Chapter 8 Conservation of Energy

Isolated System

An isolated system is one for which there are **no energy transfers across the boundary**. The *energy in such system is conserved at anytime* the **sum is a constant** but its form can change in part or in whole

- A block sliding across a frictionless table is moving in an isolated system
- If there is friction on the table (rough surface), the block is not sliding in an isolated system anymore.

Conservative Forces in Isolated System

- Work done by a conservative force on a particle moving between any two points is *independent* of the path taken by the particle
- Work done by a conservative force on a particle moving through any closed path is zero

Gravitational Potential Energy

- Gravitational potential energy is the energy associated with the **height** (configuration) of a system of objects that exert forces on each other.
  - Higher altitude = More G.P.E
- When conservative forces *act within an isolated system*, the kinetic energy gained (or lost) by the system as its members **change their relative positions is balanced by an equal loss (or gain) in potential energy**
- This is **Conservation of Mechanical Energy**

Conservation of Mechanical Energy

$E_{mech} = K + U_g$
Isolated system (final sum = initial sum):
$K_f + U_f = K_i + U_i$

> Example:
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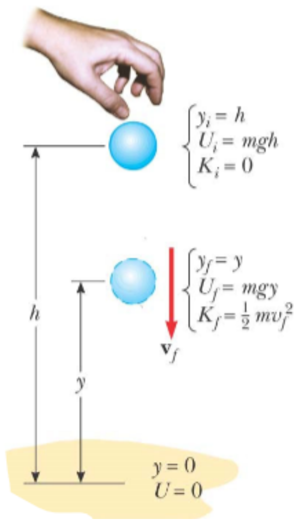
> 
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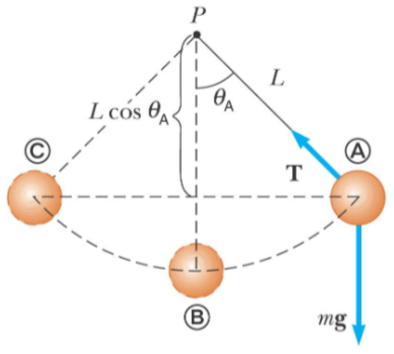
>
> - Initial conditions:
>   - $E_i = K + U_i = mgh$
>   - The ball is dropped from rest, so $K_i = 0$
> - The configuration for *zero potential energy is when the ball hits the ground*, the **potential energy will become 0**
> - Conservation rules at some point y above ground gives
>   - $\frac{1}{2}mv_f^2 + mgy = mgh$

Elastic Potential Energy

- Elastic Potential Energy is associated with a spring
- The force the spring exerts is $F_s = -kx$
- The work done by an external applied force on a spring-block system is
  - $W = \frac{1}{2}kx_f^2 - \frac{1}{2}kx_i^2$
  - The work is equal to the **difference between the initial and final values** of an expression related to the configuration of the system
- The elastic potential energy (U) **stored in a spring is zero** whenever the spring is not deformed ($U = 0 \; when \; x = 0$)
  - The energy stored in the spring only when the spring is *stretched or compressed*
- The elastic potential energy is *maximum when the spring has reached its maximum extension or compression*
- The elastic potential energy will always be positive as x^2 will always be positive

Pendulum



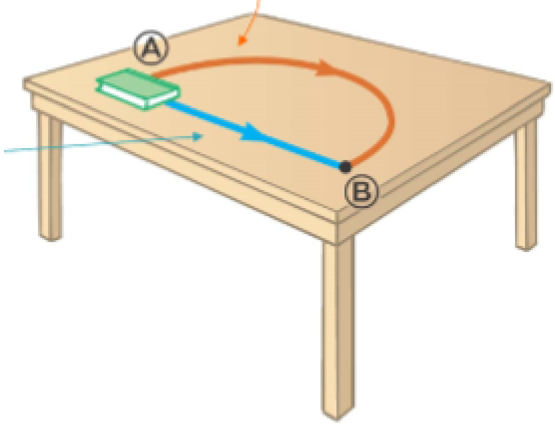
- As the pendulum swings, there is a continuous change between potential and kinetic energies
- At **A**, the energy is *potential*

- At **B**, all the potential energy at A is *transformed into kinetic energy*
    - Let zero potential energy be at B
- At **C**, the kinetic energy has been *transformed back into potential energy*

> If a system is isolated (no energy leakage at the boundary), the mechanical energy will be conserved, that is, the *sum* of **potential energy** and **kinetic energy** will be constant at all times
> The loss in KE will be a gain in PE, $\Delta KE + \Delta PE = 0$

Non-conservative Forces

A **non-conservative force** does not satisfy the conditions of conservative forces, it causes a *change* in the mechanical energy of the system



The work done against friction is greater along the brown path than along the blue path, as the work done depends on the path, friction is a non-conservative force.

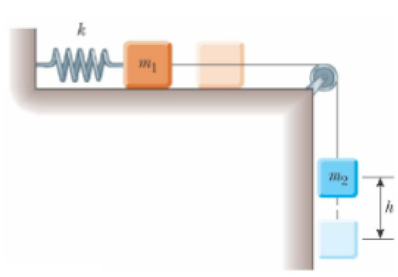
Non-conservative Forces in Mechanical Energy

$\Delta E_{mech} = \Delta K + \Delta U = -f_k d$
If *friction is zero*, this equation becomes the same as Conservation of Mechanical Energy, $\Delta E_{mech} = 0$, no change in mechanical energy.

Non-conservative Forces in Spring-Mass

- *Without friction*, the energy continues to be transformed between kinetic and elastic potential energies and the total energy remains the same
- If *friction is present*, the energy decreases $\Delta E_{mech} = -f_k d$

Non-conservative Forces in Connected Blocks



- The system consists of the two blocks, the spring and Earth
- Gravitational and potential energies are involved, and friction is not 0
- The kinetic energy is zero if out initial and final configurations are at rest
- Block 2 undergoes a change in gravitational potential energy, while the spring undergoes a change in elastic potential energy
- The coefficient of *kinetic friction* can be measured
- $m_2 gh - (\mu_k m_1 g) \times h = \frac{1}{2} kh^2$