Oscillations 2

Basic Problems

1. The envelope of LCR oscillators is an exponential function with time constant $\tau = 2\ L/R$. A particular oscillator consists of a coil with inductance 35 mH, a capacitor with capacitance 130 nF and a resistor with resistance 47 Ω. Calculate the number of oscillations it takes until the amplitude has decreased to 10 % of the initial value. What fraction of the initial energy is left at this moment?
2. The amplitude of an oscillation with linear envelope decreases in 0.3 s to 20 % of the initial value. How long does it take the energy to decrease to 50 % of the initial value?
3. The amplitude of an LCR oscillator with frequency 1.5 kHz decreases with a half life of 3.2 ms. The resistance of the circuit is 47 Ω. Calculate the inductance and the capacitance of this circuit.
4. Give some examples of situations where critical can be useful.
5. An oscillator with exponential envelope is critically damped if the product of the angular frequency and the time constant of the damping equals one. Calculate the resistance of a critically damped LCR oscillator with inductance 0.3 H and capacitance 170 nF. **Hint:** Time constant see exercise 1.
6. Give two examples for situations where resonance is useful and unwanted, respectively.
7. The phase shift between two oscillations with identical frequency 33 kHz and amplitudes 1.2 V is 45°. Calculate the amplitude of their superposition. Check the result by plotting the superposition.
8. What can you hear when you strike two pitchforks with respective frequencies 440 Hz and 450 Hz.?
9. Two identical masses and two identical springs are connected (mass to spring to mass to spring). This "double spring pendulum" is suspended from a rigid stand. Describe the system's natural oscillations.
10. A system of two coupled oscillators has natural oscillations with frequencies 0.8 Hz and 0.9 Hz. How long does it take the energy to move from the first to the second oscillator?
11. What are the properties of a good resonance body in a musical instrument?

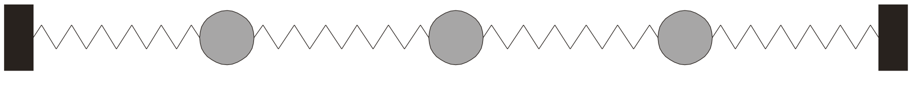
Additional Problems

12. The resonance of a driven oscillation's amplitude can be approximated in the frequency range around the resonance frequency ω_R by the *Lorentz function*

$$A(\omega) \propto \frac{\frac{\Gamma}{2}}{(\omega - \omega_R)^2 + \left(\frac{\Gamma}{2}\right)^2}.$$

    What are the units of the different quantities and the constant of proportionality (not displayed) in this expression? What is the physical phenomenon related to the parameter Γ and how does this parameter affect the resonance curve? Graph the function for realistic parameter values.

13. The phase shift between two oscillations with amplitudes 15 cm and 25 cm is 80°. Determine the amplitude and the phase shift of their superposition with both a construction and a calculation.
14. Two oscillations whose periods differ by 10% are superposed. The beat frequency is 5 Hz. Calculate the frequencies of the two oscillations.
15. Three identical masses are connected to each other and the walls by means of identical springs (see figure).



    a) Describe the natural oscillations of the system and order them in the order of increasing frequency.
    b) Which natural oscillations can be excited by moving the central mass?

Solutions: 1. 8 oscillations, 1 %; 2. 0.1 s; 3. 108 mH, 104 nF; 5. 2.7 kΩ; 7. 2.2 V; 8. 445 Hz tone pulsating at 10 Hz; 10. 10 s; 13. 31 cm, 28 ° (or 52 °); 14. 45 Hz, 50 Hz