ECSE-200 Electric Circuits 1 - Quiz #12 (April 12, 2019)

LAST NAME SOLUTIONS **MCGILL ID#** ____________

FIRST NAME ____________ **SIGNATURE** ____________

- ***Only Faculty standard calculator accepted***
- ***No cellphone allowed***
- ***Show all your work***
- ***Clearly indicate your final answer with the SI unit and multiplier***
- ***You have 45 minutes to complete this quiz***

Question 1: Consider the circuit shown. The circuit is in dc steady state for $t < 0$ with the inductor storing zero energy. Answer the following questions.

a) Plot $v_s(t)$ as a function of time *t* if $v_s(t) = 5V \cdot u(t)$ where $u(t)$ is the unit step function. [1 pt]

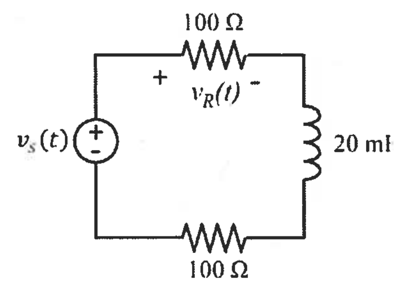
b) Plot $v_s(t)$ as a function of time *t* if $v_s(t) = 5V \cdot u(t) - 5V \cdot u(t - 200\mu s)$. [1 pt]

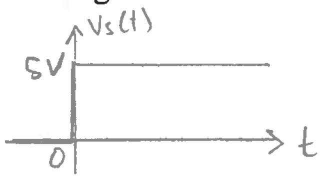
For the following questions, assume $v_s(t) = 5V \cdot u(t) - 5V \cdot u(t - 200\mu s)$.

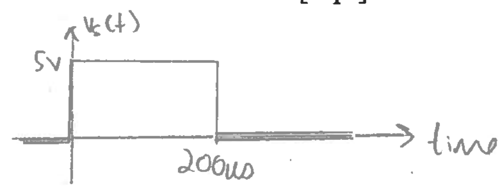
c) Solve for the voltage $v_R(t)$ for $0 < t < 200\ \mu s$. [2 pt]

d) Solve for the voltage $v_R(t)$ for $t > 200\ \mu s$. [2 pt]

e) Plot the voltage $v_R(t)$ versus time *t*. Clearly indicate the initial and final voltage values for each interval and the time constants. [2 pt]



a) 

b) 

c) $V_R(t) = 100 \cdot i_L(t)$ $\quad t<0 \Rightarrow v_s(t) = 0V \rightarrow i_L(0^-) = 0A \rightarrow i_L(0^+) = 0A$

$t \to \infty \Rightarrow v_s(t) = 5V$ (anticipated value) $\rightarrow i_L(\infty) = \frac{5V}{200\Omega} = 25mA$

$\tau = L/R_T = \frac{20mH}{200\Omega} = 100\mu s$ $\quad \therefore i_L(t) = 25 - 25e^{-t/100\mu s}$ mA $0<t<200\mu s$

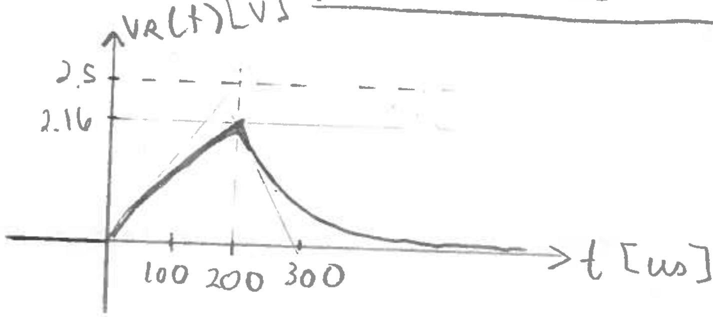
$\boxed{V_R(t) = 2.5 - 2.5e^{-t/100\mu s},\ 0<t<200\mu s}$

d) $i_L(t_0^-) = i_L(t_0^+) = i_L(200\mu s) = 25 - 25e^{-200/100} = 21.62\ mA$

$i_L(\infty) = 0A$

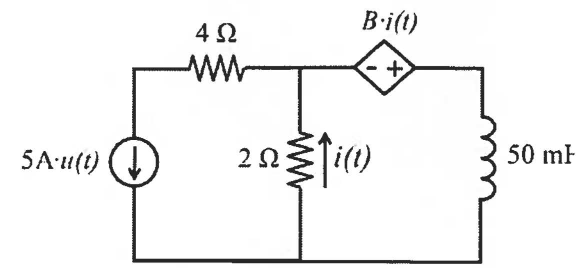
$i_L(t) = 21.62\, e^{-(t-200\mu s)/100\mu s}$ mA, $t > 200\mu s$

$\boxed{V_R(t) = 2.16\, e^{-(t-200\mu s)/100\mu s}\ V,\ t \geq 200\mu s}$

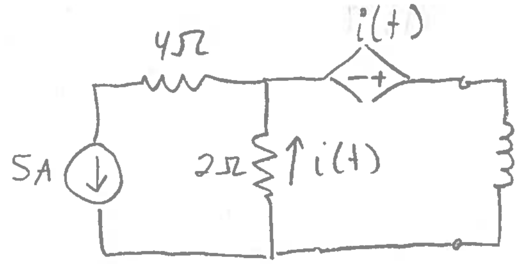
e) 

Question 2: Consider the circuit shown. $u(t)$ is the unit step function and the current-controlled voltage source has a gain of B. The circuit is in dc steady state at $t < 0\ s$. Answer the following questions.

a) Determine if the circuit is stable for $t > 0\ s$ if B = 1 V/A. [2 pt]
b) Determine the value of the gain B of the dependent source for which the stability condition will change at $t > 0\ s$. [2 pt]



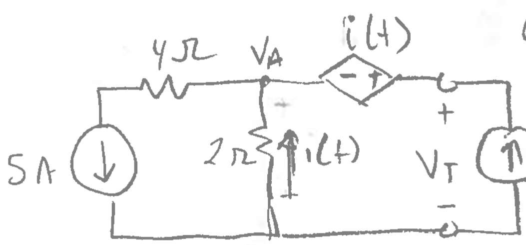
a) $t > 0$



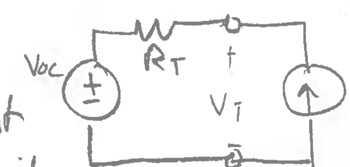
Stability if $\tau > 0 \rightarrow \frac{L}{R_T} \geq 0 \quad \therefore R_T \geq 0$

$R_T = \frac{V_{oc}}{i_{sc}}$ or $R_T = \frac{V_T}{i_T}$ (more straightforward to find R_T)

$i_T \Rightarrow$ test source replacing inductance



$\Longleftrightarrow$ equivalent Th. circuit



$R_T = \frac{V_T}{i_T}$ when Voc src is off.

KVL $\quad -V_A - i + V_T = 0$

$V_T = V_A + i = -2i + i = -i \quad \underline{V_T = -i}$

KCL @ VA: $\quad 5 - i - i_T = 0$

$\underline{i = 5 - i_T} \rightarrow \quad +V_T = -5 + i_T$

if $i_T = 1A \rightarrow V_T = -4V$

$R_T < 0$

$\boxed{\text{unstable}}$

b) Using PS #13 approach, turning off current src (open) and use test src

KVL: $\quad 2i(t) - Bi(t) + V_T = 0$

$V_T = i(t)(B-2) \qquad i(t) = -i_T$

$V_T = -i_T(B-2)$

$R_T = \frac{V_T}{i_t} = 2 - B = 0$ when stability changes

$\boxed{B = 2}$