Physics 2220
Spring 2004
George A. Williams

FIFTH MIDTERM

3

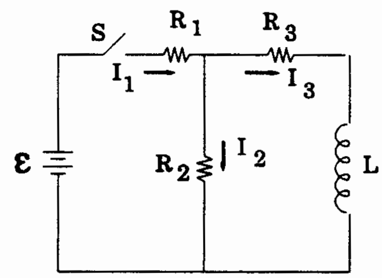
Name:________________________________

Discussion Instructor (circle): Billeter Blake Gillman Herring

Student ID #:______________________

SHOW ALL WORK!!!!!
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

In the circuit shown the switch is closed at t = 0 after being open for a long time.



5 (a) Find the current in the inductor at $t = \infty$.

5 (b) Calculate the current in the inductor after 1.25 time constants have elapsed from t = 0.

5 (c) The switch is opened after being closed for 1.25 time constants in (a). Calculate the time constant for the decay of the current in the inductor.

10 (d) Calculate the time constant for the growth of the current in the inductor with the switch closed. You **must** develop the differential equation governing the current as function of time. For convenience in grading use the branch current labels and directions given in the drawing. No shortcuts from other classes.

$\varepsilon = 225$ V, $R_1 = 7{,}500\ \Omega$, $R_2 = 12{,}500\ \Omega$, $R_3 = 12{,}500\ \Omega$, $L = 5.35$ mH

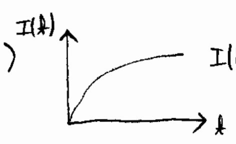
(a) $t=\infty$ inductor acts like a wire

$R_{23} = \dfrac{R_2R_3}{R_2+R_3} = 6250$, $R_{eq} = R_1 + R_{23} = 13750$, $I = \dfrac{\varepsilon}{R_{eq}} = \dfrac{225}{13750} = 0.0164$

$V_{23} = I R_{23} = 0.0164 \times 6250 = 102.5$

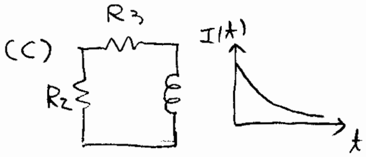
$\therefore I_3 = \dfrac{V_{23}}{R_3} = \dfrac{102.5}{12500} = 0.0082\text{ A} = \underline{8.2\times10^{-3}\text{A}}$

(b)



$I(1.25) = I_\infty(1-e^{-1.25}) = (8.2\times10^{-3})(1-e^{-1.25}) = \underline{5.84\times10^{-3}\text{A}}$

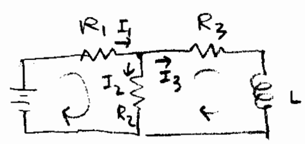
(c)



$-I_3R_3 - I_3R_2 + \varepsilon_L = 0$

$\dfrac{dI_3}{dt} + \dfrac{I_3}{L}(R_2+R_3) = 0$ $\therefore \tau = \dfrac{L}{R_2+R_3} = \dfrac{5.35\text{mH}}{25000\Omega} = \underline{2.14\times10^{-7}\text{ s}}$

(d)



$\varepsilon_0 - I_1R_1 - I_2R_2 = 0$

$-I_3R_3 + L\dfrac{dI_3}{dt} + I_2R_2 = 0$

$I_1 = I_2 + I_3$

$\dfrac{dI_3}{dt} - \dfrac{1}{L}\left(R_3 + \dfrac{R_1R_2}{R_1+R_2}\right)I_3 = -\dfrac{\varepsilon_0 R_2}{(R_1+R_2)}\cdot\dfrac{1}{L}$ $\therefore \tau = \dfrac{L}{\dfrac{R_1R_2}{R_1+R_2}+R_3} = \underline{3.11\times10^{-7}\text{ s}}$