# Engr098 Lab7

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**Circuit and convention.** Current source $I_s = 6$ A feeds a top node. A $2\,\Omega$ resistor is from that node to ground (left branch). Through a switch, the node also connects to a $4\,\Omega$ resistor in series with an inductor $L = 3\,\mathrm{H}$ to ground (right branch). The inductor current $i(t)$ is defined *downward* through $L$.

At $t = 0$ the switch *closes*. Thus:

$$i(t) = \begin{cases} i(0^-), & t < 0, \\ i(\infty) + \big[i(0^+) - i(\infty)\big]e^{-t/\tau}, & t \geq 0. \end{cases}$$

## 1. Initial current $i(0^-)$

For $t < 0$ the switch is *open*, so the RL branch is disconnected; no steady DC path exists through $L$. Therefore,

$$\boxed{i(0^-) = 0 \text{ A}}, \qquad \Rightarrow \qquad i(0^+) = i(0^-) = 0 \text{ A}.$$

(For reference, the left node voltage is $V = I_s R = 6 \times 2 = 12$ V with only the $2\,\Omega$ to ground.)

## 2. Final (steady) current $i(\infty)$

For $t \to \infty$ with the switch closed, the inductor is a short. The right branch becomes a $4\,\Omega$ to ground in parallel with the $2\,\Omega$ to ground.

$$R_\parallel = 2 \parallel 4 = \frac{2 \cdot 4}{2 + 4} = \frac{4}{3}\ \Omega, \qquad V_\text{node} = I_s R_\parallel = 6 \cdot \frac{4}{3} = 8 \text{ V}.$$

Hence the DC current in the right branch (and through the inductor) is

$$\boxed{i(\infty) = \frac{V_\text{node}}{4} = \frac{8}{4} = 2 \text{ A}}.$$

## 3. Time constant $\tau$

With the switch closed, find the Thevenin resistance seen by $L$ with independent sources killed (current source opened). Looking into the inductor terminals, the path to ground is

$$R_\text{th} = 4\ \Omega + 2\ \Omega = \boxed{6\ \Omega}.$$

Thus

$$\boxed{\tau = \frac{L}{R_\text{th}} = \frac{3}{6} = 0.5 \text{ s}}.$$

# 4. Complete response

$$\boxed{i(t) = i(\infty) + \big[i(0) - i(\infty)\big]e^{-t/\tau} = 2 + \big(0 - 2\big)e^{-t/0.5} = 2\big(1 - e^{-2t}\big)\ \text{A}, \quad t \geq 0.}$$

**Checks.** $i(0^+) = 2(1-1) = 0$ A (continuous at $t = 0$). $i(\infty) = 2(1-0) = 2$ A matches the DC analysis.

**(Optional) Inductor voltage.** With the passive sign convention (voltage drop top to bottom on $L$):

$$v_L(t) = L\,\frac{di}{dt} = 3 \cdot \big(4e^{-2t}\big) = \boxed{12e^{-2t}\ \text{V}}, \quad t \geq 0.$$

**Plot tip.** In Desmos/PSPICE, use $i(t) = 2\,(1 - e^{-2t})$ for $t \geq 0$; a time window of $0 \leq t \leq 2.5$ s $(= 5\tau)$ shows the full rise.