Exercise 1. Mutual Inductance

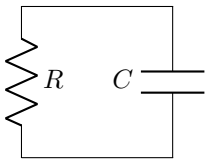
Two coils have inductance L_1 and L_2 and mutual inductance $M = \sqrt{L_1 L_2}$. If the current in the first coil increases at a uniform rate, $\dot{I}_1$, what is the magnitude of the induced electromotive force in the second coil? Is it constant? Hint: $\mathcal{E}_2 = -M\dot{I}_1$ and $\mathcal{E}_1 = -M\dot{I}_2$.

Exercise 2. Self Inductance

Find the inductance of a solenoid with 1000 turns, radius of 1 [cm], resistance 1 [Ω], and applied voltage $\mathcal{E} = 10$ [V], and relative permeability 1000 times as great as that in a vacuum. Hint: $\mathcal{E} = IR$ and $L = \Phi_B/I$ in general and $B = \mu NI$.

Exercise 3. RC Circuit I

Consider the following circuit:



The qualitative behavior of the voltage across the resistor will be:

(a) Constant voltage

(b) Monotonically increasing voltage

(c) Oscillating voltage modulated by a decaying exponential

(d) Oscillating voltage

(e) Monotonically decreasing voltage

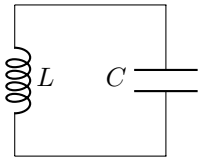
(f) Oscillating voltage modulated by a growing exponential

Exercise 4. RC Circuit II

For the circuit in the last problem, write the differential equation governing currents and charges on the capacitor. What is the solution if the initial charge on the capacitor is Q_0 and the initial current is 0?

Exercise 5. LC Circuit

Consider the following circuit:



The qualitative behavior of the charge on the capacitor will be:

(a) Constant charge

(b) Monotonically increasing charge

(c) Oscillating charge modulated by a decaying exponential

(d) Oscillating charge

(e) Monotonically decreasing charge

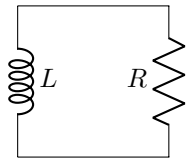
(f) Oscillating charge modulated by a growing exponential

Exercise 6. LC Circuit II

For the circuit in the last problem, write the differential equation governing currents and charges on the capacitor. What is the solution if the initial charge on the capacitor is 0 and the initial current is I_0?

Exercise 7. LR Circuit

Consider the following circuit:



The qualitative behavior of the voltage across the resistor will be:

(a) Constant voltage

(b) Monotonically increasing voltage

(c) Oscillating voltage modulated by a decaying exponential

(d) Oscillating voltage

(e) Monotonically decreasing voltage

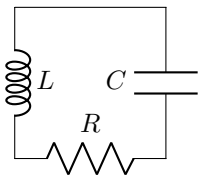
(f) Oscillating voltage modulated by a growing exponential

Exercise 8. LR Circuit II

For the circuit in the last problem, write the differential equation governing currents. Why is it not sufficient to specify only the initial current as a boundary value? What should the other boundary value be?

Exercise 9. RLC Circuit I

Consider the following circuit:



The qualitative behavior of the voltage across the resistor can be which of the following based on the values of R, L and C:

(a) Constant voltage

(b) Monotonically increasing voltage

(c) Oscillating voltage modulated by a decaying exponential

(d) Oscillating voltage

(e) Monotonically decreasing voltage

(f) Oscillating voltage modulated by a growing exponential

Exercise 10. RLC Circuit II

For the circuit in the last problem, write and solve the differential equation governing currents and charge on the capacity. Assume that the initial charge on the capacitor is Q_0 and the initial current is I_0.

Exercise 11. RLC Circuit III

Find the energy stored in the inductor, $U_L = \frac{1}{2}LI^2$, and in the capacitor, $U_C = \frac{1}{2}Q^2/C$, as functions of time. Is the sum constant? If not, why not? Think about the conservation of energy.

Exercise 12. RLC Circuit IV

Find values of R, L, and C such that the period, $T = 2\pi/\omega$, is 1 millisecond and the voltage decreases by half every second.