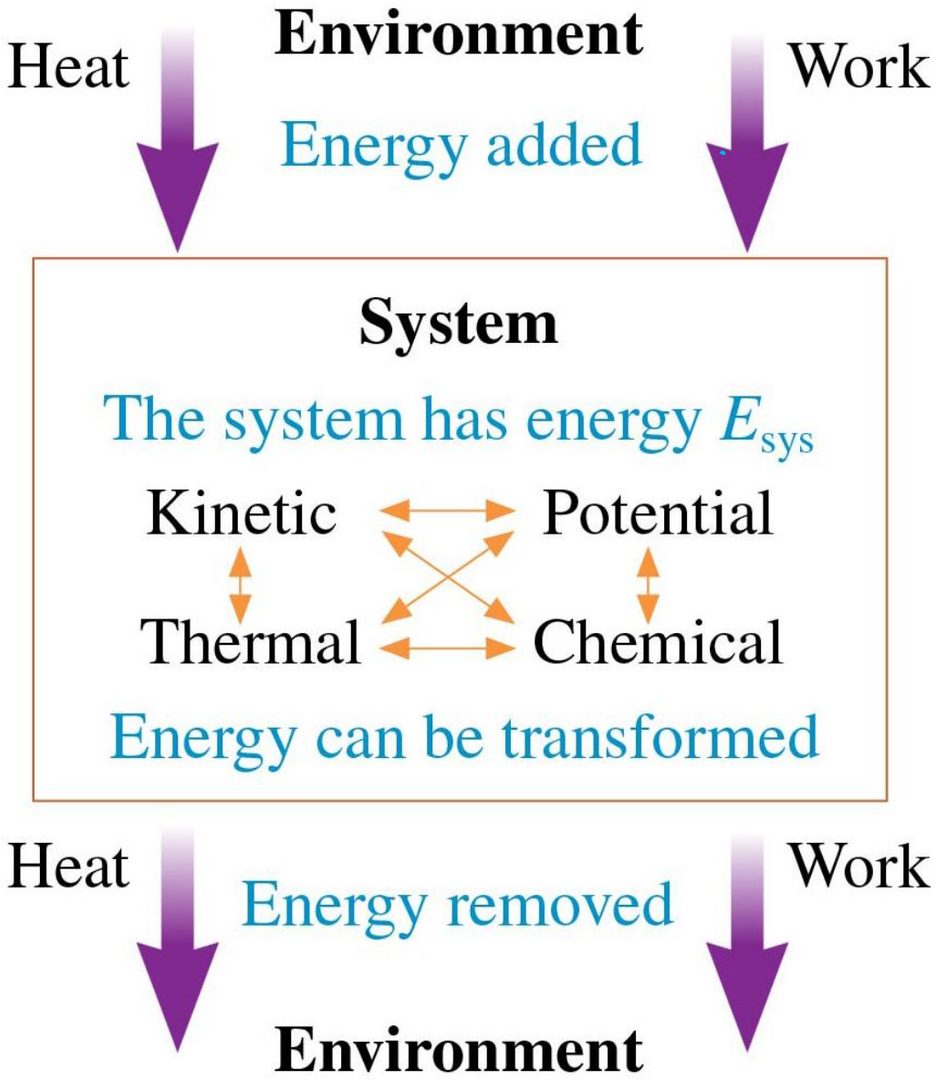
Chapter 9 – Work and Kinetic Energy

- Energy and systems
- Work
- Thermal energy
- Power

How should we think about energy?

Chapters 9 and 10 will develop the **basic energy model**, a powerful set of ideas for using energy. A key distinction is between the **system**, which has energy, and the **environment**. Energy can be **transferred** between the system and the environment or **transformed** within the system.

« **LOOKING BACK** Section 7.1 Interacting objects

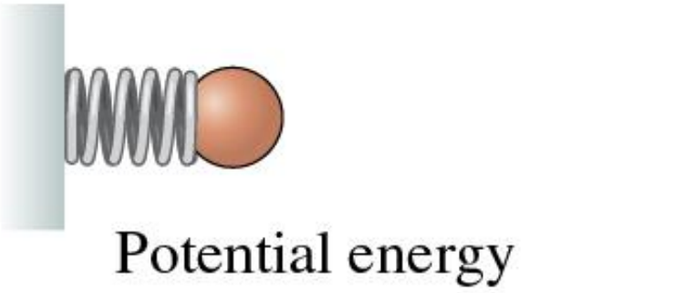


What are some important forms of energy?

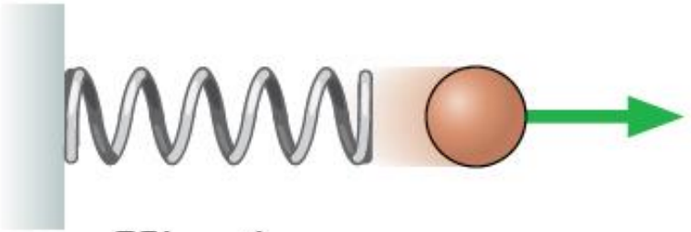
Three important forms of energy:

- **Potential energy** is energy associated with an object's *position*.
- **Kinetic energy** is energy associated with an object's *motion*.
- **Thermal energy** is the energy of the random motion of *atoms* within an object.

Energy is measured in **joules**.



Potential energy

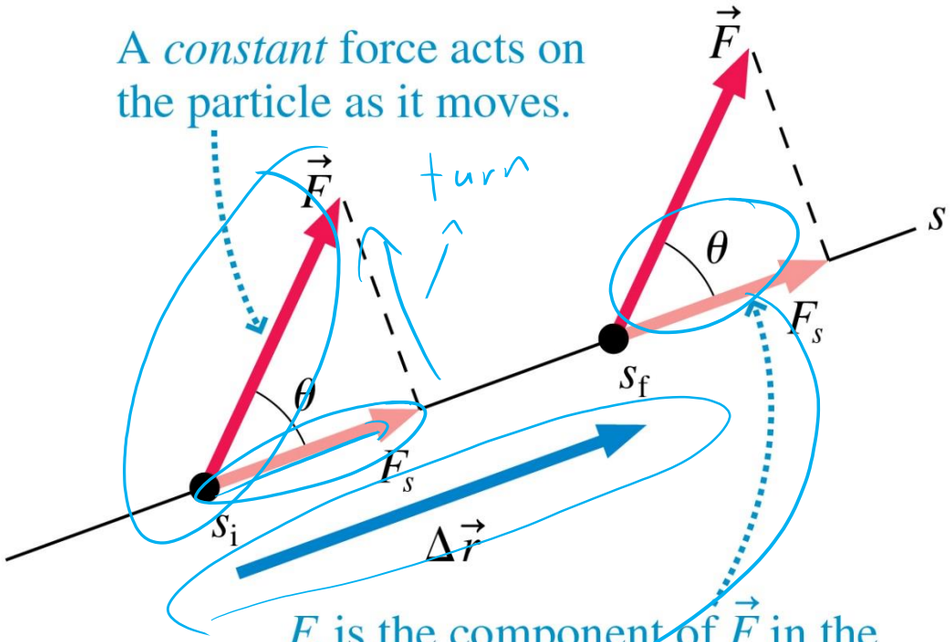


Kinetic energy

What is work?

A process that ***changes*** **the energy of a system by mechanical means**—pushing or pulling on it—is called **work**.

Work W is done when a force pushes or pulls a particle through a displacement, thus changing the particle's kinetic energy.



turn

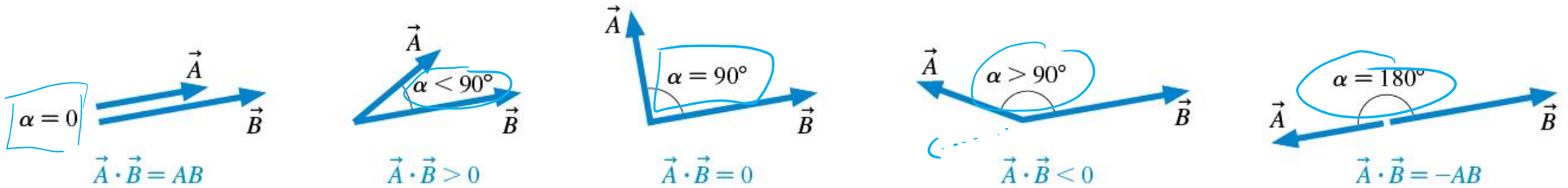
$$W = \vec{F}\cdot\Delta\vec{s} = |\vec{F}|\,|\Delta\vec{s}|\cos\theta$$

$$= (F_x\hat{i} + F_y\hat{j})\cdot(\Delta s_x\hat{i} + \Delta s_y\hat{j}) = F_x\Delta s_x + F_y\Delta s_y$$

$\hat{i}\cdot\hat{i} = 1 \quad \hat{j}\cdot\hat{j} = 1$

$\hat{i}\cdot\hat{j} = 0$

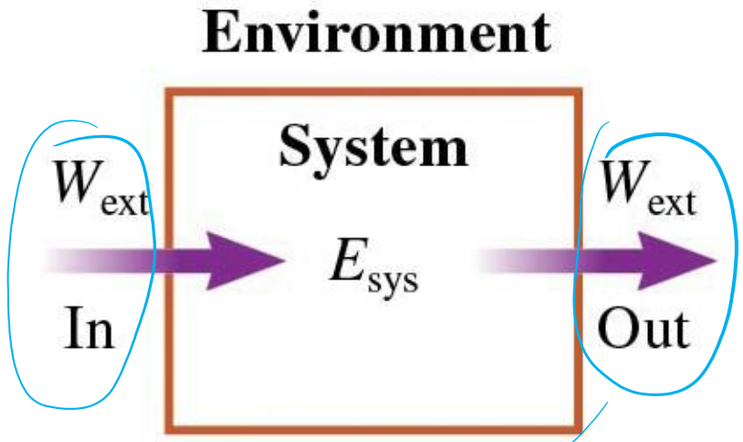
$\theta \to \alpha$



What laws govern energy?

Working with energy is very much like accounting: A system's energy E changes by the amount of work done on the system. The mathematical statement of this idea is called the **energy principle**:

$$\Delta E_{\text{sys}} = W_{\text{ext}}$$

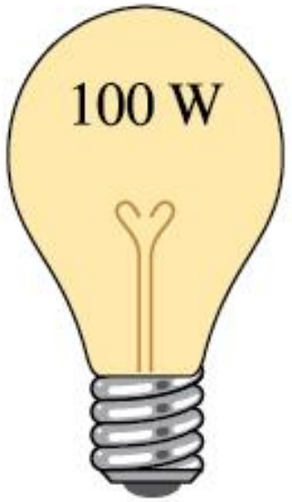


$$W = \int \vec{F} \cdot d\vec{s} = \int m \vec{a} \cdot d\vec{s} = \int m \frac{dv}{dt} \cdot d\vec{s} = \int m\, dv \left(\frac{ds}{dt}\right) = \int m v\, dv = \frac{1}{2} m v^2 \Big|_i^f$$

$$W = K_f - K_i$$

What is power?

Power is the rate at which energy is transferred or transformed. For machines, power is the rate at which they do work. For electricity, power is the rate at which electric energy is transformed into heat, sound, or light. Power is measured in **watts**, where 1 watt is a rate of 1 joule per second.



$\vec{F}$ is constant

$$P = \frac{d}{dt}E \rightarrow \frac{dW}{dt} = \frac{d}{dt}\vec{F}\cdot\vec{\Delta s} = \vec{F}\cdot\frac{d\vec{s}}{dt}$$

$$\boxed{P = \vec{F}\cdot\vec{v}}$$