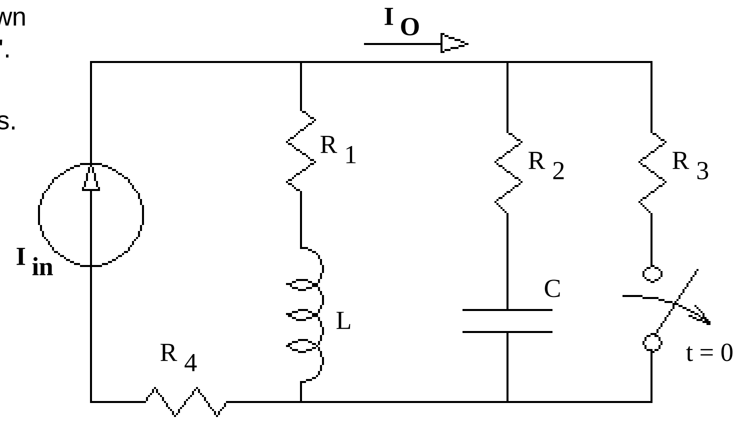
ECE 2210 Final given: Fall 21

Closed Book, Closed notes except preprinted yellow sheet, Calculators OK.

Show all work to receive credit. Circle answers, show units, and round off reasonably

1. (20 pts) Find the s-type transfer function of the circuit shown after the switch opens. $\mathbf{I_{in}}$ is the input and $\mathbf{I_O}$ is the "output". You MUST show work to get credit. Simplify your expression for H(s) so that it is a ratio of simple polynomials.

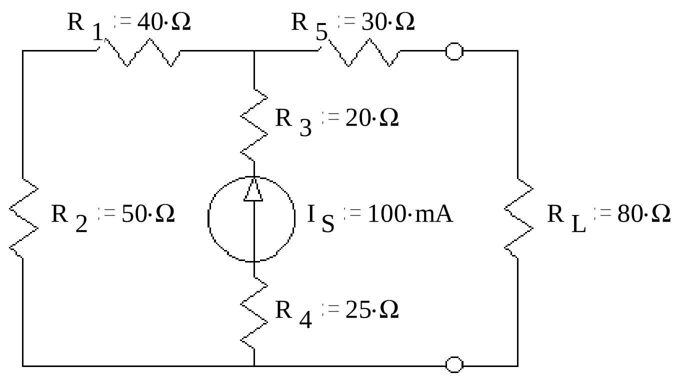
   a) $\mathbf{H}(s) = ?$



b) Find the characteristic equation of the transfer function shown.

c) Does the transfer function have one or more zeros? If yes, express it (them) in terms of R_1, R_2, C, & L.

2. (24 pts) a) Find and draw the Thévenin equivalent of the circuit shown. The load resistor is R_L.



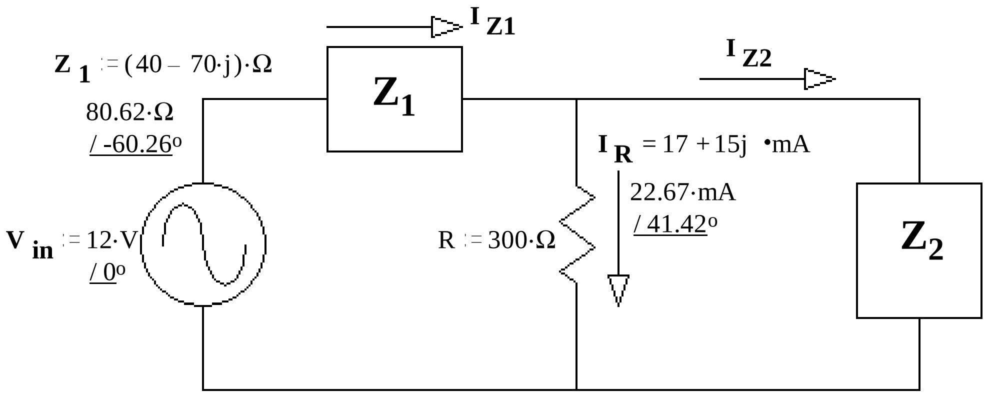
b) Find and draw the Norton equivalent of the same circuit.

c) Find current through the load (R_L).

d) What value of load resistor (R_L) would you choose if you wanted to maximize the power dissipation in the load. AND find the power dissipated by the new R_L.

3. (26 pts) Find $\mathbf{I_{Z1}}$, $\mathbf{I_{Z2}}$ & $\mathbf{Z_2}$.

a) Find $\mathbf{I_{Z1}}$ in any form.



b) Find $\mathbf{I_{Z2}}$ in any form.

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

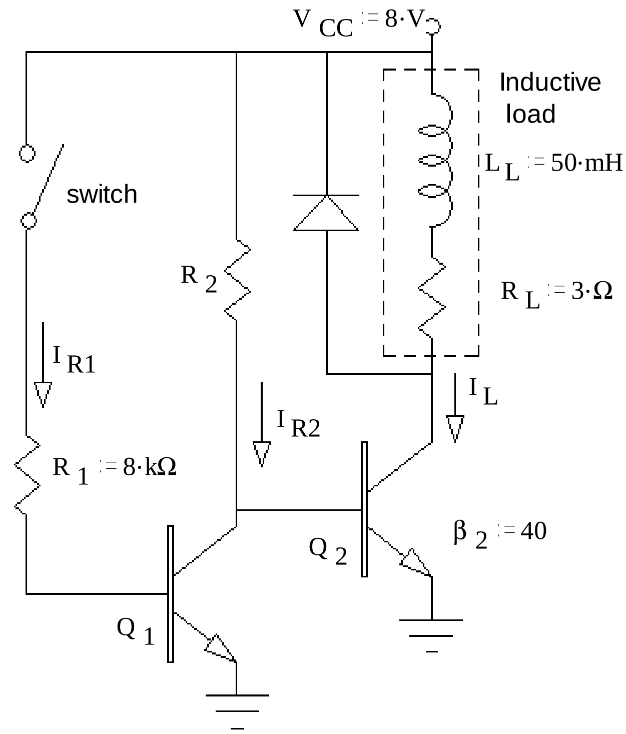
4. (36 pts) A transistor is used to control the current flow through an inductive load (in the dotted box, it could be a relay coil or a DC motor).

   a) In order for current to flow in through the load, the switch should be:

      i) closed or ii) open (Circle one)

   b) Assume the switch has been in the position you circled above for a long time and transistor Q_2 is saturated. Find the power dissipated by transistor Q_2 (neglect base current and V_{BE}).

      $P_{Q2} = ?$



   c) Assume β_2 is as shown. Find the maximum value of R_2, so that Q_2 will be in saturation. $R_2 = ?$

      Use this value of R_2 for the remainder of the problem

   d) If β_2 were actually half the value shown shown, how much power would be dissipated by transistor Q_2 (neglect base current and V_{BE})? $P_{Q2} = ?$

Use the value of $\beta_2 = 40$ for the remainder of the problem. (**NOT** the half-value)

e) When the switch is changed from the position you circled in part a), the load current should go to zero. What is the minimum value of β_1 needed to saturate Q_1?

f) If β_1 were actually half the value you found above, what would I_L be?

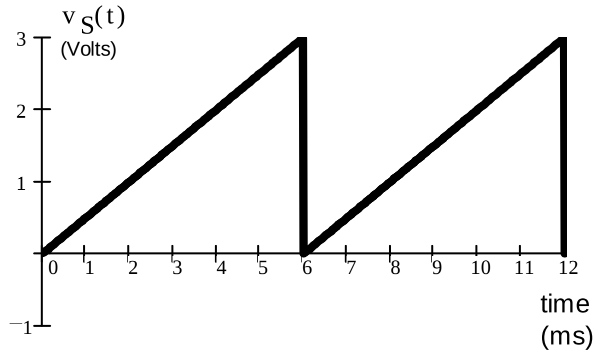
Hints: Q_2 will now be partially on. Some of I_{R2} will flow through Q_1 and the rest will flow into the base of Q_2.

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

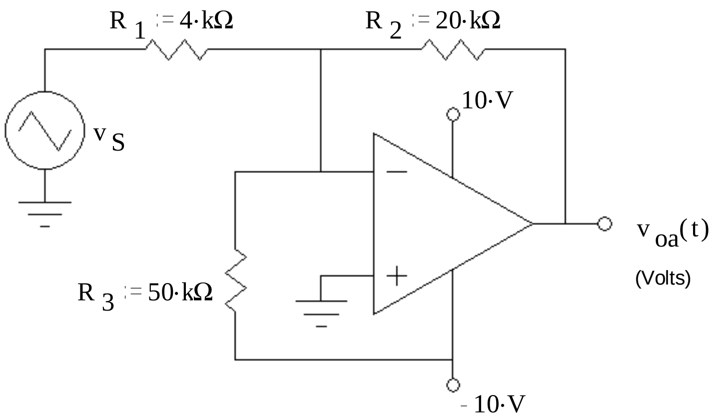
A) never.
B) when the switch closes.
C) whenever the switch is closed.
D) always.
E) when the switch opens.
F) whenever the switch is open.

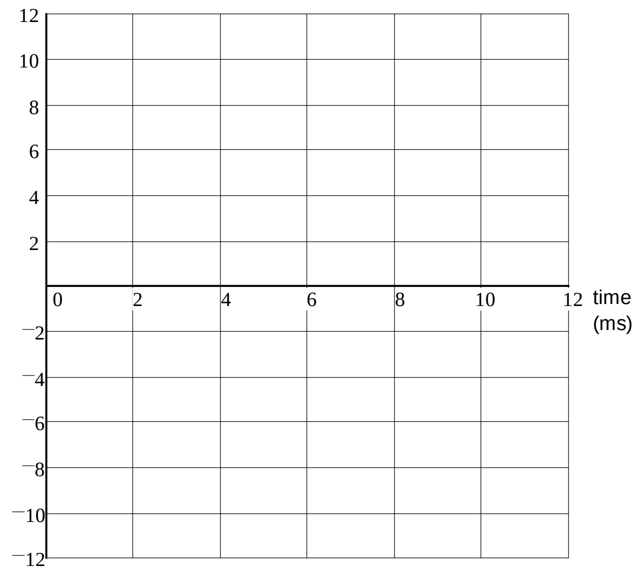
h) Assuming the conditions of part a) (no half-β's), what is the maximum diode current you expect when the switch is cycled. (Answer 0 if it never conducts.)

5. (20 pts) The same input signal (at right) is connected to several op-amp circuits.

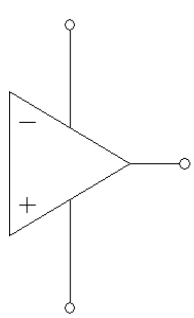


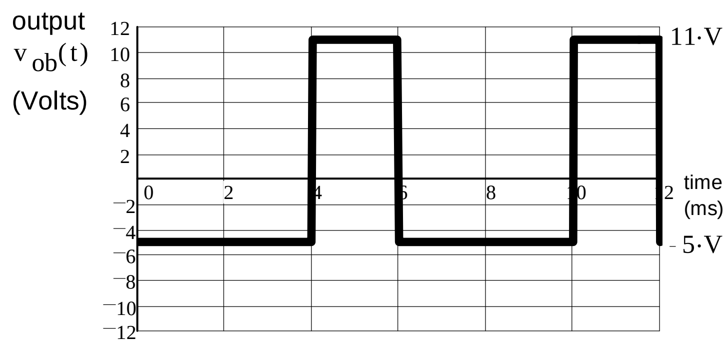
a) Sketch the output waveform for this circuit. Clearly label important voltage levels on the output. If I can't easily make out what your peak values are, I'll assume you don't know. Don't forget to show inversions.





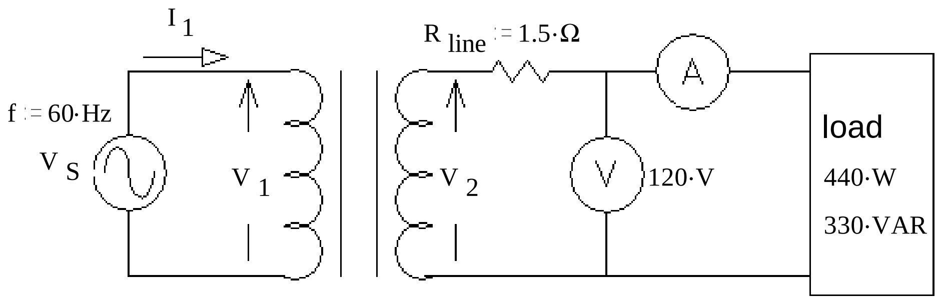
b) Devise an op-amp circuit which will output the waveform shown below given the input waveform shown at right.
Choose the power supplies and use whatever passive parts you need.
You **may not** use any other batteries, input signals, or power supplies beyond the two that power the op amp.





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? $|\mathbf{V_2}|$ = ? Hints: Remember, you can't add magnitudes of complex numbers.
Don't forget R_{line}

More on next page ===>

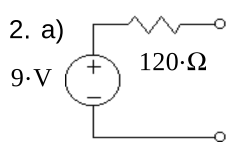
i) The transformer shown in the circuit is ideal. It is rated at 1050/300 V, 1.2 kVA, 60 Hz. Find V_1 . $|\mathbf{V}_1|$ = ?

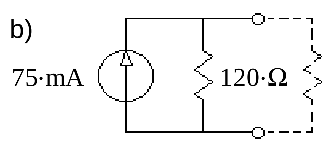
j) Is this transformer operating within its ratings? Show your evidence.

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. You may assume the load voltage remains 120V.

Answers

1. a) $\dfrac{s\cdot\left(s+\frac{R_1}{L}\right)}{s^2+\frac{R_2+R_1}{L}\cdot s+\frac{1}{L\cdot C}}$ b) $0 = s^2+\frac{R_2+R_1}{L}\cdot s+\frac{1}{L\cdot C}$ c) Yes, 0 & $-R_1/L$

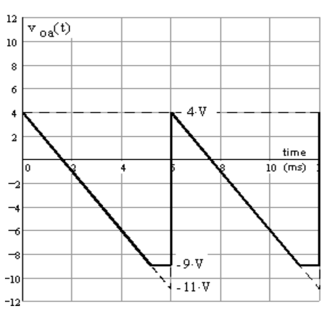
2. a)


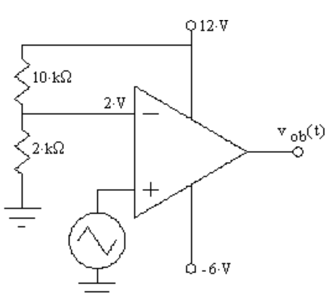
b)


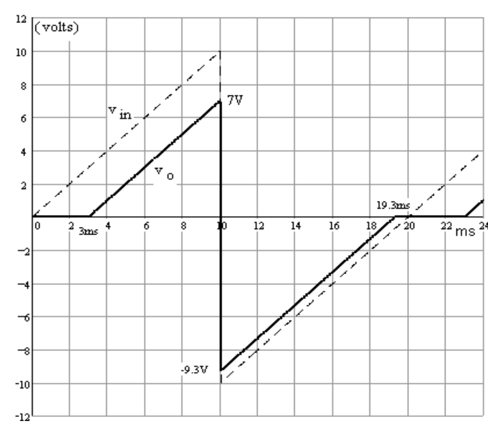
c) 45·mA d) 120·Ω 163·mW

3. a) $(90.92+46.62\cdot j)\cdot mA$ b) $(73.92+31.62\cdot j)\cdot mA$ = 80.4mA <u>/ 23.16</u>° c) 84.6·Ω <u>/ 18.3</u>°

4. a) 0.52·W b) 112.3·Ω c) 5.33·W d) 76.1 e) 1.21·A f) B) g) 2.6·A

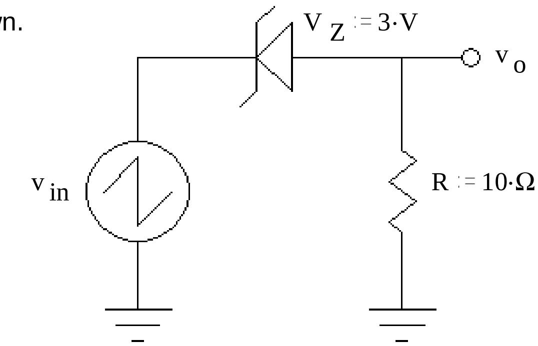
5. a)


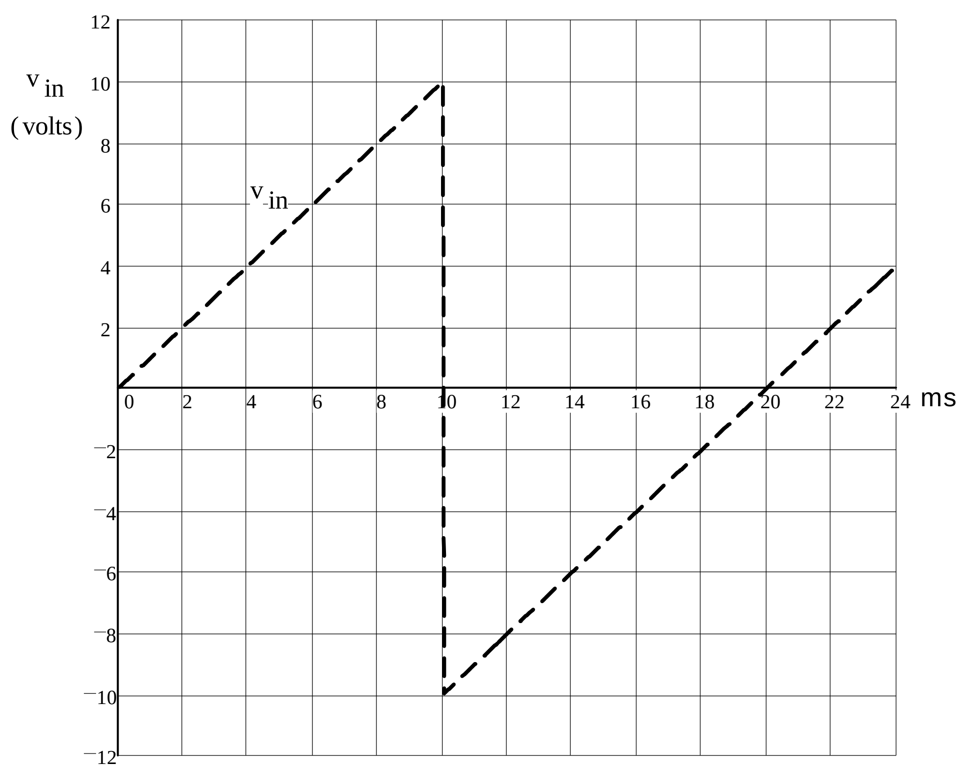
b)


7.


6. a) 550·VA b) 0.8 c) ii) d) 4.583·A e) 20.95·Ω & 41.67·mH
f) 31.5·W g) 471.5·W h) 125.6·V j) No, current > rated
k) Add a 60.8mH capacitor in parallel with load

7. (20 pts) A voltage waveform (dotted line) is applied to the circuit shown. Accurately draw the output waveform (v_o) you expect to see.
Label important times **and** voltage levels.





Answers Are on the Bottom of previous page