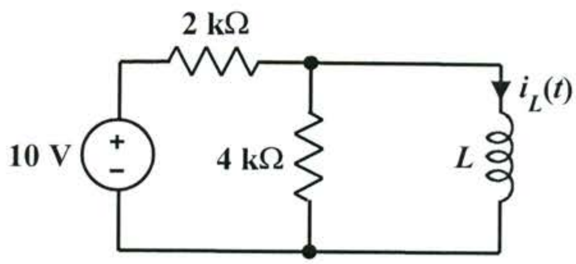
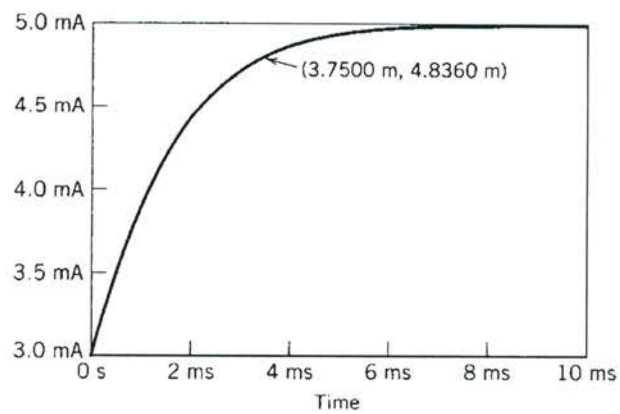
EE 2240

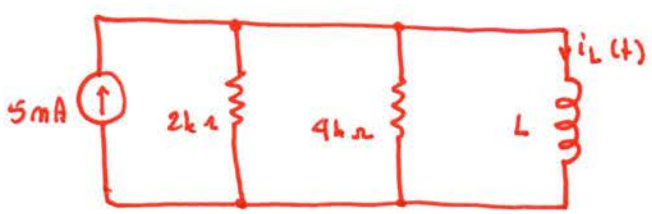
Problem #02

Consider the RL circuit shown below, where $i_L(0) = 3$ mA. The accompanying plot shows the transient response of the circuit. A point on the curve has been labeled, indicating a time and the corresponding inductor current. Determine the value of the inductance, L, required to make the plot a true representation of the inductor current in this circuit.

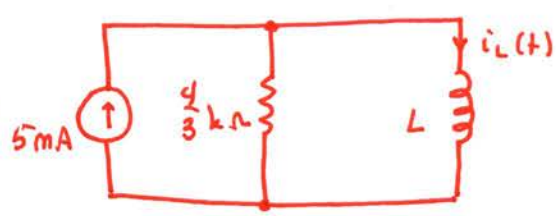




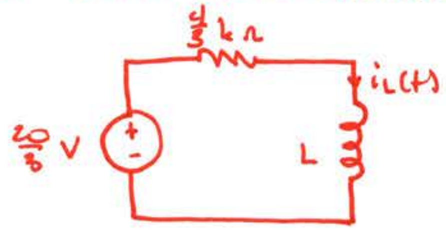
A source transformation yields the following:



=>



Another source transformation yields:



From KVL, then:

$$L \frac{di_L}{dt} + \left(\frac{4}{3} \times 10^3 \Omega\right) i_L = \frac{20}{3} V$$

or $$\frac{di_L}{dt} + \frac{4000}{3L} i_L = \frac{20}{3L}$$

Therefore, $$i_L(t) = K_1 e^{-\frac{4000}{3L} t} + K_2$$

Solving for K_1 and K_2, we have:

$$i_L(t) = -2e^{-\frac{4000}{3L} t} + 5 \quad mA, \; t \geq 0$$

The initial and final values of this expression correspond to those shown on the plot.

Comparing this expression to the labeled point, we have

$$i_L(3.75 \, ms) = -2e^{-\frac{4000}{3L}(3.75 \times 10^{-3})} + 5 = 4.8360$$

or $$e^{-\frac{5}{L}} = 0.0820$$

Solving for L,

$$-\frac{5}{L} = \ln(0.0820) \approx -2.5$$

$$\Rightarrow \quad L = 2H$$