EE 201.3 (Sections 01/03)

(Instructors: Dr. Daniel Teng/Denard Lynch)

Final Examination

Friday, December 9, 2005

9:00 AM

Time Allowed: 3 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. Please try to write neatly.**
- **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:)**

2	3	4	5	6	7	Total
/	/	/	/	/	/	/

Name: ____

Student Number: ____

1) [1] Energy is stored in inductors in the form of:

i) Current ii) Magnetic field iii) Voltage iv) Charges

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2) [1] Energy is stored in capacitors in the form of:

i) Current ii) Magnetic field iii) Voltage iv) Charges

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3) [2] Convert $v = 15\sin(120\pi t + 20°)$ to phasor form.

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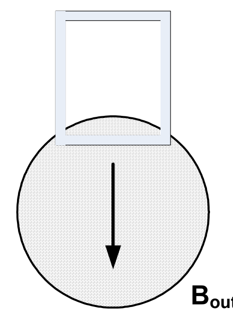
4) [2] Determine the direction of the induced current in the rectangular loop *when it falls into* a magnetic field **B** as shown in the figure on the right.

i) Clockwise ii) Counterclockwise



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5) [3] The effective value of $v = a + 10\sin(377t + 50°)$ is 8.66. Determine a.

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6) [2] Determine the number of cycles in 0.25 seconds for sin(377t + 80°).

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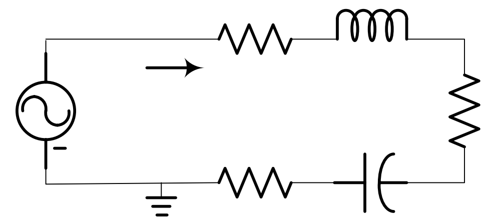
7) [3] Determine the number of turns required to make an 8μH air core inductor that is 100mm long and has a circular cross-section with radius equal to 5mm.

8) For the network shown below:
[5]

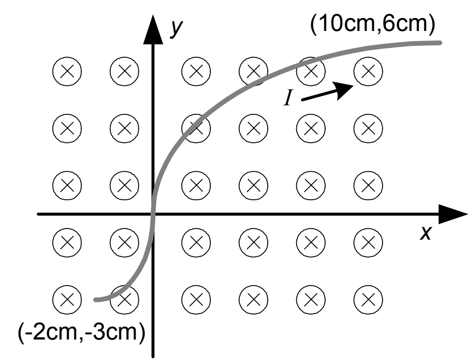
a) Determine the frequency, f_{max}, of the ac voltage source that results in the maximum current, *I*.



b) Establish and sketch the power triangle for the network at the frequency f_{max}.

9) A wire conductor carrying a current $I = 50\text{mA}$ is lying in the *x-y* plane with one end at (-2cm, -3cm) and the other end at (10cm, 6cm). Assume the magnetic field B = 0.5T.

Determine the net magnetic force (**magnitude** and **direction**) exerting on the wire.
[4]

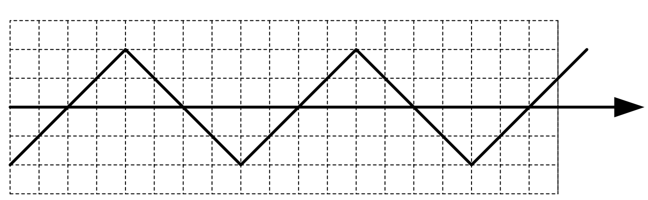


10) A series *R-L-C* resonant circuit is connected to a source $E = 2\angle 0^{\circ}$. The total resistance of the circuit is 5Ω. (Assume ideal components)
[5]

a) Determine the reactance,X_L, of the inductor if the quality factor, Q, of the resonant circuit is 25.

b) Determine voltage across inductor.

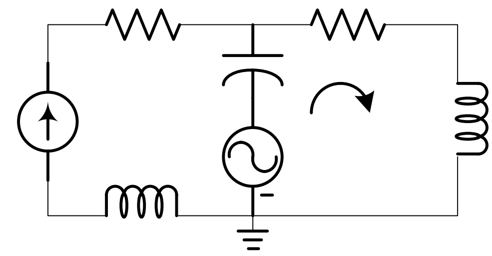
11) The **current** through an inductor is shown in the graph below. (The numbers on the graph aren't sequential…it looks like a mistake?)
[5]



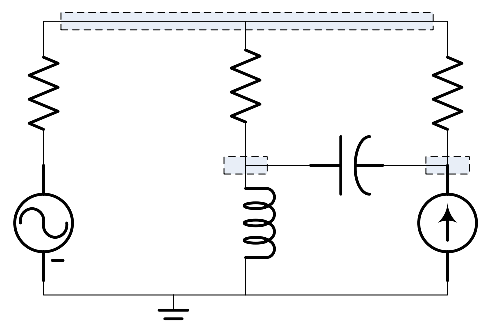
a) Determine the average value of the current.

b) Calculate the effective value of the **voltage** across the inductor if L = 1mH.

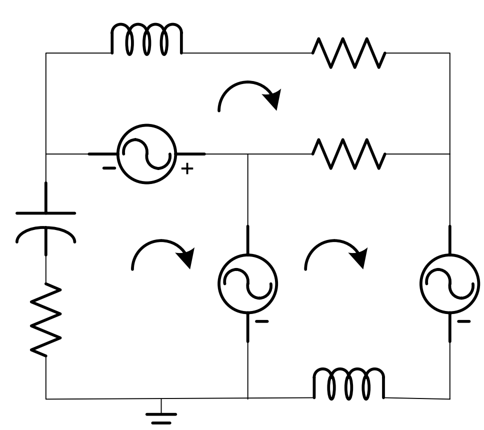
12) Determine the current I_L for the following network. [***Hint***: *Use mesh analysis, but you don't need any matrix math!*]
[8]



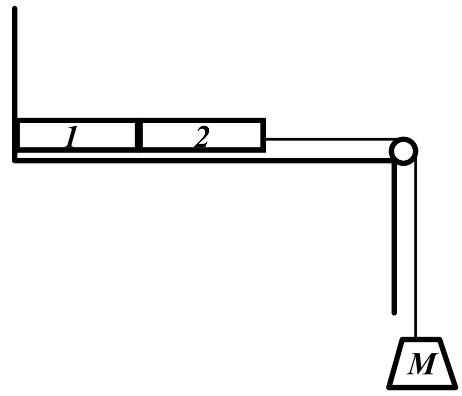
13) Write the nodal equations for the following network.
[8]



14) Write the mesh equations for the following network.
[8]



15) Two permanent magnets are arranged as shown in the sketch. They are both made out of cobalt and are each 2.5cm long with a circular cross-section of .0008m^2. Each has strength of 22.5A-t. One is firmly attached to a wall, and the other is attached through a paramagnetic cable to a mass, *M*. The two magnets are in contact with each other (i.e. no gap).



[7]

The relative permeability of the cobalt, μ_r, is 800, and can be considered constant over the range of interest. What is the maximum mass that the system can support before the magnets are pulled apart?

[***Hint*:** *You can consider the reluctance of the path through the air* <u>*outside*</u> *the magnets to be zero*.]

16) The loading of a factory on a 1000V, 60-Hz supply includes:

- 20-kW electric heating (unity power factor)
- 10-kW of induction motors (0.7 lagging power factor)
- 5-kW fluorescent lighting (0.85 lagging power factor)

[7]

a) Determine the total real power, P, reactive power, Q, and apparent power, S, for the combined load.

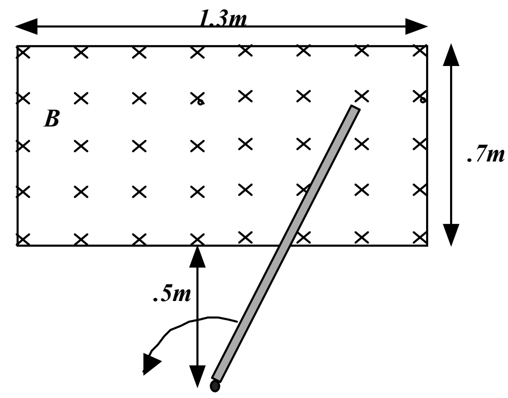
b) Draw the Power Triangle for the combined load.

c) What is the power factor, F_P for the combined load?

17) A 1m long rigid wire is rotated at 600rpm through a uniform magnet field of density B = 0.7T, which is directed into the page.

[7]

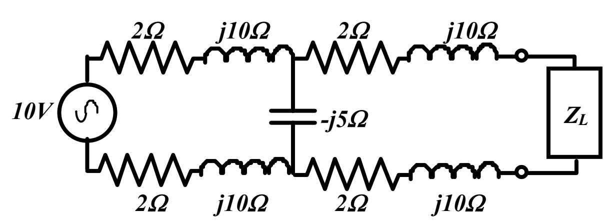
Find the maximum voltage that would be observed between the ends of the wire. (*Hint: recall from your assignments that the incremental voltage, dE, induced in a segment dr is given by* $dE=B\omega r dr$*]*



18) The network shown below is used to deliver power from the 10V source to the load.

[8]

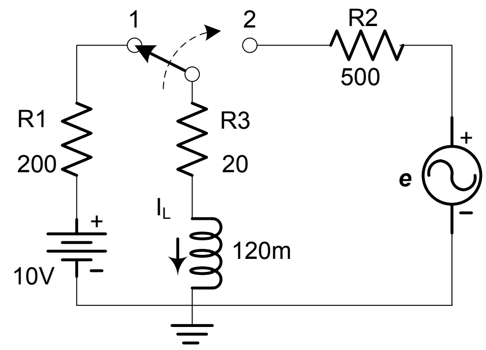
a) What is the Thevenin Equivalent impedance, Z_{Th}, of the supply network (as seen by the load)?



b) If the load impedance, $Z_L = (R_L - j5)\Omega$, what value of load resistance, R_L, will provide the maximum power transferred to the load?

19) [5] For the network shown below, $e = \sin(500t + 20°)$. Assume the switch has been on position 1 for a long time and moved to position 2 at time $t = 0$

a) Determine the initial current through inductor L at time $t = 0$.



b) Find the value of the current through the inductor at $t = 2$s.

20) [9] A motor can be modeled as $R+jX_L = (13+jX_L)\Omega$. A capacitor C = 100μF is required to raise the power factor to 1 when it is connected to a 60Hz supply.

a) Determine X_L of the motor given that the angle, θ, of the motor's impedance is < 45^0

[*Hint: recall that the roots of a quadratic equation are given by* $x_{1,2} = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$]

b) Determine the power factor of the motor *before* the compensation.

<u>Some potentially useful constants/relationships:</u>

Acceleration of gravity: $g = 9.81$ m/s^2 Magnetic force of attraction: $F_{att} = \dfrac{B^2 A}{2\mu_o}$

Permeability of free space: $\mu_o = 4\pi \times k_m = 4\pi \times 10^{-7}$ Wb/At-m 1hp = 746Watts

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