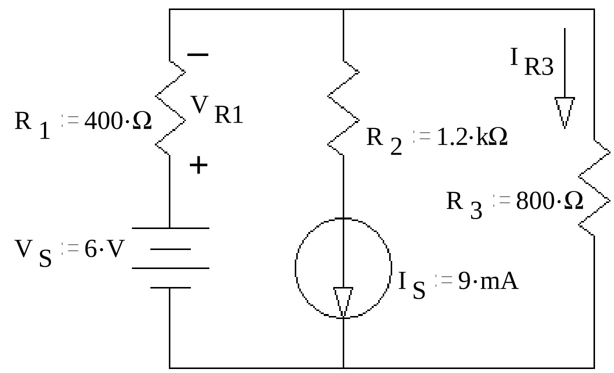
ECE 2210 Final given: Spring 20

April 26, 2020

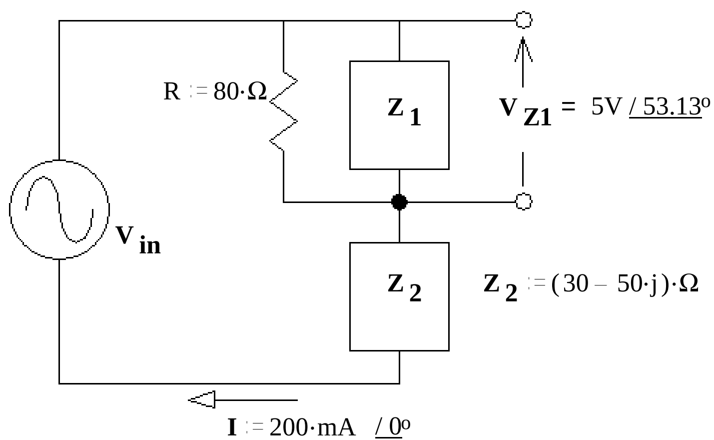
Closed Book, Closed notes except preprinted blue sheet, Calculators OK. Show all work to receive credit. Circle answers, show units, and round off reasonably

1. (17 pts) Use the method of superposition to find the voltage across R_1 (V_{R1}) and the current through R_3 (I_{R3}). Be sure to clearly show and **circle** your intermediate results.



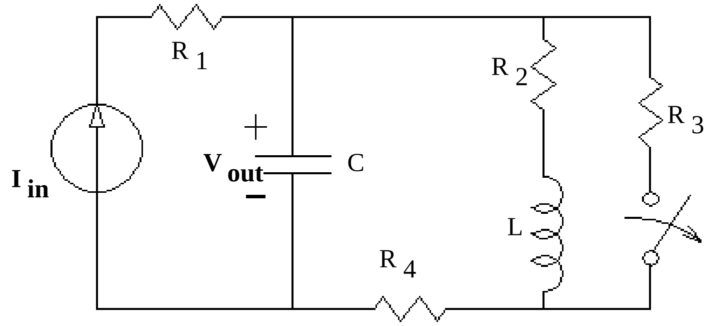
2. (20 pts)

a) Find $\mathbf{V_{in}}$.



b) Find $\mathbf{Z_1}$ in polar form.

3. (17 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".

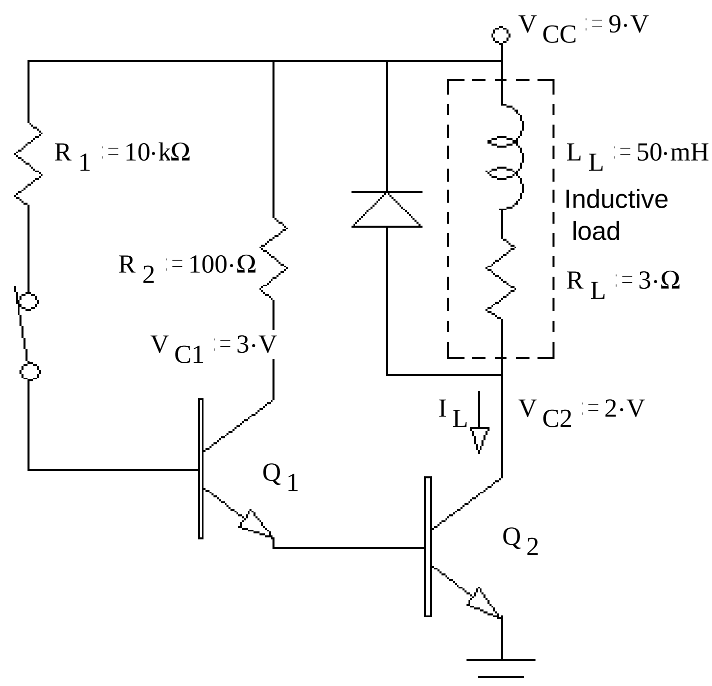


You MUST show work to get credit. Simplify your expression for H(s) so that it is a ratio of simple polynomials just like my examples.

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

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

4. (34 pts) A couple of transistors are used to control the current flow through an inductive load.



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

$P_{Q2} = ?$

b) Find the β of transistor Q_2. $\beta_2 = ?$

You may assume that the emitter current of Q_1 is approximately equal to the collector current of Q_1.

4, Continued c) Find the β of transistor Q_1 . β_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 $\beta_1 > \beta_{1min}$. Use this from now on.

e) Find the new load current. I_L = ? Be sure to explictly check any assumption you make about the state of Q_2.

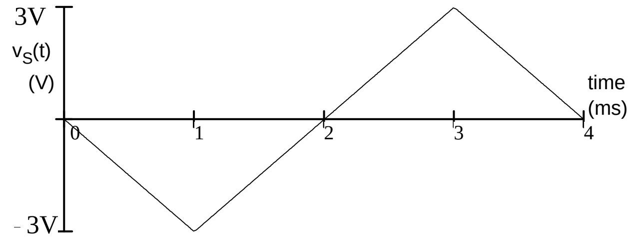
f) Find the power dissipated in transistor Q_2 . P_{Q2} = ?

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

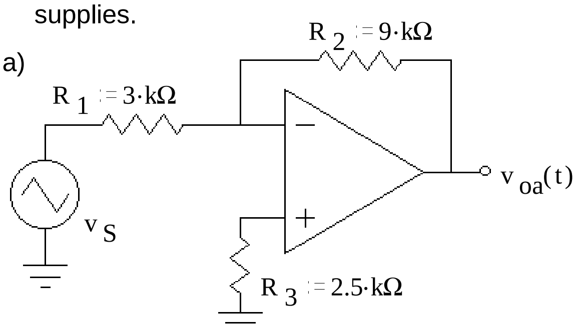
A) never.
B) when the switch first closes.
C) whenever the switch is closed.
D) always.
E) when the switch first opens.
F) whenever the switch is open.

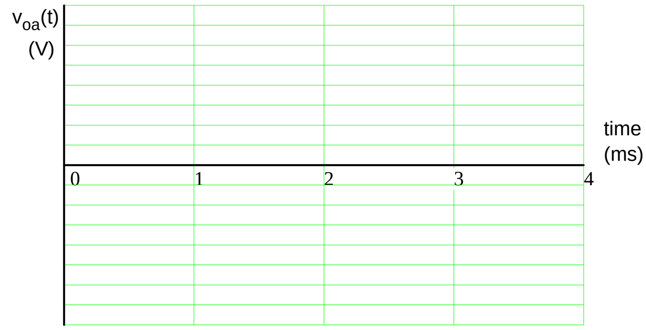
h) What is the maximum diode current you expect when the switch is cycled. (Answer 0 if it never conducts.)

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 $\pm$ 15 V power supplies.

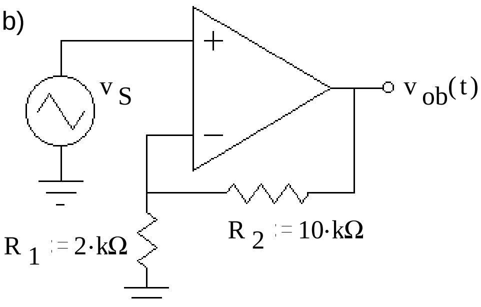


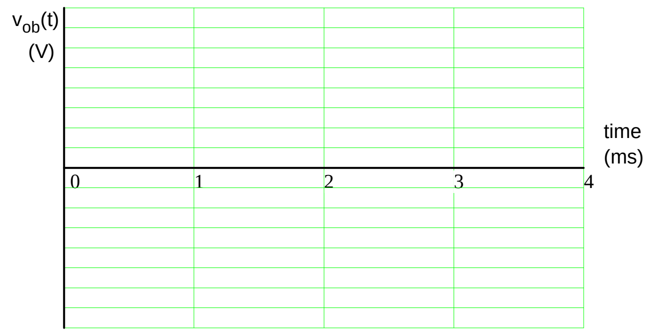
a)



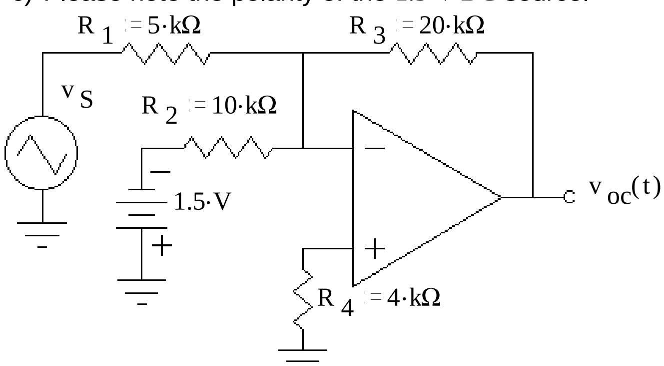


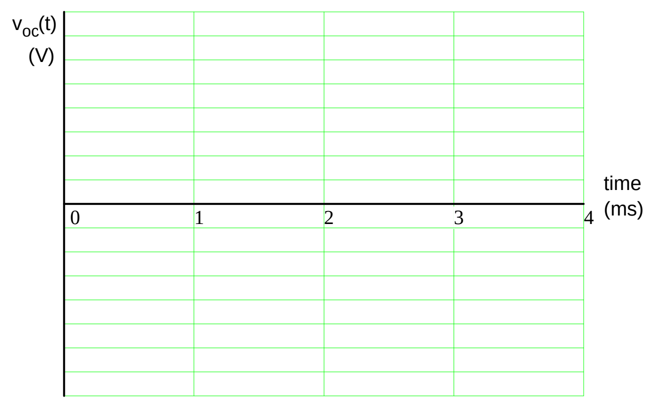
b)



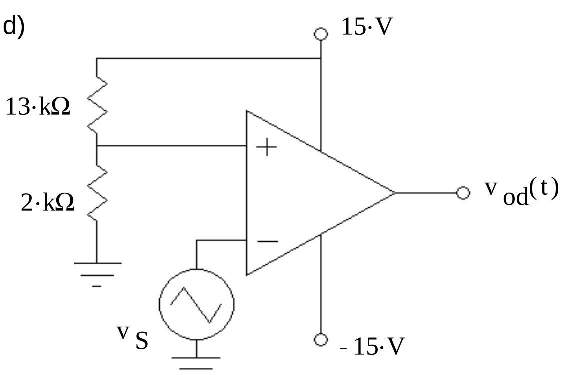


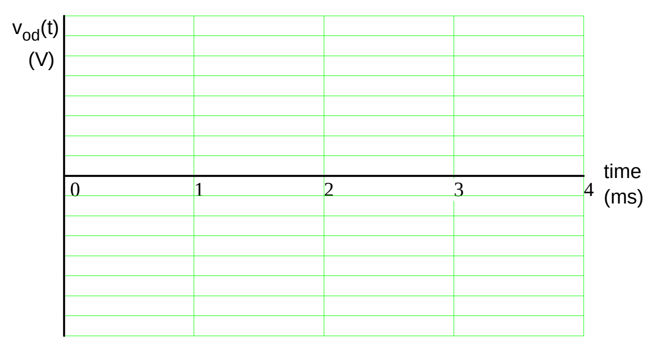
c) Please note the polarity of the 1.5-V DC source.





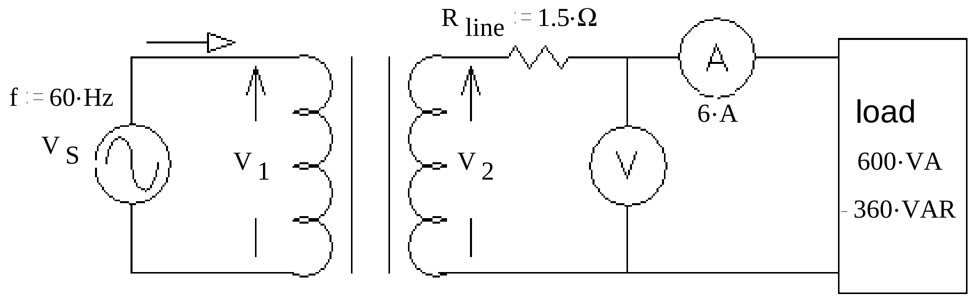
d)





6. (36 pts) A load is connected as shown. The load uses 600 VA and -360 VAR. The RMS ammeter measures 6 A. Find the following: (Be sure to use correct units for each value.)

a) The real power used by the load. P_{load} = ?



b) The load's power factor. pf_{load} = ?

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

d) What does the RMS voltmeter measure?

e) The load consists of two parts in series. Draw the parts in the box above and find the values.

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.

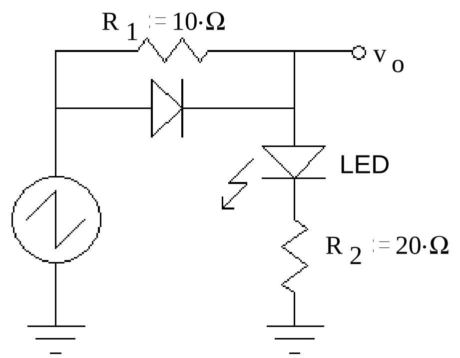
i) The transformer shown in the circuit is ideal. It is rated at 800/200 V, 1 kVA, 60 Hz. Find V_1. $|\mathbf{V_1}|$ = ?

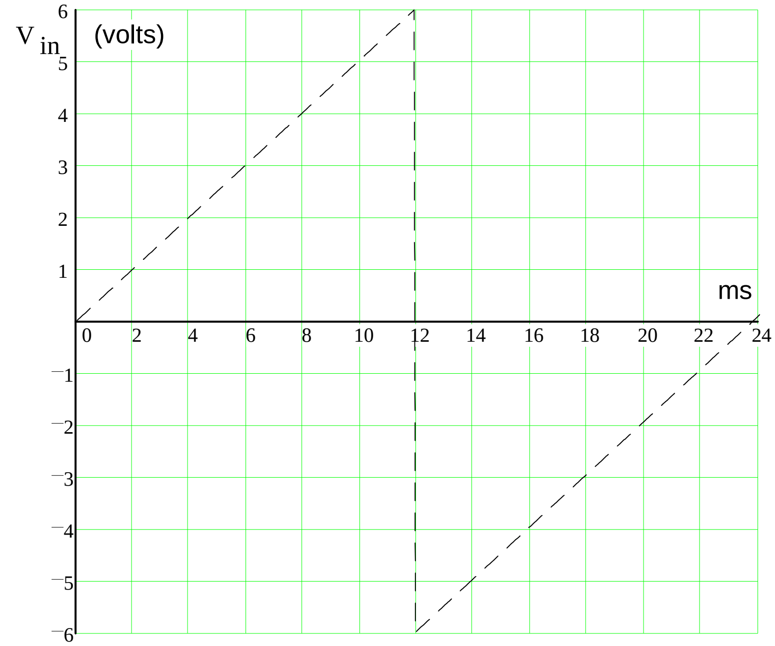
j) Is this transformer operating within its ratings? Show your evidence.

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 find its value. This component should not affect the real power consumption of the load.

l) V_L will i) decrease ii) stay the same iii) increase when this part is added.

7. (24 pts) A voltage waveform (dotted line) is applied to the circuit shown. <u>Accurately</u> draw the output waveform (v_o) you expect to see. Label important times **<u>and</u>** voltage levels.





Explicitly show important times, values and units

Answers

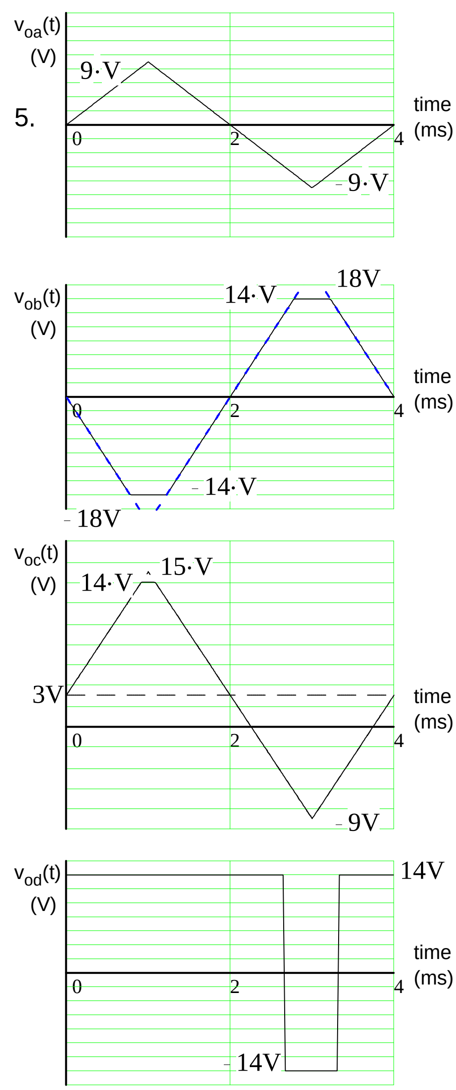
1. 4.4·V   2·mA

2. a) 10.82V /-33.69º   b) 29.4Ω / 70.2º

3. a) $$\frac{\frac{1}{C}\cdot s + \frac{R_2 + R_4}{L\cdot C}}{s^2 + \frac{R_2 + R_4}{L}\cdot s + \frac{1}{L\cdot C}}$$ b) yes, $-\frac{R_2 + R_4}{L}$

4. a) 4.67·W   b) 38.9
   c) 78.95   d) 106.6
   e) 2.93·A   f) 0.587·W
   g) E)   h) 2.93·A

5.



6. a) 480·W   b) 0.8   c) i)
   d) 100·V   e) 13.3·Ω   265·μF
   f) 54·W   g) 534·W   h) 107·3·V
   i) 322·V   j) No, too much current
   k) Add a 73.7mH inductor in parallel with load.   l) iii

7.