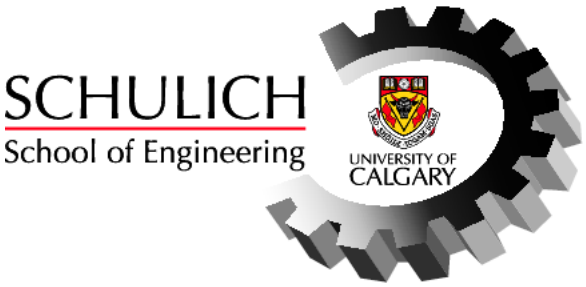

ENGG 325 - Electric Circuits and Systems

Final Examination

Thursday, December 15, 2005
Time: 3:30 - 6:30 PM

L01 (Norm Bartley) - ENE 241/243
L02 (Ed Nowicki) - ENA 201

Instructions:

- Time allowed is 3 hours.
- The examination is closed-book. One double-sided 8.5x11-inch formula sheet may be used in the examination.
- Any type of portable calculator is permitted.
- 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.
- If you use more than one examination booklet, please make sure that your name and ID number are on each.
- Where appropriate, marks will be awarded for proper and well-reasoned explanations.

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1. Consider the DC circuit shown in Fig. P1.

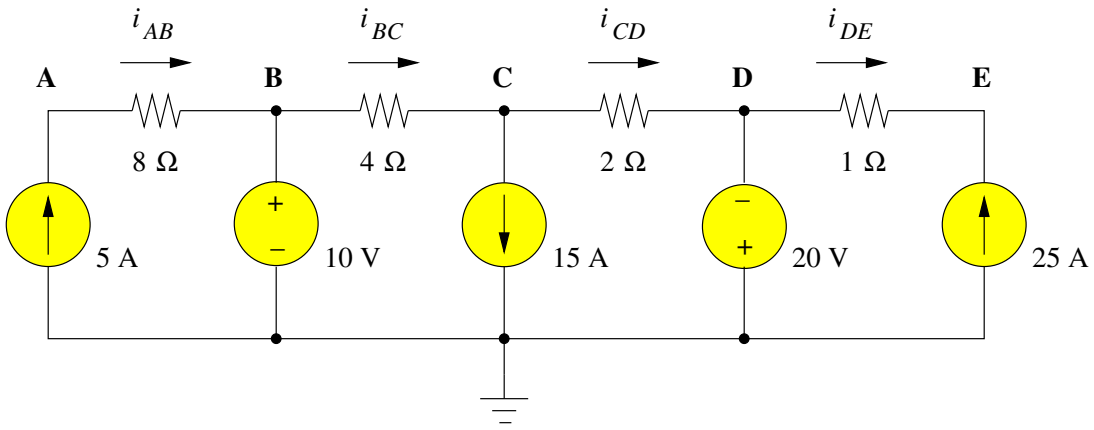

Fig. P1. Solve by node-voltage and mesh-current methods

(a) Use the node-voltage method and Ohm's Law to find V_A, V_B, V_C, V_D, V_E. **[6 marks.]**

(b) Use the mesh-current method to find i_{AB}, i_{BC}, i_{CD}, i_{DE}. **[6 marks.]**

(c) Find the power dissipated in each resistor. **[4 marks.]**

(d) Using your answer to part (c), what is the total power in the sources? **[2 marks.]**

[18 marks total.]

2. Consider the bridge circuit given in Fig. P2, which is driven by an AC voltage given by $v_s(t) = 10cos(5 \times 10^5 t)$. As indicated, the inductor is $L = 0.01H$ and the capacitor is $C = 2 \times 10^{-9}F$.

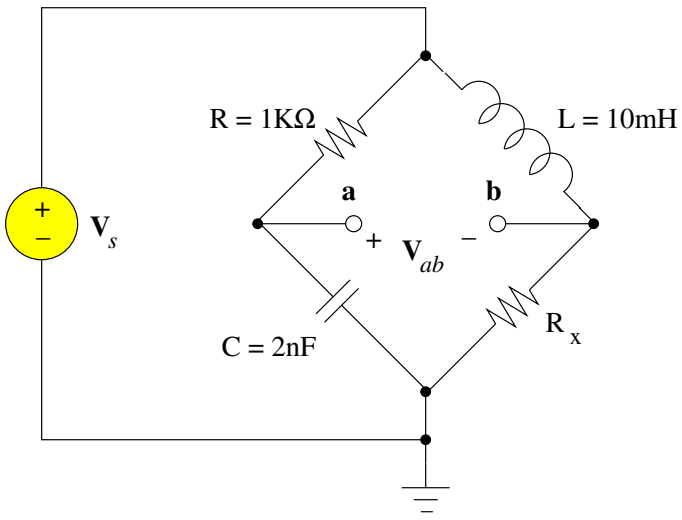

Fig. P2. Find the Thévenin equivalent circuit

(a) Find R_x in this circuit such that the bridge is balanced (i.e., $\mathbf{V}_{ab} = 0$). **[6 marks.]**

(b) For whatever you determined for R_x in part (a), find $v_b(t)$. **[6 marks.]**

(c) For whatever you determined for R_x in part (a), determine the average power in L, C, and R_x. **[4 marks.]**

[16 marks total.]

3. For the resistor-inductor 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 $t = 0$.

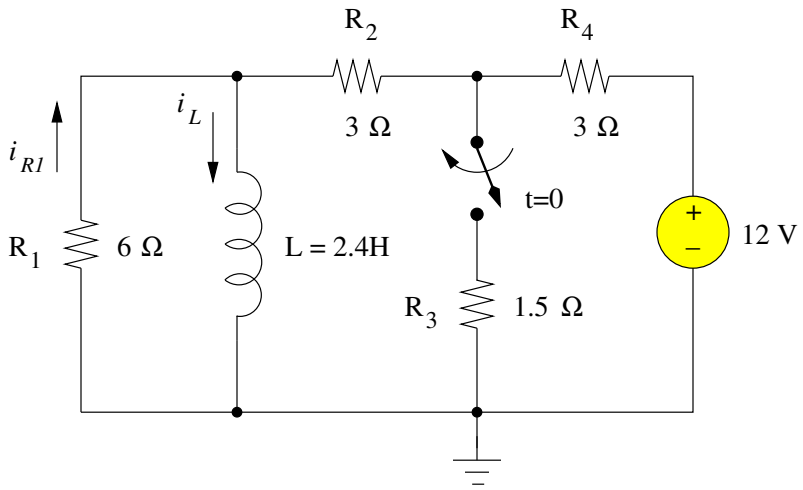

Fig. P3. A first-order RL circuit

(a) Sketch $i_L(t)$ for all t. **[10 marks.]**

(b) Determine the change in inductor energy between $t = 0$ and $t \to \infty$. Does the inductor energy increase or decrease?

[2 marks.]

(c) Sketch $i_{R1}(t)$ for all t. **[4 marks.]**

[16 marks total.]

4. The op amp in Fig. P4 is ideal.

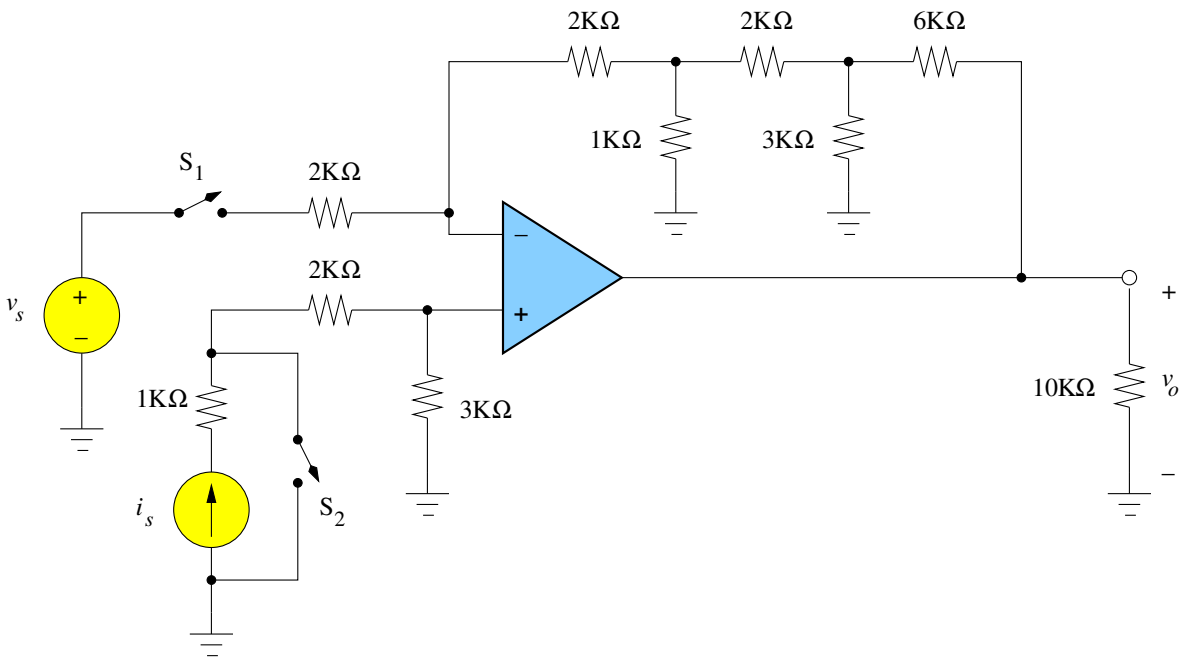

Fig. P4. An op amp circuit

(a) Find v_o if switches S_1 and S_2 are both closed. **[6 marks.]**

(b) Find v_o if switches S_1 and S_2 are both open. **[6 marks.]**

(c) Find v_o if switch S_1 is open and S_2 is closed. **[4 marks.]**

[16 marks total.]

5. Consider the piecewise-linear diode characteristic in Fig. P5.

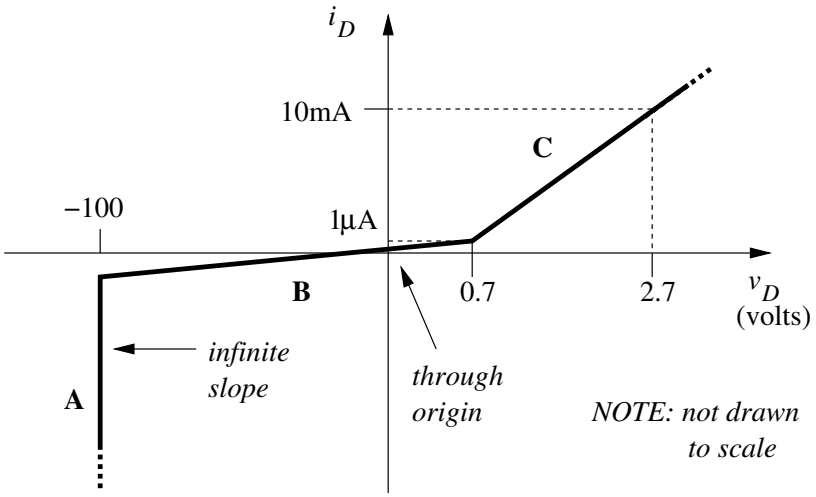

Fig. P5. Piecewise-linear diode characteristic

(a) Give the diode equivalent circuit corresponding to each line segment (label the diode current i_D and voltage v_D in each equivalent circuit). Note that $1\mu A = 10^{-6} A$. **[6 marks.]**

(b) Using these diode models, find i_1 and i_2 for each of three circuits given in Figs. P5-1, P5-2, and P5-3. *(Hint: in each case, at least one current is on the order of microamps.)* **[12 marks.]**

[18 marks total.]

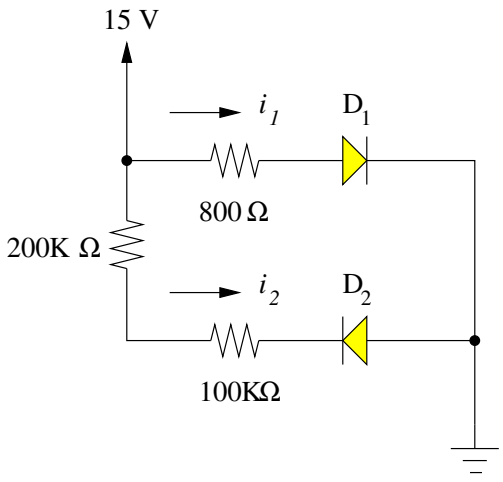

Fig. P5-1. Find i_1 and i_2

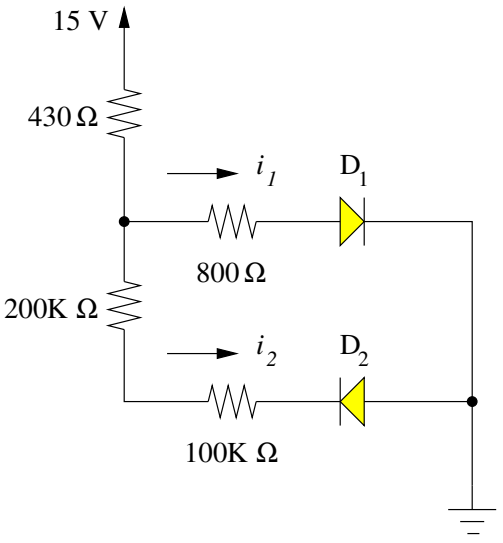

Fig. P5-2. Find i_1 and i_2

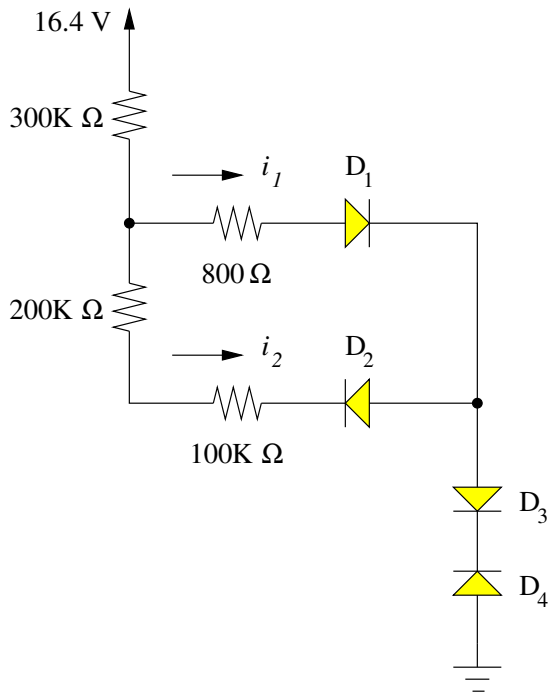

Fig. P5-3. Find i_1 and i_2.

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

   - Shaft power $P_{dev} = 30$ HP (recall 1 HP = 746 W);
   - Friction power loss $P_{rot} = 0$;
   - Terminal voltage $V_T = V_A = V_F = 230$ V;
   - Armature current $I_A = 100$ A;
   - Field current $I_F = 5$ A;
   - Shaft speed $n = 4500$ rpm.

   (a) Is the machine operating as a motor or a generator? Briefly explain.

   [3 marks.]

   (b) Determine the following:

   i. Armature resistance R_A;
   ii. The armature EMF voltage E_A;
   iii. Shaft torque T_{dev};
   iv. Efficiency η.

   [5 marks.]

(Question 6, cont'd ...)

(c) The same machine is now operating at the slightly increased speed of n = 4687 rpm. Is this machine operating as a motor or generator? Briefly explain *(Hint: this is the opposite of part (a).)* **[3 marks.]**

(d) For the machine in part (c), determine the following:

i. The new armature EMF voltage E_A;

ii. The new armature current I_A;

iii. The new shaft torque T_{dev};

iv. The new efficiency η. Is this value larger or smaller than η calculated in part (b)? Why is this so? **[5 marks.]**

[16 marks total.]