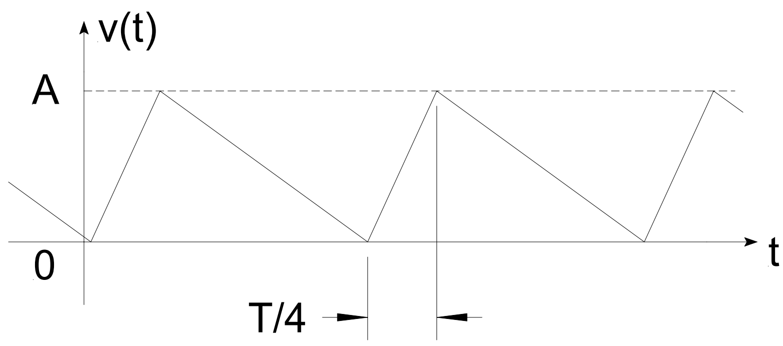
EE 201 - Electric and Magnetic Circuits II
Final Examination
December 11, 2000
Allowed Time: 3 Hours

Closed book examination. One 8.5” × 11” sheet of notes allowed.
Do all questions. Marks for each question are in [ ].

1	2	3	4	5	6	Total
/10	/10	/10	/10	/10	/10	/60

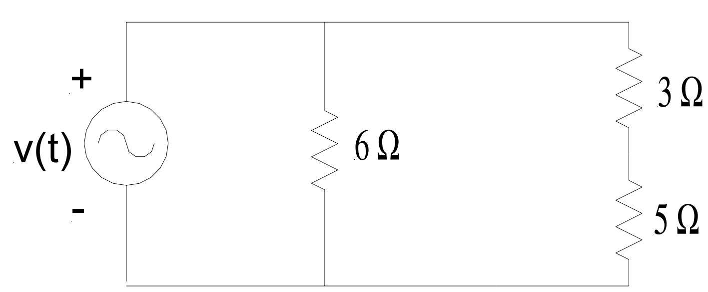
1. Consider the periodic voltage waveform v(t) below.



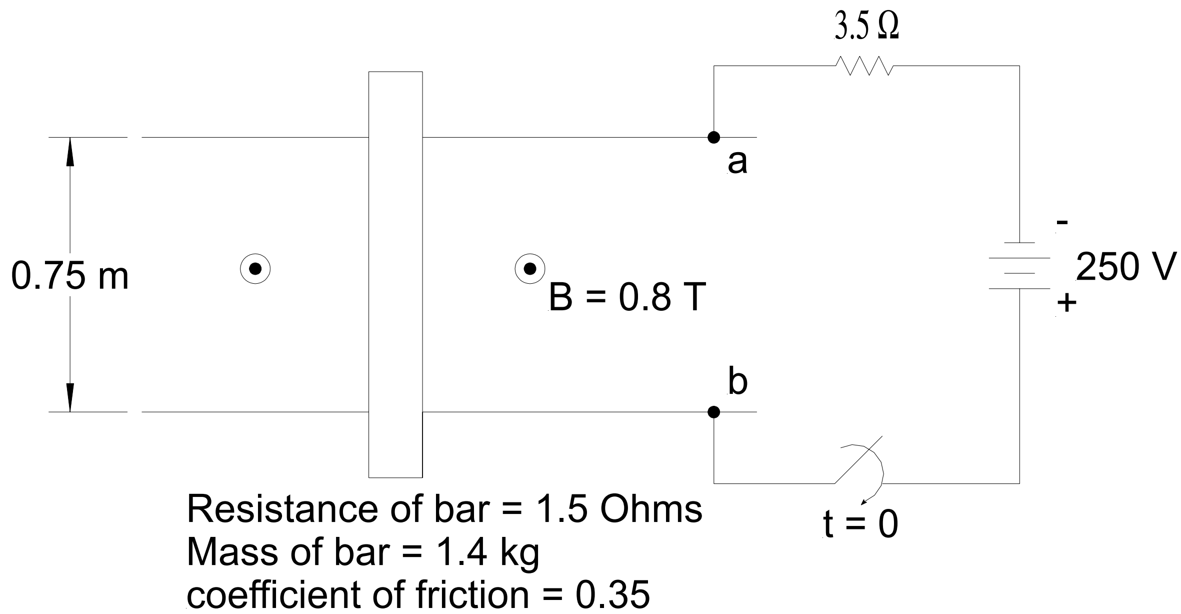
(a) What is the average value of v(t)? Leave your answer in terms of the unknown peak amplitude A. [2]

(b) The effective value of this waveform has been measured to be $V_{rms} = 7.4$ V. What is the peak value of the waveform, A? Show all calculations. [5]

(c) If v(t) is connected to the following circuit, calculate the power dissipated by each resistor. [3]



2. In the figure below, the bar is initially at rest. At t = 0, the switch is closed and after sufficient time, steady state is reached.

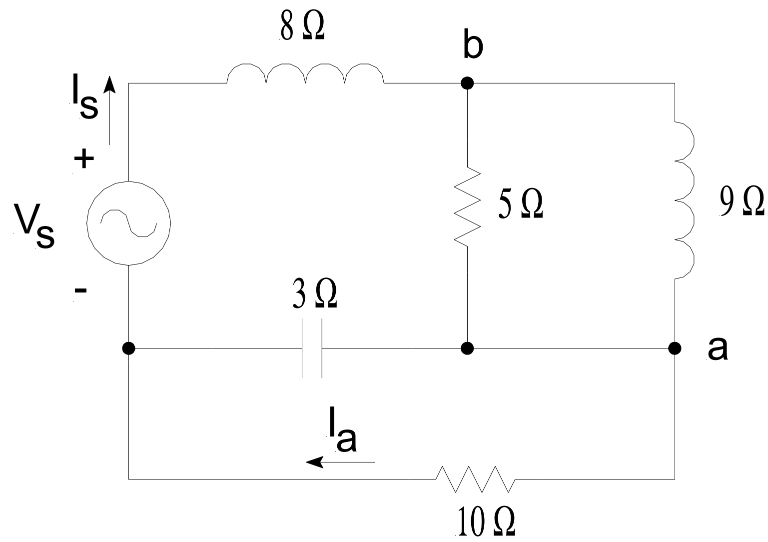


At steady state (which corresponds to the bar moving at a constant velocity), determine the following:

(a) Free body diagram of the bar, including the direction of motion. [2]
(b) Magnitude and direction of the current in the circuit. [2]
(c) Motional emf of the bar and the voltage V_{ab}. [3]
(d) Perform a complete power balance on the system. Is the bar acting as a motor or a generator? [3]

CIRCLE ALL YOUR ANSWERS

3. The source voltage in the figure below is $V_s = 15\angle 10°$ V.



Determine the following (express all answers in polar form):

(a) I_s [2]

(b) Z_{tot} [2]

(c) V_{ab} [2]

(d) I_a [2]

(e) Sketch V_{ab}, V_s, and I_s on a phasor diagram. [2]

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4. A small steel foundry receives 600 V 60 Hz service from SaskPower. The foundry is divided into three main areas, each of which is connected in parallel across the 600 V service (source). The three areas of the foundry draw the following loads:

Office area:

- 180×40W fluorescent fixtures ($F_p = 0.8$ lagging)
- 1800 W total for office equipment ($F_p = 0.9$ lagging)

Shipping/Receiving:

- 30×40W fluorescent fixtures ($F_p = 0.8$ lagging)
- 1140 W of incandescent lighting
- one fully loaded 1 hp motor running a conveyor belt ($F_p = 0.63$ lagging, $\eta = 81\%$)

Foundry floor:

- one 10 hp motor to drive the furnace fan operating at 50% of capacity ($F_p = 0.63$ lagging, $\eta = 87\%$)
- 3800 W of incandescent lighting

(Note: incandescent lights have a power factor of unity)

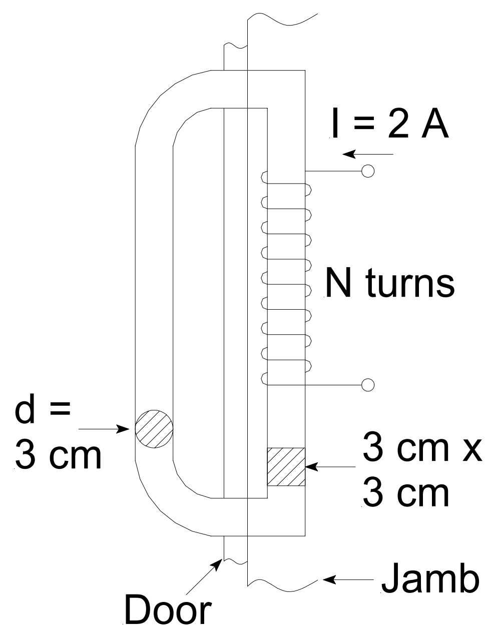
(a) Determine the real (active), reactive, and apparent power consumed by each area of the foundry. Draw each power triangle. [3]

(b) What is the total apparent power consumed by the foundry? What is the power factor of the total combined load? Be sure to state whether it is leading or lagging. [2]

(c) A reactive element has been connected in parallel with the three loads of the foundry to correct their power factor to 0.9 lagging. Determine whether the element is inductive or capacitive, its value, and its kVA rating. [3]

(d) The foundry has a 600 V, 60 Hz, 22 kVA standby generator to keep production going in the event of a power failure. To improve the reliability of the generator, its manufacturer recommends that it never be run beyond 95% of its rated capacity. Can this generator reliably keep the foundry running at the corrected power factor of 0.9? [2]

5. A magnetic door lock, proposed for an office building, is shown at right. It is composed of a "D" shaped handle of circular cross-section made from solid cast steel. A piece of solid sheet steel with a square cross-section will be installed in the door jamb. It has a coil of wire of N turns wound around it. The coil will be energized by a 13.5 VDC source capable of delivering a maximum of 2 A. It has been estimated that a force of 200 lbs will be sufficient to secure the door.



Note:

- Force due to an electromagnet: $F = \dfrac{B_g^2 A_g}{2\mu_o}$. Assume that the two air gaps between the ferromagnetic pieces are zero when the door is closed.
- 1 N = 0.2248 lb

(a) What flux density, B, is required in the cast steel to provide the necessary force to seal the door? [3]

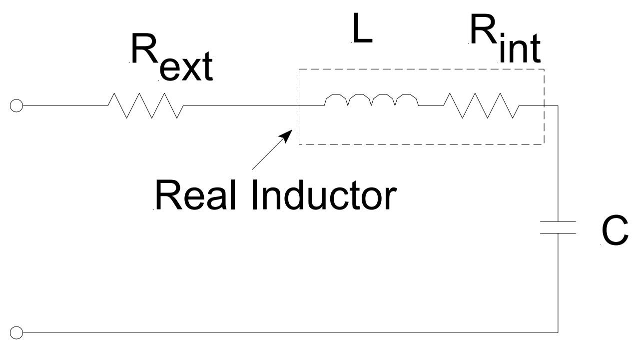
(b) What total flux must be produced by the coil? [2]

Portion	Area (m^2)	Length (m)	Φ (Wb)	B (T)	H (At/m)	$H\ell$ (At)
Top Gap						
Bottom Gap						
Cast Steel Handle		0.686				
Sheet Steel portion		0.553				

(c) Assuming the coil is supplied with the maximum 2 A source current, how many turns of wire must be wound on the sheet steel jamb section? If the coil has a 1 Ω internal resistance, what external resistor is needed to limit the current from the 13.5 V source to 2 A? How many watts of power must it dissipate? [3]

(d) What is the inductance of the coil when the door is "locked"? [2]

6. You have been assigned the task of designing a series resonant circuit (R-L-C) similar to that shown in the drawing below. It is to have a lower 1/2 power frequency of 2017 Hz and an upper 1/2 power frequency of 2317 Hz. You have been given a 100 mH inductor to work with, and it has some internal resistance. When the real inductor alone is connected to a 10 Vrms, 100 Hz source, the current through it is 0.157∠-80.96° A.



a) Using estimates for the 1/2 power frequencies, what resonant frequency should you design for? [2]

b) What value of capacitor do you need so that the circuit will have this resonant frequency? [2]

c) What value of external resistor is required to finish the circuit and provide the desired bandwidth? [2]

d) What is the Quality Factor, Q of the circuit at resonance? [2]

e) Calculate the exact 1/2 power frequencies of the completed circuit (in Hz). [2]

THE END

Name: ____________________ Student #: ______________