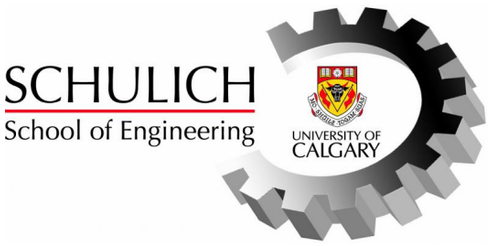
Name: _____ *Lecture Section:* _____

ID#: _____



ENGG 325 - Electric Circuits and Systems

Final Examination

Thursday, December 17, 2009
Time: 7:00 - 10:00 PM

Red Gymnasium

L01 - *Pouyan (Yani) Jazayeri (WMF 8:00)*
L02 - *Norm Bartley (MWF 13:00)*
L03 - *Anis Haque (MWF 16:00)*
L04 - *Martin Mintchev (MWF 13:00)*

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 *(16)*	**#2** *(16)*	**#3** *(18)*	**#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.

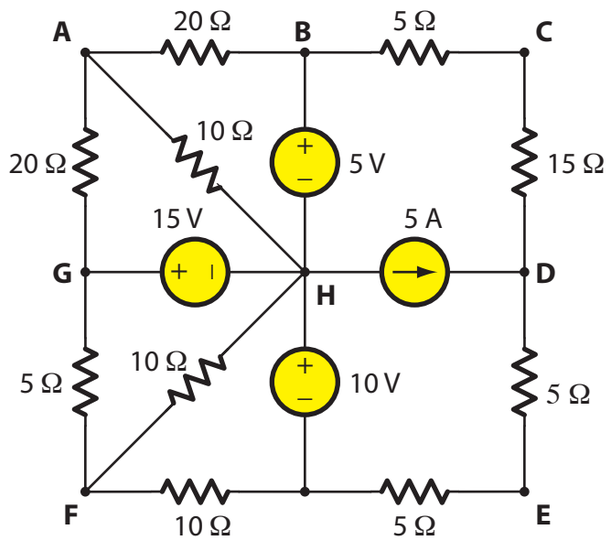


Fig. P1. Find the node voltages, power in the soures

(a) Using any method of your choosing, determine all the node voltages. **[8 marks.]**

(b) Determine the power in each of the sources, and indicate whether it is absorbing or generating. **[8 marks.]**

[16 marks total.]

(Problem #1 extra workspace.)

2. Consider the steady-state sinusoidal AC circuit shown in Fig. P2. The current source is producing:

$$i_s(t) = 0.1\cos(1000t)\ A \tag{1}$$

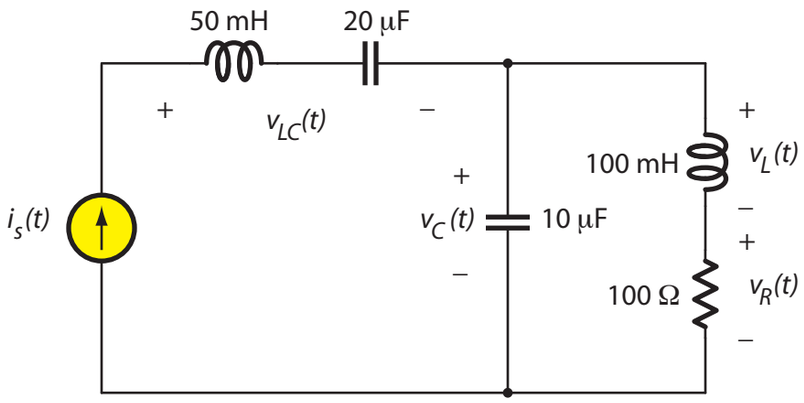


Fig. P2. Find $v_C(t)$, $v_L(t)$, $v_R(t)$, and $v_{LC}(t)$ and average power in each circuit element

(a) Find $v_C(t)$, $v_L(t)$, $v_R(t)$, and $v_{LC}(t)$, and show them on a phasor diagram. **[12 marks.]**

(b) Find the average power for each circuit element including the current source. For each calculation, state if this power is absorbed or supplied. **[4 marks.]**

[16 marks total.]

(Problem #2 extra workspace.)

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 $t = 0$.

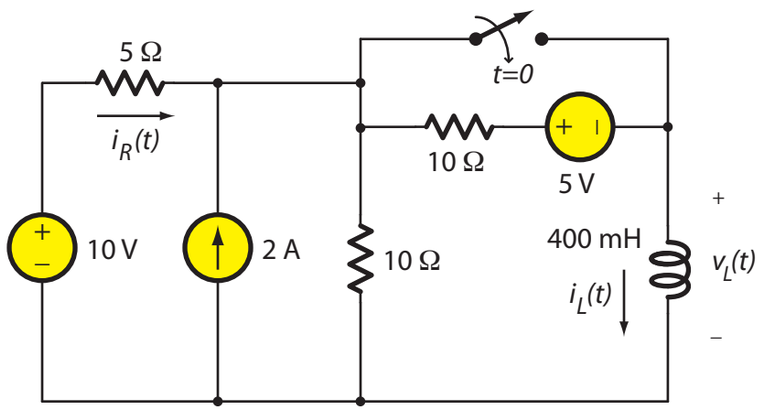


Fig. P3. Find and sketch $i_L(t)$ and $i_R(t)$; find inductor energy

(a) Determine and sketch $i_L(t)$ for all t. Indicate the $i_L(t = \tau)$ point on the curve. **[8 marks.]**

(b) Determine and sketch $i_R(t)$ for all t. Indicate the $i_R(t = \tau)$ point on the curve. **[8 marks.]**

(c) Determine the energy in the inductor at times $t = 0^-$ and $t \to \infty$. **[2 marks.]**

[18 marks total.]

(Problem #3 extra workspace.)

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

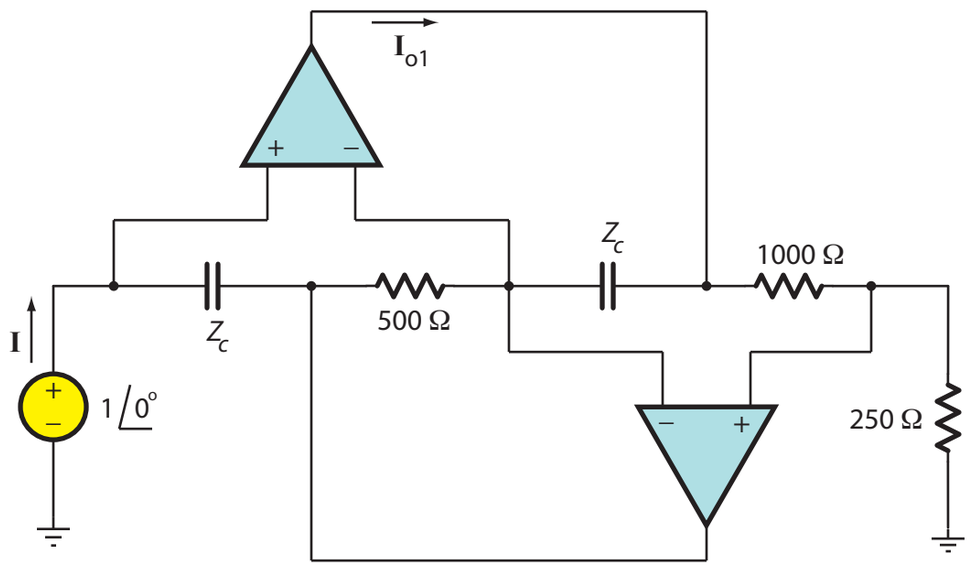


Fig. P4. Find phasor current $\mathbf{I}$*,* Z_{eq}*, and phasor current* $\mathbf{I}_{o1}$

(a) Determine the phasor current $\mathbf{I}$ in terms of the impedance variable Z_c.

[10 marks.]

(b) Assume that the voltage source operates at the angular frequency of ω rad/s (where $\omega \neq 0$), and that each capacitor is $C = 0.05\ F$ $(50\ mF)$. Determine the total equivalent impedance Z_{eq}, expressed in terms of ω, connected to the voltage source.

[4 marks.]

(c) Determine the phasor current $\mathbf{I}_{o1}$ if $\omega = 0.02$ rad/s. **[4 marks.]**

[18 marks total.]

(Problem #4 extra workspace.)

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

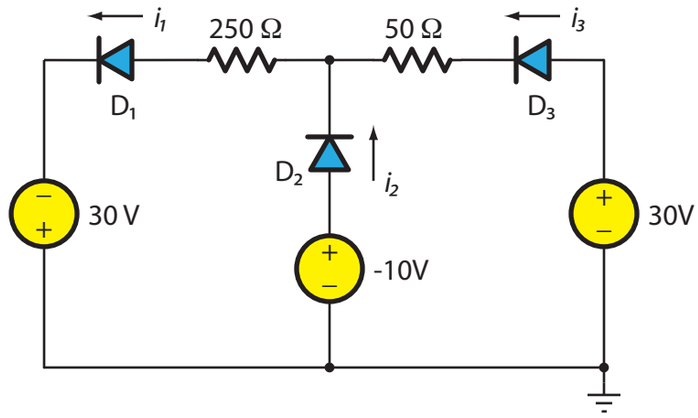


Fig. P5(a). Find i_1, i_2, and i_3.

(a) Assuming ideal diodes, find i_1, i_2, and i_3. Justify your choice of the on/off state for each diode. **[6 marks.]**

(b) Now assume that each diode is characterized by the i_d-v_d relationship shown in Fig. P5(b). Give the diode equivalent circuit corresponding to each line segment in Fig. P5(b). **[4 marks.]**

(c) Using the diode equivalent circuits in part (b), determine i_1, i_2, and i_3. **[8 marks.]**

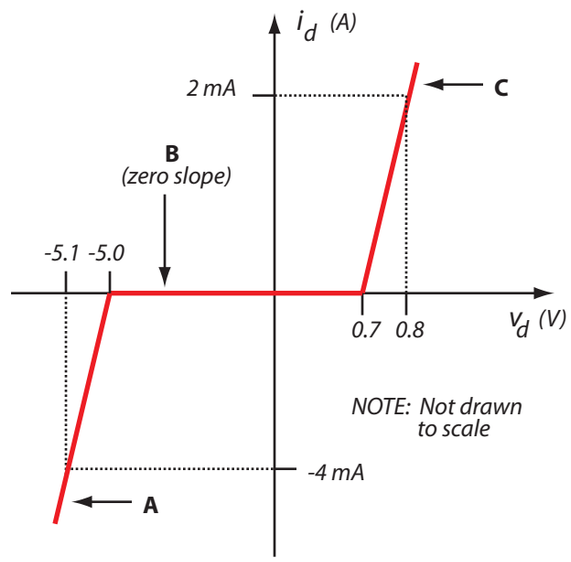


Fig. P5(b). Piecewise-linear diode characteristic

[18 marks total.]

(Problem #5 extra workspace.)

(Problem #5 extra workspace.)

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

   - Rated speed, $n_{rated} = 4000$ rpm;
   - Rated torque $T_{out} = 9.5$ Nm;
   - Terminal voltage $V_T = 100$ V and field voltage $V_F = 50$ V;
   - Armature current $I_A = 44.0925$ A;
   - Total field resistance $R_{adj} + R_f = 25\Omega$;
   - Armature resistance $R_A = 0.1134\Omega$.

   (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) Suppose that, after giving the motor a thorough tune-up, rotational losses have been reduced to zero. Assuming that the machine constant $K\phi$ remains the same, and that the delivered torque remains at $T_{out} = 9.5$ Nm, determine the following:

      - New shaft speed n in rpm.
      - New efficiency η.

      [4 marks.]

   [14 marks total.]

(Problem #6 extra workspace.)