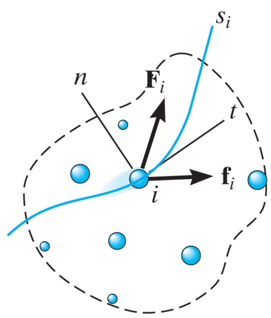
14.3 Work & Energy

- For a system of particles, the total work done by external *and internal* forces equals the energy change.

$$\sum U_{1-2} = \Delta T$$

- For a ***rigid body***, all particles undergo the same displacement, so work done by internal forces cancels to zero.
- For a deformable body, work may be done by internal forces and energy is often lost. (We will not consider this case.)



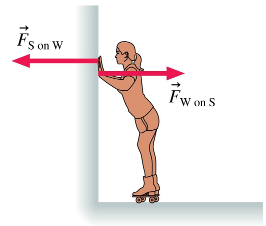
14.3 Work & Energy

A skater pushes off a wall. The wall force accelerates her.
Was work done by the wall?

No. $U = F_W \cdot \Delta s = F_W \cdot 0 = 0$

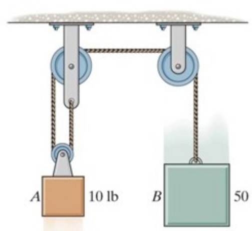
- The skater is deformable body.
- Total work done by external *and internal* forces equals the energy change.

$$\sum U_{1-2} = \Delta T$$



14.3 Work & Energy

- Tensions do work on blocks A and B separately.
- For the whole system (A, B, ropes, pulleys and fixtures) the only external forces are
  - at the fixtures (zero work)
  - gravity (+ work on B, – work on A)
- For the whole system only gravity does work. Tension does zero net work.



14.4 Power & Efficiency

- ***Power*** is rate of work done:

$$P = \frac{dU}{dt}$$

- A convenient relation:

$$P = \frac{dU}{dt} = \frac{\mathbf{F} \cdot d\mathbf{r}}{dt} = \mathbf{F} \cdot \frac{d\mathbf{r}}{dt}$$

$$P = \mathbf{F} \cdot \mathbf{v}$$

14.4 Power & Efficiency

$$P = \frac{dU}{dt} = \mathbf{F} \cdot \mathbf{v}$$

- Units of power: $1 \text{ Watt} = 1 \text{ W} = 1 \ \frac{\text{J}}{\text{s}}$

$$550 \ \frac{\text{ft} \cdot \text{lb}}{\text{s}} = 1 \text{ hp}$$ (horsepower)

- If energy is lost, a machine's ***mechanical efficiency***, ε, will be less than 1.

$$\varepsilon = \frac{\text{power out}}{\text{power in}}$$

power out: work done by machine (per second)

power in: energy provided to machine (per second)