UNIVERSITY OF CALGARY

FACULTY OF ENGINEERING

ENGG 325 - Electric Circuits and Systems

Final Examination

Tuesday, June 29, 2004
Time: 3:30 - 6:30 PM

Location: EN E328

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.
- Calculators are permitted.
- The maximum number of marks is 100, as indicated. The final examination counts toward 50% of the final grade. Please attempt all 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. Using the method of your choice, determine the power in the dependent source.

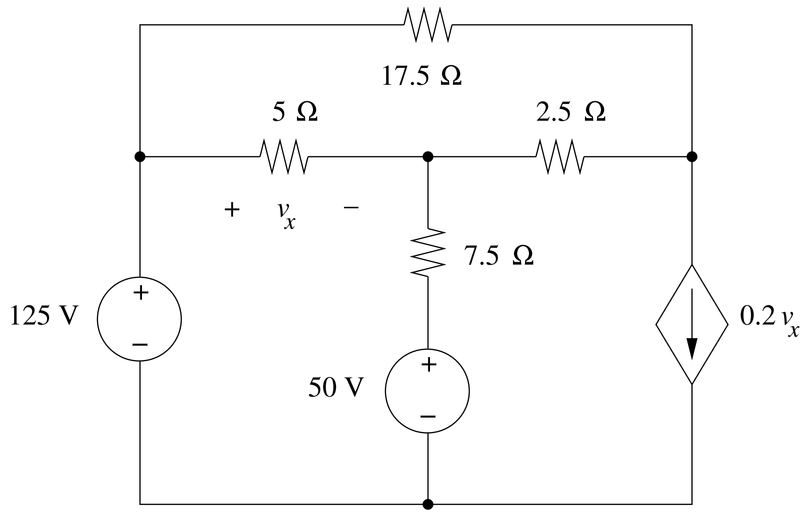

Fig. P1. Find the power in the dependent source

[14 marks.]

2. Find the Thévenin equivalent of the circuit given in Fig. P2.

   (a) Determine the Thévenin phasor voltage $\mathbf{V}_t$ and the Thévenin impedance Z_t. **[14 marks.]**

   (b) Assuming that the frequency of operation is 1000 Hz, give a series connection of two circuit elements, and their values, that has the impedance Z_t from part (a). **[4 marks.]**

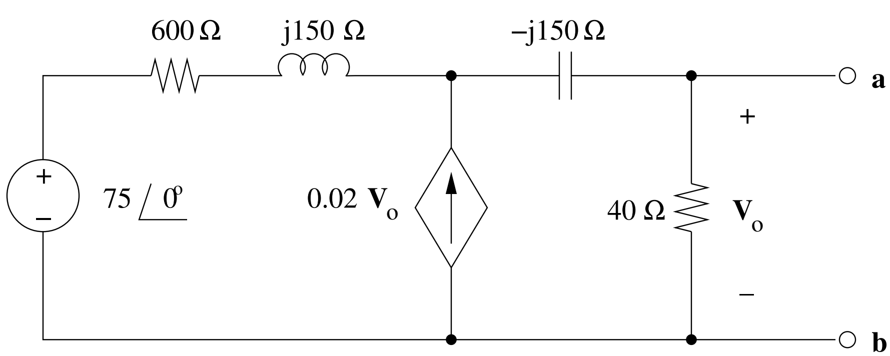

Fig. P2. Find the Thévenin equivalent circuit

[18 marks total.]

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 $t = 0$.

   (a) Determine and sketch $v_c(t)$ across the capacitor for $t \geq 0$. **[12 marks.]**

   (b) Determine the power $p(t)$ in the capacitor for $t \geq 0$. **[3 marks.]**

   (c) Determine how much energy is gained or lost in the capacitor from time $t = 0$ to time $t \to \infty$. **[3 marks.]**

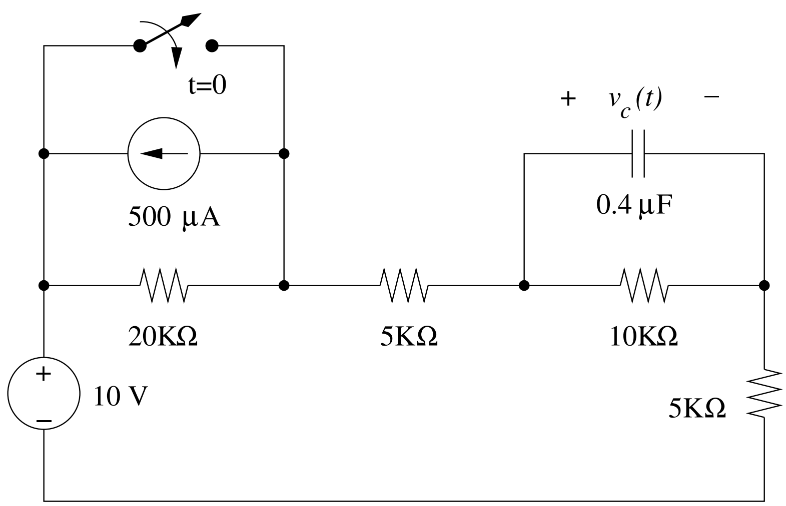

Fig. P3. Solve for $v_c(t)$, power, and energy

[18 marks total.]

4. The circuit in Fig. P4 is the equivalent circuit of a simple inverting amplifier that employs an op-amp purchased in bulk from Smiling Irving's Discount Electronics Superstore. Recall that, in the case of an ideal op-amp, the output of the circuit would be given by

$$v_o = -\frac{R_f}{R_1} \times 0.5V = -5V. \tag{1}$$

Assuming that the op-amp's actual open-loop gain for this equivalent circuit has a rather low value of $A = 1000$, determine v_o.

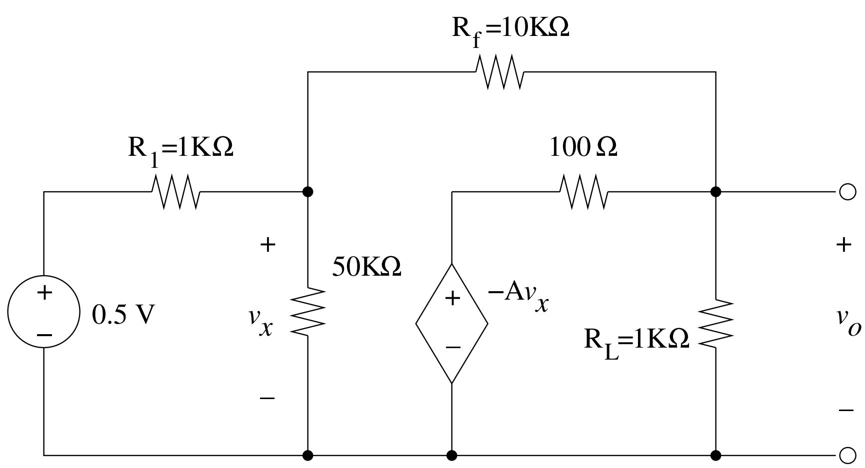

Fig. P4. Solve for $v_o(t)$

[14 marks.]

5. Consider the diode circuit in Fig. P5a.

   (a) First, assume that both diodes are ideal. Diode D_2 is known to be forward-biased. Determine whether D_1 is forward- or reverse-biased in this circuit. [**6 marks.**]

   (b) Now, assume that both diodes obey the piecewise-linear model shown in Fig. P5b. For whatever biasing conditions that you determined in part (a), appropriately use this model to determine the diode voltages v_{D1}, v_{D2}, and currents i_{D1}, i_{D2}. [**14 marks.**]

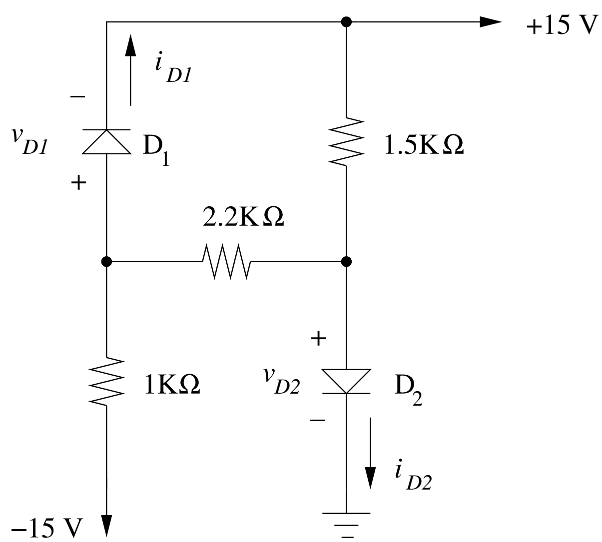

Fig. P5a. Determine how D_1 is biased; find diode voltages, and currents

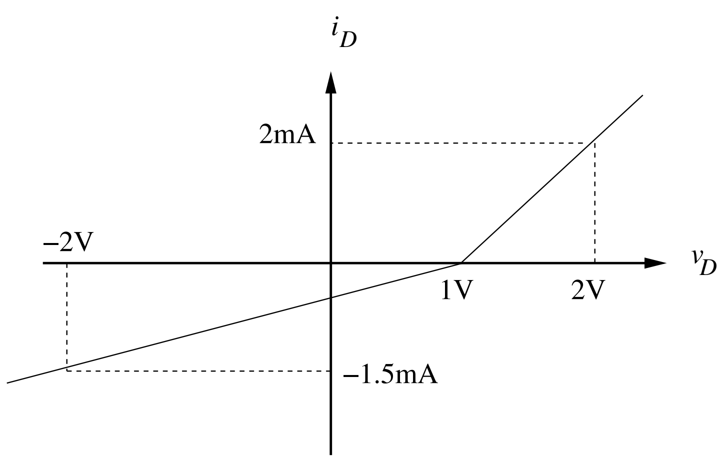

Fig. P5b. Piecewise-linear diode model

[**20 marks total.**]

6. One of many common applications of operational amplifiers is to build circuits that emulate the behaviour of certain circuit elements that are either difficult to implement or that simply don't exist. One such example is shown in Fig. P6. The shaded area is a circuit that emulates the behaviour of a single equivalent resistance, but it is *a negative resistance.* Thus, the overall circuit in Fig. P6 is a resistive voltage divider consisting of a series connection of one positive-valued resistor ($5K\Omega$) and one negative-valued resistor (shaded area).

   (a) Assuming that the op-amp is ideal in Fig. P6, determine the voltage v_1 across the $5K\Omega$ resistor. **[12 marks.]**

   (b) Using your answer to part (a), what is the value of the equivalent (negative) resistance of the shaded area. **[4 marks.]**

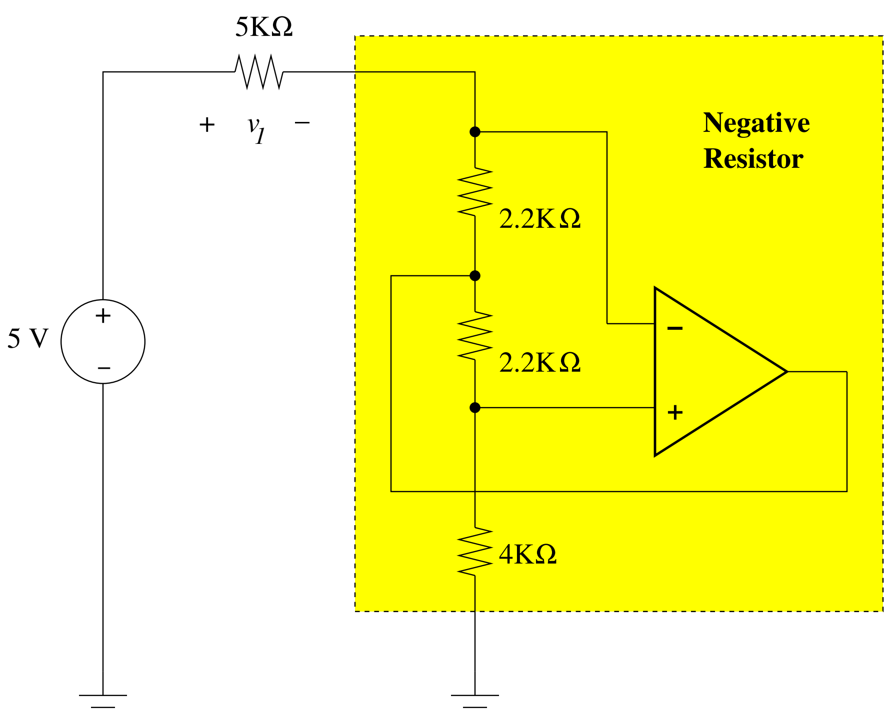

Fig. P6. Determine v_1 and equivalent resistance of shaded area

[16 marks total.]