Problem 1: Consider the circuit shown in Figure 1.

(a) Draw a graph for this circuit.

(b) Identify (draw) a tree that does **not** include the branches C_2 and R. Choose it such that you have the minimum number of equations to solve.

(c) Use mesh current method to write the equations for this circuit. Make sure that $i_C(t)$ and $i_R(t)$ are two of the unknowns. Assume that no energy is stored in any of the inductors or capacitors.

(5 + 10 + 10= 25 points)

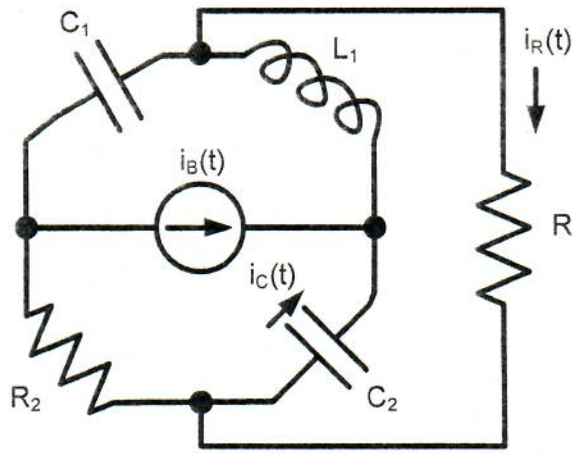
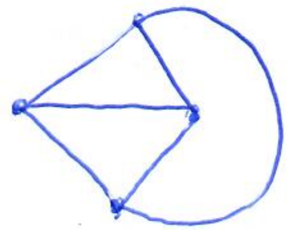


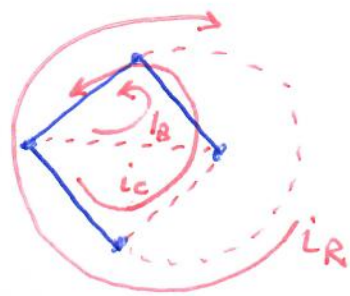
Figure 1.

Solution:

(a)



(b)



(c)

$$i_R(t)R + \left[i_R(t) - i_c(t)\right]R_2 + \frac{1}{C_1}\int_0^t \left(i_R(t) - i_c(t) - i_B(t)\right)dt = 0$$

$$\frac{1}{C_2}\int_0^t i_c(t)\,dt + L_1\frac{d\left[i_c(t)+i_B(t)\right]}{dt} + \frac{1}{C_1}\int_0^t \left(i_c(t)+i_B(t)-i_R(t)\right)dt + \left[i_c(t)-i_R(t)\right]R_2 = 0$$

Problem 2: Refer to Figure 2 for this problem. Calculate the Norton's equivalent of this network looking into the terminals 1-1'. Use any method of your choice.

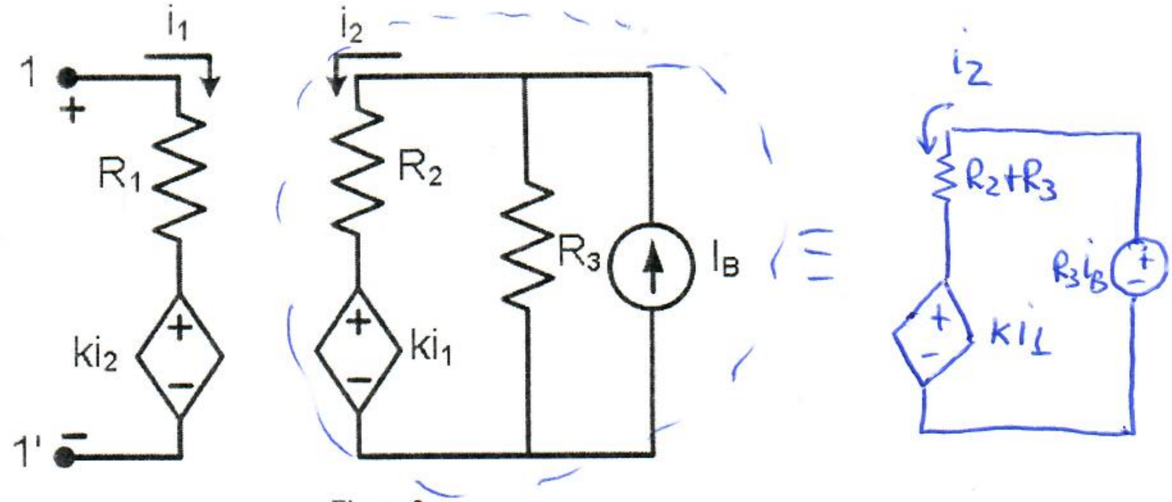


Figure 2.

(20 + 20 = 40 points)

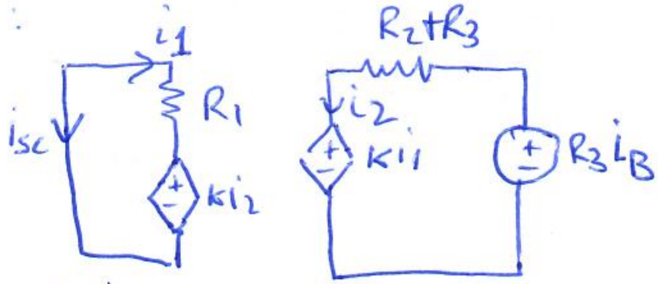
Solution:

For V_{oc}:

$i_1 = 0 \rightarrow \underbrace{V_{oc} = K i_2 \qquad i_2 = \frac{i_B R_3}{R_2+R_3}}$

$$V_{oc} = \frac{K I_B R_3}{R_2+R_3}$$

For I_{sc}:

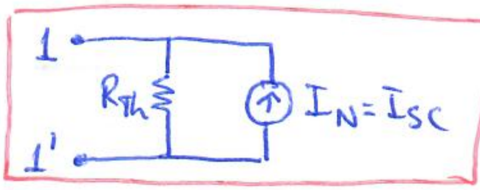


$i_{sc} = -i_1 = \frac{K i_2}{R_1}$

$i_2 = \frac{K i_{sc} + R_3 I_B}{R_2 + R_3}$

$\rightarrow R_1(R_2+R_3)\, i_{sc} = K(K i_{sc} + I_B R_3) \rightarrow \boxed{I_N = i_{sc} = \frac{K I_B R_3}{R_1(R_2+R_3) - K^2}}$

$$\boxed{R_{Th} = \frac{V_{Th}}{I_{sc}} = R_1 - \frac{K^2}{R_2+R_3}}$$



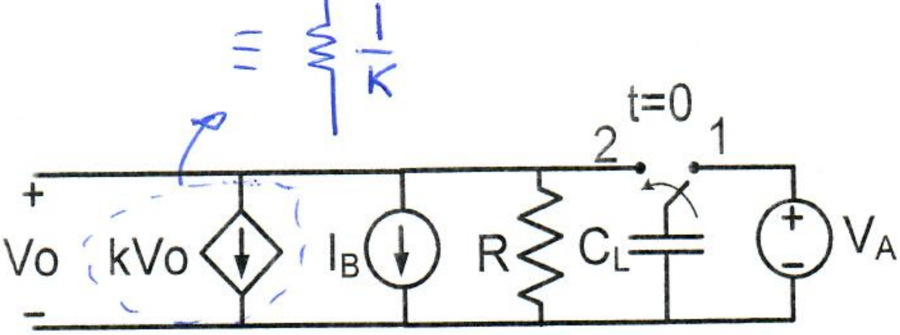
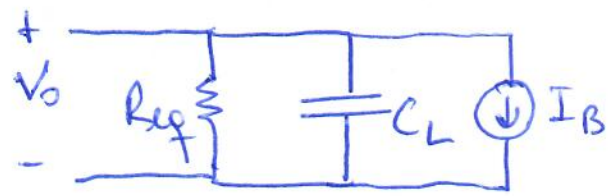


Figure 3

Problem 3: Refer to Figure 3 for this problem. Find Vo(t) for all t ≥ 0.
(35 points)

Solution: For $t > 0$:

$$R_{eq} = \frac{1}{K} \parallel R = \frac{R}{1+RK}$$



1st order circuit $\rightarrow$ so: $V_o(t) = A + B e^{-t/\tau}$

$V_o(0^+) = V_A \qquad V_o(0^+) = A + Be^{-0} = A + B$

$V_o(\infty) = -I_B R_{eq} \qquad V_o(\infty) = A + Be^{-\infty} = A$

$\rightarrow \quad A = -I_B R_{eq}$

$A + B = V_A \Rightarrow B = V_A + I_B R_{eq}$

$$\tau = R_{eq} C_L = \frac{R C_L}{1+RK}$$

$$\rightarrow \boxed{V_o(t) = -\frac{I_B R}{1+RK} + \left(V_A + \frac{I_B R}{1+RK}\right) e^{-t/\tau} \qquad \tau = \frac{R C_L}{1+RK}}$$