Assignment #7 due Thu March 14, 11:59 PM
Midterm 2 Rework due tomorrow 11:59 PM
Exam pickup 3-4pm Today KEC 4095
& after class

**Capacitor**

\[ q = C \, \varepsilon \]

\[ i = C \frac{dv}{dt} \quad \Rightarrow \quad v(t) = \frac{1}{C} \int_{t_0}^{t} i \, dt + v(t_0) \]

* For a dc voltage \( \frac{dv}{dt} = 0 \) \( \Rightarrow i = 0 \) (Charge)
  
  Capacitor acts like an open circuit at dc

- The voltage across a capacitor cannot change instantaneously (abruptly)

The capacitor is an energy storage element

\[ W = \frac{1}{2} \, C \, \varepsilon^2 \quad \text{(energy stored)} \]

The capacitor stores charge when charging and releases charge when discharging

\[ v^+ \quad \frac{1}{C} \quad \frac{1}{i} \quad v^- \quad \text{charging} \]

\[ + \quad \frac{1}{C} \quad \frac{1}{i} \quad - \quad \text{discharging} \]

**Capacitors in series:**

\[ \frac{1}{C_e} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n} \]

**Capacitors in parallel:**

\[ C_{eq} = C_1 + C_2 + \cdots + C_n \]

\[ \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n} \]
Inductor

An element that stores energy in its magnetic field.

Magnetic flux $\Lambda = L \cdot i$

Where $L$ is the inductance and its units are henry (H).

$L$ is independent of $v \times i$

$\mathbf{V} = \frac{d\mathbf{\Lambda}}{dt} = L \frac{di}{dt}$

The inductor is a linear element

- For a dc (constant) current $\frac{di}{dt} = 0 \Rightarrow \mathbf{V} = L \frac{di}{dt} = 0$
  i.e. the inductor likes a short circuit for dc

- The current through an inductor cannot change instantaneously (abruptly) $i(t)$

An ideal inductor does not dissipate energy. The inductor takes power from the circuit when storing energy and delivers power to the circuit when releasing previously stored energy.

Power and Energy

$P = vi = (L \frac{di}{dt}) \cdot i = Li \frac{di}{dt} = \frac{d}{dt} \left( \frac{1}{2} Li^2 \right)$

Energy $W = \int_{-\infty}^{t} P(t) \, dt = \frac{1}{2} Li^2$
\[ v = \frac{L \, di}{dt} \quad \Rightarrow \quad i(t) = \frac{1}{L} \int_{t_0}^{t} v \, dt + i(t_0) \]

**Series Inductors**

\[
v = v_1 + v_2 + \cdots + v_n
\]

\[
\frac{L_1}{\frac{di}{dt}} + \frac{L_2}{\frac{di}{dt}} + \cdots + \frac{L_n}{\frac{di}{dt}} = \frac{L_{eq}}{\frac{di}{dt}}
\]

\[
L_{eq} = L_1 + L_2 + \cdots + L_n
\]

**Inductors in Parallel**

\[
\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \cdots + \frac{1}{L_n}
\]

For 2 inductors in parallel

\[
L_{eq} = \frac{L_1 \cdot L_2}{L_1 + L_2}
\]

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**Example**

\[30 \, \parallel 60 = \frac{30 \times 60}{30 + 60} = 20 \, H\]

\[40 \, \parallel 120 = \frac{40 \times 120}{40 + 120} = 30 \, H\]

\[50 \, \parallel 50 = 25 \, H\]

\[20 \, H\]

\[50 \, H\]

\[30 \, H\]
Ex Find $i_L$ and $v_c$ under dc conditions.

For dc, the inductor acts like a short circuit.
The capacitor acts like an open circuit.

$$i_L = \frac{3}{3+1} \times 4 = 3A$$
by current division.

$$v_c = \text{voltage drop across } 1\Omega \text{ resistor}$$
$$= 3 \times 1 = 3V$$