Gravitational Potential Energy and Motional Kinetic Energy

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. 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.

Gravitational Potential Energy

The word *potential* means that something is capable of becoming active. Potential energy can be thought of as stored energy. Gravitational Potential Energy (GPE) is the type of energy that comes from the position (height) of an object above whatever the object would hit if it were dropped.

The formula to calculate the Gravitational potential energy of an object is the mass of the object times the acceleration due to gravity (9.8 m/s^2, you can also use $10m/s^2$) times the height of the object (above whatever it would hit if dropped):

$$E_{GP} = m \cdot g \cdot h$$

The mass of the object must be in kilograms (kg). Also, remember that the acceleration of gravity (g) times the mass of an object (m) is the same as the weight of the object in Newtons? Therefore, an object's gravitational potential energy is equal to the object's weight multiplied by it's height above the lowest point below the object:

So... $E_{GP} = (mg) \cdot h = w \cdot h$ = weight of object • height of object

Kinetic Energy

Kinetic energy is the energy of motion. Motional Kinetic Energy (MKE) depends on the mass of the object (in kilograms) as well as the velocity or 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 Motional Kinetic Energy. The formula for Motional kinetic energy is:

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

To do this calculation you need to square the velocity; then, multiply by the mass; and then multiply by ½.

Examples: How are these mechanical energy formulas used in everyday situations?

• A 50 kg boy and his 100 kg father went jogging. Both are running at a speed of 5 m/s. Who has 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:

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

The kinetic energy of the father:

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

Example: What is the Gravitational potential energy of a 10kg book that is placed on a shelf that is 2.5m high?

Solution: You know that if the book were to fall off the shelf it would move. It has the "potential" to move so it must have potential energy. What gives it this potential energy? Gravity…so the book has Gravitational Potential Energy.

$$E_{GP} = mgh$$

Worksheet: E_{MK} & E_{GP}

Name: _____

Use the motional kinetic energy and gravitational potential energy formulas to answer the following questions – Be sure to use 3 Step Math!!!

1. What is the moving kinetic energy of a 25kg object moving at a velocity of 5m/s?

2. What is the gravitational potential energy of a 150kg object suspended 5m above the earth's surface?

3. What is the motional kinetic energy of a 25kg object moving at a velocity of 10m/s?

4. What is the gravitational potential energy of a 2.5kg object that is 300m above the surface of the earth?

5. An object with a moving kinetic energy of 2160J has a mass of 120kg. What is its velocity?

6. An object whose mass is 43kg is hanging on a thin wire. The object has a gravitational potential energy of 3160.5J. How high is the object above the ground?

7. What is the motional kinetic energy of a 150gram *(* convert to kg)* object moving at a velocity of 100m/s?

8. An object has a moving kinetic energy of 96J. Its velocity is 4m/s. What is its mass?

9. An object with a motional kinetic energy of 1125J has a mass of 250kg. What is its velocity?

10. What is the mass of an object that is hanging 12.6m above the surface of the earth and has a gravitational potential energy of 2778.3J?

11. An object has a gravitational potential energy that is 833 J. Its height above ground is 4.25 m. What is its mass?

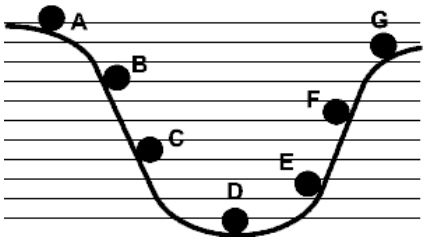
12. An object with a moving kinetic energy of 16,000J has a velocity of 8m/s. What is its mass?

13. An object has a gravitational potential energy of 41772.5J and has a mass of 1550kg. How high is it above ground?

14. What is the moving kinetic energy of a 25kg object moving at a velocity of 2.5m/s?

Energy Transformation

16. *This graph shows a ball rolling from A to G. The ball starts at point A and rolls to point G.*



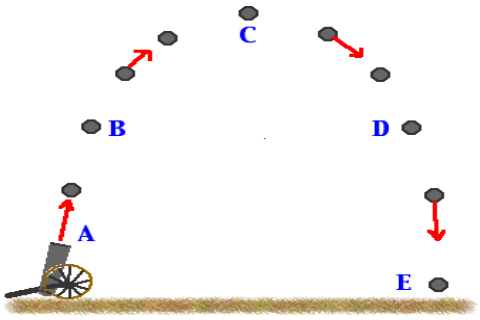
a) At what letter does the ball have the greatest motional kinetic energy? _____

b) Which letter shows the ball when it has the maximum gravitational potential energy? _____

c) Which letter shows the ball when it has the least gravitational potential energy? _____

d) Why is point G slightly lower than point A? In other words, why couldn't the ball go back to the same height at which it started?

17. *Use the diagram below to answer the next set of questions*



a) At what letter does the ball have the greatest moving kinetic energy? _____

b) Which letter shows the ball when it has the maximum grav. potential energy? _____

c) Which letter shows the ball when it has the least gravitational potential energy? _____

d) What can be said about the GPE and MKE at positions B and D?

_____

_____

_____

_____

Challenge: A+ level.

18. A 2.0kg object is dropped from a height of 30m. After it drops for 2.0 seconds, what is its kinetic energy and what is its potential energy? (Assume no air resistance.)

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 gravitational potential energy a 5.0-N book has when it is on three different shelves. The height of each shelf is 1.0 m, 1.5 m, and 2.0 m.

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

3. What is the velocity of a 500-kg elevator that has 4000 J of motional energy?

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

Energy Transfers and the Law of Conservation of Energy:

5. You are on in-line skates at the top of a small hill. Your gravitational 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 gravitational potential energy will be converted to moving kinetic energy. At the bottom of the hill, your moving kinetic energy will be equal to your gravitational potential energy at the top. Calculate your speed at the bottom of the hill.

6. A 1.0-kg ball is thrown into the air with an initial velocity of 30 m/s.
    a. How much moving kinetic energy does the ball have?

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

    c. How high into the air is the ball at the top of the throw?