Potential Energy

- Conservative forces
- Work by a conservative force
- Potential energy
- Conservation of Energy

Rules for Conservative Forces

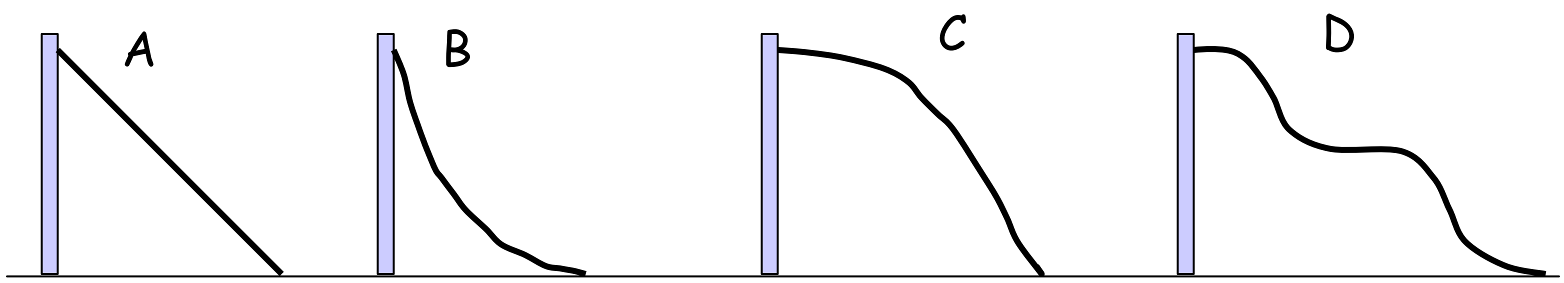
a) The work done by the force on a particle moving between any two points depends only on the coordinates of the two points. *It does not depend on the path taken or the distance traveled*

b) The work the force does on a particle moving through any *closed path* is zero.

(closed path → zero displacement)

Forces acting on an object can be classified as **conservative** and **non-conservative** depending upon how they do work.

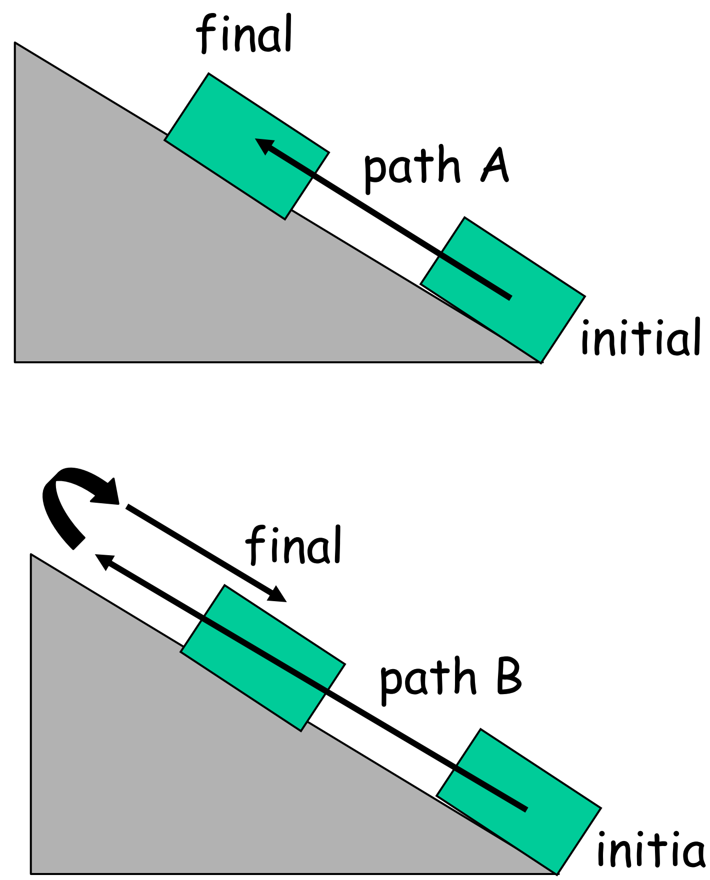
Conservative forces: the work does ***not*** depend on the path of the object, just the initial and final positions.



Gravity is a conservative force.

Non-conservative forces: the work ***does*** depend on the path of the object.

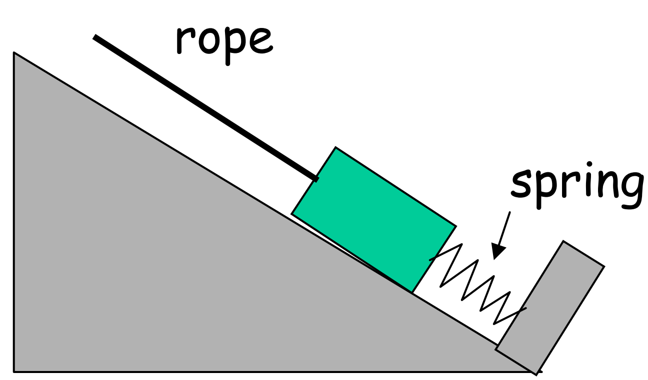
When friction does work on the block, the amount of work done over paths A and B are different, even though the initial and final positions are the same.

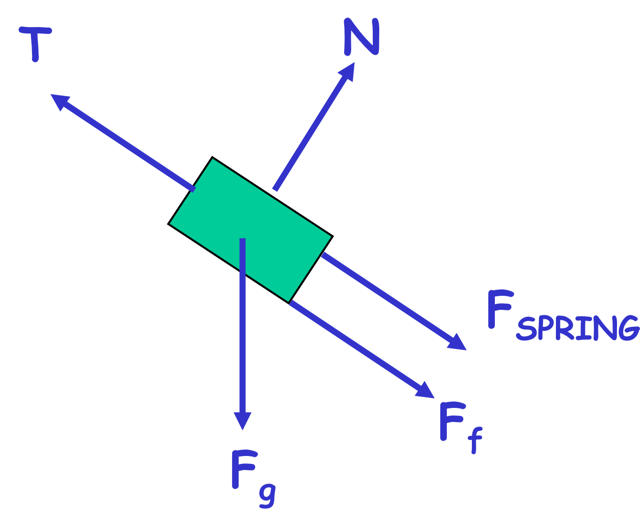


Example

A block is being pulled up a ramp despite the fact that it is attached to an ideal spring that is being stretched. Classify each force on the free body diagram as:

a) conservative
b) non-conservative
c) not clear, more information is needed





The work done by a **conservative** force can be represented by a function of just the position.

For the gravitational force, when +y points up,

$$W = -mg\,(y_f - y_i) = mgy_i - mgy_f \equiv U_g(y_i) - U_g(y_f)$$

$\Rightarrow$ $U_g(y) = mgy$ (Potential Energy of Gravity)

$$\boxed{W = -\Delta U}$$

For an ideal spring, when +x is the amount the spring is stretched:

$$W_s = \int_{x_i}^{x_f} (-k\,x)\,dx$$

$$W_s = \frac{1}{2}k\,x_i^2 - \frac{1}{2}k\,x_f^2$$

Define ➔ $U_S(x) = \frac{1}{2}kx^2$ (Potential Energy of a Spring)

$$W_s = U_i - U_f = -(U_f - U_i)$$

$$\boxed{W = -\Delta U}$$

Non-Conservative Forces

Non-conservative forces cause the mechanical energy of the system to change. The work-energy theorem states:

$$\Delta K = W$$

But work is a combination of conservative and non-conservative forces:

$$\Delta K = W_C + W_{other}$$

But $W_c = -\Delta U$

$$\rightarrow \Delta K = -\Delta U + W_{other}$$

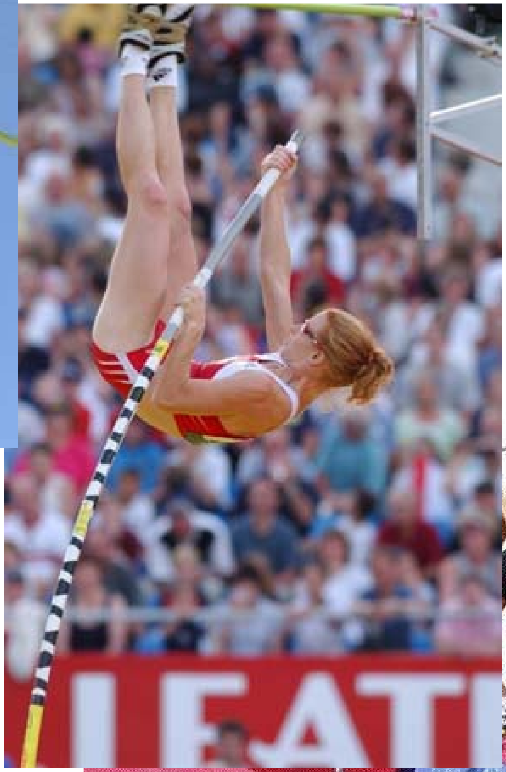
Conservation of Energy

$$\Delta E = \Delta K + \Delta U = W_{other}$$

The change in mechanical energy is equal to the work done by "other forces". "Other" forces means *any force not represented by a term in the potential energy.* It includes non-conservative forces, but also externally-applied forces, conservative or not, that transfer energy into or out of the system.

In the absence of external and non-conservative forces, mechanical energy is conserved

E-conservation in action: the pole vault



$$\frac{1}{2}mv^2$$

$$mgy$$

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

Summary:

- Work by conservative forces does *not* depend on the path, and *can* be written as a change in potential energy.

- Work by non-conservative forces *does* depend on the path, and *cannot* be written as a change in potential energy.

- Work by non-conservative forces changes the mechanical energy of a system.