Name: _____ *Lecture Section:* _____

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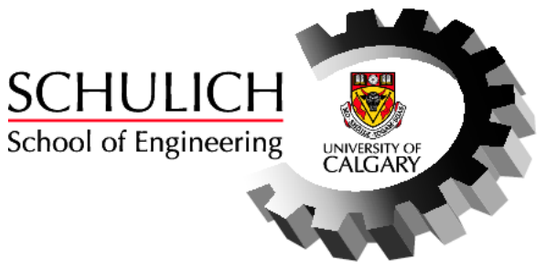

ENGG 325 - Electric Circuits and Systems

Final Examination

Monday, December 10, 2007
Time: 8:00 - 11:00 AM

Gold Gymnasium

L01 - Pouyan (Yani) Jazayeri (WMF 8:00)
L02 - Ed Nowicki (MWF 13:00)
L03 - Fabio Ayres (MWF 16:00)
L04 - Norm Bartley (MWF 13:00)

Instructions:

- Time allowed is 3 hours (except for DRC students).
- 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 *(16)*	**#2** *(18)*	**#3** *(16)*	**#4** *(16)*	**#5** *(18)*	**#6** *(16)*	**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.

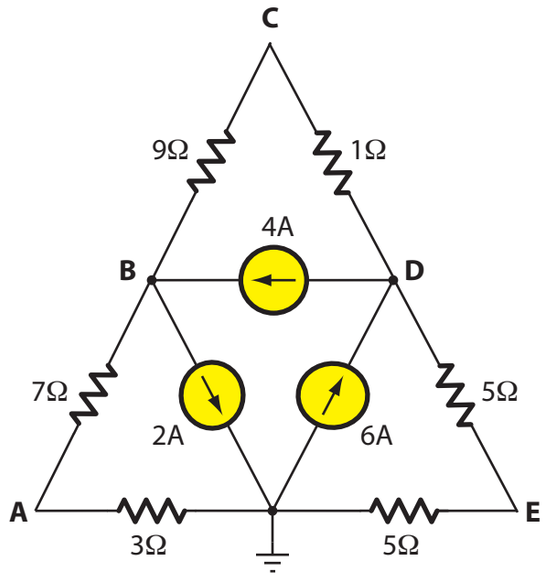

Fig. P1. Find all node voltages and confirm energy balance

(a) Use the node-voltage method and inspection to find the node voltages V_A, V_B, V_C, V_D, and V_E. **[8 marks.]**

(b) Find the power for each source, indicating if power is being absorbed or supplied. **[4 marks.]**

(c) Illustrate numerically for this circuit that energy is conserved. **[4 marks.]**

[16 marks total.]

(Problem #1 extra workspace.)

2. Consider the AC circuit shown in Fig. P2, which is operating in steady-state. Each source has a frequency of 50Hz. The three sources are defined as follows:

   - $i_3(t) = 10\cos(\omega t)$ A.
   - $i_1(t)$ has a *peak-to-peak* value of 50 A and *lags* $i_3(t)$ by 30^{o}.
   - $v_2(t)$ has an *rms* value of 100 V and *leads* $i_3(t)$ by 45^{o}.

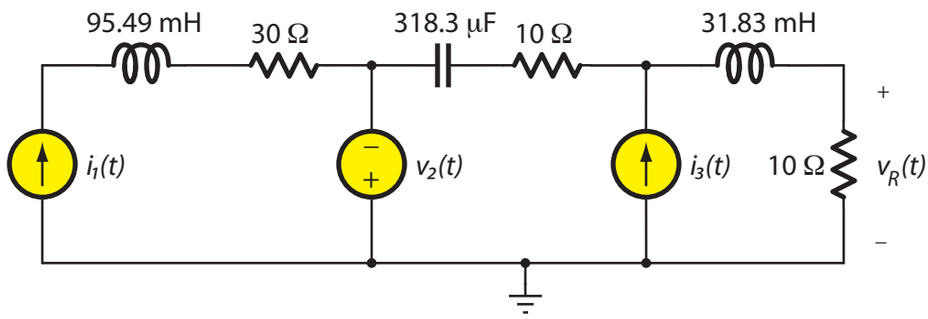

Fig. P2. Find $v_R(t)$ by superposition

(a) Redraw the circuit using phasors and impedances (three digits of accuracy is all that is necessary for the impedance values). **[4 marks.]**

(b) Find $v_R(t)$ using the principle of superposition. **[10 marks.]**

(c) Show $\mathbf{I}_1$, $\mathbf{V}_2$, $\mathbf{I}_3$, and $\mathbf{V}_R$ on a phasor diagram. **[4 marks.]**

[18 marks total.]

(Problem #2 extra workspace.)

3. For the resistor-capacitor circuit shown in Fig. P3, assume that the switch has been open for a long time allowing the circuit to reach DC steady-state. The switch is then closed at time $t = 0$.

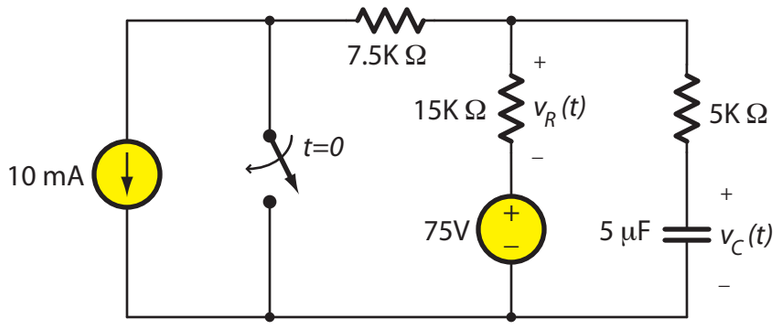

Fig. P3. Find and sketch $v_C(t)$ and $v_R(t)$

(a) Express $v_C(t)$ in equation form for all t, and sketch $v_C(t)$. Indicate the $v_C(t = \tau)$ point on the curve. **[8 marks.]**

(b) Similarly, express $v_R(t)$ in equation form for all t, and sketch $v_R(t)$. Indicate the $v_R(t = \tau)$ point on the curve. **[8 marks.]**

[16 marks total.]

(Problem #3 extra workspace.)

4. The op amps in Figs. P4(a) and P4(b) are ideal.

   (a) For the circuit of Fig. 4(a), below, find $v_0(t)$ in terms of $v_1(t)$ and $v_2(t)$. Using this result, calculate $v_0(t)$ where

   - $v_1(t) = 1 + 2\sin(100\pi t)$;
   - $v_2(t) = 1 + 5\sin(100\pi t)$.

   Sketch $v_0(t)$. **[8 marks.]**

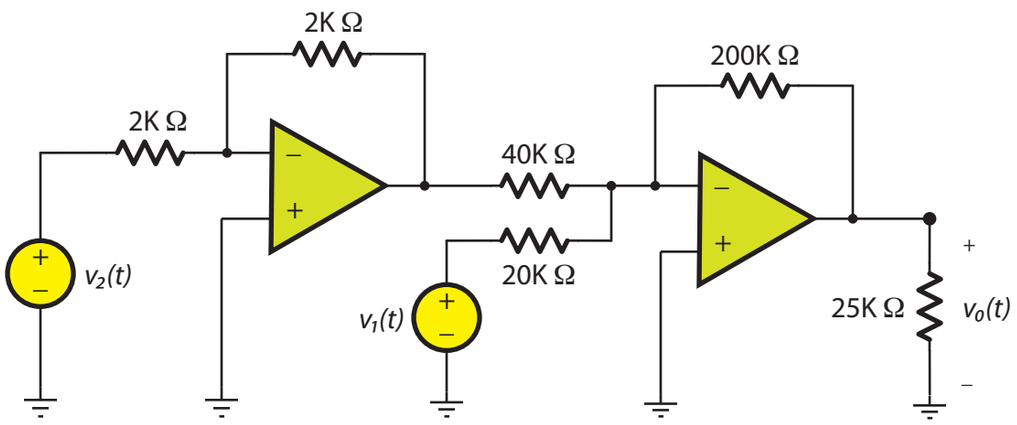

Fig. P4(a). Find $v_0(t)$

(b) Similarly for the circuit of Fig. 4(b), find $v_0(t)$ in terms of $v_1(t)$ and $v_2(t)$. Using this result, determine and sketch $v_0(t)$ using the same $v_1(t)$ and $v_2(t)$ in part (a). **[8 marks.]**

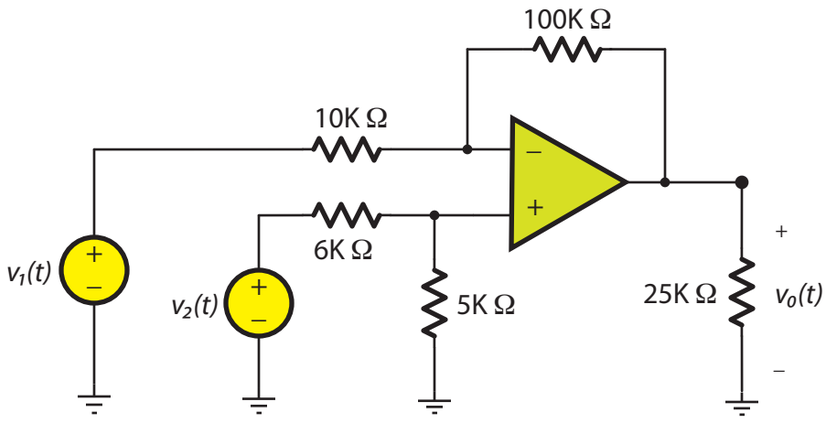

Fig. P4(b). Find $v_0(t)$

[16 marks total.]

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

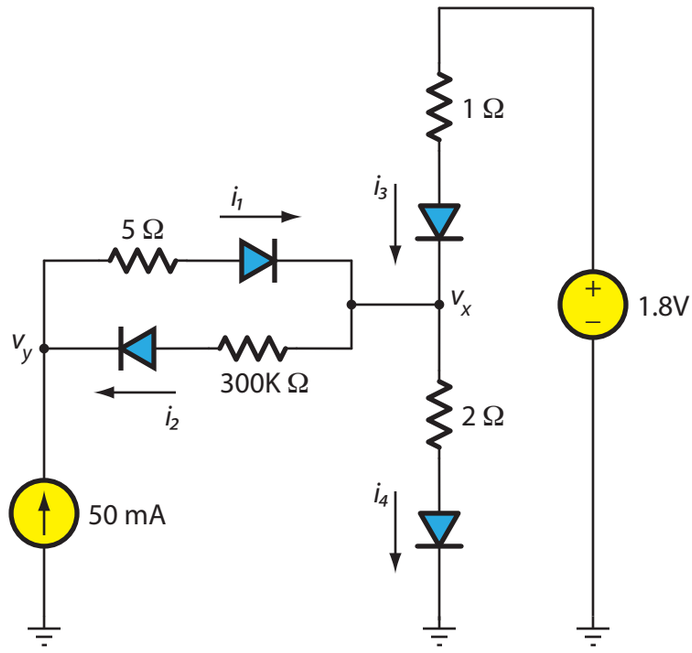

Fig. P5(a). Find v_x, v_y, i_1, i_2, i_3, and i_4.

(a) Assuming ideal diodes, find v_x, v_y, i_1, i_2, i_3, and i_4. 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, i_3, and i_4. **[10 marks.]**

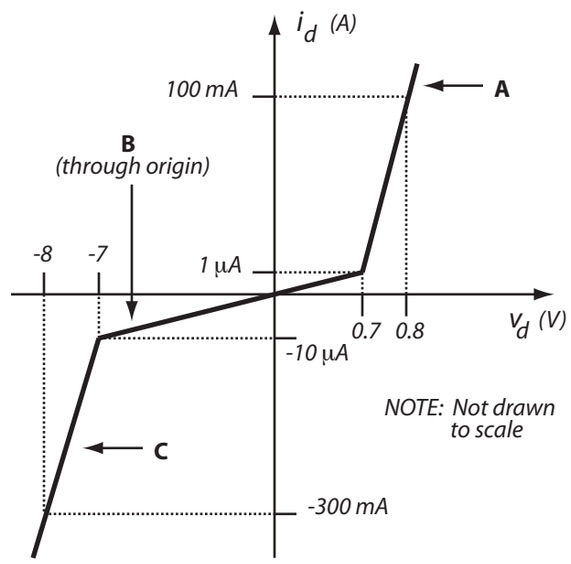

Fig. P5(b). Piecewise-linear diode characteristic

[18 marks total.]

(Problem #5 extra workspace.)

(Problem #5 extra workspace.)

6. A DC motor has its field and armature windings connected in series. The field resistance $R_F + R_{adj} = 10\Omega$. This series-connected motor is operating under the following conditions:

   - terminal voltage $V_T = V_A + V_F = 200$ V;
   - line current $I_L = I_F = I_A = 10$ A;
   - friction power loss, $P_{rot} = 104$ W;
   - shaft speed, $n = 1424.76$ rpm;
   - output torque $T_{out} = 5$ N-m.

   (a) Determine the following (note 1 HP = 746 W):

   i. output power P_{out} in HP;
   ii. developed power P_{dev} in watts;
   iii. armature EMF E_A;
   iv. armature resistance R_A.
   v. machine constant $K\phi$. **[8 marks.]**

   (b) The same motor is now reconfigured in a shunt connection so that the field winding is in parallel with the armature winding. Assume that the field winding is still operating on the linear portion of the magnetization curve; that is, the machine constant $K\phi$ is proportional to the field current I_F. The motor is operating under the following conditions:

   - terminal voltage $V_T = V_A = V_F = 200$ V;
   - friction torque loss T_{rot} is the same as in part (a);
   - output torque $T_{out} = 5$ N-m.

   Determine the following:

   i. field current I_F;
   ii. machine constant $K\phi$.
   iii. armature current I_A;
   iv. armature EMF E_A;
   v. shaft speed n in rpm. **[8 marks.]**

[16 marks total.]

(Problem #6 extra workspace.)