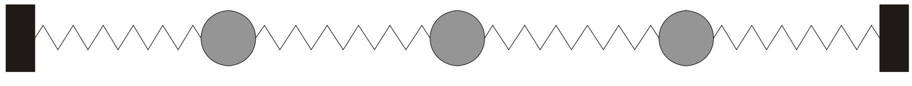
Oscillations 2

Basic Problems

1. The envelope of LCR oscillators is an exponential function with time constant $\tau = 2 \cdot L/R$. 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. An oscillator with exponential envelope is critically damped if the product of the angular frequency and the time constant of the damping equals one. Derive a formal expression for the critical resistance, i.e. the resistance at which the damping for a given LCR oscillator is critical.
4. An LCR oscillator with inductance 0.3 H and capacitance 170 nF is critically damped. Calculate the resistance of the circuit.
5. Give two examples for situations where resonance is useful and unwanted, respectively.
6. The phase shift between two oscillations with identical frequencies and amplitudes is 45°. Calculate the amplitude of their superposition. Check the result with your calculator.
7. What can you hear when you strike two pitchforks with respective frequencies 440 Hz and 450 Hz.?
8. Two masses m and $2 \cdot m$ are connected with a spring. Describe the natural oscillations of the system.
9. 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?
10. What are the properties of a good resonance body in a musical instrument?

Additional Problems

11. The amplitude of an LCR oscillator with frequency 1.5 kHz decreases with a half live of 3.2 ms. The resistance of the circuit is 47 Ω. Calculate the inductance and the capacitance of the circuit.
12. A mass is connected to a spring over a string. The string is gliding over a rod and thereby damps the oscillation of the system.
    a) Express the energy loss from the upper to the lower turning point first by the amplitudes A_1 and A_2 at these positions and then by the frictional work.
    b) Prove that the damped oscillation has a linear envelope.
    c) What does the final position of the mass depend on?
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 a construction.
14. Two oscillations whose frequencies 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 through 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 to Basic Problems: 1. 8, 1 %; 2. 0.1 s; 4. 2.7 kΩ; 6. 1.8 times amplitude; 9. 10 s