Lumped-Element Modeling

- Last lecture
  - Conjugate power variables
  - Equivalent circuit modeling
  - One-port elements
    - Ideal Flow Source
    - Ideal Effort Source
    - Generalized Resistor
- Today:
  - One-port elements
    - Generalized Capacitor
    - Generalized Inertance
    - Co-energy
  - Kirchhoff's Laws
  - Example
  - Laplace Transform

Reading: Senturia, pp. 110-118.

Generalized Capacitor

- <u>Ideal Capacitor, or Compliance</u>: "*C*"
  - Stores potential energy associated with a displacement.

$$e = \Phi(q) \;\; \text{or} \; q = \Phi^{-1}(e)$$

  - When a compliance has a non-zero effort (non-zero displacement), it is storing potential energy.

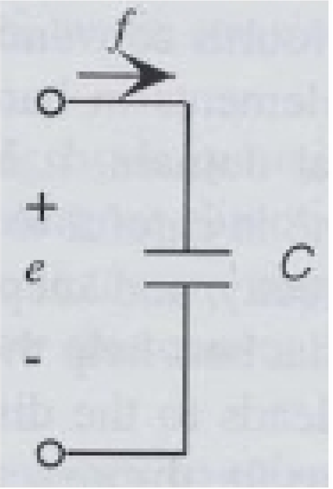
$$W(q_1) = \int_0^{q_1} e\,dq = \int_0^{q_1} \Phi(q)\,dq \equiv \text{ stored POTENTIAL ENERGY}$$

PE

$$W^*(e_1) = \int_0^{e_1} q\,de = \int_0^{e_1} \Phi^{-1}(e)\,de \equiv \text{ stored POTENTIAL CO-ENERGY}$$

Generalized Capacitor

- Ideal Compliance: "*C*"

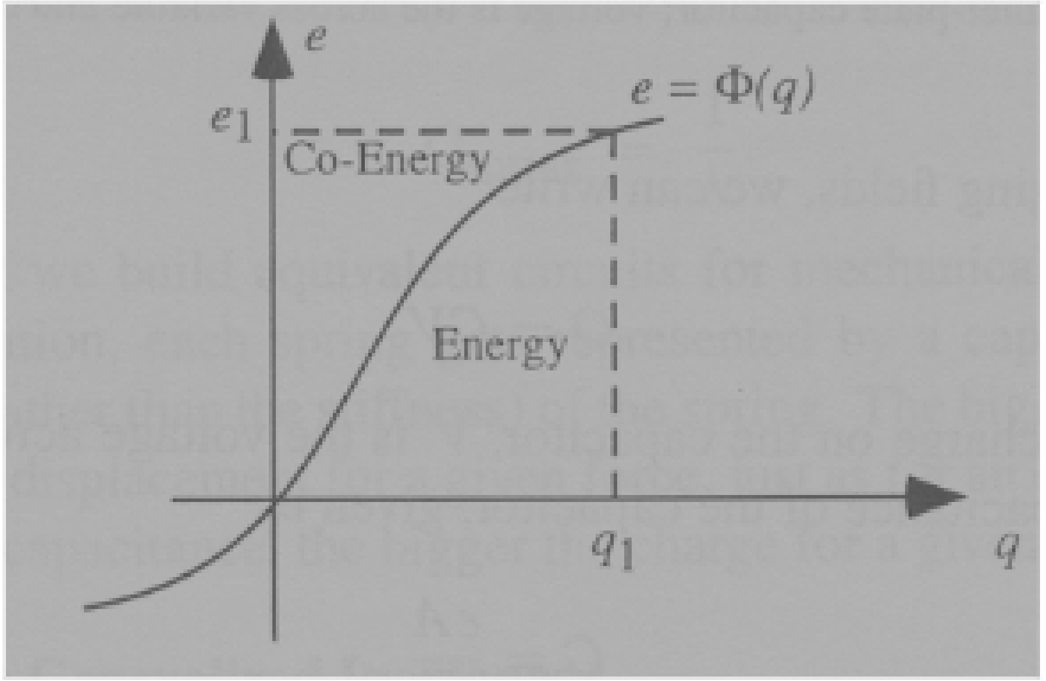


Ref. Senturia, p. 109.

$$e = \frac{1}{C}\int f\,dt \text{ or } e(j\omega) = \frac{1}{j\omega C} f(j\omega)$$

$$e(s) = Z_C(s) f(s) \qquad Z_C(s) = \frac{1}{sC}$$

Complex Impedance



Ref. Senturia, p. 110.

$$W(q_1) = \int_0^{q_1} \Phi(q)\,dq$$

$$W^*(e_1) = \int_0^{e_1} \Phi^{-1}(e)\,de$$

If Φ is linear,

then $W(q_1) = W^*(e_1)$