Problem 20.45

For the circuit shown, determine:

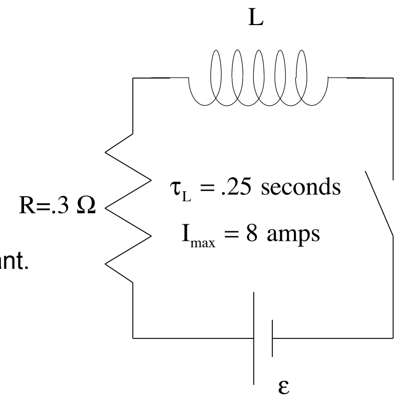
a.) the battery voltage.

b.) the inductance in the circuit.

c.) the current after one time constant.

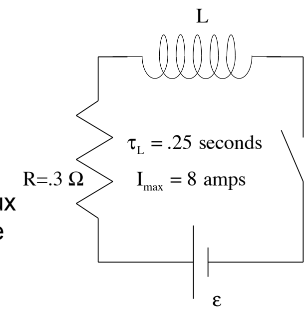
d.) the voltage across the resistor after one time constant.

e.) the voltage across the inductor after one time constant.



a.) the battery voltage.

In an RL circuit, there is initially no current as the inductor's back EMF will not allow current to happen. Initially, then, all the battery voltage drop occurring across the inductor. After a long time, the changing flux across the inductor's coils goes to zero, the back EMF drops to zero and all the battery voltage drop is across the resistor. That means the maximum current, which happens after a long time, will simply be:



$$\begin{aligned} \varepsilon &= I_{max}R \\ &= (8\text{ amps})(.3\ \Omega) \\ &= 2.4\text{ volts} \end{aligned}$$

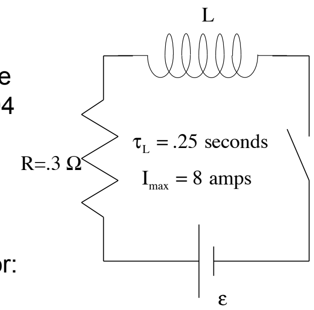
b.) the inductance in the circuit.

Using the time constant:

$$\begin{aligned} \tau_L &= L/R = .25\text{ seconds} \\ \Rightarrow\ L &= (.25\text{ sec})(.3\ \Omega) \\ &= .075\text{ H } (= 75\text{ mH}) \end{aligned}$$

c.) the current after one time constant.

After one time constant, the current will be at 63% of its maximum. That value is 5.04 amps.



d.) the voltage across the resistor and inductor after one time constant.

The voltage across the resistor will be ir, or:

$$\begin{aligned} V_R &= iR \\ &= (5.04\text{ A})(.3\ \Omega) \\ &= 1.51\text{ volts} \end{aligned}$$

e.) The voltage across the inductor is what is left over, or:

$$\begin{aligned} V_L &= \varepsilon - V_R \\ &= (2.40\text{ volts}) - (1.51\text{ volts}) \\ &= .89\text{ volts} \end{aligned}$$