(a) In this problem circuit elements are added to the RLC circuit shown in Figure 1. As a first step, find the differential equation satisfied by the voltage on the capacitor in this circuit.

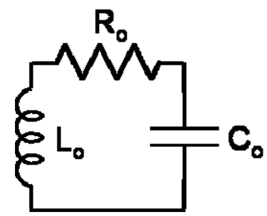

Figure 1

(b) Making the approximation $\sqrt{1/L_oC_o} \gg R_o/2L_o$, find the angular frequency of the oscillating voltage on the capacitor.

(c) Using the definition of the quality factor, Q_o, of a RLC circuit in the text box below, find an expression for Q_o in terms of R_o, L_o and C_o.

$\frac{Q_o}{\pi} =$ number of cycles for the amplitude of the voltage on the capacitor to decay by $\frac{1}{e}$

(d) As shown in Figure 2, an inductor, L_a, and a mutual inductance, M_{ao}, are added to the simple circuit. Write down Kirchoff's current law and voltage law for the two loops of this circuit, using as shown in Figure 2, loop currents i_a and i_o, and voltage V_a.

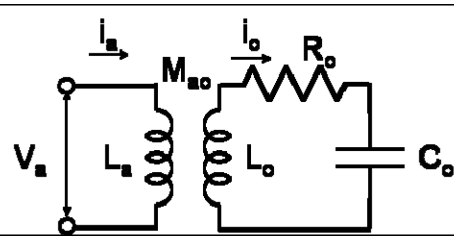

Figure 2

(e) Show that the circuit shown below in Figure 3 is equivalent to the circuit of Figure 2, i.e. show that the two circuits satisfy the same Kirchoff's current and voltage laws, when the inductances L_1, L_2, and L_3 take on the values M_{ao}, M_{ao}, and $-M_{ao}$, respectively. Because of the negative value of L_3, the circuit of Figure 3 is a theoretical, but not a physical, equivalent circuit.

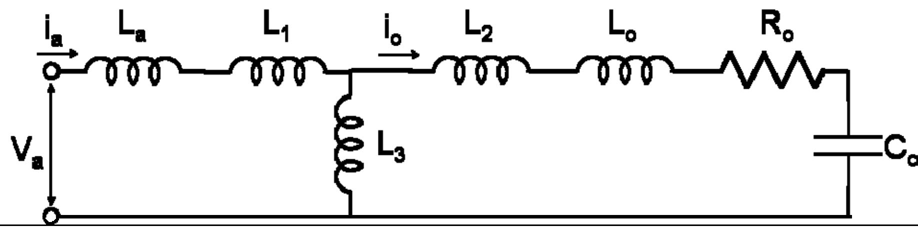

Figure 3

(f) As the final addition to the circuit, a resistor, R_c, is added as shown in Figure 4 below.

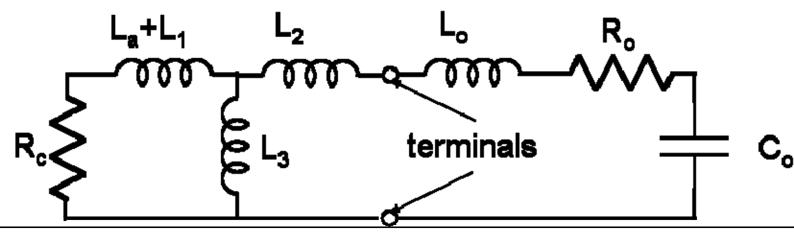

Figure 4

Let Z_o represent the complex impedance of the circuit elements to the right of the terminals in Figure 4, and let Z_k represent the circuit elements to the left of the terminals in Figure 4. The circuit shown in Figure 5 below is an equivalent circuit to the one shown in Figure 4.

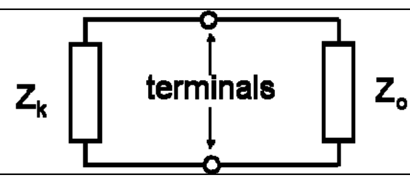

Figure 5

Find the complex impedances Z_o and Z_k. In your final answer for Z_k, let L_1, L_2, and L_3 have the values M_{ao}, M_{ao}, and $-M_{ao}$, respectively.