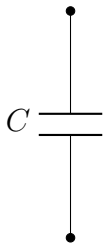
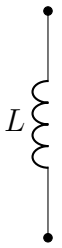
Chapter 7: Energy Storage Elements

ECE 2040



(a) A capacitor.



(b) An inductor.

Figure 1. Energy Storage Elements in a circuit.

Capacitors

- **Capacitance:** Measure of ability of a device to store energy in the form of a separated charge or electric field.

$$q(t) = Cv(t)$$

where,

$\Rightarrow$ $q(t)$ = charge stored by the capacitor

$\Rightarrow$ C = capacitance of the capacitor

$\Rightarrow$ $v(t)$ = voltage across the capacitor

- Current across the capacitor can be found by integrating above equation.

$$i(t) = C\frac{\mathrm{d}v(t)}{\mathrm{d}t}$$

- Voltage across a capacitor w.r.t. current:

$$v(t) = \frac{1}{C}\int_{t_0}^{t} i(\tau)\mathrm{d}\tau + v(t_0)$$

where,

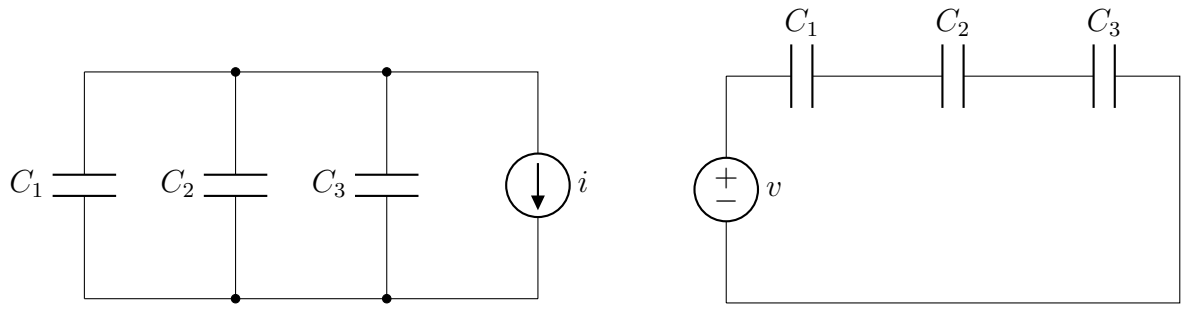
$\Rightarrow$ t_0 = initial time (usually 0s, depends on question)

- Energy stored in a capacitor

$$w_c = \frac{1}{2}Cv^2\Big|_{v(-\infty)}^{v(t)}$$

- A capacitor in a dc circuit behaves as an open circuit.

Series and Parallel Capacitors



(a) Capacitors in parallel. **(b)** Capacitors in series.

Figure 2. Combinations of capacitors.

- Capacitances in parallel add up:

$$C_p = C_1 + C_2 + C_3$$

- Inverses of capacitance in series add up:

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

Inductors

- Inductance is a measure of the ability of a device to store energy in the form of a magnetic field.

$$v(t) = L\frac{\mathrm{d}i(t)}{\mathrm{d}t}$$

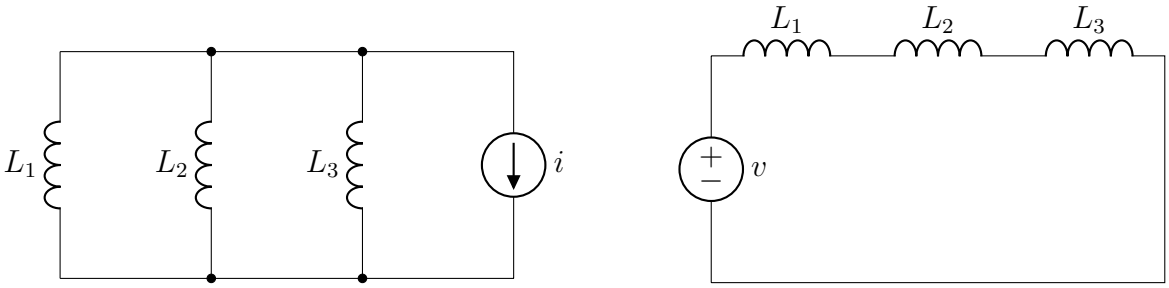
- Current through an inductor

$$i(t) = i(t_0) + \frac{1}{L}\int_{t_0}^{t} v(\tau)\mathrm{d}\tau$$

- Energy Stored in an inductor

$$w = \frac{1}{2}Li^2$$

- An inductor in a dc circuit behaves as a short circuit.



(a) Inductors in parallel. **(b)** Inductors in series.

Figure 3. Combinations of inductors.

Series and Parallel Inductors

- Inductances in series add up:

$$L_s = L_1 + L_2 + L_3$$

- Inverses of inductances in parallel add up:

$$\frac{1}{L_p} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$$