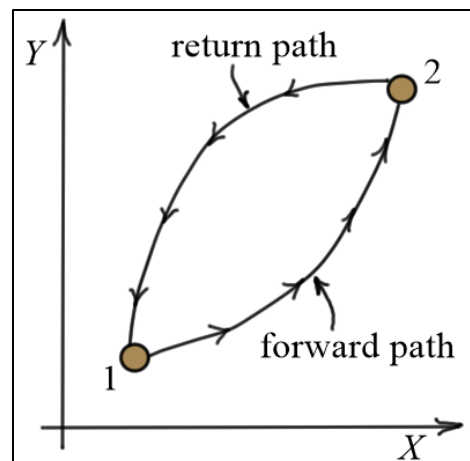


Elementary Dynamics

Conservation of Energy for Particles

Conservative and Nonconservative Forces

Consider a particle that moves from position 1 to position 2 along one path (forward path) and back again to position 1 along a second path (return path) as shown in the diagram. A force acting on the particle is said to be *conservative* if the *total work* it does over the closed path is *zero*. Suppose, for example, that the work done by the force as the particle moves from position 1 to position 2 is *positive*, then the force does the same amount of work as the particle returns to position 1, except that this work is *negative*.



In this way, conservative forces do not permanently add or remove energy from a system. When the conservative force is doing negative work, the system is said to be gaining *potential energy* that can later be transformed into *kinetic energy*. It is also true of conservative forces that the work done in moving from one position to another is *independent* of the path of the particle. Examples include weight forces and spring forces.

Forces whose *total work* around a closed circuit is *not* zero are called *nonconservative* forces. The work done by these forces as a particle moves from one position to another is *dependent* on the path of the particle. Examples include friction and damping forces.

Potential Energy (V)

The work done by conservative forces can be written in terms of a potential energy function, V . For weight forces and linear spring forces, the potential energy functions are

$$V = mgy \quad (y \text{ is the height of the particle } \textit{above} \text{ some } \textit{arbitrary datum})$$

$$V = \frac{1}{2}ke^2 \quad (e \text{ is the } \textit{elongation} \text{ or } \textit{compression} \text{ of the spring})$$

The work done by the force as the particle moves from position 1 to position 2 is given by $U_{1 \rightarrow 2} = -(V_2 - V_1) = V_1 - V_2$. For systems with multiple conservative forces, the total potential energy is $V_{total} = \sum V$.

Principle of Conservation of Energy

For a system of particles acted on only by conservative forces, the principle of work and energy can be restated as

$$\sum K_1 + \sum U_{1 \rightarrow 2} = \sum K_1 + \sum V_1 - \sum V_2 = \sum K_2$$

or

$$\boxed{\sum K_1 + \sum V_1 = \sum K_2 + \sum V_2}$$

(*total mechanical energy* is same in all positions)