ENGR-4300

Electronic Instrumentation

Quiz 2

Fall 2011

Name __________________________

Section ___

Question I (20 points) ____________

Question II (20 points) ____________

Question III (20 points) ____________

Question IV (20 points) ____________

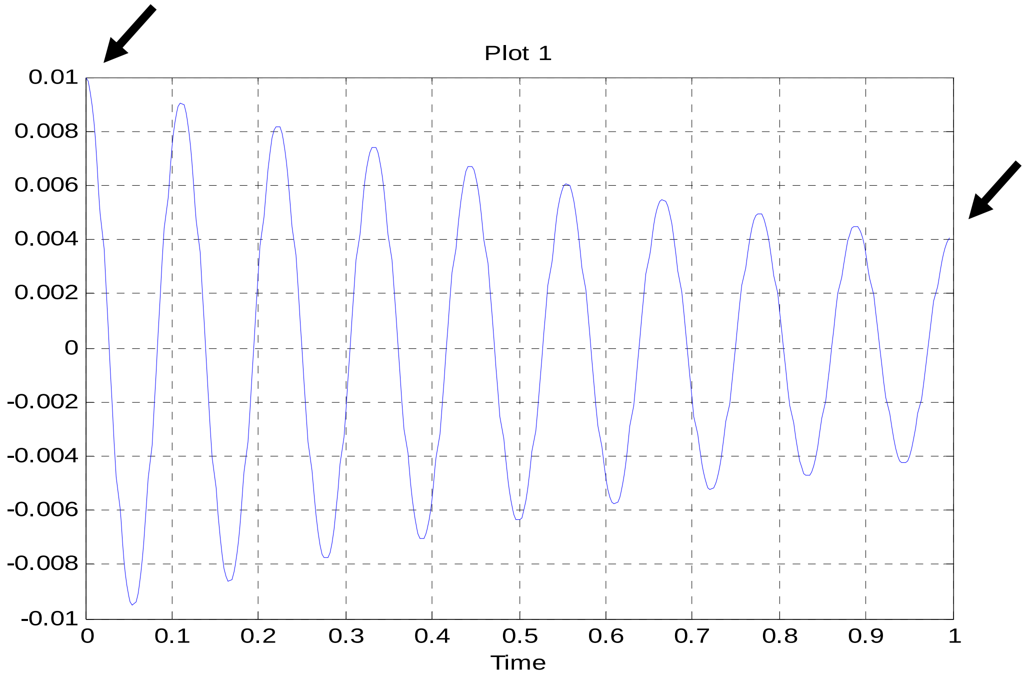
Question V (20 points) ____________

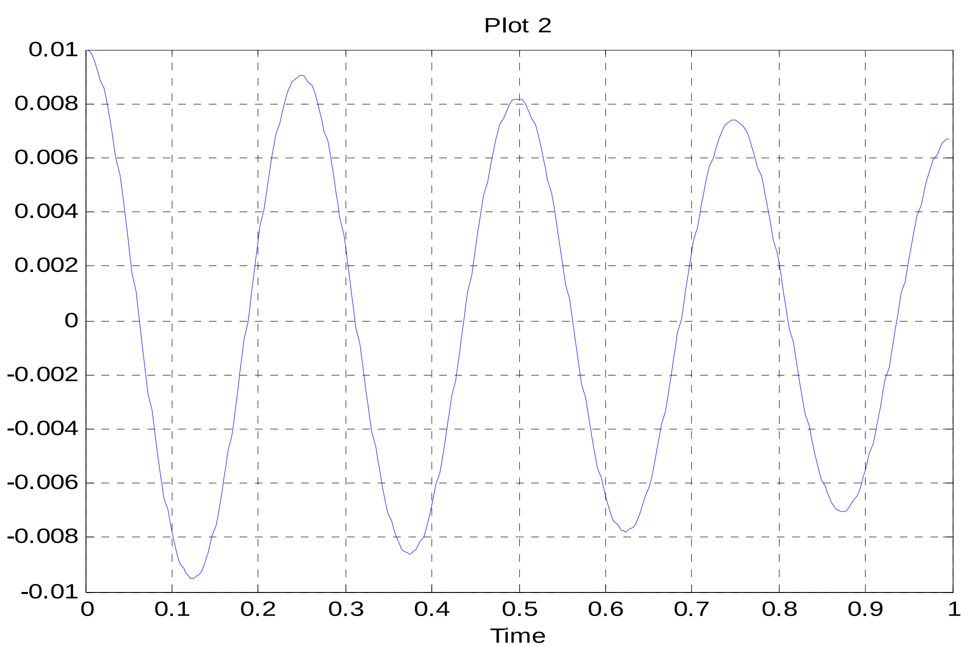
Total (100 points) _______________

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 – Bridges and Damped Sinusoids (20 points)

You are given a cantilever beam similar to the one you used in experiment 4. You place two weights on the end of the beam one at a time (0.138 kg and 0.86 kg) and you get the following two plots (may not be in order of mass listed).





Question I – Bridges and Damped Sinusoids (continued)

1) (2pt) What is the frequency of plot 1? (Use at least 2 significant figures)

9 cycles in 1 second = 9.0Hz

2) (2pt) What is the frequency of plot 2? (Use at least 3 significant figures)

4 cycles in 1 second = 4.00Hz

3) (6pt) What is the damping constant for plot 1, mark the points on the plot? (Use at least 3 significant figures)

The signal amplitude drops to 0.4 from 1 in 1 second. $e^{-\alpha 1} = 0.4$ *so that* $-\alpha = \log 0.4 = -0.916$ *where the two points are indicated with the arrows.*

The actual number used in the Matlab program that generates the curves was 0.9

4) (6pt) Given the following formula, $k = (m + m_n)(2\pi f_n)^2$, and assuming that the two data points that you found are ideal, find values for k and m.

$k = (m + m_n)(2\pi f_n)^2$ $k = (m + 0.138)(2\pi 9)^2$ $k = (m + 0.86)(2\pi 4)^2$

gives us k=570, m=0.04

Question I – Bridges and Damped Sinusoids (continued)

5) (2pt) What is the mass of the beam?

$$m_b = \frac{0.04}{0.23} = 0.174kg$$

6) (2pt) Using the chart for Young's Modulus, determine the probable material that the beam is made out of given that the dimensions of the beam are: width = 1.5 cm, length=15 cm, and thickness = 2 mm.

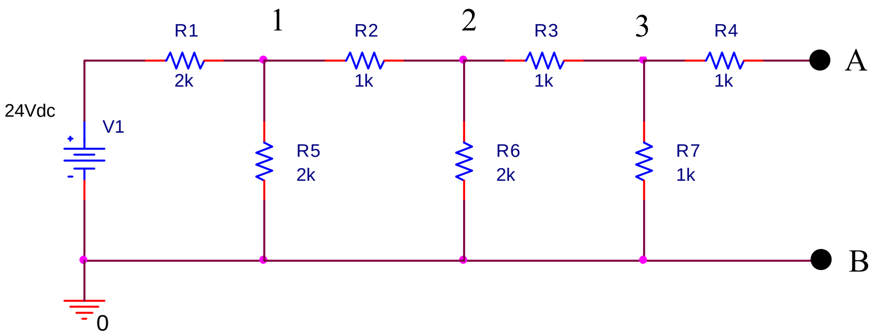
TABLE 9.1

Young's Modulus Table of Values

Metal	Elastic modulus (N/m2)	Metal	Elastic modulus (N/m2)
aluminum, 99.3%, rolled	6.96×10^{10}	lead, rolled	1.57×10^{10}
brass	9.02×10^{10}	platinum, pure, drawn	16.7×10^{10}
copper, wire, hard drawn	11.6×10^{10}	silver, hard drawn	7.75×10^{10}
gold, pure, hard drawn	7.85×10^{10}	steel, 0.38% C, annealed	20.0×10^{10}
iron, wrought	19.3×10^{10}	tungsten, drawn	35.5×10^{10}

$$k = 570 \quad w = 1.5cm \quad l = 15cm \quad t = 2mm \quad E = \frac{k4l^3}{wt^3} = 6.44x10^{10}\frac{N}{m^2} \quad aluminum$$

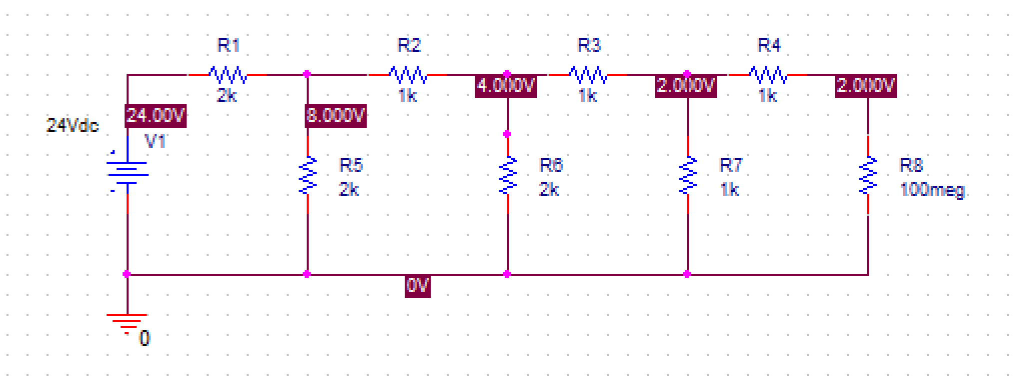
Question II – Thevenin Equivalents (20 points)



1) (7pt) Find the Thevenin equivalent voltage with respect to A and B for the circuit shown above)

For V_{th} there is no load (open circuit) so that there is no voltage drop across R4. To find the voltage from A to B, first find the voltages at points 1-3. Combine R3+R7=2k. Then R6||(R3+R7)=1k. Then R2+ R6||(R3+R7)=2k and finally R5||(R2+ R6||(R3+R7))=1k. Thus, V_1=8, V_2=4, V_3=2 are obtained from voltage divider formulas.

From PSpice

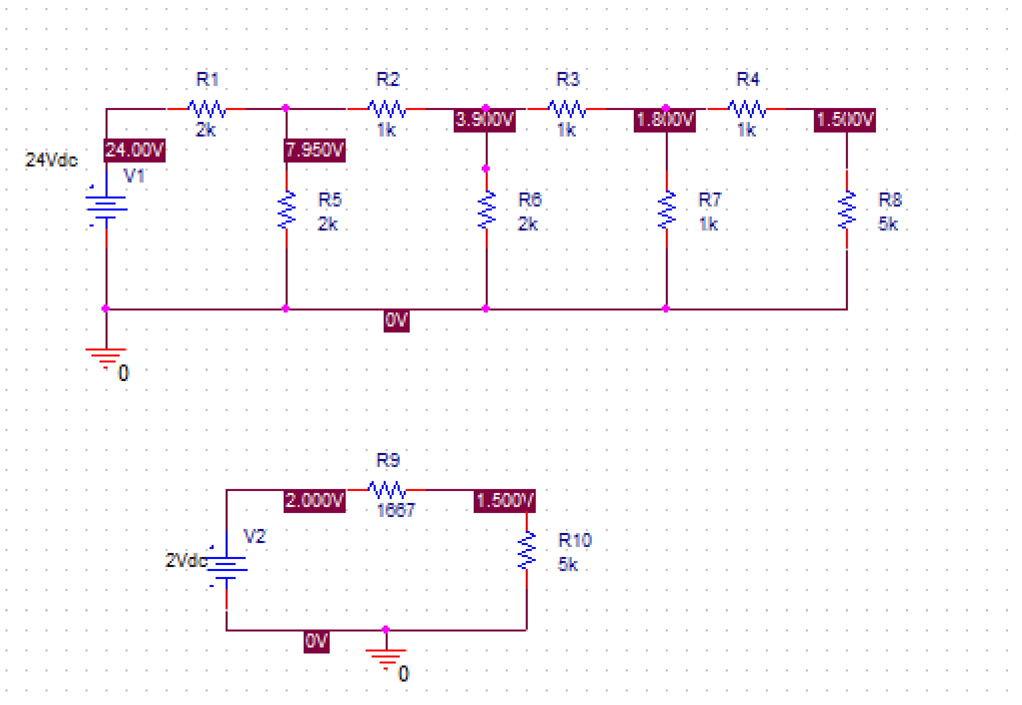


2) (6pt) Find the Thevenin equivalent resistance with respect to A and B for the circuit shown above.

Short out the voltage source. Then R_{th}=1k+1k||(1k+2k||(1k+2k||2k))=1k+1k||2k=1.67k

Question II – Thevenin Equivalents (continued)

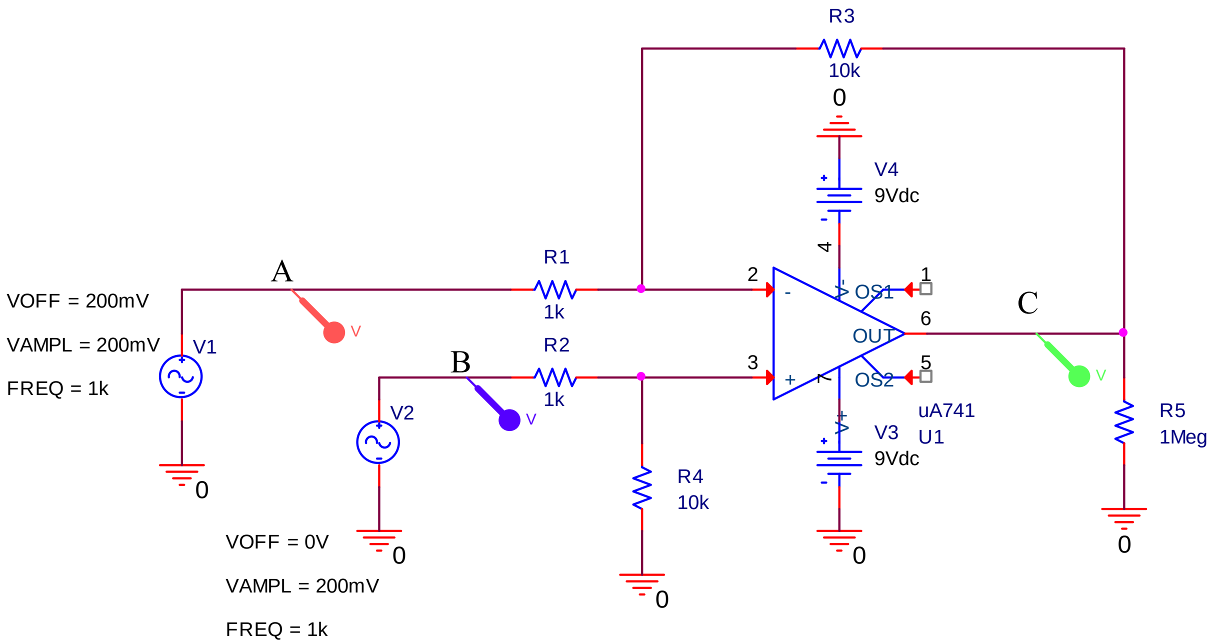
3) (5pt) Draw the Thevenin equivalent circuit with a load resistor RL of 5K between points A and B



4) (2pt) What is the voltage across R_L?

The voltage is 2(5/6.667)=1.5

Question III – Op-Amp Applications (20 points)



Assume the following components in the above circuit:

V1: V_{off}=200mV, V_{ampl}=200mV, f=1kHz; V2: V_{off}=0V, V_{ampl}=200mV, f=1kHz

R1=R2=1kΩ, R3=R4=10kΩ, R5=1MΩ

1) (1pt) The circuit above is an amplifier you've seen. What type of amplifier is it?

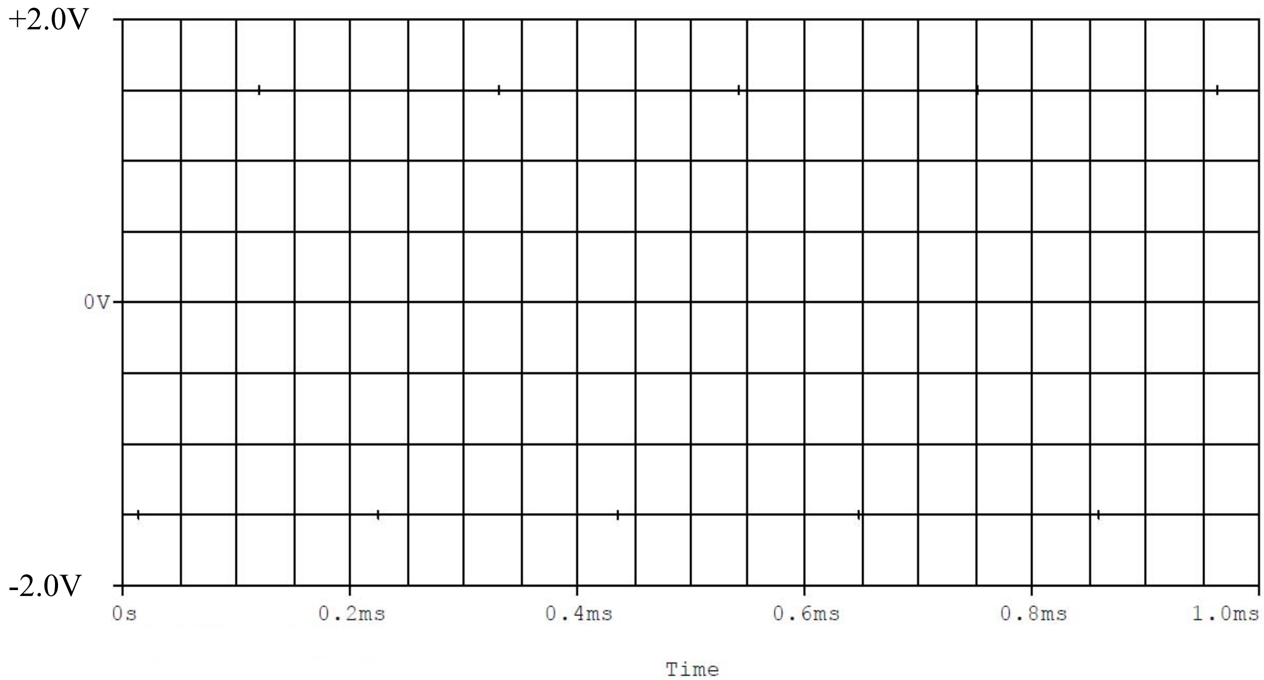
Differential Amp

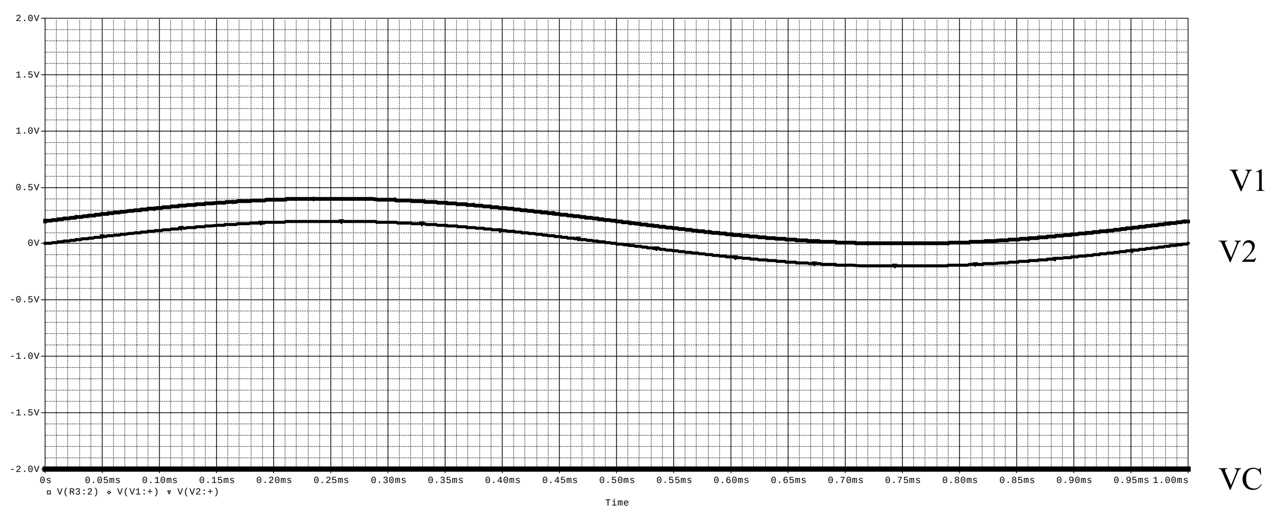
2) (3pt) Write the general equation for the output C (Vc) in terms of the input voltages V2 and V1. Simplify (Do not enter specific voltage values but use the values of the resistors)

$$V_C = V_2 \frac{R4}{R2} - V_1 \frac{R3}{R1} = 10(V_2 - V_1)$$

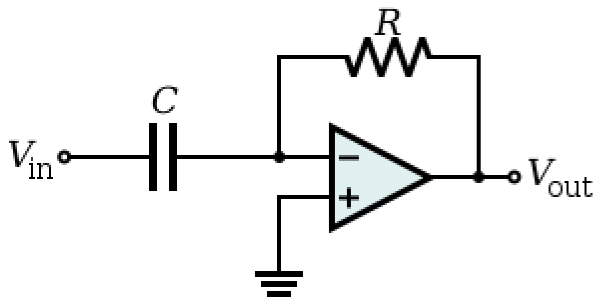
Question III – Op-Amp Applications (continued)

3) (16pt) Sketch and label one cycle of the input at V2 (point B), the input at V1 (point A) and the output at C (Vc) on the plot below





Question IV – Op-Amp Integrators and Differentiators (20 points)



1) (2pt) What function is this ideal circuit designed to perform?

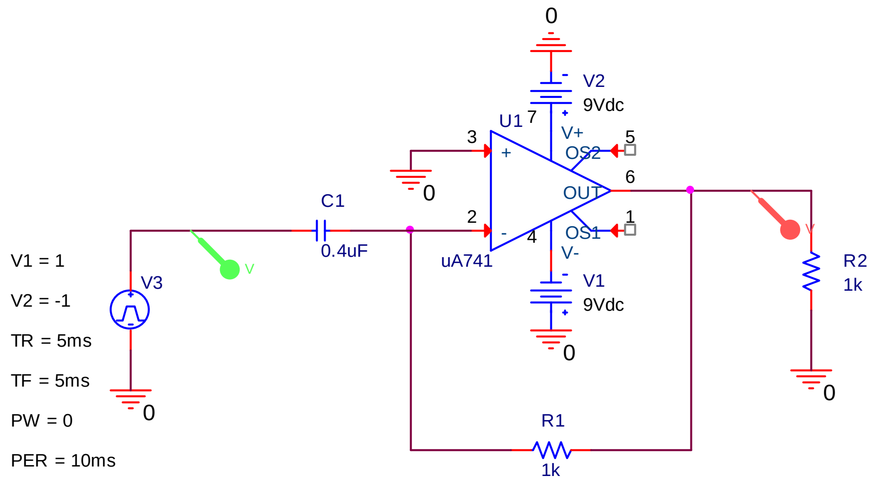
Differentiator

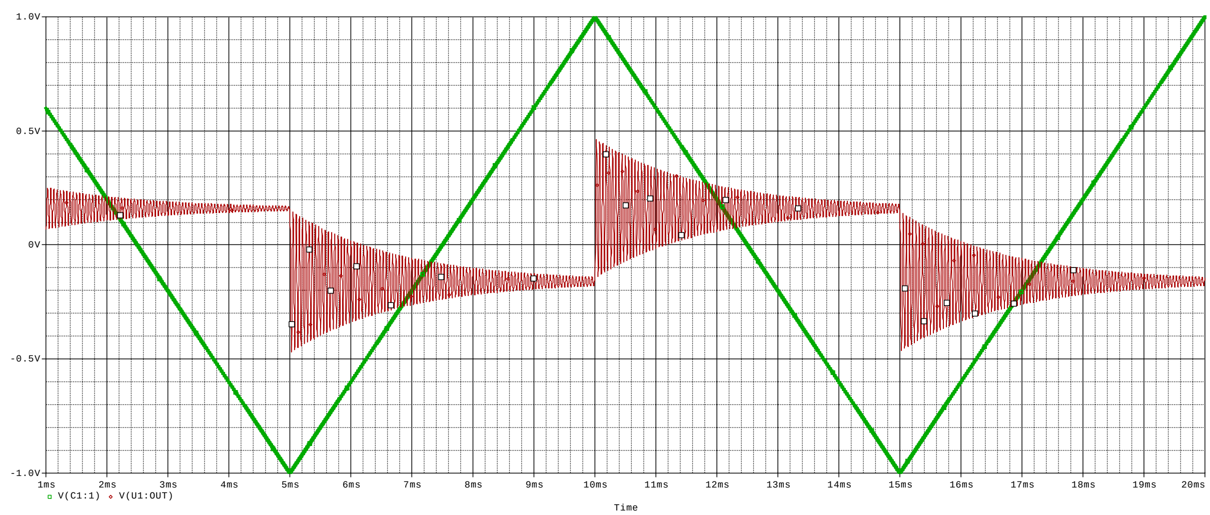
2) (2pt) Write the general, frequency dependent transfer function V_{out}/V_{in} for this circuit. Then substitute in the values R=1kΩ and C=0.4μF. Then write the expression for $V_{out}(t)$ in terms of $V_{in}(t)$ as a function of time. *Hint: use the formula sheet.*

$$\frac{V_{out}}{V_{in}} = -j\omega RC = -j\omega(0.0004) \quad V_{out} = -RC\frac{dV_{in}}{dt} = -0.0004\frac{dV_{in}}{dt}$$

3) (4pt) Based on the transfer function in time, determine the output voltage for the input shown below. Plot the output. *Slope is 2/(5ms)=400. RC times the derivative is 0.16*

Up to this point, this question has addressed the ideal op-amp configuration. The usual next step in the investigation process is to do a PSpice simulation. The circuit and the simulation results are shown below.





20ms

It is possible to achieve results much more like those predicted by the ideal model if we add a capacitor C2 = 0.015μF in parallel with the 1kΩ feedback resistor. The remaining questions relate to the modified circuit.

4) (4pt) Write the general, frequency dependent transfer function V_{out}/V_{in} for this circuit.

$$\frac{V_{out}}{V_{in}} = -\frac{R\|C2}{1/j\omega C} = -\frac{\left(\dfrac{R}{1+j\omega RC2}\right)}{1/j\omega C} = -\frac{j\omega RC}{1+j\omega RC2}$$

5) (3pt) Find the corner frequency f_c for the circuit in Hz.

The corner frequency is where $\omega RC2 = 1$ *or* $f_c = \dfrac{1}{2\pi RC2} = \dfrac{1}{2\pi 10^3 4(10^{-7})} = 397\,Hz$

6) (3pt) For which frequencies will the circuit perform the desired function? *Explain.*

a. Low frequencies below ω_c

b. Only a mid band of frequencies around ω_c

c. High frequencies above ω_c

7) (2pt) Based on your answer to the previous question, simplify the transfer function for frequencies where the circuit performs the desired function. That is, simplify for low frequencies, high frequencies or frequencies near ω_c.

$\dfrac{V_{out}}{V_{in}} = -\dfrac{j\omega RC}{1 + j\omega RC2} = -j\omega RC$ *because the second term in the denominator is small enough to be neglected.*

Question V – Troubleshooting, Debugging (20 points)

Which of the following have been discovered while troubleshooting/debugging experimental and simulated circuits for some group in this class (1 pt each)?

1. 680kΩ resistors used instead of 680Ω resistors.
2. Connections to +4V and -4V reversed.
3. Large DC offset in signal not observed because the oscilloscope was set up for AC coupling rather than DC coupling.
4. Transistor or integrated circuit plugged in backwards.
5. No power to integrated circuit.

Identify and the following circuit components:

6. Component number one (3 pts). Also give its value.

Capacitor. Value is 47 times 10^4pF or 0.47μF

474

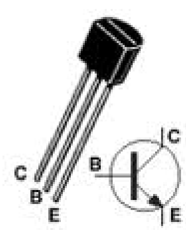
7. Component number two (3 pts). Also give its value.

Potentiometer. Value is 50 time 10^4 or 500kΩ

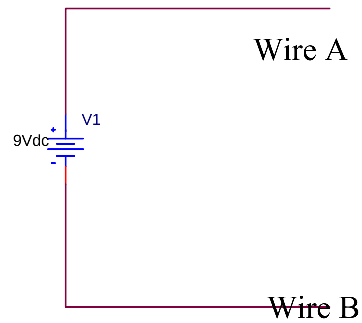
504

8. Component number three (3 pts).

Transistor



9. Power Supplies (3pts) Circle all correct answers.

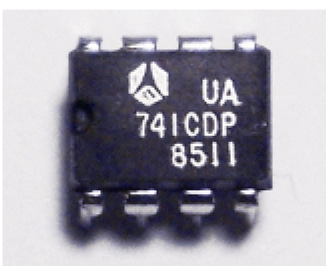


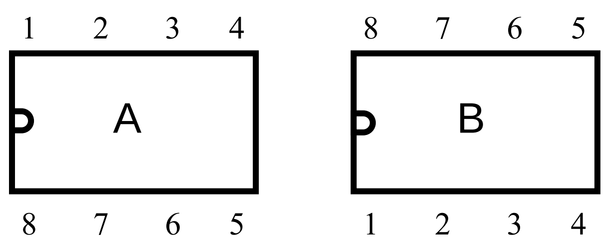
For a 9V battery connector (shown above) and the PSpice circuit diagram (above right)

- Wire A represents the red wire and Wire B represents the black wire
- Wire B represents the red wire and Wire A represents the black wire
- Wire A is connected to the circuit ground to provide +9V at some other point in a circuit
- Wire B is connected to the circuit ground to provide +9V at some other point in a circuit
- Wire A is connected to the circuit ground to provide -9V at some other point in a circuit
- Wire B is connected to the circuit ground to provide -9V at some other point in a circuit

10. 741 Op-Amp (3pts) Circle all correct answers.

Shown below is a photo of a 741 op-amp. The small dimple is at the left.





- The pins on the op-amp are numbered as shown in the figure labeled A
- The pins on the op-amp are numbered as shown in the figure labeled B
- The 741 requires a positive DC voltage (e.g. +9V) on pin 4 and a negative DC voltage (e.g. -9V) on pin 7 to operate
- The 741 requires a negative DC voltage (e.g. -9V) on pin 4 and a positive DC voltage (e.g. +9V) on pin 7 to operate
- The output signal is found on pin 6
- The output signal is found on pin 2
- The output signal is found on pin 3
- The input signal is connected to either pin 2 or pin 3