Pre-Semester 2010 - Physics Course - Extra Tutorial

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1. RC-Circuit

Consider a capacitor C which is connected in series to two parallel connected resistors R_1 and R_2. Initially, the charge Q on (one of) the capacitor's plate, is $Q(t = 0) = Q_0$.

(a) Find the charge $Q(t)$ in the capacitor as a function of time t if initially it is $Q(t = 0) = Q_0$. What is the time constant τ?

(b) What is the initial (total) current I_0 through the resistors? What is the initial voltage U_0 across the capacitor?

(c) If after time $t_{1/2} = 20.79 \, \text{ms}$ the charge Q has dropped to 50% of its initial value, what is τ?

(d) In the situation of (1c): What is R_1 if $R_2 = R_1$, $Q_0 = 0.3 \, \text{C}$ and $U_0 = 200 \, \text{V}$?

2. LR-Circuit

Consider a coil with inductance L and a resistor R connected in series. Assume that for $t < 0$ they were additionally connected in series to a voltage source with voltage U_0 driving a stationary current I_0. At $t = 0$ the voltage source is removed.

(a) What is I_0 (in terms L, R, and U_0)?

(b) Find the current $I(t)$ through the resistor as a function of time t. What is the time constant τ?

(c) What is the voltage drop $U_R(t)$ across the resistor at time t?

(d) Sketch $U_R(t)$ and mark U_0 and τ in the diagram.

3. LC-Circuit

A parallel-plate capacitor with capacitance C, which has been charged by a voltage U_0, is connected at $t = 0$ to an ideal coil with inductance L. No voltage sources are present (hence, the initial current is $I(t = 0) = 0$).

(a) What is the maximal charge Q_0 in the capacitor?

(b) Give the charge $Q(t)$ in the capacitor as a function of time t.

(c) What is the maximal current I_0 and at what time t_0 is it reached, $|I(t_0)| = I_0$, the first time?

(d) Sketch $Q(t)$ as well as the current $I(t) = \dot{Q}(t)$ and mark Q_0, I_0, t_0 and the period T in the diagrams.

(e) Assume that, in case the capacitor is empty, current oscillates with frequency $f_0 = T^{-1} = 80 \, \text{kHz}$. What would be the frequency f_r in case the capacitor is filled with a dielectric material with relative permittivity $\epsilon_r = 16$?

(f) Assume now that a resistor is connected in series to L and C. Give a *qualitative* sketch of $I(t)$ for this case. (Do not calculate anything!)