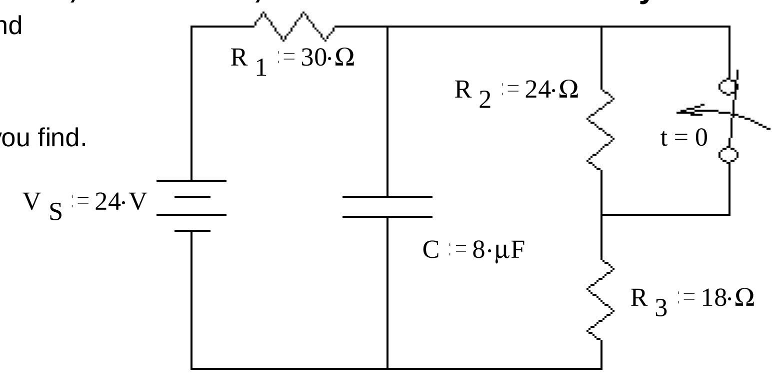
ECE2210 Final given: Fall 19

Closed Book, Closed notes except preprinted sheet, Calculators OK. Show all work to receive credit. Circle answers, show units, and round off reasonably

1. (25 pts) a) The switch has been open for a long time and is closed (as shown) at time $t = 0$.

   a) Find the initial and final conditions and write the full expression for $v_C(t)$, including all the constants that you find.



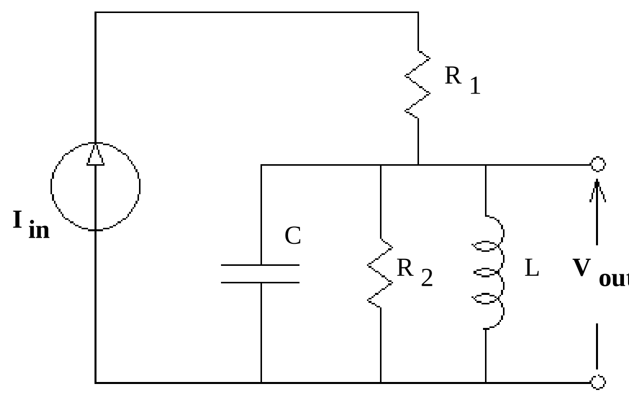
   b) What is v_C when $t = 1.5\tau$? $v_C(1.5\cdot\tau)$ = ?

   c) At time $t = 1.5\tau$ the switch is opened again. Find the complete expression for $v_C(t')$, where t' starts when the switch opens. Be sure to clearly show the time constant.

2. (12 pts) a) Find the s-type transfer function of the circuit shown. $\mathbf{I_{in}}$ is the input and $\mathbf{V_{out}}$ is the "output".

   You <u>MUST</u> show work to get credit. Simplify your expression for $\mathbf{H}(s)$ so that it is a ratio of simple polynomials.

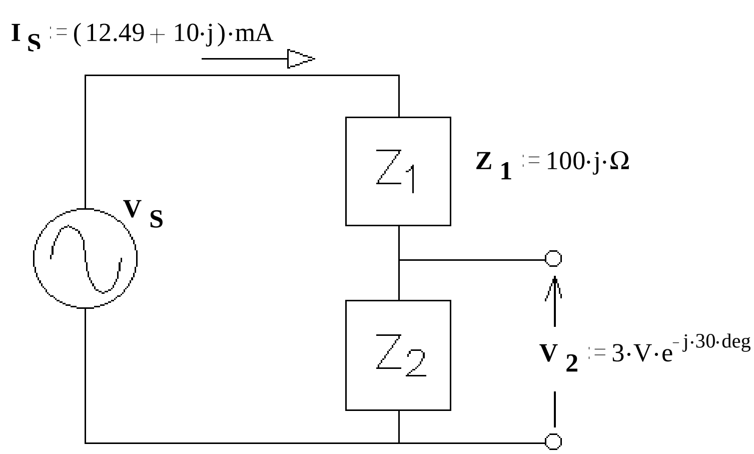
   a) $\mathbf{H}(s)$ = ?



   b) Does the transfer function have any poles? If yes, express them in terms of the circuit parts.

3. (25 pts) For partial credit, you must show work and/or intermediate results.

   a) Find $\mathbf{Z_2}$ in polar form.



   b) Find $\mathbf{V_S}$ in polar form.

   c) Circle 1: i) $\mathbf{I_S}$ leads $\mathbf{V_2}$ ii) $\mathbf{I_S}$ lags $\mathbf{V_2}$

   Why? Show numbers: _______ > _______ _______ < _______

   Or explain by other means:

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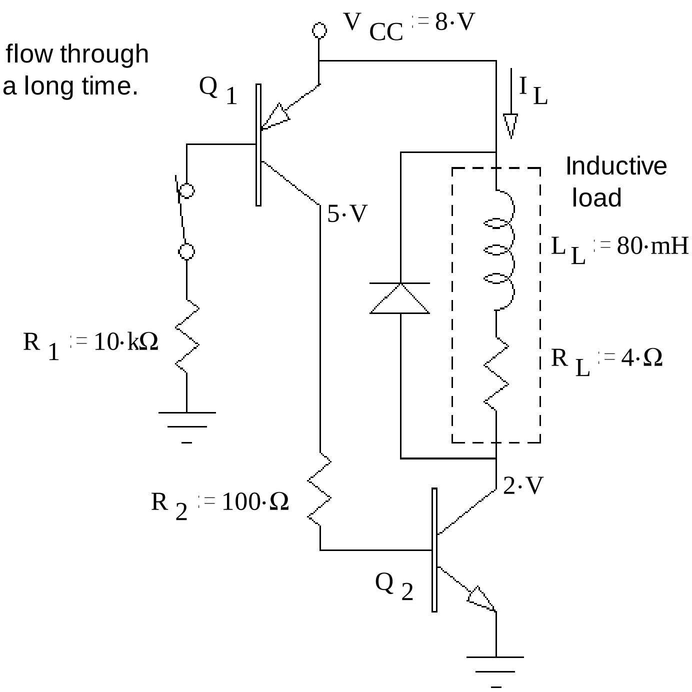
4. (34 pts) A couple of transistors are used to control the current flow through an inductive load. The switch has been closed, as shown, for a long time.

   a) You measure the voltage at each collector (referenced to ground) as shown on the drawing. Find the power dissipated by transistor Q_2 .



   b) Find the β of transistor Q_2 .

   c) Find the β of transistor Q_1 .

   d) Find the minimum β for transistor Q_1 to be in saturation. β_{1min} = ?

You replace Q_1 with a different transistor so that now: $\beta_1 := 200$ Use this from now on.

   e) Find the new load current (I_L) assuming transistor Q_2 is in the active region.

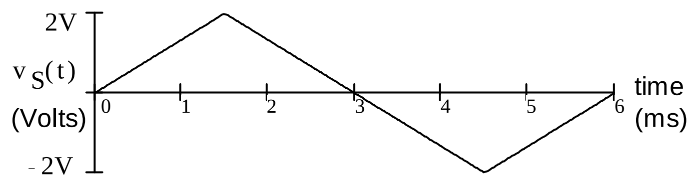
   f) Check the assumption that Q_2 is in the active region and recaculate I_L if necessary.

   g) The diode in this circuit conducts a significant current: (circle one)

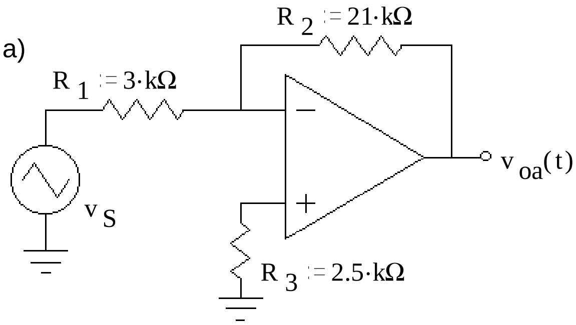
A) never.	C) when the switch first opens.	E) whenever the switch is open.
B) always.	D) when the switch first closes.	F) whenever the switch is closed.

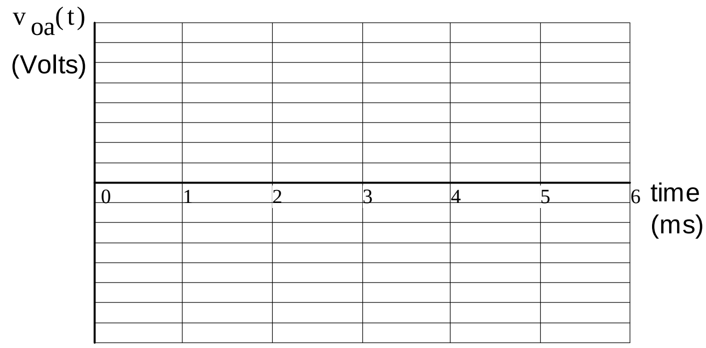
   h) What is the maximum diode current you expect when the switch is cycled. (Answer 0 if it never conducts.)

5. (32 pts) The same input signal (at right) is connected to several op-amp circuits below. Sketch the output waveform for each circuit. Clearly label important voltage levels on each output. If I can't easily make out what your peak values are, I'll assume you don't know. Don't forget to show inversions. All op-amps are powered by $\pm$ 12 V power supplies.

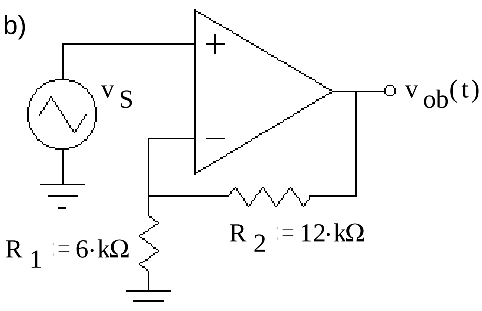


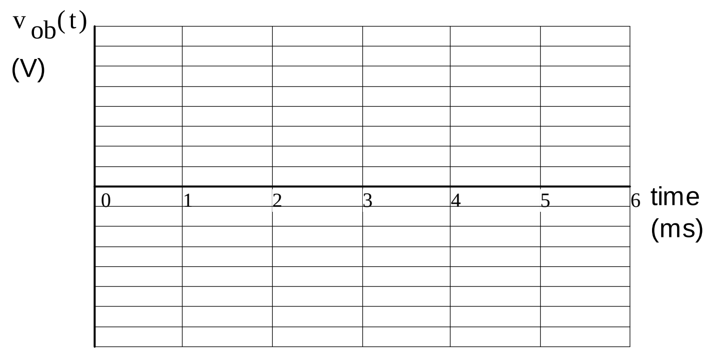
a)



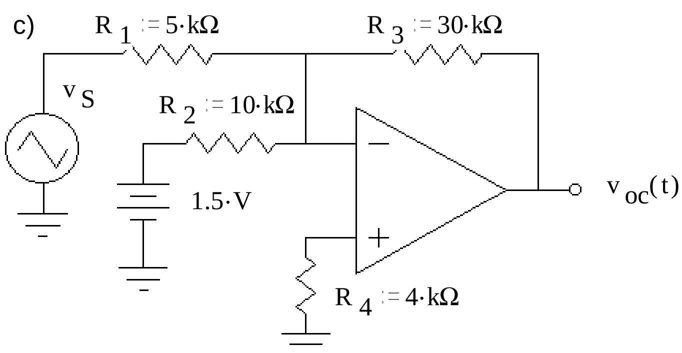


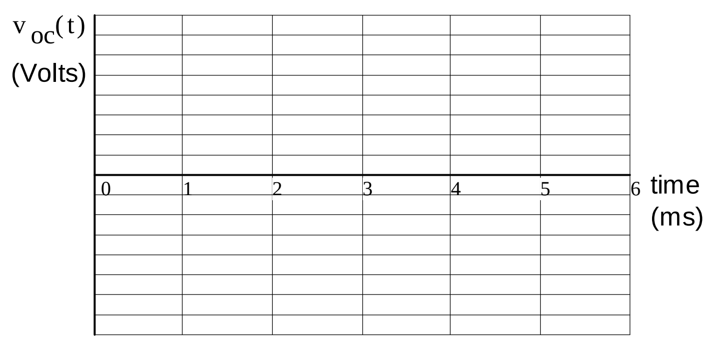
b)



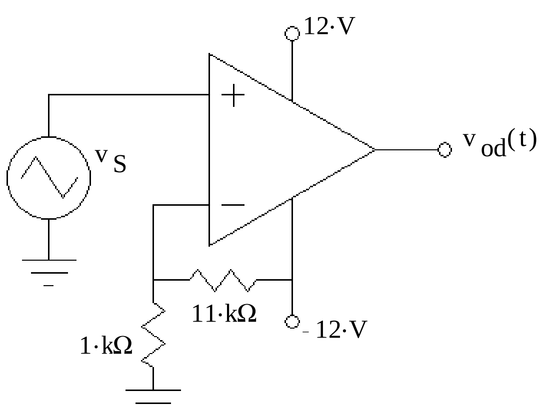


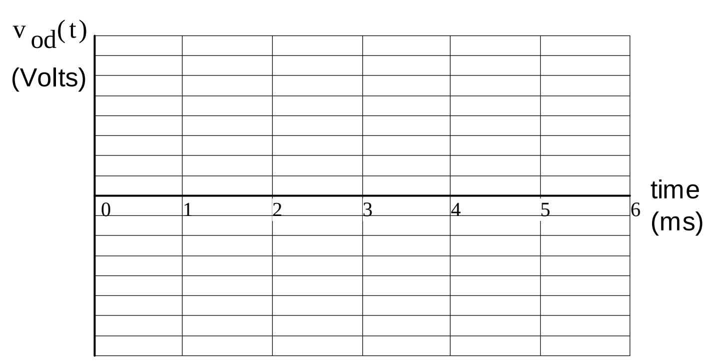
c)



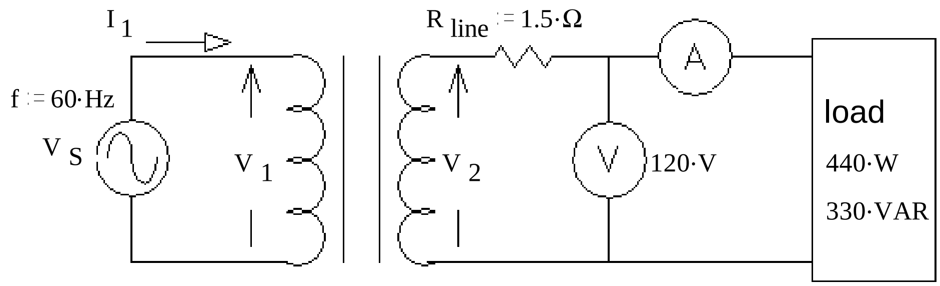


d)





6. (34 pts) A load is connected as shown. The load uses 440W and 330VAR. The RMS voltmeter measures 120 V. Find the following:
(Be sure to use correct units for each value.)



a) The apparent power used by the load. $|\mathbf{S}|$ = ?

b) The load's power factor

c) The power factor is: i) leading ii) lagging (circle one)

d) What does the RMS ammeter measure?

e) The load consists of two parts in series. Draw the parts in the box above and find the values. $\omega := 377\cdot\frac{rad}{sec}$

f) How much power does R_{line} waste? P_{Rline} = ?

g) How much power does the source provide? P_S = ?

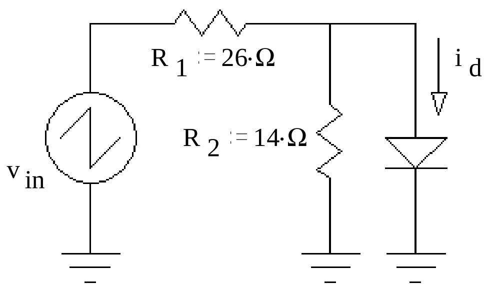
h) What is the secondary voltage? $|\mathbf{V_2}|$ = ? Hint: Remember, you can't add magnitudes of complex numbers.

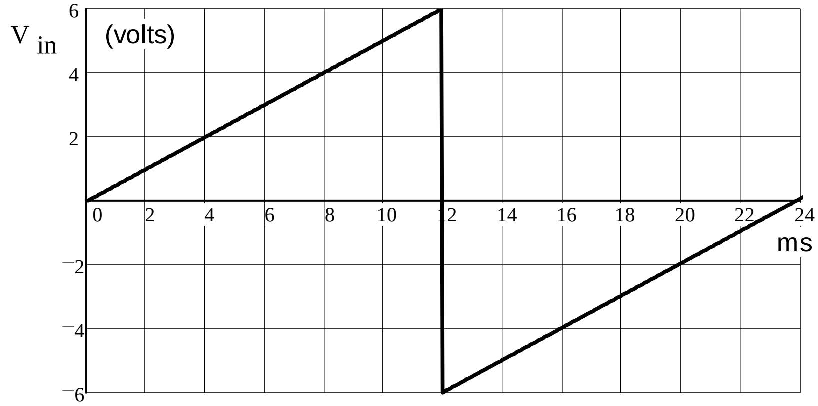
i) The transformer shown in the circuit is ideal. It is rated at 1050/300 V, 1.2 kVA, 60 Hz. Find V_1 $|\mathbf{V_1}|$ = ?

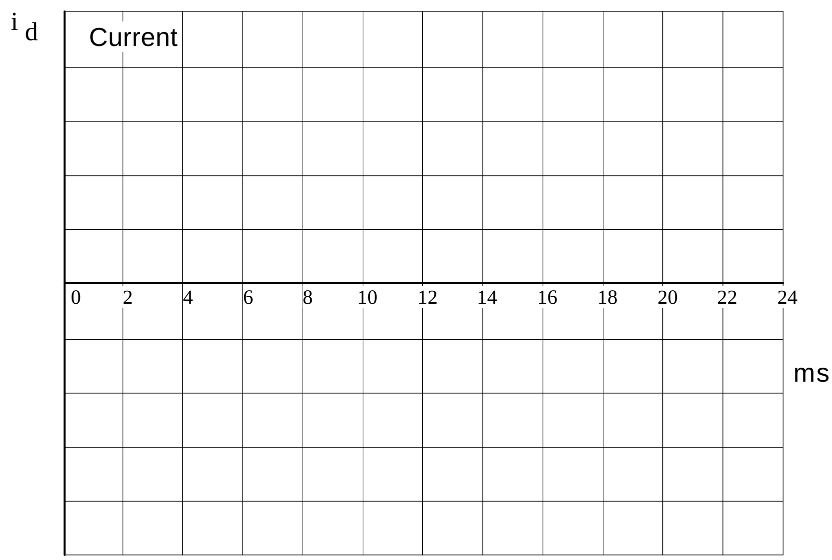
j) Is this transformer operating within its ratings? Show your evidence.

k) The load box cannot be opened. Add (draw it) another component to the circuit above which can correct the power factor (make pf = 1). Show the correct component in the correct place and <u>find its value</u>. This component should not affect the real power consumption of the load.

7. (18 pts) A voltage waveform is applied to the circuit shown. Accurately draw the diode current waveform (i_d) you expect. to see. Label important times **and** current levels







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otherwise, leave blank

The grades will be posted on line in pdf form in alphabetical order under the alias that you provide here. I **will not** post grades under your real name or an alias that looks like a real name or u-number. The pdf spreadsheet will show the homework, lab, and exam scores of everyone who answers here.

Answers

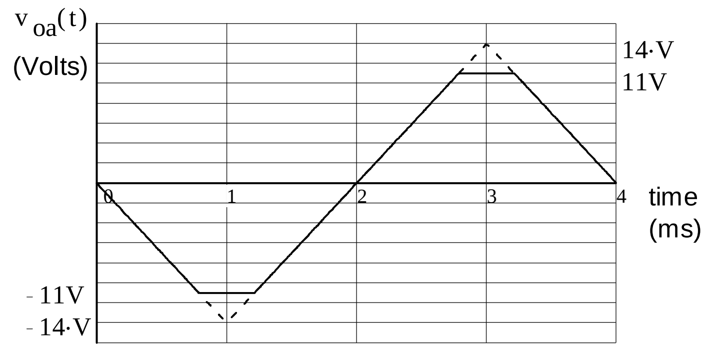
1. a) $9\cdot V + 5\cdot V\cdot e^{-\frac{t}{90\cdot \mu s}}$ b) $10.12\cdot V$ c) $14\cdot V - 3.88\cdot V\cdot e^{-\frac{t'}{140\cdot \mu s}}$

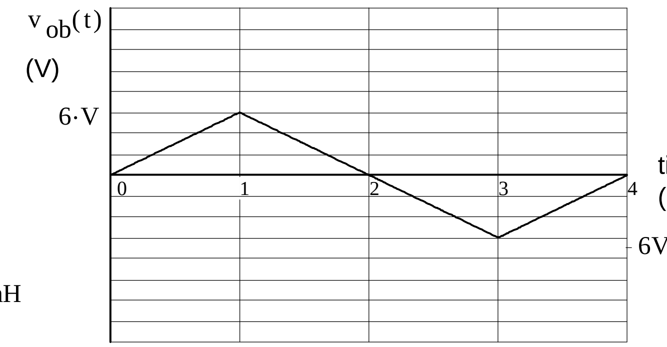
2. a) $\dfrac{\frac{1}{C}\cdot s}{s^2 + \frac{1}{C\cdot R_2}\cdot s + \frac{1}{C\cdot L}}$ b) yes, $-\frac{1}{2\cdot C\cdot R_2} \pm \frac{1}{2}\cdot\sqrt{\left(\frac{1}{C\cdot R_2}\right)^2 - 4\cdot\frac{1}{C\cdot L}}$

3. a) $187.5\Omega\ \underline{/-68.682^o}$ b) $1.62V\ \underline{/-8.93^o}$ c) i) $+38.6^o > -30^o$

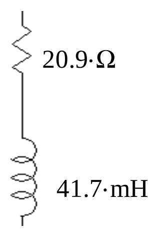
4. a) $3\cdot W$ b) 34.9 c) 58.9 d) 97.3 e) $2.48\cdot A$
   f) Not $1.95\cdot A$ g) C h) $1.95\cdot A$

5.





6. a) $550\cdot A$ b) 0.8 c) ii) d) $4.58\cdot A$ e)



   f) $31.5\cdot W$ g) $471.5\cdot W$ h) $125.6\cdot V$
   i) $439.5\cdot V$ j) NO, $4.58\cdot A > 4\cdot A = I_{2max}$
   k) Add a $60.8\mu F$ capacitor in parallel with load