[rlc circuits] .problems

1) Pieter van Musschenbroek connects his capacitor with capacitance $C = 2.2$ mF to a battery with emf $\mathcal{E} = 4.0$ V and a resistor $R = 20$ kΩ in series. The capacitor was free of charge before connecting the circuit, at time $t = 0$.
a) Calculate the time constant, τ.
b) Draw a qualitative graph for capacitor voltage, $V_C(t)$, and resistor voltage, $V_R(t)$, versus time.
c) How long it takes for the capacitor to get charged with $Q = 4.4$ mC?

2) Felix Savary uses the same setup that we had in 'RLC Circuits' lab, part B, (R and L and C in series connected to a battery) and measures the current I (or voltage V_R) versus time as shown in fig. 1. He knows $R = 100\Omega$ and wants to find L and C. These are his measurements for two consecutive peaks:

$t_1 = 0.63$ ms
$t_2 = 1.13$ ms
$I_1 = 4.4$ mA
$I_2 = 2.8$ mA

a) Write an equation for L and C using t_1 and t_2.
b) Find the time constant, τ, using the values I_1, I_2, t_1, t_2.
c) Find L and C, using previous parts.

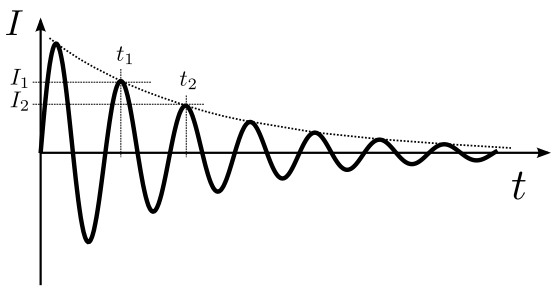

Figure 1: A series RLC circuit's current vs time.

3) Consider a series RLC circuit connected to a battery with voltage $\mathcal{E}$. The initial charge on the capacitor and the initial current are zero.

a) Find $\mathrm{d}I/\mathrm{d}t(t = 0)$.
b) If at a time $t = t_1$, the charge on the capacitor is $Q(t_1)$ and the current is changing with rate $\mathrm{d}I/\mathrm{d}t(t_1)$, determine $I(t_1)$.
c) What are the values of $Q, I, \dot{I}$ when $t \to \infty$?

4) Low-Pass, Band-Pass, & High-Pass Filters
Consider a series RLC circuit connected to an ac source, with voltage amplitude V and angular frequency ω. We want to understand the behavior of voltage across the capacitance, the resistance, and the inductance in different angular frequencies. If you use these voltages as an output, you can have a low-pass, band-pass, or high-pass filter, respectively.

a) Find the total impedance of the circuit.
b) Find V_C, V_R, and V_L, and show them in a phasor diagram.
c) Now draw the graph of these voltages in terms of frequency. To do that first find their values at $\omega = 0$ and $\omega \to \infty$.
d) For current or V_R there is a maximum point which is called resonance point. Find the frequency of this maximum point.