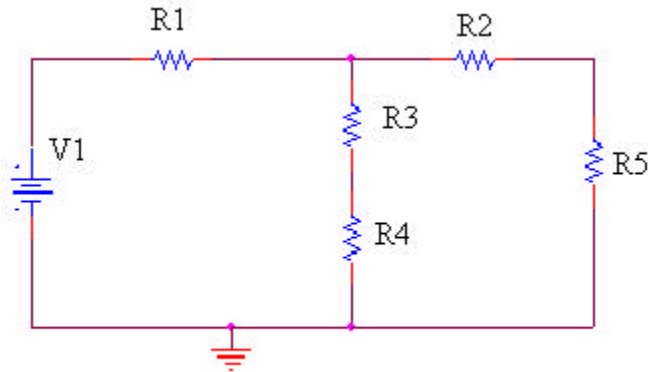**ENGR4300  Test 1A**
**Spring 2003**

Name_____*solution*_____

Section  _____

**1. Resistive circuits (20 points)**



**Given: V1=5 volts.  R1= 50Ω, R2= 3000Ω, R3= 1000Ω, R4= 550Ω, R5=440Ω**

a)  (8 points) Find the combined resistance of the circuit with respect to V1.

*R25 = R2+R5 = 3000+440 = 3440   R34 = R3+R4 = 1000+550 = 1550*
*R2345 = R25 // R34 = (3440x1550)/(3440+1550) = 1068.5*
*R12345 = 50 + 1068.5 = 1118.5*

<u>*RT = 1120 ohms (exactly 1118.5)*</u>

b) (4 points) Find the voltage across R1.

*VR1 = (V1)(R1)/(R1+R1234) = 5(50)/(1118.5) = 0.22 volts*

<u>*VR1 = 0.2 volts*</u>

c) (8 points) Find the current through R4.

*V25 = V34 = V1-VR1 = 5-0.22 = 4.78 volts*
*I34 = I4 = V34/R34 = 4.78/1550 = 3.08 milliamps*

<u>*I4 = 3.1 milliamps*</u>

*Check: I25 = V25/R25 = 4.78/3440 = 1.39 milliamps*
*        IR1 = V1/RT = 5/1120 = 4.46 milliamps*
*        IR1 = I25+I34 = 4.46 = 1.39 + 3.08 = 4.47 (close enough)*

### 2. Thevenin circuits (20 points)
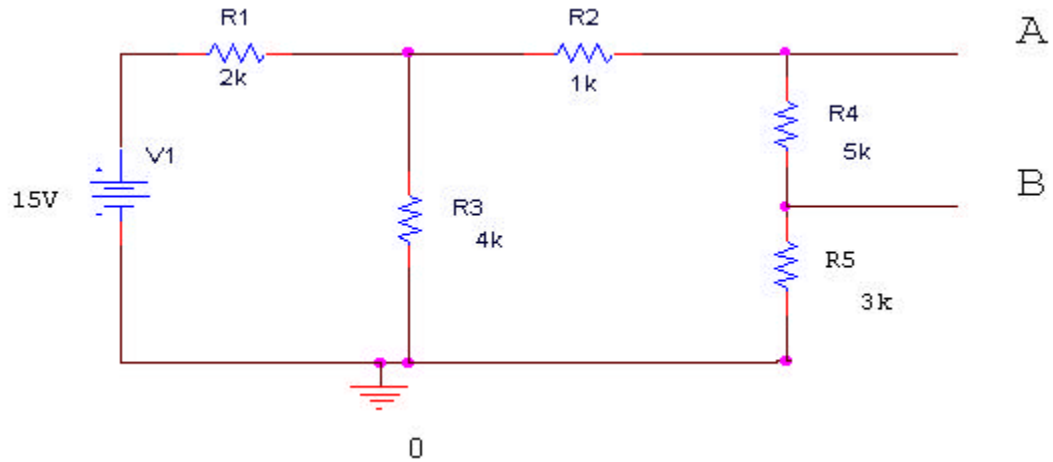


a) (6 points) Find the Thevenin voltage (Vth) of the circuit assuming the load will be connected between A and B.

> *R245 = R2+R4+R5 = 1k+5k+3k = 9k*
> *R2345 = R3 // R245 = (9kx4k)/(9k+4k) = 2.77k*
> *V2345 = V1(R2345)/(R1+R2345) = 15x2.77/(2+2.77) = 8.71 volts*
> *V4 = V2345xR4/(R2+R4+R5) = (8.71x5k)/9k = 4.84 volts*

> ***Vth = 4.84 volts***

b) (6 points) Find the Thevenin resistance.

> *R13 = R1//R3=(R1xR3)/(R1+R3) = (2kx4k)/(2k+4k) = 1.33k*
> *R1235 = R13 + R2 + R5 = 1.33K + 1K + 3k = 5.33 K*
> *R12345 = R1235//R4 = (5.33x5)/(5.33+5) = 2.58K ohms*

> ***Rth = 2.58 K ohms***

c)  (4 points) Draw the Thevinen equivalent circuit with a load of 1K ohms.

d)  (4 points) Find the voltage between A and B for this circuit with a load of 1K ohms.

*VAB = (Vthx1K)/(1K+Rth) = (4.84x1k)/(1K+2.58K) = 1.35 volts*

*VAB = 1.35 volts*

**3. Instrumentation and Sine Waves (20 points)**

You follow this procedure in the studio:
1) Turn on the 'scope and the function generator.
2) Connect a BNC cable from the function generator output to channel 1 of the 'scope.
3) Push the Freq button on the function generator.
4) Turn the dial until the frequency reads 2K Hz.
5) Push the Ampl button on the function generator.
6) Turn the dial until the peak-to-peak voltage on the function generator display reads 100 mV.
7) Push the Offset button on the function generator.
8) Turn the dial until the DC offset on the function generator display reads 50 mV
9) Adjust the volts/div for channel 1 to 1:50 mV.
10) Adjust the time/div for the horizontal trigger to 200 ìs/
11) Turn the position knob for channel 1 until the arrow lines up with the zero mark.

a) (2 points) When the function generator is connected to the scope you should notice a discrepancy between the reading on the display panel of the function generator, and the signal displayed on the scope.  What discrepancy do you see and which device is correct?

*The function generator reads half of the scope.  The scope is correct.*

b) (8 points) Find the following for the signal you have created (specify all units).

i) the frequency (f)  **$f = 2K\ Hz$**

ii) the angular frequency (ù)   $ù=2\textbf{\textit{p}}f=2\textbf{\textit{p}}x2k=4k\textbf{\textit{p}}$
**$ù=4k\textbf{\textit{p}}\ rad/sec = 12566\ rad/sec$**

iii) the period (T) *T = 1/f = 1/2k = 0.5 ms*  **$T=0.5ms$**

iv) the peak-to-peak voltage (V$_{p-p}$)  **$V_{p-p}= 200mV$**
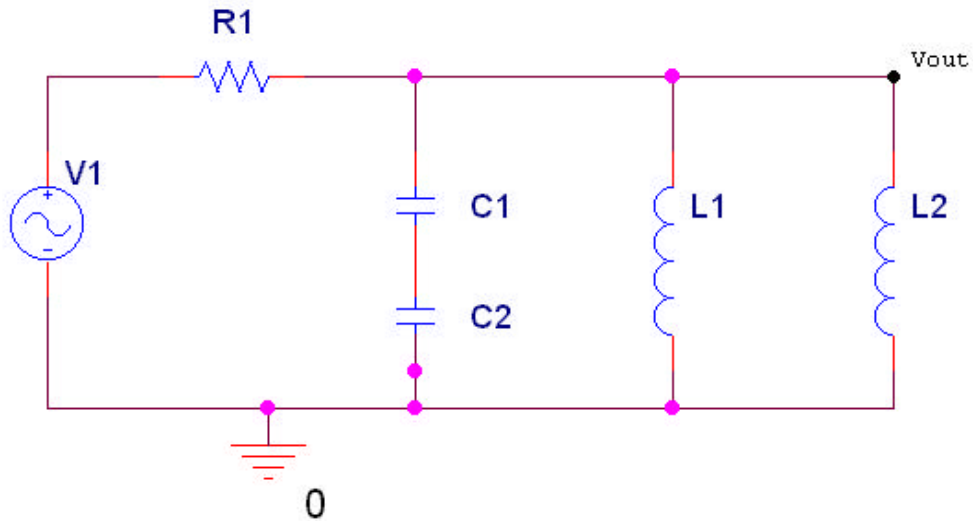
v) the amplitude (A)  **$A = 100mV$**

vi) the DC offset voltage (V$_{dc}$)  **$V_{dc} = 100mV$**

vii) the rms voltage (V$_{rms}$)      *V$_{rms}$ = sqrt(100$^2$ + 100$^2$/2) = 122.5 mV*
**$V_{rms} = 122.5mV$**

vii) the phase(φ) **$\textbf{\textit{j}} = 0$**  (scope automatically triggers at 0)

c)  (2 points) Write down the mathematical expression for the trace in the form:
$v(t) = V_{dc} + A \sin(\omega t + \varphi)$.

*v(t) = 100mV + 100mV sin(4Kpt)*

d) (8 points) Sketch what the output should look like on the display below.
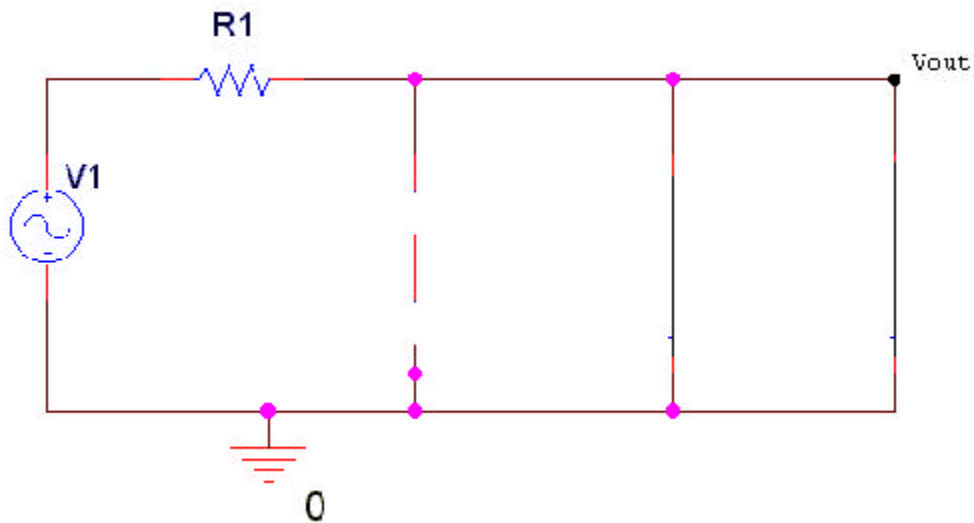
**4. Inductance and capacitance at very high and very low frequencies (20 points)**



Consider the above circuit and apply your knowledge about the behavior of capacitors and inductors (i.e., open or short circuits at very high or very low frequencies).

a) (6 points) Redraw this circuit when V1 is very low frequency.



b) (2 points) According to your redrawn circuit, what would be the value of the voltage at Vout with respect to ground at very low frequencies? (Circle the best answer.)
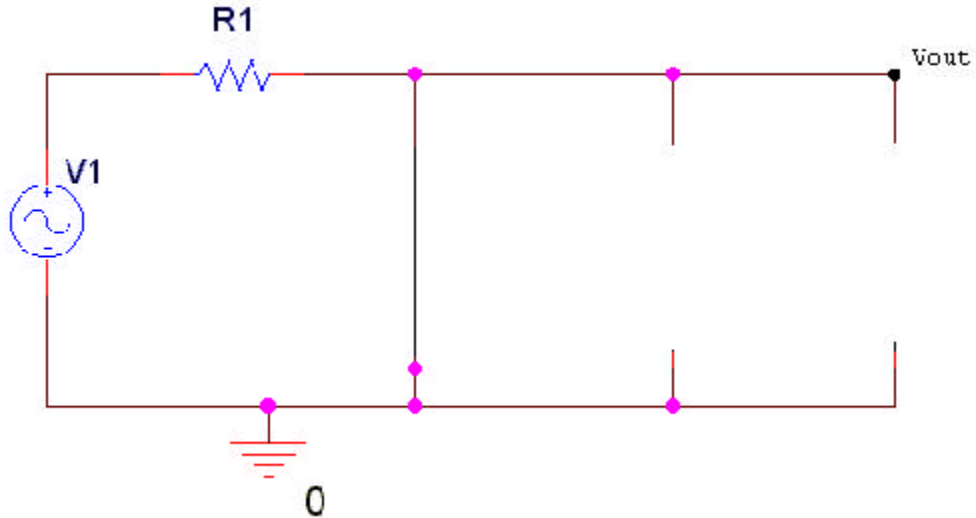
***Vout=0***          Vout = V1          0<Vout<V1/R1          V1/R1<Vout<<V1

c)  (6 points) Redraw this circuit when V1 is very high frequency.



d)  (2 points) According to your redrawn circuit, what would be the value of the voltage at Vout with respect to ground at very high frequency? (Circle the best answer.)

***Vout=0***          Vout = V1                0<Vout<V1/R1          V1/R1<Vout<V1

e)  (4 points) Using your knowledge of filters, what kind of filter would you say this is? (Circle the best answer).
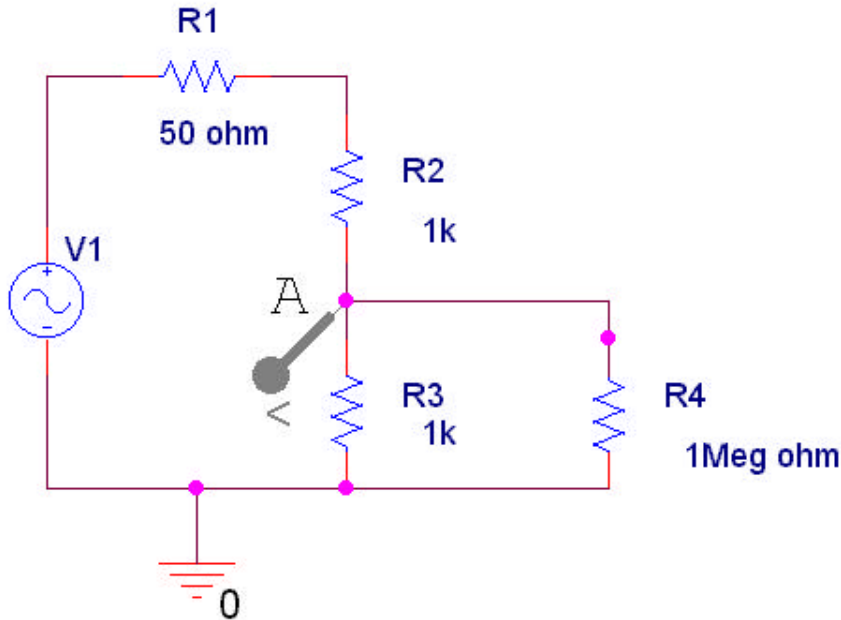
high pass filter      low pass filter      ***band pass filter***          band reject filter

**5. Capture/PSpice (20 points)**

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



a) (6 points) What does this circuit do? What do R1, R2, R3 and R4 represent?

> *The circuit is a voltage divider with the function generator as source and a measuring device attached to the second resistor.  R1 is the impedance of the function generator, R2 and R3 are the resistors in the voltage divider, and R4 is the impedance of the measuring device (DMM or 'scope).*

b) (3 points) Suppose V1 has a frequency of 0.5K Hz, an amplitude of 200mV, 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.)
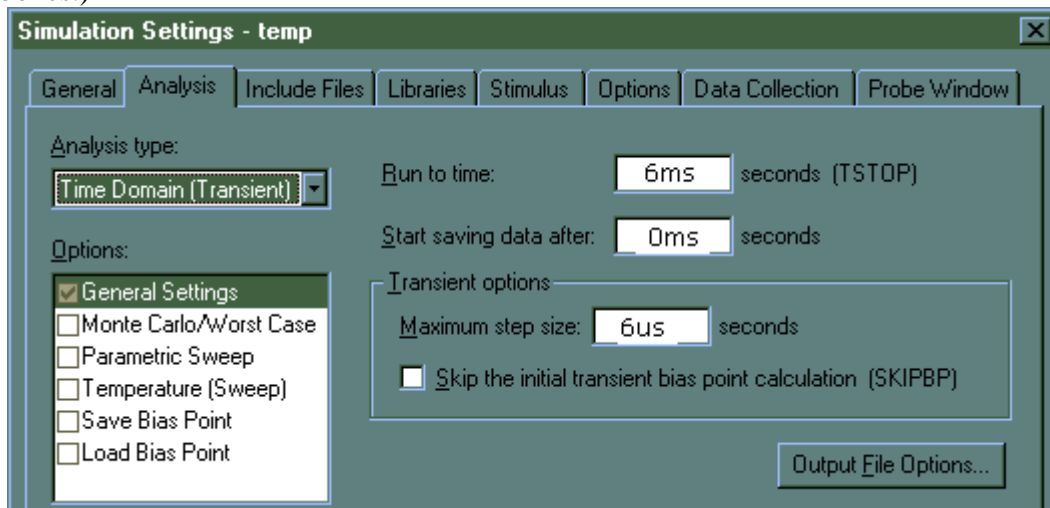
*Notes on b): Anything is acceptable for run time and start time as long as the difference is 6ms (3x1/500).  The maximum step size should be somewhere in the range from about 0.06ms (100 points) to 6us (1000 points).*

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

**_f = 0.5 Hz   V$_A$ = 100mV_**

d) (5 points) 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 point A?

*The resistance of the new resistor is 30 x 100 = 3K ohms.*
*VR3 = V1xR3/(R2+R3) = 200x1K/(1K+3K) = 50mV*
*The frequency will not change.*

**_f = 0.5 Hz   V$_A$ = 50mV_**

e)  (3 points) In experiment 2, you added a capacitor to a circuit in order to create a filter. We have added a capacitor to the circuit in this question.
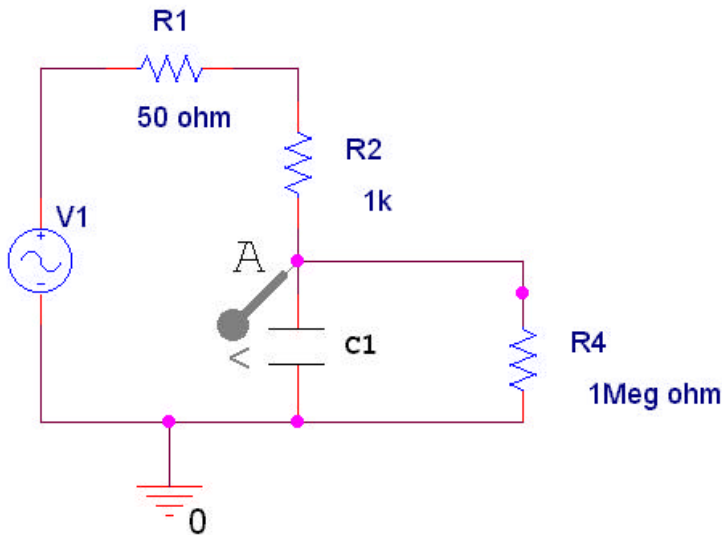


What type of analysis (simulation) would you have to run to determine if this altered circuit is a high or low pass filter? (Circle the best answer.)

Transient          DC sweep          ***AC sweep***          Bias Point

Extra credit (1 point):  What type of filter is it (at point A) and why?

**_It is a low pass filter._**  *At low frequencies, the capacitor is open, A is equal to V1. At high frequencies, the capacitor is closed, A is attached to ground.*