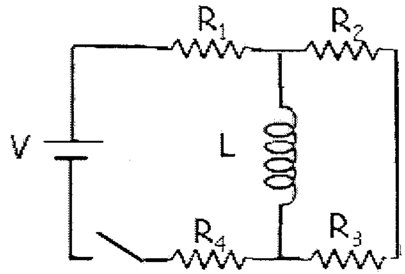
HW 18

The next six questions pertain to the situation described below.



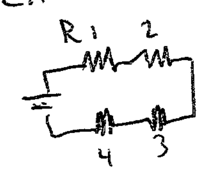
A circuit is constructed with four resistors, one inductor, one battery and a switch as shown. The values for the resistors are: $R_1 = R_2 = 73\ \Omega$, $R_3 = 62\ \Omega$ and $R_4 = 100\ \Omega$. The inductance is $L = 560$ mH and the battery voltage is $V = 24$ V.

1)The switch has been open for a long time when at time $t = 0$, the switch is closed. What is $I_1(0)$, the magnitude of the current through the resistor R_1 just after the switch is closed?

✓0.0779220779220779 A

Inductor resists change in current, so current through $L = 0$

circuit is effectively this:



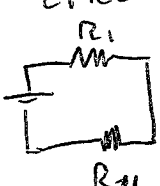
so $I = \frac{V}{R_{total}} = \frac{24\ V}{73+73+62+100\ \Omega} = .0779\ A$

2)What is $I_1(\infty)$, the magnitude of the current that flows through the resistor R_1 a very long time after the switch has been closed?

✓0.138728323699422 A

Inductor after a long time acts as a wire (no resistance), so allows current to bypass R_2 and R_3

effective circuit:



$I = \frac{V}{R_1+R_4} = \frac{24}{73+100} = .139\ A$

3)What is $V_L(0)$, the magnitude of the voltage across the inductor just after the switch is closed?

✓10.5194805194805 V

Inductor is in parallel with R_2/R_3 segment, so $V_L = V_{R23}$

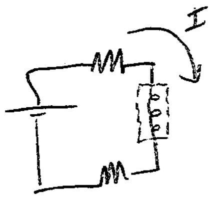
$V_{R23} = I\cdot(R_2+R_3) = (.0779\ A)(73+62\ \Omega)$

$V_L = V_{R23} = 10.5\ V$

4)What is $I_L(\infty)$, the magnitude of the current through the inductor after the switch has been closed for a very long time?

✓0.138728323699422 A

since it has 0 resitance, all current through R_1 goes through L (while 0 A goes through R_2 R_3)

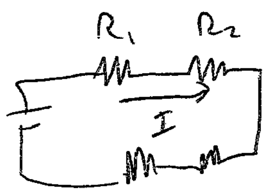


$I = .139$ A

5)What is $I_2(0)$, the magnitude of the current through the resistor R_2 just after the switch is closed?

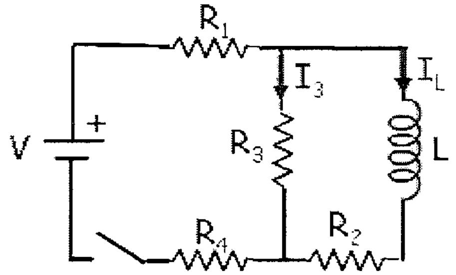
✓0.0779220779220779 A

Since no current goes through L, all current through R_1 goes through R_2



$I = .0779$ A

The next seven questions pertain to the situation described below.

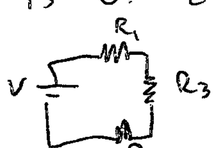


A circuit is constructed with four resistors, one inductor, one battery and a switch as shown. The values for the resistors are: $R_1 = R_2 = 40\ \Omega$, $R_3 = 63\ \Omega$ and $R_4 = 128\ \Omega$. The inductance is L = 365 mH and the battery voltage is V = 12 V. The positive terminal of the battery is indicated with a + sign.

7)The switch has been open for a long time when at time t = 0, the switch is closed. What is $I_4(0)$, the magnitude of the current through the resistor R_4 just after the switch is closed?

✓0.051948051948052 A

Inductor L resists change in ~~current~~ current, so I through L and R_2 is 0. effective circuit:



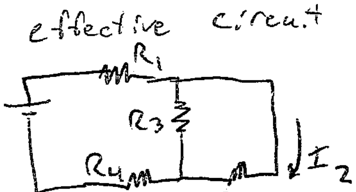
$$I = \frac{V}{R_1 + R_3 + R_4} = \frac{12\ V}{40 + 63 + 128\ \Omega} = .0519\ A$$

8)What is $I_4(\infty)$, the magnitude of the current through the resistor R_4 after the switch has been closed for a very long time?

✓0.0623486682808716 A

L ~~acts~~ acts as a wire (allows current)

effective circuit



$$R_{23} = \left[\frac{1}{R_2} + \frac{1}{R_3}\right]^{-1} = 24.5\ \Omega$$

$$R_{1234} = R_1 + R_{23} + R_4 = 192\ \Omega$$

$$I = \frac{V}{R_{1234}} = .0623\ A$$

9)What is $I_L(\infty)$, the magnitude of the current through the inductor after the switch has been closed for a very long time?

✓0.0381355932203389 A

Current through L is same through R_2 $\quad I_L = I_{R_2} = I_2$

$$I_2 = \frac{V_2}{R_2}$$

$$V_2 = V_{23} = I R_{23}$$

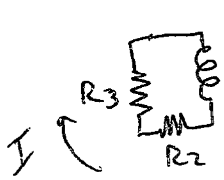
$$V_2 = (.0623 A)(24.5\Omega) = 1.5\ V$$

$$I_2 = \frac{1.5 V}{40\ \Omega} = .0381\ A$$

10)After the switch has been closed for a very long time, it is then opened. What is $I_3(t_{open})$, the current through the resistor R_3 at a time t_{open} = 6.7 ms after the switch was opened? The positive direction for the current is indicated in the figure.

✓-0.00575726836358363 A

circuit is now:



so negative

Current I through L remains the same due to inductor, so $I_{max} = I_0 = .0381$ A

for RL circuit decays $e^{-tR/L}$ $R = R_2 + R_3 = 103\,\Omega$

$I_3 = I_2 = I_L$

$I(t) = I_{max}\, e^{-tR/L}$

$I = (.0381)\, e^{-\frac{(.0067)(103)}{(.365)}}$

$= -.00576$ A

11)What is $V_{L,max}$(closed), the magnitude of the maximum voltage across the inductor during the time when the switch is closed?

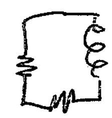
✓3.27272727272728 V

Voltage maximum ~~[illegible]~~ at $t=0$ when switch is ~~closed~~ opened. Current remains constant, but voltage changes (from 0 to new value). Voltage loop equation tells us that V_L must be equal to $V=IR$ across resistors.

$V_L = V_R = I(R_2+R_3)$

$= (.0381)(103\,\Omega)$

$= 3.93$ V



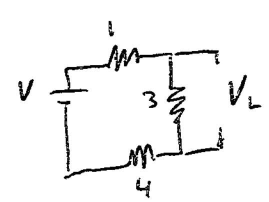
12)What is $V_{L,max}$(open), the magnitude of the maximum voltage across the inductor during the time when the switch is open?

✓3.92796610169491 V

Maximum voltage at $t=0$ when switch is closed. Voltage across $R_2 = 0$ (no current), so $V_L = V_{R_3}$ (in parallel).

$V_L = V_{R3} = I R_3 = (.0519)(63\,\Omega)$

$V_L = 3.27$ V



(I misread problem)

Switched answers

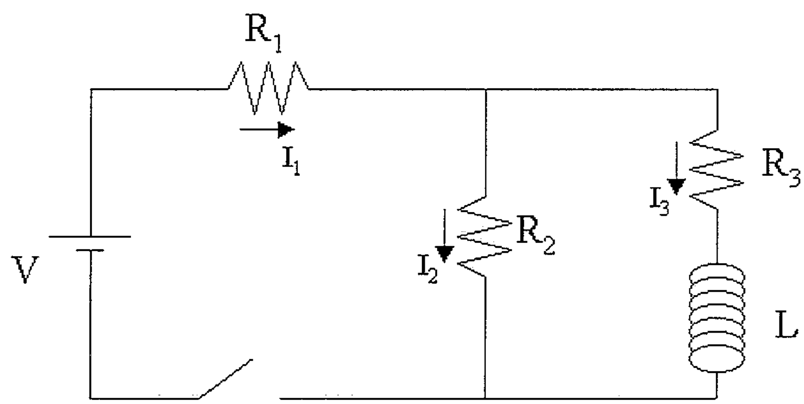
LR Time

LR TIME BASE

Welcome to this IE. You may navigate to any page you've seen already using the IE tab on the right.

Time Dependence of LR Circuit

Three resistors (R_1 = 120 Ohms, R_2 = 330 Ohms, and R_3 = 240 Ohms) and an ideal inductor (L = 1.6 mH) are connected to a battery (V = 9 V) through a switch as shown in the figure below.



The switch has been open for a long time before it is closed at t = 0. At what time t_0, does the current through the inductor (I_3) reach a value that is 63% of its maximum value? t_0 =

s Submit Graph

Help

Current will follow the formula $I = I_o\left(1 - e^{-t/\tau}\right)$

(τ is more complicated than R/L due to parallel circuit)

63% is approximately 1 "time constant" meaning when $t_o = \tau$

• To find τ:

voltage loop outer: $V - I_1 R_1 - I_3 R_3 - L\frac{dI_3}{dt} = 0$

right: $-I_3 R_3 - L\frac{dI_3}{dt} + I_2 R_2 = 0$

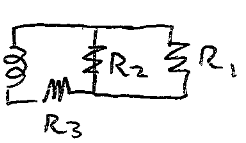
current $I_1 = I_2 + I_3$

solve to get $V - \underbrace{\left[\frac{R_1R_3 + R_2R_3 + R_1R_2}{R_2}\right]}_{A} I_3 - L\underbrace{\left[\frac{R_1 + R_2}{R_2}\right]}_{B}\frac{dI_3}{dt} = 0$

$$\boxed{\therefore \tau = \frac{B}{A} = \frac{R_1 + R_2}{R_1R_2 + R_2R_3 + R_1R_3} = 4.88 \times 10^{-6}\ s}$$

OR (don't do this)

redraw circuit (ignore battery)



$R_{eq} = R_3 + \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} = 328\Omega$

$\tau = \frac{L}{R_{eq}} = 4.88 \times 10^{-6}\ s$