Homework #4 Solution

The feedback impedance = R = $Z_{feedback}$
The input impedance = RS + 1/(jωC) =Z_{in}

Then, V_{out} = -($Z_{feedback}$/Z_{in}) Vin

From page 111, to act like an ideal differentiator, V_{out} = -jωRC V_{in}

This is only true when RS << (1/ωC) or when ω << 1/(RS C)

Remember that ω = 2πf

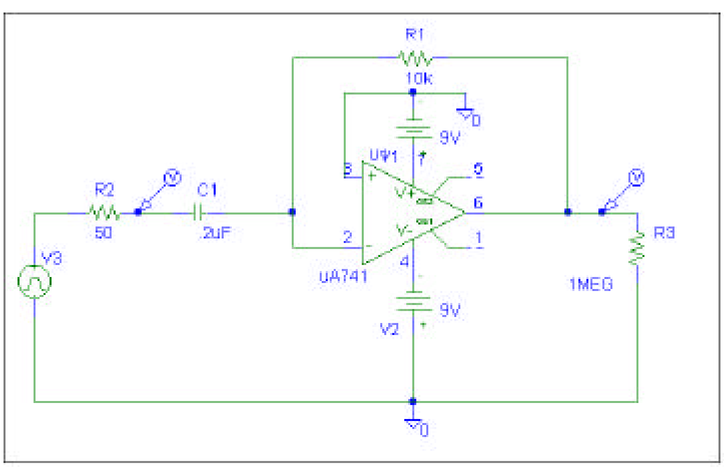
To select some component values and a frequency, we can use the values from problem 4 on last semester's Quiz 3.

C = 0.2μF, R = 10kΩ, RS = 50Ω

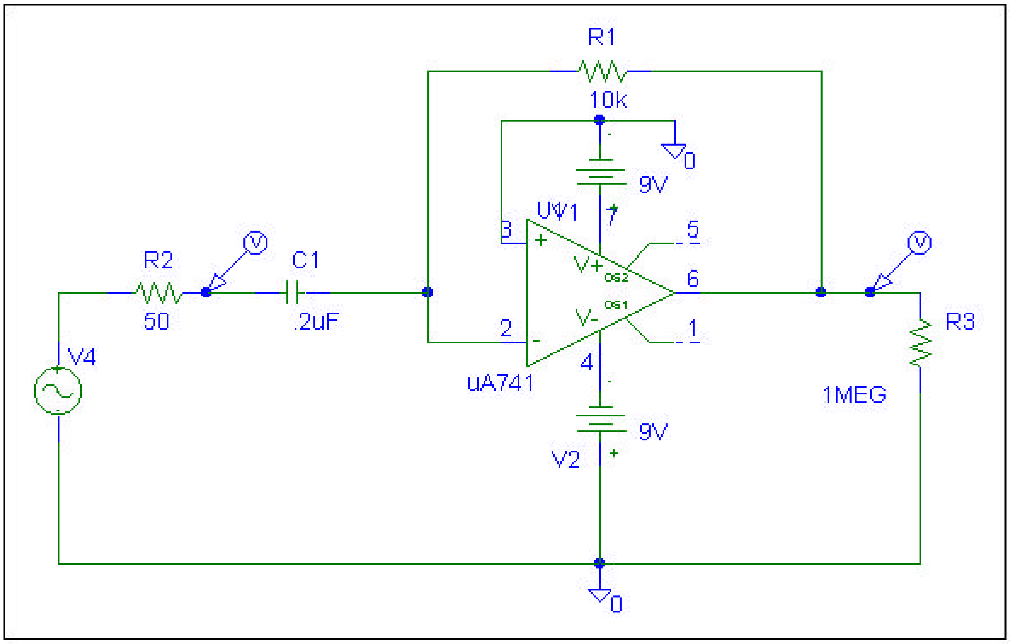
Then, RS C = 10 x 10^{-6} = 10^{-5}

f << 1/(2π10^{-5}) = 1.6 x 10^{4}
f = 1kHz should easily satisfy this inequality.

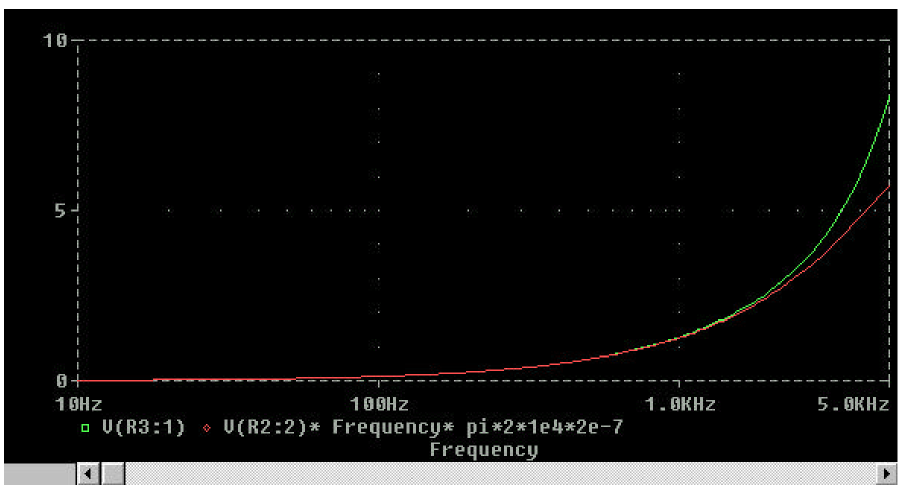
The circuit from Quiz 3 is shown below. We need to change to a sinusoidal source.



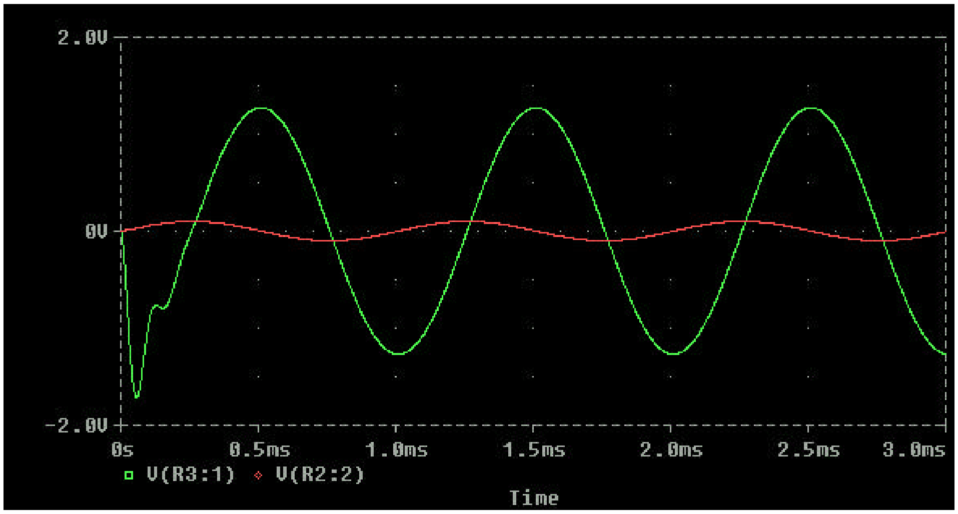
The new circuit and its probe outputs follow:



The only change to the circuit is the sinusoidal source rather than the pulse



source. The AC sweep shown demonstrates that the circuit works like a differentiator for frequencies above 1kHz, since essentially both sides of equation 6-20 are plotted. The transient analysis again shows the differentiator is working at 1kHz, since the output voltage is 90^{o} out of phase with the input.


2.0V
0V
-2.0V
0s
0.5ms
1.0ms
1.5ms
2.0ms
2.5ms
3.0ms
V(R3:1)
V(R2:2)
Time