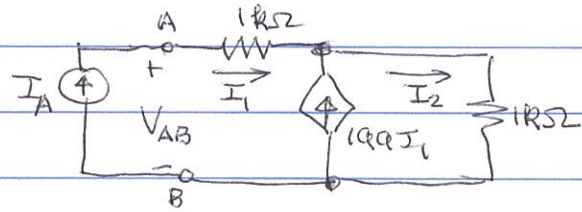
EECE 2412 REVIEW PROBLEM SOLUTIONS Sp '16 #1 1

PROBLEM 1

Equivalent resistance is $R_{AB} = V_{AB}/I_A$. Apply a current source I_A and measure V_{AB}

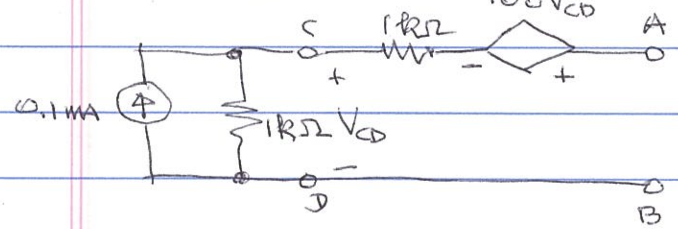


$I_1 = I_A \quad I_2 = I_1 + 199 I_1 = 200 I_1 = 200 I_A$

$V_{AB} = 1k\Omega \times I_A + 1k\Omega \times 200 I_A$

$\boxed{R_{AB} = \frac{V_{AB}}{I_A} = 1k\Omega + 200k\Omega = 201 k\Omega}$

PROBLEM 2



$V_{TH} = V_{AB}$ when A−B open-circuited.

No current exists from C to A

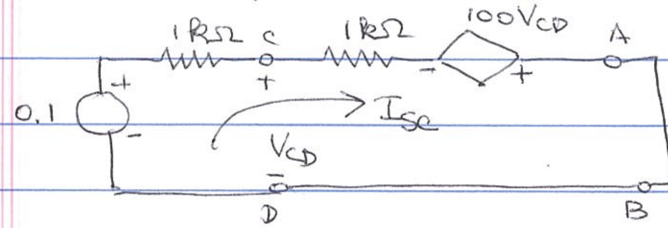
$\therefore V_{CD} = 0.1mA \times 1k\Omega = 0.1V$

$V_{AB} = \overbrace{100 \times 0.1}^{V_{AC}} + \overbrace{0.1}^{V_{CD}} = \boxed{V_{TH} = 10.1V}$

To find R_{TH} we can either find I_{SC} ($I_{SC} = I_{AB}$ when A−B short-circuited) and $R_{TH} = V_{TH}/I_{SC}$

or suppress 0.1mA and apply a current I_A and measure V_{AB} as in Problem I.

First find I_{SC}. Convert 0.1mA ∥ 1kΩ to 0.1V in series with 1kΩ as shown



KVL: $-0.1 + I_{SC}(1k + 1k) - 100V_{CD} = 0$

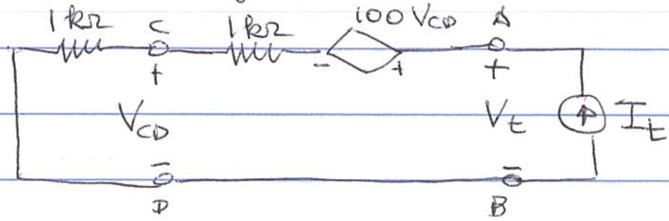
$V_{CD} = -I_{SC}(1k) + 0.1$

$\therefore -0.1 + I_{SC}(2k) - 100(-1k\, I_S + 0.1) = 0$

and $102k\, I_{SC} = 10.1$ and $I_{SC} = 10.1/102k$

$R_{TH} = 10.1 / 10.1/102k\Omega$ and $\boxed{R_{TH} = 102 k\Omega}$

Second, apply I_A with the independent source suppressed.



$V_t = 100V_{CD} + I_t(1k + 1k)$; $V_{CD} = 1k \times I_t$ so that

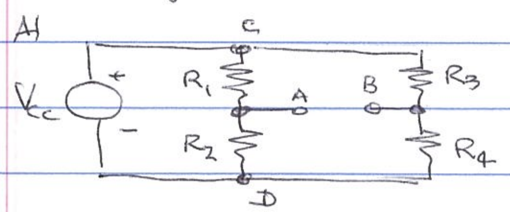
$V_t = 100(1k)I_t + 2k\,I_t$ & $R_{AB} = R_{TH} = V_t/I_t = 100k + 2k$

& $\boxed{R_{TH} = 102k\Omega}$ as before

PROBLEM III

The Wheatstone bridge shown is a widely used circuit in many sensors and instrumentation circuits. It is basically a pair of voltage dividers where V_{AB} is the difference voltage between the two dividers

A)



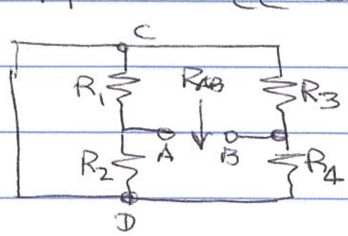
$V_{AB} = V_{AD} - V_{BD}$

$V_{AD} = \frac{R_2}{R_1+R_2}V_{CC} = \frac{1}{1+(R_1/R_2)}V_{CC}$

$V_{BD} = \frac{R_4}{R_3+R_4}V_{CC} = \frac{1}{1+(R_3/R_4)}V_{CC}$

$V_{AB} = \frac{V_{CC}}{1+(R_1/R_2)} - \frac{V_{CC}}{1+(R_3/R_4)}$ $\boxed{V_{AB} = 0 \text{ when } \frac{R_1}{R_2} = \frac{R_3}{R_4}}$

B) Suppress V_{CC} and the circuit becomes



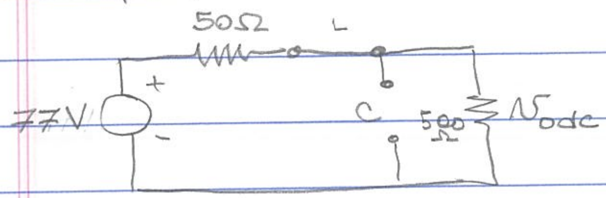
C and D are the same so $R_1 \| R_2$ and $R_3 \| R_4$. These combinations are in series

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

$R_{AB} = (4 \| 12) + (2 \| 6) = 3 + 1.5$ and $\boxed{R_{AB} = 4.5\Omega}$

PROBLEM 4

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

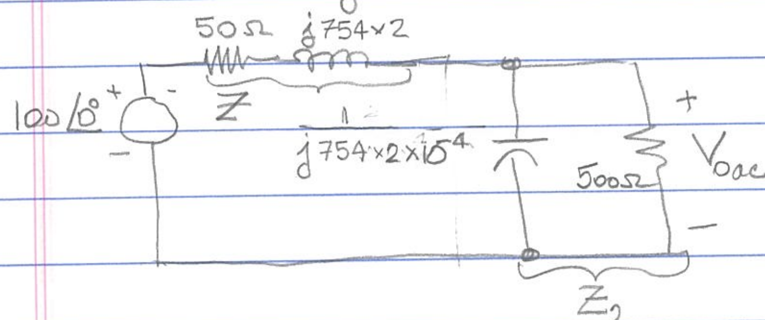


Recall that in the dc steady-state inductances are short circuits and capacitances are open circuits

The circuit is a simple voltage divider so

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

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



$Z_1 = 50 + j1508$

$Z_2 = 500 \| \left(\frac{1}{j754\times 2\times 10^{-4}}\right)$

$Z_2 = 500 \| -j6.33 = 6.63\angle -89.24^\circ$

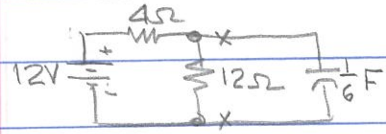
$= 0.088 - j6.63$

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

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

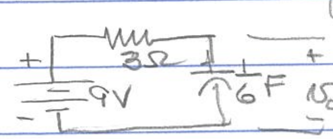
$$\boxed{v_o(t) = v_{odc} + v_{oac} = 70 + 0.441\cos(754t - 177.3^\circ)}$$

PROBLEM 5



Circuit for $t \geq 0$

Get Thèvenin equivalent to the left of x–x



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

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

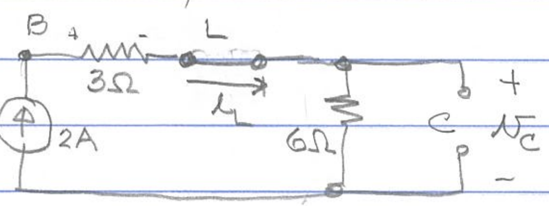
We know v_o starts at zero and charges to 9V with a time constant $= 3 \times \frac{1}{6}$

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

PROBLEM 6

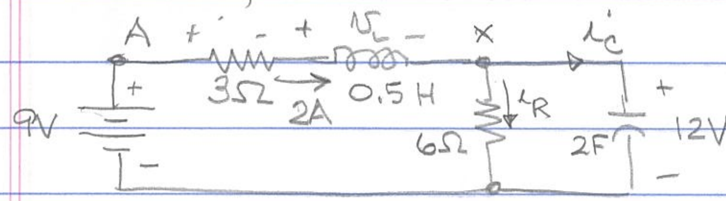
The key to this problem are the continuity relations for inductance current and capacitance voltage. These are that the current in an inductance and the voltage across a capacitance cannot change instantaneously. Thus, a change in excitation or circuit configuration at $t=T$ requires $i_L(T^+) = i_L(T^-)$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



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

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

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

KVL requires $-9 + 2\times 3 + v_L + 12 = 0$ and $\boxed{v_L(0^+) = -9V}$