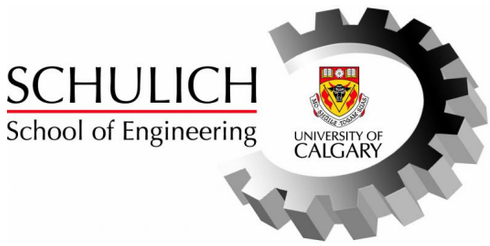
Last Name: _____ *Lecture Section:* _____

First Name: _____

ID#: _____



ENGG 225 - Fundamentals of Electrical Circuits and Machines

Winter 2017 Final Examination

Tuesday, April 18, 2017
Time: 8:00 - 11:00 AM

Gold Gymnasium (L01, L02)
Red Gymnasium (L03, L04)

L01 - *Pouyan (Yani) Jazayeri*
L02 - *Norm Bartley*
L03 - *Denis Onen*
L04 - *Anis Haque*

Instructions:

- Time allowed is 3 hours.
- Please review the examination rules on Page 2.
- The examination is closed-book and closed-notes.
- Only calculators sanctioned by the Schulich School of Engineering (Casio FX-260, Casio FX-300MS, or TI-30XIIS) 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 *(28)*	**#2** *(12)*	**#3** *(14)*	**#4** *(16)*	**#5** *(18)*	**#6** *(12)*	**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.

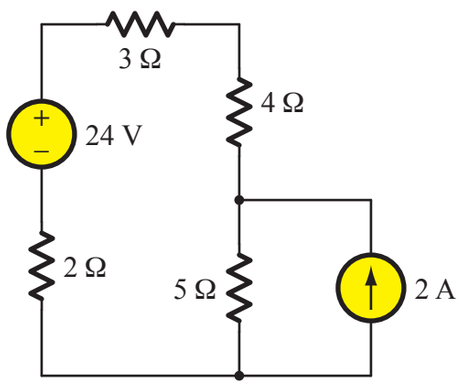
(9) During the examination a candidate must report to a supervisor before leaving the examination room.

(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.

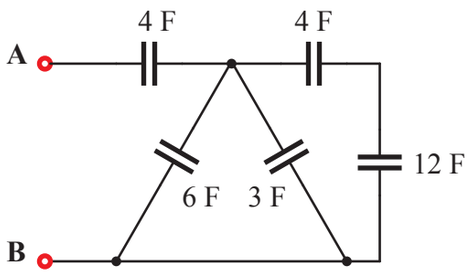
(11) If during the course of an examination a student becomes ill or receives word of a domestic affliction, the student should report at once to the supervisor, hand in the unfinished paper and request that it be cancelled. If physical and/or emotional ill health is the cause, the student must report at once to a physician/counsellor so that subsequent application for a deferred examination is supported by a completed Physician/Counsellor Statement form. Students can consult professionals at UC Wellness Center 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. **[28 marks.]** Parts (a)-(g) below each have an identical weighting of four marks. Please answer the questions in the boxes provided.

(a) **[4]** In the circuit given at right, use source transformations to simplify this circuit to a single current source and a single resistance.

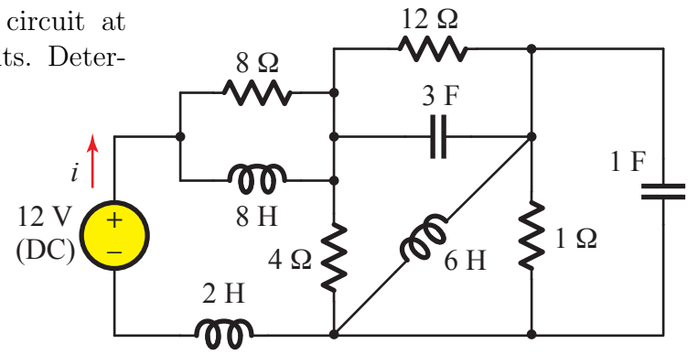


(b) **[4]** Determine the total equivalent capacitance C_{AB} between terminals **A** and **B** in the circuit shown at right.



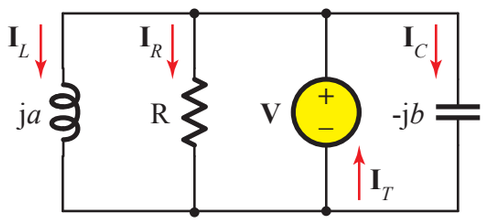
Answer: $C_{AB} =$

(c) **[4]** The voltage source in the circuit at right is DC and provides 12 Volts. Determine the current i.



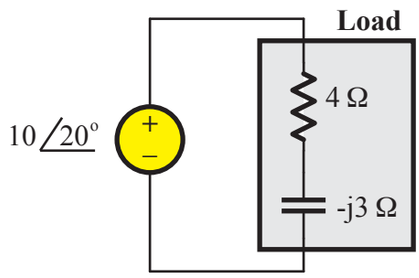
Answer: $i =$

(d) **[4]** In the circuit shown at right, assume that $a = b$. Let θ_T be the phase angle of the current $\mathbf{I}_T$, and let θ_R be the phase angle of $\mathbf{I}_R$. Calculate $\theta = \theta_T - \theta_R$.



Answer: $\theta =$

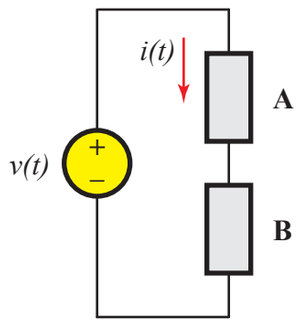
(e) **[4]** Determine the complex power **S** in the load impedance in the circuit at right, and indicate whether the power factor is leading or lagging.



Answer: **S** =

Answer: *leading / lagging*

(f) **[4]** In the circuit at right, we are given that $v(t) = 10\sin(100t + 30°)$ and $i(t) = 2\cos(100t)$. It is also known that circuit element **A** is a resistor. Determine whether circuit element **B** is an inductor or capacitor, and give its value appropriately in either Henrys (H) or Farads (F).



Answer: B's value =

(g) **[4]** Suppose that an AC load dissipates an average power $P = 6$ W, and has a power factor of 0.6 *leading*. Sketch the power triangle, and determine the apparent power $P_{app} = |\mathbf{S}|$.

Answer: $|\mathbf{S}|$ =

2. [**12 marks.**] For the circuit shown in Fig. P2, find v by superposition.

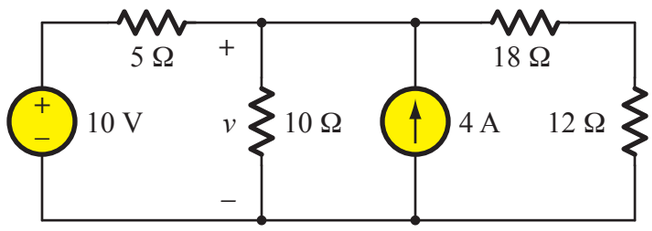


Fig. P2. Find voltage v by superposition.

3. **[14 marks.]** For the capacitor in Fig. P3, determine and carefully sketch the current $i_C(t)$, the power $p_C(t)$, and the energy $w_C(t)$ for $t \geq 0$ in response to the voltage waveform $v_C(t)$.

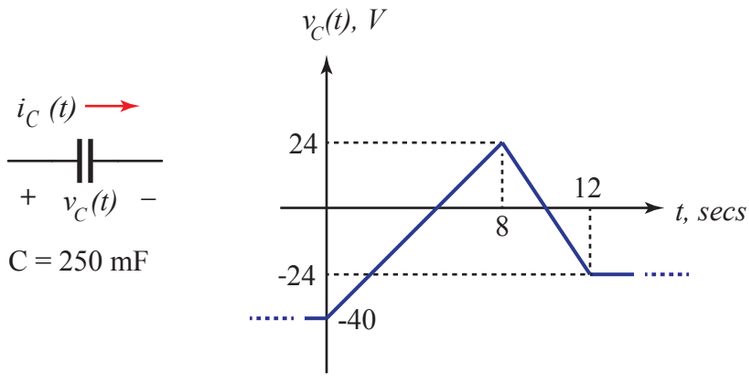


Fig. P3. Sketch $i_C(t)$, $p_C(t)$, and $w_C(t)$.

4. **[16 marks.]** The op-amps in Fig. P3 are energized using power sources as shown. Both op-amps are otherwise ideal.

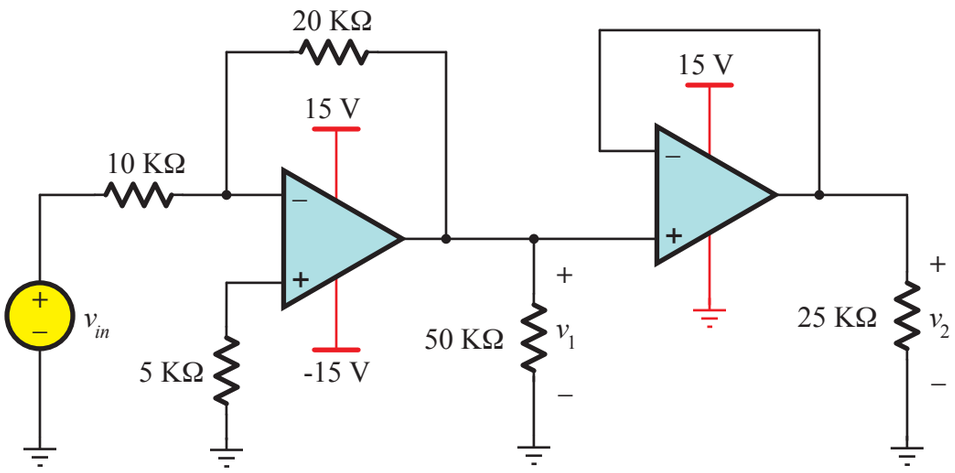


Fig. P4. Find A_{v1} and A_{v2}, and complete the table below.

(a) **[8]** Under ideal operating conditions, calculate the closed-loop gain $A_{v1} = v_1/v_{in}$ and $A_{v2} = v_2/v_1$.

(b) **[8]** Now complete the table below for the above circuit using the values of v_{in} given.

Calculation	v_{in}	v_1	v_2
(i)	6.0 V		
(ii)	-7.0 V		
(iii)	8.0 V		
(iv)	-9.0 V		

5. **[18 marks.]** Consider the steady-state sinusoidal analysis of the circuit shown in Fig. P5, where both sources operate at a frequency of $\omega = 100$ rads/s, and:

   - $v_1(t) = 50\sin(\omega t)$,
   - $i_1(t)$ has an rms value of $5/\sqrt{2}$ and phase of 0 degrees.

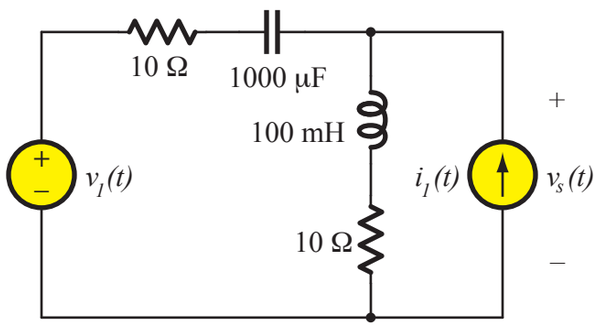


Fig. P5. Find $v_s(t)$ by any method you choose.

(a) **[4]** Redraw the circuit using phasors and impedances.

(b) **[11]** Calculate the voltage $v_s(t)$ across the current source.

(c) **[3]** Using your results obtained in part (b), show $\mathbf{V}_1$, $\mathbf{I}_1$, and $\mathbf{V}_s$ on a phasor diagram.

(Problem #5 extra workspace.)

6. **[12 marks.]** Consider the shunt-connected DC motor shown in Fig. P6, with the steady-state full-load specifications as indicated. You may assume that the rotational losses for this machine are negligable.

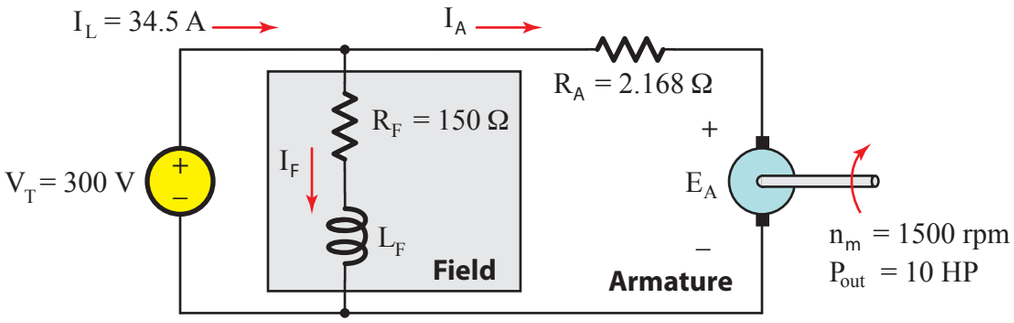


Fig. P6. Full-load specifications for a shunt-connected DC motor.

Recall the basic machine equations $E_A = K\phi\omega_m$, $T_{dev} = K\phi I_A$, and $P = T\omega_m$. (Also, $\omega_m = 2\pi n_m/60$ and 1 HP = 746 W.)

(a) **[6]** Under full load conditions, find the output torque T_{out}, field power loss P_F, armature power loss P_A, the induced voltage E_A, and the efficiency η.

(b) **[6]** Suppose that the motor is driving a pump, and the viscosity and density of the fluid being pumped changes, causing the output torque T_{out} to increase dramatically to 100 Nm. Assuming that this torque is constant (i.e., independent of rotational speed), determine the new motor speed n_m in rpm.