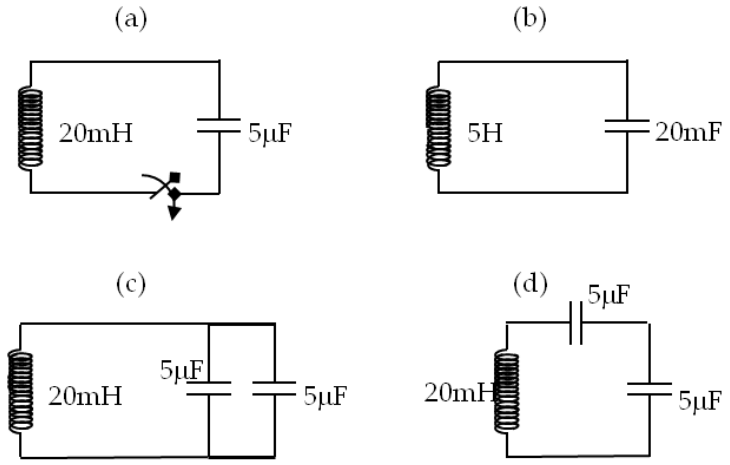
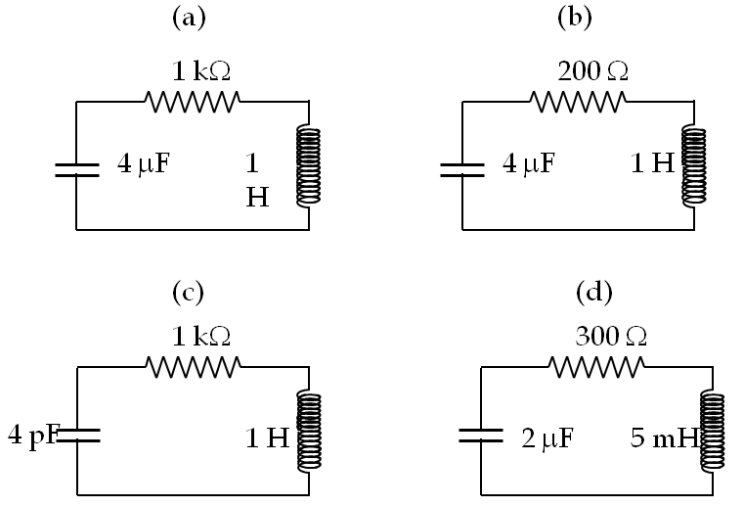
11.4 EXERCISES

Electromagnetic oscillations

Ex 11.4.1. Find the natural frequency of oscillation of the following circuits. Ans: (a) 503 Hz, (b) 0.503 Hz, (c) 356 Hz, (d) 712 Hz.



Ex 11.4.2. Determine if the following circuits are under-damped, over-damped, or critically damped. For under-damped circuits find the frequency of oscillation, Q-factor, and time it will take for 50% of the energy to dissipate. Ans: (a) critical, (b) underdamped, (c) underdamped, (d) overdamped. For (b) frequency 78 Hz, $Q = 4.9$, and $\Delta t = 3.47$ ms.



Ex 11.4.3. For each of the circuits in Exercises 11.4.1 and 11.4.2 above draw the equivalent mechanical circuit.

Ex 11.4.4. A capacitor (C = 1.6 μF) is connected across a 12-V battery and charged to maximum. The charge capacitor is then disconnected and connected to a resistor (R = 10 Ω) and inductor (L = 4 mH) in series. Plot the current in the circuit with time up to t = 30 $\sqrt{LC}$.

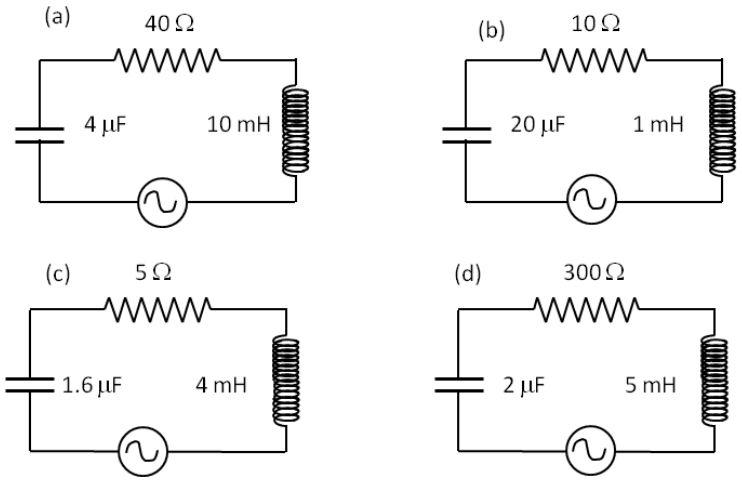
Ex 11.4.5. A capacitor (C = 1.6 μF) is connected across a 12-V battery and charged to maximum. The charge capacitor is then disconnected and connected to a resistor (R = 100 Ω) and inductor (L = 4 mH) in series. Plot the current in the circuit with time up to t = 30 $\sqrt{LC}$. Compare this plot to the plot in Exercise 11.4.4 and relate your observations to the parameters of the two circuits.

Ex 11.4.6. A capacitor (C = 1.6 μF) is connected across a 12-V battery and charged to maximum. The charge capacitor is then disconnected and connected to a resistor (R = 1000 Ω) and inductor (L = 4 mH) in series. Plot the current in the circuit with time up to t = 30 $\sqrt{LC}$. Compare this plot to the plot in Exercise 11.4.4 and 11.4.5 and relate your observations to the parameters of the circuits.

Ex 11.4.7. Find the ratio of oscillation frequency to natural frequency of the following under-damped oscillators where the elements are connected in series with a capacitor fully charged at $t = 0$ with a 3-volt across its plates. (a) $C = 1.6$ μF, $L = 4$ mH, $R = 8$ Ω, (b) $C = 1.6$ μF, $L = 4$ mH, $R = 6$ Ω, (c) $C = 1.6$ μF,$L = 4$ mH, $R = 4$ Ω, (d) $C = 1.6$ μF, $L = 4$ mH, $R = 2$ Ω. Plot one oscillation of the current in each circuit on the same graph and comment on the differences you find and how those differences relate to the parameters of the circuits.

Driven oscillations

Ex 11.4.8. Find the frequency at which current in each circuit will resonate. Ans: (a) 796 Hz, (b) 1125 Hz, (c) 1989 Hz, (d) 1592 Hz.



Ex 11.4.9. For each circuit in Ex. 11.4.8, find the amplitude of the current if the peak voltage of the source of frequency 600 Hz is 10 V. Ans: (a) 20 mA, (b) 730 mA, (c) 66 mA, (d) 31 mA.

Ex 11.4.10. For each circuit in Ex. 11.4.8, find the average power delivered to the circuit if the peak voltage of the source of frequency 600 Hz is 10 V. Ans: (a) 0.8 W, (b) 2.7 W, (c) 0.011 W, and (d) 0.14 W.

Ex 11.4.11. For circuit (a) in Exercise 11.4.8, find the average power delivered to the circuit by a 10-V source at following frequencies, plot the average power delivered versus frequency, and compare the peak frequency with the resonance frequency of the circuit: (a) 100 Hz, (b) 300 Hz, (c) 500 Hz, (d) 700 Hz, (e) 1000 Hz, (f) 2500 Hz, (g) 4500 Hz, (h) 6000 Hz, (i) 8000 Hz, and (j) 10000 Hz.

Ex 11.4.12. For circuit (b) in Exercise 11.4.8, plot the peak current as a function of frequency of a 10-V sinusoidal source.

Ex 11.4.13. (a) For circuit (c) in Exercise 11.4.8, plot the average power dissipated in the resistor versus frequency of a 10-V source. (b) At what value of the frequency is the maximum power dissipated?