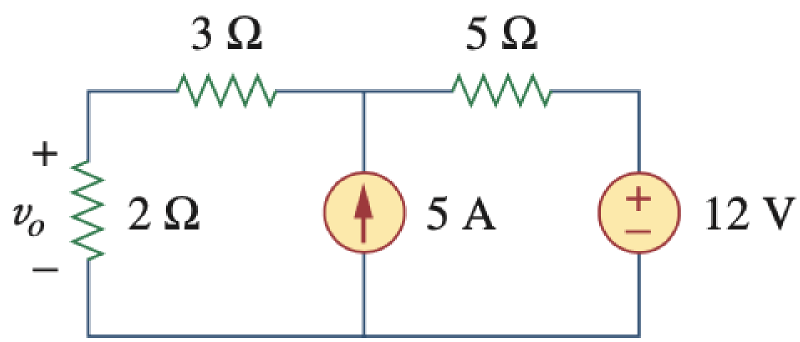
ECE 100 (Spring 2021) - Homework #5 (not graded)

This will serve as Midterm Exam preparation questions.

Due Date: Not graded

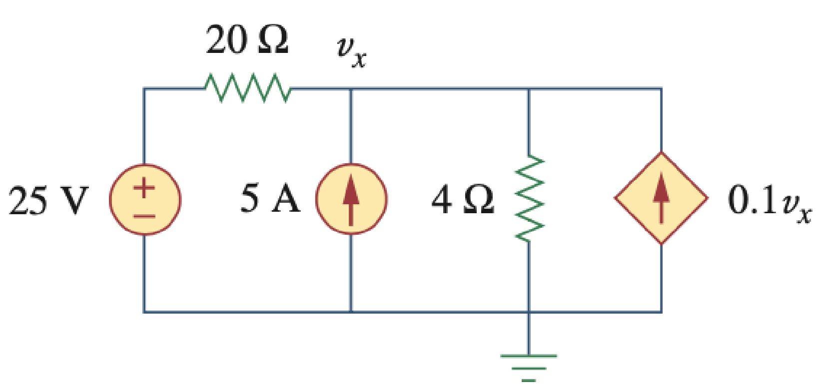
Problem 1: Solve following circuit 3 different ways



(a) Solve using KCL/KVL
(b) Solve using Source Transformations
(c) Solve using Superposition

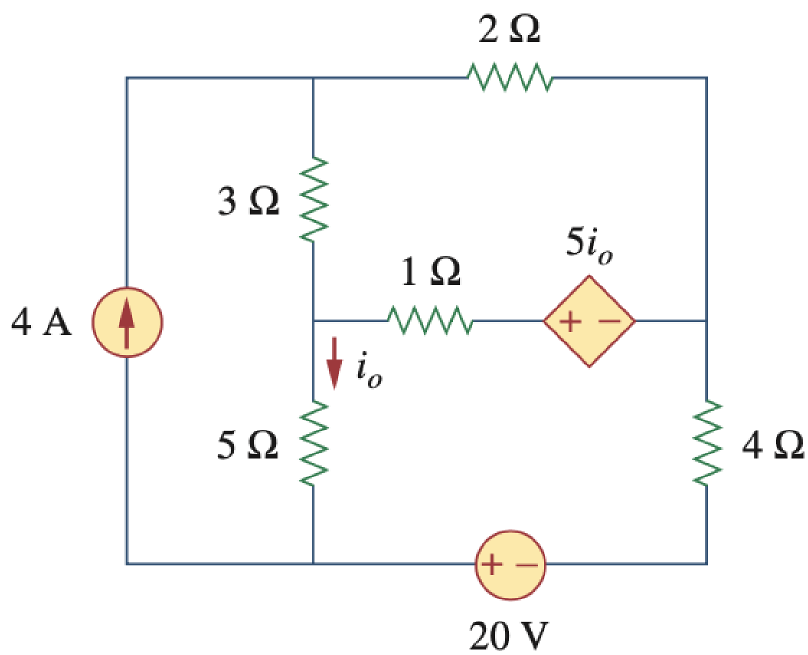
Problem 2: Superposition

Use superposition to find node voltage, v_x.



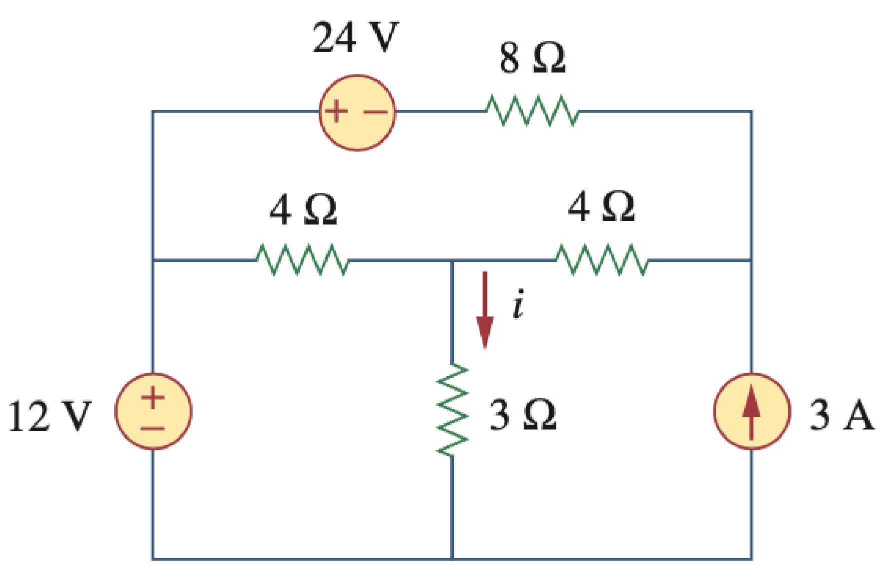
Problem 3: Superposition

Use superposition to find current, i_o.

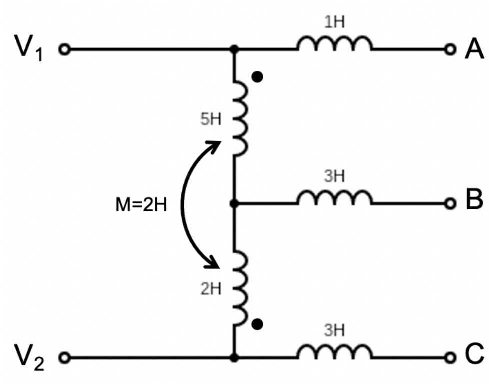


Problem 4: Superposition

Use superposition to find current, i.



Problem 5: Mutual Inductance



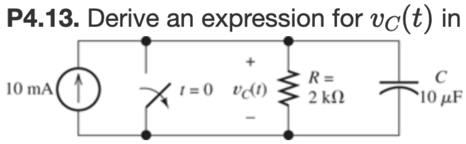
Hint: Coupling, with mutual inductance M=2H, is shown between 5H & 2H inductors. There is no coupling to any of the other branches.

(a) Find the equivalent inductance, L_{eq}, seen between terminals V_1 and V_2.

(b) Find the equivalent inductance, Leq, seen between terminals V1 and V2 if nodes B & C are connected together.

Problem 6

P4.13. Derive an expression for $v_C(t)$ in the circuit of **Figure P4.13** and sketch $v_C(t)$ to scale versus time.



Problem 7

P4.18. Consider the circuit shown in **Figure P4.18**. Prior to $t = 0,\ v_1 = 100\ \mathrm{V}$, and $v_2 = 0$.

a. Immediately after the switch is closed, what is the value of the current [i.e., what is the value of $i(0+)$]?
b. Write the KVL equation for the circuit in terms of the current and initial voltages. Take the derivative to obtain a differential equation.
c. What is the value of the time constant in this circuit?
d. Find an expression for the current as a function of time.
e. Find the value that v_2 approaches as *t* becomes very large.

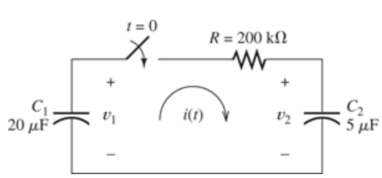
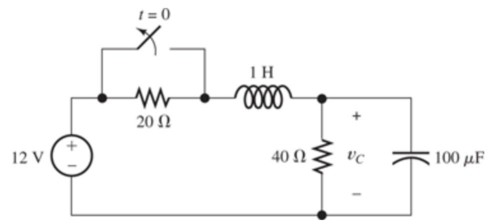


Figure P4.18

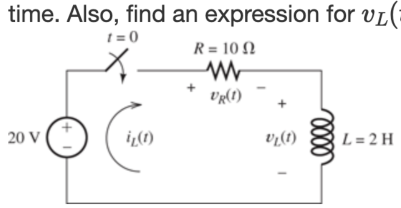
Problem 8

P4.24. The circuit shown in **Figure P4.24** has been set up for a long time prior to $t = 0$ with the switch closed. Find the value of v_C prior to $t = 0$. Find the steady-state value of v_C after the switch has been opened for a long time.



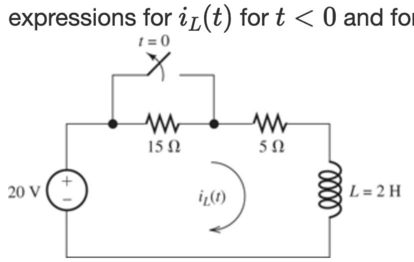
Problem 9

P4.38. For the circuit shown in **Figure P4.38**, find an expression for the current $i_L(t)$ and sketch it to scale versus time. Also, find an expression for $v_L(t)$ and sketch it to scale versus time.



Problem 10

P4.39. The circuit shown in **Figure P4.39** is operating in steady state with the switch closed prior to $t = 0$. Find expressions for $i_L(t)$ for $t < 0$ and for $t \geq 0$. Sketch $i_L(t)$ to scale versus time.



Problem 11 (Note: includes Problems 4.61-4.63)

Hint: See provided notes on 2nd order differential equations

***P4.61.** A dc source is connected to a series *RLC* circuit by a switch that closes at $t = 0$, as shown in **Figure P4.61**. The initial conditions are $i(0+) = 0$ and $v_C(0+) = 0$. Write the differential equation for $v_C(t)$. Solve for $v_C(t)$, if $R = 80\ \Omega$.

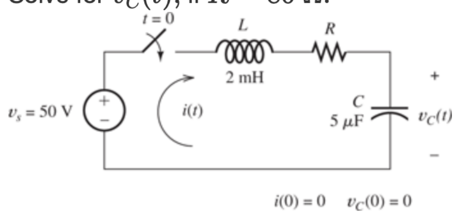


Figure P4.61

***P4.62.** Repeat **Problem P4.61** for $R = 40\ \Omega$.
***P4.63.** Repeat **Problem P4.61** for $R = 20\ \Omega$.

Problem 12

P4.64. Consider the circuit shown in **Figure P4.64** in which the switch has been open for a long time prior to $t = 0$ and we are given $R = 25\ \Omega$.

a. Compute the undamped resonant frequency, the damping coefficient, and the damping ratio of the circuit after the switch closes.
b. Assume that the capacitor is initially charged by a 25-V dc source not shown in the figure, so we have $v(0+) = 25\ \text{V}$. Determine the values of $i_L(0+)$ and $v\prime(0+)$.
c. Find the particular solution for *v*(*t*).
d. Find the general solution for *v*(*t*), including the numerical values of all parameters.

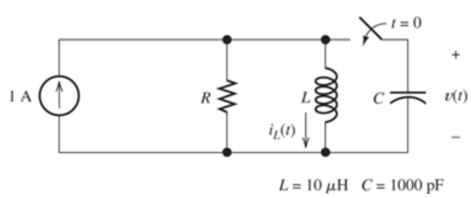


Figure P4.64

Problem 13

Refer to Figure 1 below. The inductor has no initial energy (Hint: $i_L(0^+) = 0A$)

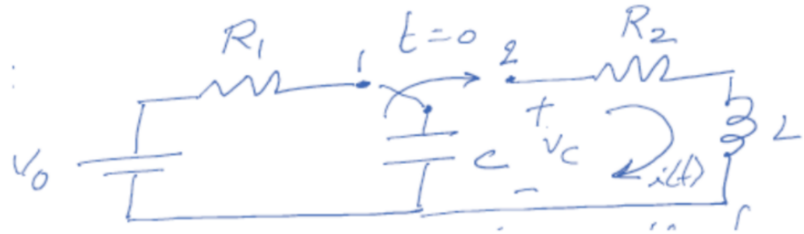


Figure 1.

a. Derive the differential equation that governs the current i(t) for time $t \geq 0$.

b. What is the characteristic equation that governs the behavior of this circuit?

For the following assume $R_1 = 5\ k\Omega$, $R_2 = 16\ \Omega$, $L = 400$ nH, $C = 4$ nF, and $V_0 = 10$ Volts.

c. Derive an expression for the voltage across the capacitor, $V_C(t)$ for $t \geq 0$. Assume that the circuit achieved steady state before $t = 0$ i.e. assume that the circuit came into being at $t = -\infty$.

d. Draw a rough sketch of the waveform.

<u>Problem 14</u>

Refer to Figure 2 below. Both switches changed from their position 1→2, respectively, at time t=0, after the circuits having already achieved steady state.

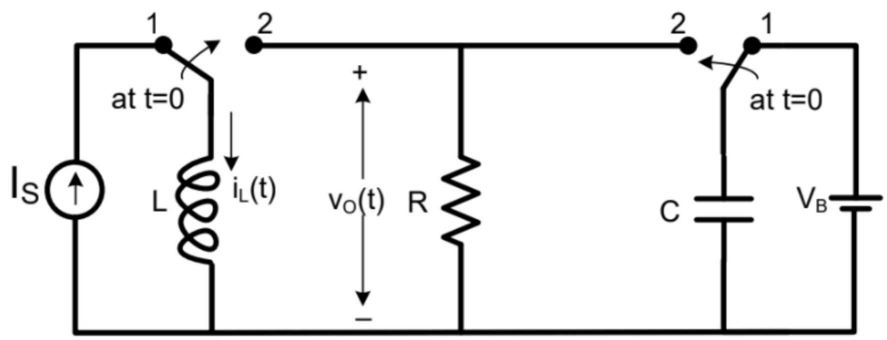


Figure 2.

For parts (a) through (d), express your answers in terms of V_B, I_S, R, L, and C.

a. Derive a differential equation in terms of $v_O(t)$ that characterizes circuit behavior for $t \geq 0$.

b. What is the characteristic equation of this circuit for time $t \geq 0$?

c. Determine the value of $v_O(t)$ just after $t = 0$.

d. Determine the value of $\left.\frac{dv_O(t)}{dt}\right|_{t=0+}$.

For the rest, use $V_B = 2V$, $I_S = 0.6mA$, $C = 1nF$, $L = 64nH$, and $R = 5$ Ohms.

e. Calculate the damping factor of the circuit. What kind of damping is this?

f. Derive an expression for the complete solution of $v_O(t)$ in this circuit.

g. Derive an expression for the current, $i_L(t)$ in this circuit.

h. Draw a rough sketch of the solution, $v_O(t)$. Do not forget to show the initial and final values of $v_O(t)$. If $v_O(t)$ shows some ringing, mark the period and the time constant of the envelope as well.

i. What will happen if R were infinitely large? Derive an expression for $v_O(t)$ and sketch it.