

Physics 234
Homework 1 (Due Wednesday, January 13)
LRC circuits

Problem 1.

LC oscillators have been used in circuits connected to loudspeakers to create some of the sounds of "electronic music". What inductance must be used with a $6.7 \mu F$ capacitor to produce a frequency of 10000 Hz, about the middle of the audible range of frequencies?

Problem 2.

Consider the circuit shown in the figures page. With the switch S_1 closed and the other two switches open, the circuit has a time constant τ_C . With switch S_2 closed and the other two switches open, the circuit has a time constant τ_L . With switch S_3 closed and the other two switches open, the circuit oscillates with a period of oscillation T . Show that $T = 2\pi\sqrt{\tau_C\tau_L}$.

Problem 3.

You are given a 10 mH inductor and two capacitors of $6 \mu F$ and $3 \mu F$. Find the resonant frequencies that can be generated by connecting these elements in various combinations. Note: the capacitors will only be in series or parallel with each other, and you can determine the equivalent capacitance.

Problem 4.

In an LRC series circuit, show that the fraction of the energy lost per cycle of oscillation, $\Delta U/U$, is given to a close approximation by $2\pi R/(\omega L)$. The quantity $\omega L/R$ is called the "Q" of the circuit. A "high-Q" circuit has low resistance and a narrow resonance.

Problem 5.

A 50 mH inductor is connected to an ac generator that has a maximum voltage $V_{max} = 30 \text{ V}$. What is the amplitude of the resulting current if the frequency of the ac voltage is (a) 1.0 kHz , (b) 8.0 kHz ?

Problem 6.

At what frequency would a 6.0 mH inductor and a $10 \mu F$ capacitor have the same reactance?

Problem 7.

A coil of self-inductance 88 mH and unknown resistance and a $0.94\text{ }\mu\text{F}$ capacitor are connected in series with an oscillator of frequency 930 Hz . If the phase angle between the applied voltage and current is 75° , what is the resistance of the coil?

Problem 8.

The ac generator shown in the figures page supplies 120 V (rms) at 60 Hz . With the switch open as shown, the resulting current leads the generator voltage by 20° . With the switch in position 1, the current lags the generator voltage by 10° . When the switch is in position 2 the rms current is 2.0 A . Find the values of R , L , and C .

Problem 9.

In the figure shown, $R = 15\text{ }\Omega$, $C = 4.7\text{ }\mu\text{F}$, and $L = 25\text{ mH}$. The internal resistance of the inductor is $5\text{ }\Omega$. The generator provides a sinusoidal voltage of 75 V (rms) and frequency $f = 550\text{ Hz}$. Calculate (a) the rms current amplitude, and (b) V_{ab} , V_{bc} , V_{cd} , V_{bd} , and V_{ac} .

Problem 10.

Consider the LC resonant circuit shown in the figures page. The capacitor is a parallel plate capacitor that has an area A and plate separation d . The inductor has a total of N turns, a length L , and a radius r . Find an expression for the resonant frequency in terms of ϵ_0 , μ_0 , A , d , L , and r . Note, if one could measure the resonant frequency and the other parameters, one could get an estimate of the product $\epsilon_0\mu_0$.

See the next page for the figures

Figures for HWK 1,

