

Chapter 15

Energy

15.1 Energy and Its Forms

Energy and Work

How are energy and work related?

Energy is the ability to do work.

Work is a transfer of energy.

Work and energy are closely related.

- 10 Energy is known by the changes it causes.**
- 10 Work is done when a force moves an object through a distance. Energy is transferred by a force moving an object through a distance.**
- 10 Both work and energy are typically measured in joules (J).**

Kinetic Energy

What factors does the kinetic energy of an object depend on?

The energy of motion is called kinetic energy.

- depends upon its mass and speed.

Kinetic Energy

- Doubling the mass in the formula doubles the kinetic energy.
- Doubling the speed quadruples the kinetic energy.

Kinetic Energy

$$\text{Kinetic energy (KE)} = \frac{1}{2}mv^2$$

Kinetic Energy

Calculating Kinetic Energy

A 0.10-kilogram bird is flying at a constant speed of 8.0 m/s. What is the bird's kinetic energy?

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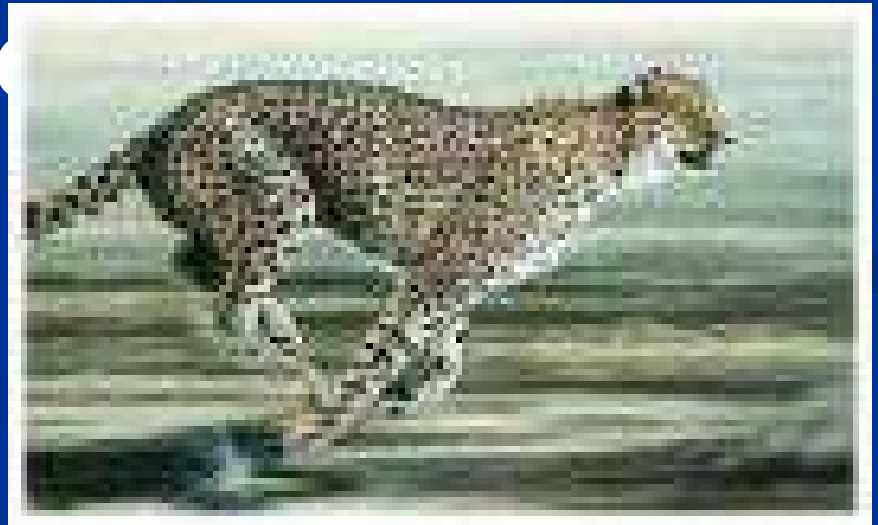
$$\text{KE} = \frac{.10 \times 8^2}{2} = \frac{6.4}{2} = 3.2$$

Kinetic Energy

2. A 1400-kilogram car is moving at a speed of 25 m/s. How much kinetic energy does the car have?

Kinetic Energy

3. A 50.0-kilogram cheetah has a kinetic energy of 18,000 J. How fast is the cheetah running? (*Hint: Rearrange the equation to solve*



KE Practice



1. Calculate KE of a 1500 kg car moving at 29 m/s
2. If you use the sun as your frame of reference, you always have kinetic energy. Why?

Potential Energy

How is gravitational potential energy determined?

Potential energy is energy that is stored as a result of position or shape.

- **using its mass, its height, and the acceleration due to gravity.**

Potential Energy

Gravitational Potential Energy

Potential energy that depends upon an object's height is called gravitational potential energy.

This type of potential energy increases when an object is raised to a higher level.

Potential Energy

- The unit for mass is kilograms.
- The unit for height is meters.
- Acceleration due to gravity, g , has a value in SI units of 9.8 m/s^2 on Earth.
- The unit for gravitational potential energy is joules.

Gravitational Potential Energy

$$\text{Potential energy (PE)} = mgh$$

Potential Energy

Doubling either the mass of the object or its height doubles its gravitational potential energy.

Gravitational potential energy depends on the mass and the height.



Potential Energy

What is the potential energy relative to the water surface of a diver at the top of a 10.0-meter-high diving platform. Suppose she has a mass of 50.0 kilograms.

GPE Example

- A 65 kg rock climber ascends a cliff. What is the climber's GPE at a point 35 m above the base of the cliff?



GPE Practice



1. A car with a mass of 1200 kg at the top of a 42 m hill
2. A 65 kg climber on top of Mount Everest (8800 m high)
3. A 0.52 kg bird flying at an altitude of 550 m

Potential Energy

Elastic Potential Energy

The potential energy of an object that is stretched or compressed is known as elastic potential energy.

Something that is elastic springs back to its original shape after it is stretched or compressed.

Forms of Energy

What are the major forms of energy?

The major forms of energy are mechanical energy, thermal energy, chemical energy, electrical energy, electromagnetic energy, and nuclear energy.

All energy can be considered to be one of three forms:

- ⑩ kinetic energy,**
- ⑩ potential energy, and**
- ⑩ energy in fields such as those produced by electromagnetic waves.**

Each of these forms of energy can be converted into other forms of energy.

Forms of Energy

Mechanical Energy

The energy associated with the motion and position of everyday objects is mechanical energy.

Mechanical energy is the sum of an object's potential energy and kinetic energy.

Forms of Energy

Thermal (Heat) Energy

The total potential and kinetic energy of all the microscopic particles in an object make up its thermal energy.

When an object's atoms move faster, its thermal energy increases, and the object becomes warmer.

Forms of Energy



Chemical Energy

Chemical energy is the energy stored in chemical bonds.

When bonds are broken, the released energy can do work. All chemical compounds, including fuels such as coal and gasoline, store energy.

Forms of Energy

Electrical Energy

Electrical energy is the energy associated with electric charges.

Electric charges can exert forces that do work.

Forms of Energy

Electromagnetic Energy



Electromagnetic energy is a form of energy that travels through space in the form of waves.

Visible light and X-rays are examples of electromagnetic energy.

Forms of Energy

Nuclear Energy



The nucleus of an atom is held together by strong and weak nuclear forces, which can store an enormous amount of potential energy.

- 10 The energy stored in atomic nuclei is known as nuclear energy.
- 10 Nuclear fission (splitting nuclei)
- 10 Nuclear fusion (nuclei combine to form a more massive nucleus)

Assessment Questions

1. How are work and energy related?
 - a. Energy is the rate of doing work.
 - b. Work is a form of energy.
 - c. Work is the transfer of energy.
 - d. Energy is created by work.

Assessment Questions

2. A moving object with a mass of 10 kg has 320 J of kinetic energy due to its motion. How fast is the object moving?
- a. 64 m/s
 - b. 32 m/s
 - c. 8 m/s
 - d. 10 m/s

Assessment Questions

- 3. Which of these is an example of elastic potential energy?**
- a. a bow prepared to release an arrow**
 - b. a rubber ball thrown into the air**
 - c. a book about to fall from a table**
 - d. a truck pulling a trailer**

Assessment Questions

4. A small airplane and a helicopter have identical masses. If the airplane's altitude compared to the ground is three times that of the helicopter, how much more gravitational potential energy does the airplane have than the helicopter?
- a. 0.333 times as much
 - b. 3 times as much
 - c. 6 times as much
 - d. 9 times as much

Assessment Questions

5. The energy stored in the bonds between atoms of a compound is called
- a. electromagnetic energy.
 - b. chemical energy.
 - c. atomic energy.
 - d. thermal energy.

Chapter 15

Energy

15.2 Energy Conversion and Conservation

■ Explain the energy conversions in:

■ A) a pendulum

■ B) pole vaults

Energy Conversion

Energy can be converted
from one form to another.

Conservation of Energy



What is the law of conservation of energy?



The law of conservation of energy states that energy cannot be created or destroyed.

Energy Conversions

What energy conversion takes place as an object falls toward Earth?

The gravitational potential energy of an object is converted to the kinetic energy of motion as the object falls.

Energy Conversions

Energy Conversion in Pendulums

A pendulum consists of a weight swinging back and forth from a rope or string.

Energy Transformations



■ Flight of a ball

Energy Transformations

■ Bouncing ball



Energy Conversions

Energy Conversion Calculations

When friction is small enough to be ignored, and no mechanical energy is added to a system, then the system's mechanical energy does not change.

Mechanical energy = KE + PE

Energy Conversions

The law of conservation of energy applies to any mechanical process. If friction can be neglected, the total mechanical energy remains constant.

Conservation of Mechanical Energy

$$(KE + PE)_{\text{beginning}} = (KE + PE)_{\text{end}}$$

Conservation of Mechanical Energy

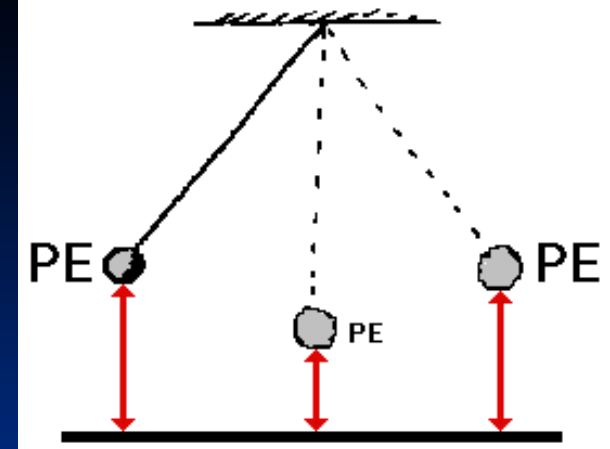
At a construction site, a 1.50-kg brick is dropped from rest and hits the ground at a speed of 26.0 m/s. Assuming air resistance can be ignored, calculate the gravitational potential energy of the brick before it was dropped.

Energy Conversions



1. A 10-kg rock is dropped and hits the ground below at a speed of 60 m/s. Calculate the gravitational potential energy of the rock before it was dropped. You can ignore the effects of friction.

Conversions Review



1. Describe conversions between potential and kinetic as a tennis ball drops, hits the ground, and bounces back up.
2. What energy conversions take place in a pendulum? Why does it eventually stop?

Conversions Review



3. Describe the energy conversions that take place when a flashlight is turned on.
4. Identify the conversions: An object is raised and then allowed to fall. As it hits the ground it stops, produces a sound, and becomes warmer.

Energy and Mass

How are energy and mass related?

Einstein's equation, $E = mc^2$, says that energy and mass are equivalent and can be converted into each other.

Energy and Mass

Albert Einstein developed his special theory of relativity in 1905. This theory included the now-famous equation $E = mc^2$.

- ⑩ E is energy, m is mass, and c is the speed of light.
- ⑩ The speed of light is an extremely large number, 3.0×10^8 meters per second.
- ⑩ A tiny amount of matter can produce an enormous amount of energy.

Energy and Mass

Suppose 1 gram of matter were entirely converted into energy.

Energy and Mass

In nuclear fission and fusion reactions, however, large amounts of energy are released by the destruction of very small amounts of matter.

The law of conservation of energy has been modified to say that mass and energy together are always conserved.

Assessment Questions

1. What energy conversion occurs as a result of friction?
 - a. chemical energy to thermal energy
 - b. kinetic energy to potential energy
 - c. kinetic energy to thermal energy
 - d. potential energy to thermal energy

Assessment Questions

2. At what point in a pendulum's swing does it have maximum kinetic energy?
- a. the highest point of the swing
 - b. the lowest point of the swing
 - c. halfway between the lowest and highest point
 - d. same at all positions of the swing

Assessment Questions

3. According to the law of conservation of mass, energy can be converted from one form to another but not created or destroyed.

True

False