Lecture 2, Wednesday, January 19, 2022

- *Node voltage:* energy gain per Coulomb moved from a reference node to a specific node.

  It changes if the reference changes. Element voltages do no change.

- *Kirchhoff's voltage law (***KVL***):* Around any closed loop

$$\sum V_{\text{rise}} = \sum V_{\text{drop}} \quad \Rightarrow \quad \sum V_{\text{drop}} - \sum V_{\text{rise}} = 0$$

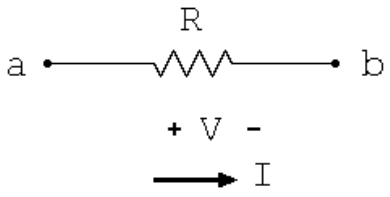
  – don't loose or gain energy when you return to the same node

- *Kirchhoff's current law (***KCL***):* At any node

$$\sum I_{\text{in}} = \sum I_{\text{out}}$$

  – don't create/loose current at any node

- *Resistor:*



  – Resistance, $R \in [0, \infty)$

    * If $R = 0$ it acts as a short
    * If $R = \infty$ it acts as an open circuit

  – Units: Ohms: $\Omega = \frac{V}{A}$

  – *Ohm's law:* $V = RI$

    * assumes SRS: current enters the $\oplus$ terminal

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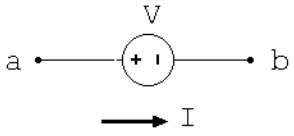
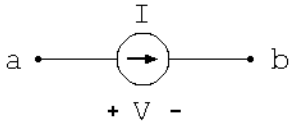
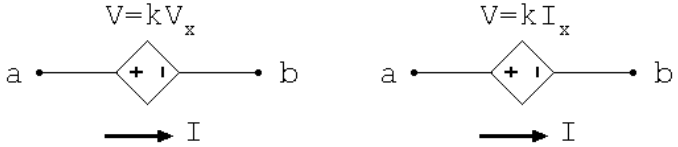
- *Independent voltage source:* voltage and polarity are fixed



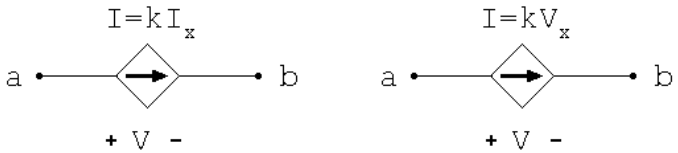
- *Independent current source:* current and its direction are fixed



- *Dependent voltage source:* voltage depends on voltage or current somewhere else in circuit



- *Dependent current source:* current depends on voltage or current somewhere else in circuit



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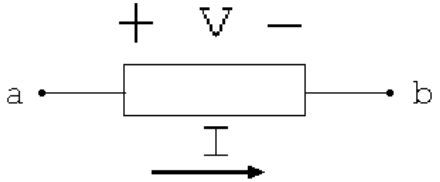
- *Absorbed power*: total energy loss of charge carriers per unit time from terminal $\oplus$ to $\ominus$.

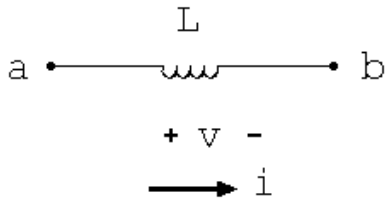


$$P = \frac{dW}{dt} = \frac{dW}{dq}\frac{dq}{dt} = VI \begin{cases} > 0 \text{ absorbs} \\ = 0 \\ < 0 \text{ injects} \end{cases}$$

  - assume SRS: current enters the $\oplus$ terminal
  - Units: Watts: $W = \frac{J}{s}$
  - Resistor:

$$P = VI = (RI)I = RI^2 \geq 0 \qquad P = VI = V\left(\frac{V}{R}\right) = \frac{V^2}{R} \geq 0$$

  - *Inductor:*



    * Inductance $L \in [0, \infty)$
    * Units: Henries (H)
    * $v(t) = L\dfrac{di}{dt}$
        · if current, i, is constant then inductor acts as a short
    * $P = vi = \left(L\dfrac{di}{dt}\right) i = \dfrac{d}{dt} \underbrace{\left(\dfrac{1}{2}Li^2\right)}_{\text{energy stored}} \begin{cases} > 0 \text{ absorbs} \\ = 0 \\ < 0 \text{ injects} \end{cases}$

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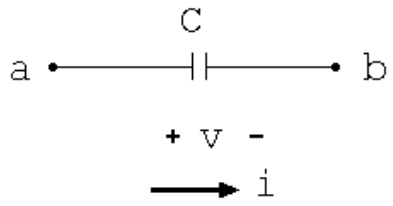
– *Capacitor:*



* Capacitance $C \in [0, \infty)$
* Units: Farads (F)
* $i(t) = C\dfrac{dv}{dt}$
  - if voltage, v, is constant then capacitor acts as an open circuit
* $P = vi = v\left(C\dfrac{dv}{dt}\right) = \dfrac{d}{dt}\underbrace{\left(\dfrac{1}{2}Cv^2\right)}_{\text{energy stored}}$ $\begin{cases} > 0 \text{ absorbs} \\ = 0 \\ < 0 \text{ injects} \end{cases}$

