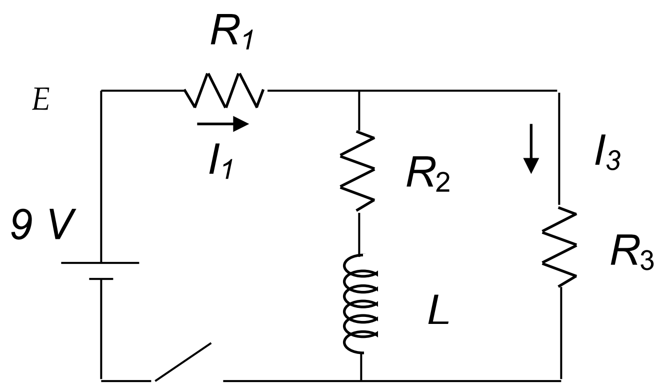
Name ______________________________ Section _______ **P212: Quiz for Week 10**

The circuit shown below consists of a 9 V battery, three resistors, an ideal inductor and a switch. Assume that the switch has been open for a long time.



$R_1 = 30\ \Omega$
$R_2 = 100\ \Omega$
$R_3 = 150\ \Omega$
$L = 0.02$ H

1). The switch is now closed at $t = 0$. Immediately afterwards, what is the current I_3 flowing through resistor R_3? [5]

At t=0, no current flows through the inductor. So all the current flows through R_1 and R_3. The current through R_3 is therefore:

$I = V/R_{13} = V/(R_1+R_3) = (9V)/(30+150 \text{ ohms})$

I = 50 mA

(2) Understanding that no current flows through inductor at t=0
(2) Correct set-up of problem
(1) Correct numerical answer

2). A very long time after the switch has been closed, what is the voltage drop across the inductor? [3]

After a long time, the current through inductor has stabilized, so dI/dt = 0. Therefore:

$\mathbf{\Delta V_L = L\, dI/dt = 0}$

(2) Understanding that current stabilizes after a long time, so that dI/dt = 0
(1) Correct numerical answer

3). A very long time after the switch has been closed, what is the current I_1 through R_1? [7]

After a very long time, the inductor offers no resistance to current flow because the current has stabilized. So what we need to do is find the total resistance of the circuit by adding up the individual resistors, then solve for $I = V/R_{tot}$.

R_2 and R_3 add in parallel to give:
$R_{23} = R_2R_3/(R_2+R_3) = (100*150)/(100+150) = 60$ ohms

Then R_1 adds in series with R_{23} to give:
$R_{tot} = R_1+R_{23} = 30+60 = 90$ ohms

$I = V/R_{tot} = (9\ V)/(90\ ohms)$
I = 100 mA

(3) Realizing that inductor offers no resistance to current after a long time
(2) Correctly adding individual resistors to get total circuit resistance
(2) Correct numerical answer

4). The switch is now suddenly opened. How long after opening the switch does it take for the current through the inductor to reach 1/e of its value just before the switch is opened? [5]

The time constant is L/R_{tot}, so we just need to find R_{tot}.
R_2 and R_3 add in series to give R_{tot}=100+150 ohms = 250 ohms.
Time constant $\tau = L/R_{tot} = 0.02$ H / 250 ohms

$\tau = 80\ \mu s$

(2) Understanding that $\tau = L/R_{tot}$
(2) Correct calculation of R_{tot}
(1) Correct numerical answer