Universität Leipzig, Fakultät für Physik und Geowissenschaften

Exercises for Experimental Physics 3 – IPSP

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Exercise Sheet 4 (WS 2012/13)

Date of Issue to Students: Nov. 2nd 2012

Date of Submission: Nov. 9th 2012

Submission Place: Marked mailbox next to room 302 (Linnestr. 5)
Submission Time: 11:00 a.m. at the submission day noted above

Please note: Write your name and matriculation number on EACH sheet of paper.
Only submit the calculations and results for exercise 1-3, exercise 4 will be discussed during the instruction classes.

Exercises:

1. Plot the circuit impedance Z versus the angular frequency ω for each of the following circuits. (a) A driven series LR circuit, (b) a driven series RC circuit, and (c) a driven series RLC circuit. (6 Points)

2. Show by direct substitution that $L\frac{d^2Q}{dt^2} + R\frac{dQ}{dt} + \frac{1}{C}Q = 0$ is satisfied by $Q = Q_0 e^{-t/\tau}\cos\omega' t$, where $\tau = 2L/R$, $\omega' = \sqrt{1/(LC) - 1/\tau^2}$, and Q_0 is the charge on the capacitor at $t = 0$. (8 Points)

3. (a) Show that a parallel-plate capacitor with empty space between the plates has a displacement current in the region between its plates that is given by $I_d = C\frac{dU}{dt}$, where C is the capacitance and U is the potential difference between the plates. (b) A 5.00-nF parallel-plate capacitor with empty space between the plates is connected to an ideal ac generator so the potential difference between the plates is given by $U = U_0\cos\omega t$, where $U_0 = 3.00\,\mathrm{V}$ and $\omega = 500\,\pi$ rad/s. Find the displacement current in the region between the plates as a function of time. (6 Points)

4. One method for determining the compressibility of a dielectric material uses a driven LC circuit that has a parallel-plate capacitor. The dielectric is inserted between the plates and the change in resonance frequency is determined as the capacitor plates are subjected to a compressive stress. In one such arrangement, the resonance frequency is 120 MHz when a dielectric of thickness 0.100 cm and dielectric constant $\kappa = 6.80$ is placed between the plates. Under a compressive stress of 800 atm, the resonance frequency decreases to 116 MHz. Find the Young's modulus of the dielectric material. (Assume that the dielectric constant does not change with pressure.)