Physics 2220
Spring 2001
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SIXTH MIDTERM

4

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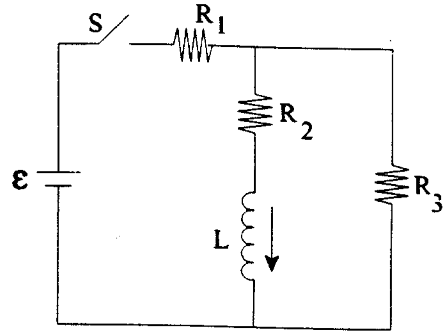
Discussion Section # ____________ Student ID #: ____________

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.



(a) At $t = 0$, what is the current in R_2?
(b) Calculate the current in R_3 at $t = \infty$.
(c) Find the current in the inductance at $t = 1.2$ time constants.
(d) Calculate completely, using loops and junctions as done in class (no short cuts), the time constant for the current in the inductance with the switch closed and give a numerical value for this quantity.

$\varepsilon = 175$ V; $R_1 = 200\ \Omega$; $R_2 = 350\ \Omega$; $R_3 = 250\ \Omega$; $L = 7.80\ \mu$H

a) $I_2(t=0) = 0$

b) $I_3 = \frac{U_3}{R_3}$; $U_3 = \mathcal{E} - U_1$; $U_1 = I_1 R_1 = \frac{\mathcal{E} R_1}{R_1 + \frac{R_2 \cdot R_3}{R_2 + R_3}}$ $\Rightarrow I_3 = \frac{\mathcal{E}}{R_3}\left(1 - \frac{R_1}{R_1 + \frac{R_2 R_3}{R_2+R_3}}\right) \simeq 0.3 A$

c) $I_2(t) = I_\infty\left(1 - e^{-\frac{t}{\tau}}\right)$; $I_\infty = \frac{U_2}{R_2} = \frac{I_3 R_3}{R_2} = \frac{\mathcal{E}}{R_2}\left(1 - \frac{R_1}{R_1 + \frac{R_2 R_3}{R_2+R_3}}\right) \simeq 0.21 A$

$I_2(t = 1.2\tau) = 0.21\cdot\left(1 - e^{-1.2}\right) \simeq 0.15 A$

d) Have the following equations:

$$\left.\begin{aligned} -I_3 R_3 + I_2 R_2 + L\frac{dI_2}{dt} &= 0 \\ I_1 R_1 + I_3 R_3 &= \mathcal{E} \\ I_1 &= I_2 + I_3 \end{aligned}\right\}$$

$$I_3 = \frac{\mathcal{E} - I_2 R_1}{R_1 + R_3}$$

$$\frac{I_2 R_1 - \mathcal{E}}{R_1 + R_3} R_3 + I_2 R_2 + L\frac{dI_2}{dt} = 0$$

or $+I_1 R_1 + I_2 R_2 + L\frac{dI_2}{dt} = \mathcal{E}$ instead of any of the first two

or $I_2\left(\frac{R_1 R_3}{R_1 + R_3} + R_2\right) + L\frac{dI_2}{dt} = A = \text{const}$

or $\frac{dI_2}{dt} + \frac{I_2}{L\frac{R_1+R_3}{R_1R_2 + R_1R_3 + R_2R_3}} = B = \text{const}$

from which $\tau = L\frac{R_1 + R_3}{R_1R_2 + R_1R_3 + R_2R_3} \simeq 1.7\times10^{-8}$ sec.