Name: Key 2017 Date:

PRACTICE 112m = 4 sec 3.2

Potential and Kinetic Energy

READ

Potential energy is stored energy. The formula for the potential energy of an object is: $E_p = mgh$

where m equals mass in kilograms, g is the acceleration of gravity, and h equals the height of the object. The mass (m) 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.

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

Kinetic energy is energy of motion. The formula for the kinetic energy of an object is: $E_k = \frac{1}{2}mv^2$

where m equals mass in kilograms and v equals the velocity or speed of the object in meters per second. To do this calculation, square the velocity value. Next, multiply by the mass, and then, divide by 2.

Energy is measured in joules or newton-meters.

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

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

EXAMPLES

Example 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?

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

The kinetic energy of the father: $E_k = \frac{1}{2}mv^2 = \frac{1}{2}(100\ \text{kg})\left(\frac{5\ \text{m}}{\text{sec}}\right)^2 = 1,250\ \text{kg} \cdot \frac{\text{m}^2}{\text{sec}^2}$

Example 2: What is the potential energy of a 10-newton book that is placed on a shelf that is 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:

$$E_p = mgh = (10\ \text{N})(2.5\ \text{m}) = 25\ \text{N} \cdot \text{m}$$

PRACTICE

Show all calculations. Write all energy values in units of joules. One joule = one newton·meter

1. What is the potential energy of a 2-kilogram potted plant that is on a 1 meter-high plant stand?

2. What is the kinetic energy of a 3-kilogram ball that is rolling at 2 meters per second?
3. The potential energy of an apple is 6.00 joules. The apple is 3.00-meters high. What is the mass of the apple?
4. Determine the amount of potential energy of a 5-newton book that is moved to three different shelves on a bookcase. The height of each shelf is 1.0 meter, 1.5 meters, and 2.0 meters.
5. 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 a rate of 3 m/sec.
   a. Which object had more kinetic energy while it was being lifted?
   b. Which object had more potential energy when it was lifted to a distance of 10 meters? Show your calculation. (Remember that gravity = 9.8 m/sec^2)
6. You are on roller blades on top of a small hill. Your potential energy is equal to 1,000.0 joules. The last time you checked your mass was 60.0 kilograms.
   a. What is your weight in newtons?
   b. What is the height of the hill?
   c. If you start skating 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. What will be your speed at the bottom of the hill?
7. Answer the following:
   a. What is the kinetic energy of a 1-kilogram ball is thrown into the air with an initial velocity of 30 m/sec?
   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 that is 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 traveling at 30 m/sec?
12. In a lab investigation, one group of students (group A) measures the speed of a 0.1-kilogram car at 2.5 m/sec at the bottom of a hill. Another group of students (group B) measures the speed of the car at 3 m/sec at the bottom of the hill. The car's starting position at the top of the hill is one-meter high.
    a. What is the potential energy of the car at the beginning of the experiment before its speed is measured?
    b. Calculate the kinetic energy of the car for group A using the speed (2.5 m/sec) and mass values above.
    c. Calculate the kinetic energy of the car for group B using the speed (3.0 m/sec) and mass values above.
    d. At the bottom of a hill, the kinetic energy of the cars should be equal to the potential energy of the car at the top of the hill. Are the kinetic energy values for groups A and B equal to, less than, or greater than the potential energy value?
    e. The energy of an object can be converted to heat due to the friction of the car on the hill. The difference between the potential energy of the car and its kinetic energy at the bottom of the hill equals the energy lost due to friction. How much energy is lost due to heat for group A's car? How much for group B's car?

Name _____ Class _____ Date _____

Assignment _____

1

Looking for	Solution
E_p	$= 2kg(9.8m/s^2)(1m)$ $= 19.6J$
Given	
Relationships/Formula	

2

Looking for	Solution
E_k	$= 1/2mv^2$ $= 1/2(3kg)(2m/s)^2$ $= 1.5kg(4m^2/s^2)$ $= 6J$
Given	
Relationships/Formula	

3

Looking for	Solution
m	$E_p = mgh$ $6J = m(9.8m/s^2)(3m)$ $6kg \cdot m^2/s^2 = m(29.4m^2/s^2)$ $\frac{6kg \cdot m^2/s^2}{29.4m^2/s^2}$ $0.204kg = m$
Given	
Relationships/Formula	

Name _____ Class _____ Date _____

Assignment _____

4

Looking for	Solution
	$5N(1m) = 5Nm$
Given	$5N(1.5m) = 7.5Nm$
	$5N(2m) = 10Nm$
Relationships/Formula	

5

Looking for	Solution
	a) Obj. 1 $= \frac{1}{2}(2kg)(2m/s)^2$
Given	$= 1kg(4m^2/s^2) = 4J$
	Obj. 2 $= \frac{1}{2}(4kg)(3m/s)^2$
Relationships/Formula	$= 2kg(9m^2/s^2) = 18J$
	b) Obj. 1 $= 2kg(9.8m/s^2)(10m) = 196J$
	Obj. 2 $= 4kg(9.8m/s^2)(10m) = 392J$

6

Looking for	Solution
	a) Weight
Given	$F = mg$
	$= 60kg(9.8m/s^2) = 588N$
Relationships/Formula	b) $\frac{1000\,J = 588N(m)}{588N} = 1.7m$
	c) $1000J$

Name _____ Class _____ Date _____

Assignment _____

7

Looking for	Solution
	a) $= 1/2\,(1\text{kg})(30\text{m/s})^2$ $0.5\text{kg}(900\ \text{m}^2/\text{s}^2)$ $= 450\text{J}$
Given	b) 450J
	c) $450\text{J} = 1\text{kg}(9.8\text{m/s}^2)(h)$ $\frac{450\text{kg}\cdot\text{m}^2/\text{s}^2}{9.8\text{kg}\cdot\text{m}/\text{s}^2} = \frac{9.8\text{m/s}^2(h)}{9.8\text{m/s}^2}$ $h = 45.92\text{m}$
Relationships/Formula	

8

Looking for	Solution
E_p	$3\text{kg}(9.8\text{m/s}^2)(0\text{m})$ $= 0\text{J}$
Given	
Relationships/Formula	

9

Looking for	Solution
E_k	$= 1/2\,(2000\text{kg})(5\text{m/s})^2$ $1000\text{kg}(25\text{m}^2/\text{s}^2)$ $= 25000\text{J}$
Given	
Relationships/Formula	

Name _____ Class _____ Date _____

Assignment _____

10

Looking for	Solution
v	$4000\,J = \frac{1}{2}(500\,kg)(v^2)$ $4000\,kg\cdot m^2/s^2 = 250\,kg\,(v^2)$ $\frac{4000\,kg\cdot m^2/s^2}{250\,kg} = \frac{250\,kg\,(v^2)}{250\,kg}$ $\sqrt{16\,m^2/s^2} = \sqrt{v^2}$ $4\,m/s = v$
Given	
Relationships/Formula	

11

Looking for	Solution
m	$33750\,J = \frac{1}{2}(m)(30\,m/s)^2$ $33750\,kg\cdot m^2/s^2 = \frac{1}{2}(m)(900\,m^2/s^2)$ $\frac{33750\,kg\cdot m^2/s^2}{450\,m^2/s^2} = \frac{450\,m^2/s^2\,(m)}{450\,m^2/s^2}$ $75\,kg = m$
Given	
Relationships/Formula	

12

Looking for	Solution
a) $= 0.1\,kg(9.8\,m/s^2)(1\,m)$ $= 0.98\,J$	d) Less than because group A & B $E_p = 0.98\,J$ at top of hill and are $0.3125\,J$ & $0.45\,J$ at bottom.
Given b) $= \frac{1}{2}(0.1\,kg)(2.5\,m/s)^2$ $(.05\,kg)\ 6.25\,m^2/s^2$ $= 0.3125\,J$	e) $0.98\,J - 0.3125\,J = 0.6675\,J$ $0.98\,J - 0.45\,J = 0.53\,J$
Relationships/Formula c) $= \frac{1}{2}(0.1\,kg)(3\,m/s)^2$ $= 0.05\,kg\,(9\,m^2/s^2)$ $= 0.45\,J$	