Name: _____ *Lecture Section:* **L20**

ID#: _____

NRB
RWB

SCHULICH School of Engineering
UNIVERSITY OF CALGARY

ENGG 325 - Electric Circuits and Systems

Final Examination

Spring Session, 2008

Monday, June 30, 2008
Time: 12:00 - 3:00 PM

ENE 322

L20 - Norm Bartley

Instructions:

- Time allowed is 3 hours.
- Please review the examination rules on Page 2.
- The examination is closed-book. One double-sided 8.5x11-inch formula sheet may be used in the examination.
- 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** *(16)*	**#5** *(20)*	**#6** *(10)*	**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 physican/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. P1.

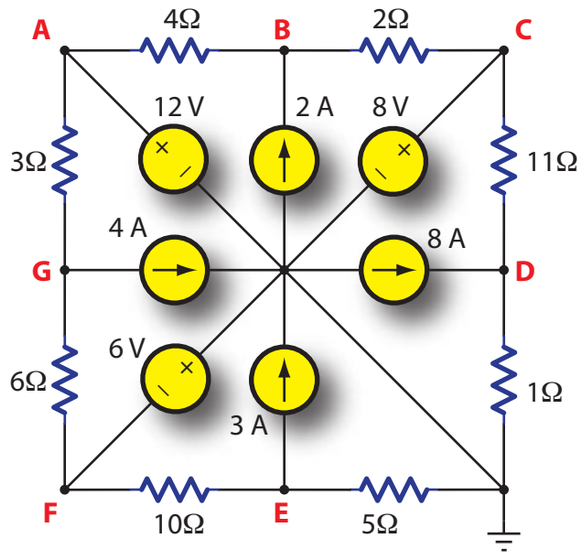

Fig. P1. Find all node voltages and power in the sources

(a) Use a method of your choosing to find all of the indicated node voltages **A-G**. **[8 marks.]**

(b) Using whatever values you calculated in part (a), determine the power in all of the sources. **[10 marks.]**

[18 marks total.]

(Problem #1 extra workspace.)

2. Consider the AC circuit shown in Fig. P2, which is operating in AC steady-state. The two voltage sources are at *different frequencies* and are defined as follows:

   - $v_1(t) = 10\cos(100t)$ V.
   - $v_2(t) = 5\cos(50t + 90°)$ V.

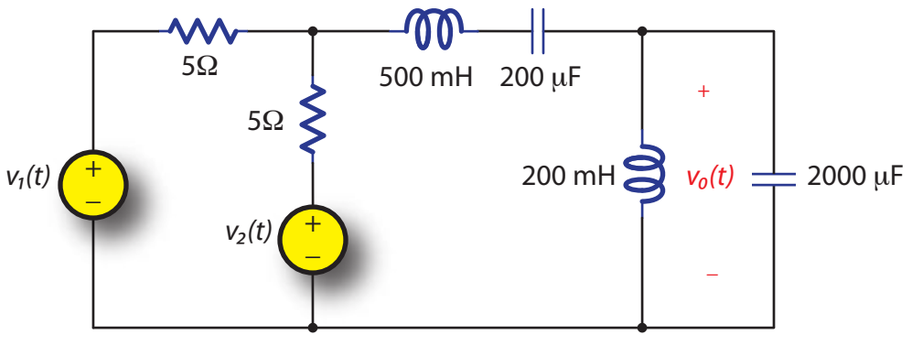

Fig. P2. Find $v_o(t)$ by superposition

(a) Determine $v_o(t)$ using the principle of superposition. **[14 marks.]**

(b) Sketch two phasor diagrams, one showing $\mathbf{V}_1$ and its contribution to $\mathbf{V}_o$, the other showing $\mathbf{V}_2$ and its contribution to $\mathbf{V}_o$. **[4 marks.]**

[18 marks total.]

(Problem #2 extra workspace.)

3. For the resistor-inductor (RL) circuit shown in Fig. P3, there are two switches S_1 and S_2. Assume that both switches have been open for a long time for $t < 0$, allowing the circuit to reach DC steady-state.

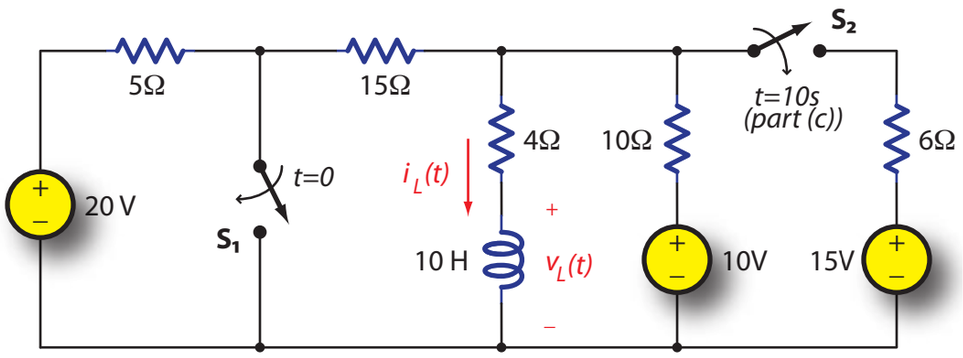

Fig. P3. Find $i_L(t)$ and $v_L(t)$ in an RL circuit with two switches

(a) Switch S_1 closes at time $t = 0$, and S_2 remains open forever. Express $i_L(t)$ in equation form for all t, and sketch $i_L(t)$. Indicate the value of $i_L(t)$ after one time constant $t = \tau$. **[8 marks.]**

(b) Using whatever expression you obtained in part (a) for $i_L(t)$, determine and sketch $v_L(t)$. **[4 marks.]**

(c) Let switch S_1 close at $t = 0$ as above, and now assume that switch S_2 closes at time $t = 10$ seconds. Determine the following:

- The new time constant τ for $t \geq 10$s;
- The value of $i_L(t)$ at $t = 10$ seconds;
- The new DC steady-state value of $i_L(t)$ as $t \to \infty$.

It is not necessary to sketch $i_L(t)$. **[6 marks.]**

[18 marks total.]

(Problem #3 extra workspace.)

4. The op amps in Fig. P4 are ideal. The independent current source supplies a sinusoidal current of phasor value **I**.

   (a) Determine the phasor voltage **V** across this current source in terms of **I** and the other circuit component values. **[12 marks.]**

   (b) Use whatever you calculated in part (a) to determine the total equivalent impedance Z_{eq} of the circuit connected to the current source. Sketch a simple equivalent circuit with the current source **I** and this Z_{eq}. **[4 marks.]**

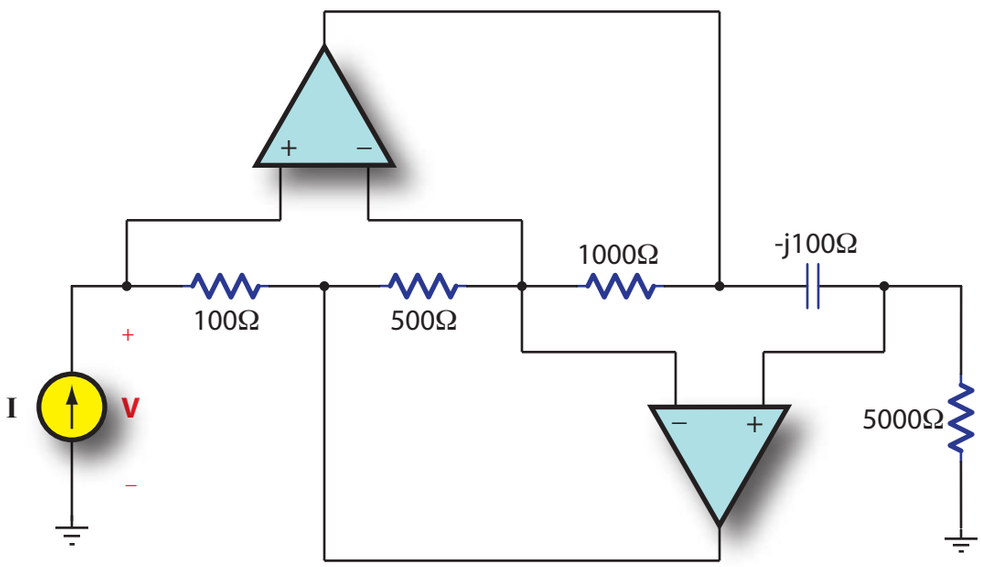

Fig. P4. Find phasor voltage **V** *and the equivalent* Z_{eq}

[16 marks total.]

(Problem #4 extra workspace.)

5. Consider the diode circuit shown in Fig. P5(a).

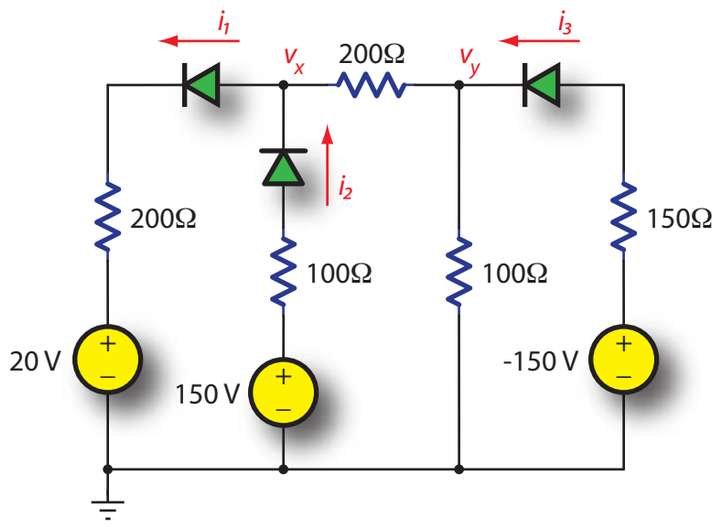

Fig. P5(a). Find v_x, v_y, i_1, i_2, and i_3

(a) Assuming ideal diodes, find v_x, v_y, i_1, i_2, and i_3. Justify your choice of the on/off state for each diode. **[8 marks.]**

(b) Now assume that each diode is characterized by the i_d-v_d relationship shown in Fig. P5(b). Find v_x, v_y, i_1, i_2, and i_3. **[12 marks.]**

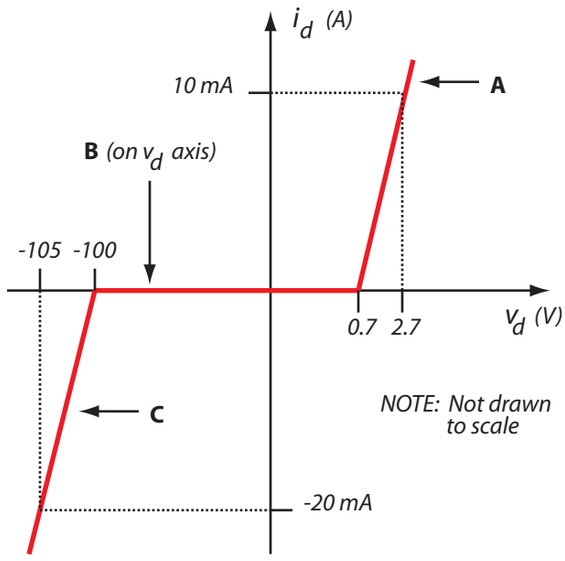

Fig. P5(b). Piecewise-linear diode characteristic

[20 marks total.]

(Problem #5 extra workspace.)

(Problem #5 extra workspace.)

6. A separately-connected DC machine (i.e., the machine configuration in which the field windings and the armature are connected to separate voltage sources) has been determined to have the following operating conditions:

   - Rotation speed $n = 3000$ rpm;
   - Total developed power $P_{dev} = 30$ HP (1 HP = 746 W);
   - Friction power loss $P_{rot} = 2$ HP at 3000 rpm;
   - Armature voltage $V_A = 250$ V; field voltage $V_F = 100$ V;
   - Armature current $I_A = 100$ A;
   - Total field resistance $R_F + R_{adj} = 20\Omega$;

   (a) Determine the following:

      i. Armature EMF E_A;
      ii. Armature resistance R_A;
      iii. Machine constant $K\phi$;
      iv. Efficiency η. **[8 marks.]**

   (b) Suppose that the mechanics in the shop discovered that the machine's bearings were in need of lubrication, which they then lubricated with a special concoction to eliminate all rotational losses ($P_{rot} = 0$ W). Suppose they tested the motor with the mechanical load also disconnected, so the total $P_{dev} = 0$ W. Determine the rotation speed in rpm of the motor running no-load and frictionless, assuming the same value of $K\phi$ in part (a).
   [2 marks.]

[10 marks total.]

(Problem #6 extra workspace.)