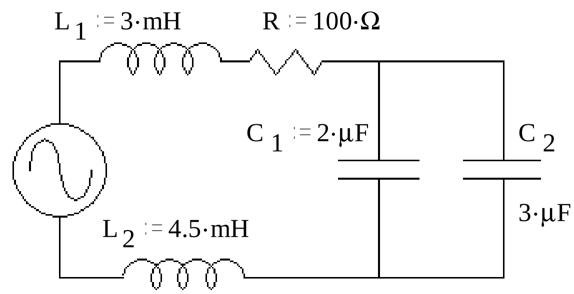
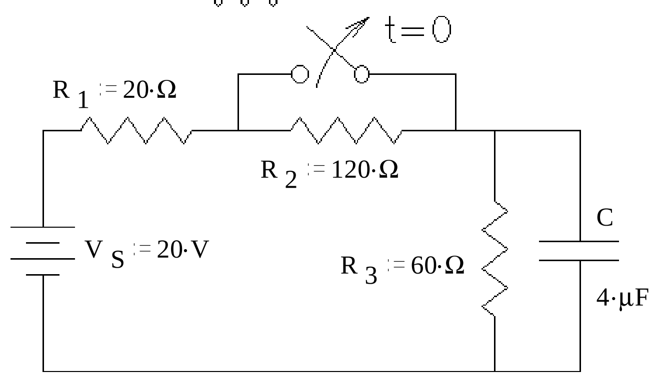
ECE2210 Final given: Spring 11

1. (10 pts) Find the resonant frequency (or frequencies) of the circuit shown (in cycles/sec or Hz).



2. (25 pts) The switch has been closed (making contact) for a long time and is switched open (as shown) at time $t = 0$.



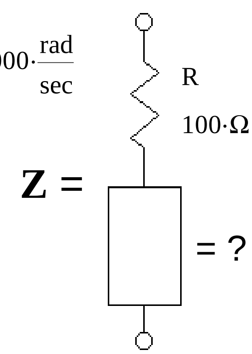
a) Find the complete expression for $v_C(t)$.

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

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

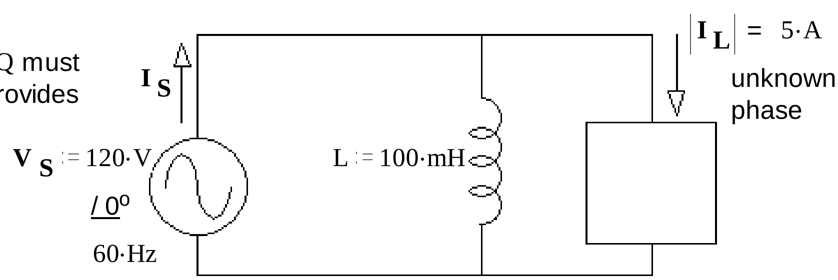
3. 9 pts) $\mathbf{Z} := |\mathbf{Z}| \cdot e^{j \cdot 40 \cdot deg}$ We don't know its magnitude, but its phase angle is $+40^o$. $\omega := 3000 \cdot \frac{rad}{sec}$

$\mathbf{Z}$ is made of a 100Ω resistor in series with one other part. What is the part? Give type and value.



4. (24 pts) An inductor is used to completely correct the power factor of a load. Find the following:

a) The power consumed by the load. $P_L = ?$
Hint 1: Since L corrects the power factor, its Q must exactly cancel the load's Q and the source provides only P and no Q.



Hint 2: If hint 1 doesn't make sense to you, you don't know AC power well enough to do part a) -- so skip to part b).

If you can't find this power, mark an x here _____ and assume $P_L = 550W$ for the rest of the problem.

b) The power supplied by the source. $P_S = ?$

c) The source current (magnitude and phase). $\mathbf{I_S} = ?$

d) The load can be modeled as 2 parts in series.
Draw the model and find the values of the parts.

e) The inductor, L, is replaced with a 50 mH inductor.

circle one

i) The **new** source current $|\mathbf{I_S}|$ is **greater** than that calculated in part c).

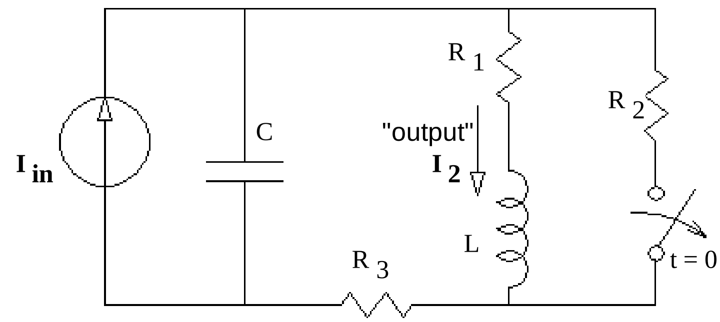
ii) The **new** source current $|\mathbf{I_S}|$ is **the same** as that calculated in part c).

iii) The **new** source current $|\mathbf{I_S}|$ is **less** than that calculated in part c).

5. (15 pts) a) Find the s-type transfer function of the circuit shown after time $t = 0$. Consider $\mathbf{I_2}$ as the "output".

You MUST show work to get credit. Simplify your expression for $H(s)$ so that the denominator is a simple polynomial with no coefficient before the highest-order s term in the denominator.

$$\mathbf{H}(s) = \frac{\mathbf{I_2}(s)}{\mathbf{I_{in}}(s)} = ?$$



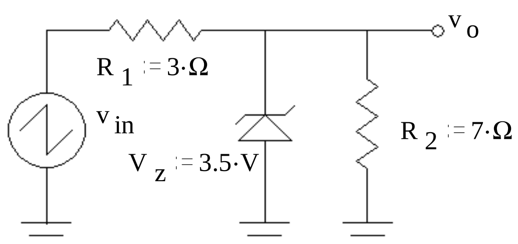
b) How many zeroes does this transfer function have?

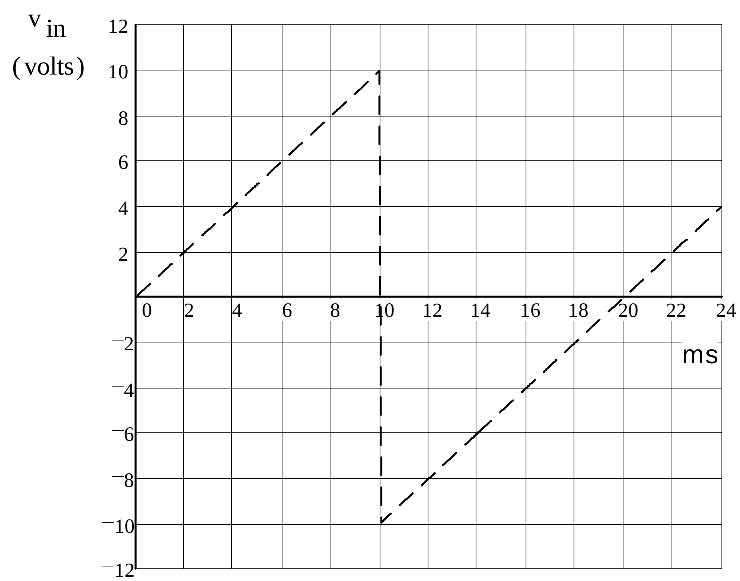
If it has 1 or more, express them (probably in terms of R_1, R_2, R_3, L and C).

c) How many poles does this transfer function have?

If it has 1 or more, express them (probably in terms of R_1, R_2, R_3, L and C).

6. (22 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.





7. (31 pts) A couple of transistors are used to control the current flow through an inductive load.

a) The switch is open, as shown. What is the maximum R_2 can be if transistor Q_2 is in saturation.

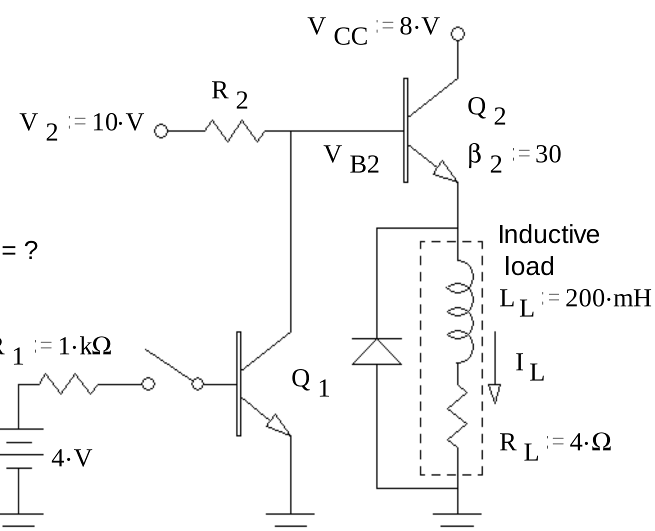
$\beta_2 = 30$ $\quad R_2 = ?$

b) Find the power dissipated in transistor Q_2 with this R_2. $\quad P_{Q2} = ?$

c) When the switch is closed, you would like transistor Q_1 to saturate. What minimum β_1 would be required to achieve saturation?

$\beta_{1min} = ?$

Assume at least this β_1 for the remainder of the problem.



d) What if the voltage V_2 was too low so that the base voltage of transistor Q_2 was only 6V, how much power would be dissipated in transistor Q_2?

IF $V_{B2} := 6 \cdot V$ $\quad P_{Q2} = ?$

e) The transistor Q_2 was selected to be able to handle the power found in part b) (with a 2x factor of safety). What would happen with the V_2 of part d)?

V_2 is NOT too low for the remainder of the problem, that is, use the original $V_2 = 10 \cdot V$

f) 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.

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

h) This circuit design is: (circle as many as apply and don't forget to say **why**)

- A) incredibly fantastic.
- B) a very good design.
- C) dumb.
- D) not a good design.

Why?

Use constant-voltage-drop models for the diodes and LEDs on this exam.

8. (24 pts) Assume that diode D_1 does **NOT** conduct.

Assume that diodes D_2 and D_3 **DO conduct.**

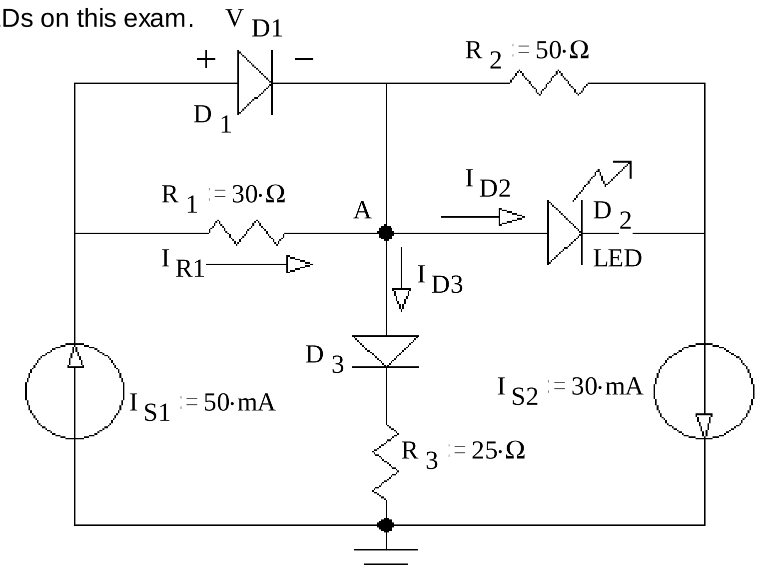
a) Stick with these assumptions even if your answers come out absurd.
Find the following:

V_{D1} = ________

I_{D2} = ________

I_{D3} = ________

V_A = ________



b) Based on the numbers above, was the assumption about D_1 correct? yes no (circle one)
How do you know? (Specifically show a value which is or is not within a correct range.)

c) Was the assumption about D_2 correct? yes no
How do you know? (Show a value & range.) (circle one)

d) Was the assumption about D_3 correct? yes no
How do you know? (Show a value & range.)

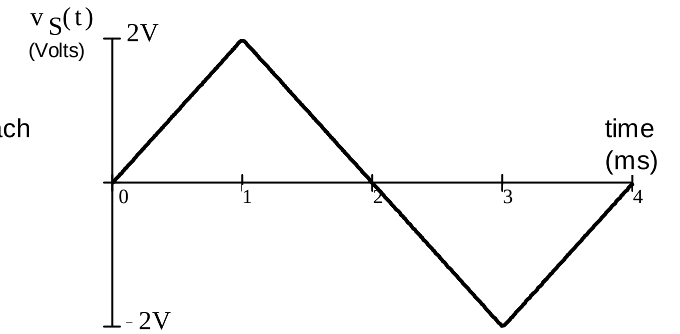
e) Based on your answers to parts b), c) & e), Circle one: (circle one)

i) The ***real*** $I_{R1} < I_{R1}$ calculated in part a.

ii) The ***real*** $I_{R1} = I_{R1}$ calculated in part a.

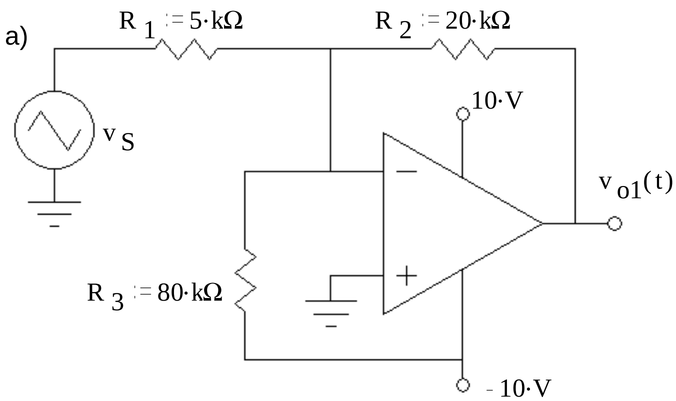
iii) The ***real*** $I_{R1} > I_{R1}$ calculated in part a.

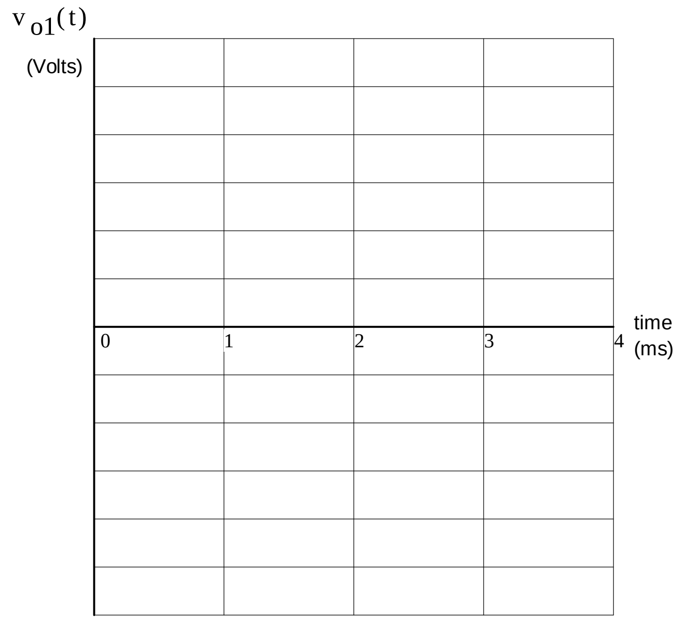
Justify your answer.



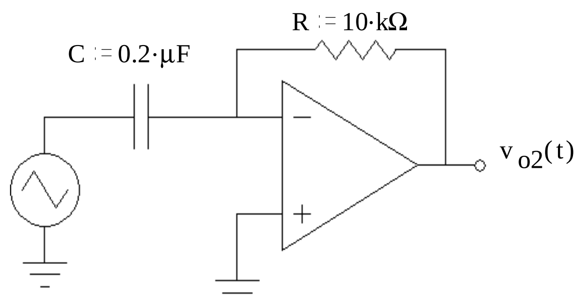
10. (18 pts) The same input signal (at right) is connected to several op-amp circuits below. Sketch the output waveform for each circuit. Clearly label important voltage levels on each output. If I can't easily make out what your peak values are, I'll assume you don't know. Don't forget to show inversions. All op-amps are powered by ± 10 V power supplies.

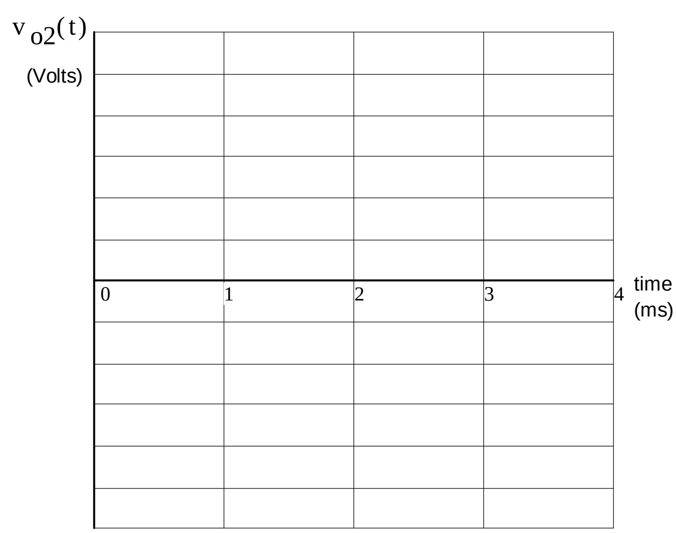
a)





b)





9. Do you want your grade and scores posted on the Internet?
If your answer is yes, then provide some sort of alias. ______________________________
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. It will show the homework, lab, and exam scores of everyone who answers here.

Answers

1. $822\cdot Hz$

2. a) $6\cdot V + 9\cdot V\cdot e^{-\frac{t}{168\cdot\mu s}}$ b) $9.31\cdot V$ c) $15\cdot V - 5.69\cdot V\cdot e^{-\frac{t}{60\cdot\mu s}}$

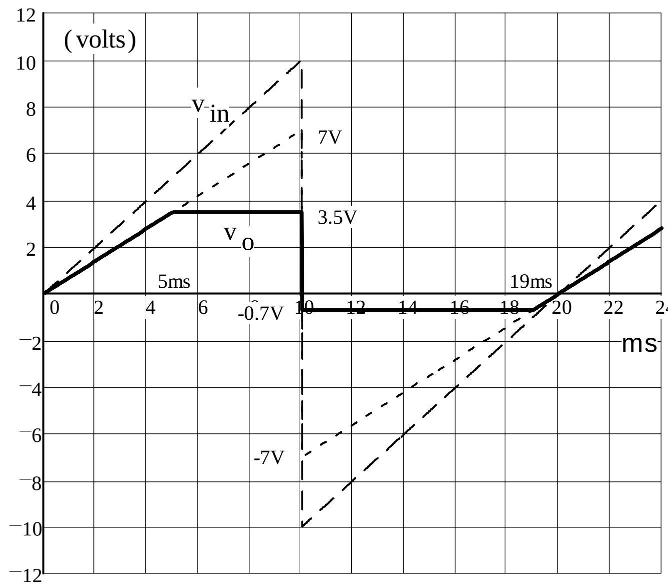
3. $28\cdot mH$ Inductor

4. a) $463\cdot W$ b) $463\cdot W$ c) $3.86\cdot A \ \angle 0^o$ d) $R := 18.5\cdot\Omega$ $C := 174\cdot\mu F$ e) i)

5. a) $\frac{\frac{1}{LC}}{s^2 + \frac{R_1 + R_3}{L}\cdot s + \frac{1}{L\cdot C}}$ b) 0

c) 2 $\frac{-\frac{R_1+R_3}{L} \pm \sqrt{\left(\frac{R_1+R_3}{L}\right)^2 - \frac{4}{L\cdot C}}}{2}$

6.



7. a) $23.1\cdot\Omega$ or $23.8\cdot\Omega$ (2nd ans is more accurate) b) $0.39\cdot W$

c) 129 or 125 d) $3.58\cdot W$

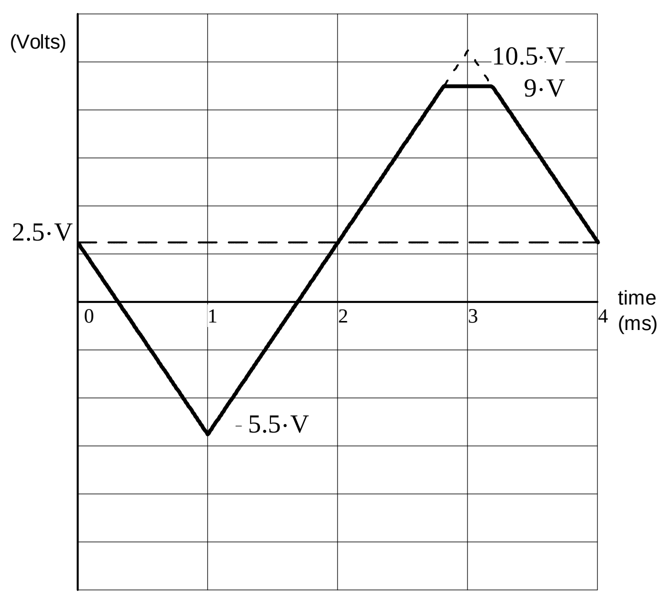
e) The smoke would get out. f) B g) $1.95\cdot A$

h) C & D There are good ways to do this same thing without the extra requirement of V_2, and this extra voltage makes the transistor Q_2 more vulnerable to failure (see part d)).

8. a) $1.5\cdot V$ $-10\cdot mA$ $20\cdot mA$ $1.2\cdot V$ b) no $V_{D1} := 1.5\cdot V > 0.7V$ c) no $I_{D2} := -10\cdot mA < 0$

d) yes $I_{D3} := 20\cdot mA > 0$ e) i) V_{R1} is actually $0.7\cdot V$ which is less than $1.5\cdot V$
so less current will flow through R_1

9. $v_{o1}(t)$



$v_{o2}(t)$