Problem 1. In an oscillating LC circuit in which \( C = 4.0 \mu F \), the maximum potential difference across the capacitor during the oscillations is 1.50 V and the maximum current through the inductor is 50.0 mA.

a) What is the inductance \( L \)?

Use the conservation of energy to write an expression of equivalence between the energy in the inductor and the energy in the capacitor

Use algebraic manipulation to solve for the inductance \( L \) using the above expression. For \( Q \), use the maximum charge when the voltage is at maximum.
b) What is the frequency of the oscillations?

<table>
<thead>
<tr>
<th>Write an expression between the frequency $f$ and the angular frequency $\omega$.</th>
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<tbody>
<tr>
<td>Write an expression between the angular frequency $\omega$ and the inductance $L$ and capacitance $C$.</td>
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<tr>
<td>Use the numerical values to calculate the frequency.</td>
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</table>
c) How much time does the charge on the capacitor take to rise from 0 to its maximum value?

Calculate the period of the oscillation. (Hint: $T = 1/f$)

In the unit circle, the sine function goes from 0 to its maximum value in the first quadrant or in only $\frac{1}{4}$ of the circle. Based on this reasoning calculate the time inductor takes to go from 0 to its maximum value.
Problem 2. In the figure below, $R=160 \, \Omega$, $C=70.0 \, \mu F$, $L=230 \, mH$, $f_d =60.0 \, Hz$, and $E_{\text{max}}=36.0 \, V$.

a) Find $Z$, $\phi$, and $i_{\text{max}}$ for the circuit.

Calculate the angular frequency of the circuit.

Calculate the capacitive reactance of the circuit.

Calculate the inductive reactance of the circuit.

Calculate the impedance using these values.
Calculate the phase angle in degrees using these values.

Calculate the maximum current using these values.

Explain if the voltage leads or lags the current.
Problem 3. In the figure below, a generator with an adjustable frequency of oscillation is connected to a resistance of $R=100$ W, inductances $L_1=1.70$ mH, $L_2=2.3$ mH, and capacitances of $C_1=4.00$ μF, $C_2=2.5$ μF, and $C_3=3.5$ μF.

![AC Circuit Diagram]

a) What is the resonance frequency of the circuit?

Calculate the total inductance.

Calculate the total capacitance.

Calculate the resonant frequency from these values.
b) What happens to the resonant frequency if the value of R is increased?

Does the resonance frequency depend on R?

Explain R’s effect on the frequency

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c) Or if the value of L is increased?

Is the resonant frequency inversely or directly proportional to L?

Explain L’s effect on the frequency

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d) Or if the capacitance is removed from the circuit?

Is the resonant frequency inversely or directly proportional to C?

Explain C’s effect on the frequency

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Problem 4. The ac generator below supplies 120 V at 60 Hz. When the switch is open, as in the diagram, the current leads the generator emf by 20°. With the switch in position 1, the current lags the generator emf by 10°. When the switch is in position 2, the current is 2 A. Find the values of R, L, and C.

Set \( \tan(-20°) = \tan(\phi_1) \). Write the equation for the phase angle when the switch is open and set it equal to this quantity. (Hint: it is best to leave the capacitive/inductive reactances as symbols such as \( X_C \))

Set \( \tan(10°) = \tan(\phi_2) \). Write the equation for the phase angle when the switch is in position 1 and set it equal to this quantity. (Hint: Note the capacitance is now 2C)

Derive the quantity \( \tan(\phi_2) - \tan(\phi_1) \).

Solve for \( X_C \) in terms of the difference: \( \tan(\phi_2) - \tan(\phi_1) \) as well as R and \( \omega \).
Perform algebraic manipulation to find $X_L$ in terms of $\tan(\phi_1)$, $\tan(\phi_2)$, $R$ and $\omega$.

With the switch in position 2, write the expression between current, the emf, and the impedance. Let the impedance $Z = \sqrt{X_L^2 + X_C^2}$.

Use the expressions derived above for $X_L$ and $X_C$ and substitute them into the impedance for switch position 2. Solve for $R$.

Use the numerical values and calculate $L$. 
Use the numerical values and calculate C.
Problem 5. A transformer has 500 primary turns and 10 secondary turns.

a) If $V_P = 120 \, \text{V}_{\text{rms}}$, what is $V_s$?

Calculate the ratio of primary to secondary turns

Use this ratio to calculate the voltage on the secondary.

b) If the secondary is now connected to a resistive load of $15 \, \Omega$, what are the currents in the primary and secondary?

Calculate the current in the secondary.

Use the ratio of turns to calculate the current in the primary.