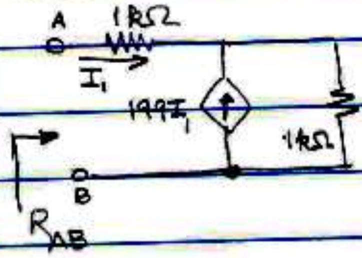
ECE 2412 Sp'16 #①

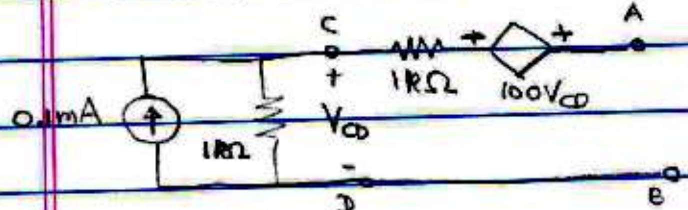
CIRCUITS REVIEW PROBLEMS

PROBLEM 1



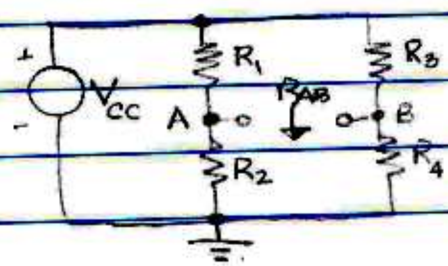
Evaluate R_{AB}

PROBLEM 2



Obtain the Thevenin equivalent at terminals A-B.

PROBLEM 3



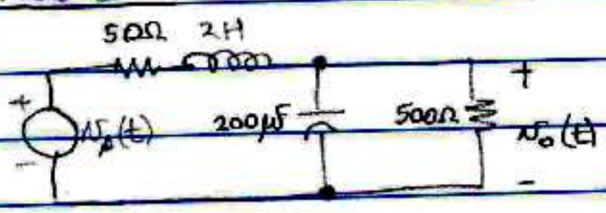
A) Find the condition for which

$V_{AB} = 0$

B) If $R_1 = 4\Omega$, $R_2 = 12\Omega$, $R_3 = 2\Omega$, $R_4 = 6\Omega$

Evaluate R_{AB}.

PROBLEM 4



$v_s(t) = 77 + 100\cos 754t$

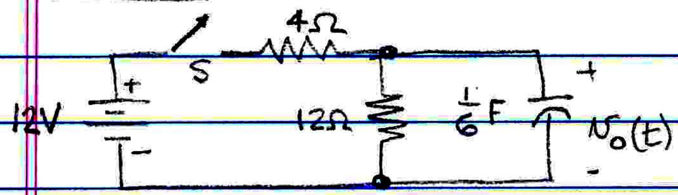
A) Evaluate the steady-state response $v_o(t)$.

B) Derive the transfer function

$H(j\omega) = V_o/V_s$

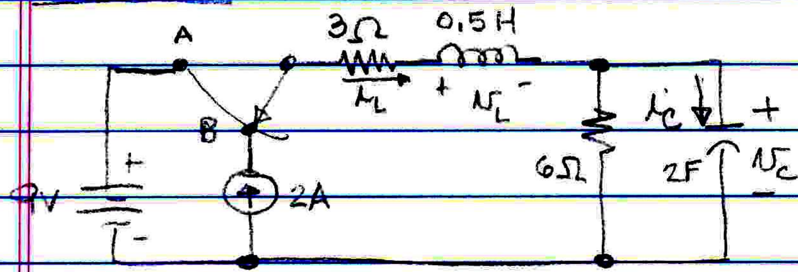
C) Use the result in (B) to verify the result in (A).

PROBLEM 5



The switch S has been open for a long time and is closed at t = 0.
Evaluate $v_o(t)$ for $t \geq 0$.

PROBLEM 6



The switch S has been in position B for a long time. At t = 0 S is moved to position A

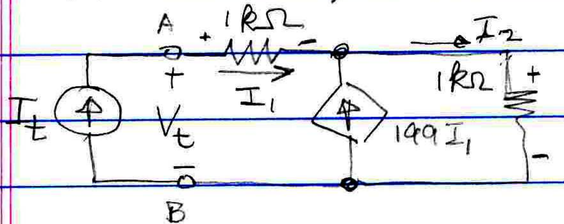
Determine the following:

A) $i_L(0^+)$, $i_c(0^+)$, $v_L(0^+)$, $v_c(0^+)$

B) $i_L(\infty)$, $v_c(\infty)$.

PROBLEM 1

To calculate the resistance at a pair of terminals, apply a source (current/voltage) and measure the response (voltage/current) at the terminal pair. Then, $R = V/I$. In this problem a current source is applied as shown



$I_1 = I_t$

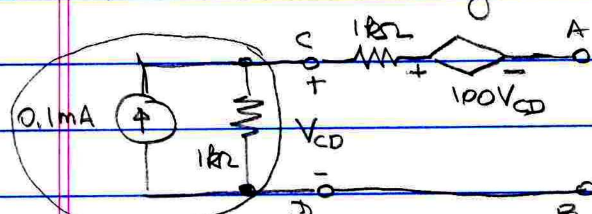
$V_t = 1k\Omega \times I_t + \underbrace{(I_t + 199\,I_t)}_{I_2} \times 1k\Omega$

$V_t = 201\,k\Omega\, I_t$ & $\boxed{R_{AB} = 201\,k\Omega}$

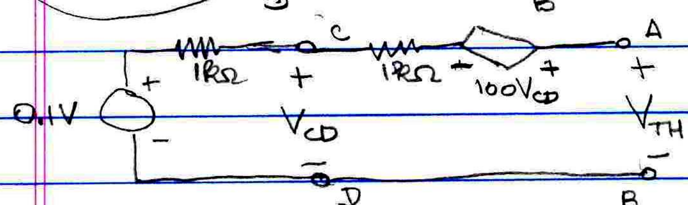
PROBLEM 2

To obtain a Thévenin equivalent we must evaluate 2 of the following: V_{TH}, the open-circuit voltage; I_{SC}, the short-circuit current; R_{TH}, the resistance seen at the terminals in question. In this example, V_{TH} and I_{SC} will be evaluated, with $R_{TH} = V_{TH}/I_{SC}$.

WARNING: With a controlled source in the circuit, in general, one cannot use series/parallel reductions to get R_{TH}



Convert the encircled 0.1mA current source in parallel with 1kΩ to its voltage source equivalent



No current exists so

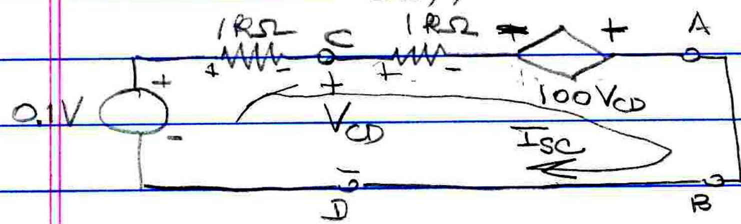
$V_{TH} = +100V_{CD} + 0.1$

$V_{CD} = 0.1$ so $V_{TH} = +100 \times 0.1 + 0.1$

$\boxed{V_{TH} = 10.1\,V}$

PROBLEM 2 (continued)

To obtain I_{SC}, short terminals A–B as shown



KVL is

(1) $-0.1 + I_{SC}\times 1 + I_{SC}\times 1 - 100V_{CD} = 0$

where I_{SC} is in mA

($1mA \times 1k\Omega = 1V$)

(2) $V_{CD} = -1\cdot I_{SC} + 0.1$

Substitute (2) into (1) and solve for I_{SC} which yields

$I_{SC} = 10.1/102$. $R_{TH} = V_{TH}/I_{SC} = 10.1/(10.1/102)$ & $\boxed{R_{TH} = 102\,\Omega}$

PROBLEM 3

A) The balance condition for the Wheatstone bridge is obtained by calculation V_A and V_B with respect to ground. Each is a simple voltage divider.

$$V_A = \frac{R_2}{R_1+R_2}V_{CC} \qquad V_B = \frac{R_4}{R_3+R_4}V_{CC}$$

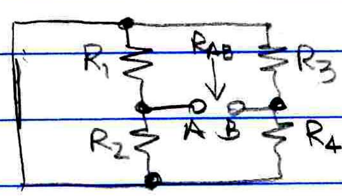
$$V_{AB} = V_A - V_B = V_{CC}\left[\frac{R_2}{R_1+R_2} - \frac{R_4}{R_3+R_4}\right] = V_{CC}\left[\frac{R_2(R_3+R_4) - R_4(R_1+R_2)}{(R_1+R_2)(R_3+R_4)}\right]$$

$$V_{AB} = V_{CC}\left[\frac{R_2R_3 - R_1R_4}{(R_1+R_2)(R_3+R_4)}\right]$$

$V_{AB} = 0$ when $R_2R_3 - R_1R_4 = 0$

or $R_2R_3 = R_1R_4$ or $\boxed{\frac{R_1}{R_2} = \frac{R_3}{R_4}}$

B) To calculate R_{AB} we must suppress the <u>independent</u> source in the circuit. Thus,

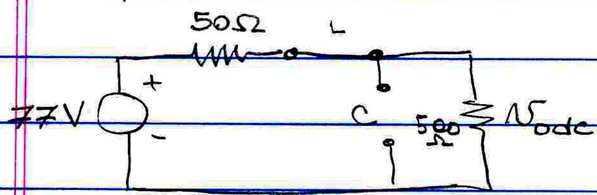


Note R_1 is in parallel with R_2 and R_3 is in parallel with R_4. These combinations are in series so

$$\boxed{R_{AB} = (R_1 \| R_2) + (R_3 \| R_4)}$$

PROBLEM 4

With two excitations, one dc and one ac, we must use superposition. For the dc excitation, the circuit is

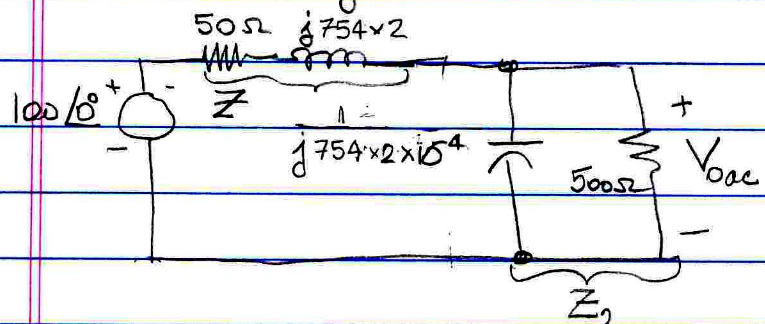


Recall that in the dc steady-state inductances are short circuits and capacitances are open circuits

The circuit is a simple voltage divider so

$v_{odc} = \frac{500}{50+500} \times 77$ and $v_{odc} = 70V$

For the ac circuit we use phasor analysis in which L becomes $j\omega L$ and C becomes $1/j\omega C$. The circuit is



$Z_1 = 50 + j1508$

$Z_2 = 500 \| \left(\frac{1}{j754\times2\times10^{-4}}\right)$

$Z_2 = 500 \| -j6.33 = 6.63\angle{-89.24°}$

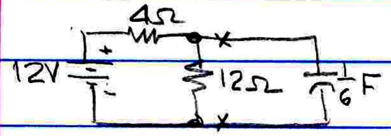
$= 0.088 - j$

$V_{oac} = \frac{6.63\angle{-89.24°} \times 100}{50 + j1508 + 0.088 - j6.63} = \frac{663\angle{-89.24°}}{1502\angle{88.09}} = 0.441\angle{-177.3°}$

$\therefore v_{oac} = 0.441\cos(754t - 177.3°)$

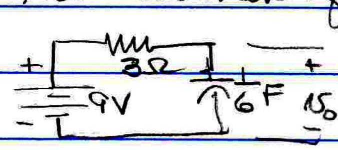
$$\boxed{v_o(t) = v_{odc} + v_{oac} = 70 + 0.441\cos(754t - 177.3°)}$$

PROBLEM 5



Circuit for $t \geq 0$

Get Thèvenin equivalent to the left of x–x



$R_{TH} = 4 \| 12 = 3\Omega$

$V_{TH} = \frac{12}{12+4} \times 12 = 9V$

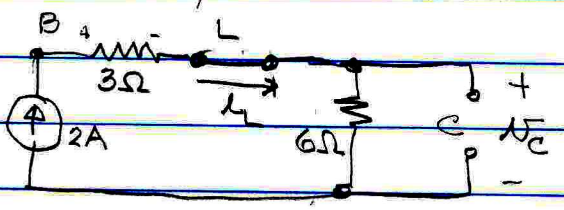
We know v_o starts at zero and charges to 9V with a time constant $= 3 \times \frac{1}{6} = \frac{1}{2}$

$$\therefore \boxed{v_o(t) = 9(1 - e^{-t/\frac{1}{2}}) = 9(1 - e^{-2t})}$$

PROBLEM 6

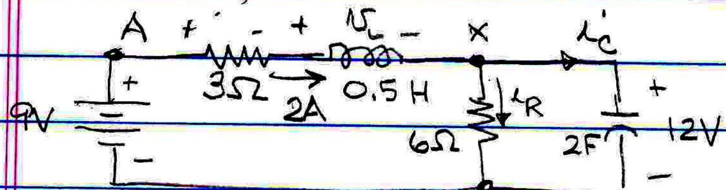
The key to this problem are the continuity relations for inductance current and capacitance voltage. These are that the current in an inductance and the voltage across a capacitance cannot change instantaneously. Thus, a change in excitation or circuit configuration at $t=T$ requires $i_L(T^+) = i_L(T^-)$ and $v_C(T^+) = v_C(T^-)$ where T^- is the instant before and T^+ is the instant just after the change occurs.

At $t=0^-$, the circuit is in the dc steady state and is



Thus, $i_L(0^-) = 2A$ and $v_C(0^-) = 6 \times 2 = +12V$

At $t=0^+$, the circuit becomes



$\boxed{\begin{array}{l} i_L(0^+) = i_L(0^-) = 2A \\ v_C(0^+) = v_C(0^-) = 12V \end{array}}$

$i_R = 12/6 = 2$ and KCL @ X gives

$-2 + i_R + i_C = 0$ and $\boxed{i_C = 2-2 = 0}$

KVL requires $-9 + 2\times3 + v_L + 12 = 0$ and $\boxed{v_L(0^+) = -9V}$