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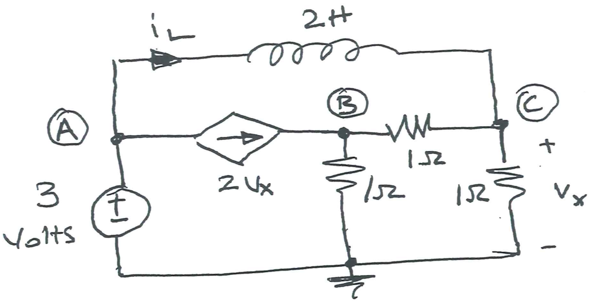
EEE 202 CIRCUIT THEORY
Second Midterm, Spring 2013-14

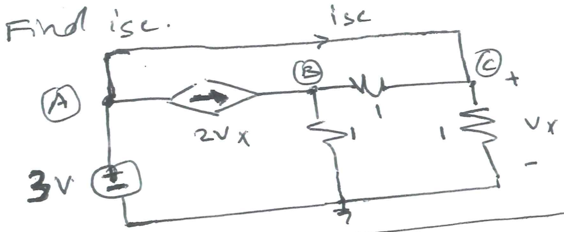
No credits will be given for unjustified answers. **Good luck.**

Prob. 1 : (30 pt.s)

i : Consider the following circuit. Let $i_L(0) = 1$ Amps. Find $i_L(t)$ and $v_x(t)$.



Find isc.



Ⓐ $V_A = V_C = 3$

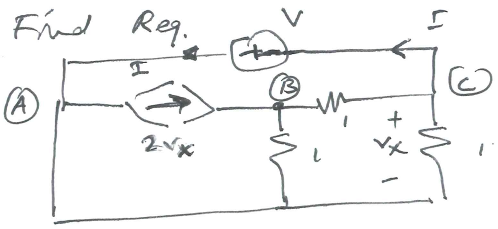
Ⓑ $\Rightarrow 2V_x = 2V_B - V_C$

$6 = 2V_B - 3$

$V_B = 9/2$ V.

Ⓒ $\Rightarrow$ $\boxed{i_{sc} = 2V_C - V_B = 6 - \frac{9}{2} = \frac{3}{2} \text{ A.}}$ (04)

Find Req.



$V_A = 0$ $V_C = -V = V_x$

Ⓑ $\Rightarrow$ $2V_x = 2V_B - V_C \Rightarrow -3V = 2V_B \Rightarrow \boxed{V_B = -\frac{3}{2}V}$

Ⓒ $I + 2V_C - V_B = 0 \Rightarrow I - 2V + \frac{3}{2}V = 0 \Rightarrow I = (2 - \frac{3}{2})V$

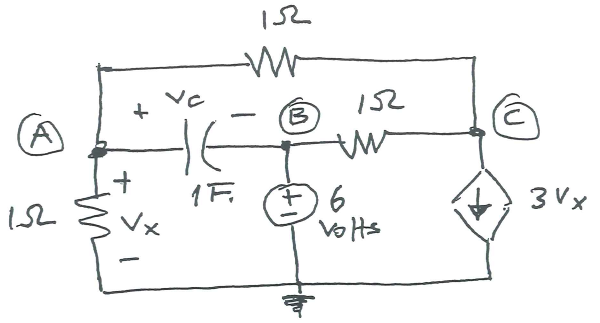
$\boxed{I = \frac{1}{2}V}$ (04)

$\boxed{R_{eq} = \frac{V}{I} = 2\Omega}$ (04)

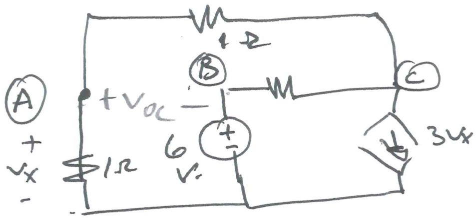
$\Rightarrow \tau = \frac{L_{eq}}{R_{eq}} = 1\text{sec.}$ $\Rightarrow i_L(t) - \frac{3}{2} = \left[1 - \frac{3}{2}\right] e^{-t} \Rightarrow$ $\boxed{i_L(t) = \frac{3}{2} - \frac{1}{2} e^{-t} \text{ Amp.}}$

$\Rightarrow v_L = L \frac{di_L}{dt} = 2 \cdot (-\frac{1}{2} \cdot (-1)) e^{-t} = e^{-t}$ V. $\Rightarrow 3 = V_L + V_x \Rightarrow$ $\boxed{V_x = 3 - V_L = 3 - e^{-t} \text{ V.}}$ (03)

ii : Consider the following circuit. Let $v_C(0) = 1$ Volts. Find $v_C(t)$ and $v_x(t)$.



Find Voc



(A) $\Rightarrow V_A = \frac{V_C}{2}$

(B) $\rightarrow V_B = 6$

(C) $3V_A + \frac{V_C}{2} + (V_C - 6) = 0$

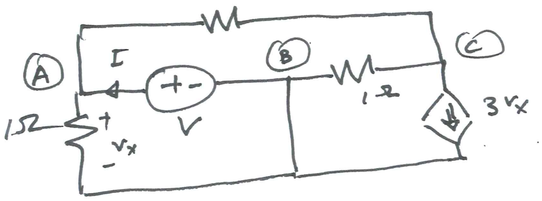
$\frac{3}{2}V_C + \frac{V_C}{2} + V_C - 6 = 0$

$\boxed{V_C = 2V}$

$\Rightarrow V_A = 1V = \frac{V_C}{2}$

$\Rightarrow \boxed{V_{OC} = V_A - 6 = -5V.}$ (04)

Find Req.



$V_B = 0$, $V_A = V$. , (C) $V_C + 3V_A + (V_C - V_A) = 0$

$V_x = V_A$

$\boxed{V_C = -V_A = -V}$ (04)

(A) $(V_C - V_A) + I = V_A$

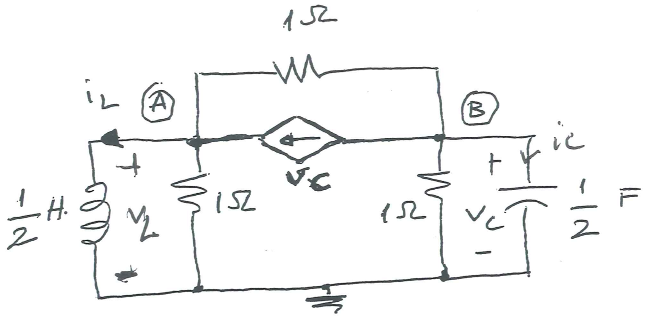
$\Rightarrow -V - V + I = V \Rightarrow I = 3V \Rightarrow \boxed{R_{eq} = \frac{V}{I} = \frac{1}{3}\Omega}$

$\Rightarrow \tau = R_{eq}C = \frac{1}{3}$ sec

$\Rightarrow V_C(t) + 5 = [1 + 5]e^{-3t} \Rightarrow \boxed{V_C(t) = -5 + 6e^{-3t} \text{ Volts}}$ (04)

$V_x = V_C + 6 \Rightarrow \boxed{V_x = 1 + 6e^{-3t} \text{ volts.}}$ (03)

Prob. 2 : (20 pt.s) Consider the following circuit. Let $v_C(0) = 1$ Volts and $i_L(0) = 1$ Amps. Find $v_C(t)$.



01

$\boxed{V_B = V_C}$ $\boxed{V_A = V_L}$

(B) $i_C + V_C + V_C + V_C - V_A = 0 \Rightarrow \boxed{i_C + 3V_C - V_L = 0}$

(A) $i_L + V_A + V_A - V_B - V_B = 0$ $\boxed{i_L + 2V_L - 2V_C = 0}$ 01

$\Rightarrow \boxed{V_L = V_C - \frac{1}{2} i_L}$ 01 $\Rightarrow \boxed{\frac{1}{2}\dot{i}_L = V_C - \frac{1}{2} i_L}$

$\Rightarrow \boxed{\dot{i}_L = 2V_C - i_L}$ (1) 02

$\rightarrow i_C + 3V_C - (V_C - \frac{1}{2} i_L) = 0 \Rightarrow \boxed{i_C = -2V_C - \frac{1}{2} i_L} \Rightarrow \boxed{\frac{1}{2}\dot{V}_C = -2V_C - \frac{1}{2} i_L}$

$\Rightarrow \boxed{\dot{V}_C = -4V_C - i_L}$ (2) 02

$$(1) \& (2) \Rightarrow \begin{bmatrix} \dot{V}_C \\ \dot{i}_L \end{bmatrix} = \begin{bmatrix} -4 & -1 \\ 2 & -1 \end{bmatrix} \begin{bmatrix} V_C \\ i_L \end{bmatrix} \Rightarrow \boxed{\ddot{V}_C + 5\dot{V}_C + 6V_C = 0}$$ 03

$\boxed{V_C(0) = 1 \qquad \dot{V}_C(0) = -4 - 1 = -5}$ 02

$\Rightarrow \boxed{s^2 + 5s + 6 = 0}$ 02 $\Rightarrow \boxed{\begin{matrix} s_1 = -2 \\ s_2 = -3 \end{matrix}}$

$\Rightarrow \boxed{V_C(t) = C_1 e^{-2t} + C_2 e^{-3t}}$ 02 $\rightarrow \boxed{\begin{matrix} C_1 + C_2 = 1 \\ -2C_1 - 3C_2 = -5 \end{matrix}}$ 02

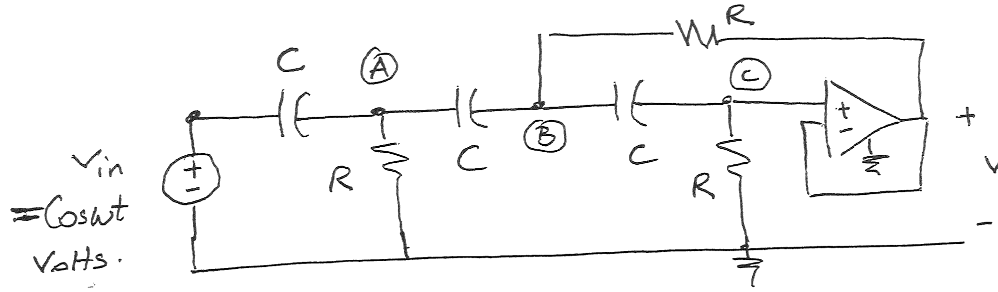
$C_1 = -2 \qquad C_2 = 3$

$\Rightarrow \boxed{V_C(t) = -2e^{-2t} + 3e^{-3t}}$ 02

Prob. 3 : (24 pt.s) Consider the following circuit. Assume that the op-amp is linear and operates in the linear region. Assume that the circuit is in sinusoidal steady state.

i : Find the transfer function $H(\jmath\omega) = \frac{V_o}{V_{in}}$.

ii : Let $R = 1\ \Omega$ and $C = 1$ F, $\omega = 1\ rad/sec$. Find $v_o(t)$.



$V_{in} = \cos\omega t$ Volts

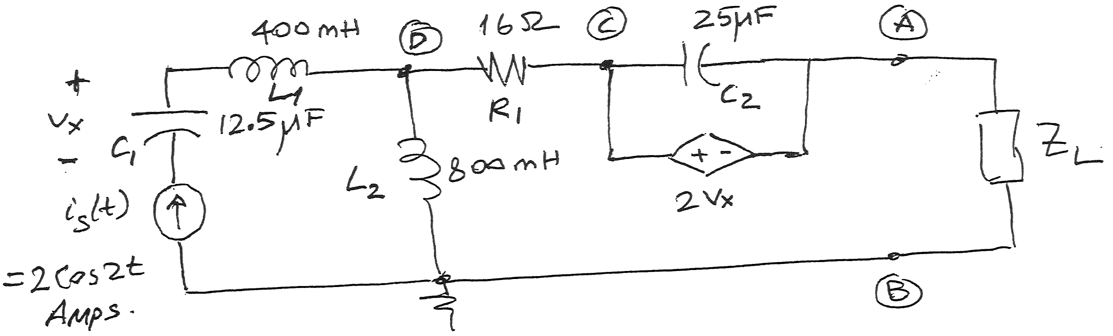
Prob. 4 : (26 pt.s) Consider the following circuit. Assume that the circuit is in sinusoidal steady state. Here Z_L represents an arbitrary load impedance.

i : Draw the circuit in sinusoidal steady state by using the phasor values of $i_s(t)$ and indicate the impedance values of all relevant elements.

ii : Assume that Z_L is replaced by an open circuit. Find the open circuit voltage phasor V_{TH} between the nodes $A-B$, and evaluate $v_{TH}(t)$.

iii : Assume that Z_L is replaced by a short circuit. Find the short circuit current phasor I_N between the nodes $A-B$, and evaluate $i_N(t)$.

iv : Find an impedance Z_L so that the power transferred to the load is maximum.



$i_s(t) = 2\cos 2t$ AMPS