PASSIVE CIRCUIT ELEMENTS

- **Examples:**

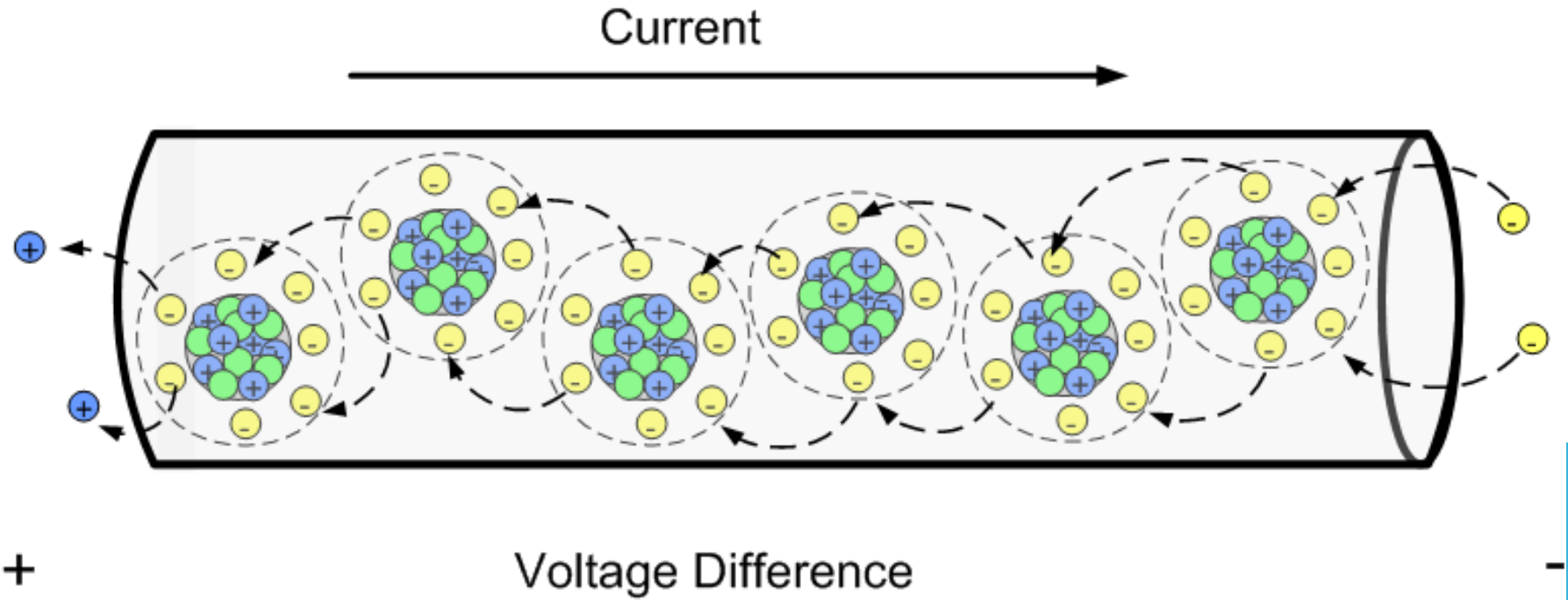
- **Resistors**
- **Capacitors**
- **Inductors**

PASSIVE CIRCUIT ELEMENTS - RESISTORS

- ***Resistance*** **models the fact that energy is always lost during charge motion**
- **Electrons moving through a material "collide" with the atoms composing the material**
- **These collisions impede the motion of the electrons**

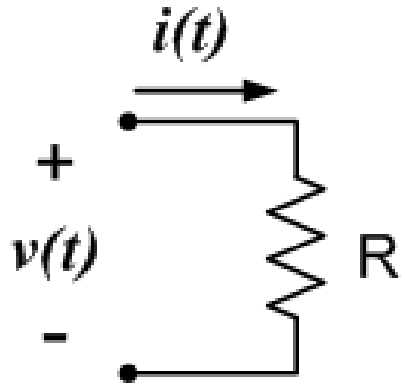
Thus, a voltage potential difference is required for current to flow. This potential energy balances the energy lost in these collisions.

RESISTANCE



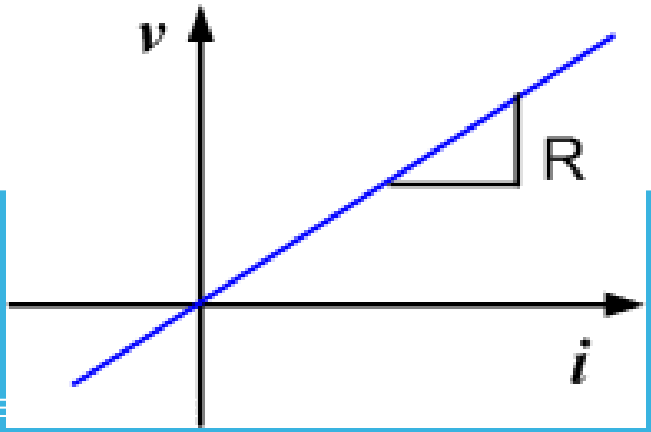
RESISTORS

- **Circuit symbol:**



- **Voltage-current relation (Ohm's Law):**

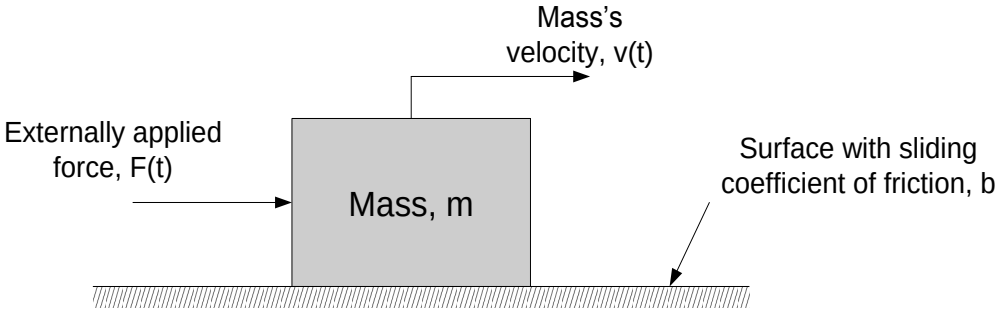
$$v(t) = R \cdot i(t)$$



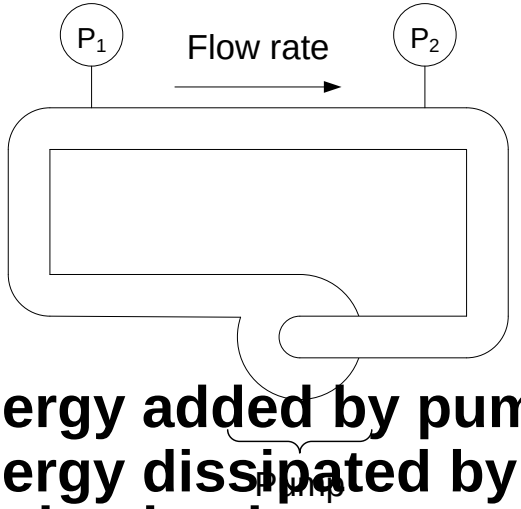
- **R is the resistance**
  - **Units are ohms (Ω)**

RESISTANCE ANALOGIES

- Sliding mass with constant velocity on surface with friction



- Pressure loss in horizontal pipe

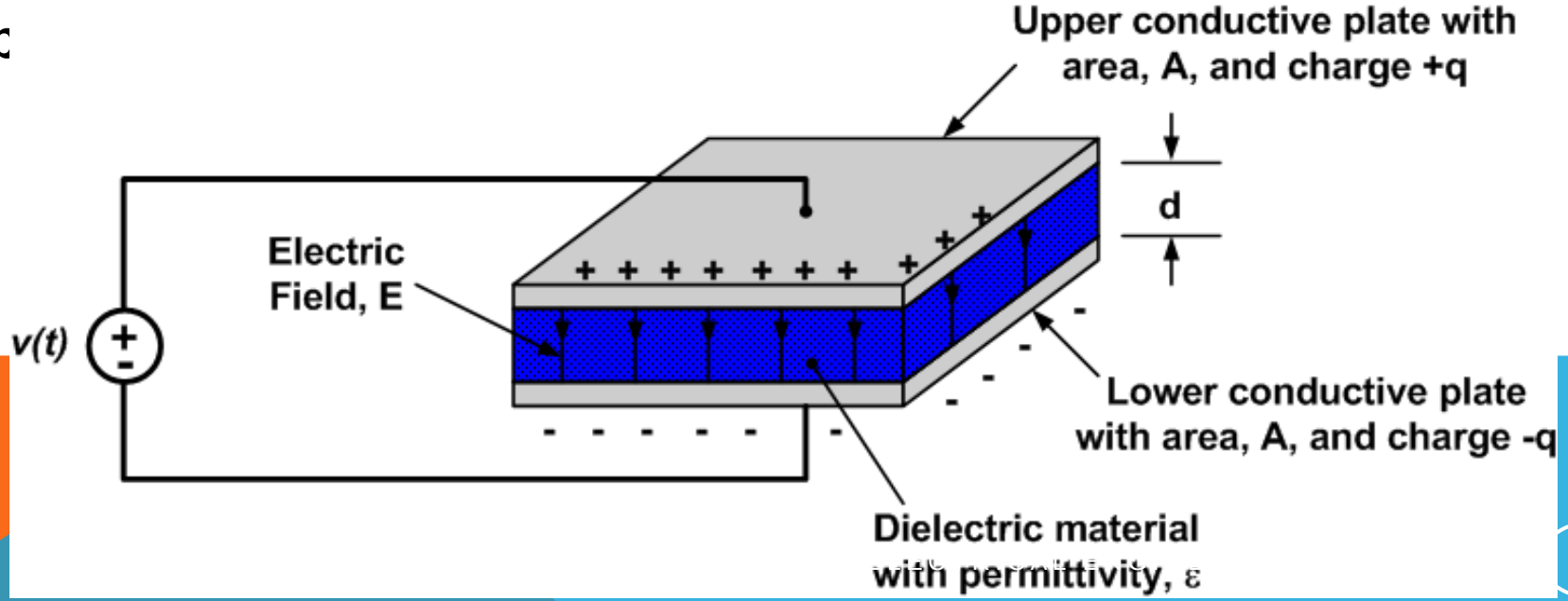


- Energy added by pump
- Energy dissipated by friction in pipe

Energy added by force applied to mass
Energy dissipated by friction as heat

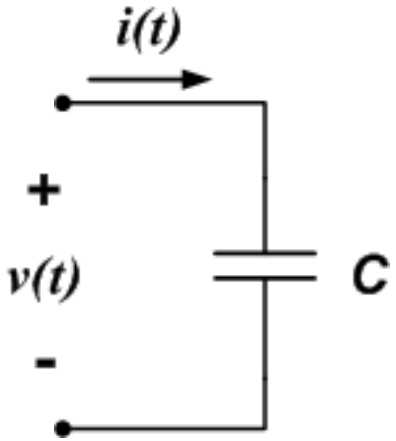
PASSIVE CIRCUIT ELEMENTS – CAPACITORS

- **Capacitors store energy in the form of an electric field**
- **Typically constructed of two conductive materials separated b**



CAPACITORS

- **Circuit symbol:**



- **C is the capacitance**
  Units are Farads (F)

- **Voltage-current relation:**

$$i(t) = C\frac{dv(t)}{dt}$$

- **Capacitors can store energy**

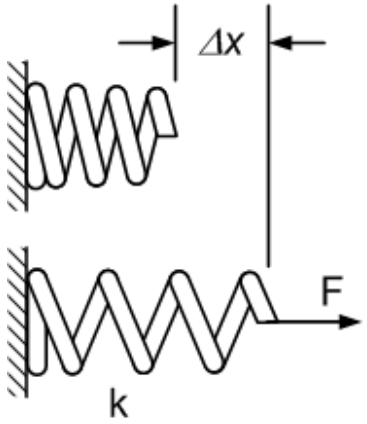
$$W_c = \frac{1}{2}Cv^2$$

CAPACITORS

- **Notes:**
- **Capacitors can store energy**
- **The voltage-current relation is a differential equation**
- **Capacitance limits rate of change of voltage**
- **If the voltage is constant, the current is zero and the capacitor looks like an open-circuit**

CAPACITANCE ANALOGIES

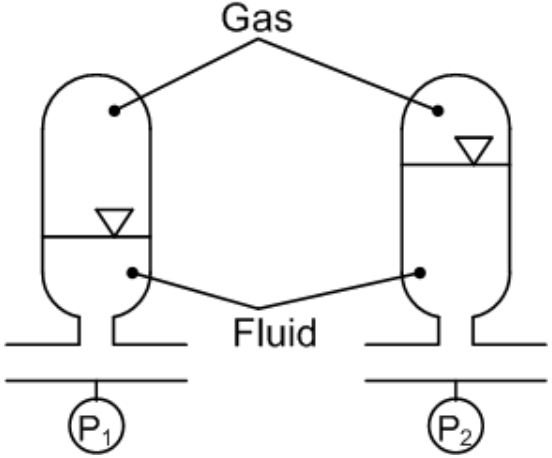
- **Stretched spring**



- **Energy added by force in spring**
- **Energy stored in spring:**

$$W_s = \frac{1}{2} C_s F^2$$

- **Pressurized accumulator**

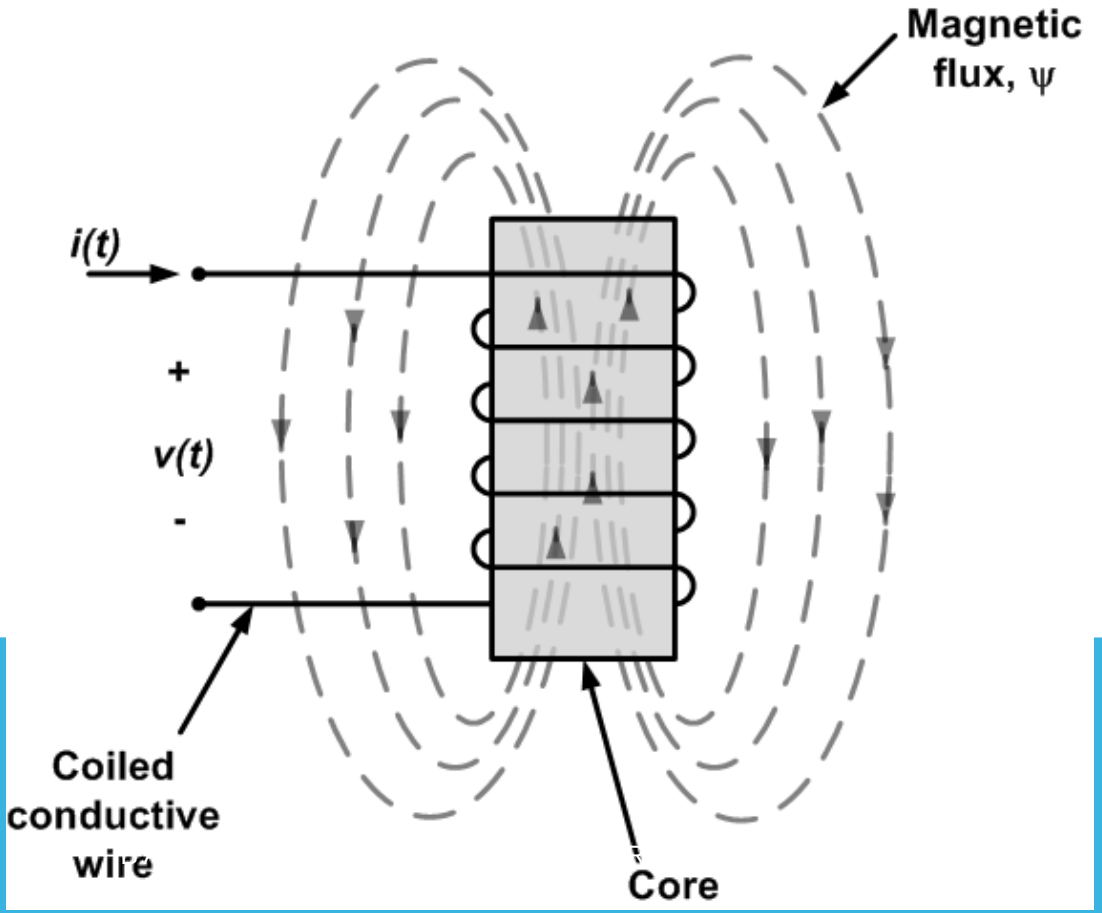


- **Energy added by pressure change**
- **Energy stored by pressure change**

$$W_f = \frac{1}{2} C_f (P_{gas})^2$$

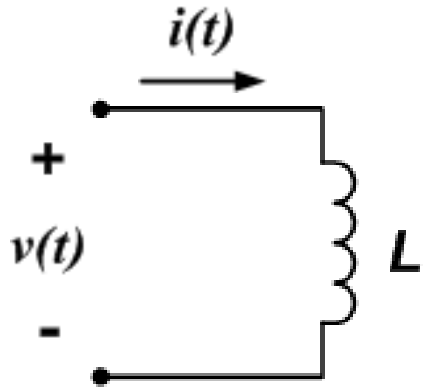
PASSIVE CIRCUIT ELEMENTS - INDUCTORS

- Inductors store energy in the form of a magnetic field
  - Often constructed by coiling a conductive wire around a ferrite core



INDUCTORS

- **Circuit symbol:**



- **Voltage-current relation:**

$$v(t) = L\frac{di(t)}{dt}$$

- **Inductors can store energy**

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

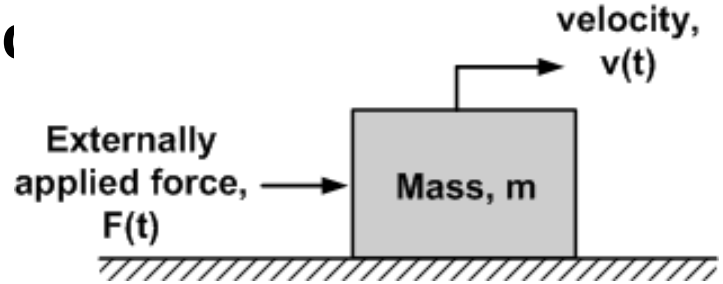
- **L is the inductance**
  Units are Henries (H)

INDUCTORS

- **Notes:**
- **Inductors can store energy**
- **The voltage-current relation is a differential equation**
- **If the current is constant, the voltage difference is zero and the inductor looks like a perfect conductor**

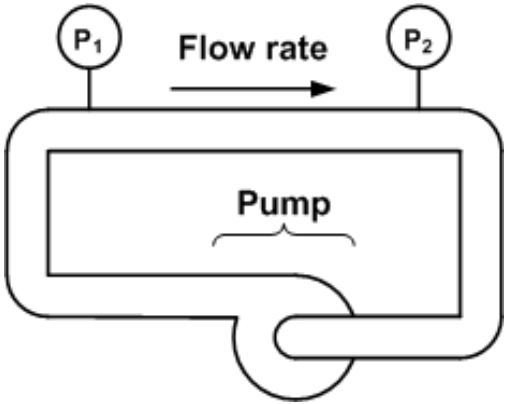
INDUCTOR ANALOGIES

- Increasing velocity of sliding mass (with no fri



- Applied force increases energy applied to mass
- Energy stored in change of velocity of mass: $W = \frac{1}{2}mv^2$

- Increased flow rate in fluid system



- Applied pressure adds energy
- Energy stored in increased fluid flow rate: $W_f = \frac{1}{2}L\dot{w}^2$