Energy Conversion

- Can energy be converted from one form into another?
- Energy can be converted from one form to another.

Energy Conversion

The process of changing energy from one form to another is **energy conversion.** The striking of a match is a good example.

- Muscles use chemical energy to move the match.
- Friction between the match and the matchbox converts kinetic energy into thermal energy.
- Chemical energy is converted into thermal energy and electromagnetic energy in the flame.

DOK Question:

Hypothesize what is similar in the examples above.

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

One of the most common energy conversions is between potential energy and kinetic energy.

- An avalanche brings tons of snow from the top of a mountain to the valley floor.
- The elastic potential energy of a compressed spring is converted into kinetic energy as the spring expands.
- Energy conversions can go from kinetic to potential energy or from potential to kinetic energy.

DOK Question:

Hypothesize what is different in the examples above.

Energy Conversions

Energy Conversion in Pendulums

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

- At the highest point in its swing, the pendulum has zero kinetic energy and maximum potential energy.
- As the pendulum swings downward, potential energy is converted to kinetic energy.
- At the bottom of the swing, the pendulum has maximum kinetic energy and zero potential energy.

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

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

Energy Conversions

Math Practice

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.

Answer:

Energy Conversions

Math Practice

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.

Answer:

$(PE)_{beginning} = (KE)_{end} = \frac{1}{2}mv^2$

$=(0.50)(10\ kg)(60\ m/s)2 = 18{,}000\ J$

Energy Conversions

Math Practice

2. A diver with a mass of 70.0 kg stands motionless at the top of a 3.0-m-high diving platform. Calculate his potential energy relative to the water surface while standing on the platform, and his speed when he enters the pool. (*Hint:* Assume the diver's initial vertical speed after diving is zero.)

Answer:

Energy Conversions

Math Practice

2. A diver with a mass of 70.0 kg stands motionless at the top of a 3.0-m-high diving platform. Calculate his potential energy relative to the water surface while standing on the platform, and his speed when he enters the pool. (*Hint:* Assume the diver's initial vertical speed after diving is zero.)

Answer: $(PE)_{beginning} = mgh =$
$(70.0\ kg)(9.8\ m/s^2)(3.0\ m) = 2100\ J;$
At the beginning, KE = 0 and at the end, PE = 0, so $(PE)_{beginning} = (KE)_{end}$
$= \frac{1}{2}mv^2$; Substituting the known values,
$2100\ J = (0.5)(70.0\ kg)(v^2);$
Solving for v, $v = \sqrt{(2)\ (2100\ J)/70.0\ kg}$
$= 7.7\ m/s$

Energy Conversions

Math Practice

3. A pendulum with a 1.0-kg weight is set in motion from a position 0.04 m above the lowest point on the path of the weight. What is the kinetic energy of the pendulum at the lowest point? (*Hint:* Assume there is no friction.)

Answer:

Energy Conversions

Math Practice

3. A pendulum with a 1.0-kg weight is set in motion from a position 0.04 m above the lowest point on the path of the weight. What is the kinetic energy of the pendulum at the lowest point? (*Hint:* Assume there is no friction.)

Answer:

$(PE)_{beginning} = mgh$

$= (1.0\ kg)(9.8\ m/s^2)(0.04\ m) = 0.4\ J;$

at the beginning, KE = 0, and at the lowest point, PE = 0;

therefore $(PE)_{beginning} = (KE)_{end} = 0.4\ J$

Energy and Mass

- **How are energy and mass related?**
- **Einstein's equation, $E = mc2$, 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 $E = mc^2$.

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

DOK Question:

Formulate a relationship on how the above information effects us as humans.

Energy and Mass

Suppose 1 gram of matter were entirely converted into energy.

$$E = mc^2$$
$$= (10^{-3}\ kg) \times (3 \times 10^8\ m/s) \times (3 \times 10^8\ m/s)$$
$$= 9 \times 10^{13}\ kg \cdot m^2/s^2$$
$$= 9 \times 10^{13}\ J$$

1 gram of TNT produces only 2931 joules of energy.

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

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

   ANS: C

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

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   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

   ANS: B

Assessment Questions

3. Based on Einstein's equation for the equivalence of energy and mass, how much energy is produced by the conversion of 1 gram of mass to energy?
   a. $3x10^3$ J
   b. $3x10^5$ J
   c. $9x10^5$ J
   d. $9x10^{13}$ J

Assessment Questions

3. Based on Einstein's equation for the equivalence of energy and mass, how much energy is produced by the conversion of 1 gram of mass to energy?
   a. $3x10^3$ J
   b. $3x10^5$ J
   c. $9x10^5$ J
   d. $9x10^{13}$ J

   ANS: D

Assessment Questions

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

   True
   False

Assessment Questions

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

   True
   False

   ANS: F, law of conservation of energy