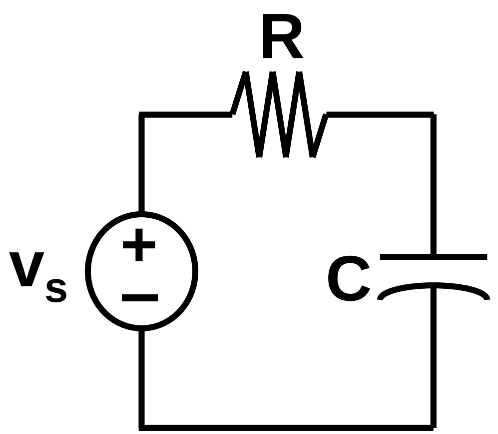
Outline

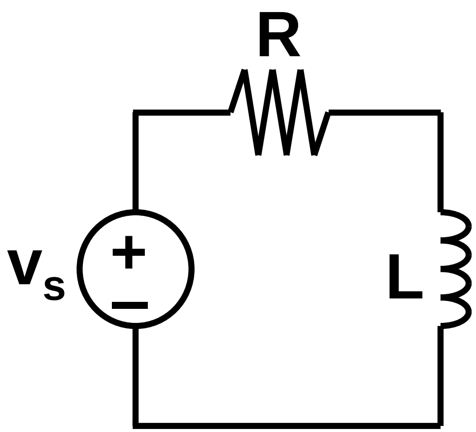
- Capacitors and inductors
- Natural response of RC/RL circuits
- Step response of RC/RL circuits
- Others

RC and RL Circuits

- A circuit that contains only sources, resistors and a capacitor is called an ***RC circuit***.



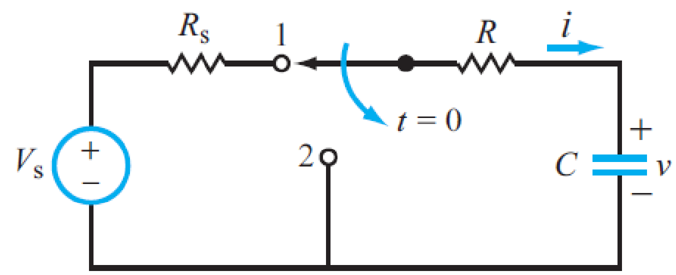
- A circuit that contains only sources, resistors and an inductor is called an ***RL circuit***.



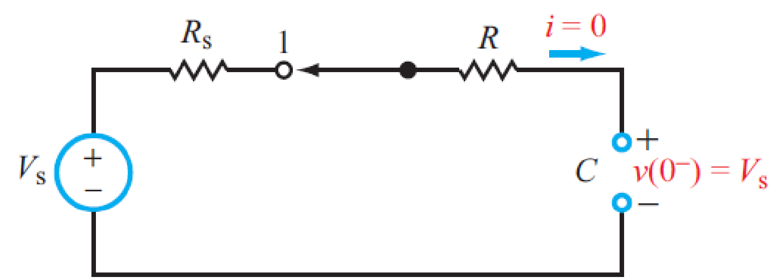
Natural Response

Behavior (*i.e.*, current and voltage) when stored energy in the inductor or capacitor is released to the resistive part of the network (containing <u>no independent sources</u>).

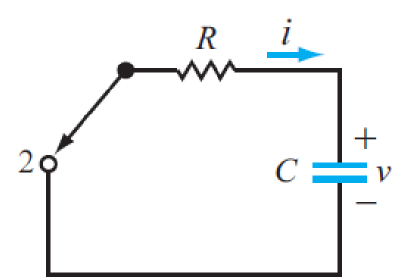
Natural Response of a Charged Capacitor



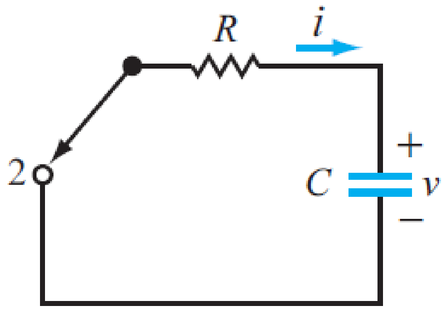
(a) $t = 0^-$ is the instant just before the switch is moved from terminal 1 to terminal 2;



(b) $t = 0$ is the instant just after it was moved, $t = 0$ is synonymous with $t = 0^+$.

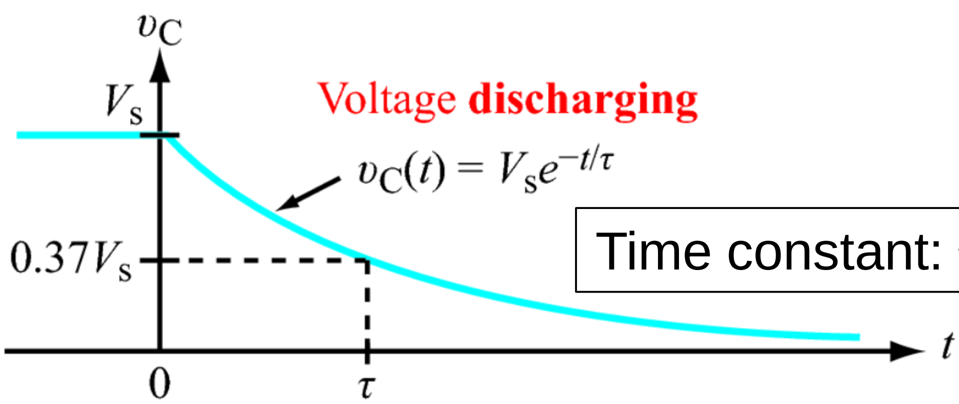


Natural Response of a Charged Capacitor

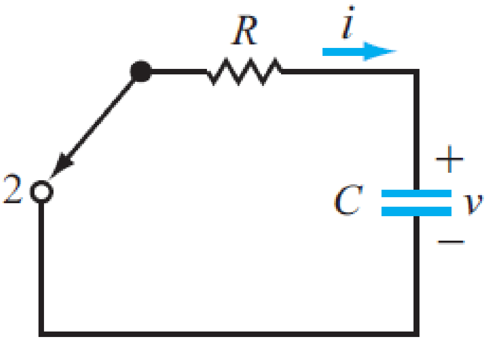


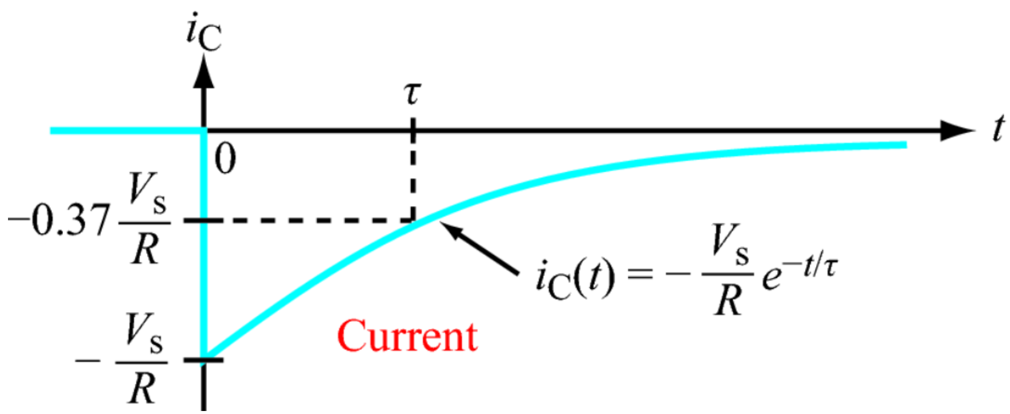
[Source: Berkeley]

Natural Response of RC Circuit



Time constant: $\tau = RC$

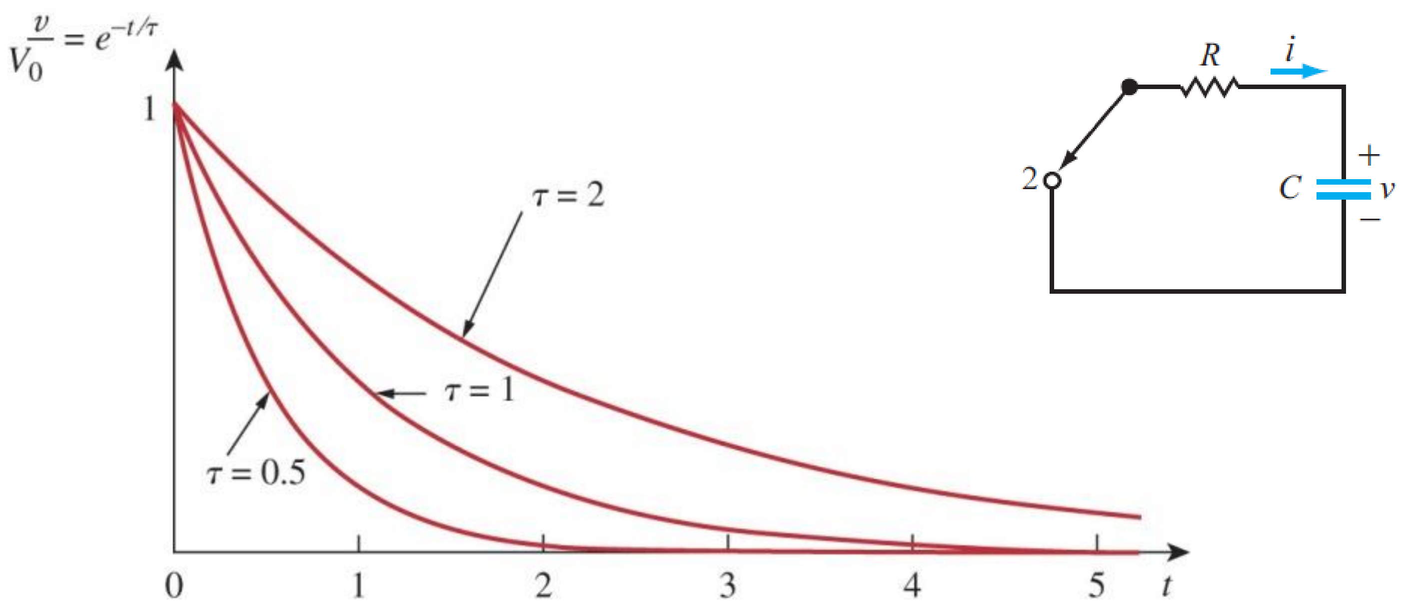




[Source: Berkeley]

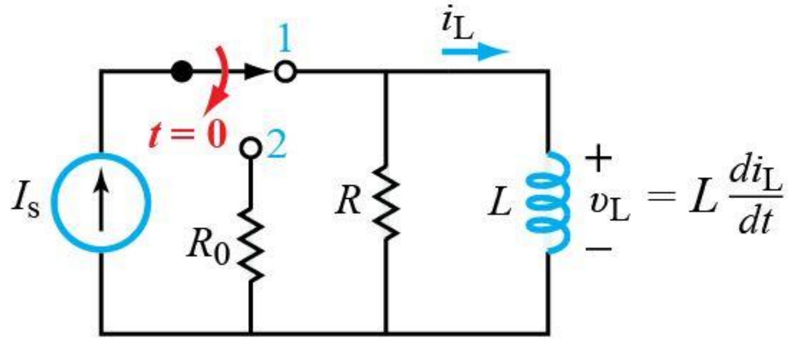
Time Constant τ (= RC)

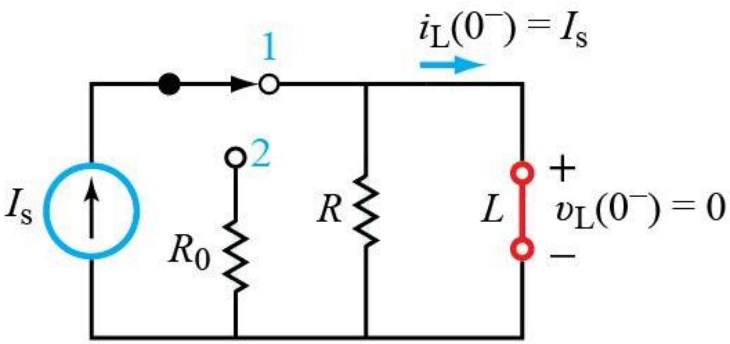
- A circuit with a small time constant has a fast response and vice versa.

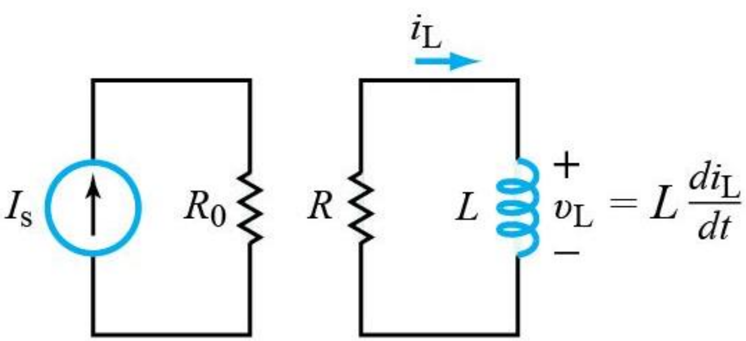


[Source: Berkeley]

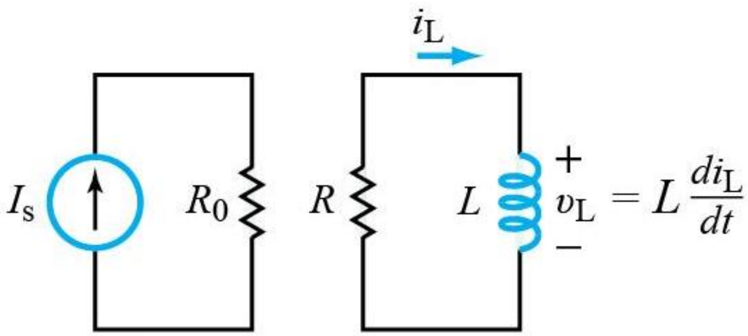
Natural Response of the RL Circuit





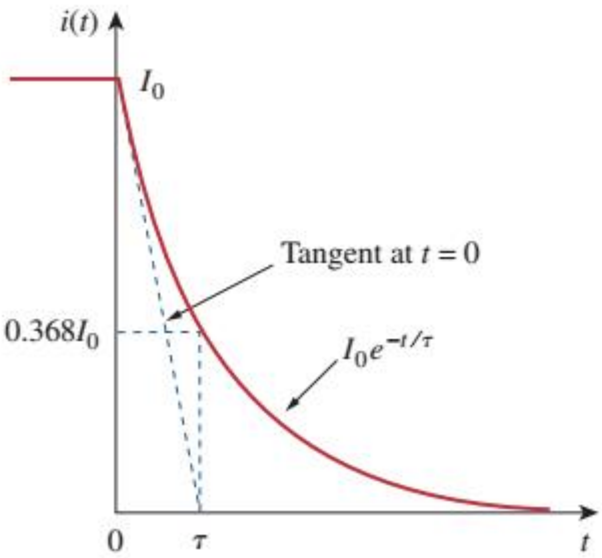


Natural Response of the RL Circuit



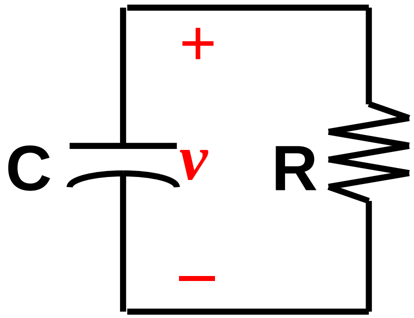
[Source: Berkeley]

Natural Response of the RL Circuit



Natural Response Summary

RC Circuit



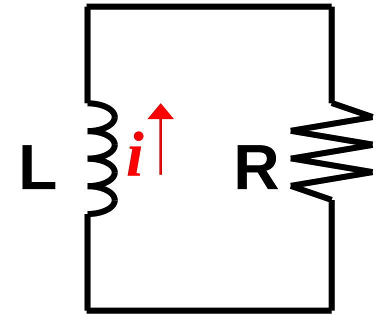
- Capacitor voltage cannot change instantaneously

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

$$v(t) = v(0)e^{-t/\tau}$$

- time constant $\tau = RC$

RL Circuit



- Inductor current cannot change instantaneously

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

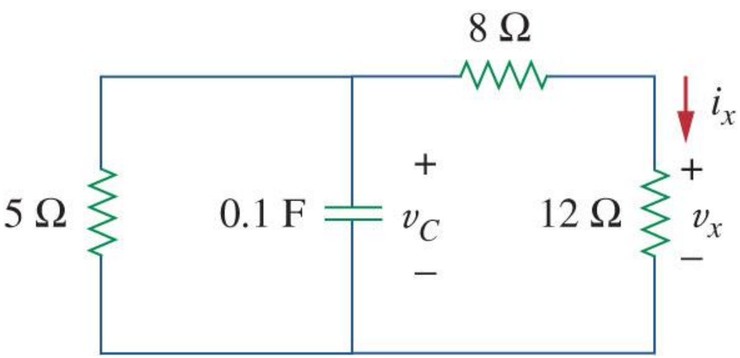
$$i(t) = i(0)e^{-t/\tau}$$

- time constant $\tau = \dfrac{L}{R}$

[Source: Berkeley]

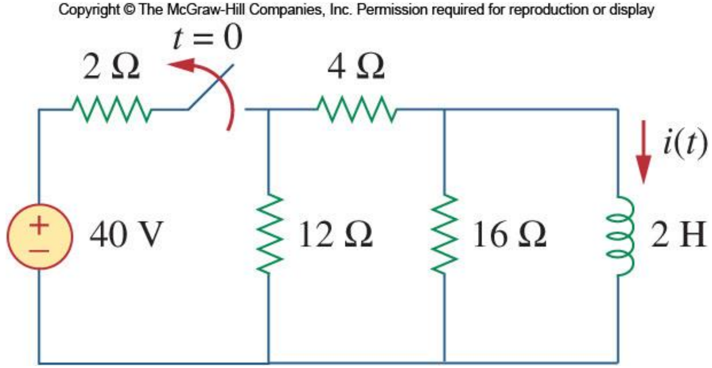
Example

- In the circuit below, let $v_C(t=0) = 15\text{V}$. Find v_C, v_x, and i_x for $t > 0$.

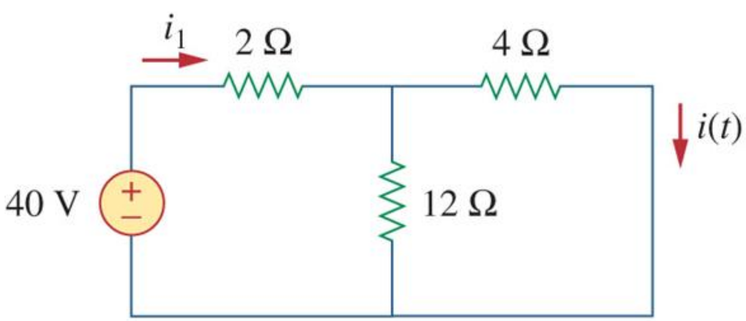


Example

- The switch in the circuit below has been closed for a long time. At $t = 0$, the switch is opened. Calculate $i(t)$ for $t > 0$.



When $t < 0$



When $t > 0$