ENGR-4300
Fall 2008
Test 1

Name ______SOLUTION__________

Section: 1(MR 8:00) 2(TR 2:00) 3(MR 6:00)
(circle one)

Question I (20 points) ___________

Question II (20 points) ___________

Question III (20 points) ___________

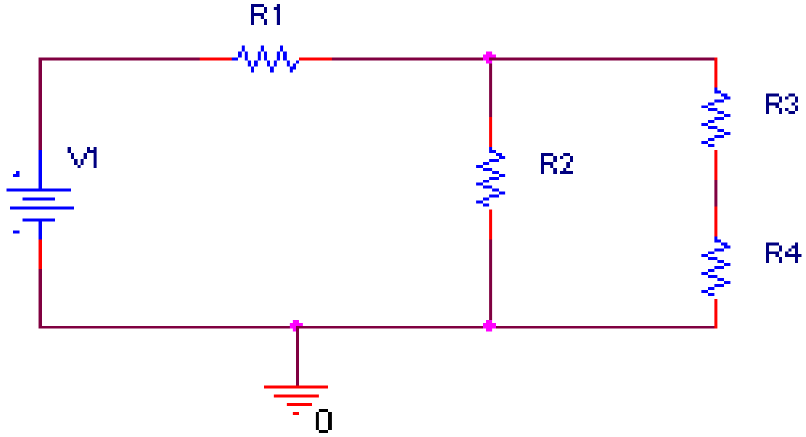
Question IV (20 points) ___________

Question V (20 points) ___________

Total (100 points) ______________

On all questions: SHOW ALL WORK. BEGIN WITH FORMULAS, THEN SUBSTITUTE VALUES AND UNITS. No credit will be given for numbers that appear without justification.

Question I. Resistive circuits (20 points)



Given: V1=5 volts. R1= 2000Ω, R2= 1000Ω, R3= 500Ω, R4= 400Ω

1) (7 pts) Find the total resistance of the circuit.

RT=R1+R2//(R3+R4)
(R3+R4) = .5K + .4K = .9K
R234 = R2//(R3+R4) = (1K.9K)/(1K+.9K) =0.474K*
RT=2K+0.474K = ***2.474 Kohms***

2) (5 pts) Find the voltage across R1. (Note that this is not referenced to ground.)

IT = VT/RT = 5V/2.474K = 2.02 mA
V1 = IT*R1 = 2.02m * 2K = **4.04 V**

3) (6 pts) Find the current through R4.

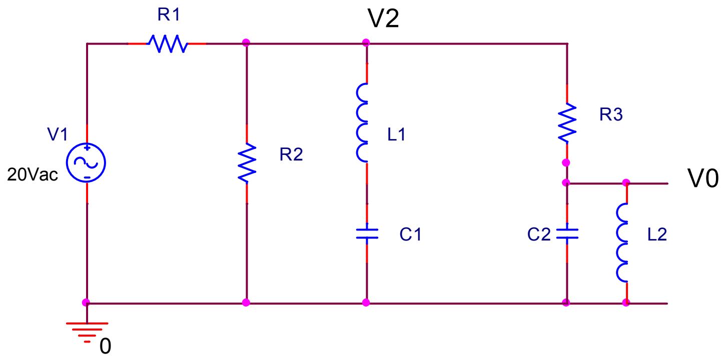
V2 = VT-V1 = 5 – 4.04 = 0.96 V
I2 = V2/R2 = 0.96/1K = 0.96 mA
I3=I4=IT-I2=2.02m-0.96m = **1.06 mAa**

4) (2 pts) Which resistor has the largest voltage drop across it?

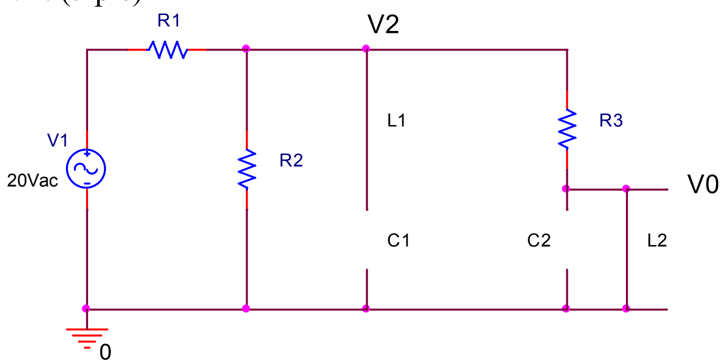
$V_{R2} = 5 - 4.04 = 0.96V$ $V_{R3} < V_{R2}$ & $V_{R4} < V_{R2}$ => **R1 has largest voltage drop**

Question II – Filters (20 points)

You are given the following circuit. The input at V1 is a 20V AC signal. Leave all answers for 1) – 4) in terms of R1, R2, R3, C1, C2, L1, and L2. V0 and V2 are measured with respect to ground.



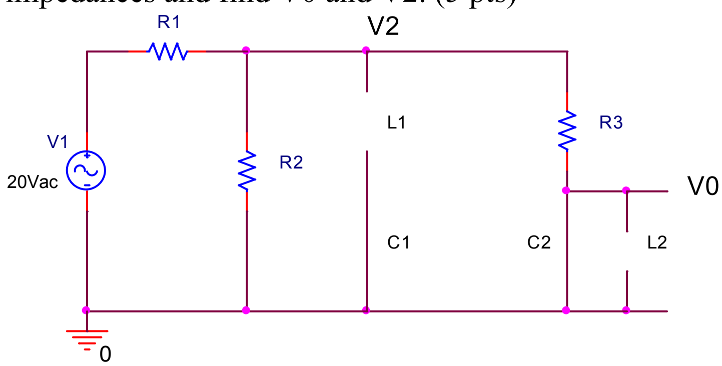
1) Redraw the circuit for ω → 0 with appropriate simplifications for the impedances and find V0 and V2. (5 pts)



V0 = 0

$$V2 = \left(\frac{\frac{R2R3}{R2+R3}}{\frac{R2R3}{R2+R3}+R1}\right)20V = \frac{20R2R3}{R2R3+R1(R2+R3)}$$

2) Redraw the circuit for ω → ∞ (high frequencies) with appropriate simplifications for the impedances and find V0 and V2. (5 pts)



V0 = 0

$$V2 = \left(\frac{\frac{R2R3}{R2+R3}}{\frac{R2R3}{R2+R3}+R1}\right)20V = \frac{20R2R3}{R2R3+R1(R2+R3)}$$

3) At what value of ω (greater than 0 and less than ∞) would you expect to find V0 minimized? (3 pts)

At $\omega = \frac{1}{\sqrt{L1C1}}$ the voltage at V2 =0 when $Z_{L1C1} = 0$ and V0 is also 0

4) At what value of ω (greater than 0 and less than ∞) would you expect to find V0 maximized? (3 pts)

At $\omega = \frac{1}{\sqrt{L2C2}}$ the voltage at V0 is at a maximum when $Z_{L2C2} = \infty$

5) What special name is given to the ω values in 3) and 4)? (2 pts)

The resonant frequency of the LC (either parallel or series).

6) TRUE or FALSE: If V1 had a DC offset and ω is neither the value in 3) nor 4), the output V0 would also have a DC offset. (2 pts)

Question III – Transfer Functions (20 points)

1) For ω = 10, a circuit has a transfer function $H(j10) = \frac{2 + j5}{-8 - j6}$. Find the magnitude and phase of H(j10). (4 pts)

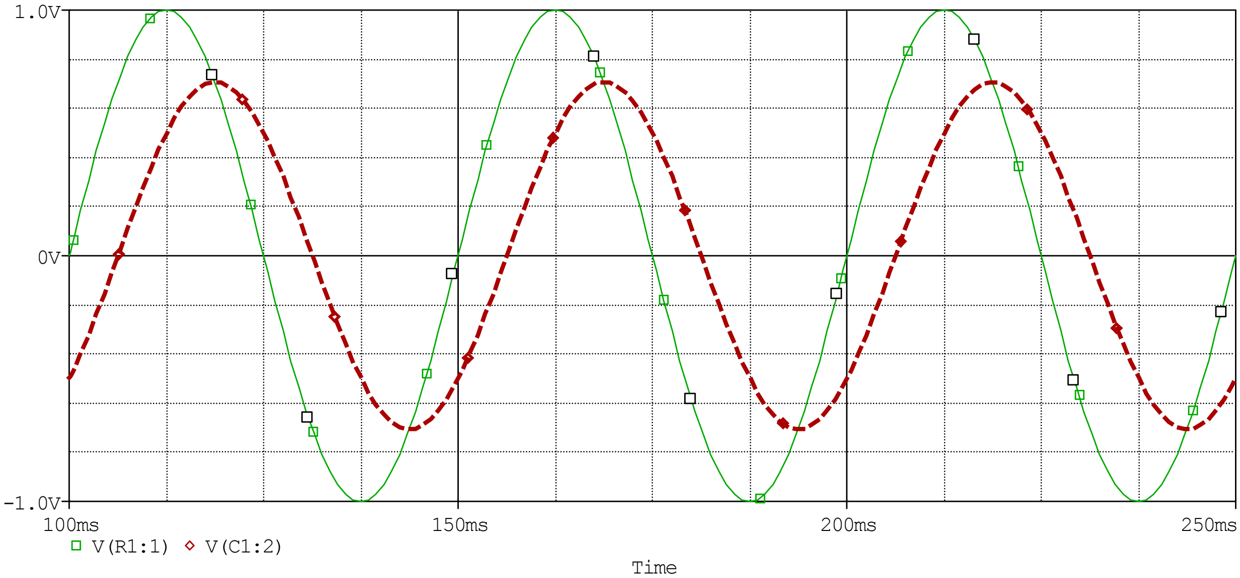
$$|H(j\omega)| = \frac{\sqrt{2^2 + 5^2}}{\sqrt{8^2 + 6^2}} = 0.5385$$

$$\angle H(j\omega) = \angle(2 + j5) - \angle(-8 - j6) = \arctan\left(\tfrac{5}{2}\right) - \arctan\left(\tfrac{-6}{-8}\right) = 68.2° - (-143.1°) = 211.3° = -148.7°$$

2) For an H(j5) = 0.75/π/3 and Vin(t) = 2cos(5t - π/2), find Vout(t). (6 pts)

Vout = H x Vin = |H|x|Vin|(/H + /Vin) = (0.75)(2)cos(5t - π/2 + π/3) = 1.5cos(5t - π/6)

The plot below shows the input (solid thin line) and output (dashed wide line) of a circuit whose transform is H(jω) = Vout(jω)/Vin(jω). Note that the time axis is from 100ms to 250ms.



3) Determine ω (radians/s) for the input and output signals? (2 pts)

ω = 2π/T = 2π/50ms = 125.7radians/s

4) Determine the magnitude of H(jω) at this frequency. (3 pts)

|H| = Vout/Vin = 0.707/1.0 = 0.707

5) Determine the phase of H(jω) at this frequency? (3 pts)

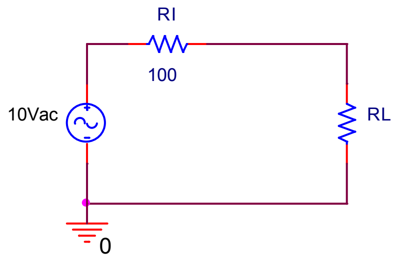
/H = /Vout - /Vin = (-2π/8) – 0 = -π/4

6) If H(jω) is a 1st order LPF, ω is most likely: (2 pts)

a. the resonant frequency b. in the pass band c. in the stop band d. the corner frequency

With magnitude down by $\frac{1}{\sqrt{2}}$ and phase shifted by -π/4 => corner frequency

Question IV – Signals, Transformers and Inductors (20 points)



1) Given the circuit above, for what value of RL will the power in RL be maximized? (2 pts)

RL = RI = 100Ω

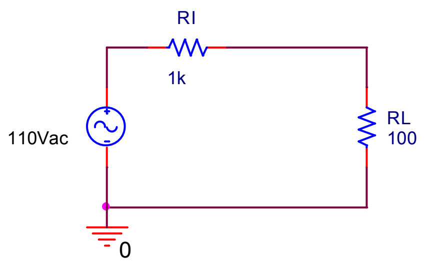
2) What is the power dissipated in RI and in RL? (4 pts)

(10V)(100)/(100 + 100) = 5V

$P_{RL} = 5^2/100 = 0.25W$ $P_{RI} = 5^2/100 = 0.25W$

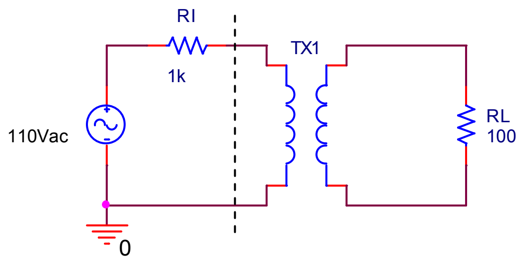
3) What is the efficiency of the circuit in terms of the power dissipated in RL over the total power dissipated in the circuit $\left(\frac{\text{Power in RL}}{\text{Total Power}}\right)$? (2 pts)

Eff = 0.25/(0.25 + 0.25) = 0.5 = 50%



4) Now with RI = 1kΩ and RL = 100Ω, assume P_{RL} = 1.0W and P_{RI} = 10.0W. What is the efficiency of this circuit $\left(\frac{\text{Power in RL}}{\text{Total Power}}\right)$? (2 pts)

Eff = 1.0/(1.0+ 10.0) = 0.091 = 9.1%



5) An ideal transformer is added to improve the efficiency as shown above. The desire is to have Z_{in} of the transformer at the dashed line equal to RI (1kΩ). What turns ratio 'a' will do this? (5 pts)

$Z_{in} = RL/a^2$ $\quad$ $a^2 = RL/Z_{in} = 100/1000 = 0.1$ $\quad$ a = 0.316

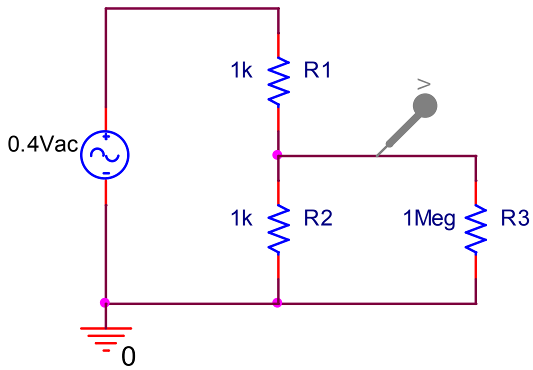
6) TRUE or FALSE: the expected efficiency of the modified circuit in 5) is 50%. (1 pt)

7) For the transformer with turns ratio a = 5, if L_1 = 10mH what is L_2? (4 pts)

$$a = \sqrt{\frac{L_2}{L_1}} \qquad L_2 = L_1 a^2 = 10mH \cdot 5^2 = 250mH$$

Question V – Instrumentation, PSpice and components (20 points)

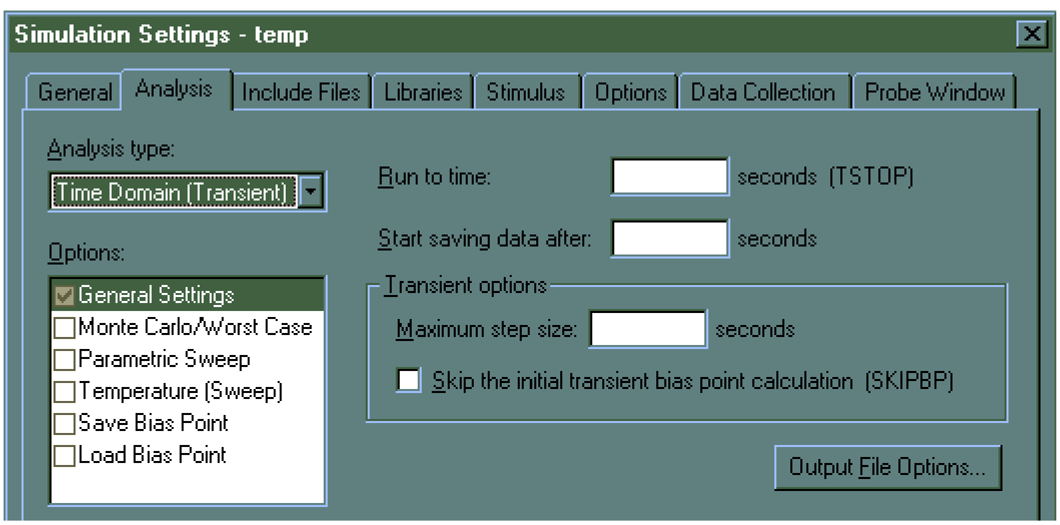
In experiment 1, you wired a circuit similar to the one below using real components and in PSpice:



1) (6 pts) What does this circuit do? What do R1, R2, and R3 represent?

The circuit is a voltage divider with the function generator as source and a measuring device attached to the second resistor. R1 and R2 are the resistors in the voltage divider, and R3 is the impedance of the measuring device (DMM or IOBoard oscilloscope input).

2) (3 pts) Suppose V1 has a frequency of 0.5kHz, an amplitude of 400mV, and a DC offset of 0. You want to run a transient analysis. How would you set up the simulation screen below to show exactly 3 smooth cycles of the output wave? (Fill in the three empty boxes.)



Notes on 2): Anything is acceptable for run time and start time as long as the difference is 6ms (3x1/500). The maximum step size should be somewhere in the range from about 0.06ms (100 points) to 6us (1000 points). Ex: 6ms 0s 0.05ms

3) (3 pts) If you set up this transient simulation, what would be the frequency (in Hz) and the approximate amplitude (in mV) of the signal at the point of the voltage probe?

f = 0.5kHz V_{probe} = 200mV

4) (5 pts) If you replaced R2 with a resistor with color code orange-black-red-gold, what would be the frequency (in Hz) and the approximate amplitude (in mV) of the signal at the point of the voltage probe?

The resistance of the new resistor is 30 x 100 = 3K ohms.
VR2 = V1xR2/(R1+R2) = 400x3K/(1K+3K) = 300mV
The frequency will not change.

f = 0.5 Hz V_{probe} = 300mV

5) (3 pts) To get an IOBoard function generator to output the signal in the circuit above, the voltage must be specified as: a. 0.4V b. 0.2Vp-p c. 0.8V d. 0.8Vp-p e. none of these

d. 0.8Vp-p