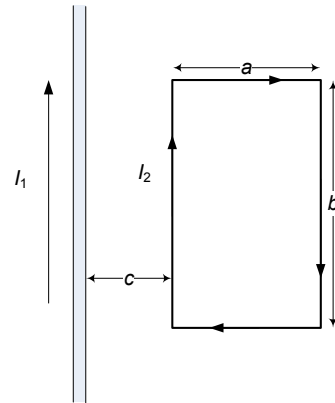


[2]

- 6) A 30-turn circular coil of radius 4 cm and resistance 1Ω is placed 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 $t = 5s$

[5]

- 7) A rectangle loop and a long straight current-carrying conductor lie in the same plane, where the current in the wire, $I_1 = 10A$, the current in the loop, $I_2 = 5A$, $a = 10\text{ cm}$, $b = 20\text{ cm}$, and $c = 5\text{ cm}$. 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!)



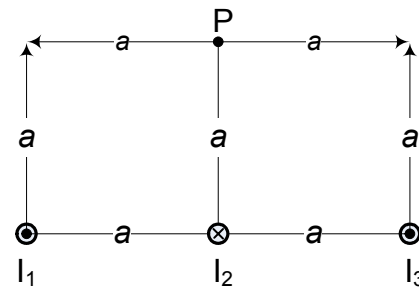
[7]

- 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]

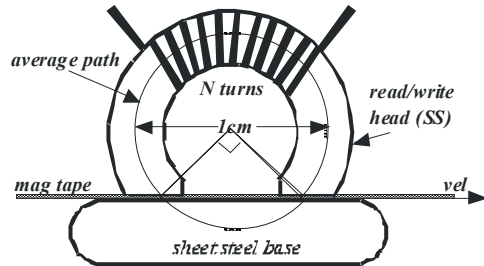
- 9) In the figure below, wire 1 carries a current $I_1 = 30\text{ mA}$, wire 2 carries a current $I_2 = 20\text{ mA}$, and wire 3 carries a current $I_3 = 40\text{ mA}$. Currents I_1 and I_3 are out of the page. Current I_2 is into the page.

Find the resultant magnetic field \mathbf{B} at point P when $a = 10\text{ cm}$.



[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.

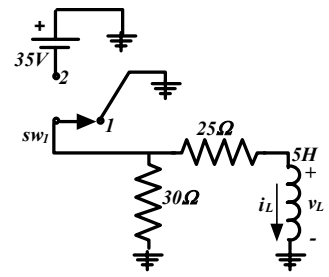
- [10] a) How many turns are required in the head coil to supply the necessary magnetic field strength?
- [5] b) How much *extra* force is required to pull the tape through the mechanism due only to the magnetic attraction at this flux density (1.3T) if the coefficient of friction, μ , is 0.05?

(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) | HI (At) | | |
|-----|-------------|---------------------|-------|----------|-------|---------|--|--|
| | | | | | | | | |
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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 1 for 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]

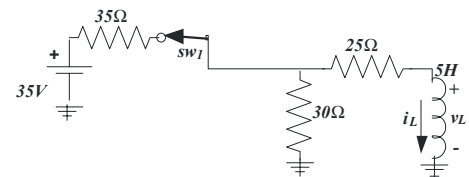
- iii) What is the value of the current through the inductor 0.1s after the switch is moved to position 2?

[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:

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

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

[1]

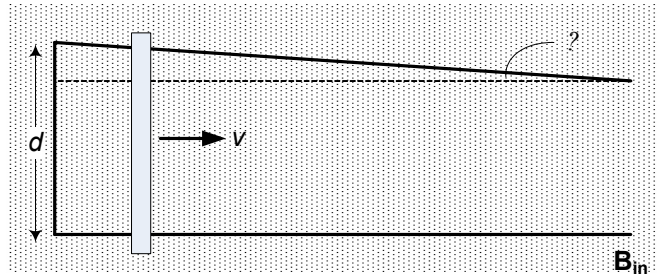
- ii) What is the final current (@ $t = \infty$)

[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 $\mathbf{B} = 0.5\text{T}$. The bar is moving to right at a constant velocity $v = 1.0\text{ m/s}$. The two rails, 1 m apart (i.e. $d = 1\text{ m}$), form an angle $\theta = 1^\circ$.



- a) Assume the bar is at rest at the left end at $t = 0$. Find the motional emf, \mathbf{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 $R/\ell = 0.1\Omega/\text{m}$. Find the induced current at $t = 30\text{ s}$.

[3]

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

[2]

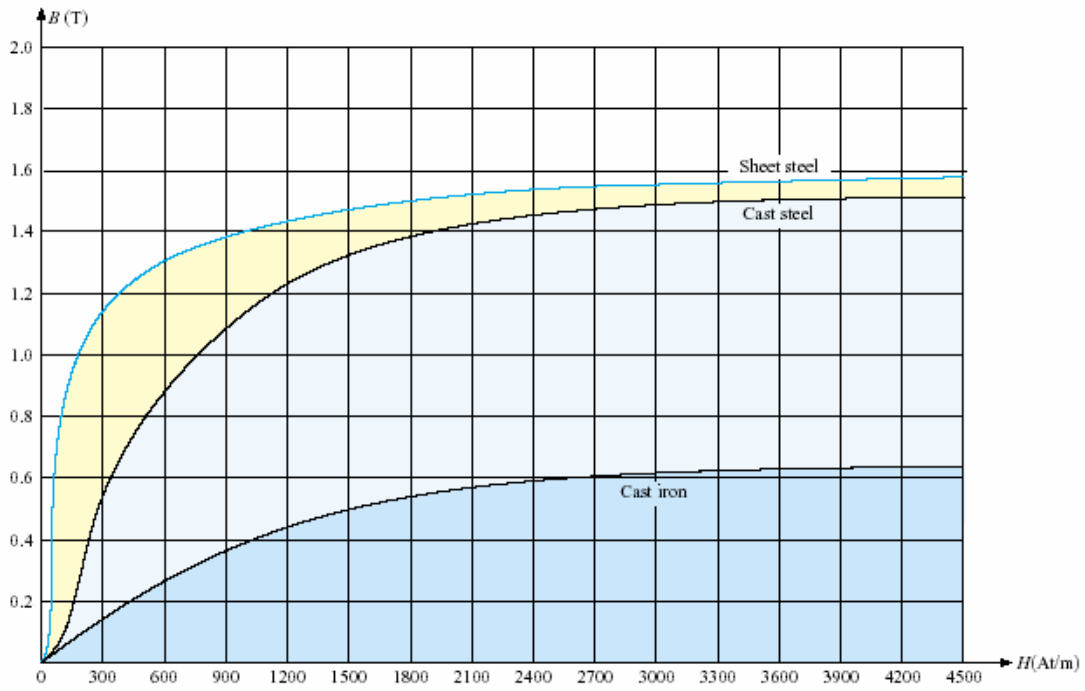


FIG. 11.23
Normal magnetization curve for three ferromagnetic materials.

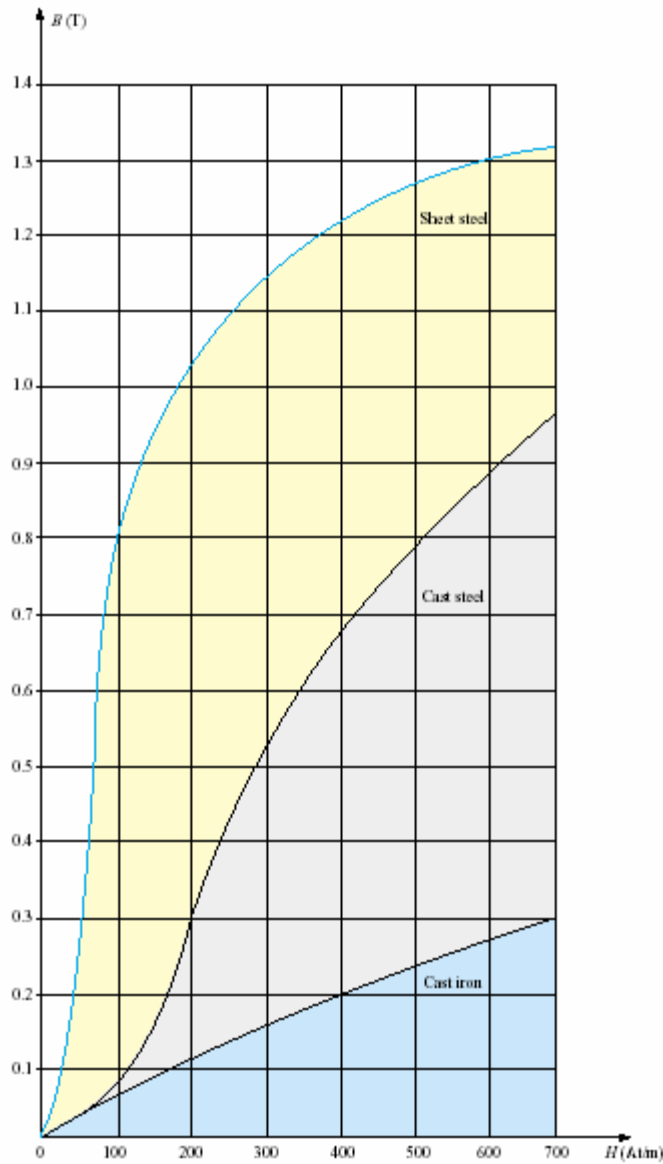


FIG. 11.24
Expanded view of Fig. 11.23 for the low magnetizing force region.

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