Name:

Skill Sheet 10.3 Potential and Kinetic Energy

In this skill sheet, you will review the forms of energy and formulas for two kinds of energy: potential and kinetic. After having worked through this skill sheet, calculating the amount of kinetic or potential energy for an object will be easy!

1. Forms of energy

Energy can be used or stored. When talking about motion, energy that is stored is called *potential energy*. Energy that is used when an object is moving is called *kinetic energy*. Other 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. Energy is measured in joules or newton-meters.

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

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

2. 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 board has more potential energy than someone who dives into the pool from the low board.

The formula to calculate the potential energy of an object is the mass of the object times the acceleration of gravity times the height of the object.

$$E_p = mgh$$

The mass of the object times the acceleration of gravity (g) is the same as the weight of the object in newtons. The acceleration of gravity is equal to 9.8 m/sec^2.

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

3. Kinetic energy

The second category of energy is kinetic energy, the energy of motion. Kinetic energy depends on the mass of the object as well as the speed of that object. Just imagine 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, you need to square the velocity value. Next, multiply by the mass, and then divide by 2.

4. Solving problems

Now you can practice calculating potential and kinetic energy. Make sure to show your work with all units present in your calculations as well as in your answer. Write your answers in joules. The first two problems have been done for you.

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

   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:

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

   The kinetic energy of the father:

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

2. What is the potential energy of a 10-newton book sitting on a shelf 2.5 meters high?

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

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

3. Determine the amount of potential energy of a 5-newton book that is moved to three different shelves on a bookcase. The height of the shelves is 1.0 meter, 1.5 meters, and 2.0 meters.

4. Two objects were lifted by a machine. One object had a mass of 2 kilograms, and was lifted at a speed of 2 m/sec. The other had a mass of 4 kilograms and was lifted at 3 m/sec. Which object had more kinetic energy while it was being lifted? Show all calculations.

5. In problem 4, which object had more potential energy when it was lifted a distance of 10 meters? Show your calculation. (Remember that gravity = 9.8 m/sec^2)

6. You are standing in your in-line skates at the top of a large hill. Your potential energy is equal to 1,000 joules. The last time you checked, your mass was 60 kilograms.
   a. What is your weight in newtons?

   b. What is the height of the hill?

   c. If you start skating downhill, 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. What will be your speed at the bottom of the hill?

7. Answer the following:
   a. A 1-kilogram ball is thrown into the air with an initial velocity of 30 m/sec. 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?

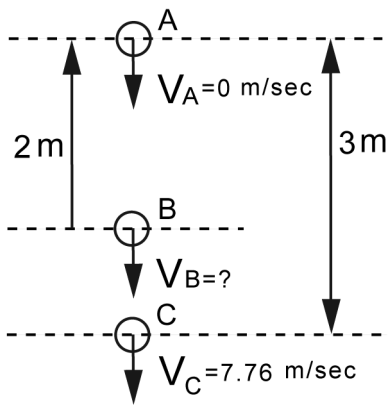
8. What is the potential energy of a 3-kilogram ball lying on the ground?

9. What is the kinetic energy of a 2,000-kilogram boat moving at 5 m/sec?

10. What is the velocity of an 500-kilogram elevator that has 4,000 joules of energy?

11. What is the mass of an object that creates 33,750 joules of energy by moving at 30 m/sec?

12. **Challenge problem:** In the diagram at right, the potential energy of the ball at position A equals its kinetic energy at position C. At position A, the ball has zero velocity so its kinetic energy equals zero. At position C, the ball does not have potential energy because its height is zero. The mass of the ball is 1 kilogram. Use this information to find the velocity of the ball at position B.



   a. Write an equation that shows how the energy of the ball at position B relates to its potential energy at position A.

   b. What is the velocity of the ball at position B?