Transient Circuit

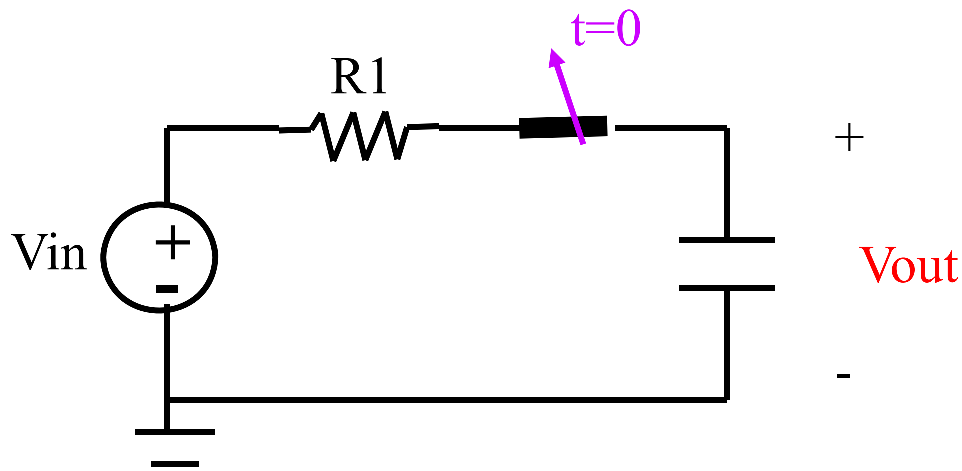
- DC circuits
- Transient Circuits

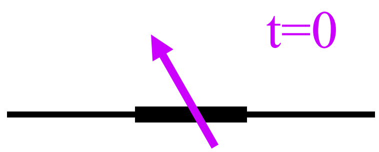
$\Big\}$ ***Different ?***

$$\mathbf{v_c(t) = v_c(\infty) + \left[v_c(0^+) - v_c(\infty)\right] * \left(e^{-\frac{t}{\tau}}\right)}$$

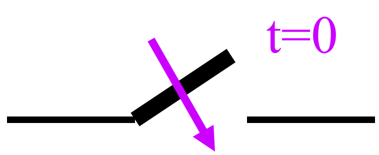
$$\mathbf{i_L(t) = i_L(\infty) + \left[i_L(0^+) - i_L(\infty)\right] * \left(e^{-\frac{t}{\tau}}\right)}$$

$$\tau = RC \qquad\qquad \tau = \frac{L}{R}$$



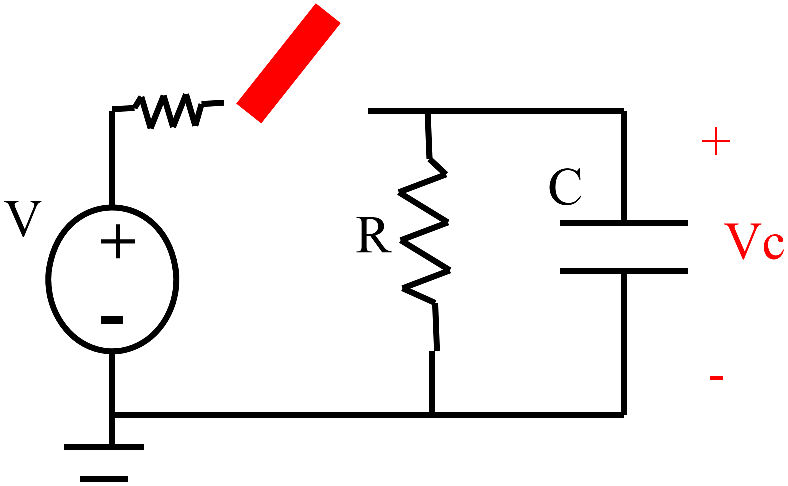


$t < 0$ -- close, $t \geq 0$ -- open

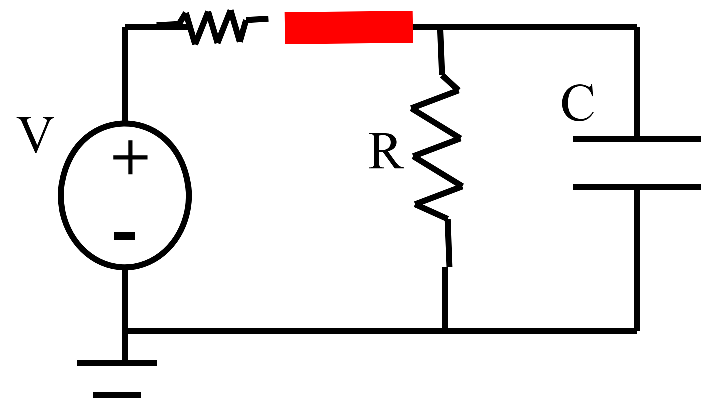


$t < 0$ -- open, $t \geq 0$ -- close

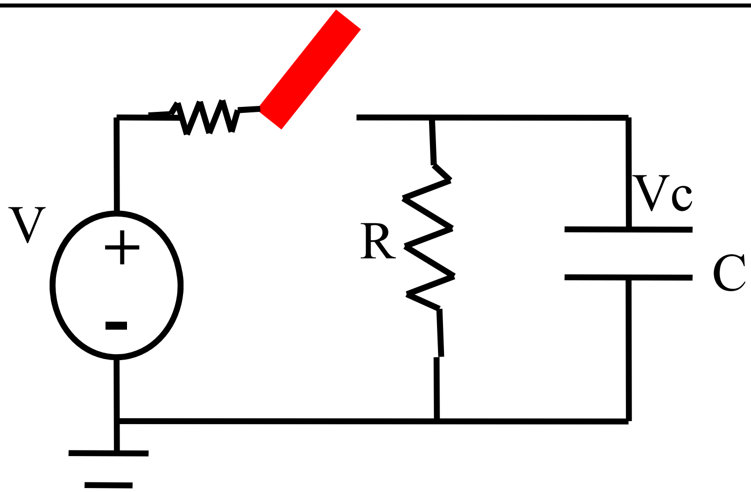
Ex.



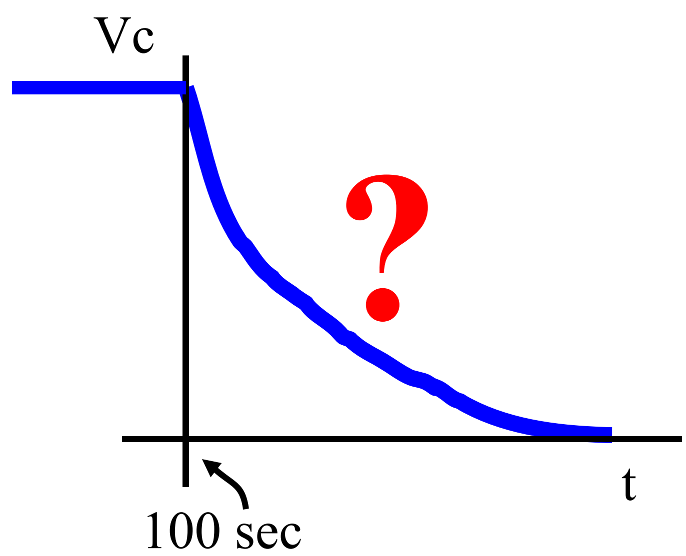
@ t < 0 sec , Initial Vc = 0

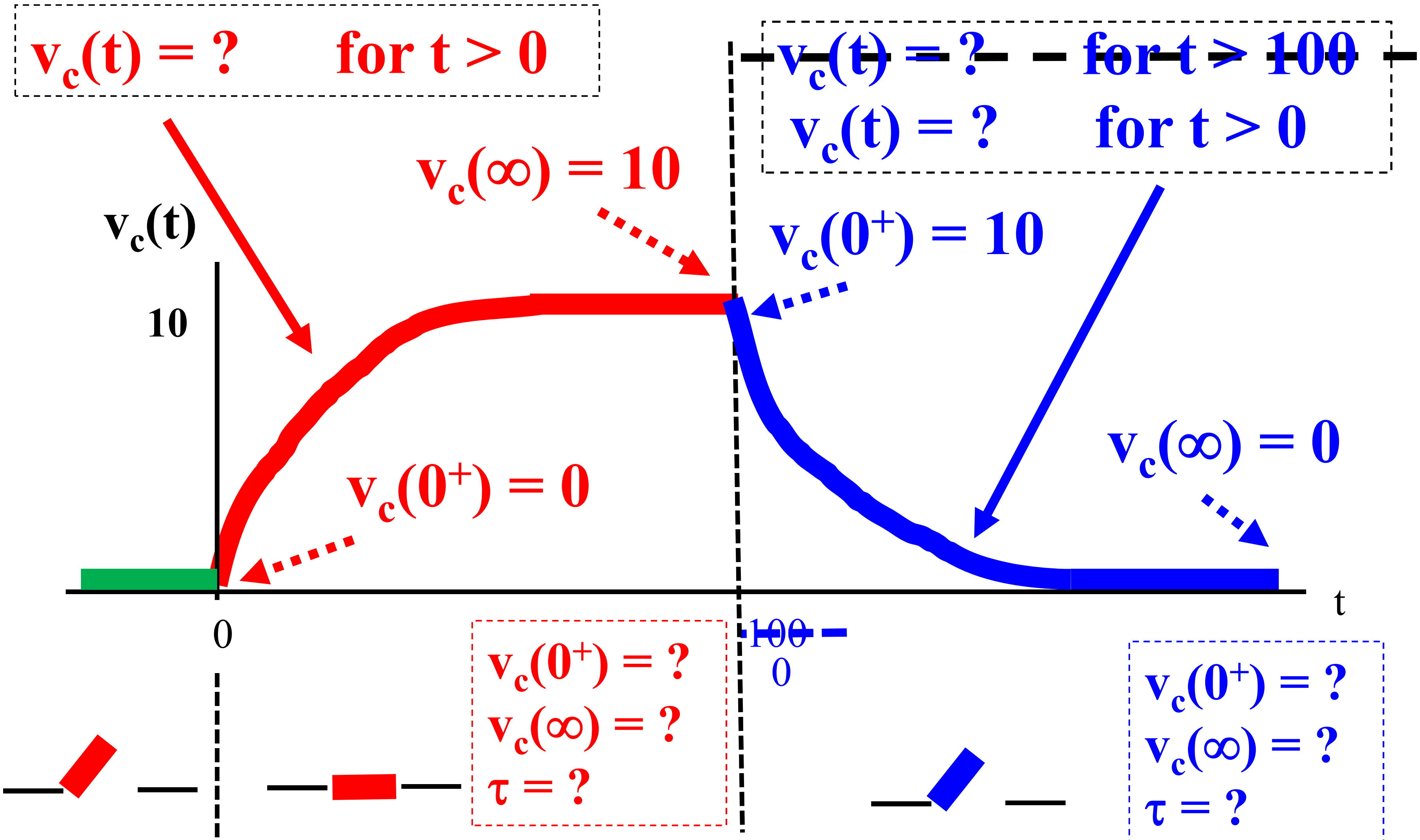


@ t = 0 sec



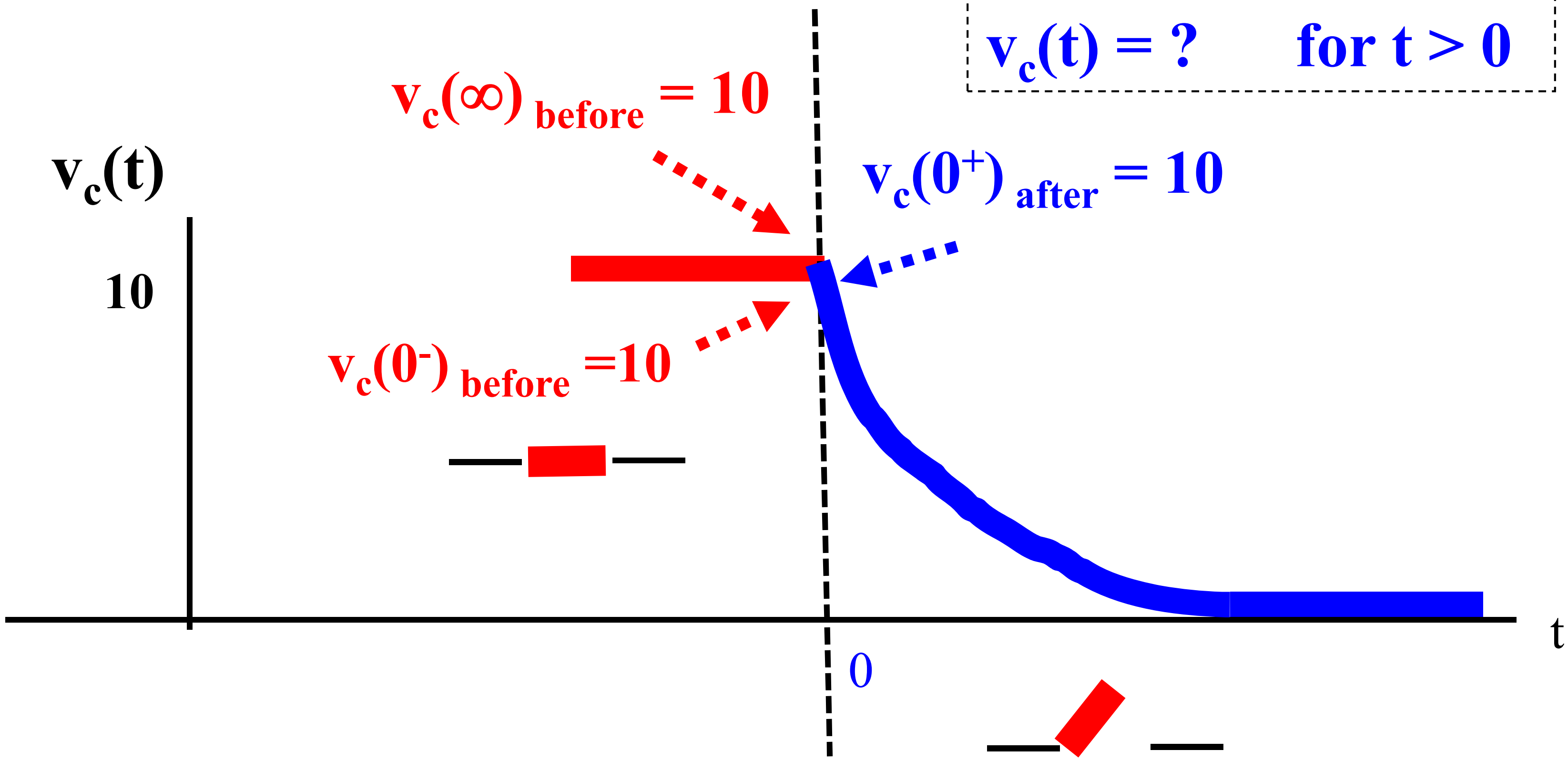
@ t = 100 sec





$$v_c(t) = v_c(\infty) + \left[v_c(0^+) - v_c(\infty)\right] * \left(e^{-\frac{t}{\tau}}\right)$$

$v_c(t) = ?$ for $t > 0$



$v_c(\infty)_{after} = ?$ ✓

$\tau_{after} = ?$ ✓

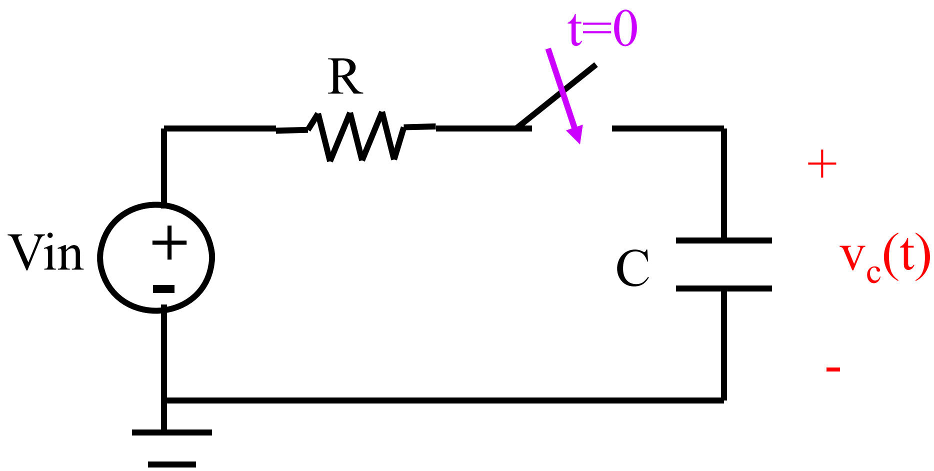
$v_c(0^+)_{after} = ?$ X

$v_c(0^+)_{after} = v_c(0^-)_{before} = v_c(\infty)_{before}$

$v_c(\infty)_{before} = ?$ ✓

$v_c(0^+)_{after} = v_c(\infty)_{before}$

Ex.



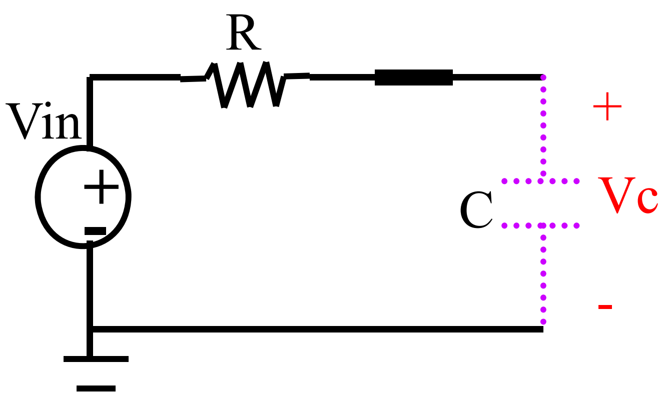
$$\boxed{\tau = RC}$$

Initial $v_c = 0$

$$\boxed{v_c(t) = ? \quad \text{when } t>0}$$

$V_c(0^-)=0$ $\quad$ $V_c(0^-)=V_c(0^+)$ $\quad$ $\boxed{V_c(0^+) = 0}$

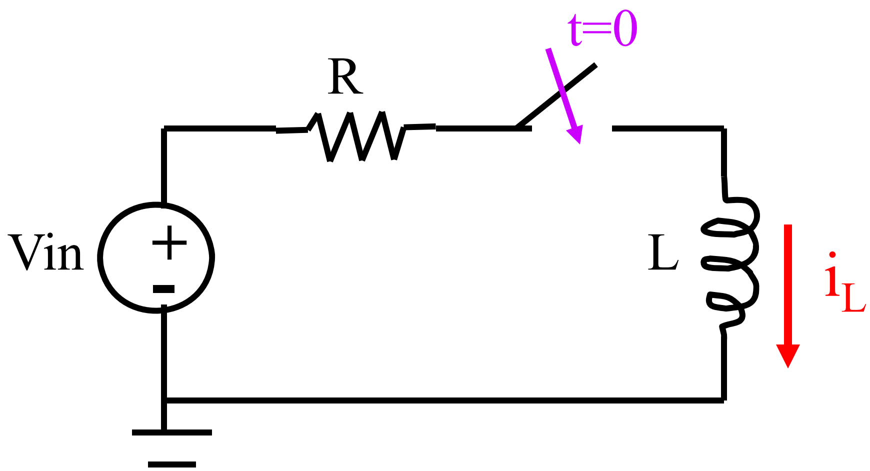
$V_c(\infty)= ?$ $\quad$ @ C (open) $\quad$ $\boxed{V_c(\infty) = Vin}$



$$\mathbf{v_c(t) = v_c(\infty) + \left[v_c(0^+) - v_c(\infty)\right] * \left(e^{-\frac{t}{\tau}}\right)}$$

$$\mathbf{v_c(t) = V_{in} * \left(1 - e^{-\frac{t}{RC}}\right)}$$

Ex.



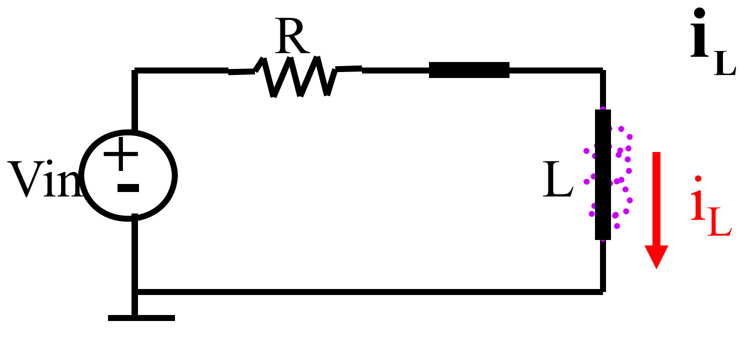
$$\boxed{\tau = \frac{L}{R}}$$

Initial $I_L = 0$

$\boxed{i_L(t) = ? \quad \text{when } t>0}$

$i_L(0^-)=0$ $\qquad$ $i_L(0^-)=i_L(0^+)$ $\qquad$ $\boxed{i_L\,(0^+) = 0}$

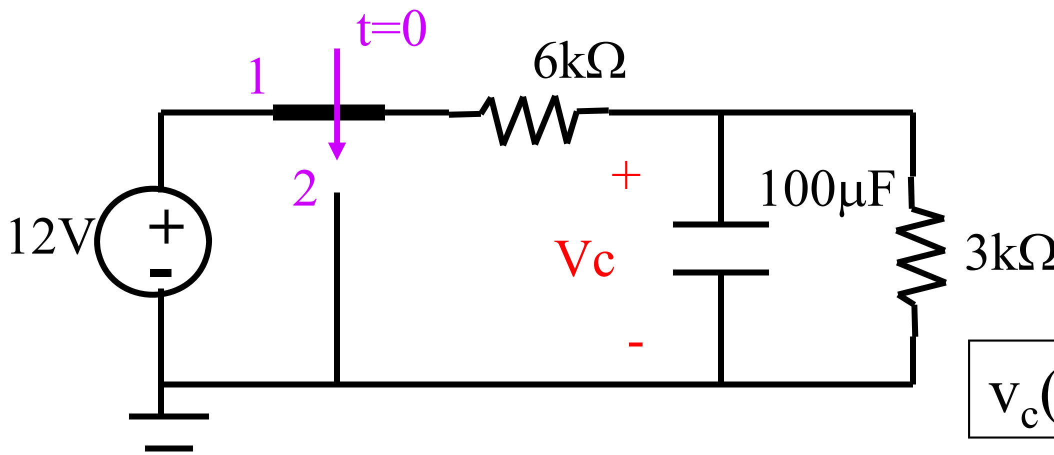
$i(\infty) = ?$ $\qquad$ @ L (short) $\qquad$ $\boxed{i_L\,(\infty) = V_{in}\,/\,R}$



$$\mathbf{i_L(t) = i_L(\infty) + \left[i_L(0^+) - i_L(\infty)\right] * \left(e^{-\frac{t}{\tau}}\right)}$$

$$\mathbf{i_L(t) = \frac{V_{in}}{R} * \left(1 - e^{-\frac{t}{L/R}}\right)}$$

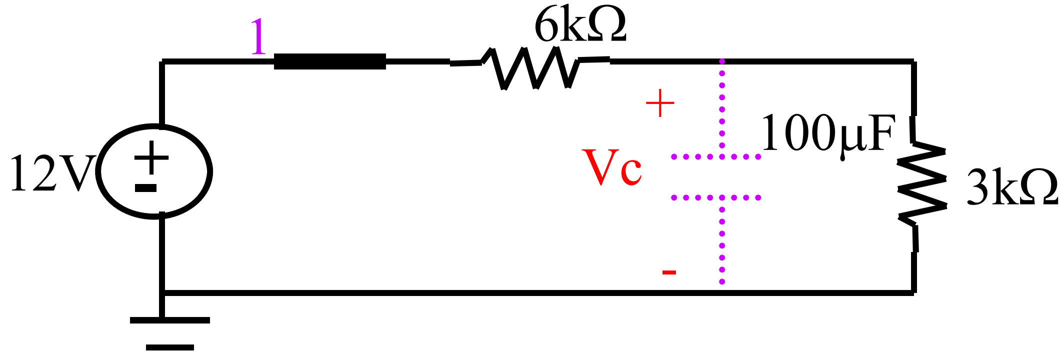
Ex.



$v_c(t) = ?$ when $t>0$

$V_C(0^-) = ?$

$V_c(0^+) = V_c(0^-)$



@ C (open)

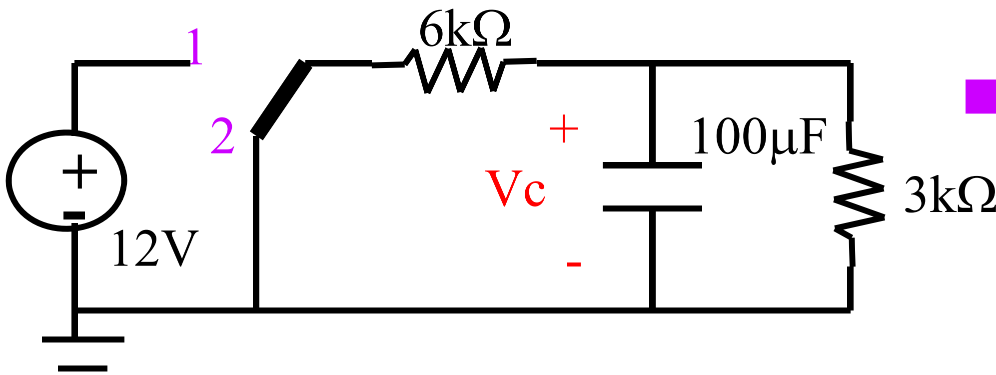
$$\mathbf{v_c(0^-) = \left(\frac{3k}{6k+3k}\right)12}$$

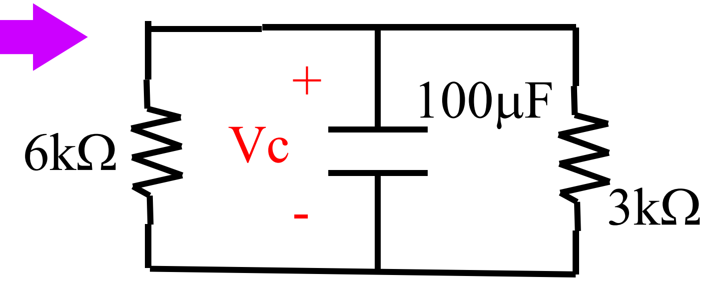
$$\mathbf{v_c(0^-) = 4V}$$

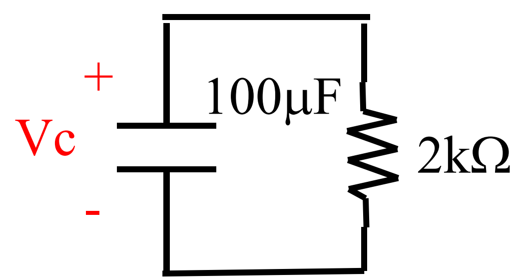
$$\mathbf{v_c(0^+) = v_c(0^-) = 4V}$$

$$\boxed{\mathbf{v_c(0^+) = 4V}}$$

$t \geq 0 \quad v(\infty) = ?$







$$\boxed{\mathbf{v_c}(\infty) = 0}$$

$$\mathbf{v_c(t)} = \mathbf{v_c}(\infty) + \left[\mathbf{v_c}(0^+) - \mathbf{v_c}(\infty)\right] * \left(\mathbf{e}^{-\frac{t}{\tau}}\right)$$

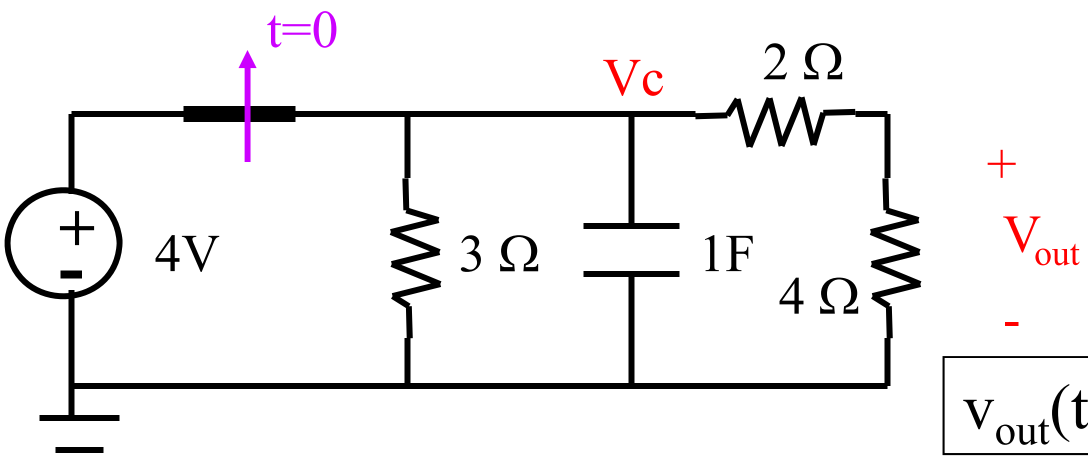
$$\mathbf{v_c(t)} = 0 + \left[4 - 0\right] * \left(\mathbf{e}^{-\frac{t}{0.2}}\right)$$

$$\boxed{= 4 * \mathbf{e}^{-\frac{t}{0.2}}}$$

$$\tau = (2k) * 100\mu$$

$$\boxed{\tau = 0.2}$$

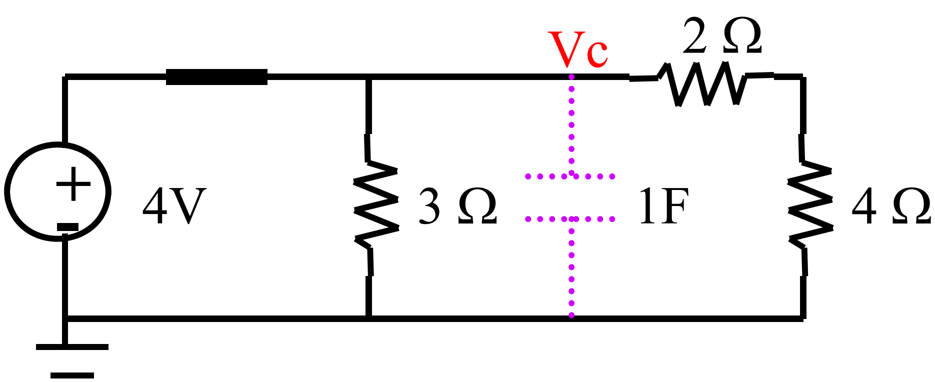
Ex.



$v_{out}(t) = ?$ when $t>0$

$v_c(0^-) = ?$

$v_c(0^+) = v_c(0^-)$



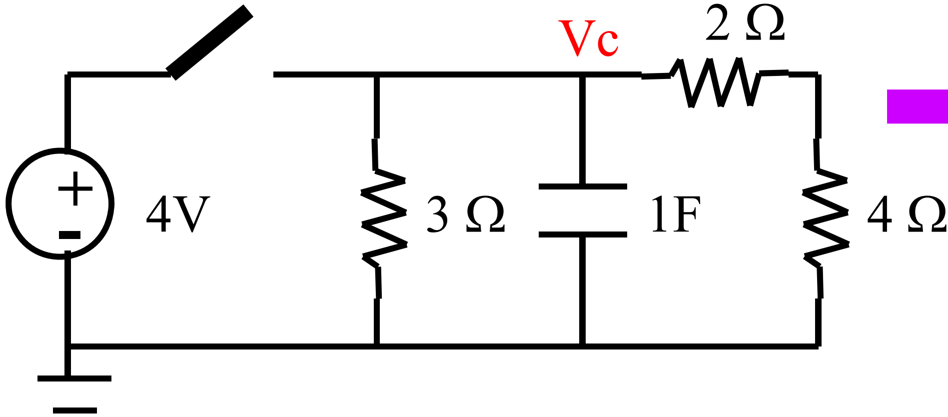
@ C (open)

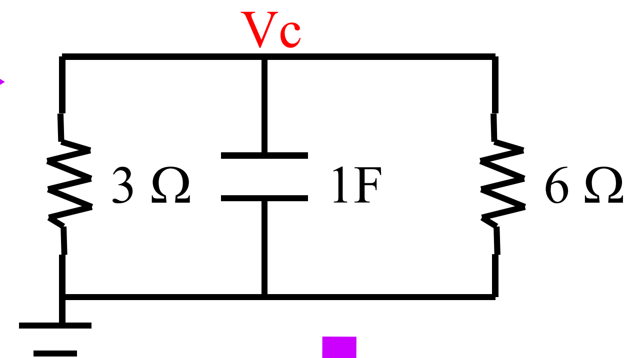
$v_c(0^-) = 4$

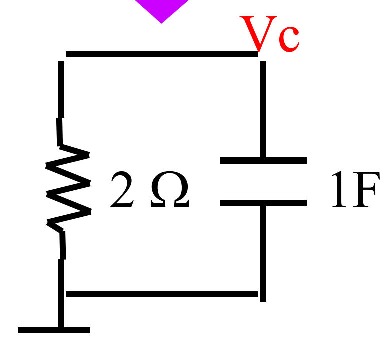
$v_c(0^+) = v_c(0^-) = 4$

$$\boxed{\mathbf{v_c(0^+) = 4v}}$$

$t \geq 0 \quad v(\infty) = ?$







$$\boxed{\mathbf{v_c(\infty) = 0}}$$

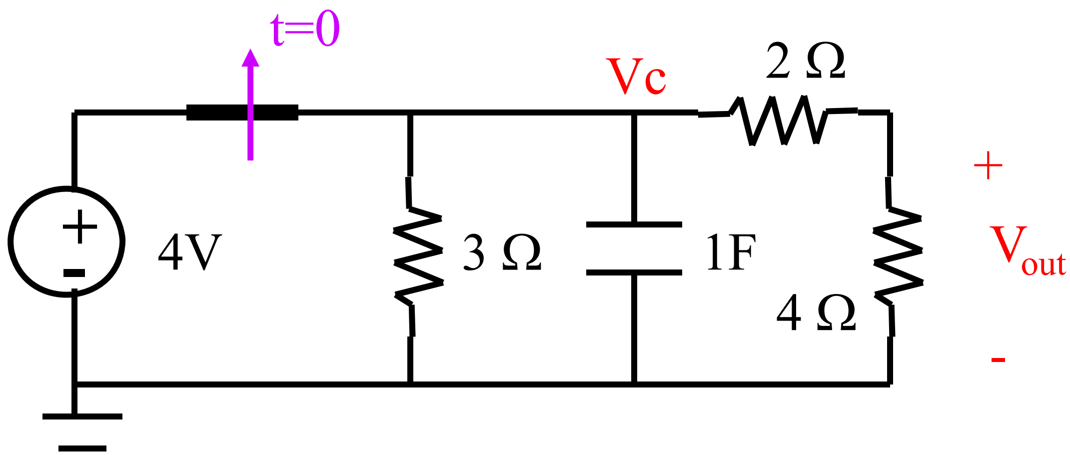
$$\mathbf{v_c(t) = v_c(\infty) + \left[v_c(0^+) - v_c(\infty)\right] * \left(e^{-\frac{t}{\tau}}\right)}$$

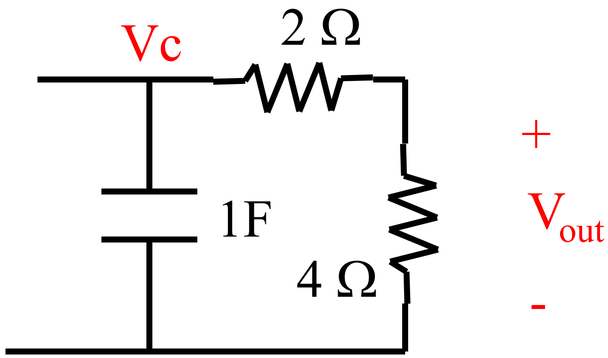
$$\mathbf{v_c(t) = 0 + \left[4 - 0\right] * \left(e^{-\frac{t}{2}}\right)}$$

$$\boxed{= 4 * e^{-\frac{t}{2}}}$$

$$\tau = (2) * 1$$

$$\boxed{\tau = 2}$$



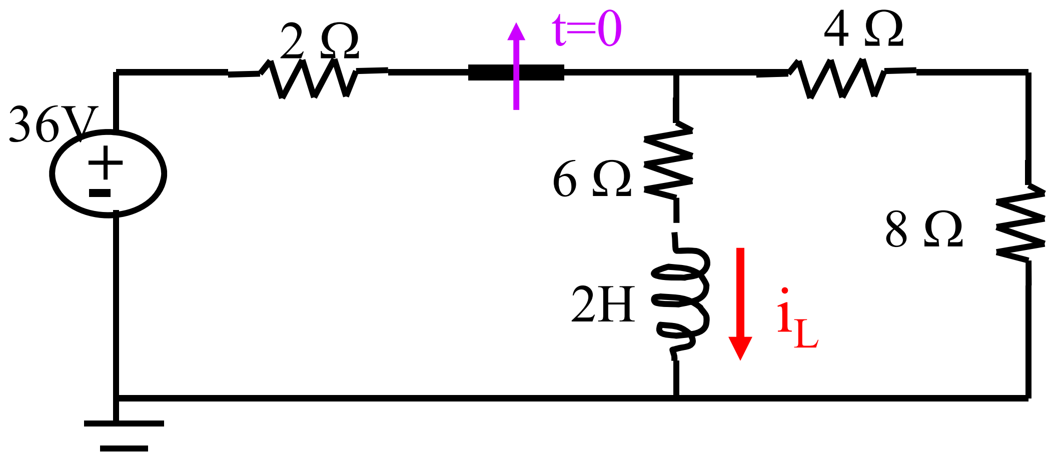


$$v_{out}(t) = \left(\frac{4}{2+4}\right) * v_c(t)$$

$$\mathbf{v}_{\mathbf{out}}(\mathbf{t}) = \left(\frac{4}{2+4}\right) \cdot \left(4 * \mathbf{e}^{-\frac{\mathbf{t}}{2}}\right)$$

$$\boxed{v_{out}(t) = \frac{8}{3} e^{-\frac{t}{2}}}$$

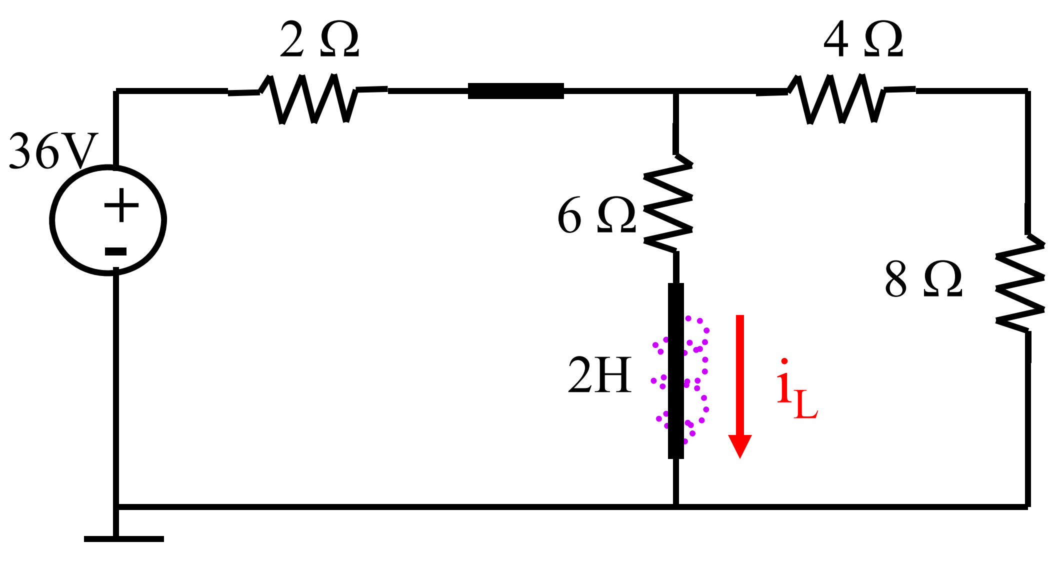
Ex.



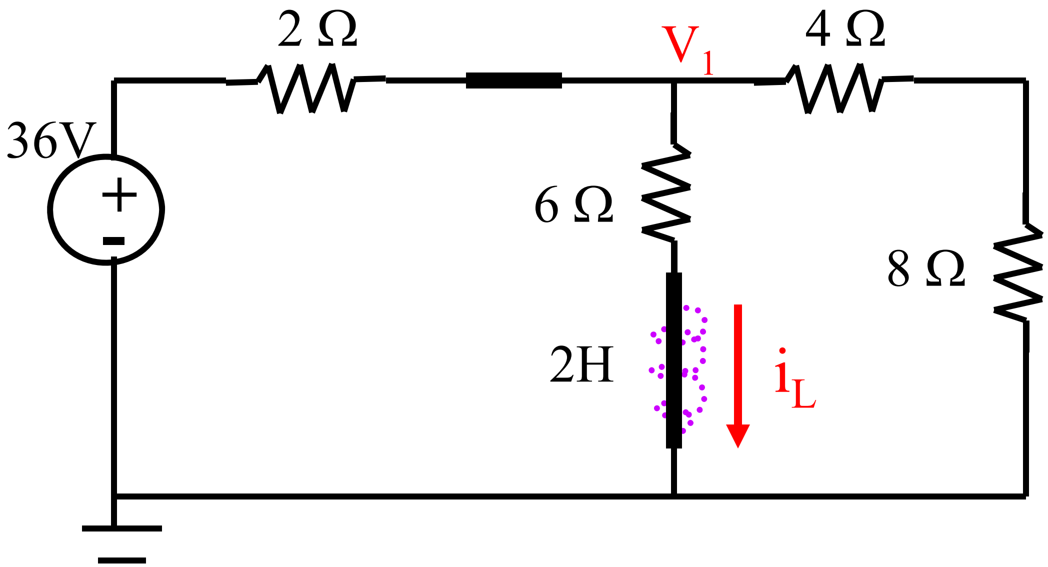
$i_L(t) = ?$

when $t>0$

$i_L(0^-) = ?$ $\quad$ $i_L(0^+) = i_L(0^-)$



@ L (short)



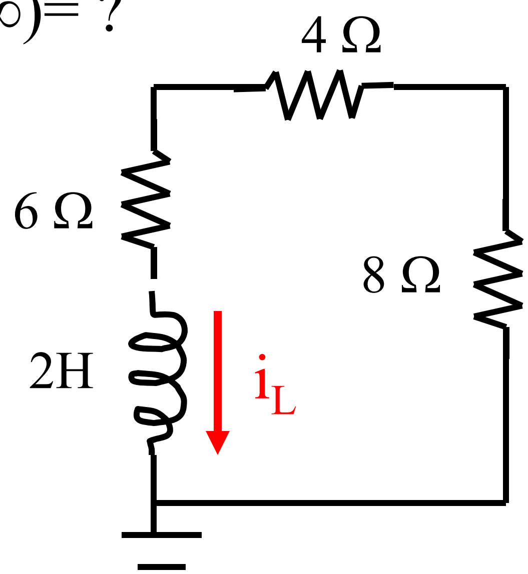
$$\frac{V_1 - 36}{2} + \frac{V_1 - 0}{6} + \frac{V_1 - 0}{4+8} = 0 \quad \Rightarrow V_1 = 24V$$

$$i_L(0^-) = \frac{V_1}{6} = \frac{24}{6} = 4A$$

$$i_L(0^+) = i_L(0^-) = 4A$$

$$\boxed{i_L(0^+) = 4A}$$

$t \geq 0 \quad i(\infty) = ?$



$$\boxed{\mathbf{i_L(\infty) = 0}}$$

$$\tau = \frac{L}{R} = \frac{2}{6+4+8}$$

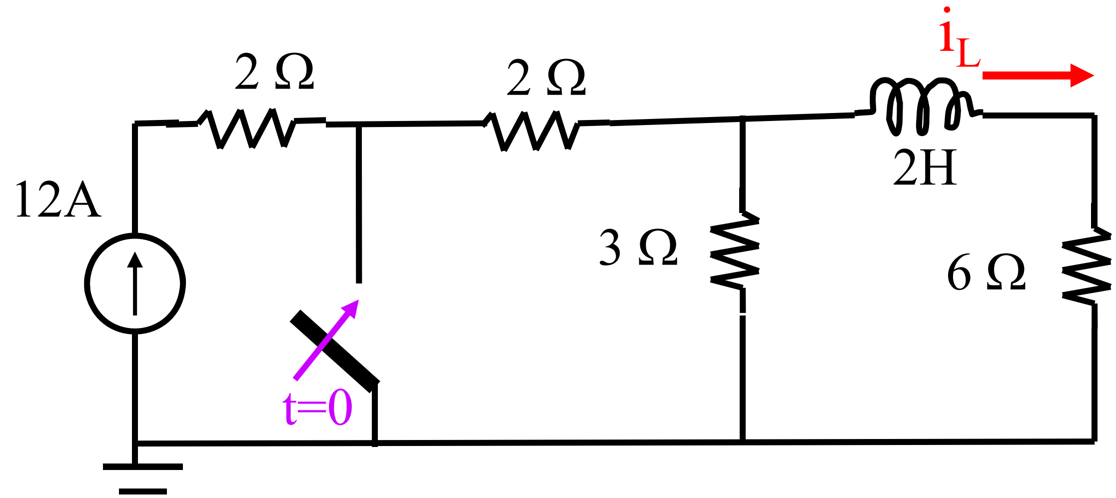
$$\boxed{\tau = \frac{1}{9}}$$

$$\mathbf{i_L(t) = i_L(\infty) + \left[i_L(0^+) - i_L(\infty)\right] * \left(e^{-\frac{t}{\tau}}\right)}$$

$$\mathbf{i_L(t)} = 0 + [4 - 0] * \left(\mathbf{e}^{-\frac{t}{1/9}}\right)$$

$$\boxed{i(t) = 4e^{-9t}}$$

Ex.

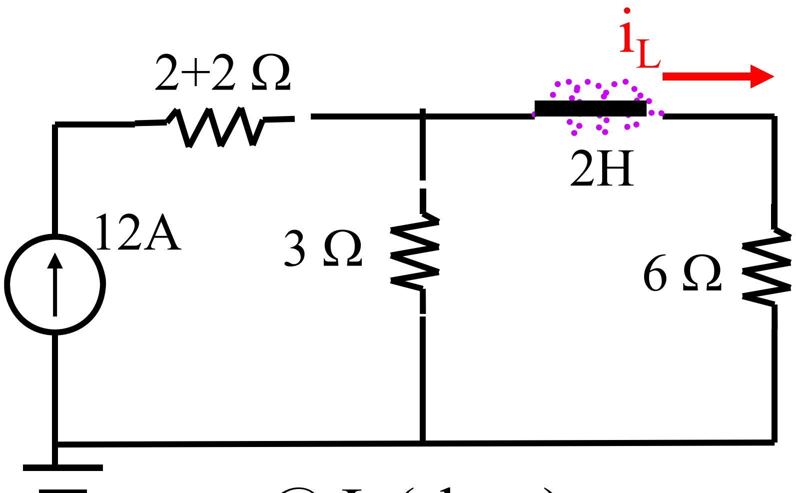


$i_L(t) = ?$

when t>0

$i_L(0^-) = ?$

$i_L(0^+) = i_L(0^-)$



@ L (short)

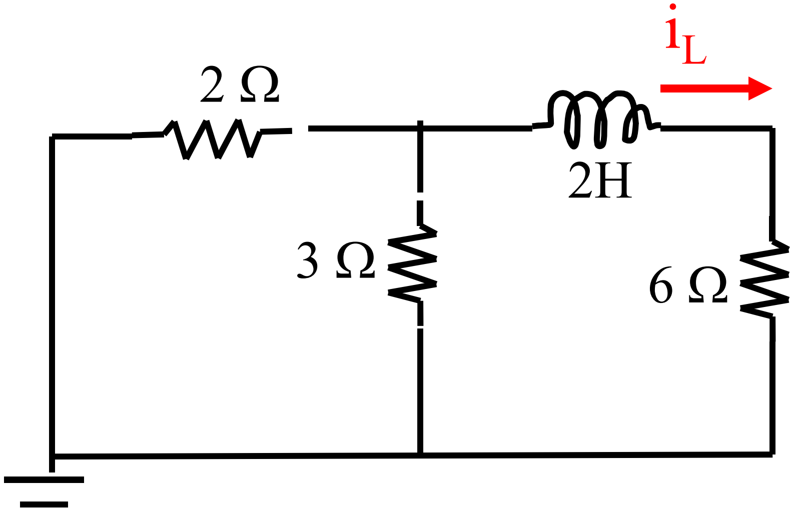
$$i_L(0^-) = \frac{3}{3+6} * 12$$

$i_L(0^-) = 4A$

$i_L(0^+) = i_L(0^-) \;\; = 4A$

$$\boxed{i_L(0^+) = 4A}$$

$t \geq 0 \quad i(\infty) = ?$



$$\boxed{i_L(\infty) = 0}$$

$$\tau = \frac{L}{R} = \frac{2}{2 // 3 + 6}$$

$$\tau = 0.277$$

$$\mathbf{i_L(t) = i_L(\infty) + \left[i_L(0^+) - i_L(\infty)\right] * \left(e^{-\frac{t}{\tau}}\right)}$$

$$\mathbf{i_L(t)} = 0 + [4 - 0] * \left(\mathbf{e}^{-\frac{t}{0.277}}\right)$$

$$\mathbf{i_L(t)} = 4 * \mathbf{e}^{-\frac{t}{0.277}}$$