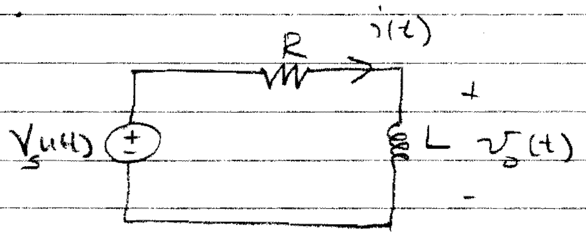
Section 16.1

Let's consider this simple RL circuit:



Will assume zero initial conditions for the voltage and current.

By KVL : $V_s u(t) = R\,i(t) + L\,\dfrac{di(t)}{dt}$ (1)

You analyzed this circuit in Section 7.6.

For $t>0$, (1) becomes $\dfrac{di(t)}{dt} + \dfrac{R}{L}\,i(t) = V_s$

The current $i(t)$ that satisfies this 1st order ODE is

$$i(t) = \underbrace{K_1 e^{-t/\tau}}_{\text{transient}} + \underbrace{K_2}_{\text{steady state.}}$$

or

$$i(t) = i(\infty) + [i(0) - i(\infty)]\,e^{-t/\tau} \qquad (7.53), (2)$$

In our case, $i(\infty) = \dfrac{V_s}{R}$; $i(0) = 0$

$\therefore\ i(t) = \dfrac{V_s}{R} - \dfrac{V_s}{R} e^{-t/\tau} = \dfrac{V_s}{R}\left[1 - e^{-t/\tau}\right]$ where $\tau = \dfrac{L}{R}$.

$$i(t) = \begin{cases} 0 & t<0 \\ \dfrac{V_s}{R}\left[1 - e^{-t/\tau}\right] & t>0 \end{cases}$$

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We can use this current sol'n to calculate the voltage

By KVL,

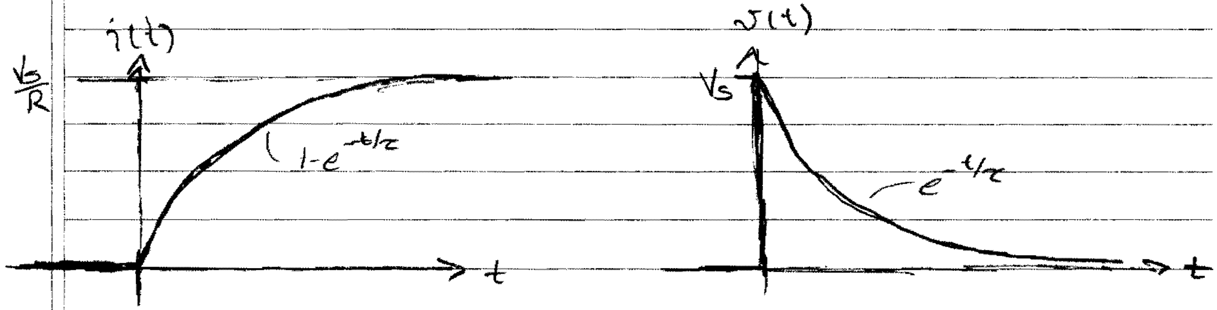
$$V_S u(t) = R i(t) + v_o(t)$$

$$\Rightarrow v_o(t) = V_S u(t) - R i(t)$$

$\therefore$ for $t > 0$

$$v_o(t) = V_S - R\left(\frac{V_S}{R} - \frac{V_S}{R} e^{-t/\tau}\right) = + V_S e^{-t/\tau}$$

$$\therefore v_o(t) = \begin{cases} 0 & t < 0 \\ V_S e^{-t/\tau} & t > 0 \end{cases}$$



Let's do the same analysis, but now using the Laplace Transform.