1. Prove that applying conservation of energy principle for a block-spring oscillator system without friction is equivalent to the fundamental differential equation that describes a simple harmonic oscillator.

2. Prove the same for a LC circuit.

3. A 1.5 \( \mu \text{F} \) capacitor is charged to 57 V by a battery, which is then removed. At time \( t = 0 \), a 12 mH coil is connected in series with the capacitor to form an LC oscillator (Fig 1).
   (a) What is the potential difference \( v_L(t) \) across the inductor as a function of time?
   (b) What is the maximum rate \( (di/dt)_{\text{max}} \) at which the current \( i \) changes in the circuit?

4. Using the conservation of energy principle deduce the differential equation that governs the charge dynamics in the circuit shown in figure 2.

5. A series RLC circuit has inductance \( L = 12 \text{ mH} \), capacitance \( C = 1.6 \mu \text{F} \), and resistance \( R = 1.5 \Omega \) and begins to oscillate at time \( t = 0 \).
   (a) At what time \( t \) will the amplitude of the charge oscillations in the circuit be 50% of its initial value?
   (b) How many oscillations are completed within this time?

6. Consider the circuit shown in Fig. 3. With switch \( S_1 \) closed and the other two switches open, the circuit has a time constant \( \tau_C \). With switch \( S_2 \) closed and the other two switches open, the circuit has a time constant \( \tau_L \). With switch \( S_3 \) closed and the other two switches open, the circuit oscillates with a period \( T \). Show that \( T = 2\pi\sqrt{\tau_C\tau_L} \).
7. A series RLC circuit, driven with $\varepsilon_{\text{rms}} = 120 \, V$ at frequency $f_d = 60.0 \, \text{Hz}$, contains a resistance $R = 200 \, \Omega$, an inductance with inductive reactance $X_L = 80.0 \, \Omega$, and a capacitance with capacitive reactance $X_C = 150 \, \Omega$

(a) What are the power factor $\cos \phi$ and phase constant $\phi$ of the circuit?
(b) What is the average rate $P_{\text{avg}}$ at which energy is dissipated in the resistance?
(c) What new capacitance $C_{\text{new}}$ is needed to maximize $P_{\text{avg}}$ if the other parameters of the circuit are not changed?

8. Choose approximate values for L and C for an FM radio so that the amplitude of the next station is 1/100 the amplitude of the “tuned” station, given that the circuit has a resistance of 0.6 $\Omega$. 