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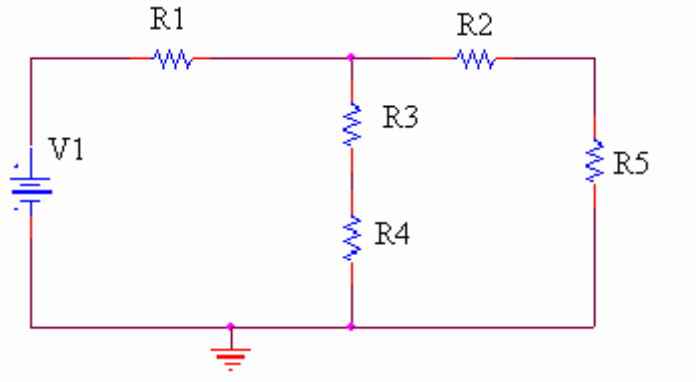
1. Resistive circuits (20 points)



Given: V1=5 volts. R1= 50Ω, R2= 1500Ω, R3= 2000Ω, R4= 680Ω, R5=430Ω

a) (8 points) Find the combined resistance of the circuit including resistors R1 to R5.

R_3 and R_4 are in series.
R_2 and R_5 are in series.
Branch containing R_3 and R_4 is in parallel with branch containing R_2 and R_5.
R_1 is in series with the equivalent resistance of the two branches.

$$R_{eq} = R_1 + (\frac{1}{R_3 + R_4} + \frac{1}{R_2 + R_5})^{-1}$$

$$R_{eq} = 1172\Omega$$

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

Use voltage division to determine voltage across R_1

$$V_{R1} = \frac{R_1}{R_{eq}} \cdot V_1$$

$$V_{R1} = 0.213V$$

Or find the current through R_1 and then find the voltage across R_1 using Ohms's Law
Let I_1 = current through R_1.

$$I_1 = \frac{V_1}{R_{eq}}$$

$$V_{R1} = I_1 \cdot R_1 = \frac{V_1}{R_{eq}} \cdot R_1$$

c) (8 points) Find the current through R5.

Let V_2 = Voltage of the node connecting R_2 and R_3 relative to the ground.
By Kirchoff's Voltage Law and then determining the current through R_5, I_5, using Ohm's Law.

$$V_2 = V_1 - V_{R1} = 4.787V$$

$$I_5 = \frac{V_2}{R_2 + R_5} = 0.00248A = 2.48mA$$

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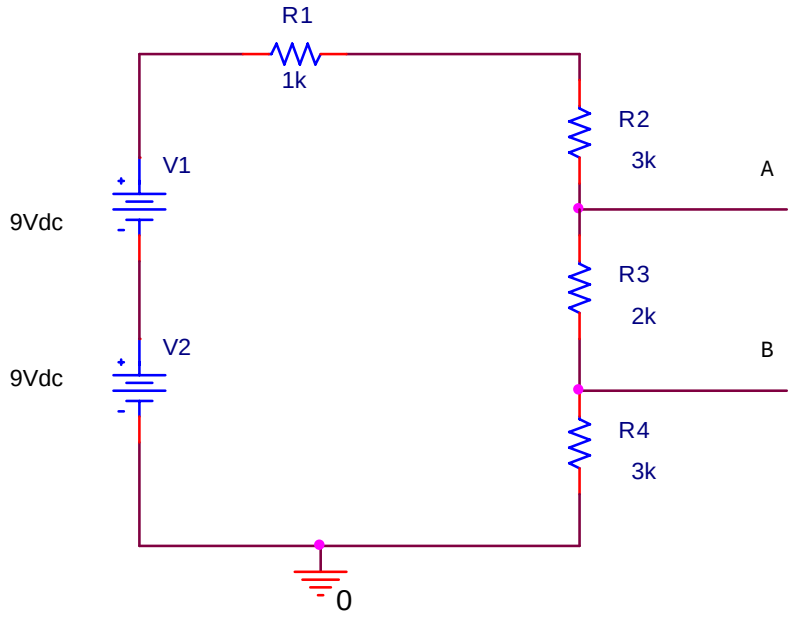
2. Thevenin circuits (20 points)



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

b) (6 points) Find the Thevenin resistance.

c) (4 points) Draw the Thevinen equivalent circuit with a load of 2k ohms.

d) (4 points) Find the voltage between A and B for this circuit with a load of 2k ohms.

Vtotal	V1	V2	R1	R2	R3	R4	Rtotal	I	Rload
	18	9	9	1000	3000	2000	3000	9000	0.002	2000

Voc	Rth	Vload
4	1555.556	2.25

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3. Instrumentation and Sine Waves (20 points)

You follow this procedure using the Mobile Studio IOBoard and the Mobile Studio Desktop software:

1) Plug in the IOBoard and Open the Mobile Studio Desktop
2) Open the Oscilloscope and Function Generators on the Desktop
3) Connect a wire from AWG1 to A1+
4) Connect a wire from the AWG1 GND to the A1 GND and to A1-
5) Adjust Channel 1 of the Function Generator to 2kHz
6) Adjust the Pk-Pk Voltage of Channel 1 to 0.4V
7) Adjust the DC Offset of Channel 1 to 0.2V
8) In the Channel 1 Window of the Oscilloscope, adjust the Volts/Div to 200mV, Coupling to DC and Input to A1 SE.
9) In the Horizontal Window adjust the Time/Div to 200 μs and the Mode to Y-T.
10) Adjust the vertical position for Channel 1 on the 'scope until it lines up with the horizontal axis on the display
11) Click the Start button and set the Trigger to Channel 1, Rising, and Trigger Level to 50%

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

i) the frequency (f)

ii) the angular frequency (ω)

iii) the period (T)

iv) the peak-to-peak voltage ($V_{p\text{-}p}$)

v) the amplitude (A)

vi) the DC offset voltage (V_{dc})

vii) the rms voltage (V_{rms})

vii) the phase (φ)

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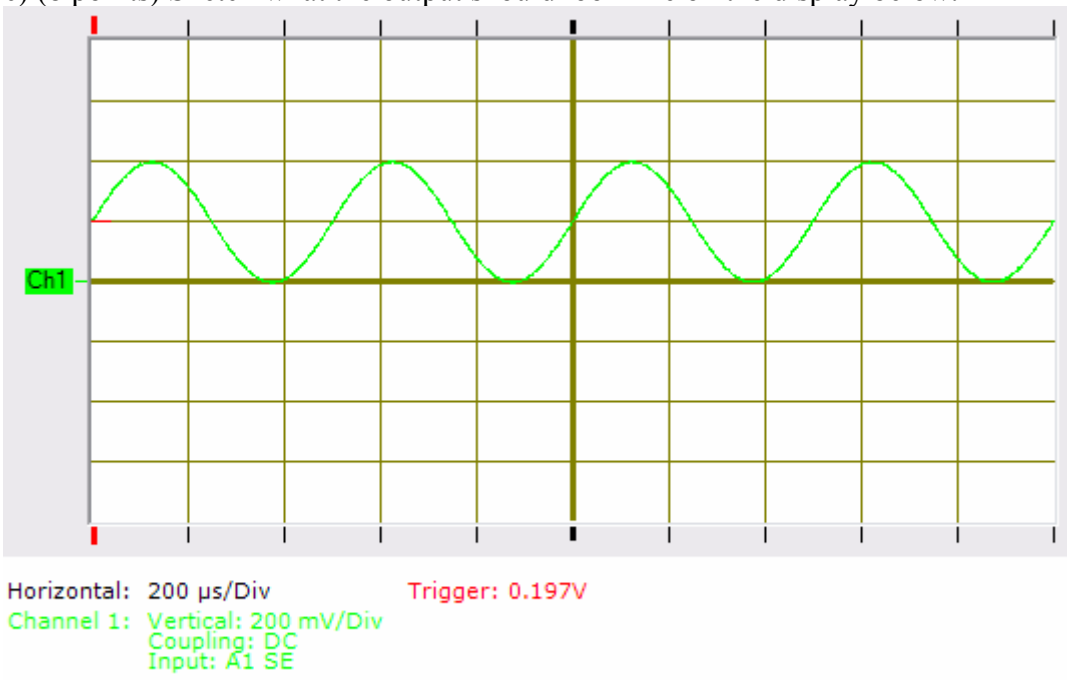
1frequency	2000Hz		**1 points**
2w=2*pi*f	12566.37061rad/sec		**1 points**
3period	1/f	0.0005sec	**1 points**
4Vp-p		0.4V	**1 points**
5amplitude	(Vp-p)/2	0.2V	**1 points**
6offset		0.2V	**1 points**
7Vrms	(Vamp)/(sqrt(2)	0.14V	**1 points**
8phase	w*t_0	0	**1 points**
mathematical expression		0.2+0.2sin(12566t+0)	**2 points**

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

See table above.

c) (8 points) Sketch what the output should look like on the display below.



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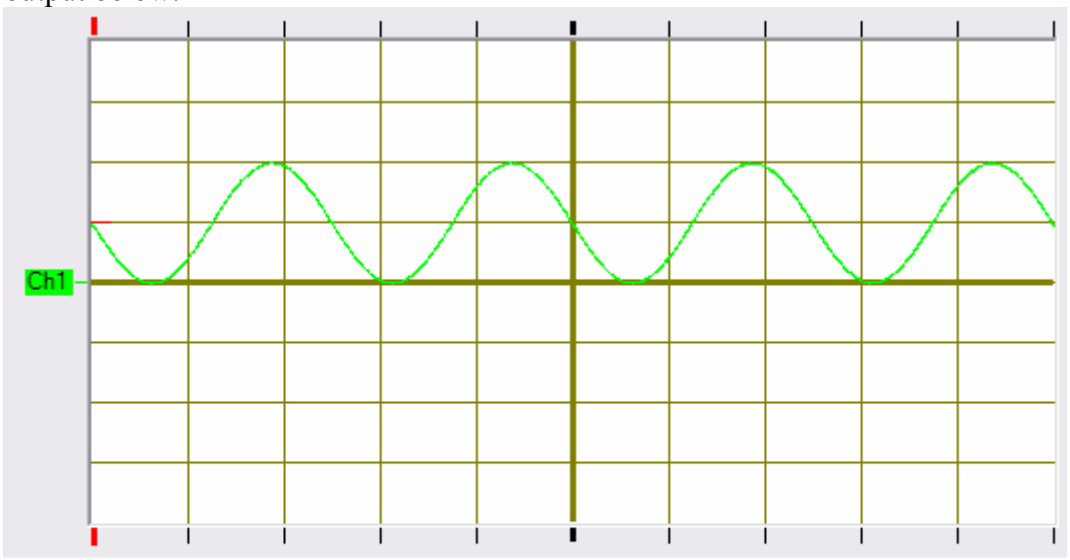
d) (2 points) Assume that the Trigger setting was changed to Falling. Sketch the resulting output below.



Horizontal: 200 µs/Div Trigger: 0.197V
Channel 1: Vertical: 200 mV/Div
Coupling: DC
Input: A1 SE

Things checked on plots :

	points
amplitude	**2 points**
offset	**2 points**
frequency	**2 points**
start (raise/fall)	**2 points**

last plot
main thing looked is whether the plot changed its characteristic (raise-fall)

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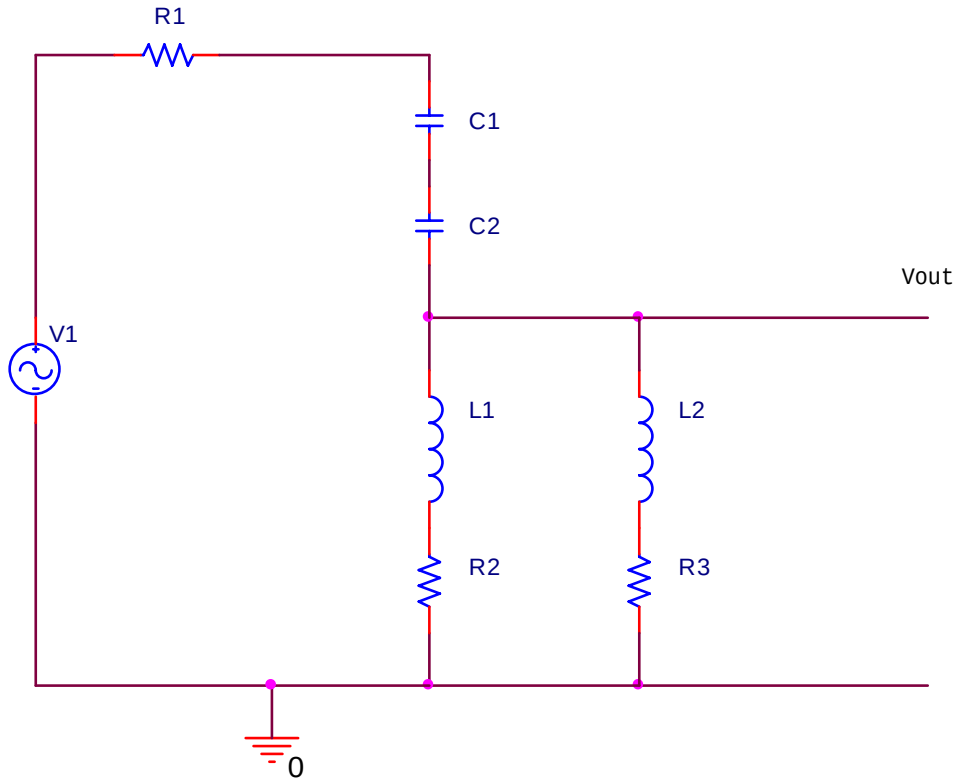
4. Inductance and capacitance at very high and very low frequencies (20 points)



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 the source (V1) frequency is very low.

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 the source (V1) frequency is very high.

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

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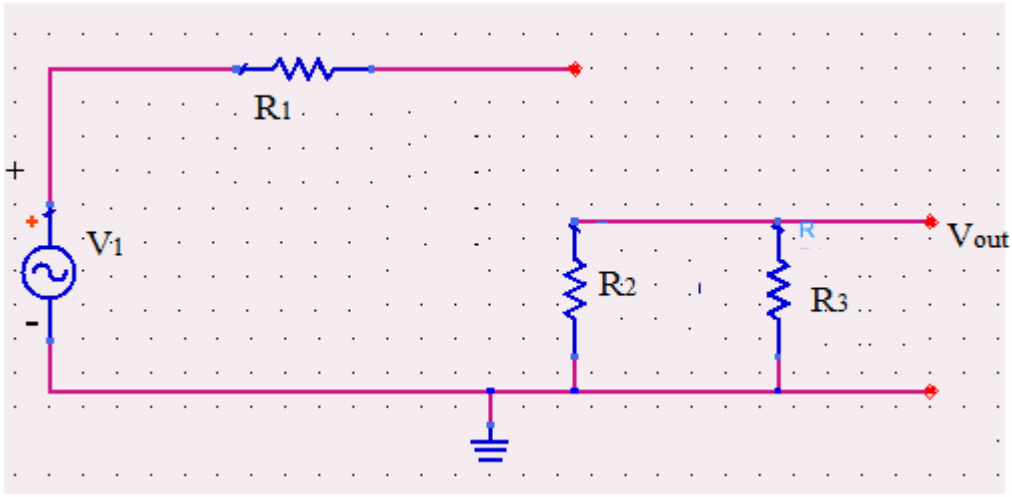
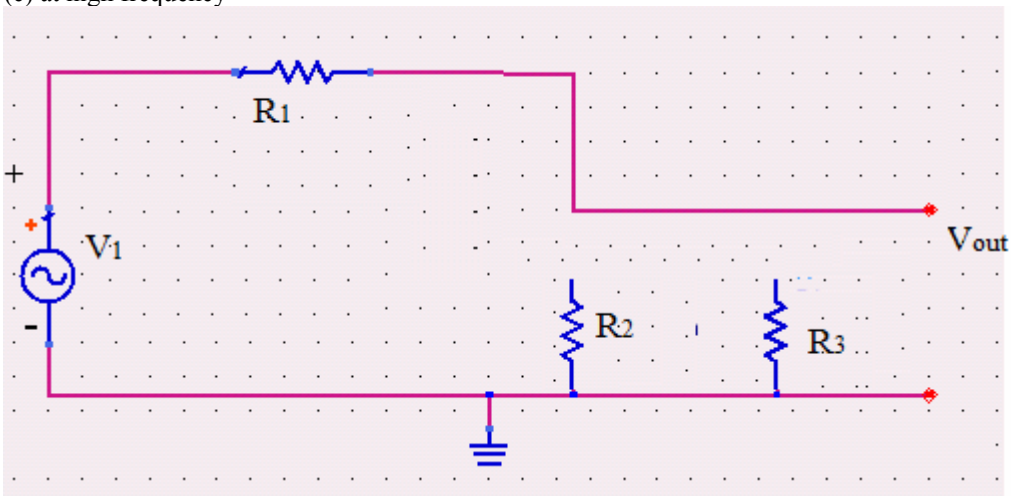
(a) at low frequency



(b) Vout =0

(c) at high frequency



(d) Vout = V1

(e) High pass

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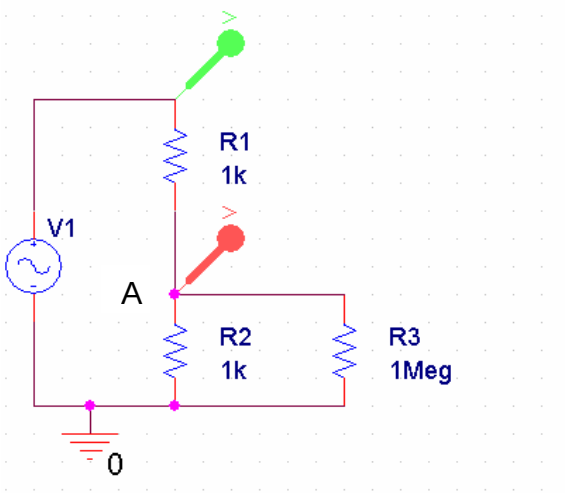
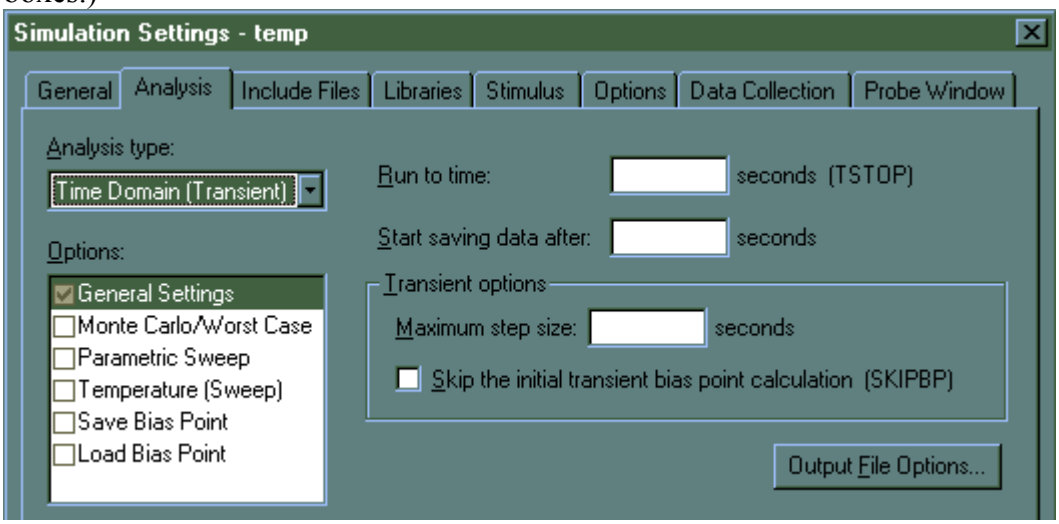
5. Capture/PSpice (20 points)

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 V1, R1, R2, and R3 represent?

b) (3 points) Suppose V1 has a frequency of 400 Hz, an amplitude of 3V, 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.)



You can put your answers here for clarity:

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

d) (5 points) If you replaced R2 with a resistor with color code green-black-brown-gold, what would be the frequency (in Hz) and the approximate amplitude (in V) of the signal at point A?

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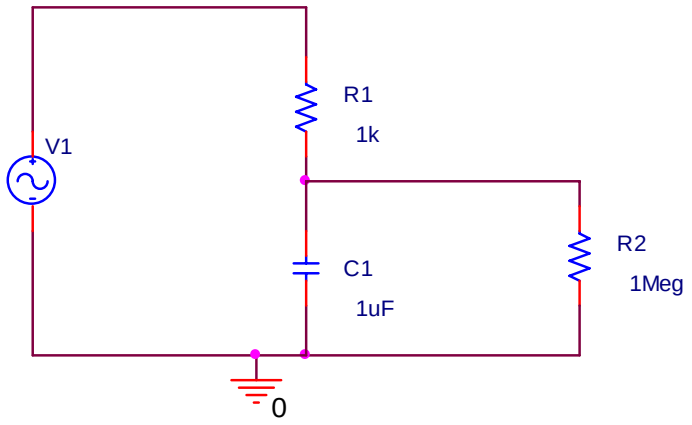
e) (3 points) In experiment 2, you added a capacitor to a circuit in order to create a filter. We have added a capacitor to the circuit in this question.



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 and why?

Voltage divider
V1 is source, R1 and R2 are divider resistors, 1Meg is scope or some other measuring device
Freq 400
Period 0.0025
Four cycles 0.01 Three cycles 0.0075
Start at t=0
Use four cycles/1000 for time step Use three cycles/1000 for time step
At pt A half the voltage, same frequency
Figure out the color code and then do new divider
AC Sweep would be good
Low pass filter

Note that an answer is provided for both 4 and 3 cycles because one ends up looking neater than the other.