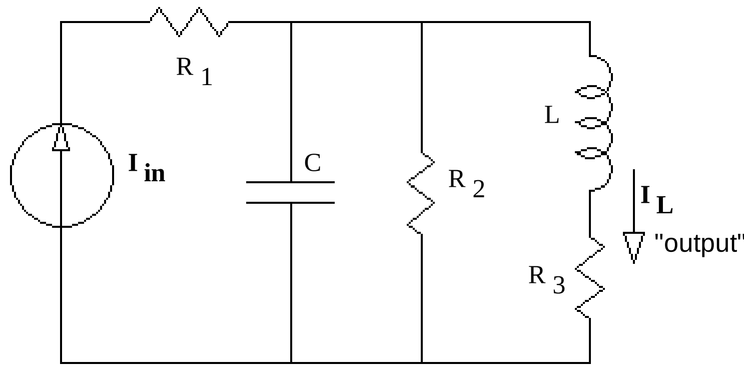
ECE2210 Final given: Fall 17

1. (18 pts) a) Find the s-type transfer function of the circuit shown. Consider $\mathbf{I_{in}}$ as the input and $\mathbf{I_L}$ 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.



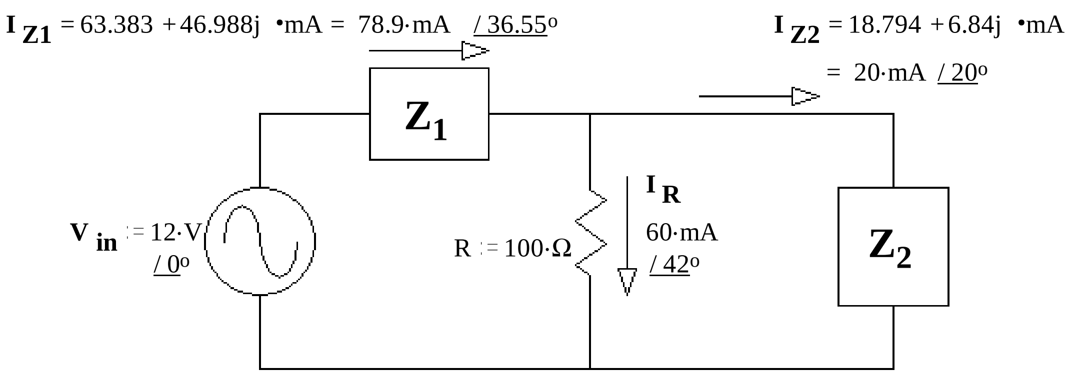
   $\mathbf{H}(s) = ?$

   b) How many zeroes does this transfer function have?

   c) How many poles does this transfer function have?

2. (25 pts)

   a) Find $\mathbf{Z_2}$

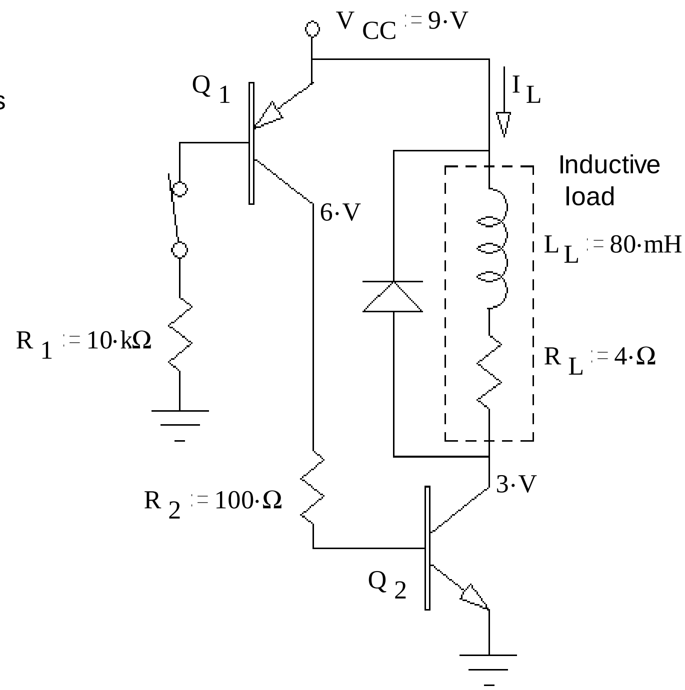


   b) Find $\mathbf{Z_1}$ in polar form.

   c) Circle the best, most comprehensive answer:

   i) $\mathbf{Z_1}$ must contain a capacitor
   ii) $\mathbf{Z_1}$ must contain a resistor and a capacitor
   iii) $\mathbf{Z_1}$ must contain an inductor
   iv) $\mathbf{Z_1}$ must contain a resistor and an inductor

3. (36 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. $\beta_{1min} = ?$

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.

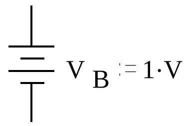
f) Check the assumption that Q_2 is in the active region and recaculate I_L if necessary.

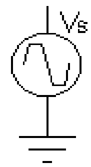
g) The diode in this circuit conducts a significant current: (circle one)

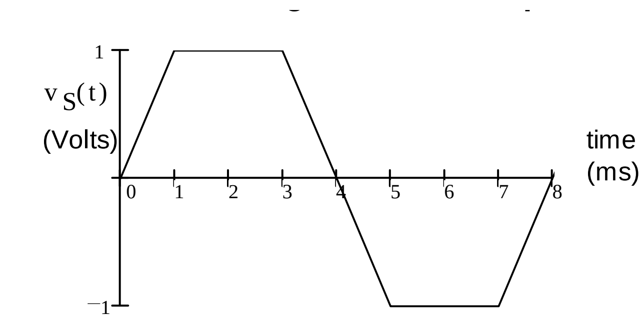
A) never.
B) when the switch closes.
C) whenever the switch is closed.
D) always.
E) when the switch opens.
F) whenever the switch is open.

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

4. (36 pts) You have two input voltages to work with.
   A 1V battery and the waveform (at right).

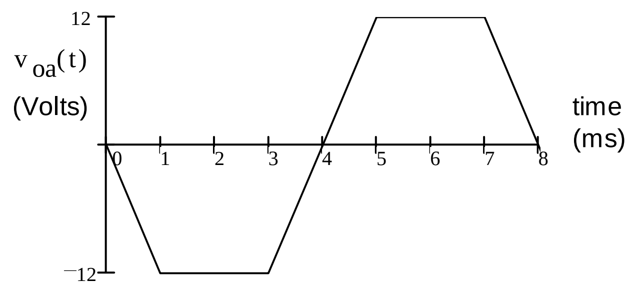




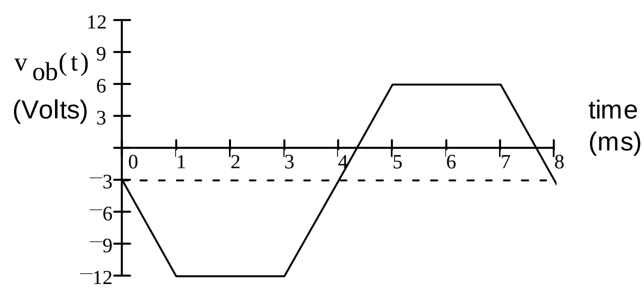


The problems below are op-amp design problems. The answer should be a schematic of a circuit showing the values of all the parts. Use reasonable resistor values (in the 100Ω to 1 MΩ range). Also show how one or both of the sources are hooked up to your circuit. Most circuits won't need both.

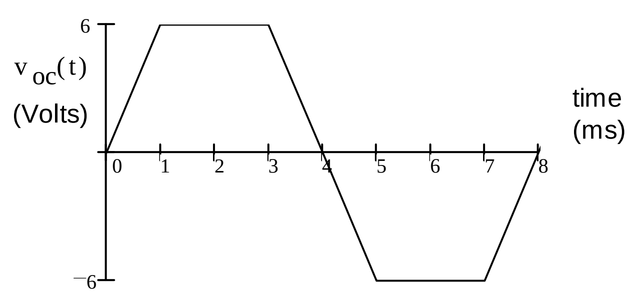
a) Design a circuit which will output the waveform at right.



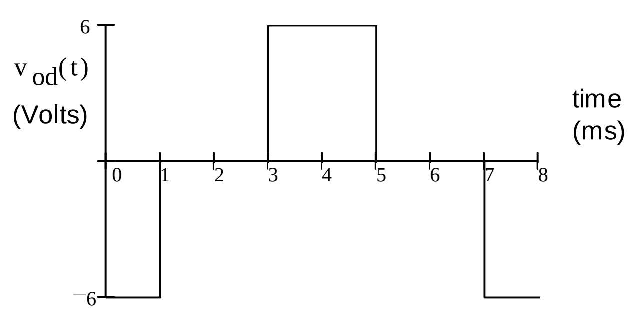
b) Design a circuit which will output the waveform at right.



c) Design a circuit which will output the waveform at right.

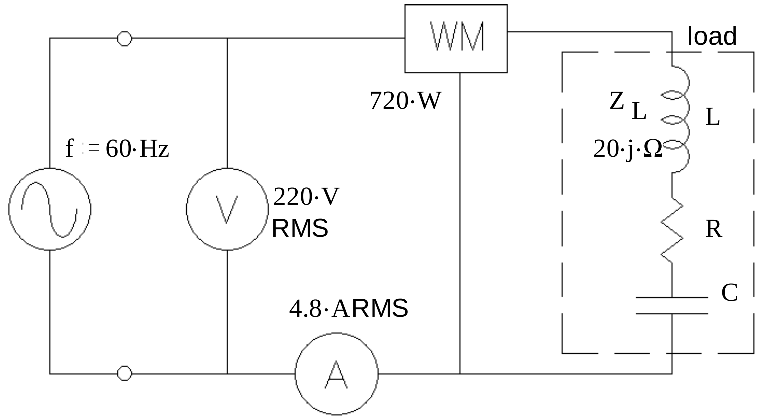


d) Design a circuit which will output the waveform at right.
   Hint: Think of a mathmatical operation.



e) To make ALL of these circuits work, what minimum power supplies would you need for the op amps?

5. (26 pts) L, R, & C together are the load in the circuit shown. The RMS voltmeter measures 220V, the RMS ammeter measures 4.8 A, and the wattmeter measures 720 W. Find the following: Be sure to show the correct units for each value.



a) The value of the load resistor. R = ?

b) The apparent power. $|\mathbf{S}|$ = ?

c) The magnitude of the reactive power. $|Q|$ = ? (sign unknown)

d) The impedance of the capacitor. $\mathbf{Z}_C$ = ?

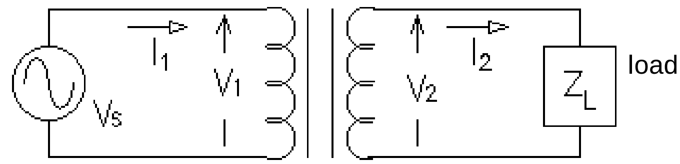
e) The complex power. $\mathbf{S}$ = ?

f) The power factor. pf = ?

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

h) The two components of the load are in a box which 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 here or on next page</u>. This component should not affect the real power consumption of the load.

6. (21 pts) A transformer is rated at 1000V / 200V, 1kVA. Assume the transformer is ideal and all voltages and currents are RMS.



$f := 60 \cdot Hz$

$|\mathbf{S_L}| = 720 \cdot VA$

$pf := 82 \cdot \%$ leading

a) The the source voltage, $\mathbf{V_S} := 600 \cdot V \angle 0^o$

Find the voltage across the load ($|\mathbf{V_2}|$)?

b) The secondary load draws 720VA of apparent power at a power factor of 82%, leading. Find the secondary load, $\mathbf{Z_L}$ (magnitude **and <u>angle</u>**).

c) Find the primary current, $\mathbf{I_1}$ (magnitude **and <u>angle</u>**).

d) How much average power does the load dissipate?

e) How much average power does the power source ($\mathbf{V_S}$) supply?

h) Is this transformer operating within its ratings?
How do you know? (Specifically show enough values in correct range or one that is not.)

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 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.

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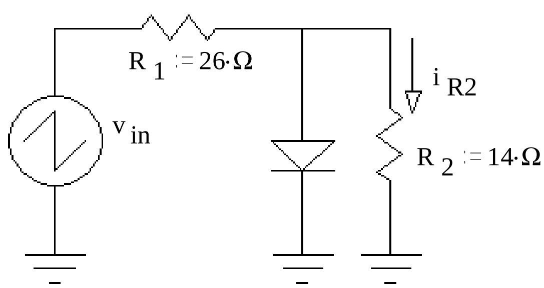
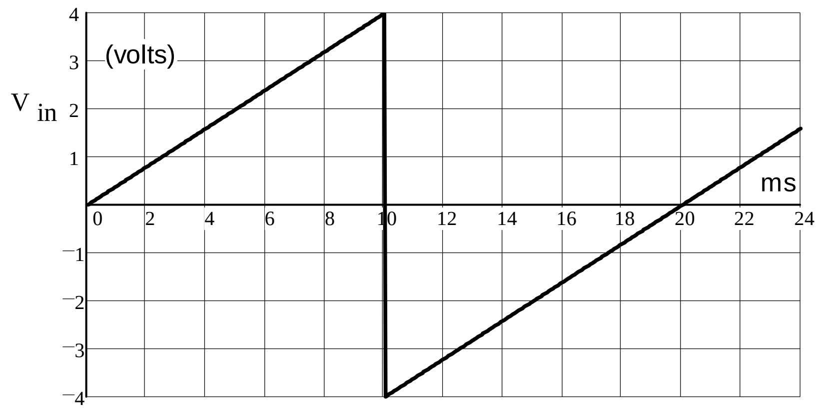
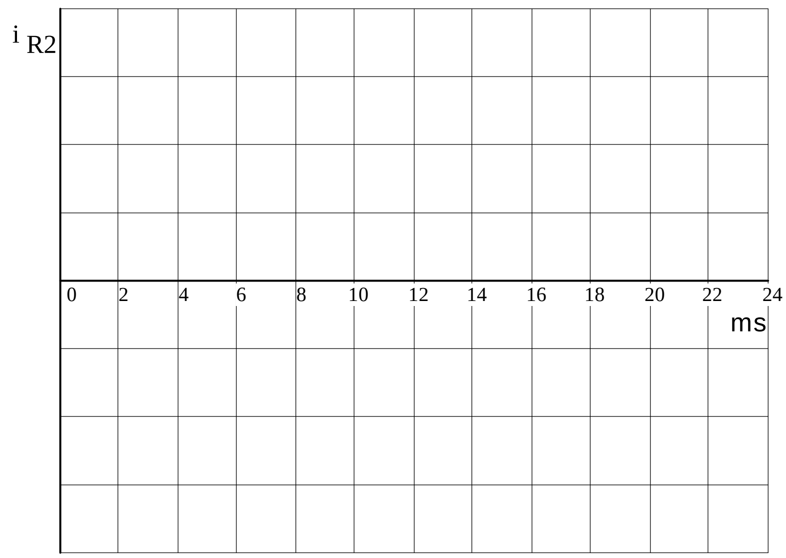
7. (18 pts) A voltage waveform is applied to the circuit shown. Accurately draw the R_2 current waveform (i_{R2}) that you expect to see. Label important times **and** current levels.







Answers

1. $$\frac{\frac{1}{L \cdot C}}{s^2 + \left(\frac{1}{R_2 \cdot C} + \frac{R_3}{L}\right) \cdot s + \frac{1}{L \cdot C} \cdot \left(\frac{R_3}{R_2} + 1\right)}$$

2. a) $300 \cdot \Omega \cdot e^{j \cdot 22 \cdot deg} = 278.155 + 112.382j \ \cdot \Omega$

   b) 108.3 Ω /-64.6º   c) ii)

3. a) 4.5·W   b) 28.3   c) 63.9   d) 97.6   e) 2.29·A   f) 2.2·A   g) E)   h) 2.2·A

4. a) inverting amp with $R_f = 12R_1$

   b) summer with $R_f = 9R_1$, waveform is hooked to R_1. $R_f = 3R_2$, battery + terminal is hooked to R_2 and **-** to ground

   c) non-inverting amp with $R_f = 5R_1$ d) differentiator with R_f = 6V/(C(1000V/s)), if C = 1μF then R_f = 6kΩ   e) ± 13V

5. a) 31.25·Ω   b) 1056·VA   c) 772.5·VAR

   d) −53.53·j·Ω   e) (720 − 772.5·j)·VA   g) i)

   h) Add an second 166-mH inductor in parallel with load

6. a) 120·V   b) 20 Ω /-34.9º   c) 1.2 A / 34.9º

   d) 590.4·W   e) 590.4·W

   h) $|\mathbf{I_2}| = 6 \cdot A \ > \ \frac{1 \cdot kVA}{200 \cdot V} = 5 \cdot A$ NO