

# Conservation Laws

2<sup>nd</sup> Newton's Law

$$m\Delta\vec{v} = \vec{F}\Delta t$$

Only conservative forces:  
Energy conservation

$$K + U = \text{const}$$

Mo external forces:  
Momemtum conservation

$$\vec{p}_1 + \vec{p}_2 + \dots + \vec{p}_n = \text{const}$$

Examples of Potential Energy, U:

$$\text{Earth gravity, } F = -mg: \quad U(x) = mgh$$

$$\text{Hooke's spring, } F = -kx: \quad U(x) = \frac{kx^2}{2}$$

# Homework

A bullet of mass  $m$  that moves horizontally with speed  $v$ , hits boxer's punch bag that is hang up from the ceiling. The punch bag has mass  $M$ , and bullet gets stuck in it. As a result, the punch bag starts moving as a pendulum. Find the maximum height  $\Delta h$  that it will reach, with respect to its initial position.

*Hint: you need to split the problem onto two parts: momentum is conserved in one part, and energy in the other.*

