Name: _____ *Lecture Section:* _____

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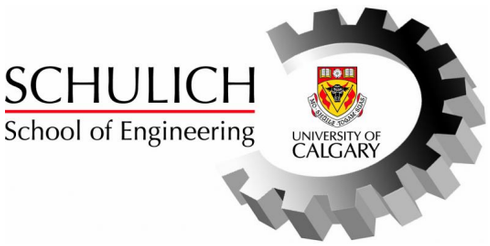

ENGG 225 - Fundamentals of Electrical Circuits and Machines

Final Examination

Saturday, April 21, 2012
Time: 12:00 - 3:00 PM

Red and Gold Gymnasium

L01 - *Anis Haque*
L02 - *Anders Nygren*
L03 - *Norm Bartley*
L04 - *Michel Fattouche*

Instructions:

- Time allowed is 3 hours.
- Please review the examination rules on Page 2.
- The examination is closed-book and closed-notes.
- Only calculators sanctioned by the Schulich School of Engineering are permitted in the examination.
- The maximum number of marks is 100, as indicated. The final examination counts toward 50% of the final grade. Please attempt all six questions.
- Please use a pen or heavy pencil to ensure legibility.
- Please answer questions in the spaces provided; if space is insufficient, please use the back of the pages.
- Where appropriate, marks will be awarded for proper and well-reasoned explanations.

(Please do not write in this space.)

#1 *(18)*	**#2** *(18)*	**#3** *(18)*	**#4** *(18)*	**#5** *(16)*	**#6** *(12)*	**Total** *(100)*

Student Identification

Each candidate must sign the Seating List confirming presence at the examination. All candidates for final examinations are required to place their University of Calgary I.D. cards on their desks for the duration of the examination. (Students writing mid-term tests can also be asked to provide identity proof.) Students without an I.D. card who can produce an **acceptable** alternative I.D., e.g., one with a printed name and photograph, are allowed to write the examination.

A student without acceptable I.D. will be required to complete an Identification Form. The form indicates that there is no guarantee that the examination paper will be graded if any discrepancies in identification are discovered after verification with the student's file. **A student who refuses to produce identification or who refuses to complete and sign the Identification Form is not permitted to write the examination.**

Examination Rules

(1) Students late in arriving will not normally be admitted after one-half hour of the examination time has passed.

(2) No candidate will be permitted to leave the examination room until one-half hour has elapsed after the opening of the examination, nor during the last 15 minutes of the examination. All candidates remaining during the last 15 minutes of the examination period must remain at their desks until their papers have been collected by an invigilator.

(3) All inquiries and requests must be addressed to supervisors only.

(4) **The following is strictly prohibited:**

   (a) speaking to other candidates or communicating with them under any circumstances whatsoever;
   (b) bringing into the examination room any textbook, notebook or document not authorized by the examiner;
   (c) making use of calculators, cameras, cell-phones, computers, headsets, pagers, PDA's, or any device not authorized by the examiner;
   (d) leaving examination papers exposed to view;
   (e) attempting to read other student's examination papers.

   The penalty for violation of these rules is suspension or expulsion or such other penalty as may be determined.

(5) Candidates are requested to write on both sides of the page, unless the examiner has asked that the left hand page be reserved for rough drafts or calculations.

(6) Discarded matter is to be struck out and not removed by mutilation of the examination answer book.

(7) Candidates are cautioned against writing on their examination paper any matter extraneous to the actual answering of the question set.

(8) The candidate is to write his/her name on each answer book as directed and is to number each book.

(9) During the examination a candidate must report to a supervisor before leaving the examination room.

(10) Candidates must stop writing when the signal is given. Answer books must be handed to the supervisor-in-charge promptly. Failure to comply with this regulation will be cause for rejection of an answer paper.

(11) If during the course of an examination a student becomes ill or receives word of a domestic affliction, the student should report at once to the supervisor, hand in the unfinished paper and request that it be cancelled. If physical and/or emotional ill health is the cause, the student must report at once to a physician/counsellor so that subsequent application for a deferred examination is supported by a completed Physician/Counsellor Statement form. Students can consult professionals at University Health Services or Counselling and Student Development Centre during normal working hours or consult their physician/counsellor in the community. **Once an examination has been handed in for marking a student cannot request that the examination be cancelled for whatever reason. Such a request will be denied. Retroactive withdrawals will also not be considered.**

1. Consider the DC circuit shown in Fig. 1.

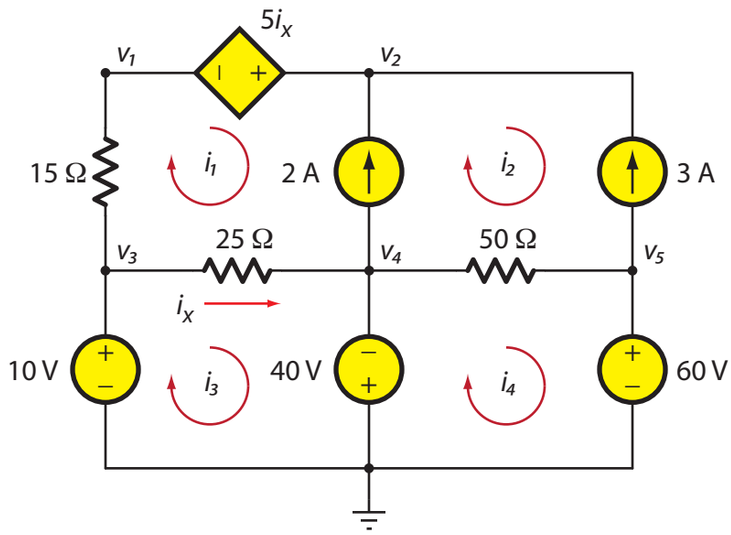

Fig. 1. Find the node voltages and mesh currents; confirm energy balance.

(a) Determine all of the indicated node voltages. **[5 marks.]**

(b) Determine all of the indicated mesh currents. **[4 marks.]**

(c) Using your answers to parts (a) and (b), calculate the total power in the circuit, and confirm that the total power is zero.

(Note: If you are unable to determine answers to parts (a) or (b), you may assume any non-zero values to solve this part.) **[9 marks.]**

Please write your answers in the table below. **[18 marks total.]**

v_1=	v_2=	v_3=	v_4=	v_5=
i_1=	i_2=	i_3=	i_4 =	
$p_{15\Omega}$=	p_{5i_x}=	p_{2A}=	p_{3A} =	$p_{25\Omega}$=
$p_{50\Omega}$=	p_{10V}=	p_{40V}=	p_{60V}=	

(Problem #1 extra workspace.)

2. Consider the steady-state sinusoidal AC circuit shown in Fig. 2, which operates at a frequency of $f = 60$ Hz. The voltage source $\mathbf{V}$ is given in phasor form as follows:

$$\mathbf{V} = 100\angle 0^\circ \text{ V}_{rms}.$$

(Note that the amplitude is specified as an rms quantity, not peak.)

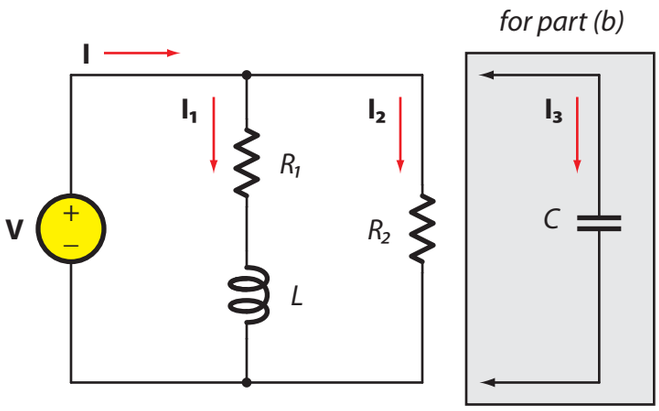

Fig. 2. Find R_1, R_2, and L; then attach $C = 265.26\mu F$, and find $\mathbf{I}$, $\mathbf{I}_1$, $\mathbf{I}_2$, $\mathbf{I}_3$

(a) For this circuit, suppose that it is known that:

- total phasor current $\mathbf{I} = 20 - j10$ A$_{rms}$, and
- the average power absorbed by R_2 is 1000 W.

Determine the values of R_1, R_2, and L. **[12 marks.]**

(b) Now add the capacitor with $C = 265.26\mu F$ to the circuit, as shown. Determine the phasor currents $\mathbf{I}_1$, $\mathbf{I}_2$, $\mathbf{I}_3$, and the new total phasor current $\mathbf{I}$. Sketch a phasor diagram showing the four phasor currents. Label the magnitudes as *rms* values and label the angles in degrees.

(Note: If you are unable to determine the component values in part (a), you may assume any non-zero values to solve this part.) **[6 marks.]**

[18 marks total.]

(Problem #2 extra workspace.)

3. Consider the inductor in Fig. 3(a). The inductor voltage $v_L(t)$ is shown in Fig. 3(b). There is no initial inductor current; i.e., $i(0) = 0$ A.

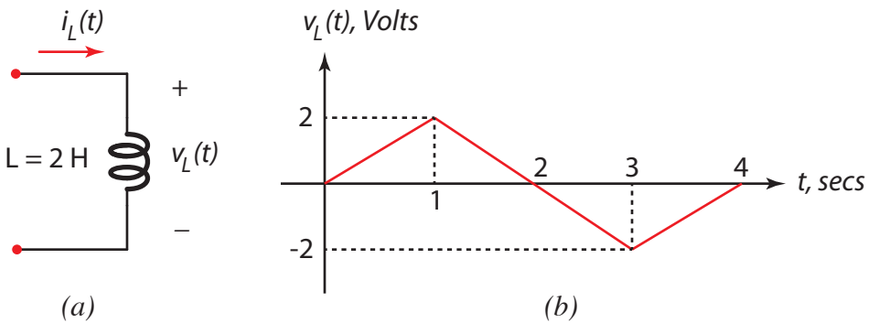

Fig. 3. Find and sketch $i_L(t)$; find power $p_L(t)$

(a) Find and sketch the inductor current $i_L(t)$ for $0 \leq t \leq 4$ seconds. **[12 marks.]**

(b) Find the inductor power $p_L(t)$ for $0 \leq t \leq 4$ seconds (it is not necessary to sketch this). **[6 marks.]**

[18 marks total.]

(Problem #3 extra workspace.)

4. The op-amps in Fig. 4 are ideal and are operating in their linear regions.

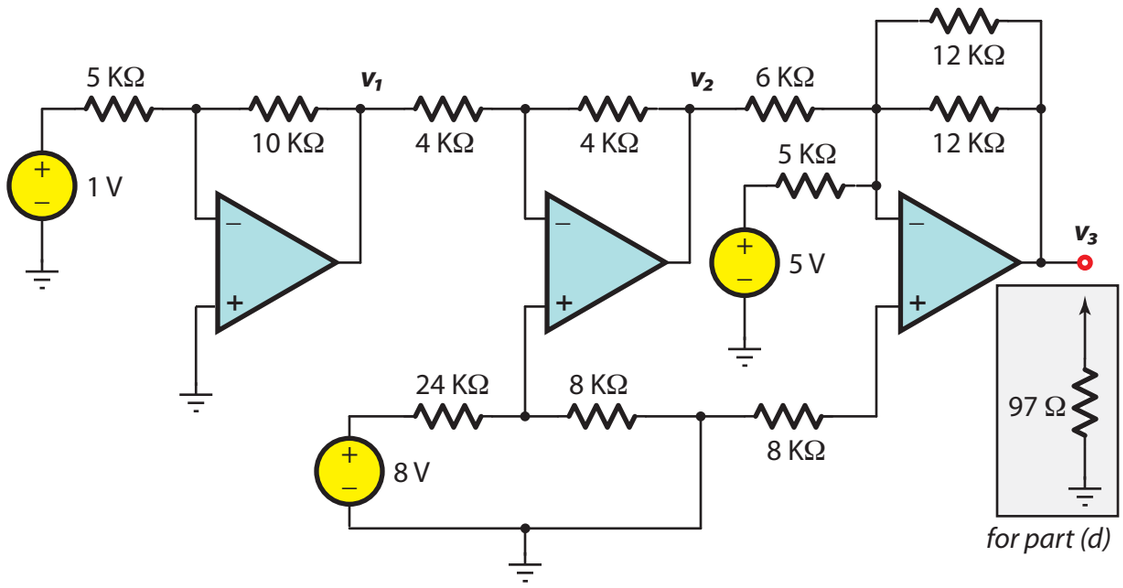

Fig. 4. Find v_1, v_2, v_3 in parts (a-c); attach 97 Ω resistor in part (d).

(a) Determine node voltage v_1. **[4 marks.]**

(b) Using your answer for v_1, determine node voltage v_2. **[6 marks.]**

(c) Using your answer for v_2, determine node voltage v_3. **[6 marks.]**

(d) Repeat part (c) now with the 97 Ω resistor attached to node v_3, as shown. **[2 marks.]**

[18 marks total.]

(Problem #4 extra workspace.)

5. Consider the steady-state sinusoidal AC circuit in Fig. 5, which contains two sources that operate at different frequencies. The current source produces a *DC (i.e., zero-frequency) current* of 3 A. The voltage source produces an *AC voltage* $v(t)$ given as follows:

$$v(t) = 10\cos(1000t) \text{ V}$$

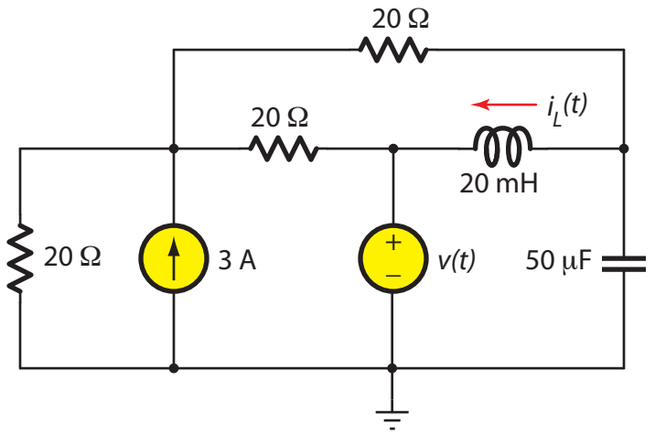

Fig. 5. Find $i_L(t)$ by the principle of superposition

Determine the inductor current $i_L(t)$ using the principle of superposition.

[16 marks total.]

(Problem #5 extra workspace.)

6. Consider a separately excited DC motor (i.e., the DC machine configuration in which the field windings and the armature are connected to different voltage sources). This motor has the following full-load specifications:

   - Terminal voltage for the armature circuit is $V_T = 220$ V;
   - Output power $P_{out} = 3$ HP (1 HP = 746 W);
   - Armature current $I_A = 12.2$ A;
   - Shaft speed $n_m = 950$ rpm;
   - Armature resistance $R_A = 1.3\ \Omega$;

   The field current remains constant for both parts of this problem. Recall the basic machine equations $E_A = K\phi\omega_m$, $T_{dev} = K\phi I_A$, and $P = T\omega_m$.

   (a) Find the developed power P_{dev}, developed torque T_{dev}, power lost in R_A, and the rotational power loss P_{rot}. Express your power calculations in Watts. **[6 marks.]**

   (b) Assuming that the rotational torque loss T_{rot} is independent of speed, find the no-load speed of the motor. **[6 marks.]**

   [12 marks total.]