EE281

First Order Circuits

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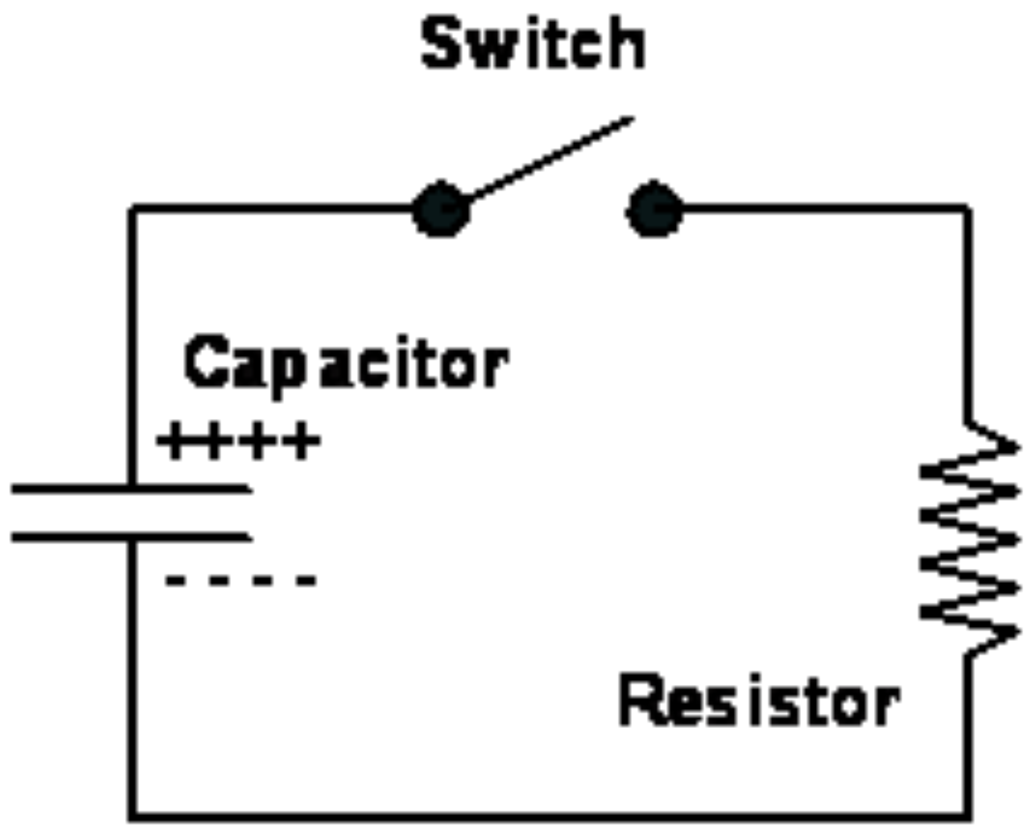
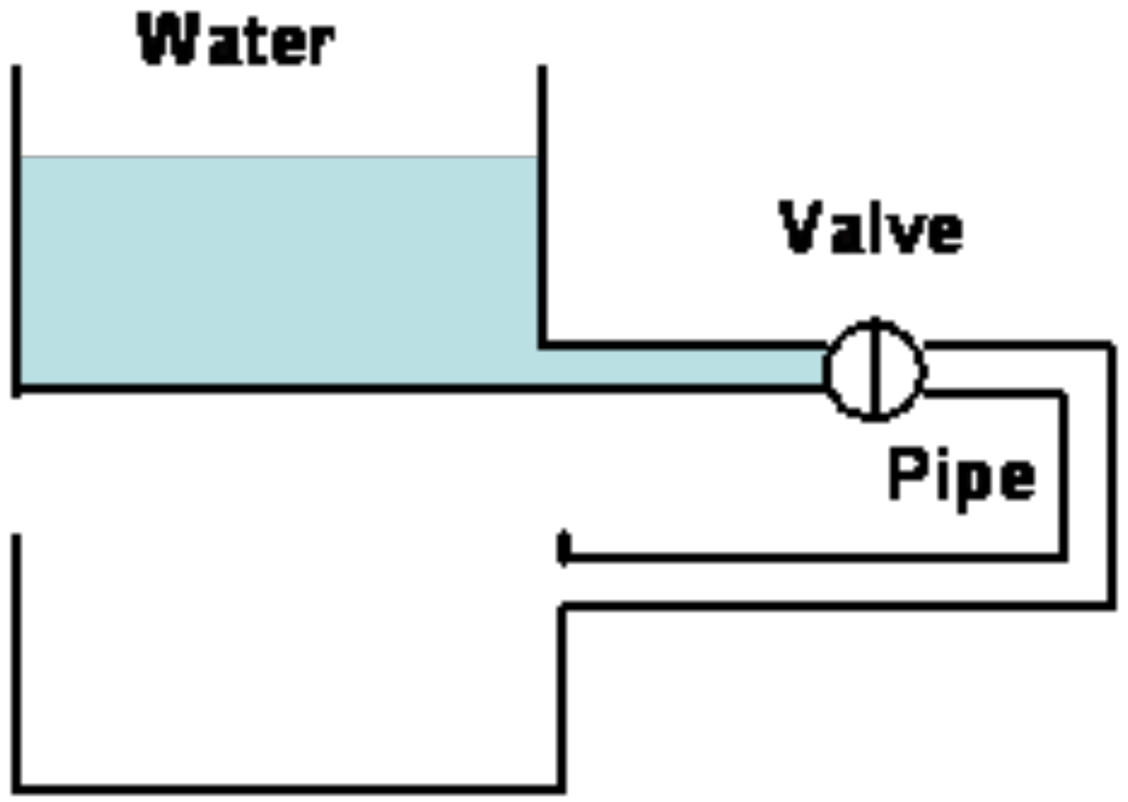
First-Order Circuits

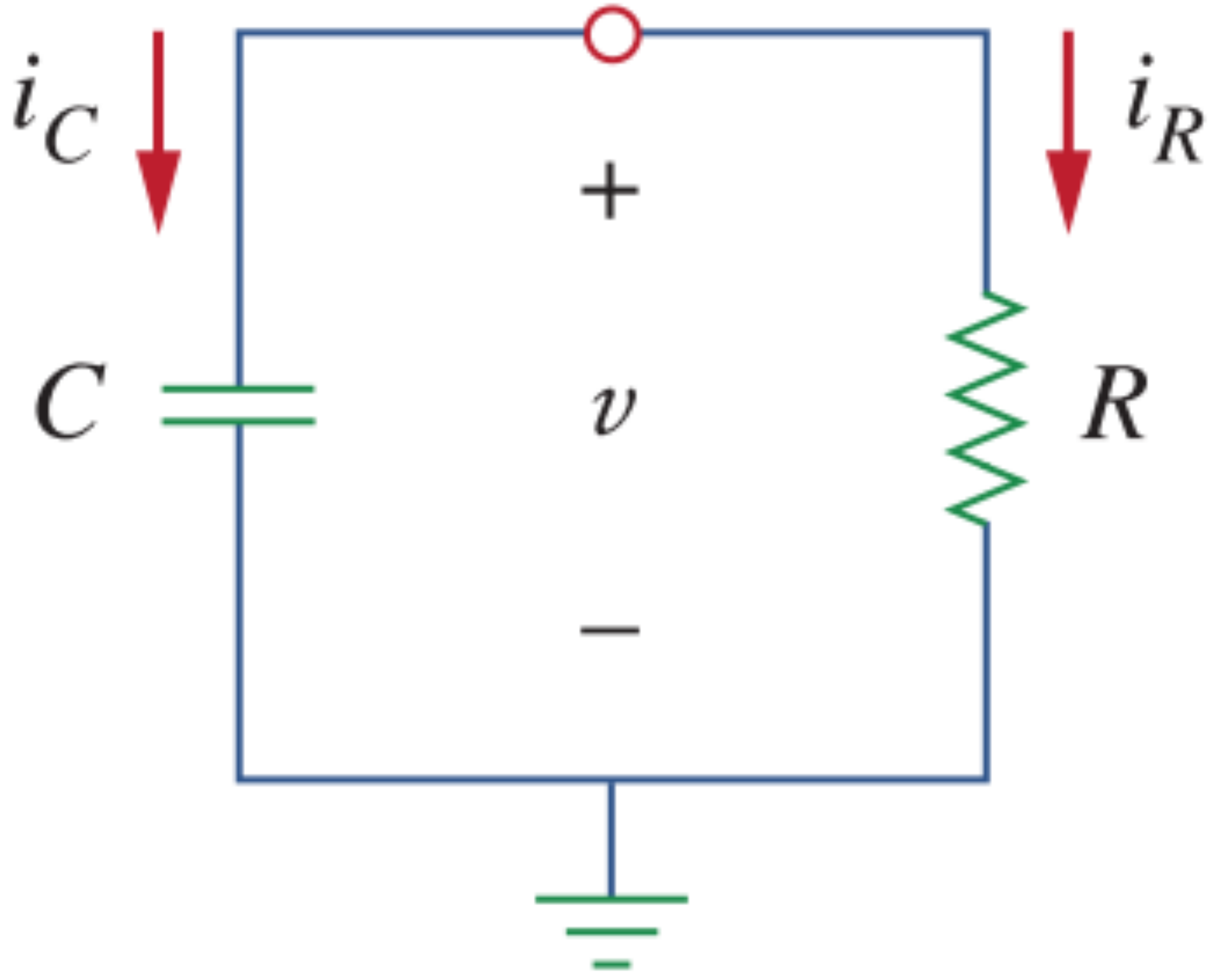
- Contains one independent energy storage element (capacitor or inductor)
- Can be described using a first-order differential equation
- Two types: RC or RL circuits
- Electrical RC Circuit and Hydraulic Analogy





RC Circuits

- Assume that at t=0, the capacitor voltage is equal to V_o



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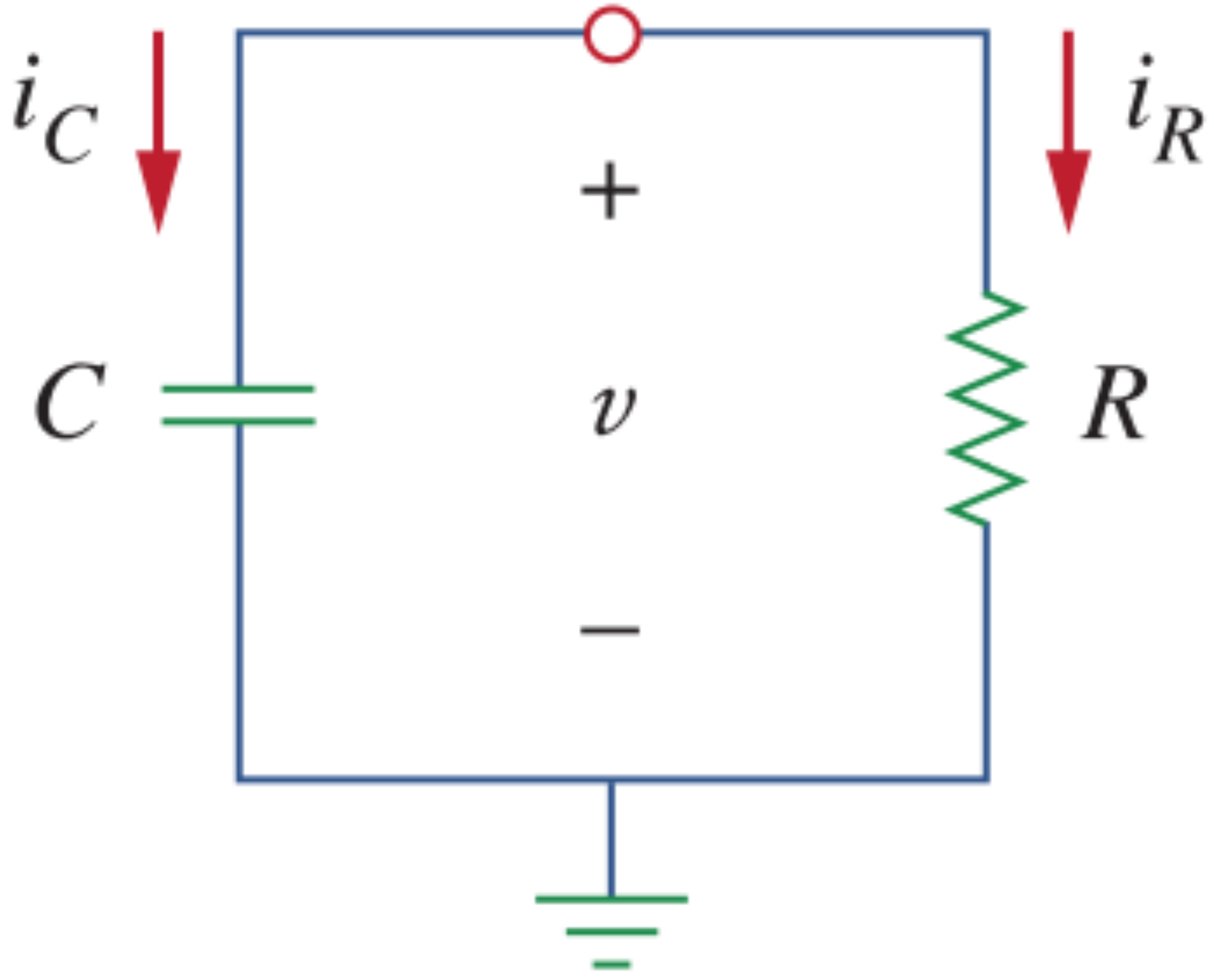

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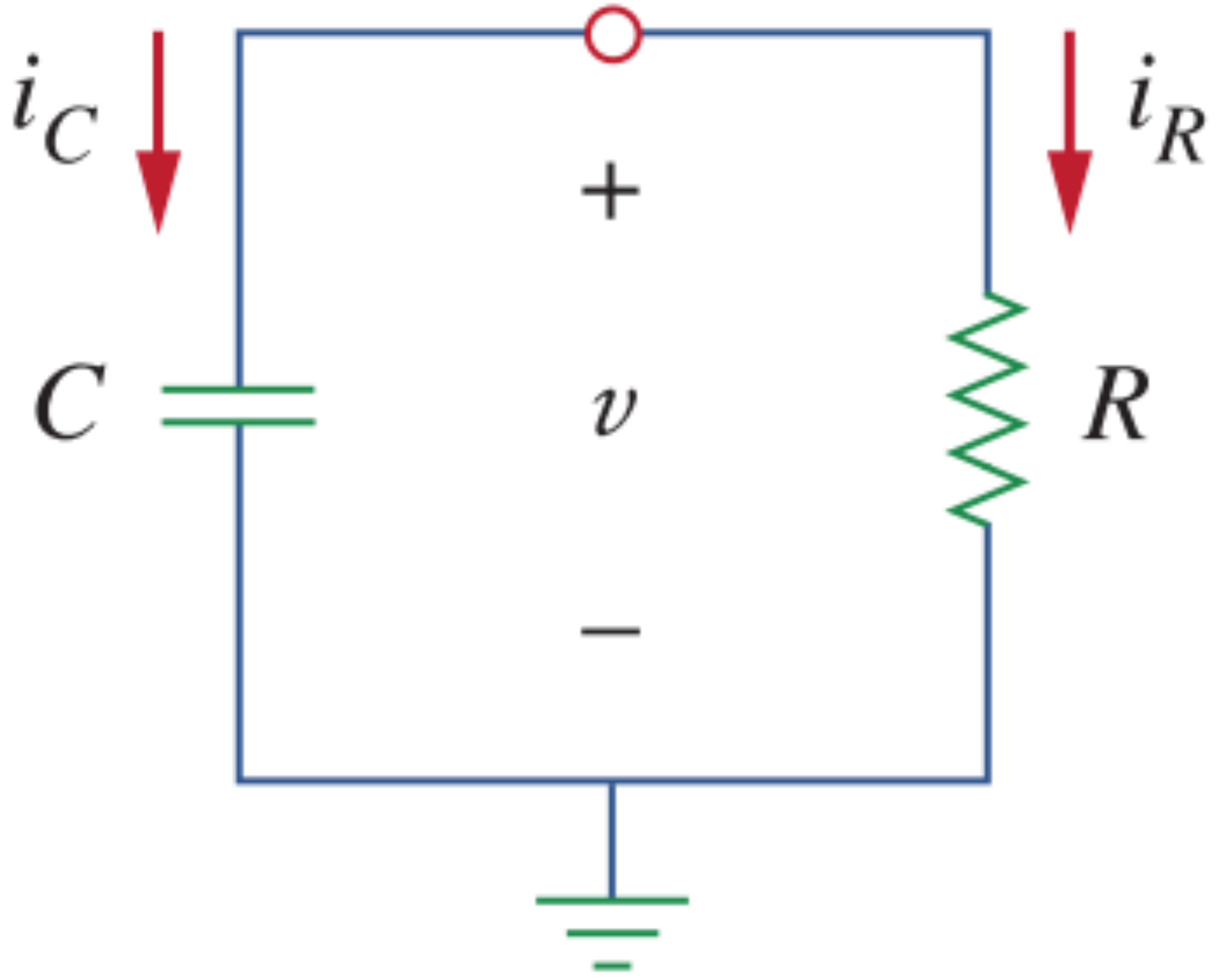
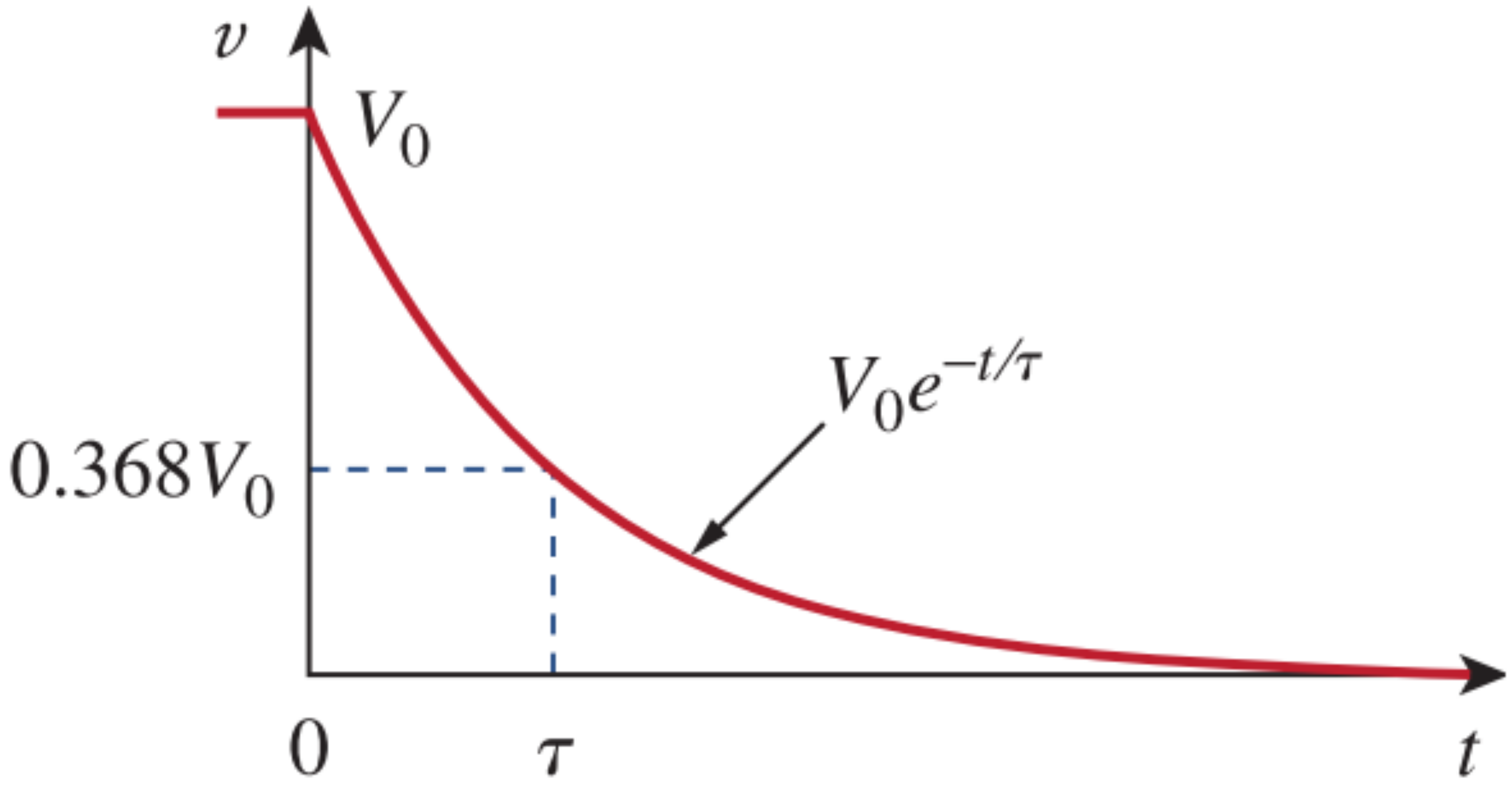


$$V_0(t) = V_0 e^{\frac{-t}{RC}} = V_0 e^{\frac{-t}{\tau}}$$

$$\tau : \text{Time Constant}$$

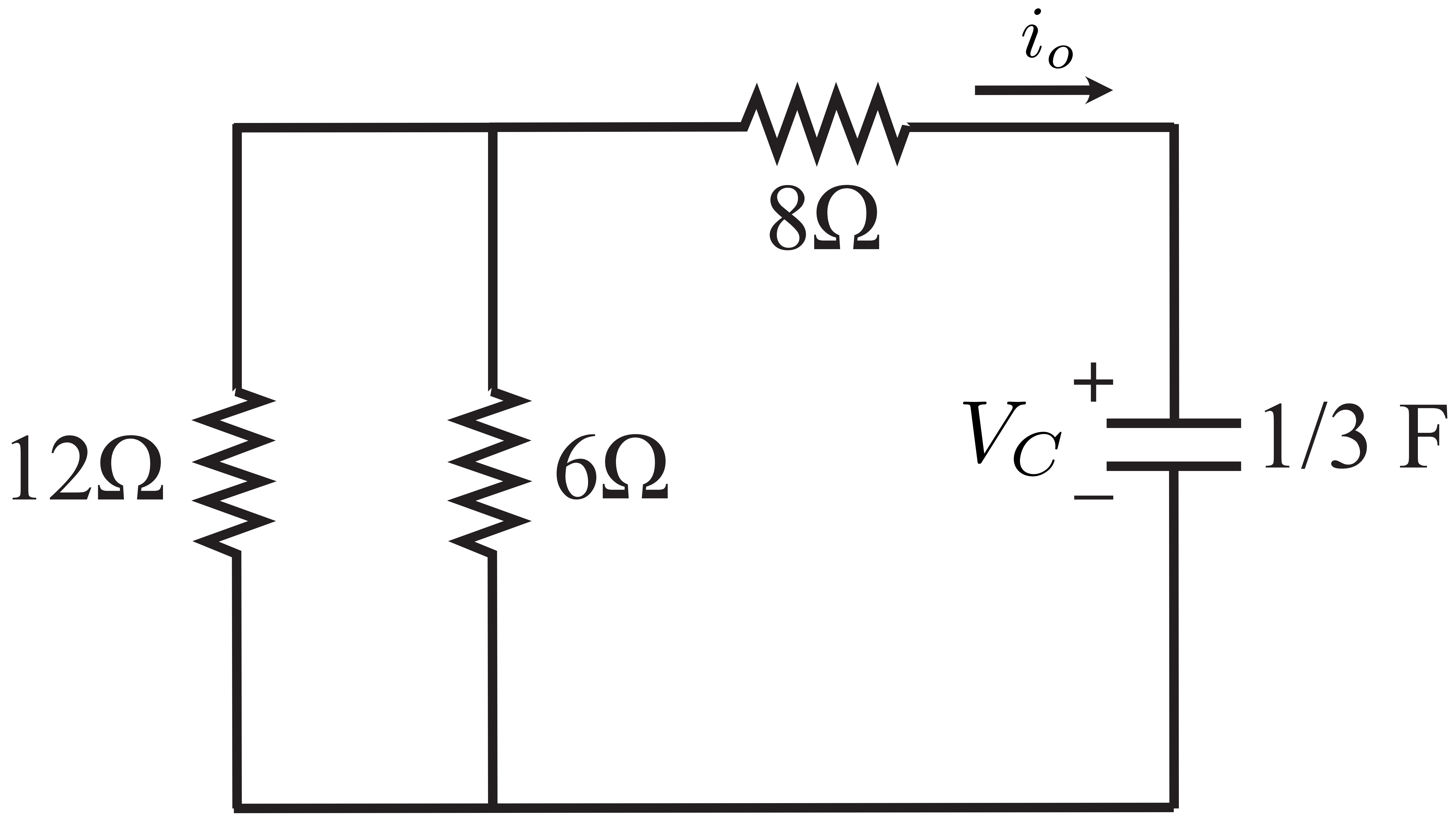
Exponential Decay

- Chemical Reactions, Fluid Dynamics, Heat Transfer, Atmospheric Pressure, Radioactivity



RC Example

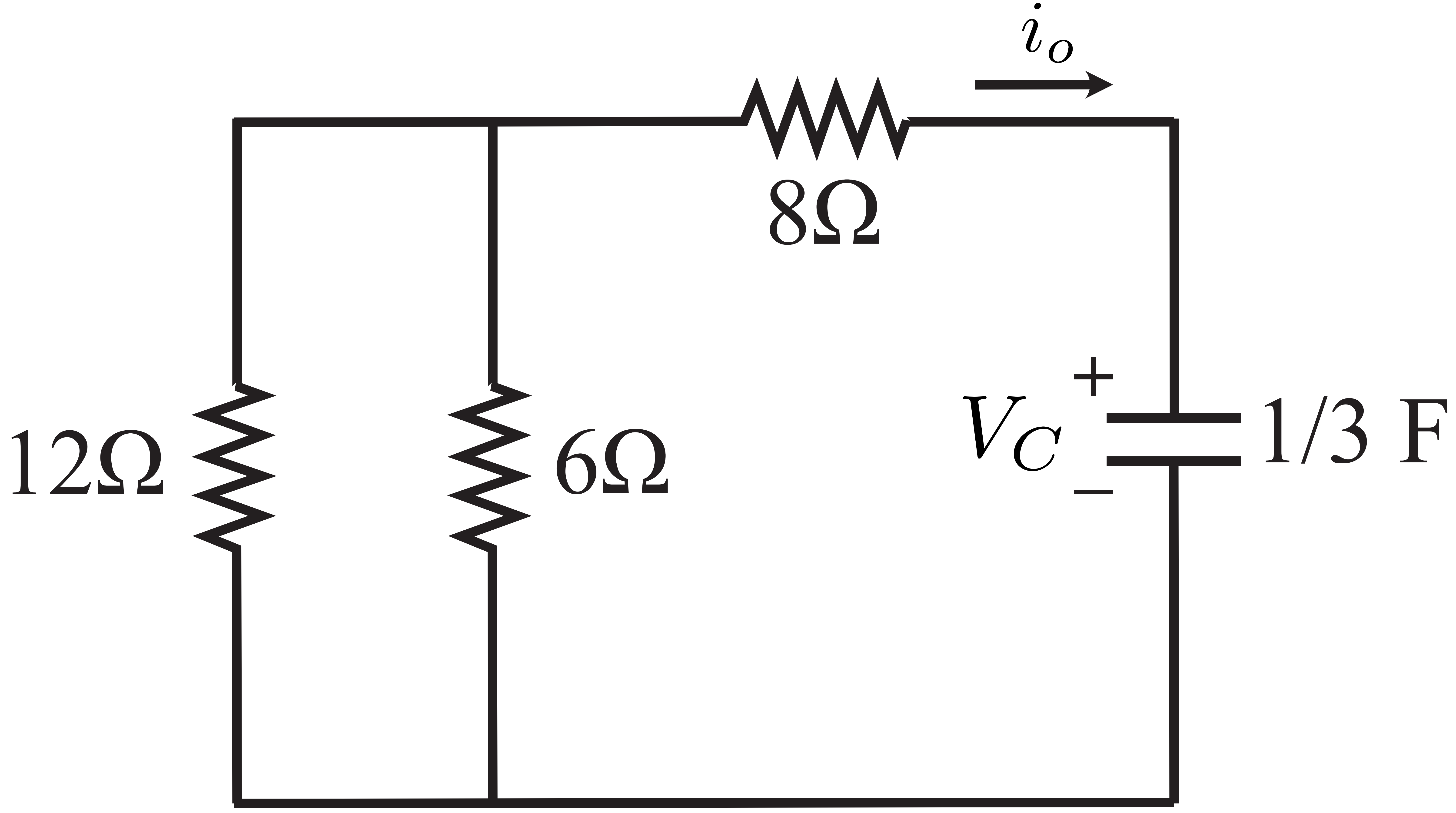
- Initial voltage of the capacitor is 60 V, then determine V_C & i_o



RC Example

$$R_{eq} = \left[8 + \left(\frac{12 \cdot 6}{12 + 6}\right)^{-1}\right] \Omega = 12\Omega$$

$$\tau = R_{eq} C = 4\, s$$



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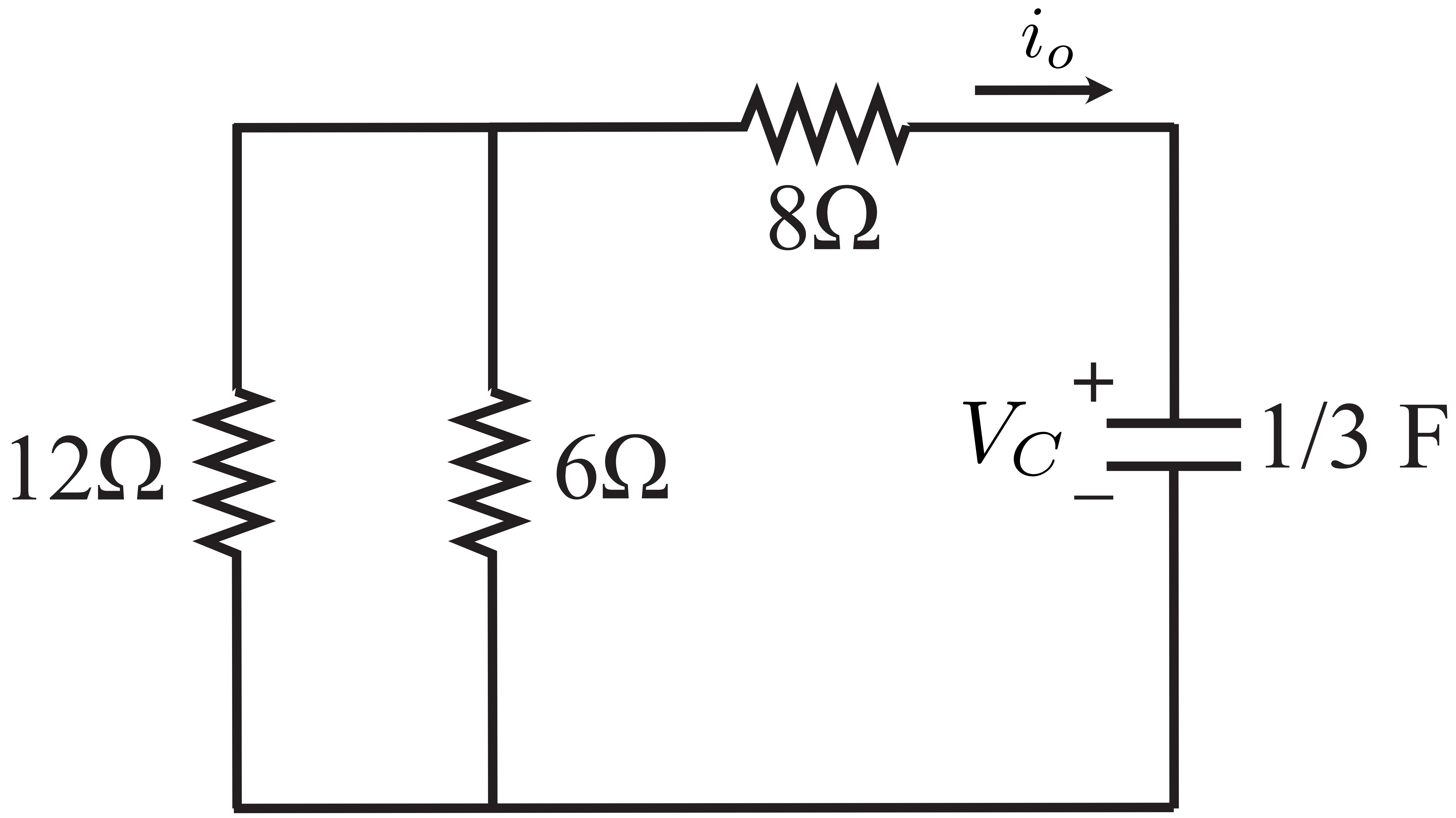
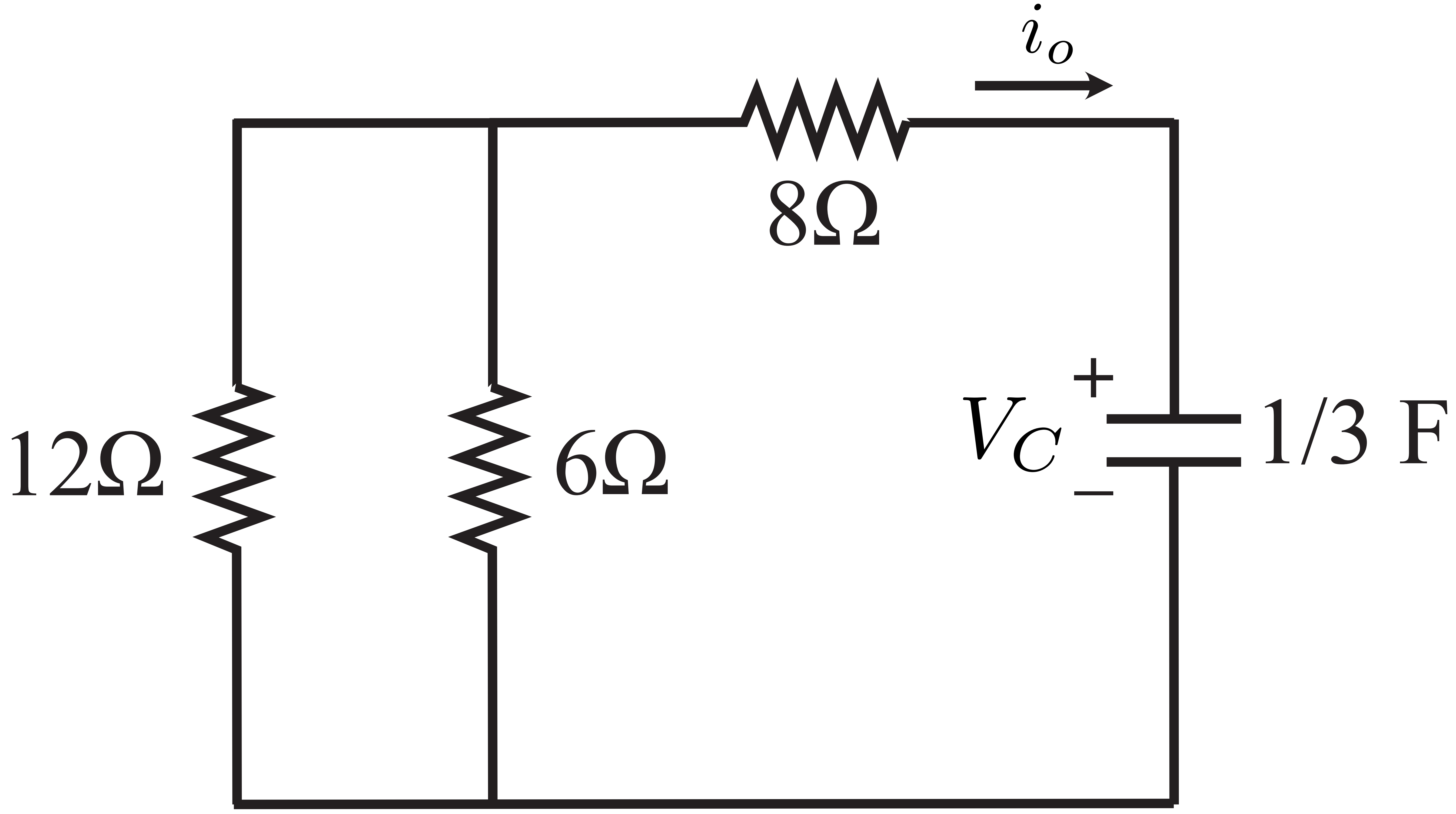


$$R_{eq} = \left[8 + \left(\frac{12 \cdot 6}{12 + 6}\right)^{-1}\right]\Omega = 12\Omega$$

$$V_c(t) = 60\, e^{-t/4}$$

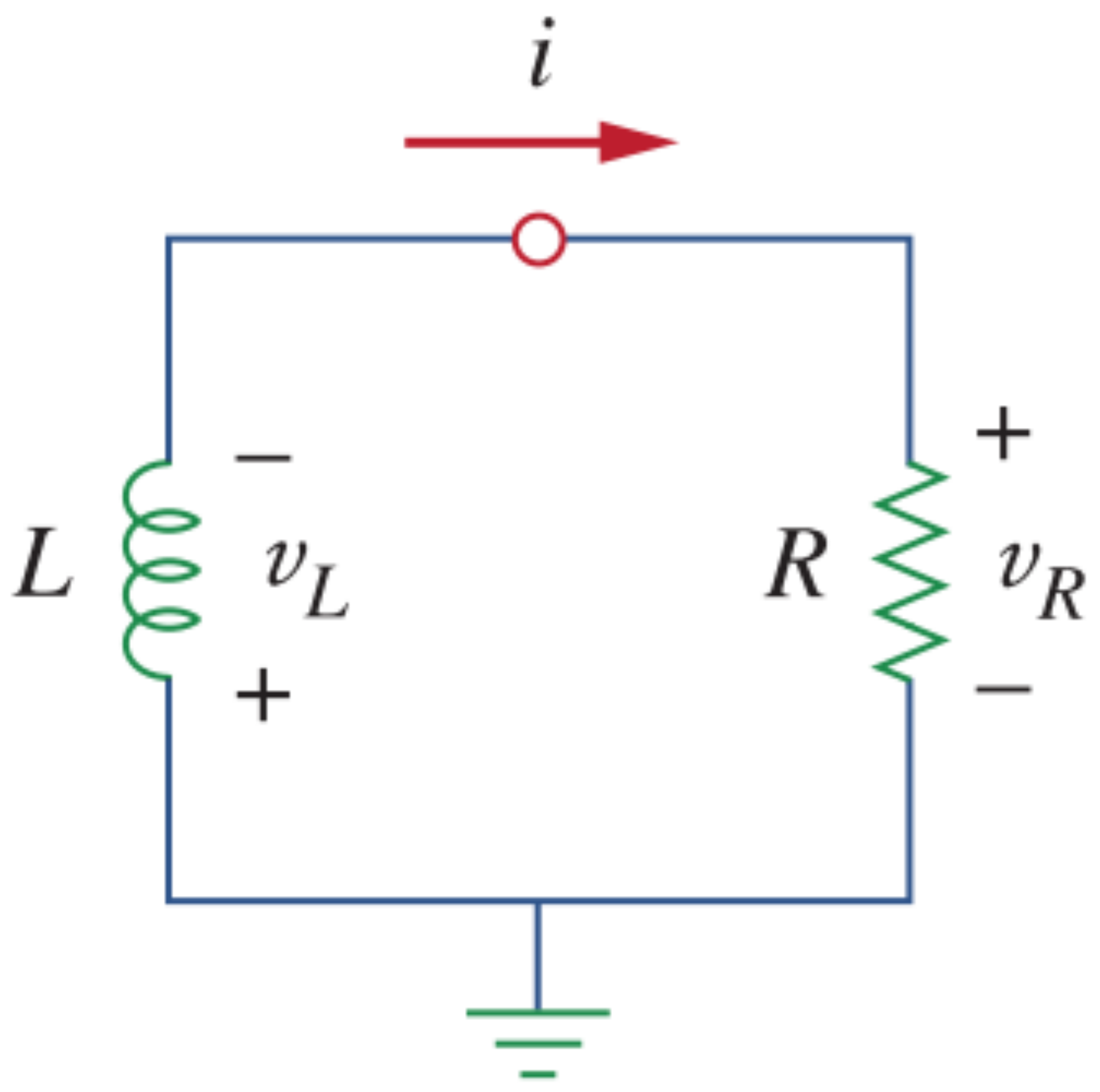
$$\tau = R_{eq}C = 4\, s$$

$$i_o(t) = -\,5\, e^{-t/4} A$$



RL Circuits

- Assume that at t=0, the inductor current is equal to I_o



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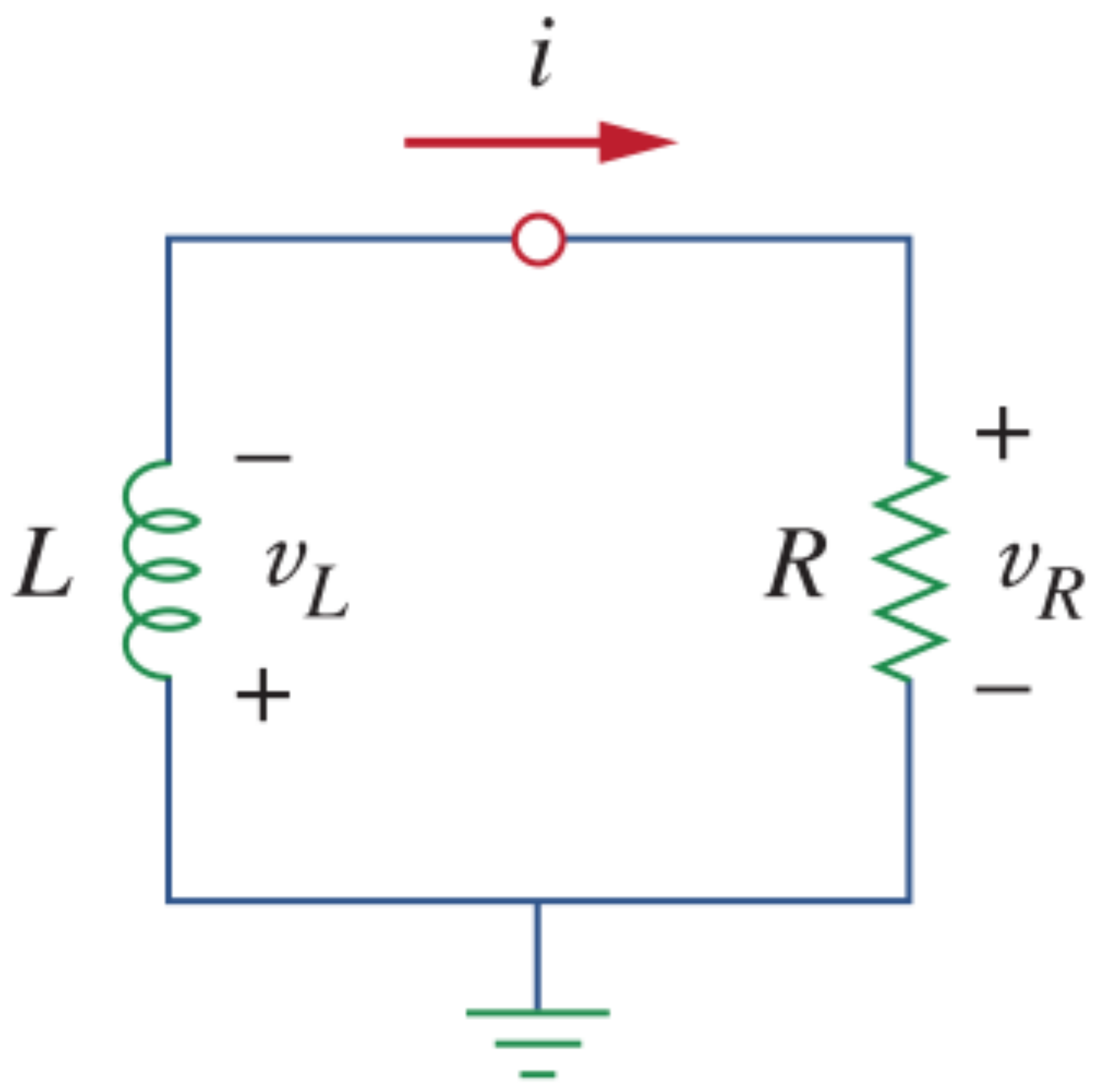
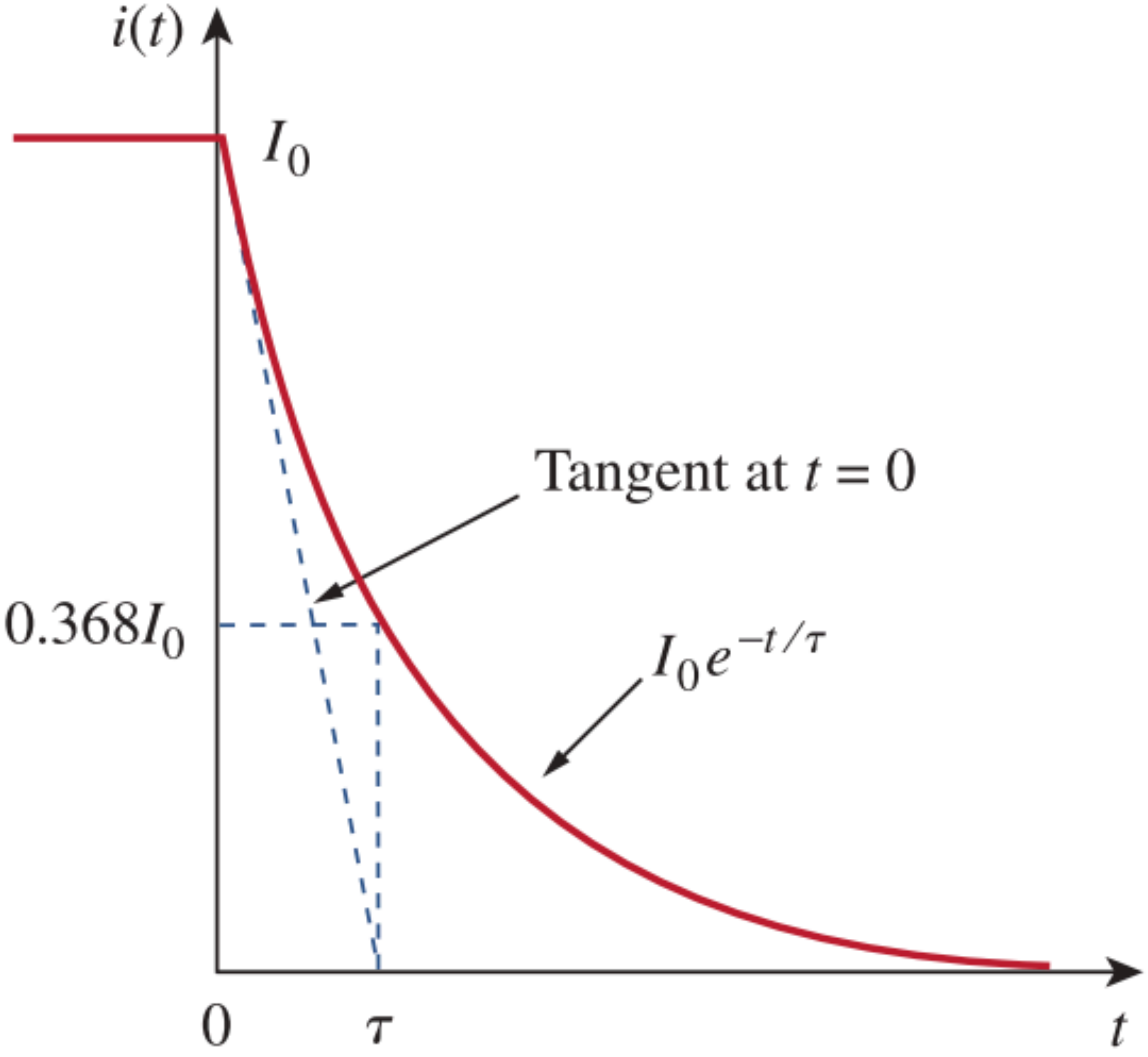


$$\tau = L/R$$

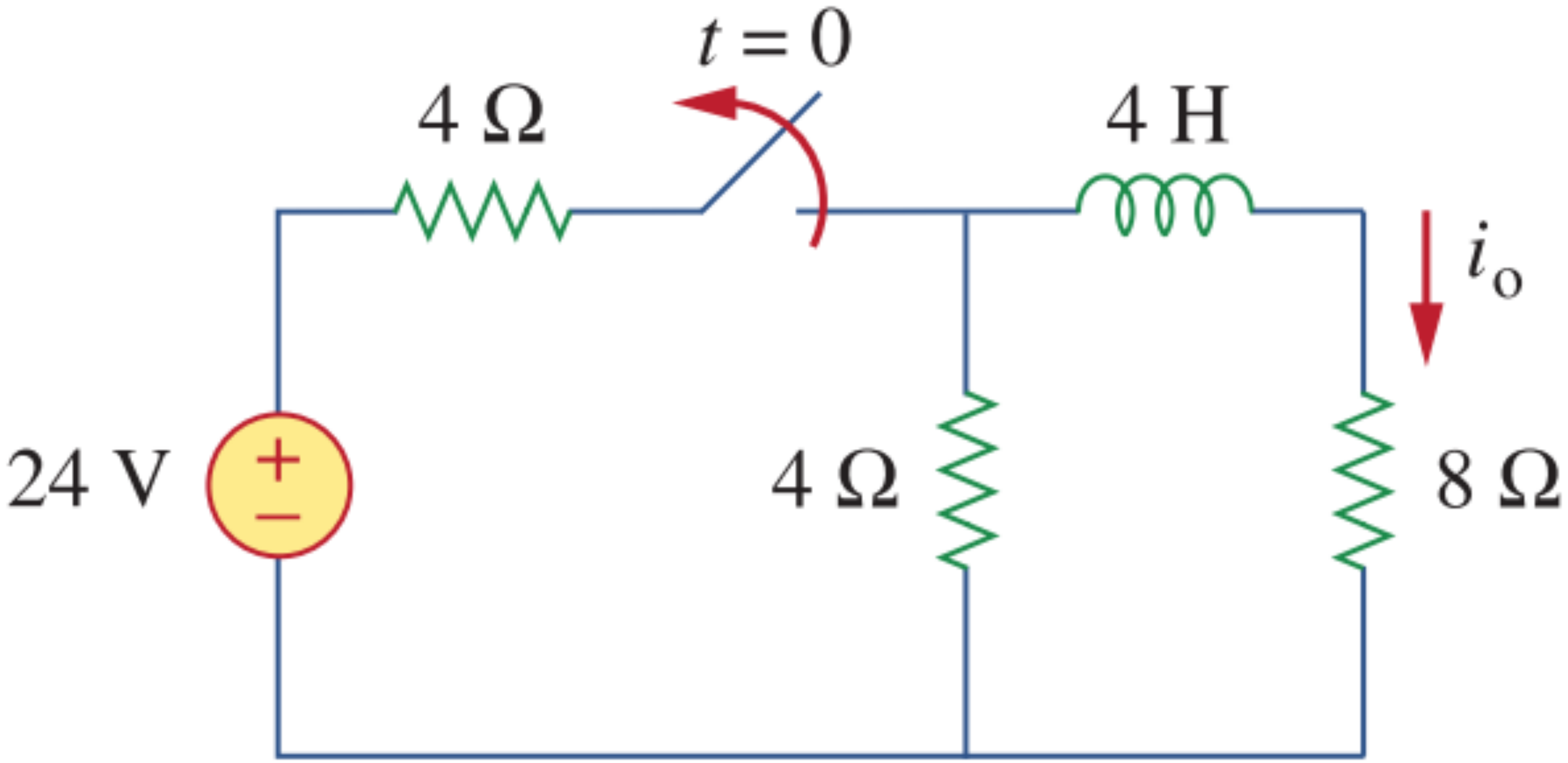
$$I_0(t) = I_0 e^{\frac{-t}{\tau}} = I_0 e^{\frac{-R}{L}t}$$

RL Circuits



RL Example

- Assume that at t<0 the switch is in closed condition and the circuit had reached steady-state conditions
- At t = 0, we open the switch. Compute $I_o(t)$



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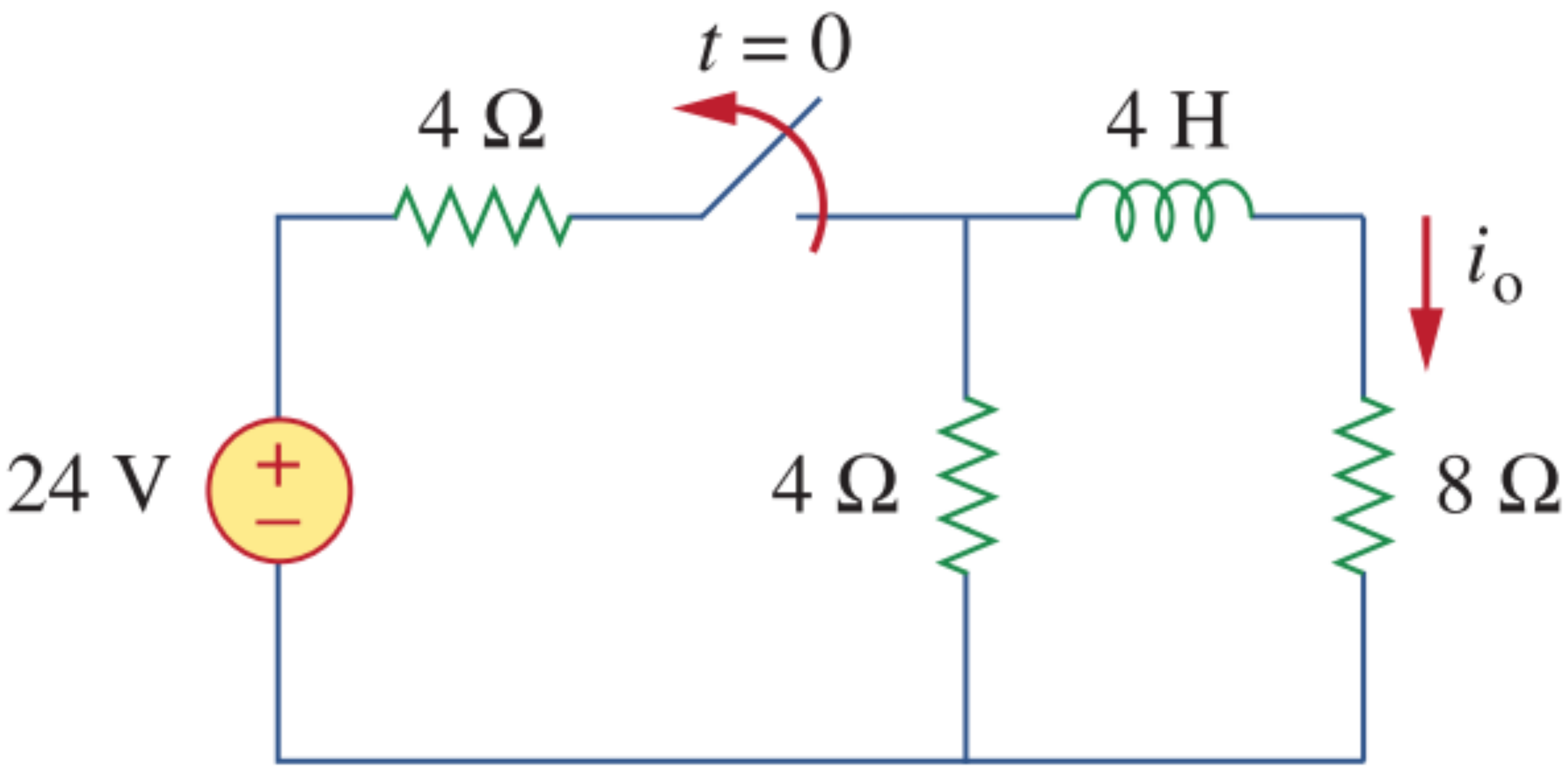
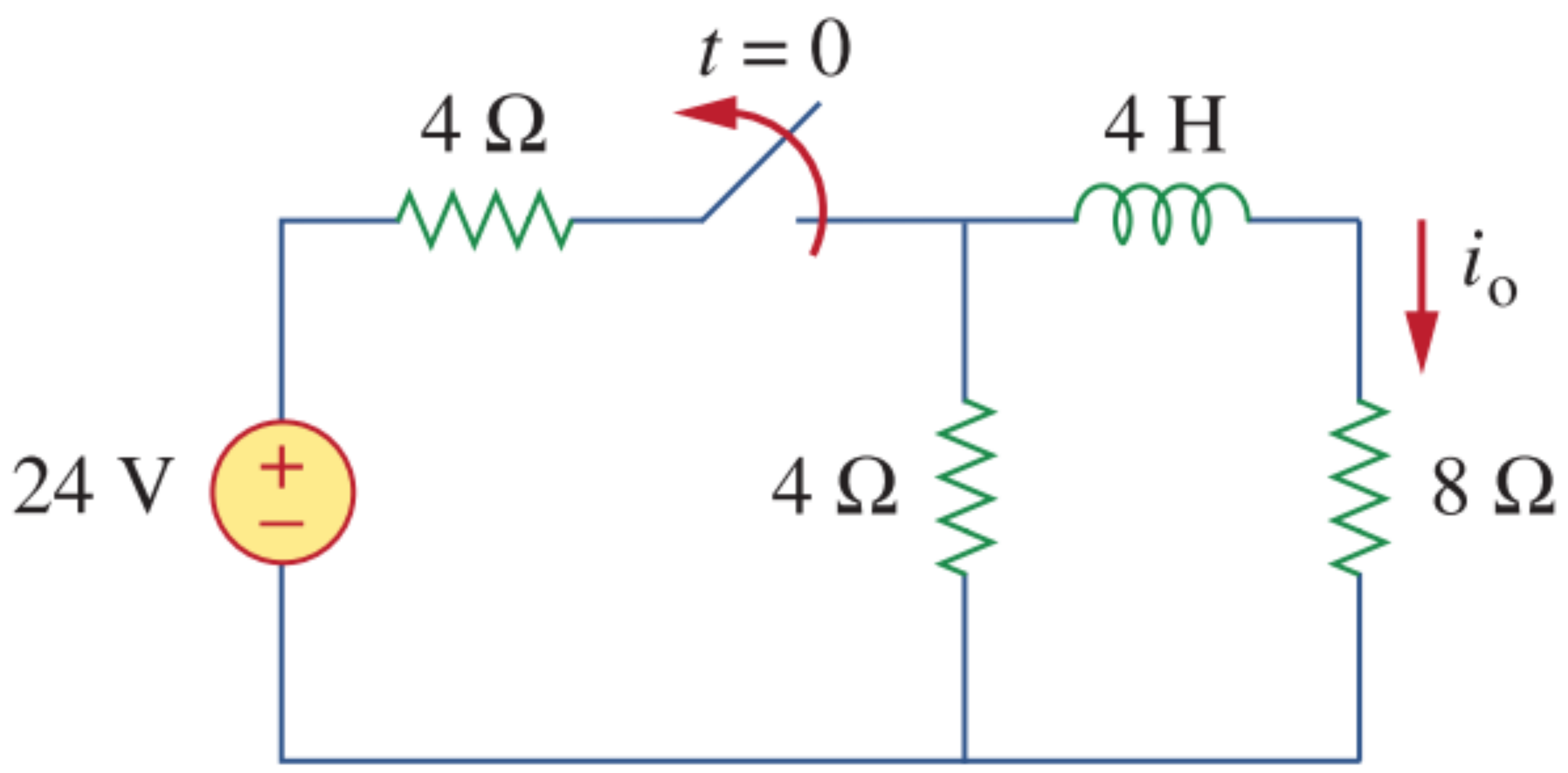
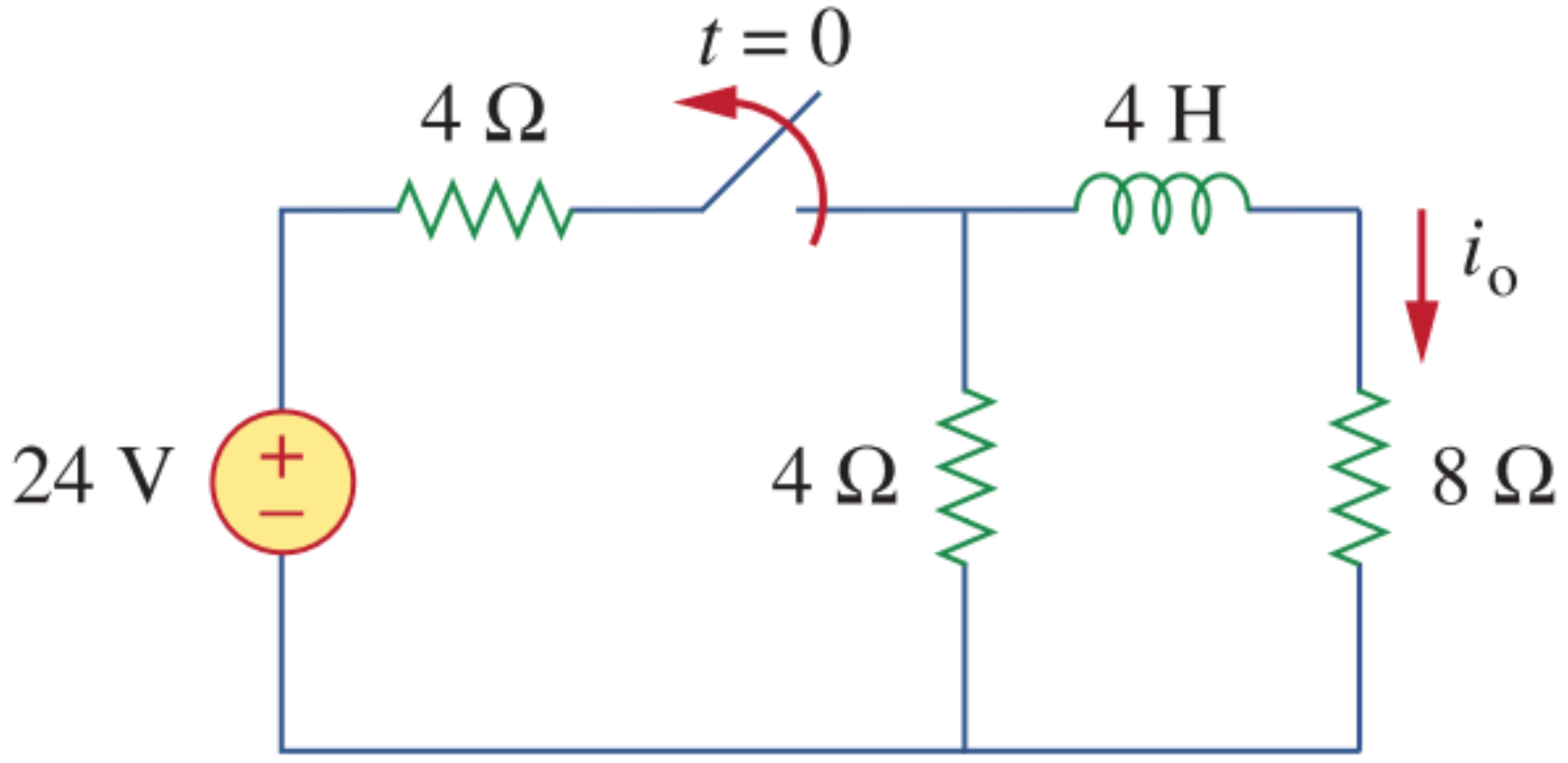


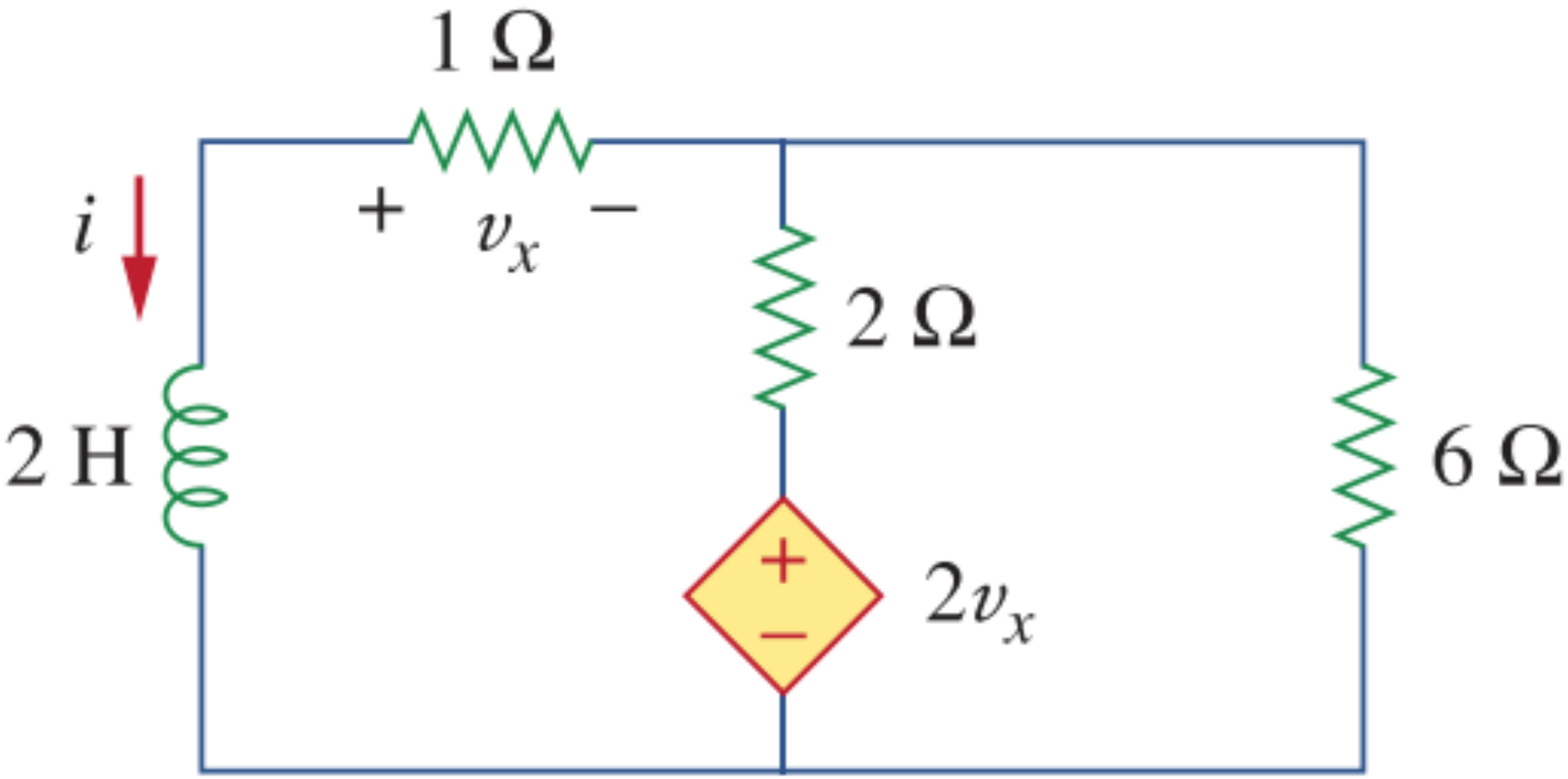


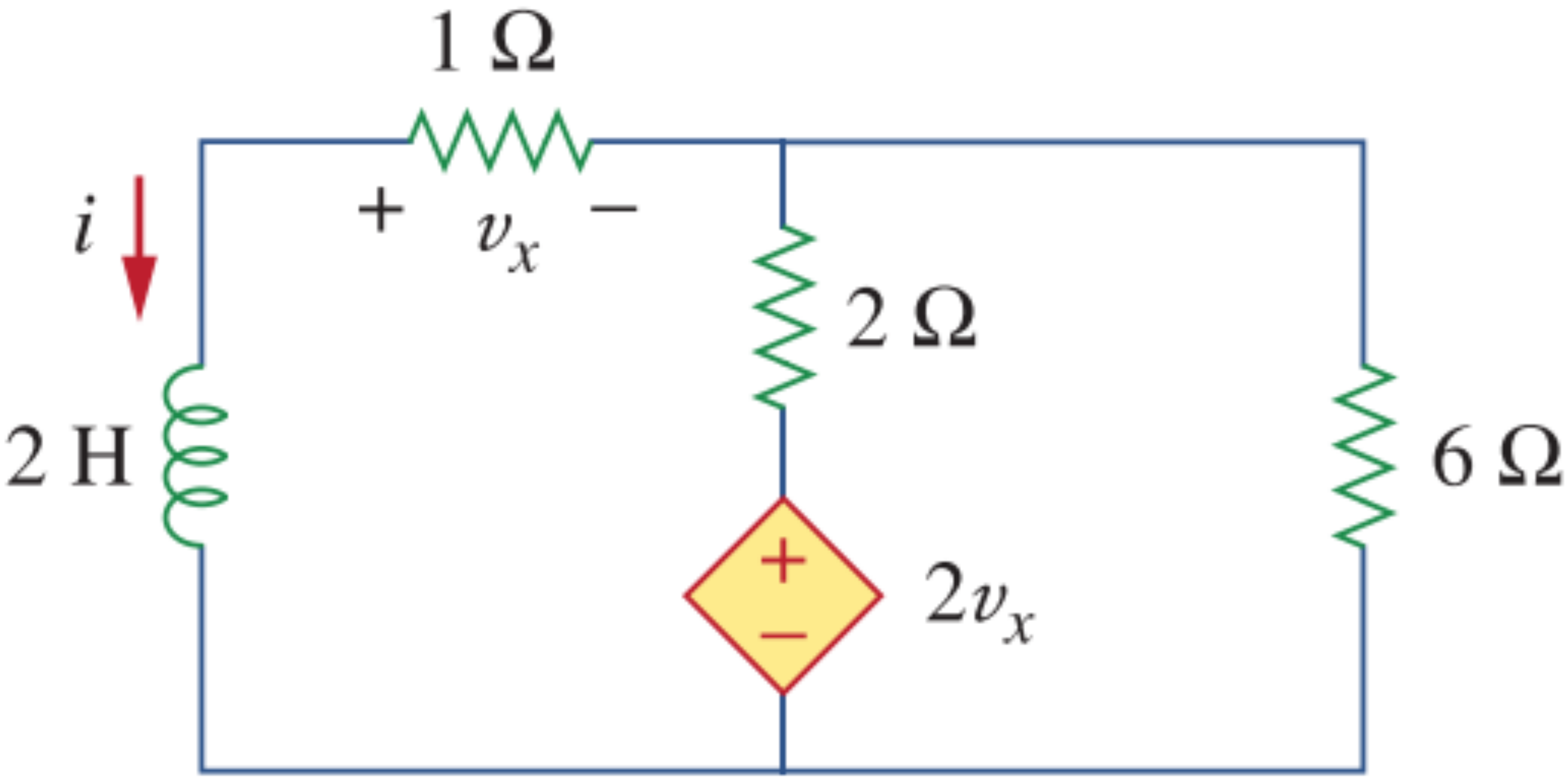
t = 0
4 Ω
4 H
i_o
24 V
4 Ω
8 Ω

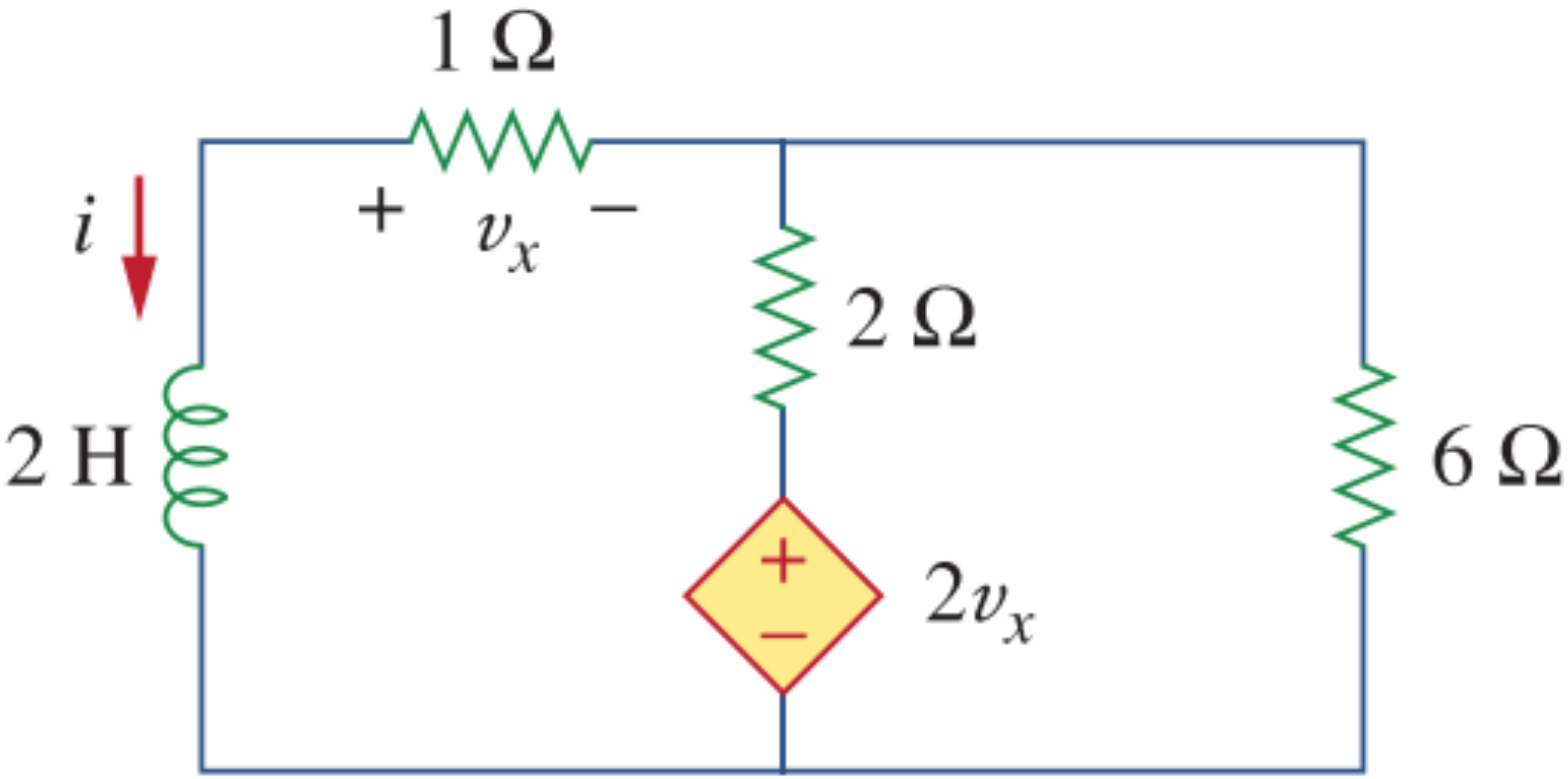


$$i_o(t) = 1.2e^{-3t}A$$

RL Example 2




1 Ω
+ v_x −
i
2 Ω
2 H
6 Ω
$2v_x$



$$\tau = 1/2s$$