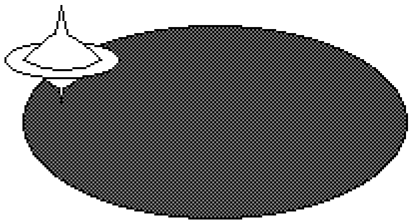
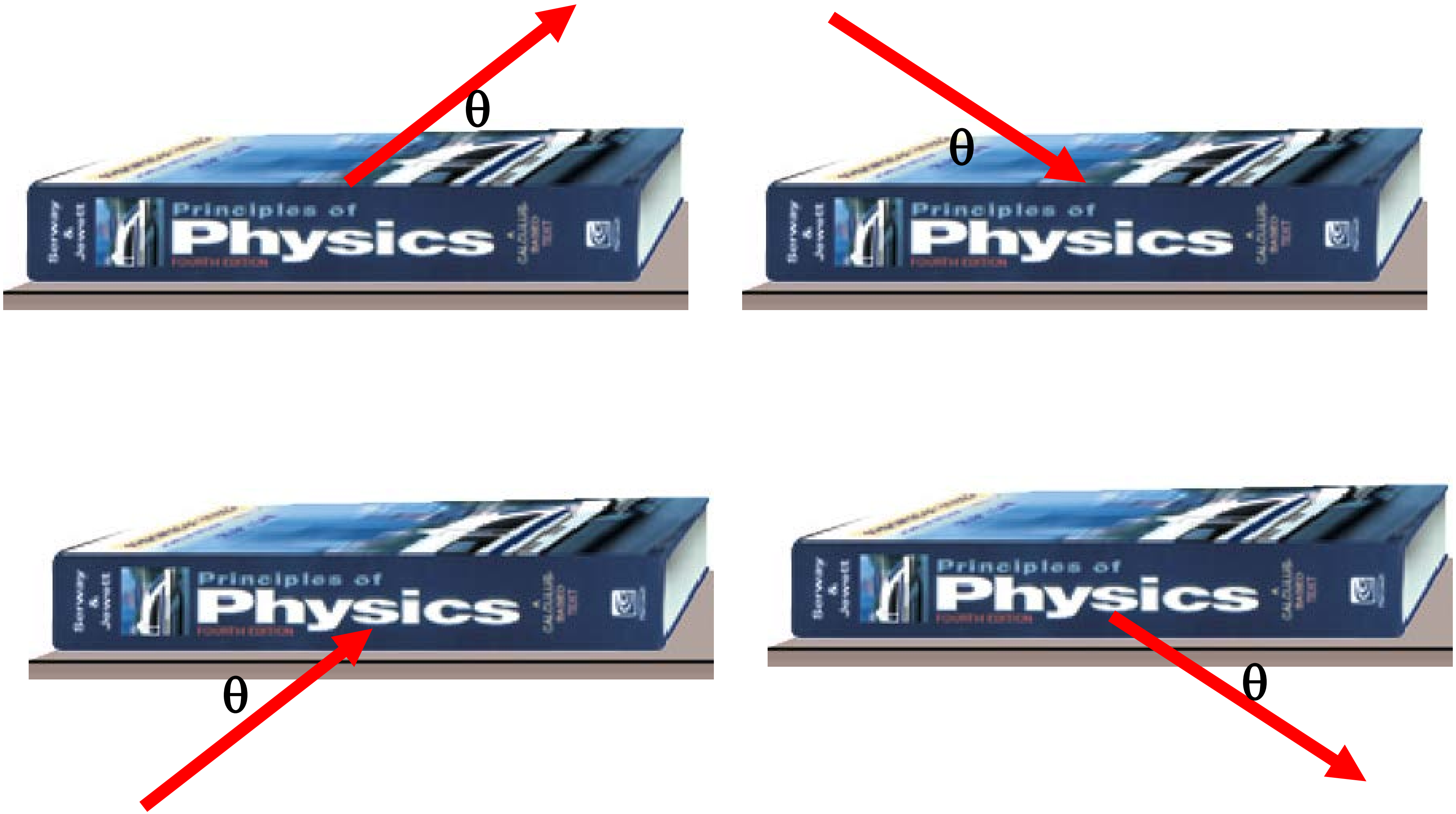
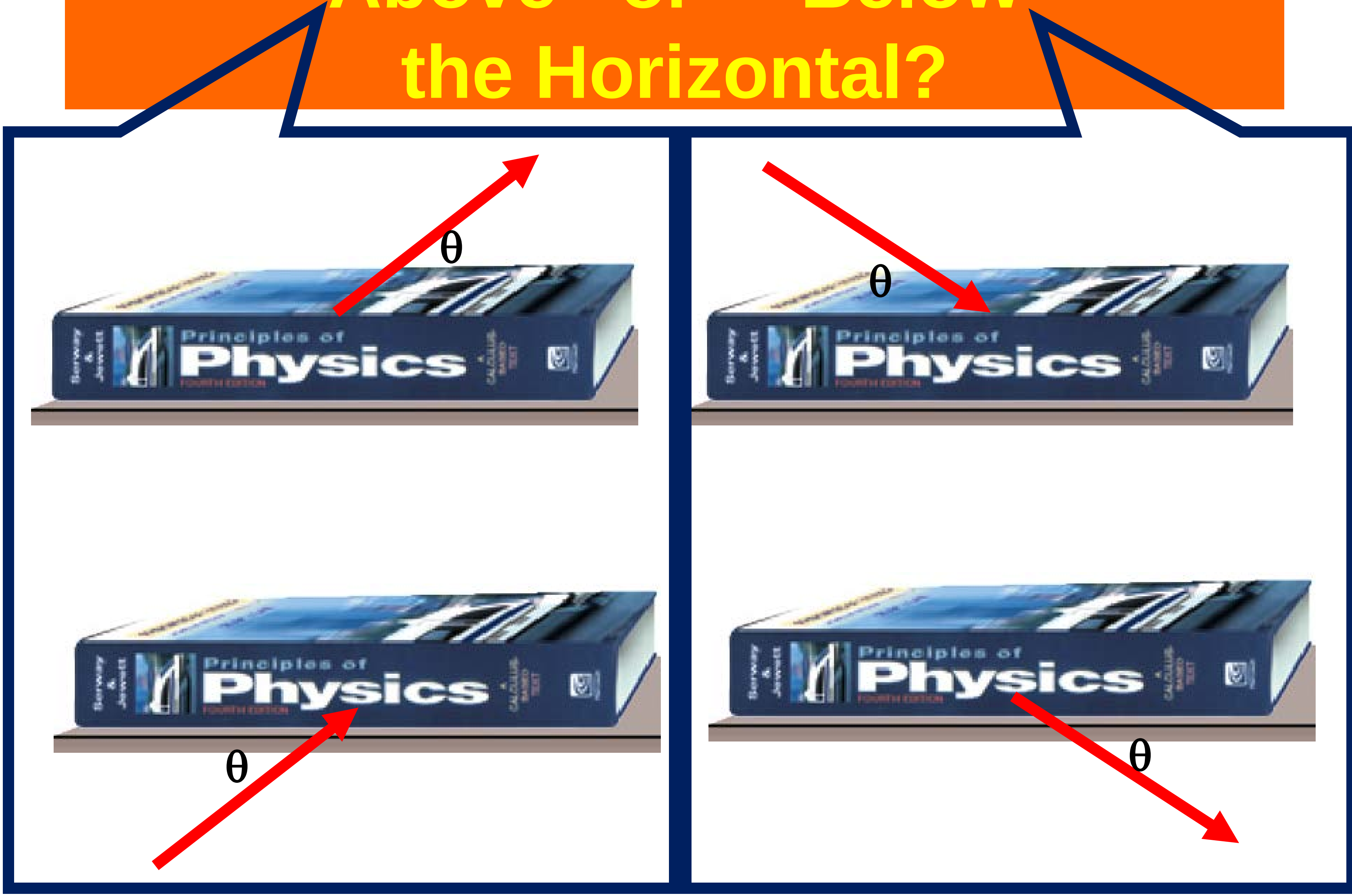
Work and Energy



Above or Below the Horizontal?

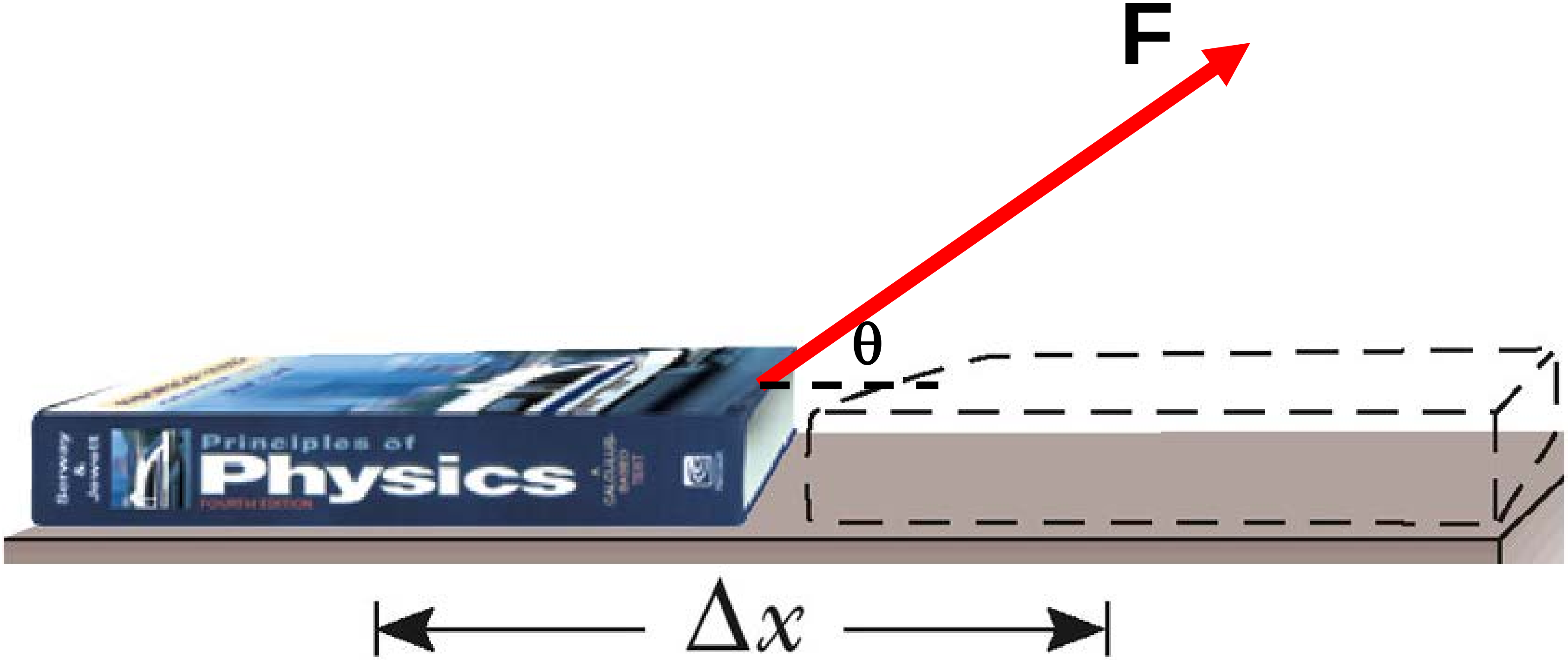


Above or Below the Horizontal?



Work done by a constant force

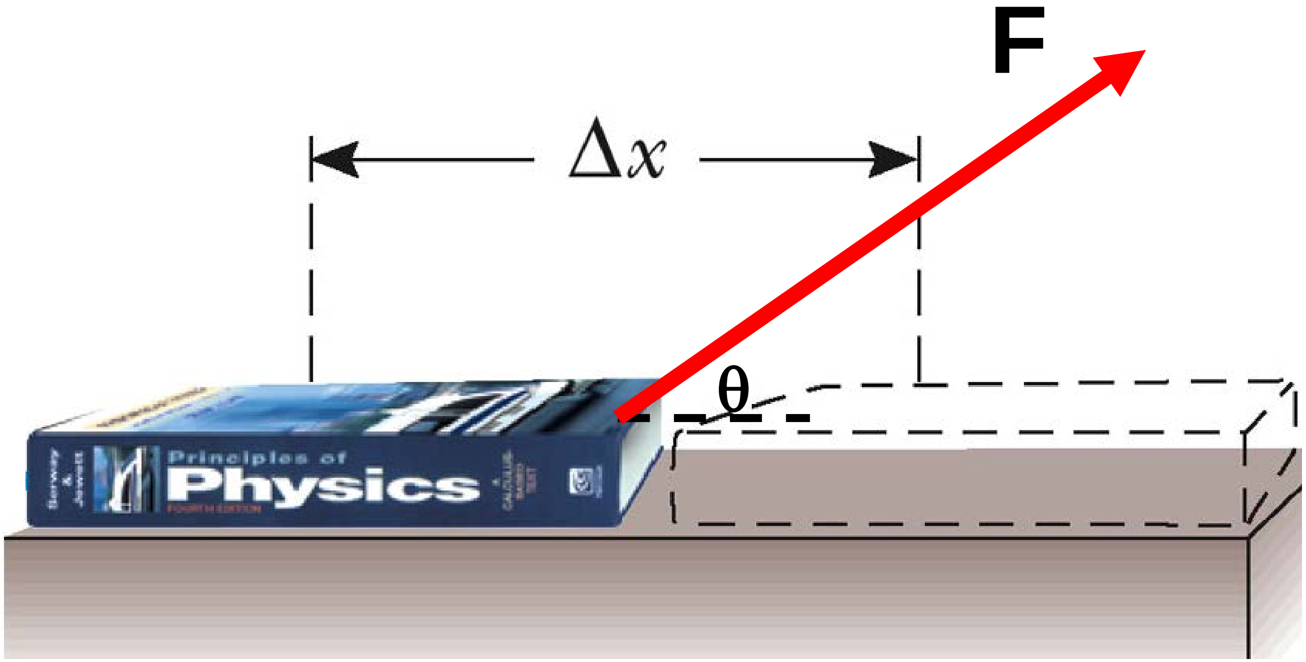
$$W_F = F \Delta s \cos\theta$$



Work

$$W = F\Delta x\cos\theta$$

Constant force

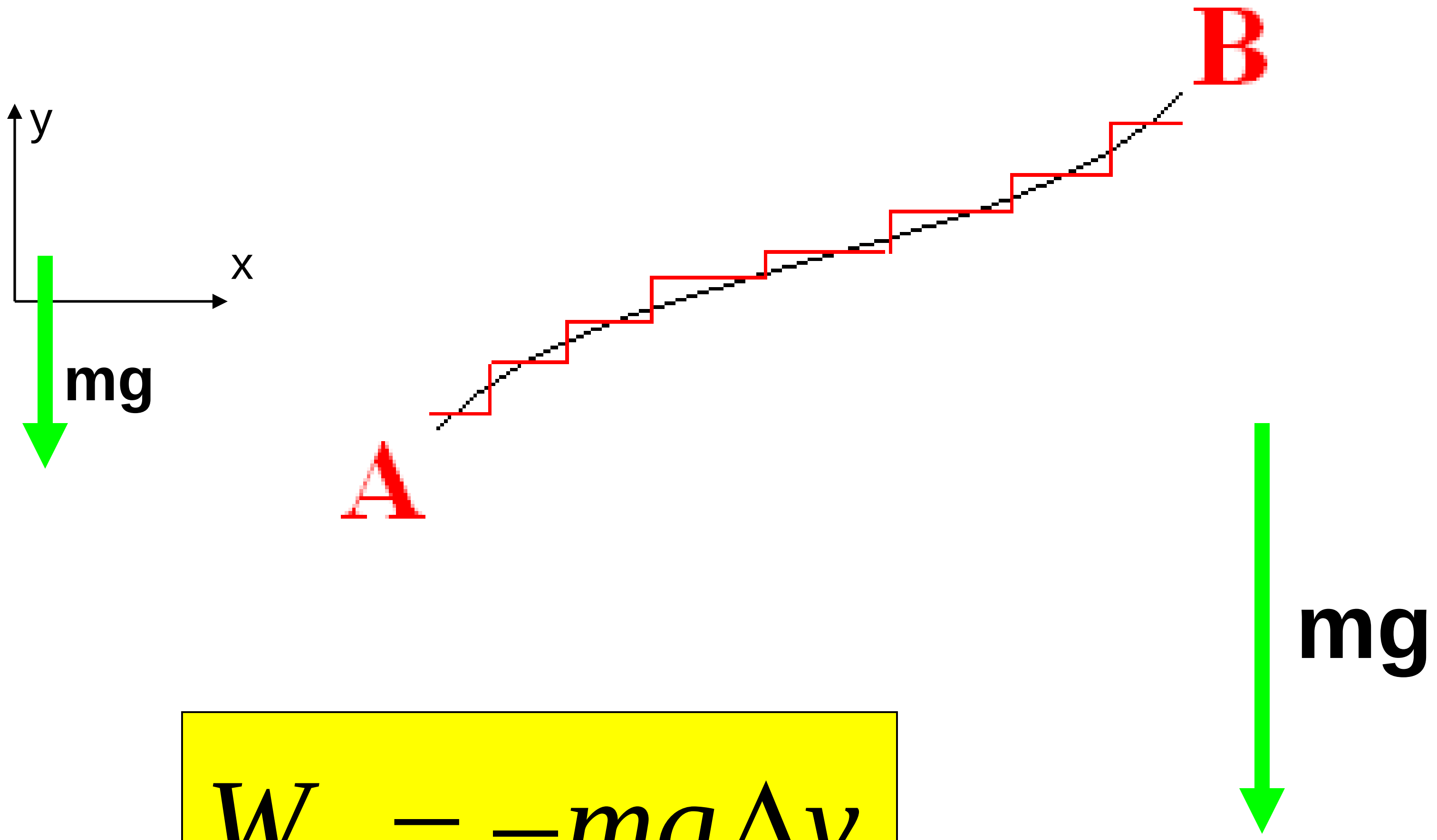


Work

$$W = \int_1^2 F dx\cos\theta$$

Variable force

Work done by gravity



$$W_g = -mg\Delta y$$

Work-Energy Theorem

$$F_{net} = ma$$

$$F_{net}\Delta x = ma\Delta x$$

$$v^2 = v_o^2 + 2a\Delta x$$

$$W_{net} = \frac{1}{2}m\left(v^2 - v_o^2\right)$$

VECTOR versus SCALAR

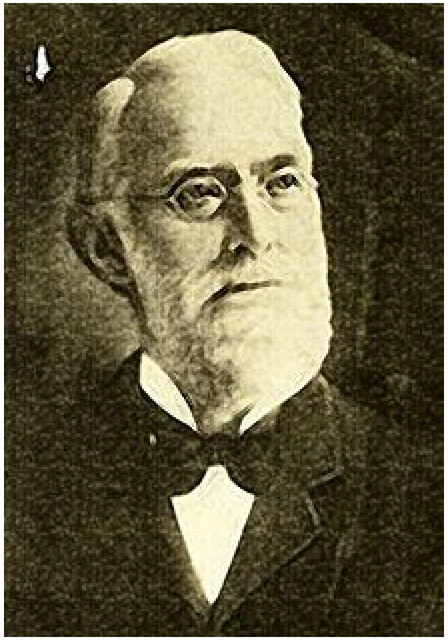
$$\vec{F}_{net} = m\frac{\Delta\vec{\mathrm{v}}}{\Delta \mathrm{t}} = m\frac{(\vec{\mathrm{v}} - \vec{\mathrm{v}}_o)}{\Delta \mathrm{t}}$$

$$W_{net} = \frac{1}{2}m\left(\mathrm{v}^2 - \mathrm{v}_o^2\right)$$

Lester Pelton (1829-1908)

In 1850, at age 20, Lester and some local friends moved to California during the California gold rush

- American inventor, best known for developing the most efficient form of an impulse water turbine, the Pelton wheel. He is considered one of the fathers of hydroelectric power, was awarded the Elliott Cresson Medal and was inducted into the National Inventors Hall of Fame in 2006.



The Pelton Wheel (spoon-shaped cups)

The curved blades cause the water to “bounce” and make a U-turn

Pelton Wheel at San Francisquito Power Plant #1 LA DWP

Conservation of Energy

$$W_{NET} = \frac{1}{2}mv^2 - \frac{1}{2}mv_o^2$$

If only work done by gravity

$$W_g = -mg\Delta y = -mg(y - y_o)$$

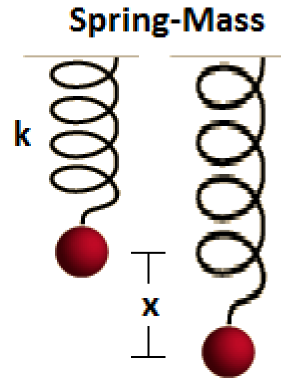
$$\frac{1}{2}mv_o^2 + mgy_o = \frac{1}{2}mv^2 + mgy$$

Escher’s Waterfall

Elastic Potential Energy (GPE)

Restoring Force

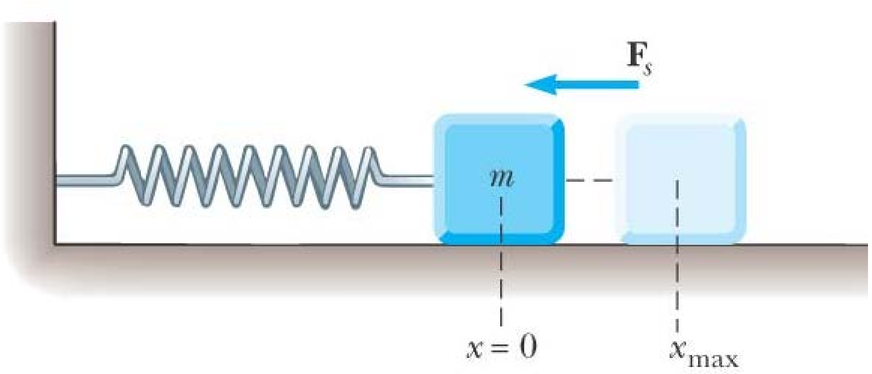
$$F_s = -kx$$



Elastic Potential Energy

$$EPE = \frac{1}{2}kx^2$$

Springs: Elastic Potential Energy



$$F_s = -kx$$

Hooke's Law

$$W_s = \int_{x_o}^{x} F_s dx = -\int_{x_o}^{x} kx dx = -\frac{1}{2}k(x^2 - x_o^2)$$

Types of Energies

Kinetic Energy	$KE = \frac{1}{2}mv^2$
Gravitational Potential Energy	$GPE = mgy$
Elastic Potential Energy	$EPE = \frac{1}{2}kx^2$

Conservation of Energy

Plus work done by a spring

$$\frac{1}{2}mv_o^2 + mgy_o + \frac{1}{2}kx_o^2 = \frac{1}{2}mv^2 + mgy + \frac{1}{2}kx^2$$

Plus work done by a **force of friction**

$$\frac{1}{2}mv_o^2 + mgy_o + \frac{1}{2}kx_o^2 - f_k\Delta s = \frac{1}{2}mv^2 + mgy + \frac{1}{2}kx^2$$

$f_k\Delta s \rightarrow \Delta E_{\text{int}}$

Conservation of Energy

$$\frac{1}{2}mv_o^2 + mgy_o + \frac{1}{2}kx_o^2 - f_k\Delta s = \frac{1}{2}mv^2 + mgy + \frac{1}{2}kx^2$$

$f_k\Delta s \rightarrow \Delta E_{\text{int}}$

KE_o + GPE_o + EPE_o - Losses = KE + GPE + EPE

SUMMARY

$$W_F = F\Delta s\cos\theta$$

or

$$W_F = \int_1^2 F dx\cos\theta$$

$$W_{NET} = \frac{1}{2}mv^2 - \frac{1}{2}mv_o^2$$

$$\frac{1}{2}mv_o^2 + mgy_o + \frac{1}{2}kx_o^2 - f_k\Delta s = \frac{1}{2}mv^2 + mgy + \frac{1}{2}kx^2$$