Name: ______________________________________ Date: _________

Skill and Practice

4F Potential and Kinetic Energy

Read:

This skill sheet reviews various forms of energy and introduces formulas for two kinds of mechanical energy—potential and kinetic. You will learn how to calculate the amount of kinetic or potential energy for an object.

Forms of energy

Forms of energy include radiant energy from the sun, chemical energy from the food you eat, and electrical energy from the outlets in your home. Mechanical energy refers to the energy an object has because of its motion. All these forms of energy may be used or stored. Energy that is stored is called *potential energy*. Energy that is being used for motion is called *kinetic energy*. All types of energy are measured in joules or newton-meters.

$$1\ \text{N} = 1\ \text{kg} \cdot \frac{\text{m}}{\text{s}^2}$$

$$1\ \text{joule} = 1\ \text{kg} \cdot \frac{\text{m}^2}{\text{s}^2} = 1\ \text{N} \cdot \text{m}$$

Potential energy

The word *potential* means that something is capable of becoming active. Potential energy sometimes is referred to as stored energy. This type of energy often comes from the position of an object relative to Earth. A diver on the high diving board has more energy than someone who dives into the pool from the low dive.

The formula to calculate the potential energy of an object is the mass of the object times the acceleration due to gravity (9.8 m/s^2) times the height of the object.

$$E_p = mgh$$

Did you notice that the mass of the object in kilograms times the acceleration of gravity (g) is the same as the weight of the object in newtons? Therefore you can think of an object's potential energy as equal to the object's weight multiplied by its height.

$$\text{mass of the object (kilograms)} \times \frac{9.8\ \text{m}}{\text{s}^2} = \text{weight of the object (newtons)}$$

So...

$$E_p = \text{weight of object} \times \text{height of object}$$

Kinetic energy

Kinetic energy is the energy of motion. Kinetic energy depends on the mass of the object as well as the speed of that object. Just think of a large object moving at a very high speed. You would say that the object has a lot of energy. Since the object is moving, it has kinetic energy. The formula for kinetic energy is:

$$E_k = \frac{1}{2}mv^2$$

To do this calculation, square the velocity value. Next, multiply by the mass, and then divide by 2.

Example:

How are these mechanical energy formulas used in everyday situations? Take a look at two example problems.

- A 50 kg boy and his 100 kg father went jogging. Both ran at a rate of 5 m/s. Who had more kinetic energy? Show your work and explain.

  Solution: Although the boy and his father were running at the same speed, the father has more kinetic energy because he has more mass.
  The kinetic energy of the boy:

  $$\frac{1}{2}(50\text{ kg})\left(\frac{5\text{ m}}{\text{s}}\right)^2 = 625\text{ kg}\cdot\frac{\text{m}^2}{\text{s}^2} = 625\text{ joules}$$

  The kinetic energy of the father:

  $$\frac{1}{2}(100\text{ kg})\left(\frac{5\text{ m}}{\text{s}}\right)^2 = 1{,}250\text{ kg}\cdot\frac{\text{m}^2}{\text{s}^2} = 1{,}250\text{ joules}$$

- What is the potential energy of a 10 N book that is placed on a shelf that is 2.5 m high?

  Solution: The book's weight (10 N) is equal to its mass times the acceleration of gravity. Therefore, you can easily use this value in the potential energy formula:

  $$\text{potential energy} = mgh = (10\text{ N})(2.5\text{ m}) = 25\text{ N}\cdot\text{m} = 25\text{ joules}$$

Practice:

Now it is your turn to try calculating potential and kinetic energy. Don't forget to keep track of the units!

1. Determine the amount of potential energy of a 5.0-N book that is moved to three different shelves on a bookcase. The height of each shelf is 1.0 m, 1.5 m, and 2.0 m.

2. You are on in-line skates at the top of a small hill. Your potential energy is equal to 1,000 J. The last time you checked, your mass was 60.0 kg.
   a. What is your weight in newtons?

   b. What is the height of the hill?

c. If you start rolling down this hill, your potential energy will be converted to kinetic energy. At the bottom of the hill, your kinetic energy will be equal to your potential energy at the top. Calculate your speed at the bottom of the hill.

3. A 1.0-kg ball is thrown into the air with an initial velocity of 30. m/s.

a. How much kinetic energy does the ball have?

b. How much potential energy does the ball have when it reaches the top of its ascent?

c. How high into the air did the ball travel?

4. What is the kinetic energy of a 2,000-kg boat moving at 5.0 m/s?

5. What is the velocity of an 500-kg elevator that has 4000 J of energy?

6. What is the mass of an object traveling at 30 m/s if it has 33,750 J of energy?