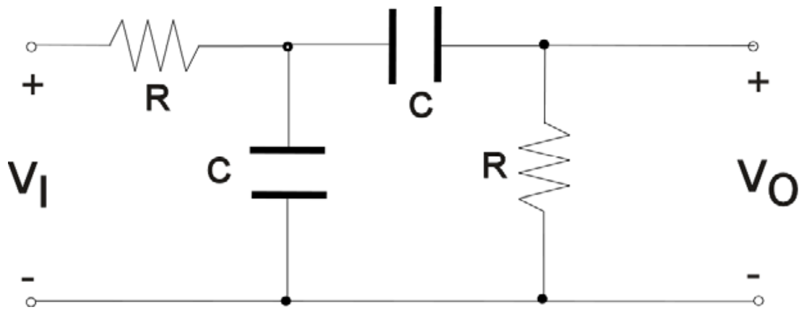
ENG 100
Pre-lab #3

For the 2^{nd}-order RC circuit shown below:



where:
R = 1500 Ω = 1.5 kΩ
C = 0.01 μF.

Analyze the circuit to find the transfer function $H(s) = V_O(s)/V_I(s)$ assuming V_I is connected to a sinusoidal voltage source. Calculate and plot the amplitude (in dB) versus frequency (in Hz) and the phase (in degrees) versus frequency (in Hz) of the transfer function. For the plots, use a log scale for the frequency axis. Calculate the amplitude and phase at the frequencies in the table at the end of this prelab, and fill in the 'calculated' data columns in the table.

<u>Bring the plots and your table of calculated values to lab with you</u>; you will be putting your measurements in the same table that contains your calculated values.

Matlab, Excel, Mathematica, etc. are all okay to use.

Hints:
The form of the following transfer function is a band-pass function:

$$H(s) = \frac{V_O(s)}{V_I(s)} = \frac{Ks}{s^2 + \left(\frac{\omega_o}{Q}\right)s + \omega_o^2}$$

where we have used $s = j\omega$.

For your transfer function at $f_0 = \omega_0/2\pi \approx 10$ kHz, the amplitude or magnitude of $H(j\omega)$ is 1/3 (or $20 \log |H(j\omega)| = -9.54$ dB) and the phase [the angle of $H(j\omega)$] is about zero degrees.

f (Hz)	$\omega=2\pi f$ (rad/s)	Calculated $\lvert H(j\omega)\rvert$	Calc. $\lvert H\rvert$ (dB)	Calc. phase = ang(H) (deg)	Calc. delay t_d (sec)	Measured ampl. of V_I (Vpp)	Measured ampl. of V_O (Vpp)	Measured delay t_d (sec)	$\lvert H\rvert$ (dB) [from measured amplitudes]	Phase = ang(H) (deg) [from measured t_d]
100										
178										
316										
562										
1,000										
1,780										
3,160										
5,620										
10 000										
17,800										
31,600										
56,200										
100,000										
178,000										
316,000										
562,000										
1,000,000										

Fill in the left portion of the above table with calculated values; you should do this before your lab period.

Calculate the phase from methods given in class, then calculate delay, t_d, using the formula t_d = phase / (–360° · f).

Example: If the expected phase at 17800 Hz is –23°, then the expected delay is –23° / (–360° · 17800 Hz) = 3.59 μs.

Example: If the expected phase at 3160 Hz is +61°, then the expected delay is +61° / (–360° · 3160 Hz) = –53.6 μs.

Notice that a positive phase (an "advance" in phase) results in a <u>negative</u> delay!

When you get to lab, measure and then fill in the "Measured" columns with your measurements, then calculate the last two columns.

Using the measured delay, calculate phase shift using the formula: phase (deg) = –360° · f · t_d.

Plot your amplitude in dB vs. f (Hz), **not** vs. ω (radians/s). Plot your phase in degrees (°) vs. f (Hz), **not** vs. ω.

Updated 1/3/2015