Al-Mustaqbal University
College of Science
Department of Medical Physics
Second Stage

جامـــــعة المـــستـقـبـل
AL MUSTAQBAL UNIVERSITY

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Potential Energy

LECTURE (9_10)

Second stage

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Potential energy

Potential energy is the energy that an object retains because of its position relative to other things, the pressures within itself, its electric charge, or other factors.

Energy

In physics, energy is defined as the quantity transferred to objects for use in performing work. Energy is a conserved quantity, based on the law of conservation of energy, which states that energy cannot be created or destroyed, but only transformed from one form to another. Energy is measured in joules, which is the energy transferred to an object by moving it a distance of 1 meter with a force of 1 Newton. Energy is of great importance to life. Living organisms need it and obtain it from food to survive. Human civilization also requires energy for work, which it obtains from energy resources such as fossil fuels or renewable energy. This article will explain what potential energy is and its various forms. The concept of energy, in its simplest form, is the ability to do something; nothing can be accomplished or done without it. Although it is a measurable physical concept, we only observe it through its transformation from one form of energy to another. One of the most important forms of energy is the energy stored in objects, which we call potential energy. So, what exactly is this form of energy?

Potential Energy in Physics

Potential energy is the energy stored in 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 possesses while in motion. Potential energy is a fundamental concept in any discussion of physics and is one of the most influential variables in the equations that explain our known universe.

The term "potential energy" in physics is quite apt, although there are some complexities. The potential energy of an object depends on its position relative to other objects. For example, a brick has more potential energy when it is suspended from a two-story building than when it is lying on the ground.

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

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

?How is potential energy calculated

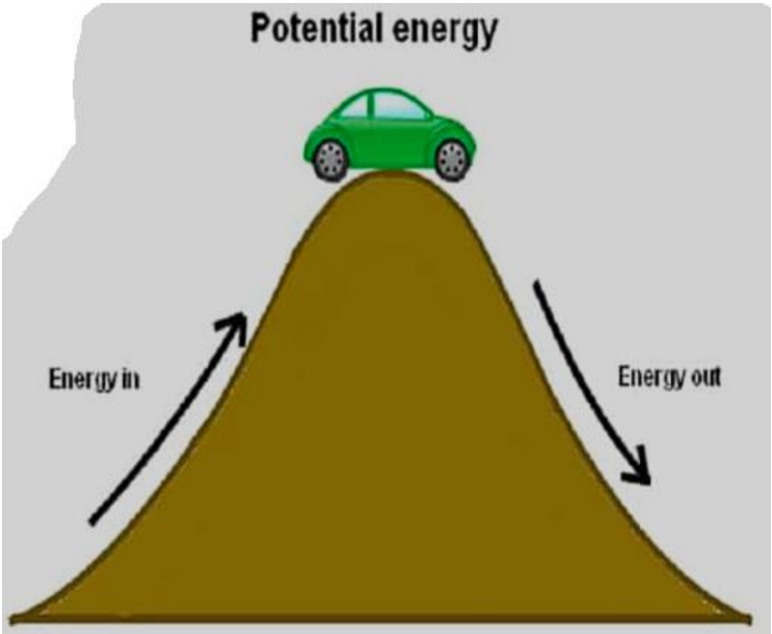
Energy refers to the ability of a body or system to do work. It exists in many forms, including mechanical, thermal, chemical, nuclear, and others. Work refers to the transfer of energy from one body to another and is closely related to kinetic energy. Power is the rate of energy transfer between two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

Measuring Potential Energy

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

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

Potential energy = mass * gravitational field strength * height



?Where do we observe latent energy in our daily lives

Practical applications all around us
Latent energy is everywhere, even though we may not be aware of it. Have you ever encountered it in the context of your daily life? Let me illustrate with some real-life examples:

The food we eat contains chemical 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 cell phones store chemical energy that is converted into electrical energy when used. Recent advancements in lithium-ion batteries, expected in 2025, have increased the density of stored potential energy.

Hydroelectric dams rely entirely on the gravitational potential energy of water stored at high altitudes. As the water flows down, its potential energy is converted into kinetic energy and then into electricity.

Games and sports: Archery, slingshots, and trampolines all rely on elastic potential energy. When you pull the bowstring, it stores energy that is released with force upon release.

Cars on hills: When you park your car on a slope, it has gravitational potential energy that can be converted into motion if the brakes are not used correctly.

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

Let's consider a personal example: As a child, I loved playing with small spring-loaded cars. I would pull the car backwards on the ground, compressing the internal spring and storing elastic potential energy, then release it to speed away. This simple conversion of potential energy into kinetic energy was a practical physics lesson, though I didn't realize it at the time.

Forms of potential energy:

It is not limited to one type, but rather varies and several forms exist, while the general concept remains constant. These forms are:

Gravitational Potential Energy

This is the energy an object possesses when placed at a height above a reference point, usually the Earth. The object gains energy directly proportional to its mass, as explained in the previously mentioned law. When this object is released to fall under the influence of its own weight, the gravitational potential energy it has acquired is gradually converted into kinetic energy, reaching its peak just before impact with the Earth's surface. At this point, the potential energy has been completely converted into kinetic energy.

Magnetic Potential Energy

A magnet consists of two poles, positive and negative. These poles affect metals; the negative pole attracts them, and the positive pole repels them. If the metal is positively charged, the negative pole attracts it, and vice versa. Every magnet generates a magnetic field for a certain distance, which affects metallic objects within the field. Thus, we can say that the energy stored within a magnetic field is potential energy. Electrical Potential Energy.

The process of separating charges results in an electrical potential difference. This difference affects negatively charged electrons, giving them electrical potential energy that causes them to move towards the positive electrode, thus producing an electric current.

Chemical Potential Energy

This is the energy that matter possesses based on its composition and the type and number of bonds that hold its atoms together. These bonds give matter specific properties that allow it to participate in reactions, which are expressed 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 energy

This type of energy is produced when a large force is applied to any elastic body, causing a change in the body's position within its elastic limits. The potential energy of the body increases with the increasing force and decreases with its decreasing. Once the force is removed, the potential energy of the body begins to express itself 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 that a spring naturally assumes when no force is applied to it.

Effect of Height and Mass on Potential Energy

1_ Definition of Gravitational Potential Energy

Gravitational potential energy is the energy stored in an object due to its position (height) in the Earth's gravitational field, and is given by the relationship:

$$U=mgh$$

where:

U: Potential energy (joules)

m: Body mass (kg)

g: The acceleration due to gravity is $\approx 9.8\ m/s^2$, or $\approx 29.8\ m/s^2$

h: Height above a reference level (meters)

2_ The Effect of Mass

Potential energy is directly proportional to mass.

When mass increases while height remains constant, potential energy increases proportionally.

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 an object is above a reference level, the greater its potential energy.

When the height is doubled while the mass remains constant, the potential energy is doubled.

4_ Reference Level

The potential energy value depends on the chosen reference level (ground surface, table, building floor, etc.).

In practical applications, what matters is the change in potential energy, not its absolute value.

5_ Practical Examples

Dams: The greater the height and mass of the water, the greater the potential energy and therefore the greater the potential for generating electricity.

Elevators: Lifting a larger mass or to a higher height requires more work due to the increased potential energy.

Sports: Jumping from a greater height results in greater potential energy, which is converted into kinetic energy during the fall.

6_ Conclusion

Potential energy increases with increasing mass or height.

The relationship is linear and simple according to the law.

$$U=mghU = mghU=mgh.$$

This concept is fundamental to understanding the conservation of energy and the conversion between potential and kinetic energy.

The Relationship Between Potential Energy and Work

1. The Concept of Work in Physics

Work is defined as the amount of energy transferred when a force acts on an object and causes it to be displaced:

$$W = Fd\cos\theta$$

:Where

W: Work (J) •

F: Force (N) •

d: Displacement (m) •

θ: Angle between the direction of the force and the displacement •

2. Definition of Potential Energy

Potential energy is energy stored in an object due to its position or shape, such as:

Gravitational potential energy

Elastic potential energy

3. The fundamental relationship between work and potential energy

In conservative forces (such as gravity and spring force):

$$W = -\Delta U$$

That is:

The work done by a conservative force is equal to the negative of the change in potential energy.

If the potential energy increases, the work done by that force is negative.

If the potential energy decreases, the work done is positive.

4. Example: Gravity

When lifting an object upwards:

The person does positive work on the object.

The object's gravitational potential energy increases.

The work done by the force of gravity is negative.

When falling an object downwards:

Gravity does positive work.

The potential energy decreases and is converted into kinetic energy.

5_ Example: Spring (Elastic Potential Energy)

When a spring is compressed or stretched.

Work is done on the spring.

This work is stored as elastic potential energy.

$$^{2}kx\,\frac{1}{2} = U$$

6. Conservative and Non-Conservative Forces

Conservative Forces:

They have associated potential energy.

The work done depends only on the starting and ending positions.

Examples: Gravity, elastic force.

Non-conservative forces:

They do not store potential energy.

Work depends on the path.

Example: Friction (converts energy into heat).

7. Conclusion

Work is the cause of changes in potential energy.

An increase in potential energy means work is done on the system.

The relationship $W = -\Delta U$ is the basis of the principle of conservation of mechanical energy.