Folder Number______ Name___________________________ c

ECE 2210 homework # 14 Due: Tue, 10/22/18

Read the *Frequency Response, Filters & Bode Plots* handout and/or sections 2.31-33 in your textbook.

1. Convert the following ratios to dB. Example: ratio = 12 $20 \cdot \log(12) = 21.6 \cdot dB$

   a) $\frac{4}{1}$ b) $\frac{1}{4}$

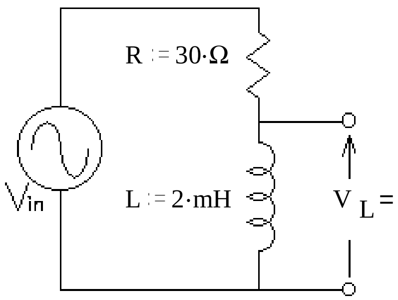
   c) 500 d) 20000

2. Convert 20 dB, 46 dB, -46 dB and 80 dB to voltage ratios. Example: 50 dB, voltage ratio = $10^{\frac{50}{20}} = 316.23$

   a) $20 \cdot dB$ b) $46 \cdot dB$

   c) $-46 \cdot dB$ d) $80 \cdot dB$

3. a) Find the transfer function of the filter circuit shown. $\mathbf{V_{in}}$ is the input and $\mathbf{V_L}$ is the output. $H(\omega) = ?$



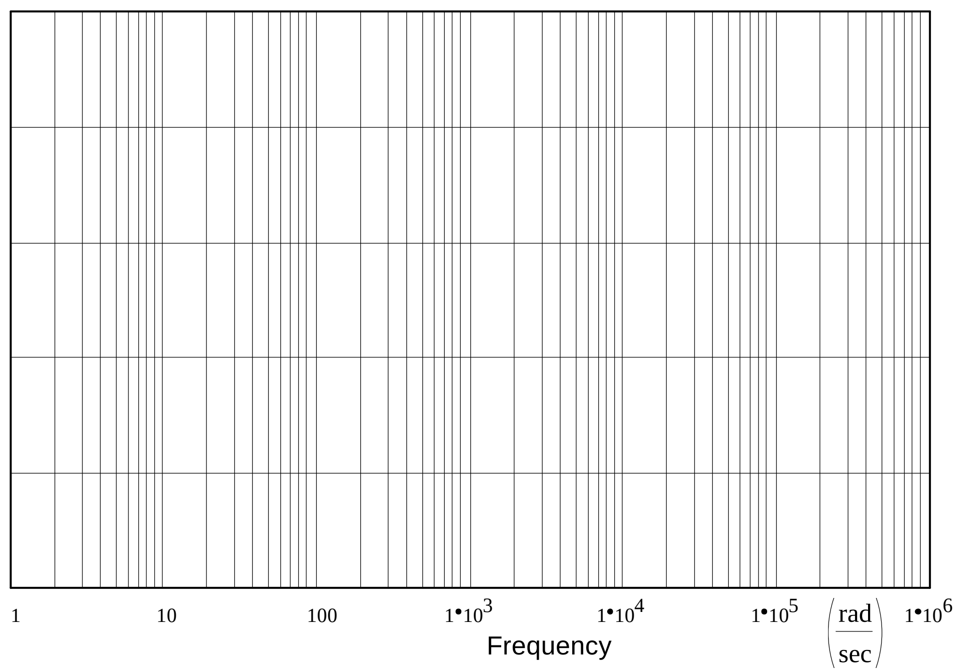
   b) Find the corner frequency(ies).

Transcribe the results of parts a) and b) here: $H(\omega) =$

Corner frequency(ies):

c) Find the approximations of the transfer function in each frequency region, find magnitudes in dB, and slopes in dB/decade.

d) Draw the asymptotic Bode plot (the straight-line approximation) of the filter circuit shown above. Accurately draw it on the graph paper provided. Label the vertical axis with numbers in dB.



e) The asymptotic Bode plot is not exact. Sketch the actual magnitude of the transfer function on the same plot. For the frequency where this difference is largest (the corner frequency), calculate the actual magnitude.

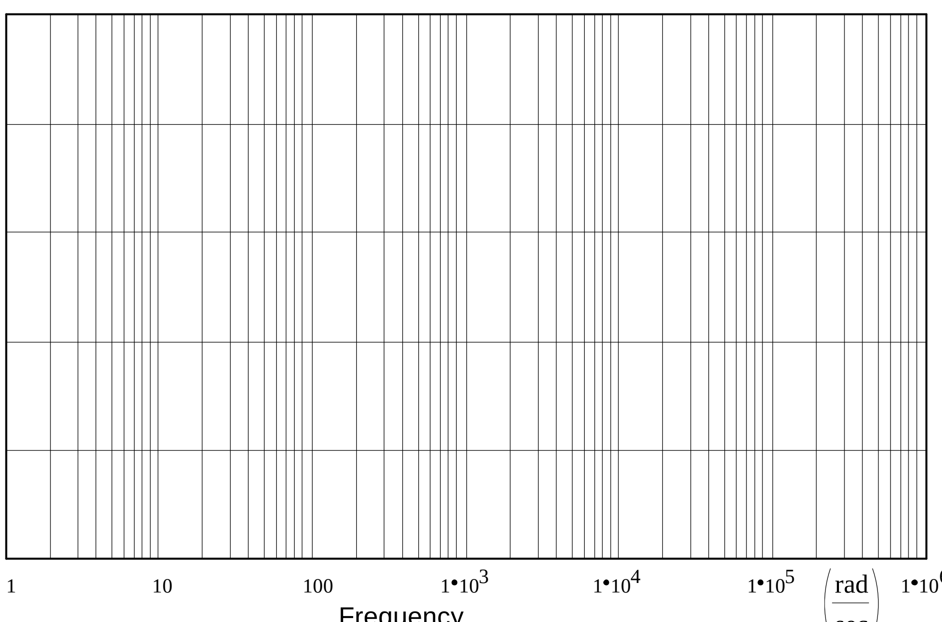
f) Calculate the actual magnitude of the transfer function at the corner frequency.

g) Calculate the actual magnitude of the transfer function at one octave above the corner frequency ($2\omega_c$).

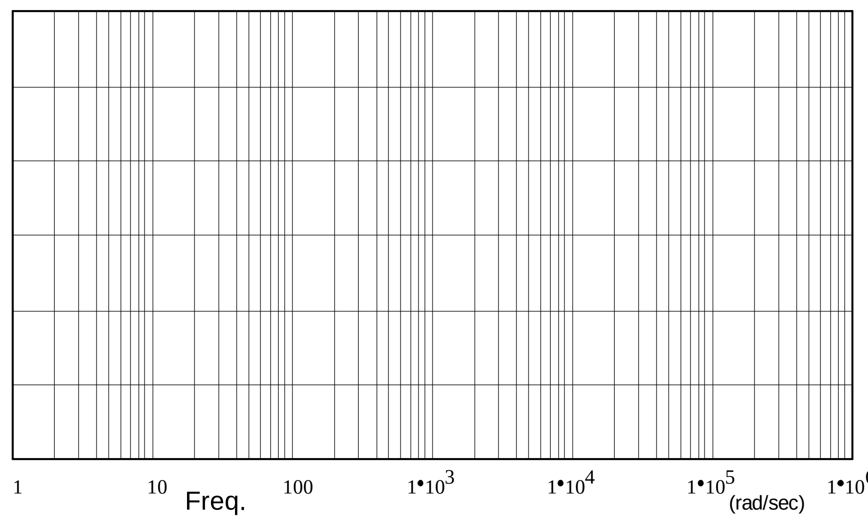
For **ALL** plotting problems, you must show the steps you use to get the Bode plot like I showed in lecture and the notes. That is, show things like the corner frequency(ies), the approximations of the transfer function in each frequency region, slopes and calculations of dB, numbers on plots, actual magnitude plots, etc..

4. Draw the asymptotic Bode plot (the straight-line approximation) of the following transfer functions.

a) $\mathbf{H_a}(\omega) := \dfrac{20}{1 + j \cdot \dfrac{\omega}{4000 \cdot \dfrac{rad}{sec}}}$



b) $\mathbf{H}_b(\omega) := \dfrac{120 \cdot j \cdot \omega}{400 \cdot \dfrac{rad}{sec} + j \cdot 4 \cdot \omega}$



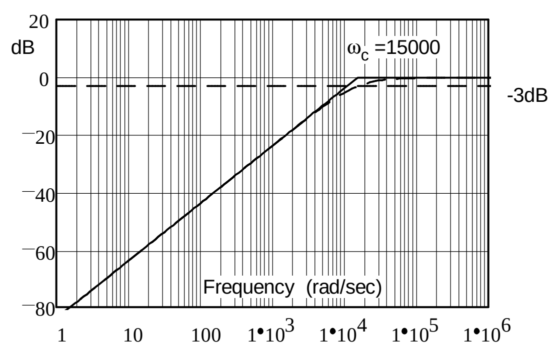
Turn over, more on next page

Answers 1. 12dB, -12dB, 54dB, 86dB 2. 10, 200, 0.005, 10^4

3. a) $\dfrac{j \cdot \omega \cdot L}{j \cdot \omega \cdot L + R}$ b) $15000 \cdot \dfrac{rad}{sec}$ d) Magnitude plot $|\mathbf{H}(\omega)|$

Straight-line approximation __

Actual _ _ _ _ (part e)

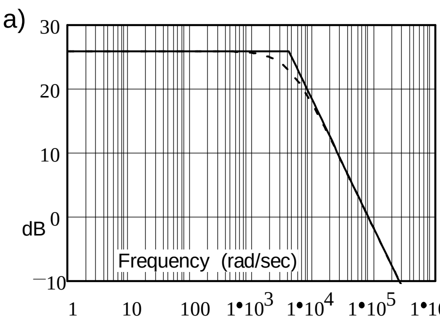


c) $\omega < \omega_c$ $\quad \mathbf{H}(\omega) \simeq \dfrac{j \cdot \omega \cdot L}{R}$ proportional to ω, slope +20 dB/dec

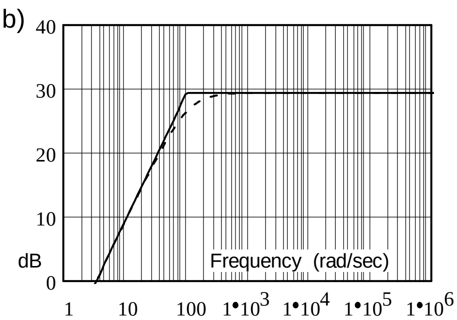
$\omega > \omega_c$ $\quad \mathbf{H}(\omega) \simeq \dfrac{j \cdot \omega \cdot L}{j \cdot \omega \cdot L} = 1$ flat at $20 \cdot \log(1) = 0 \cdot dB$

c) -3dB at 15000 rad/sec d) -1dB at 30000 rad/sec

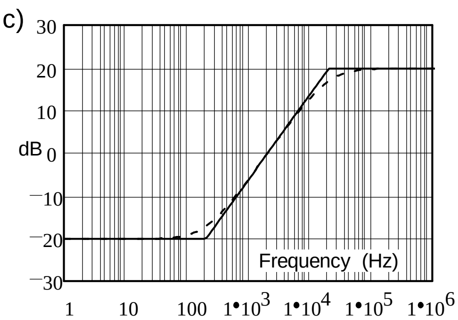
4. a)



b)



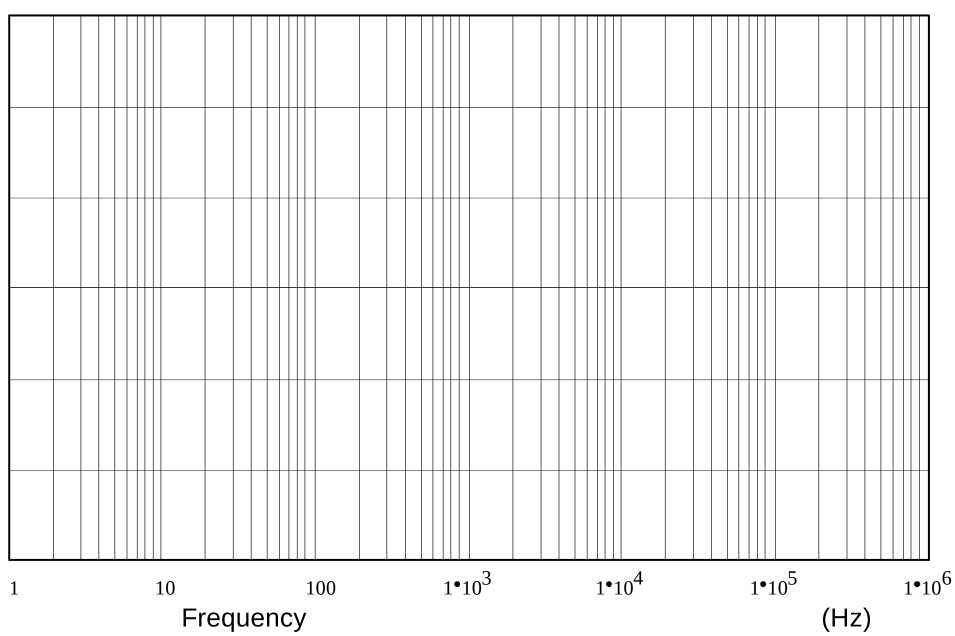
c)



5. 3. high-pass 4.a) low-pass b) high-pass c) high-pass

6. Slope -20dB/dec to 20Hz, flat at 3.5dB to 3kHz, slope +20dB/dec to 40kHz, rest flat at 26dB.
b) Actual magnitudes: 6.5dB at 20Hz, 6.5dB at 3kHz, 23dB/dec at 40kHz. c) zeros: 20Hz, 3kHz, pole: 40kHz

c) $$\mathbf{H_c}(f) := 0.1 \cdot \frac{1 + j \cdot \dfrac{f}{200 \cdot Hz}}{1 + j \cdot \dfrac{f}{20000 \cdot Hz}}$$



5. Determine the type of each of the filters in problems 3 and 4, low-pass, band-pass, or high-pass.

3. 4.a) b) c)

6. a) Draw the asymptotic Bode plot (the straight-line approximation) of the transfer function shown. Accurately draw it on the graph provided.

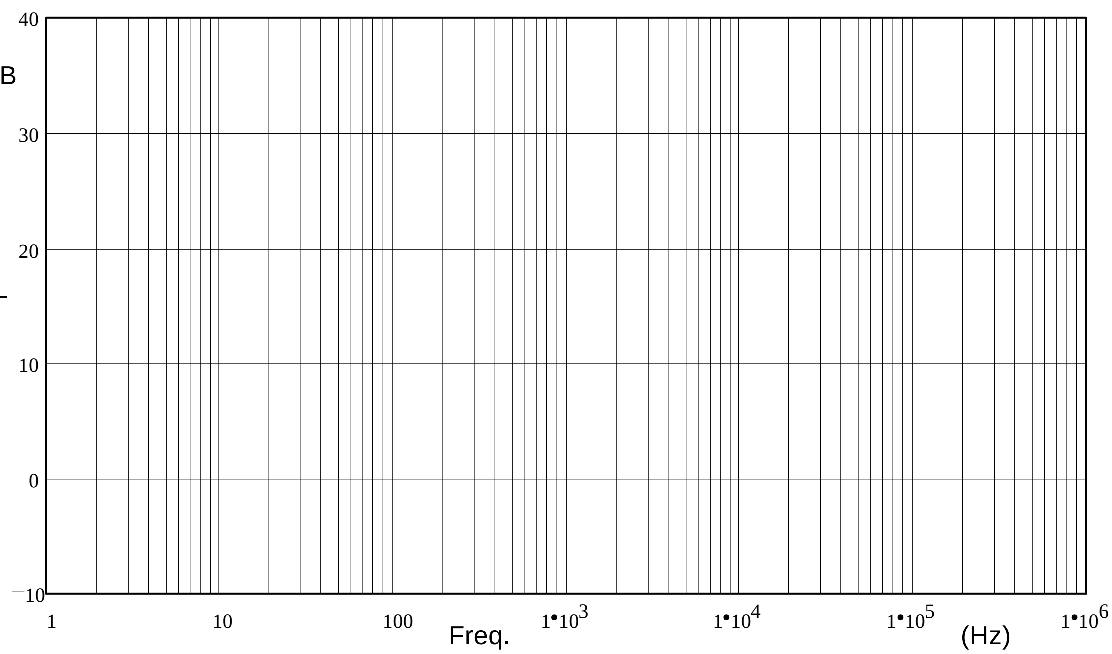
$$H(f) = \frac{(3\cdot kHz + j\cdot f)\cdot\left(1\cdot Hz + \frac{j\cdot f}{20}\right)}{j\cdot f\cdot\left(\frac{j\cdot f}{400} + 100\cdot Hz\right)}$$

Magnitude plot dB

$|H(f)|$

Straight-line approximation ____

Actual _ _ _ _



b) The asymptotic Bode plot is not exact. Using a dotted line, sketch the actual magnitude of the transfer function $|H(f)|$ on the plot above. Indicate the point(s) where the difference between the two lines is the biggest (draw arrow(s)) and write down the actual magnitude(s) at that (those) point(s).

c) Identify all zeros and poles of the transfer function.

ECE 2210 homework # 15

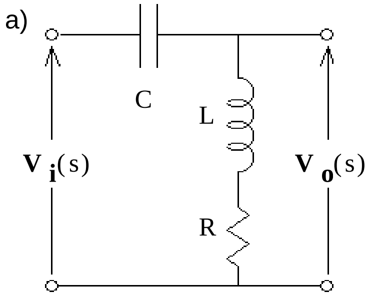
Due: Fri, 10/24/19

1. Read the *Second-Order Transcients* handout.

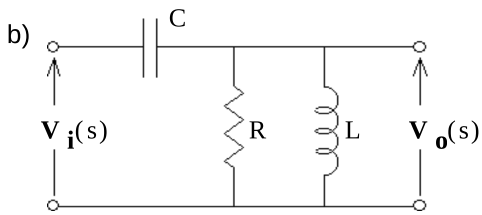
2. Find the transfer function $\mathbf{H}(s) = \dfrac{\mathbf{V_o}(s)}{\mathbf{V_i}(s)}$ for these circuits. Write $\mathbf{H}(s)$ in the normal form, as shown below.

$$\mathbf{H}(\mathbf{s}) = K \cdot \frac{s^n + k_1 \cdot s^{n-1} + \ldots + k_{n-1}}{s^m + c_1 \cdot s^{m-1} + \ldots + c_{m-1}}$$

a)

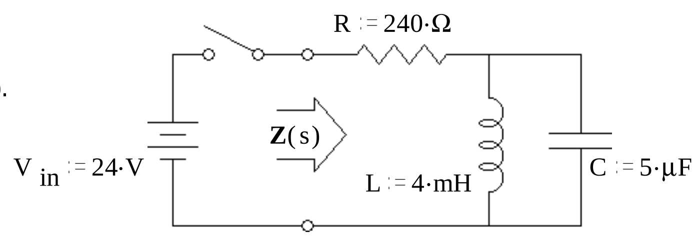


b)



3. Write the characteristic equation for each of the circuits in problem 2.

4. For the circuit shown, with a disconnected source:



   a) Find the generalized impedance of the circuit, $\mathbf{Z}(s)$.

   b) What is the impedance at $\mathbf{s} = 0$?

   c) What is the impedance at $\mathbf{s} = \infty$?

   d) When the switch is closed, current will begin to flow. The voltage source is the input and the current (through R) can be considered the "output" (i.e. caused by the input). Find the transfer function and the natural frequencies of the circuit (**s** solutions to the characteristic equation).

   e) What is the character of the response (undamped, underdamped, critically damped, or overdamped)?

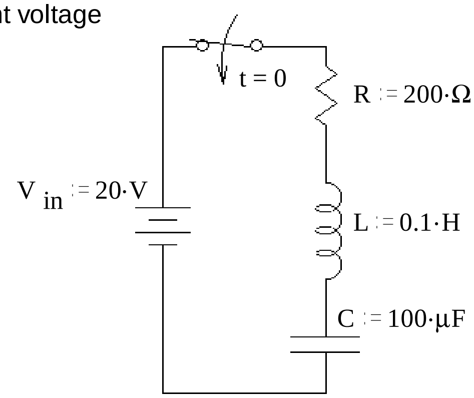
   f) Find the initial values of all three currents.

   g) Find the final values of all three currents

ECE 2210 homework # 16

Due: Tue, 10/29/19

1. A series RLC circuit with $R = 200\ \Omega$, $L = 0.1\ H$ and $C = 100\ \mu F$ has a constant voltage $V = 20$ volts applied at $t = 0$. The capacitor has no initial charge.



   a) Find the characteristic equation of the circuit at right. (hint: take $i(t)$ as the "output")

   b) Find the solutions to the characteristic equation.

   c) Is this circuit over, under, or critically damped?

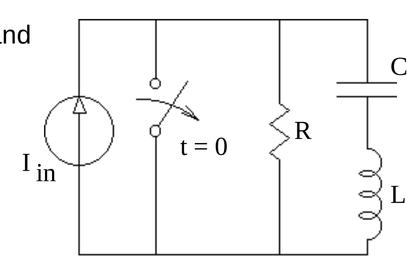
   d) The switch is switched down at time $t = 0$. Find the final and initial conditions: final: $i(\infty)$ initial: $i(0)$, $v_C(0)$ and $\frac{d}{dt} i(0)$

   e) Write the full expression for i(t), including all the constants that you find.

2. A series RLC circuit with $R = 200\ \Omega$, $L = 0.1\ H$ and $C = ?\ \mu F$ is to be made critically damped by the selection of the capacitance. Find the required value of C.

3. Find the natural frequency of a series RLC circuit in which $R = 200\ \Omega$, $L = 0.1\ H$ and $C = 5\ \mu F$. (The natural frequency is the ω part of $s_1 = \alpha + j\omega$)

4. In the circuit shown, when the switch is opened, the current I_{in} (current source) is forced to flow through the circuit.



   a) Write a differential equation for i_L. Hint: use LaPlace impedance method.

   b) Write a differential equation for v_C.

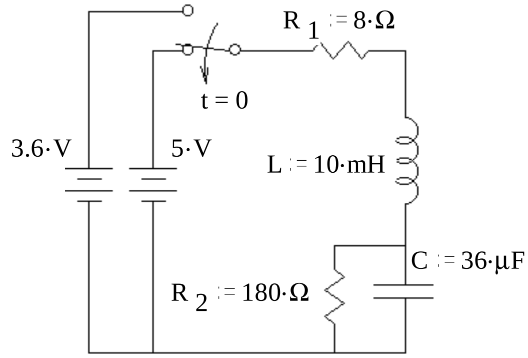
   c) Find the characteristic equation for the circuit shown.

ECE 2210 homework # 17 Due: Fri, 11/1/19 b

1. For the circuit at right:
   a) Find the characteristic equation of the circuit at right.
   b) Find the solutions to the characteristic equation.
   c) Is this circuit over, under, or critically damped?
   d) The switch has been in the top position for a long time and is switched down at time $t = 0$. Find the final and initial conditions:

   $v_C(\infty)$, $i_L(\infty)$, $v_C(0)$, $i_L(0)$, $\frac{d}{dt}v_C(0)$ and $\frac{d}{dt}i_L(0)$

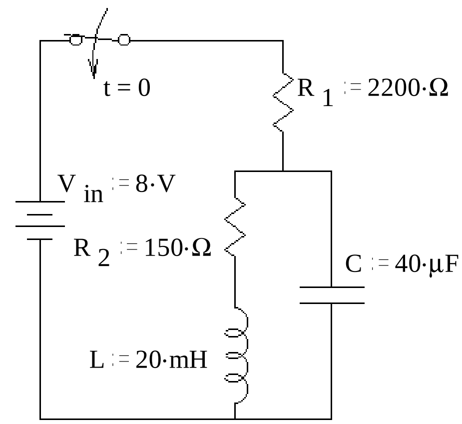
   e) Write the full expression for $i_L(t)$, including all the constants that you find.



2. a) Find the characteristic equation of the circuit at right.
   b) Find the solutions to the characteristic equation.
   c) Is this circuit over, under, or critically damped?
   d) Find the final conditions: $i_L(\infty)$ and $v_C(\infty)$
   e) The switch has been open for a long time and is switched down at time $t = 0$. Find the initial conditions:

   $i_L(0)$, $v_C(0)$ and $\frac{d}{dt}v_C(0)$

   f) Write the full expression for $v_C(t)$, including all the constants.



Answers

HW 15

2.a) $\mathbf{H}(s) = \dfrac{s^2 + \frac{R}{L}\cdot s}{s^2 + \frac{R}{L}\cdot s + \frac{1}{L\cdot C}}$ b) $\mathbf{H}(s) = \dfrac{s^2}{s^2 + \frac{1}{C\cdot R}\cdot s + \frac{1}{L\cdot C}}$ 3.a) $0 = s^2 + \frac{R}{L}\cdot s + \frac{1}{L\cdot C}$ b) $0 = s^2 + \frac{1}{C\cdot R}\cdot s + \frac{1}{L\cdot C}$

4.a) $\dfrac{240\cdot\Omega\cdot s^2 + 2\cdot 10^5\cdot\frac{\Omega}{sec}\cdot s + 1.2\cdot 10^{10}\cdot\frac{\Omega}{sec^2}}{s^2 + 5\cdot 10^7\cdot\frac{1}{sec^2}}$ b) $240\cdot\Omega$ c) $240\cdot\Omega$ d) $\dfrac{\frac{1}{240\cdot\Omega}\cdot s^2 + 2.083\cdot 10^5\cdot\frac{1}{\Omega\cdot sec^2}}{s^2 + 833.333\cdot\frac{1}{sec}\cdot s + 5\cdot 10^7\cdot\frac{1}{sec^2}}$ s values below

e) underdamped

f) R $0.1\cdot A$, L $0\cdot A$, C $0.1\cdot A$ g) R $0.1\cdot A$, L $0.1\cdot A$, C $0\cdot A$

$(-417 + 7059\cdot j)\cdot\frac{1}{sec}$ $(-417 - 7059\cdot j)\cdot\frac{1}{sec}$

HW 16

1. a) $0 = s^2 + \frac{R}{L}\cdot s + \frac{1}{L\cdot C}$ b) $-51.3\cdot\frac{1}{sec}$ $-1949\cdot\frac{1}{sec}$ c) overdamped

   d) $i(\infty) = 0\cdot A$ $i(0) = 0$ $V_C(0) = 0$ $\frac{d}{dt}i(0) = 200\cdot\frac{A}{sec}$ e) $i(t) = 0.1054\cdot e^{-\frac{51.3}{sec}\cdot t} - 0.1054\cdot e^{-\frac{1949}{sec}\cdot t}$

2. $10\cdot\mu F$ 3. $159\cdot Hz$

4. a) $\frac{R}{L}\cdot\frac{d}{dt}i_{in} = \frac{d^2}{dt^2}i_L + \frac{R}{L}\frac{d}{dt}i_L + \frac{1}{L\cdot C}\cdot i_L$ b) $\frac{R}{L\cdot C}\cdot i_{in} = \frac{d^2}{dt^2}v_c + \frac{R}{L}\frac{d}{dt}v_c + \frac{1}{L\cdot C}\cdot v_c$ c) $s^2 + \frac{R}{L}\cdot s + \frac{1}{L\cdot C} = 0$

HW 17

1. a) $s^2 + \left(\frac{R_1}{L} + \frac{1}{C\cdot R_2}\right)\cdot s + \left(\frac{1}{C\cdot L} + \frac{R_1}{R_2\cdot C\cdot L}\right) = 0$ b) $s_1 := (-477 + 1635j)\cdot\frac{1}{sec}$, $s_2 := (-477 - 1635j)\cdot\frac{1}{sec}$

   c) underdamped d) $4.79\cdot V$ $26.6\cdot mA$ $3.45\cdot V$ $19.15\cdot mA$ $0\cdot\frac{V}{sec}$ $140\cdot\frac{A}{sec}$

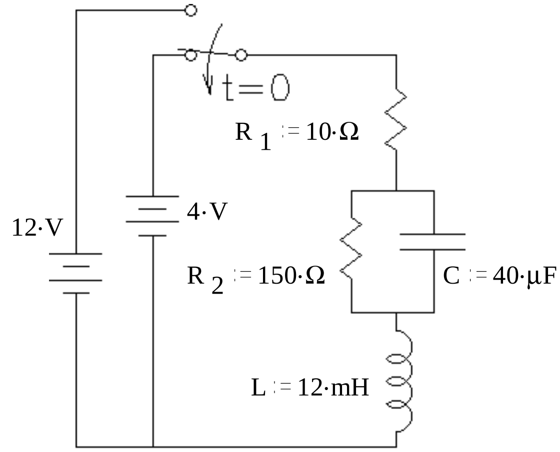
   e) $i_L(t) = 26.6\cdot mA + e^{\frac{-477.2}{sec}\cdot t}\cdot\left(-7.45\cdot\cos\left(\frac{1635}{sec}\cdot t\right) + 83.45\cdot\sin\left(\frac{1635}{sec}\cdot t\right)\right)\cdot mA$

2a) $0 = s^2 + \left(\frac{R_2}{L} + \frac{1}{R_1\cdot C}\right)\cdot s + \left(\frac{1}{L\cdot C} + \frac{R_2}{R_1\cdot L\cdot C}\right)$ b) $s_1 := -182.2\cdot\frac{1}{sec}$, $s_2 := -7329\cdot\frac{1}{sec}$ c) overdamped

d) $i_L(\infty) = 3.404\cdot mA$ $v_C(\infty) = 0.511\cdot V$ e) $i_L(0) = 0\cdot mA$ $v_C(0) = 0\cdot V$ $\frac{d}{dt}v_C(0) = 90.91\cdot\frac{V}{sec}$

f) $v_C(t) = 0.511\cdot V - 0.511\cdot V\cdot e^{-182.2\cdot t} + 0.000295\cdot V\cdot e^{-7329\cdot t}$

1. Analysis of the circuit shown yields the characteristic equation below. The switch has been in the top position for a long time and is switched down at time $t = 0$. Find the initial conditions and write the full expression for $i_L(t)$, including all the constants that you find.



$$s^2 + \left(\frac{1}{C\cdot R_2} + \frac{R_1}{L}\right)\cdot s + \left(\frac{R_1}{L\cdot C\cdot R_2} + \frac{1}{L\cdot C}\right) = 0$$

$$\left(\frac{1}{C\cdot R_2} + \frac{R_1}{L}\right) = 1000\cdot sec^{-1} \qquad \left(\frac{R_1}{L\cdot C\cdot R_2} + \frac{1}{L\cdot C}\right) = 2.222\cdot 10^6 \cdot sec^{-2}$$

$$s^2 + 1000\cdot\frac{1}{sec}\cdot s + 2.222\cdot 10^6\cdot\frac{1}{sec^2} = 0$$

2. What value of R_1 would make the above circuit critically damped?

3. Look at the circuit in HW 17, problem 2. Change R_1 and R_2 to 50Ω and consider the voltage across R_1 to be the output voltage. The transfer function would be:

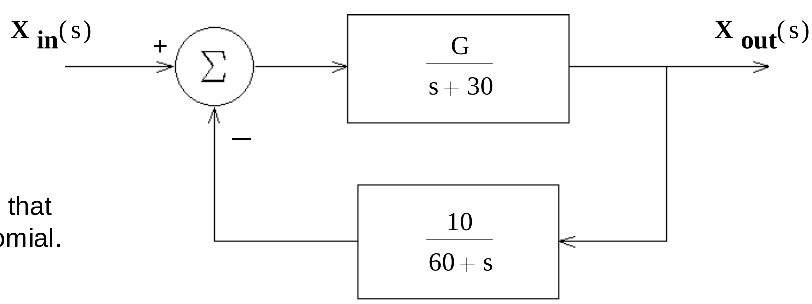
$$\mathbf{H}(s) = \frac{\mathbf{V_{R1}}(s)}{\mathbf{V_{in}}(s)} = \frac{s^2 + \frac{R_2}{L}\cdot s + \frac{1}{L\cdot C}}{s^2 + \frac{R_1\cdot R_2\cdot C + L}{R_1\cdot L\cdot C}\cdot s + \frac{R_1 + R_2}{R_1\cdot L\cdot C}} = \frac{s^2 + 2500\cdot s + 1.25\cdot 10^6}{s^2 + 3000\cdot s + 2.5\cdot 10^6}$$

a) What are the poles and zeros of this transfer function?

b) Plot these poles and zeros on the complex plane.

4. A feedback system is shown in the figure. a) What is the transfer function of the whole system, with feedback.

$$\mathbf{H}(s) = \frac{\mathbf{X_{out}}(s)}{\mathbf{X_{in}}(s)} = \ ?$$



Simplify your expression for $\mathbf{H}(s)$ so that the denominator is a simple polynomial.

b) $G := 5$ Find the poles and zeroes of the system.

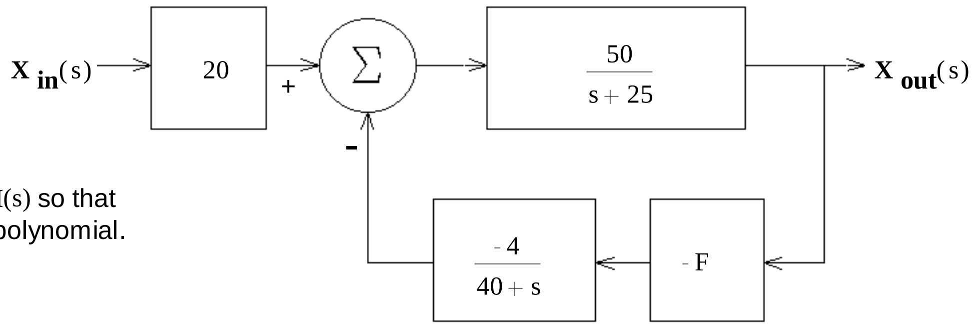
c) What type of damping response does this system have?

d) Find the value of G to make the transfer function critically damped.

e) If G is double the value found in part d) what will the damping response of the system will be?

5. a) A feedback system is shown in the figure. What is the transfer function of the whole system, with feedback.

$$\mathbf{H}(s) = \frac{\mathbf{X}_{out}(s)}{\mathbf{X}_{in}(s)} = ?$$



Simplify your expression for $\mathbf{H}(s)$ so that the denominator is a simple polynomial.

b) Find the maximum value of F so that the system does not become underdamped.

c) Find the transfer function with $F := 0.2$

d) With $F = 0.2$, at what value of **s** can the system produce an output even with no input?
(That is, what value of **s** makes $\mathbf{H}(s) = \infty$?)

e) Does the transfer function have a zero? Answer no or find the s value of that zero.

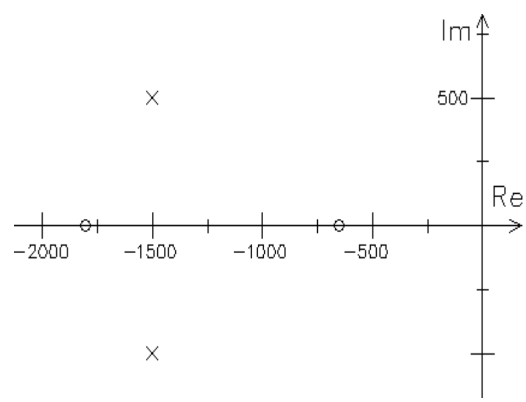
Answers

1 $i_L(0) = 75\cdot mA$ $\quad v_C(0) = 11.25\cdot V$

$$i_L(t) = 25\cdot mA + e^{\frac{-500}{sec}\cdot t}\cdot\left(50\cdot mA\cdot\cos\left(\frac{1404}{sec}\cdot t\right) - 457\cdot mA\cdot\sin\left(\frac{1404}{sec}\cdot t\right)\right)$$

2. $R_1 = 36.64\cdot\Omega$

3. a) Zeroes: -691 & -1809 Poles: $-1500 \pm 500\cdot j$ b)



4. a) $\dfrac{G\cdot(s+60)}{s^2 + 90\cdot s + 1800 + G\cdot 10}$ b) poles: -31.8 & -58.2 zero: -60
c) overdamped d) 22.5 e) underdamped

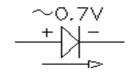
5. a) $1000\cdot\dfrac{s+40}{s^2 + 65\cdot s + 1000 + 200\cdot F}$ b) 0.281 c) $1000\cdot\dfrac{s+40}{s^2 + 65\cdot s + 1040}$ d) -28.5 or -36.5
e) -40

Folder:____ Name:______________________ ECE 2210 hw # DO1 Due: Fri, 11/8/19

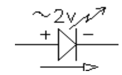
A.Stolp rev b

Fill in the blanks in the following circuits. For some of the simple calculations, you may simply write down the answer without showing work.

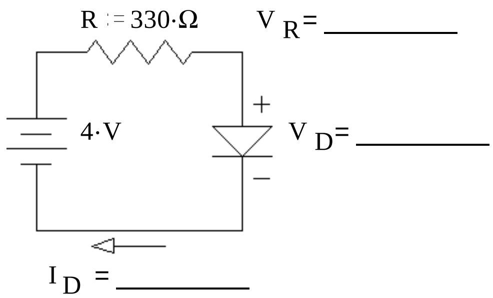
Assume the diodes are silicon with a 0.7V forward voltage drop:



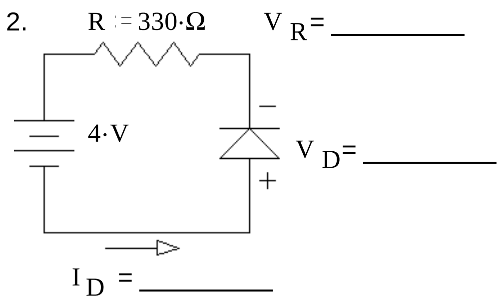
Assume the LEDs have a 2V forward voltage drop:



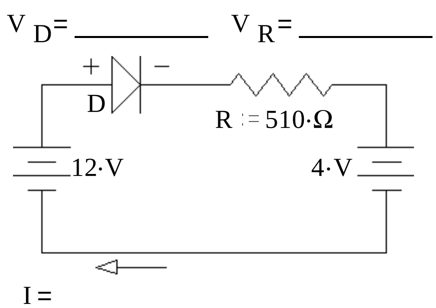
1.



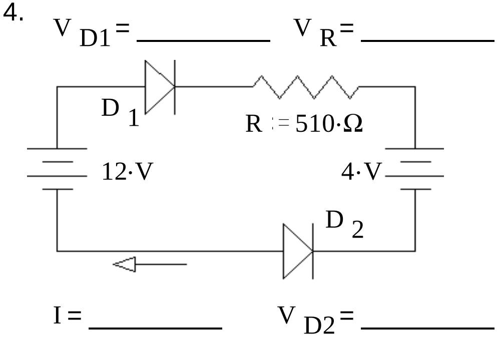
2.



3.

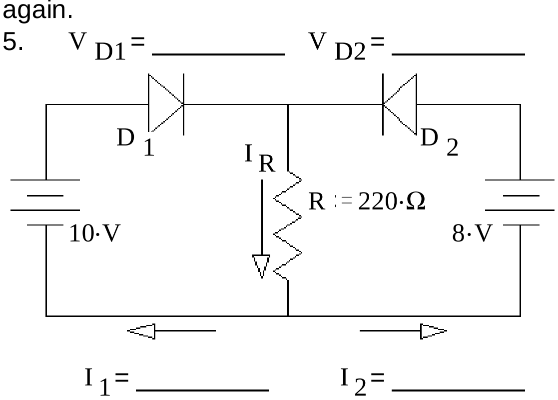


4.



Note: In problems 5 and 6 you'll have to make some assumptions about which diode(s) is/are conducting. Work the problem with those assumptions and see if you arrive at impossible answers. If so, change your assumptions and try again.

5.

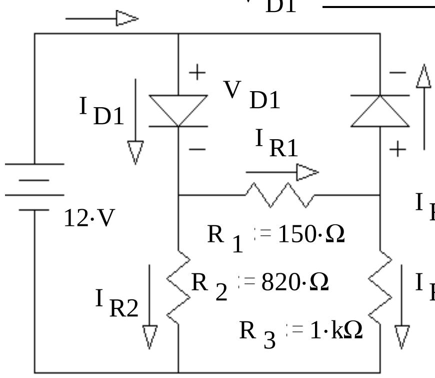


There are four possible assumptions.

1. Neither diode conducts.
2. Only D_1 conducts.
3. Only D_2 conducts.
4. Both diodes conduct.

NOTE: You don't have to try all four possibilities. As soon as you find one that works, that's the answer. So make your best guess first.

6. I_T = __________ V_{D1} = __________



V_{D2} = __________

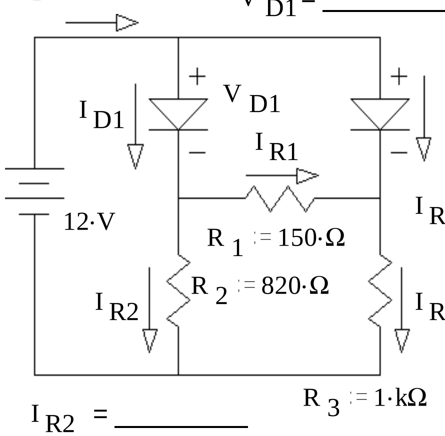
I_{D2} = __________

I_{R1} = __________

I_{R3} = __________

I_{R2} = __________

7. I_T = __________ V_{D1} = __________



V_{D2} = __________

I_{D2} = __________

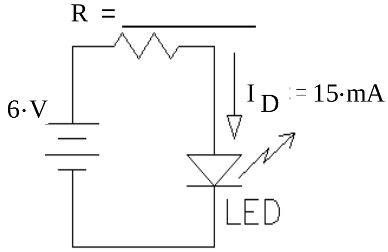
I_{R1} = __________

I_{R3} = __________

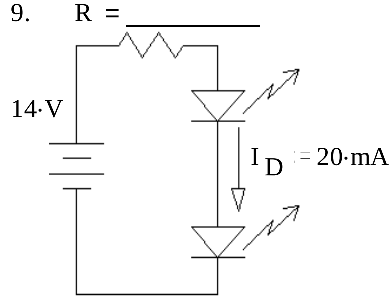
I_{R2} = __________

8. V_R = __________

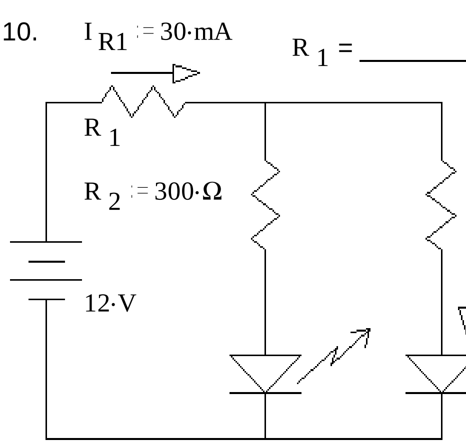
R = __________



9. R = __________



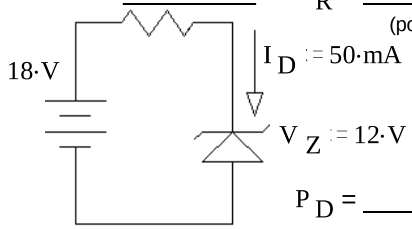
10. $I_{R1} := 30 \cdot mA$ R_1 = __________



R_3 = __________

11. V_R = __________

R = __________ P_R = __________ (power)

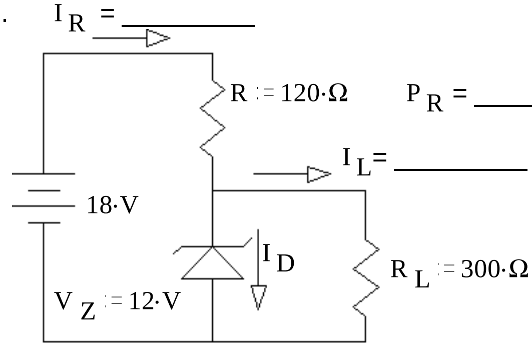


P_D = __________

12. I_R = __________

P_R = __________

I_L = __________

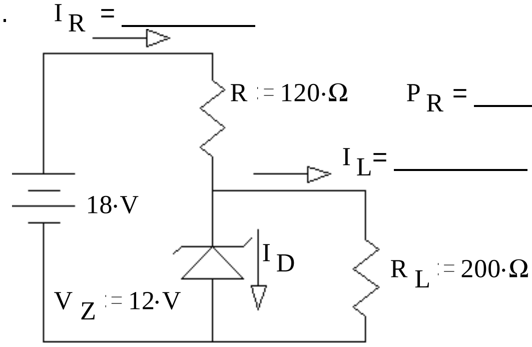


I_D = __________ P_D = __________

13. I_R = __________

P_R = __________

I_L = __________



I_D = __________ P_D = __________

Warning: If I_D turns out negative, it is actually 0 and you must recalculate everything else.

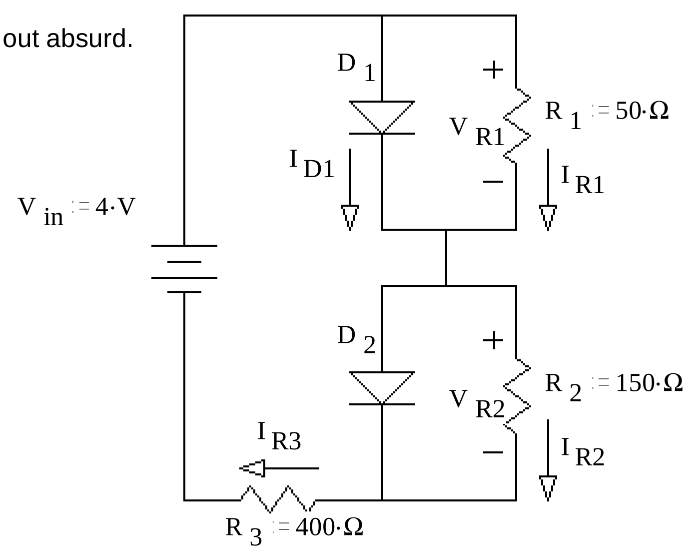
You will need more paper for the next two problems, add a sheet or two.

14. Assume that diode D_1 does conduct. Assume that diode D_2 does NOT conduct.

a) Find V_{R1}, I_{R1}, I_{R3}, I_{D1}, V_{R2} based on these assumptions.
Stick with these assumptions even if your answers come out absurd.

V_{R1} = ? I_{R1} = ? I_{R3} = ? I_{D1} = ?

V_{R2} = ?



b) Was the assumption about D_1 correct? yes or no

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 or no

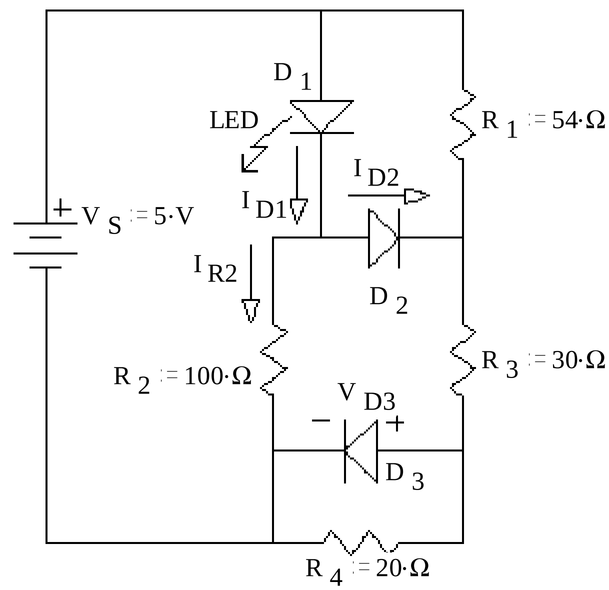
How do you know?

15. Assume that diodes D_1 and D_2 **DO** conduct.

Assume that diode D_3 does **NOT** conduct.

a) Find I_{R2}, I_{D2}, I_{D1}, & V_{D3} based on these assumptions. Stick with these assumptions even if your answers come out absurd.

$I_{R2} = ?$ $I_{D2} = ?$ $I_{D1} = ?$ $V_{D3} = ?$



b) Based on the numbers above, was the assumption about D_1 correct? yes no
How do you know? (Show a value & range.)

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

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):

i) The ***real*** $I_{R2} < I_{R2}$ calculated in part a.

ii) The ***real*** $I_{R2} = I_{R2}$ calculated in part a.

iii) The ***real*** $I_{R2} > I_{R2}$ calculated in part a.

You do not need to justify your answer.

Answers

1 $V_D := 0.7 \cdot V$ $V_R := 3.3 \cdot V$ $I_D := 10 \cdot mA$

2. $I_D := 0 \cdot mA$ $V_D := -4 \cdot V$ $V_R := 0 \cdot V$

3. $V_D := 0.7 \cdot V$ $V_R := 7.3 \cdot V$ $I := 14.3 \cdot mA$

4. $I := 0 \cdot mA$ $V_{D2} := -8 \cdot V$ $V_{D1} := 0 \cdot V$ $V_R := 0 \cdot V$

5. $V_{D1} := 0.7 \cdot V$ $V_{D2} := -1.3 \cdot V$ $I_1 := 42.3 \cdot mA$ $I_2 := 0 \cdot mA$

6. $I_{D2} := 0 \cdot mA$ $V_{D1} := 0.7 \cdot V$ $I_{R2} := 13.8 \cdot mA$ $I_{R1} = I_{R3} := 9.83 \cdot mA$ $V_{D2} := -2.17 \cdot V$ $I_{D1} = I_T := 23.6 \cdot mA$

7. $V_{D1} := 0.7 \cdot V$ $V_{D2} := 0.7 \cdot V$ $I_{R1} := 0 \cdot mA$ $I_{R2} := 13.8 \cdot mA = I_{D1}$ $I_{R3} := 11.3 \cdot mA = I_{D2}$ $I_T := 25.1 \cdot mA$

8. $V_R := 4 \cdot V$ $R := 267 \cdot \Omega$

9. $R := 500 \cdot \Omega$

10. $R_1 := 233 \cdot \Omega$ $R_3 := 150 \cdot \Omega$

11. $V_R := 6 \cdot V$ $I_D := 50 \cdot mA$ $R := 120 \cdot \Omega$ $P_R := 0.3 \cdot W$ $P_D := 0.6 \cdot W$

12. $I_L := 40 \cdot mA$ $I_R := 50 \cdot mA$ $I_D := 10 \cdot mA$ $P_R := 0.3 \cdot W$ $P_D := 0.12 \cdot W$

13. $I_D := 0 \cdot mA$ $I_L = I_R := 56.3 \cdot mA$ $V_L := 11.3 \cdot V$ $P_R := 0.38 \cdot W$ $P_D := 0 \cdot W$

14. a) $V_{R1} := 0.7 \cdot V$ $I_{R1} := 14 \cdot mA$ $I_{R3} := 6 \cdot mA$ $I_{D1} := -8 \cdot mA$ $V_{R2} := 0.9 \cdot V$ b) no $I_{D1} = -8 \cdot mA < 0$

c) no $V_{D2} = V_{R2} = 0.9 \cdot V > 0.7V$ _/

15. a) $I_{R2} := 30 \cdot mA$ $I_{D2} := -4 \cdot mA$ $I_{D1} := 26 \cdot mA$ $V_{D3} := 0.92 \cdot V$

b) yes $I_{D1} := 26 \cdot mA > 0$

c) no $I_{D2} := -4 \cdot mA < 0$

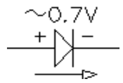
d) no $V_{D3} := 0.92 \cdot V > 0.7V$

e) ii)

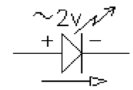
Folder:____ Name:______________________ ECE 2210 hw # DO2 Due: Tue, 11/12/19

A.Stolp
rev a

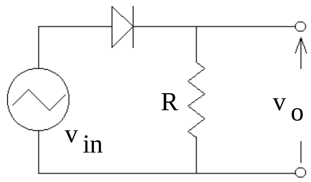
Assume the diodes are silicon with a 0.7V forward voltage drop:

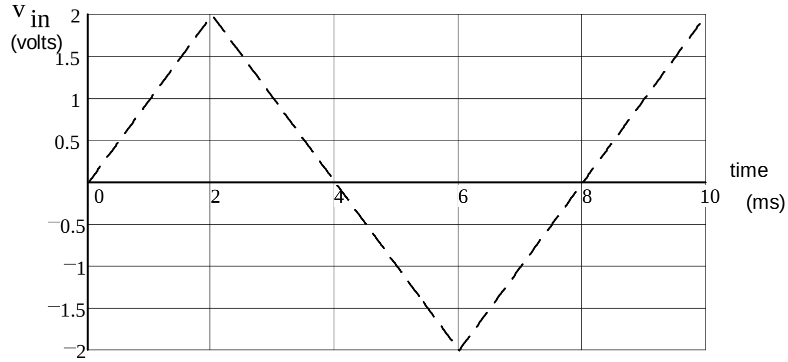


Assume the LEDs have a 2V forward voltage drop:

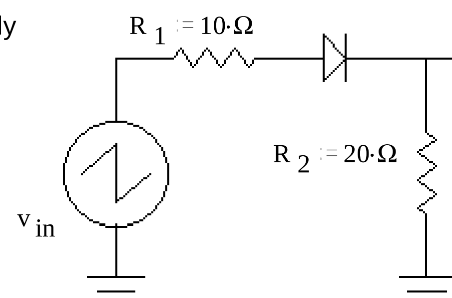


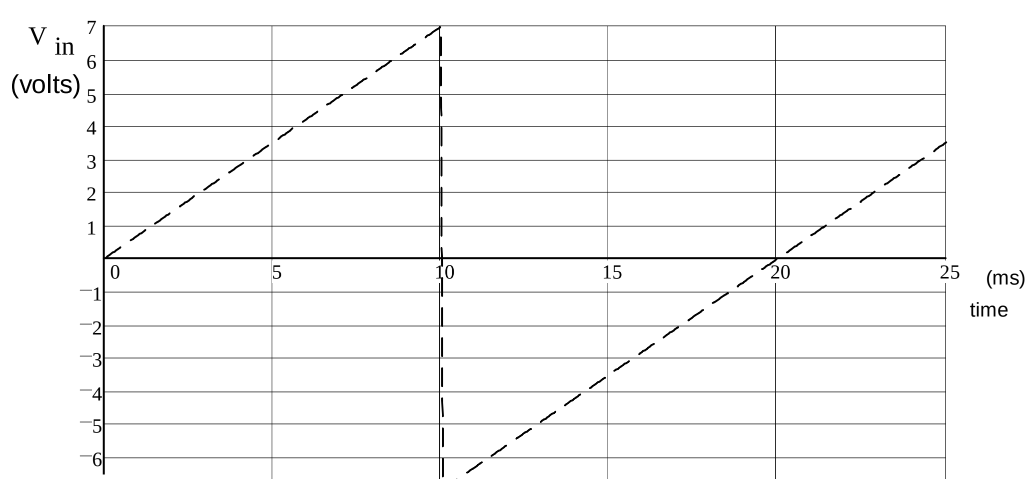
1. The input voltage to the circuit below is shown at right (dotted line). Show the output voltage across the resistor. Make it accurate and label the important voltages **and** times. You can draw your answer right on my drawing, that's why the input is shown as a dotted line.



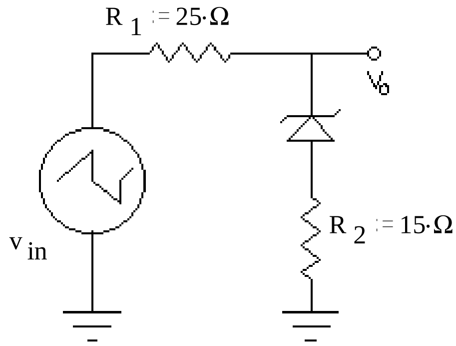


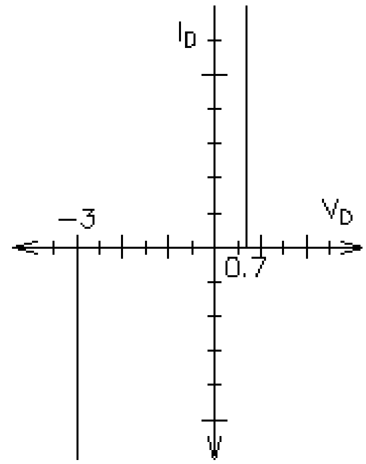
2. The voltage waveform shown (dotted line) is applied to the circuit. Accurately draw the output voltage you expect to see across the 20 Ω resistor. Label the important voltages **and** times.

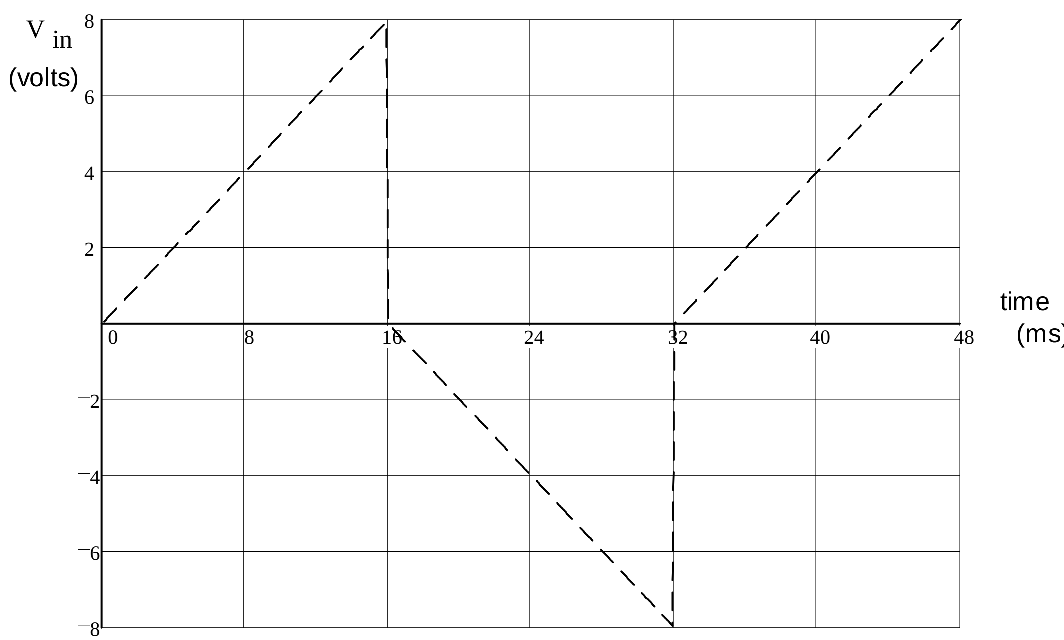




3. The voltage waveform shown below is applied to the circuit shown. Accurately draw the output voltage (v_o) you expect to see. The characteristic curve for the 3-V silicon zener diode is also shown. Label important times **and** voltage levels.

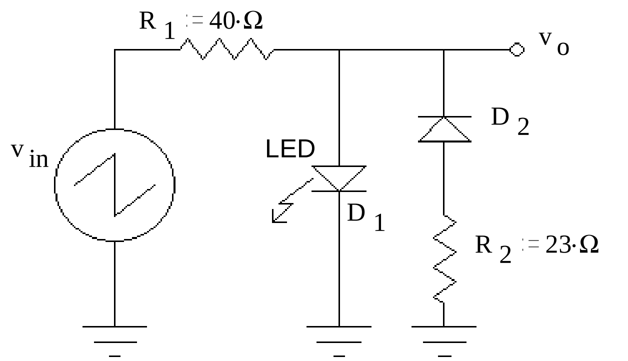


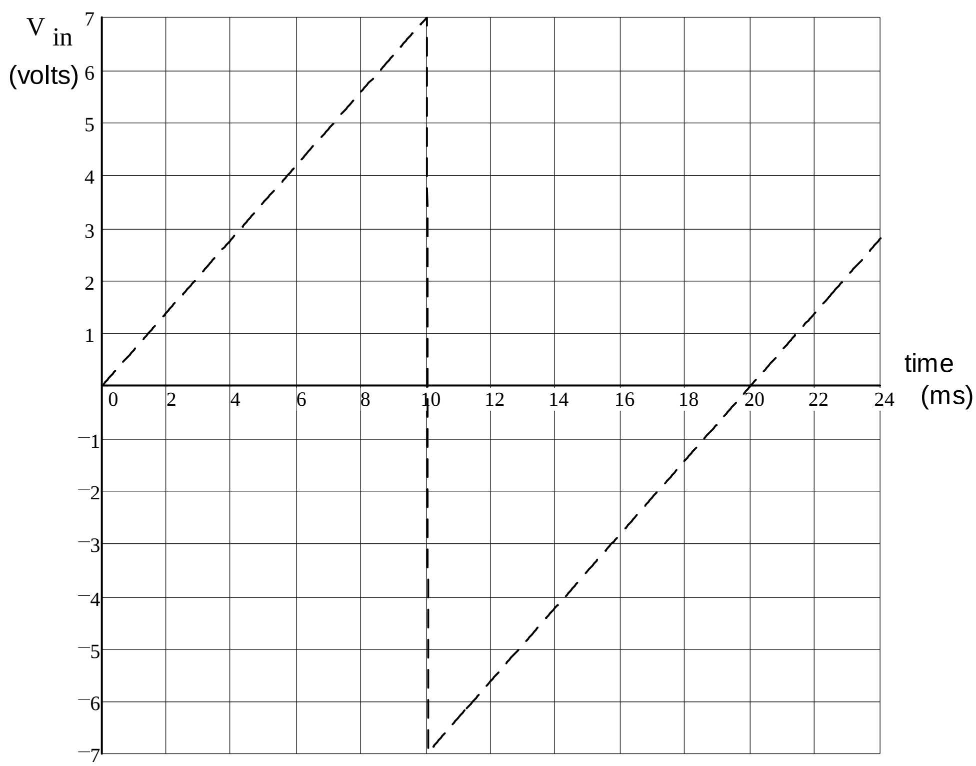




ECE 2210 homework # DO2, p2

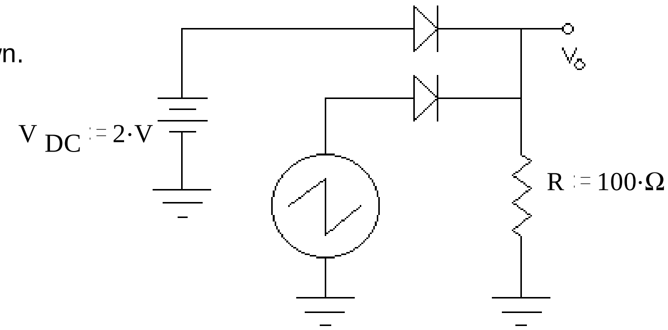
4. A voltage waveform (dotted line) is applied to the circuits shown. Accurately draw the output waveform (v_o) you expect to see. Label important times **and** voltage levels.

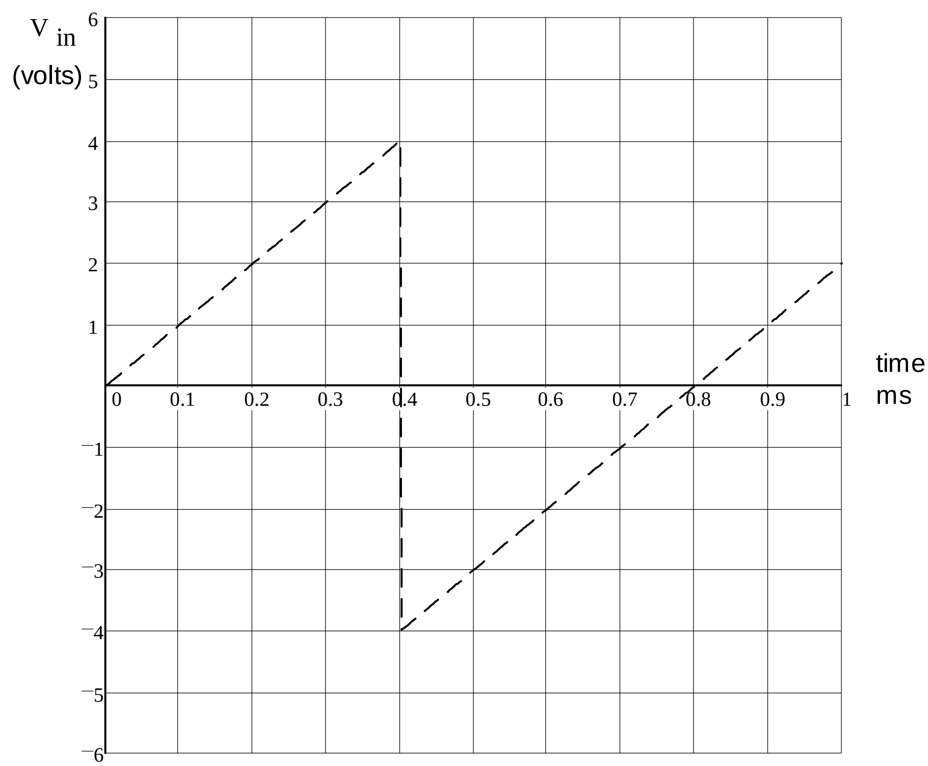




ECE 2210 homework # DO2, p4

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





Answers

1 Straight lines between the following points: (0ms,0V), (0.7ms,0V), (2ms,1.3V), (3.3ms,0V), (8.7ms,0V), then ramps up as between 0.7ms & 2ms.

2. Straight lines between the following points: (0ms,0V), (1ms,0V), (10ms,4.2V), (10ms,0V), (21ms,0V), then ramps up as between 0.7ms & 10ms.

3. Straight lines between the following points: (0ms,0V), (6ms,3V), (16ms,4.875V), (16ms,0V), (17.4ms,-0.7V), (32ms,-3.438V), (32ms,0V), (38ms,3V), then ramps up as between 6ms & 16ms.

4. Straight lines between the following points: (0ms, 0), (2.86ms, 2V), (10ms, 2V), (10ms, -3V), (19ms, -0.7V), (22.86ms, 2V), flat at 2

5. Straight lines between the following points: (0ms,1.3V), (0.2ms,1.3V), (0.4ms,3.3V), (0.4ms,1.3V), (1ms,1.3V) .

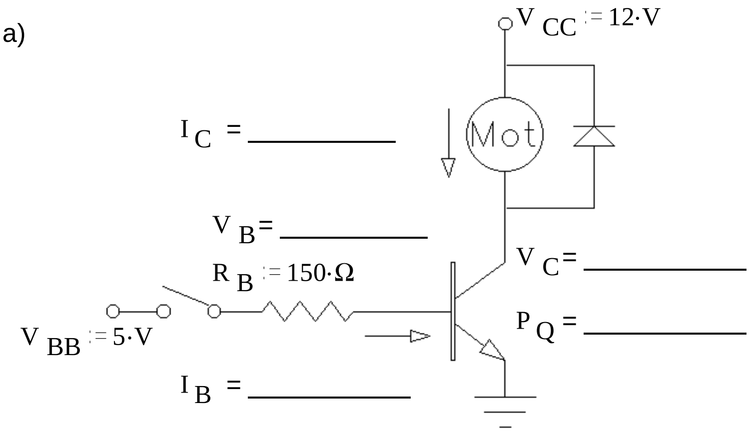
ECE 2210 homework # DO2, p4

Folder:____ Name:______________________ ECE 2210 hw # TR1 Due: Tue, 11/19/19

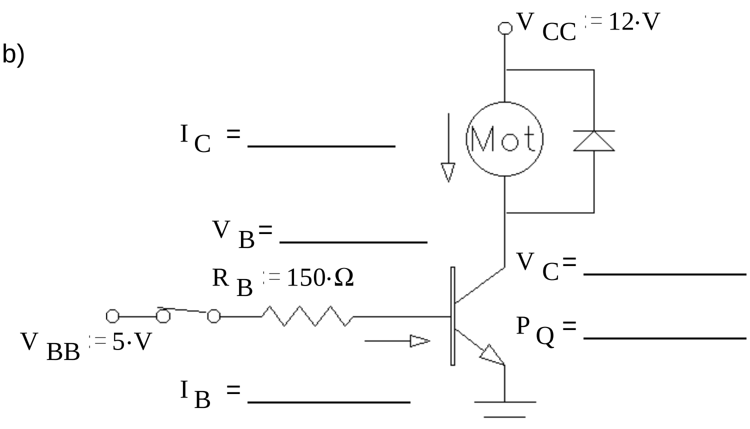
1. Fill in the blanks in the circuits below and on the next page. Assume that the motor can be modeled with a 20 Ω resistor and that transistor β's are 25 (a very conservative estimate). A.Stolp b

$R_{mot} := 20\cdot\Omega$ $\beta := 25$

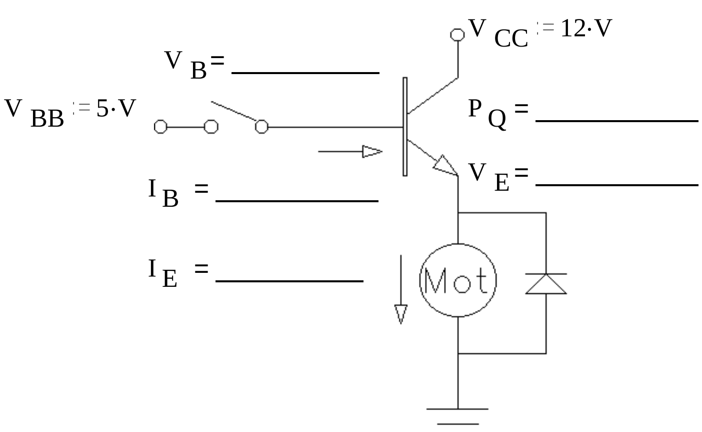
a)



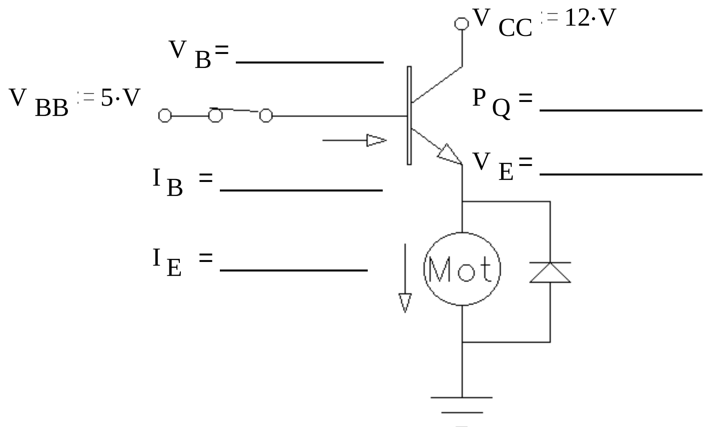
b)



c)

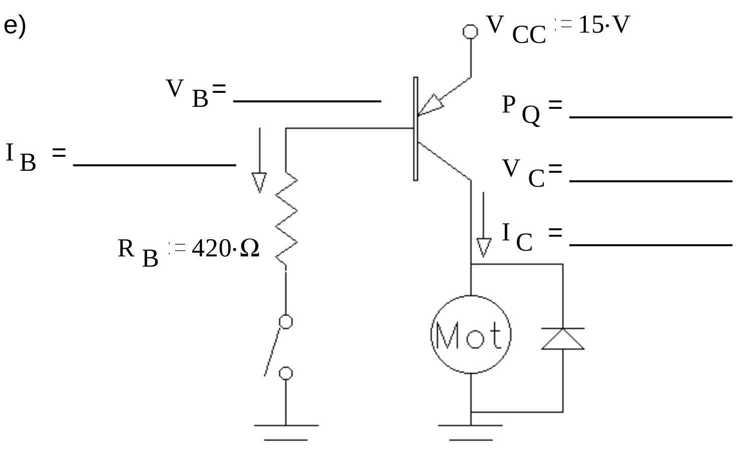


d)



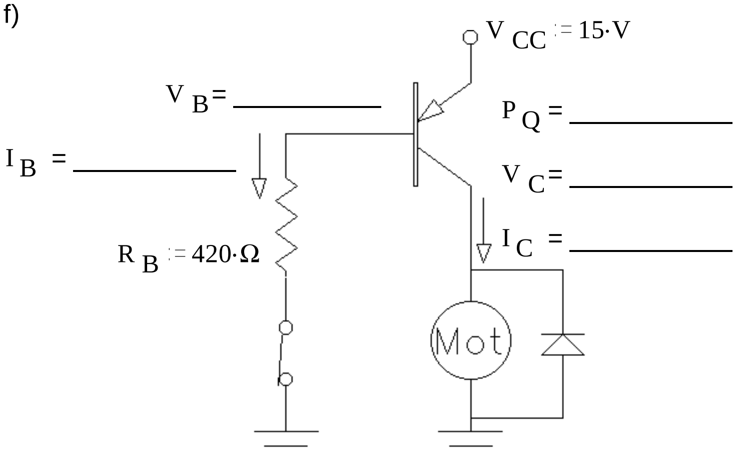
$V_{CC} := 12 \cdot V$
$V_B =$
$V_{BB} := 5 \cdot V$
$P_Q =$
$V_E =$
$I_B =$
$I_E =$
Mot

e)



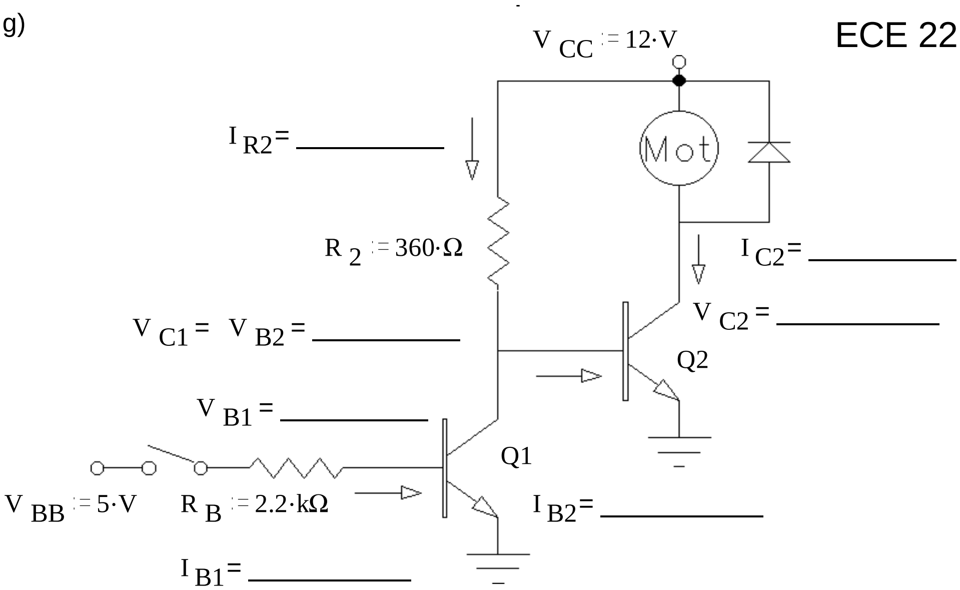
$V_{CC} := 15 \cdot V$
$V_B =$
$P_Q =$
$I_B =$
$V_C =$
$I_C =$
$R_B := 420 \cdot \Omega$
Mot

f)

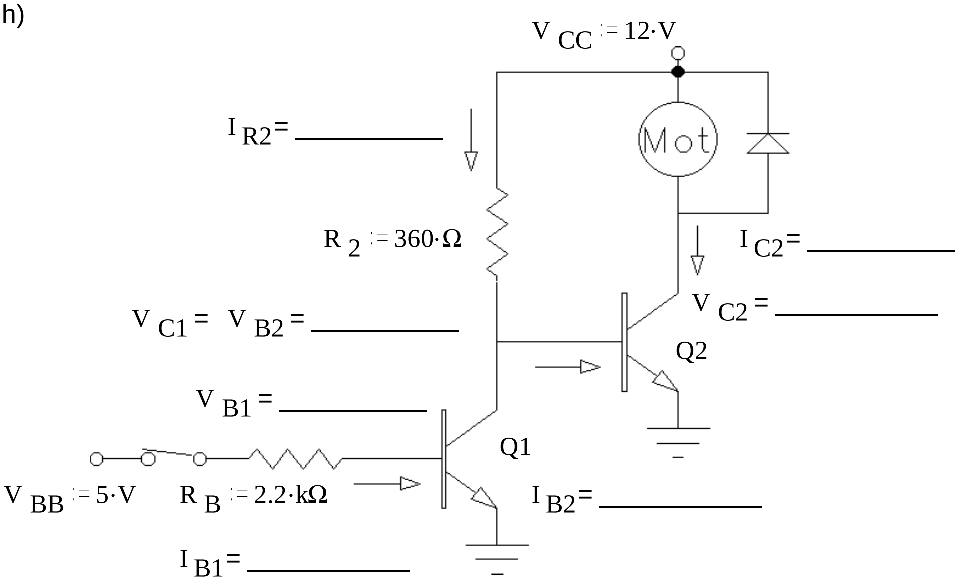


$V_{CC} := 15 \cdot V$
$V_B =$
$P_Q =$
$I_B =$
$V_C =$
$I_C =$
$R_B := 420 \cdot \Omega$
Mot

g)



h)

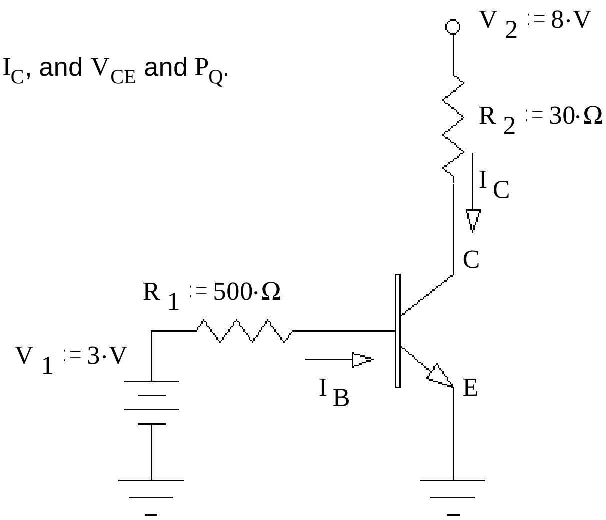


2. In problem 1b, What is the largest value that R_B could be and still keep the transistor in saturation?

3. In problem 1f, What is the largest value that R_B could be and still keep the transistor in saturation?

4. a) $\beta := 40$ Assume the transistor is in the active region, find I_C, and V_{CE} and P_Q.

I_C = ? V_{CE} = ? P_Q = ?



b) Was the transistor actually operating in the active region? yes no circle one

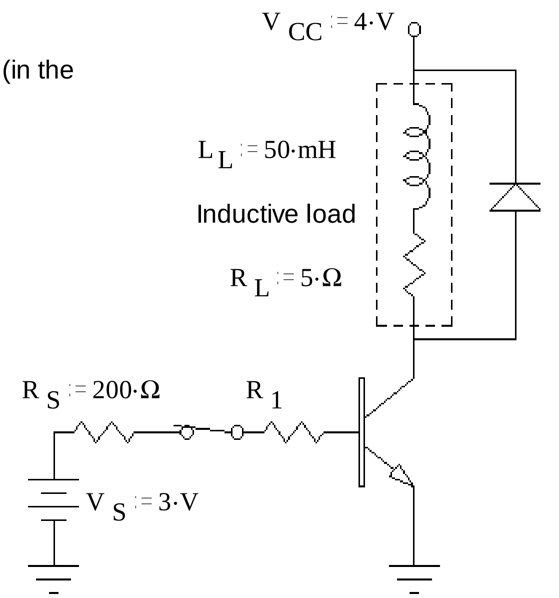
How do you know? (Specifically show a value which is or is not within a correct range.)

c) $\beta := 40$ find the maximum value of R_1, so that the transistor will be in saturation.

d) $R_1 = 500 \cdot \Omega$ and can't be changed, find the minimum value of β, so that the transistor will be in saturation.

ECE 2210 homework # TR1 p5

5. 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) Assume the transistor is in saturation (fully on) and that switch has been closed for a long time. What is the load current?

I_C = ?

b) $\beta := 80$ find the maximum value of R_1, so that the transistor will be in saturation.

Use this R_1 for the rest of the problem.

c) You got a bad transistor. $\beta := 40$ Find the new I_C, and V_{CE} and P_Q.

I_C = ? V_{CE} = ? P_Q = ?

The power dissipation was too high for the transistor and it burned out. You replace the transistor with a new one that has $\beta \geq 80$

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

A) never.

B) when the switch opens.

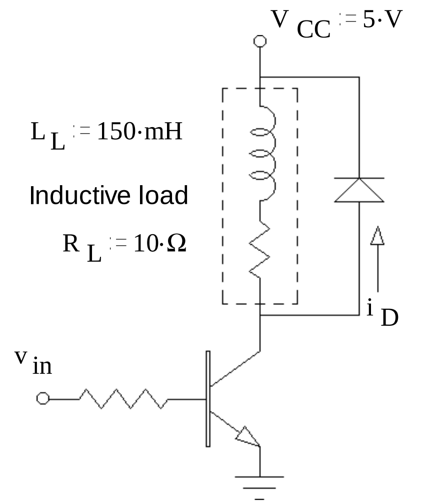
C) whenever the switch is open.

D) when the switch closes.

E) whenever the switch is closed.

F) always.

e) The switch is opened and closed a few times. What is the maximum diode current you expect. (Answer 0 if it never conducts.)

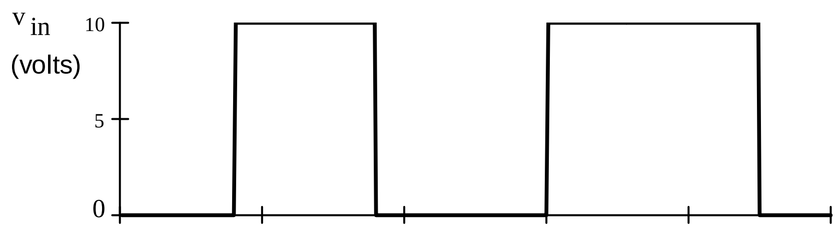


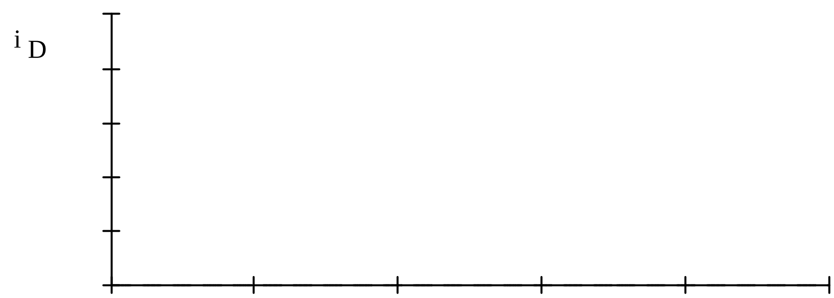
6. A power transistor is used to control the current flow through an inductive load (in the dotted box, it could be a relay coil or a DC motor). The input to the base of the transistor is shown below (v_{in}). The time constant of the RL load is much shorter than the on or off times of v_{in}. When the transistor conducts, consider $V_{CE} = 0.2V$.

   a) what is the maximum load current you expect.

   b) If the diode ever conducts, what is the maximum diode current you expect.

   c) If the diode ever conducts, sketch the approximate diode waveform below.





Answers

1. a) $V_B = 0$ V, $I_B = 0$ mA, $V_C = 12$ V, $I_C = 0$ mA, $P_Q = 0$ mW

   b) $V_B = 0.7$ V, $I_B = 28.7$ mA, $V_C = 0.2$ V, $I_C = 590$ mA, $P_Q = 118$ mW

   c) $V_B = 0$ V, $I_B = 0$ mA, $V_E = 0$ V, $I_E = 0$ mA, $P_Q = 0$ mW   d) $V_B = 5$ V, $V_E = 4.3$ V, $I_E = 215$ mA,

   d, con't) $I_B = 8.3$ mA, $P_Q = 1.59$ W, **OR:** $I_B = 8.6$ mA, $P_Q = 1.66$ W if you neglect I_B contribution to I_E .

   e) $V_B = 15$ V (emitter-base junction is not a perfect "open" even when $V_{EB} < 0.7V$), $I_B = 0$ mA, $V_C = 0$ V,
   $I_C = 0$ mA, $P_Q = 0$ mW   f) $V_B = 14.3$ V, $I_B = 34$ mA, $V_C = 14.8$ V, $I_C = 740$ mA, $P_Q = 148$ mW

   g) $V_{B1} = 0$ V, $I_{B1} = 0$ mA, $V_{C1} = V_{B2} = 0.7$ V, $I_{B2} = I_{R2} = 31.4$ mA, $V_{C2} = 0.2$ V, $I_{C2} = 590$ mA

   h) $V_{B1} = 0.7$ V, $I_{B1} = 1.95$ mA, $V_{C1} = V_{B2} = 0.2$ V, $I_{R2} = I_{C1} = 32.8$ mA, $I_{B2} = 0$ mA, $I_{C2} = 0$ mA, $V_{C2} = 12$ V

2. $182\ \Omega$ 3. $483\ \Omega$

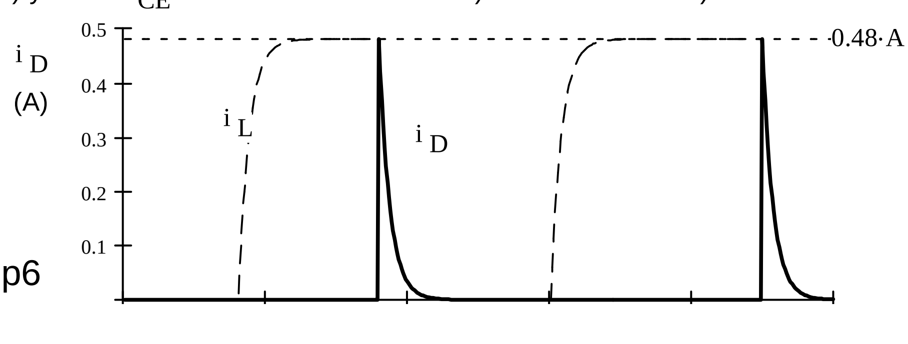
4. a) $184 \cdot mA$ $2.48 \cdot V$ $0.456 \cdot W$ b) yes $V_{CE} = 2.5 \cdot V > 0.2 \cdot V$ c) $354 \cdot \Omega$ d) 56.5

5. a) $0.76 \cdot A$ b) $42.1 \cdot \Omega$

   c) $380 \cdot mA$ $2.1 \cdot V$ $0.798 \cdot W$

   d) B   e) $0.76 \cdot A$

6. a) $0.48 \cdot A$ b) $0.48 \cdot A$ c) at right



b

ECE 2210 Homework DD Go to ME Design day in the Union, **Tue, 12/3,**

Due Thur, 12/5 : Write 3 or 4 paragraphs (1/2 - 1 page) about what you see there, especially mention the electrical circuits and electronics.

ECE 2210 Homework OA1 Due: Fri, 11/22/19

A. Stolp, 11/28/01

Refer to the Operational Amplifier handout. Most of the problems below are design problems. The answer should be a schematic of a circuit showing the values of all the parts. Use resistor values in the 1 kΩ to 1 MΩ range. You **MUST** choose resistor values that are **DIFFERENT** than those in my answers.

1. Design a buffer circuit which will allow a sensor with a high source resistance to be connected to fairly low resistance load. You don't need any voltage gain, but it is important that the load does not interfere with the measurement.

2. Design an amplifier with a gain of 12. The output voltage must be in phase with the input voltage (no inversion is allowed).

3. Design an amplifier with a gain of 25. The output voltage may be 180° out of phase with the input voltage (inversion is allowed). Its input resistance should be ≥10 kΩ. That is, from the input's point of view, the amplifier should look like a 10 kΩ resistor hooked to ground, or larger.

4. Design an amplifier with two inputs where $v_o = -10v_1 - 4v_2$.

5. Design an amplifier with two inputs where $v_o = +10v_1 + 4v_2$. You may use more than one op-amp.

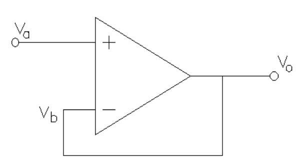
6. Design an amplifier with two inputs where $v_o = 12v_2 - 12v_1$.

7. Design a differentiator using an op-amp, a resistor, and an inductor. You do not need to show parts values, but you need to show that the circuit differentiate by showing a derivation similar to the ones in my handout.

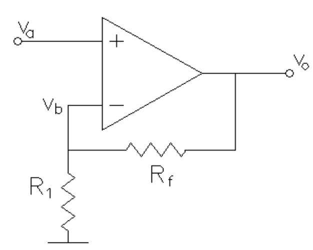
8. Design a comparator whose output will be high (about 8 or 9 V) when the input is greater than 5 V and whose output will be low (about 1 V or so) when the input is less than 5 V.

Answers

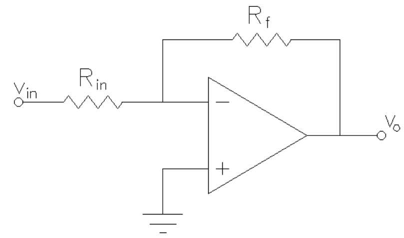
1.) Draw a voltage follower.



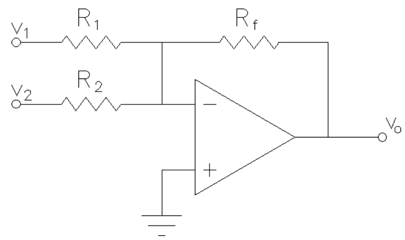
2.) Draw a noninverting amplifier. Choose an R_1 and an R_f which is 11 times bigger than R_1. Say R_1 = 10 kΩ and R_f = 110 kΩ.



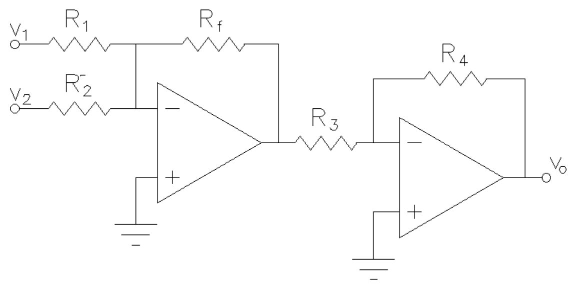
3.) Draw an inverting amplifier. Rin = 10 kΩ, Rf = 250 kΩ.



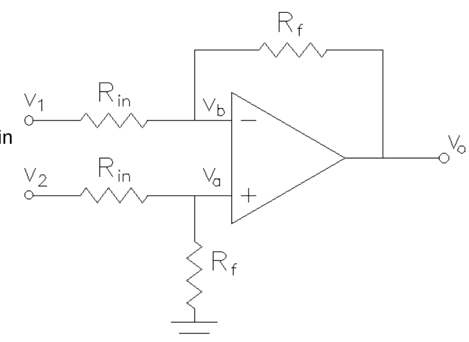
4.) Draw a two-input summer. Choose a value for R_f. Choose a value for R_1 which is $R_f/10$ and a value for R_2 which is $R_f/4$. Say 100 kΩ, 10 kΩ and 25 kΩ.



5.) Redraw the same circuit as problem 4, only now follow it with an inverting amp with a gain of 1. Say $R_3 = R_4 = 10$ kΩ for the second op-amp.



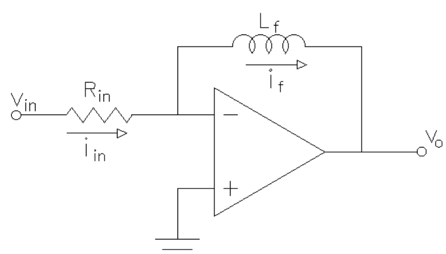
6.) Draw a differential amplifier. Choose an R_{in} value. Make R_f 12 times bigger than R_{in}. Say R_{in} = 10 kΩ and R_f = 120 kΩ.



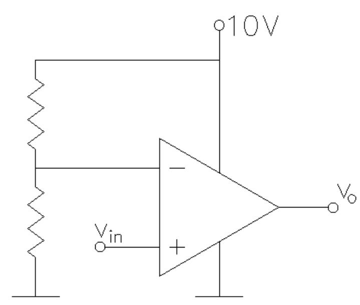
7.)

$$i_{in} = \frac{v_{in}}{R_{in}} = i_L = -\frac{1}{L}\int v_o dt$$

$$v_o = -\frac{L}{R_{in}}\frac{dv_{in}}{dt}$$



8.) Just choose the two resistor values to be equal, so the voltage at the inverting input pin will be 5 V. Now, anytime the voltage on the noninverting pin is above 5 V the output will be high (~8 V) and anytime the voltage on the noninverting pin is below 5 V the output will be low (~2 V).



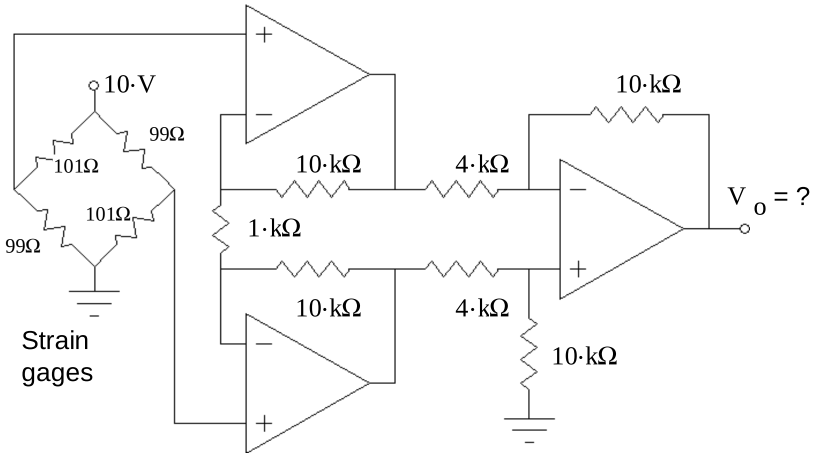
ECE 2210 homework DD   Go to ME Design day in the Union, Tue, 12/3, Due Thur, 12/5

Write 3 or 4 paragraphs (1/2 - 1 page) about what you see there, especially mention the electrical and circuits electronics.

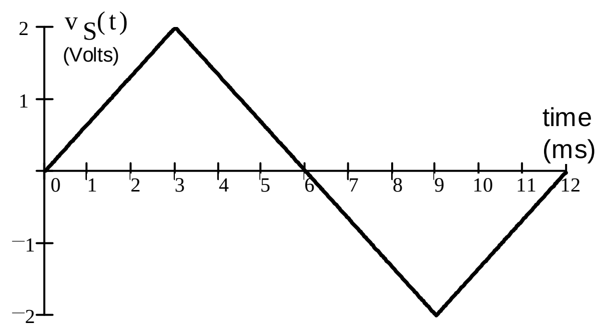
Folder:______ Name:______________________________ ECE 2210 Homework OA2 a

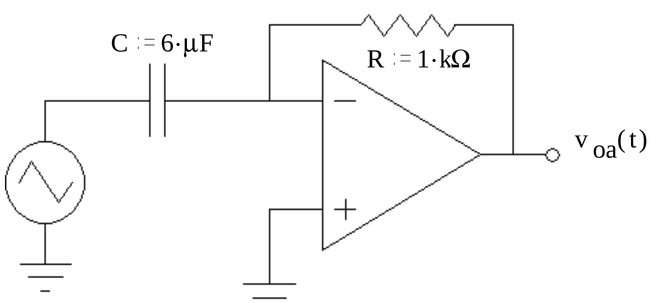
Due: Tue, 11/26/19

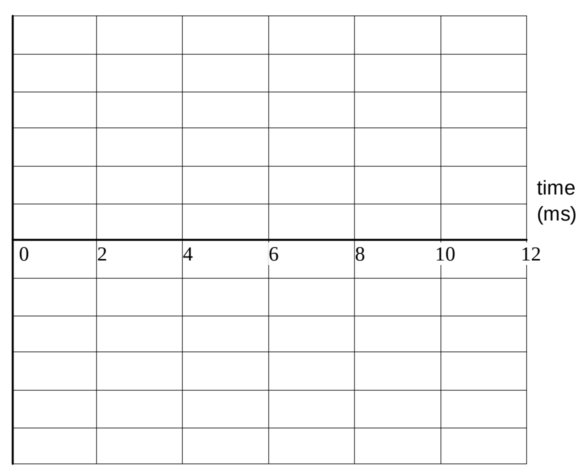
1. The op-amps are powered by ± 12 V power supplies. What output do you expect? SHOW WORK, possibly on another page.



2. The same input signal (at right) is connected to several op-amp circuits. Sketch the output waveforms for the circuits shown.
   a) Op amp powered by ± 12 V power supplies.

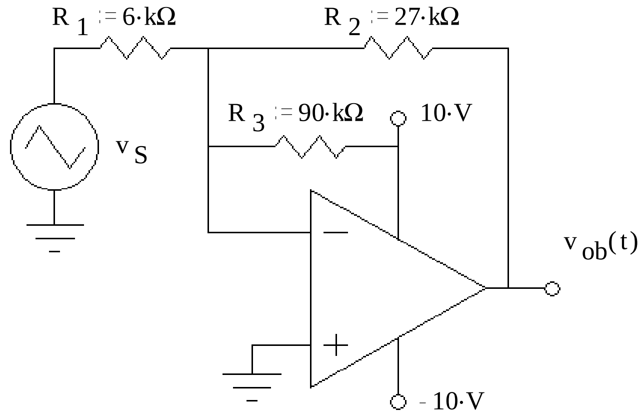


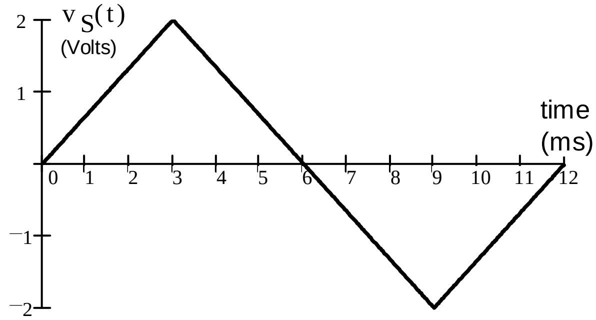


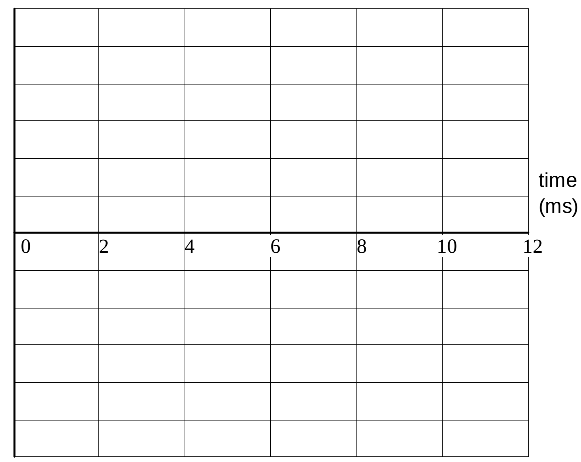


ECE 2210 Homework OA2,   p.2

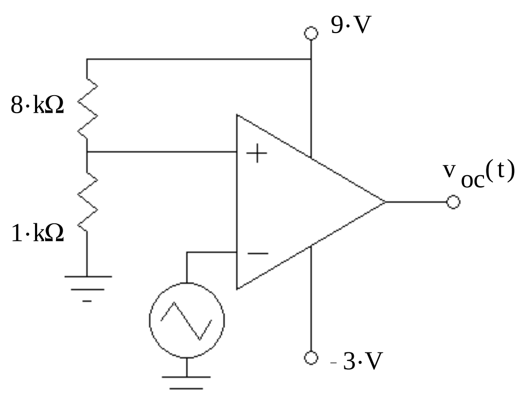
2.b)

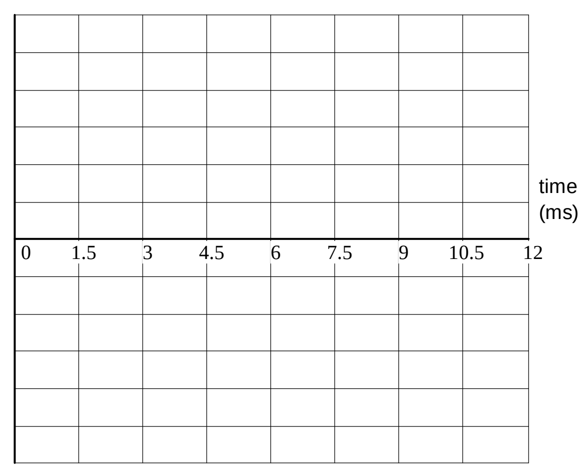






c)





Answers

1. $5.25 \cdot V$

2. a) $(0ms, -4V)$ to $(3ms, -4V)$ to $(3ms, 4V)$ to $(9ms, 4V)$ to $(9ms, -4V)$ to $(12ms, -4V)$

b) $(0ms, -3V)$ to $(2ms, -9V)$ to $(4ms, -9V)$ to $(9ms, 6V)$ to $(12ms, -3V)$

c) $(0ms, 8V)$ to $(1.5ms, 8V)$ to $(1.5ms, -2V)$ to $(4.5ms, -2V)$ to $(4.5ms, 8V)$ to $(12ms, 8V)$

ECE 2210 homework PA1 Due: Wed, 12/4/19

c

Note: In the following problems, you may assume voltages and currents are RMS unless stated otherwise or given as a function of time.

1. Read the AC power notes and examples.

2. Compute the power factor for an inductive load consisting of $L := 20 \cdot mH$ and $R := 6 \cdot \Omega$ in series. $\omega := 377 \cdot \frac{rad}{s}$

3. The complex power consumed by a load is $620 \angle 29^o$ VA. Find:

   a) Apparent power (as always, give the correct units). b) Real power. c) Reactive power.

   d) Power factor. e) Is the power factor leading or lagging? f) Draw a phasor diagram.

4. In the circuit shown, the voltmeter measures 120V, the ammeter measures 6.3A and the wattmeter measures 560W. The load consists of a resistor and an inductor. The frequency is 60Hz. Find the following:

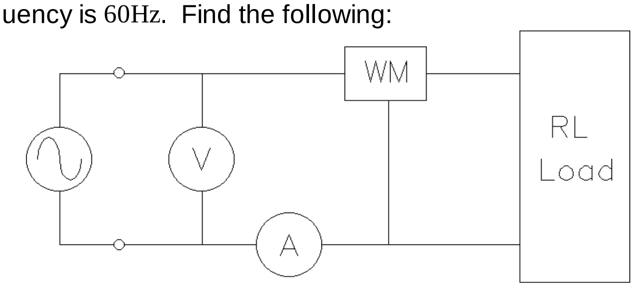
   a) Power factor b) Leading or lagging?

   c) Real power.

   d) Apparent power.

   e) Reactive power.

   f) Draw a phasor diagram.



   g) The load is in a box which cannot be opened. Add another component to the circuit above to correct the power factor (make pf = 1). Draw the correct component in the correct place and find its value. This component should not affect the real power consumption of the load.

5. For the circuit shown, find the following:
   (as always, give the correct units)

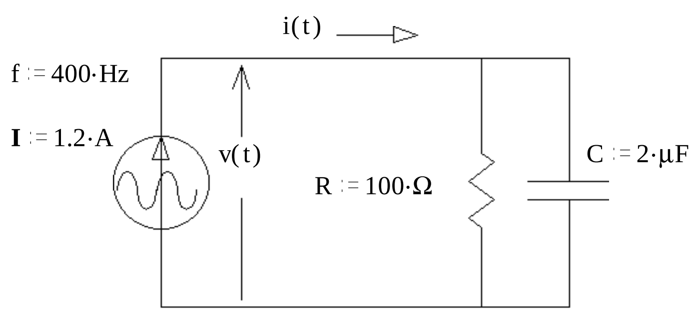
   a) The complex power.

   b) Real power.

   c) Reactive power.

   d) Apparent power.

   e) Draw a power phasor diagram.



Answers

2. $pf := 0.623$

3. a) $620 \cdot VA$

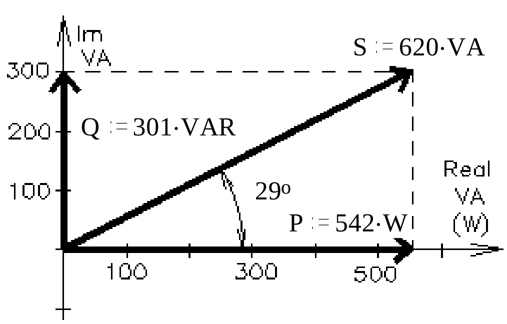
   b) $542 \cdot W$

   c) $301 \cdot VAR$

   d) 0.875

   e) lagging

   f) ------->



4. a) 0.741

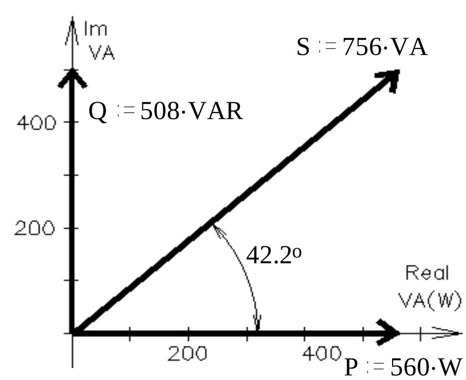
   b) lagging

   c) $560 \cdot W$

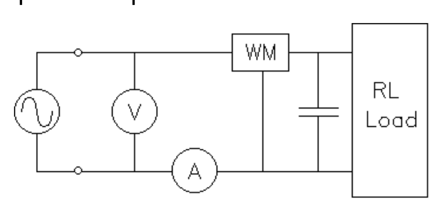
   d) $756 \cdot VA$

   e) $508 \cdot VAR$

   f) ------->



   g) $93.6 \cdot \mu F$ capacitor in parallel with load



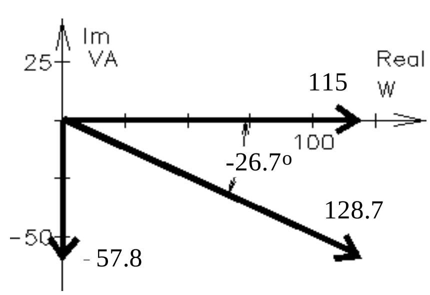
5. a) $(115 - 57.8 \cdot j) \cdot VA$

   b) $115 \cdot W$

   c) $-57.8 \cdot VAR$

   d) $128.7 \cdot VA$

   e) ------->



ECE 2210   homework PA2   Due: Thur, 12/5, may be handed in with final, Mon, 12/9

Note: In the following problems, you may assume voltages and currents are RMS unless stated otherwise or given as a function of time. Transformers are ideal unless stated otherwise.

1. A load draws 12kVA at 0.8 pf, lagging when hooked to 480V. A capacitance is hooked in parallel with the load and the power factor is corrected to 0.9, lagging.

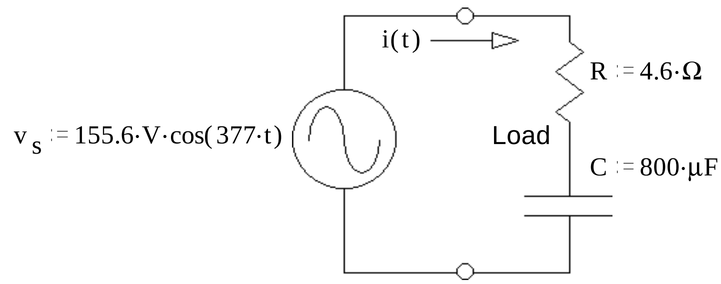
   a) Find the reactive power (VAR) of the capacitor.   Draw a phasor diagram as part of the solution.

   b) Find the value of the capacitor assuming f = 60Hz.

2. Consider the circuit at right.
   The resistor and capacitor together make up the load.

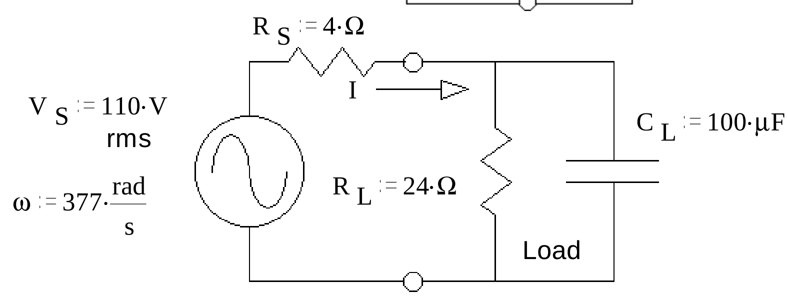
   a) Find the load impedance of the circuit.

   b) Compute the average power dissipated by the load.



3. a) Compute the average power dissipated by the load (R_L and C_L taken together).

   b) Compute the power dissipated by the internal source resistance (R_S) in this circuit.



4. Read sections 2.28, 3.8, & 7.1 in your textbook.

5. An ideal transformer has 330 turns on the primary winding and 36 turns on the secondary. If the primary is connected across a 110 V (rms) generator, what is the rms output voltage?

6. A transformer has N_1 = 320 turns and N_2 = 1000 turns. If the input voltage is v(t) = (255 V)cos(ωt), what rms voltage is developed across the secondary coil?

7. A step-up transformer is designed to have an output voltage of 2200 V (rms) when the primary is connected across a 240 V (rms) source.

   a) If there are 150 turns on the primary winding, how many turns are required on the secondary?

   b) If a load resistor across the secondary draws a current of 1.2 A, what is the current in the primary, assuming ideal conditions?

8. The primary current of an ideal transformer is 8.5 A and the primary voltage is 80 V. 1.0 A is delivered to a load resistor connected to the secondary.   Calculate the voltage across the secondary.

9. An ideal transformer has a turns ratio ($N = N_1/N_2$) of 1.5 . It is desired to operate a 200 Ω resistive load at 150 V (rms).

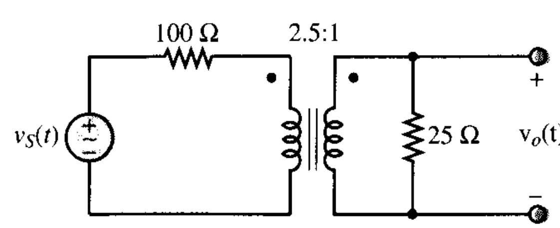
   a) Find the secondary and primary currents.

   b) Find the source voltage ($\mathbf{V_1}$).

   c) Find the power dissipated in the load resistor and the power delivered to the primary from the source.

   d) Find the impedance the source sees looking into the primary winding by calculating $\mathbf{Z_{eq}} = N^2\,\mathbf{Z_L}$ and again by calculating $\mathbf{V_1} / \mathbf{I_1}$.

10. For the ideal transformer shown in the figure, find $v_o(t)$ if $v_s(t)$ is 320Vcos(377t).

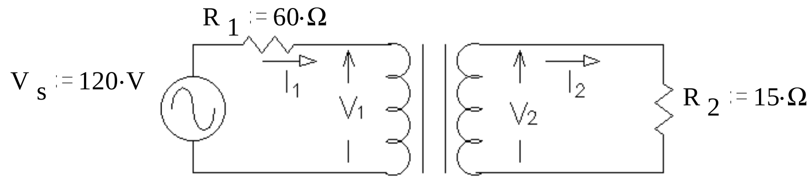


ECE 2210 Homework PA2 p2

11. The transformer shown in the circuit below is ideal. It is rated at 120/30 V, 80 VA, 60 Hz
    Find the following:

    a) I_1 = ?

    b) V_2 = ?



12. A transformer is rated at 13,800/480 V, 60 kVA, 60 Hz. (Note: kVA stands for kilo-Volt-Amp, in this case it is the transformer's voltage rating times its current rating.) Find the allowable primary and secondary currents at a supply voltage of 12,000 V at 100% power factor. Repeat for a power factor of 50%.

13. An ideal transformer has a rating of 500/125 V, 10 kVA, 60 Hz. It is loaded with an impedance of 5Ω at 80% pf (0.80). The source voltage applied to the primary winding is 440 V (rms). Find:
    a) the load voltage
    b) the load current
    c) the kVA delivered to load
    d) the power delivered to load
    e) the primary current
    f) the power factor of primary
    g) the impedance the source sees looking into primary.

14. An ideal transformer is rated to deliver 400 kVA at 460 V to a customer.

    a) How much current can the transformer supply to the customer?

    b) If the customer's load is purely resistive (i.e. if the pf = 1), what is the maximum power the customer can receive?

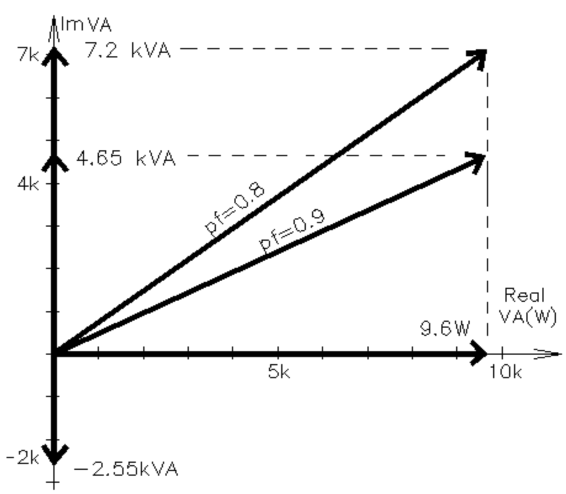
    c) If the customer's power factor is 0.8 (lagging), what is the maximum usable power the customer can receive?

    d) What is the maximum power if the power factor is 0.7 (lagging)?

    e) If the customer requires 300 kW to operate, what is the minimum allowable power factor given the rating of this transformer?

Answers

1.



a) $-2.55 \cdot kVA$ b) $29.4 \cdot \mu F$

2. a) $\mathbf{Z} := 5.67 \cdot \Omega \cdot e^{-j \cdot 35.8 \cdot deg}$ b) $P_{av} := 1.73 \cdot kW$

3. a) $P_{av} := 364 \cdot W$ b) $110 \cdot W$

5. 12 V

6. 563 V

7. a) 1375 turns b) 11 A

8. 680 V

9. a) 0.75 A, 0.50 A b) 225 V c) 112.5 W d) 450Ω

10. 78Vcos(377t)

11. a) $0.4 \cdot A$ b) 24V

12. 4.35 A, 125 A any pf, (Using the transformer at a lower voltage does not increase its current rating.)

13. a) 110 V b) 22 A c) 2.42 kVA d) 1.94 kW e) 5.5 A f) 0.80 g) 80Ω $\angle 36.9^{o}$ Ω

14. a) $870 \cdot A$ b) $400 \cdot kW$ c) $320 \cdot kW$ d) $280 \cdot kW$ e) 0.75