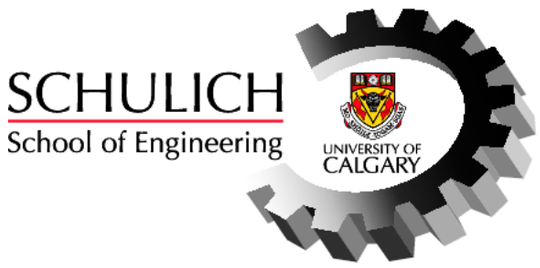
Name: _____ *Lecture Section:* _____
L01 – Norm Bartley
L02 – Ed Nowicki

ID#: _____



ENGG 325 - Electric Circuits and Systems

Final Examination

Wednesday, December 20, 2006
Time: 8:00 - 11:00 AM

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

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.
- 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.
- 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** *(16)*	**#3** *(16)*	**#4** *(18)*	**#5** *(18)*	**#6** *(14)*	**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.

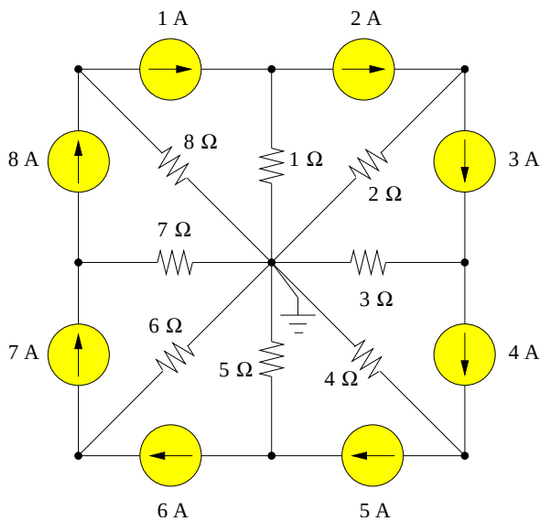


Fig. P1. Find all node voltages and confirm energy balance

(a) Find all the node voltages *(Hint: The node-voltage method may not be the best approach.)* **[10 marks.]**

(b) Using numerical calculations, illustrate how this circuit satisfies the principle of the conservation of energy.

[8 marks.]

[18 marks total.]

(Problem #1 extra workspace.)

2. Consider the AC circuit shown in Fig. P2, which is understood to be operating in steady-state. Each source has a frequency of 1000Hz.

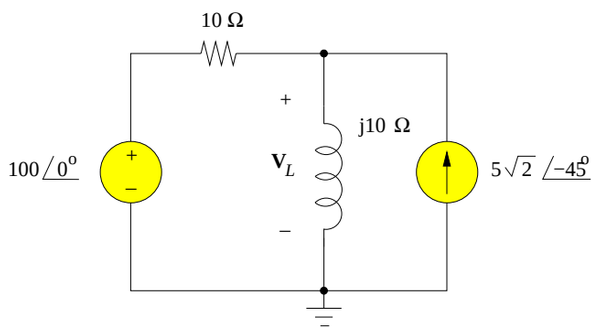


Fig. P2. Find phasor voltage $\mathbf{V}_L$ *and* $v_L(t)$

(a) Set up (but *do not solve*) the node-voltage equation for this circuit. **[3 marks.]**

(b) Using the principle of superposition, find the phasor voltage $\mathbf{V}_L$ and the corresponding expression for $v_L(t)$. **[10 marks.]**

(c) Take your solution for $\mathbf{V}_L$ in part (b), and substitute it into, and verify, your node equation in part (a). **[3 marks.]**

[16 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 so that the circuit has reached DC steady-state. The switch is then closed at time $t = 0$.

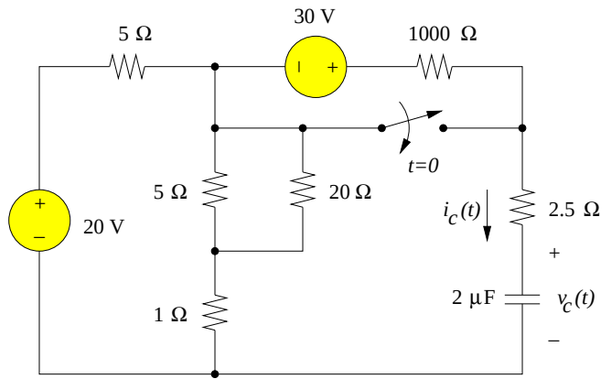


Fig. P3. A first-order RC circuit

(a) Find v_C and i_C at $t = 0^-$. **[4 marks.]**

(b) Find expressions for $v_C(t)$ and $i_C(t)$ for $t > 0$. **[8 marks.]**

(c) Sketch $v_C(t)$ and $i_C(t)$ for all t, indicating τ, $v_C(\tau)$, and $i_C(\tau)$. **[4 marks.]**

[16 marks total.]

(Problem #3 extra workspace.)

4. The op amps in Fig. P4 are ideal.

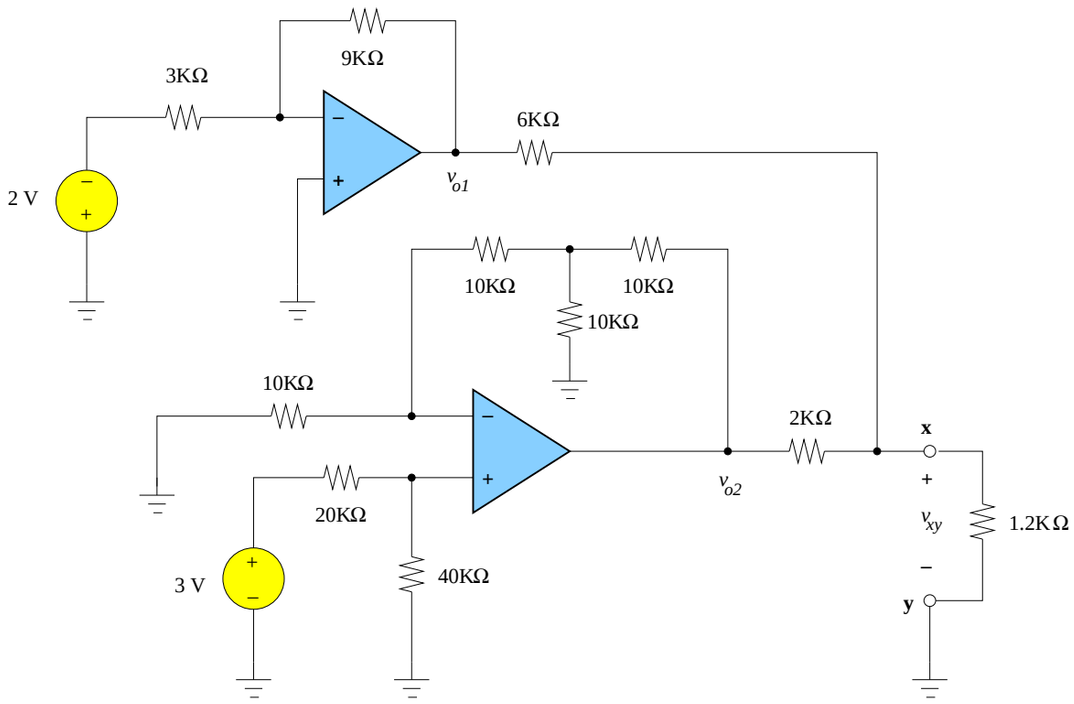


Fig. P4. Find v_{o1}, v_{o2}, v_{xy}, and Thévenin equivalent circuit

(a) Determine v_{o1}, v_{o2}, and v_{xy}. **[12 marks.]**

(b) Disconnect the $1.2K\Omega$ resistor from the terminals **x** and **y**, and determine the Thévenin equivalent circuit to the left of **x** and **y**. *(Hint: Note that the values for v_{o1} and v_{o2} are the same as those found in part (a).)* **[4 marks.]**

(c) Re-attach the $1.2K\Omega$ resistor across the terminals **x** and **y**, and use the Thévenin equivalent circuit found in part (b) to find v_{xy}. **[2 marks.]**

[18 marks total.]

(Problem #4 extra workspace.)

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

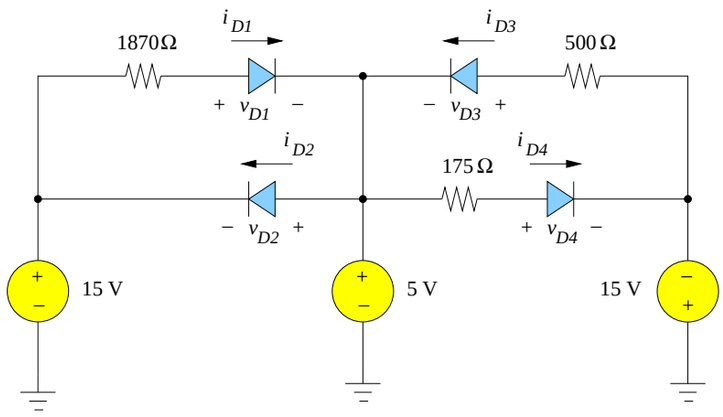


Fig. P5(a). Find diode voltages and currents

(a) Assuming ideal diodes, find all the indicated diode voltages and currents. 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 all the indicated diode voltages and currents. **[10 marks.]**

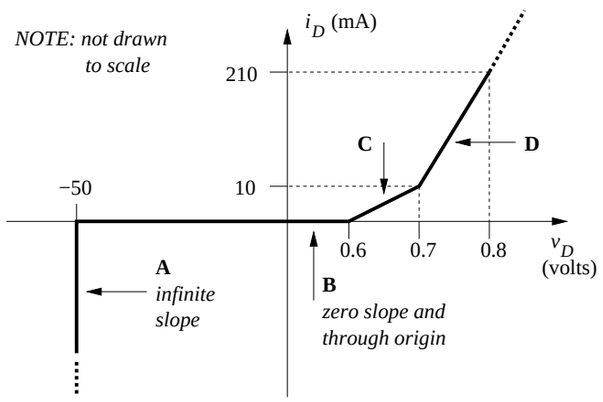


Fig. P5(b). Piecewise-linear diode characteristic

[18 marks total.]

(Problem #5 extra workspace.)

(Problem #5 extra workspace.)

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

   - Rated speed, $n_{rated} = 5000$ rpm;
   - Rated torque $T_{out} = 14.5$ N-m;
   - Terminal voltage $V_T = 150$ V;
   - Line (total input) current $I_L = 58.1$ A;
   - Total field resistance $R_{adj} + R_f = 75\Omega$;
   - Armature resistance $R_A = 0.178\Omega$.

   (a) Under these full-load conditions, determine the following (note 1 HP = 746 W):

      i. Power lost in the field resistance $P_{field-loss}$;
      ii. Power lost in the armature resistance $P_{arm-loss}$;
      iii. Induced voltage E_A.
      iv. Developed power P_{dev} in horsepower.
      v. Rotational power loss P_{rot} in horsepower.
      vi. The efficiency. **[10 marks.]**

   (b) Assume that the mechanical load is removed from the motor shaft so that the output torque is now $T_{out} = 0$ (i.e., "no-load" operation). However, rotational power loss is still present and has the same value of torque T_{rot} as in part (a). Using the machine constant $K\phi$, find the no-load speed $n_{no-load}$ and hence determine the speed regulation (SR) for the motor. *(Recall from the lab that SR is given as follows.)*

$$SR = \frac{n_{no-load} - n_{full-load}}{n_{full-load}} \times 100\% \quad (1)$$

[4 marks.]

[14 marks total.]

(Problem #6 extra workspace.)