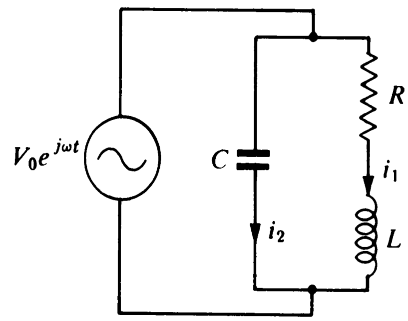
Physics 4700 HOMEWORK III

Due Oct 11

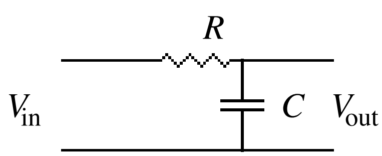
Note: 1 MHz given below refers to the frequency, not angular frequency ω.

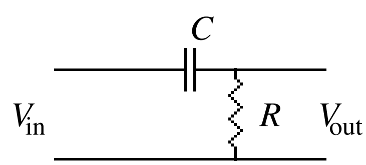
1. Design a LC parallel circuit or tank to resonate at 1 MHz. Assume the inductance L = 100 μH and has a DC resistance of 10 Ω. What is the Q of this circuit at resonance?



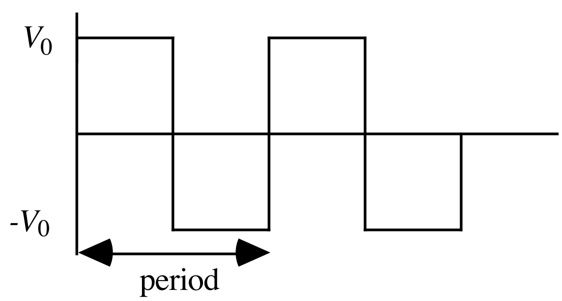
Note: For a given RC filter how does gain vs. frequency plot look for different T? Charging and discharging of the capacitor depends on the frequency of the input. The output is not always a square wave.

2. Consider the following two circuits.



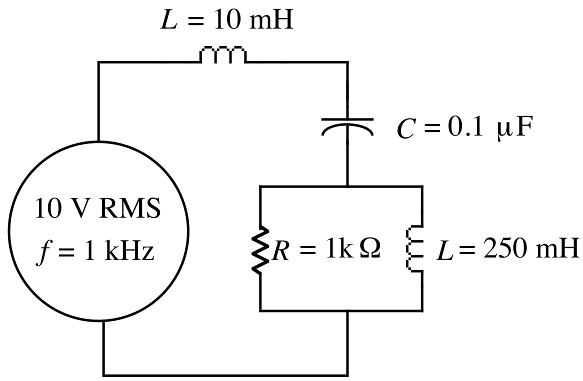


The input voltage looks like:



Plot the output voltage for $RC = T/20$, $T/2$, $20T$, where T = period, for both circuits (6 plots in all). Of the six cases which output is most like integration, and which is most like differentiation of the input signal?

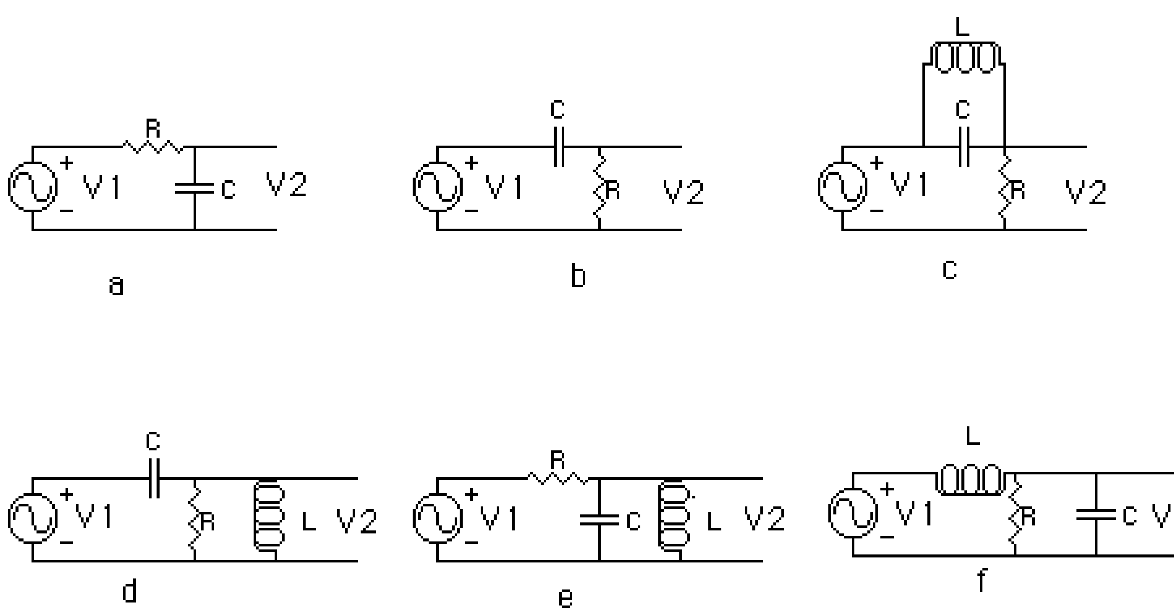
3. Show that the RMS current in the 1 kΩ resistor is 6.5 mA. If the AC voltage source was replaced by a battery, what would the current in the resistor be?

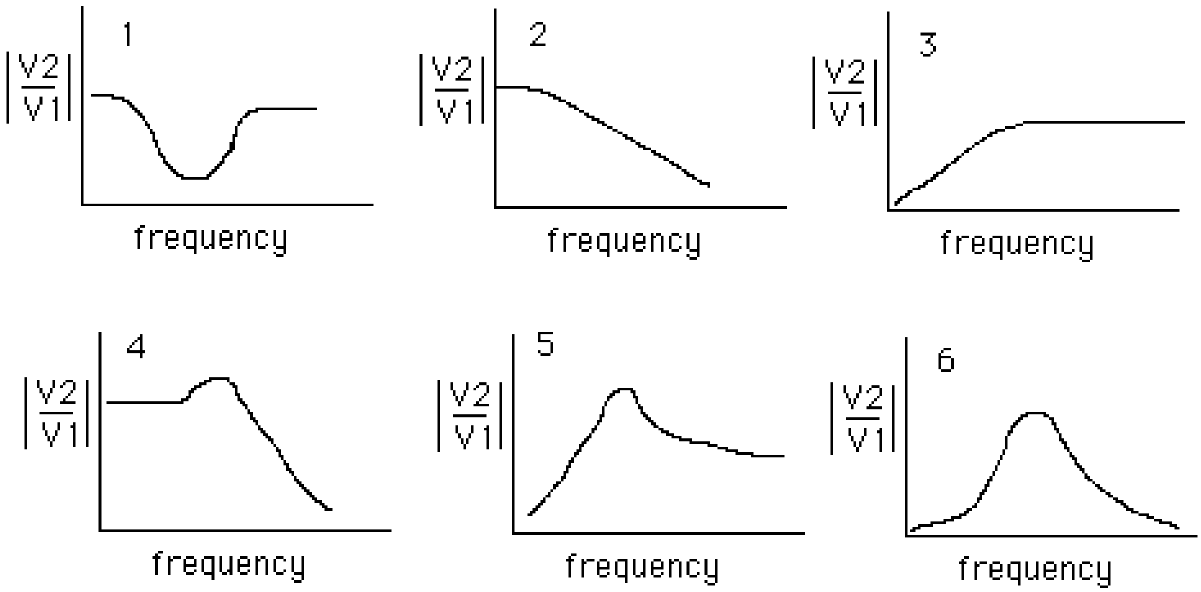


4. We want to design a tuner (actually a band pass filter) for an AM radio station whose frequency is $f = 700$ kHz. The tuner must be able to detect the AM sidebands which are located at ±5 kHz (695 kHz and 705 kHz) from the central frequency. An easy way to achieve the above is to use a series RLC circuit and take V_R for the output voltage. The resonant frequency of this circuit is that of the radio station. The rest of the circuit parameters are fixed by matching the 3 dB points of the circuit to the upper and lower sidebands. Calculate the value of R and L necessary for the above circuit if $C = 300$ pF.

Note: Understand how the impedance of capacitor and inductor changes with frequency.

5. For each of the following circuits identify the corresponding magnitude Bode plot. For most of the cases the Bode plot can be identified by considering the limits $\omega \to 0$ and $\omega \to \infty$.





Note: Solve for the magnitude of $V2/V1$ and verify with Mathematica.

6. For each of the six circuits in problem 5), find an expression for the gain $|V_2/V_1|$ in terms of R, L, and C.