



جامعة المستقبل  
AL MUSTAQL UNIVERSITY

## كلية العلوم قسم الادلة الجنائية

Lecture ( 9 -10 )

# Potential Energy

Second stage

Msc. Ali Jaafar

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## Potential Energy

Potential energy is the energy that an object possesses due to its position relative to other objects, internal stresses within itself, its electric charge, or other factors.

## Energy

Energy is defined physically as the quantity that is transferred to objects and used to perform work. Energy is a conserved quantity according to the law of conservation of energy, which states that energy is neither created nor destroyed, but only transformed from one form to another. It is worth noting that energy is measured in joules, which is the amount of energy transferred to an object by moving it a distance of one meter under the action of a force of one newton.

Energy has great importance in life: living organisms need it and obtain it from food in order to survive. Human civilization also requires energy to function, which it obtains from energy resources such as fossil fuels or renewable energy sources.

This article explains what potential energy is and the forms of potential energy. The concept of energy in its simple sense—meaning the ability to do something—is well known, and nothing can be accomplished or performed without it. Although energy is a physical, measurable concept, we can only observe it through its transformation from one form to another. One of the most important forms of energy is the energy stored in objects, which we call potential energy. So, what is this form of energy?

## Potential Energy in Physics

Potential energy is the stored energy of an object at rest, and it is one of the two forms of energy. The other form is kinetic energy, which is the energy an object exhibits when it is in motion. Potential energy is considered a fundamental concept in any physical discussion, and it is one of the most influential variables in the equations that explain our known universe.

In physics, potential energy truly lives up to its name, despite involving some complexities. The potential energy of an object depends on its position relative to other objects. For example, a brick has greater potential energy when it is suspended and hanging from a two-story building than when it is placed on the ground.



This is because the position of the hanging brick relative to the ground gives it more energy. However, when two bricks are placed next to each other, this does not affect the potential energy of either one, because no force is acting between them.

The same principle can be applied on any scale, whether galactic or atomic. In fact, atoms also possess potential energy, although their continuous motion converts much of their potential energy into kinetic energy.

## How Is Potential Energy Calculated?

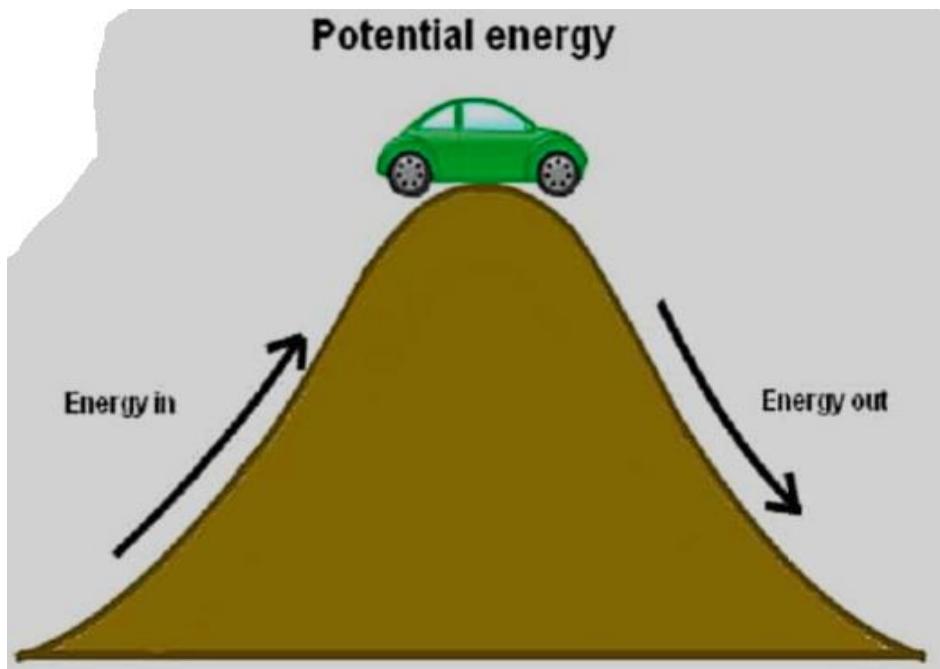
Energy refers to the ability of a body or a system to perform work. It exists in many forms, including mechanical, thermal, chemical, nuclear, and others. Work refers to the transfer of energy from one object to another and is closely related to kinetic energy. Power is the rate at which energy is transferred between two or more objects. These three concepts are closely interconnected, and understanding each one requires understanding the context of the others.

## Measuring Potential Energy

The gravitational potential energy of the massive ball of a demolition machine depends on two variables: the mass of the ball and the height to which it is raised. There is a direct relationship between gravitational potential energy and the mass of an object; more massive objects possess greater gravitational potential energy.

There is also a direct relationship between gravitational potential energy and the height of the object. As the height of the object increases, its gravitational potential energy increases. These relationships are expressed by the following equation:

**Gravitational Potential Energy = mass × gravitational field strength × height**



## Where Do We Observe Potential Energy in Our Daily Lives?

### Practical Applications Around Us

Potential energy exists everywhere around us, even though we may not always notice it. Have you encountered it before in the context of your daily life? Let me illustrate this with some real-world examples:

The food we eat: It contains chemical potential energy stored in its molecular bonds. When we digest food, this energy is released and used by our bodies for movement, growth, and maintaining body temperature.

Batteries and mobile phones: They store chemical potential energy that is converted into electrical energy during use. Recent developments in lithium-ion batteries in 2025 have increased the density of stored potential energy. Hydroelectric dams: These rely entirely on the gravitational potential energy of water stored at high elevations. When the water flows downward, its potential energy is converted into kinetic energy and then into electricity. Games and sports: Bows and arrows, slingshots, and trampolines all depend on elastic potential energy. When you pull back a bowstring, energy is stored in it and released forcefully when let go.



Cars on hills: When you park your car on a slope, it possesses gravitational potential energy that can turn into motion if the brakes are not applied properly.

Old mechanical watches: They rely on elastic potential energy stored in a tightly wound spring. In contrast, modern digital watches use chemical energy from batteries.

Let us reflect on a personal example: when I was a child, I loved playing with small spring-powered toy cars. I would pull the car backward along the ground, compressing the internal spring and storing elastic potential energy, then release it and watch it race forward. This simple transformation from potential energy to kinetic energy was a practical lesson in physics, even though I did not realize it at the time.

## **Forms of Potential Energy**

Potential energy is not limited to a single type; rather, it exists in several forms while the general concept remains the same. These forms include:

### **Gravitational Potential Energy**

This is the energy that an object possesses when it is placed at a height above a reference point, which is most often the Earth. An object acquires energy that is directly proportional to its mass, as described by the law mentioned earlier. When the object is released and allowed to fall under the influence of gravity, the gravitational potential energy it has gained is gradually converted into kinetic energy, reaching its maximum just before the object strikes the ground, at which point the potential energy has been completely transformed into kinetic energy.

### **Magnetic Potential Energy**

A magnet consists of a positive pole and a negative pole, and these poles affect metals: the negative pole attracts them while the positive pole repels them if they are positively charged, and vice versa. Each magnet generates a magnetic field over a certain distance that affects metallic objects within that field. Therefore, the energy stored within the magnetic field can be described as magnetic potential energy.



## Electrical Potential Energy

The process of separating electric charges from one another leads to a state of electric potential difference. This affects negatively charged electrons, giving them electrical potential energy that drives them to move toward the positive pole, thereby producing an electric current.

## Chemical Potential Energy

This is the energy that a substance possesses based on its composition and the type and number of bonds that hold its atoms together. These bonds give the substance certain properties that allow it to undergo reactions and express its energy in other forms, such as heat. For example, when fossil fuel is exposed to a small flame, its chemical potential energy is converted into heat as a result of the combustion reaction.

## Elastic Potential Energy

This type of energy is produced when a large force is applied to any elastic object, causing a change in its shape or position within the limits of its elasticity. The energy increases as the applied force increases and decreases as the force decreases. Once the force is removed, the stored potential energy begins to manifest as kinetic energy, just as happens when a spring is compressed or stretched. The greater the compression, the greater the force required to compress it further. The equilibrium position is the position the spring naturally assumes when no external force is applied.



## Effect of Height and Mass on Potential Energy

### 1. Definition of Gravitational Potential Energy

Gravitational potential energy is the energy stored in an object as a result of its position (height) in the Earth's gravitational field. It is given by the relation:

$$U=mgh$$

Where:

- **U**: potential energy (joules)
- **m**: mass of the object (kg)
- **g**: acceleration due to gravity  $\approx 9.8 \text{ m/s}^2$
- **h**: height above a reference level (meters)

### 2. Effect of Mass

- Potential energy is directly proportional to mass.
- When the mass increases while the height remains constant, the potential energy increases by the same proportion.
- Example: An object with a mass of 10 kg has twice the potential energy of an object with a mass of 5 kg at the same height.

### 3. Effect of Height

- Potential energy is directly proportional to height.
- The higher the object is above the reference level, the greater its potential energy.
- Doubling the height while keeping the mass constant doubles the potential energy.

### 4. Reference Level

- The value of potential energy depends on the choice of the reference level (ground surface, a table, a building floor, etc.).



- In practical applications, what matters is the change in potential energy rather than its absolute value.

## 5. Practical Examples

- **Dams:** The greater the height and mass of the water, the greater the potential energy, and thus the greater the ability to generate electricity.
- **Elevators:** Lifting a larger mass or lifting to a higher height requires more work due to the increase in potential energy.
- **Sports:** Jumping from a greater height results in greater potential energy, which is converted into kinetic energy during the fall.

## 6. Summary

- Potential energy increases with increasing mass or height.
- The relationship is linear and simple according to the law  **$U=mgh$**
- This concept is fundamental to understanding energy conservation and the transformation between potential and kinetic energy.