Name: ____________________

Period: ____________________

# Conservation of Energy

**3.4**

**Law of Conservation of Energy: $E_{before} = E_{after}$**
**"Energy is never created nor destroyed, just transformed into other forms of energy."**

The principle of **conservation of energy** is one of the more far-reaching general laws of physics. It states that energy is neither created nor destroyed but can only be transformed from one form to another in an isolated system. Because the total energy of the system always remains constant, the law of conservation of energy is a useful tool for analyzing a physical situation where energy is changing form. Imagine a swinging pendulum with negligible frictional forces. At the top of its rise, all the energy is gravitational potential energy due to height above the stationary position. At the bottom of the swing, all the energy has been transformed into kinetic energy of motion. The total energy is the sum of the kinetic and potential energies. It maintains the same value throughout the back and forth motion of a swing.

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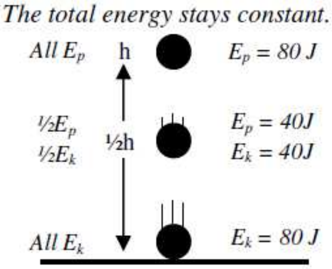
**Energy Before Equals Energy After**

Conservation of energy means energy is saved, retained. All the energy before an energy transformation must equal all of the energy afterwards OR $E_{before} = E_{after}$.

When an object falls or rises without friction, potential energy becomes kinetic energy.

*The total energy stays constant.*




*By Conservation of Energy if you know the height of the object at the top, you can find its speed at the bottom and vice versa!*

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**Calculating Potential Energy and Kinetic Energy of a Rolling Marble**

**INTRODUCTION AND OBJECTIVES** The Law of Conservation of Energy states that energy can be neither created nor destroyed. However, energy can change from one form to another. In the case of a marble on a roller coaster, a marble starts at the top of the roller coaster with a relatively large amount of potential energy and no kinetic energy. As the marble starts rolling down the roller coaster, the amount of potential energy stored in the marble decreases while its kinetic energy increases. Potential energy is also converted into heat energy due to friction. In this experiment, you will be calculating the Total Mechanical Energy, Kinetic and the change in Potential Energy of a marble traveling between seven points on a roller coaster.

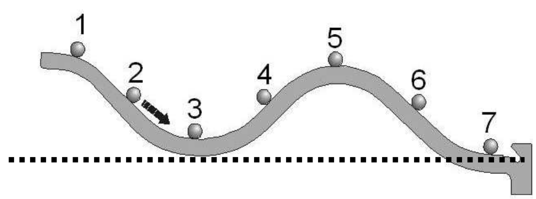
**PROCEDURE I. Selecting the starting point.** Calculate the Total Mechanical Energy of the marble at the starting point. Choose seven sections of the roller coaster in which the marble accelerates. Calculate the Total Mechanical Energy at each of these points.

**PROCEDURE II. The gravitational potential energy of the marble** To simplify calculations, treat the height of point 7 as the reference point where gravitational potential energy equals zero. The gravitational potential energy of the marble depends on the height of the starting point compared to the ending point of the marble's path. Gravitational potential energy equals (mass)*(acceleration due to gravity)*(height). This can be written as P.E.= mgh.

Note: At each of the seven points, you will need to make sure that your height is measured in meters. Use the chart below to convert from centimeter to meters.

$$\left(\underline{\qquad\quad} cm\right) \times \left(\frac{\underline{\qquad\quad} m}{cm}\right) = \underline{\qquad} m$$

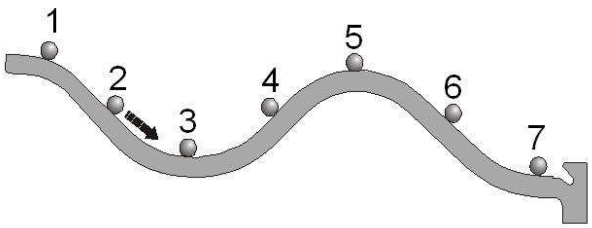
Reference Point = 0 meters




**Find the mass of the marble.** Measure the mass of the marble.__________ grams Convert the mass of the marble to kilograms.

$$\left(\underline{\qquad\quad} grams\right) \times \left(\frac{\underline{\qquad\quad} kg}{grams}\right) = \underline{\qquad} kg$$

**III. Calculating the kinetic energy of the marble** As the marble is rolling down the roller coaster, it will gaining Kinetic Energy as it is losing Potential Energy. The Total Mechanical Energy of the system will stay constant during this change. Calculate the Kinetic Energy by subtracting the Potential Energy from the Total Mechanical Energy (KE = TME — PE).




| Position | Mass kg | Height m | g $m/s^2$ | PE J | KE J | TME J |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |

**IV. Conclusion**

1. What is the total Mechanical Energy of the marble at point 1, before the marble starts to roll? ____________
2. What is the total Mechanical Energy of the marble at point 7? ______________________________________
3. Compare your answers to questions 1 and 2. Should these answers be the same? _______________________ why or why not?

______________________________________________________________________________

______________________________________________________________________________

Consider the three situations below. Identify whether or not the total Mechanical energy (TME) is being conserved. Explain why.


TME Conserved? _________

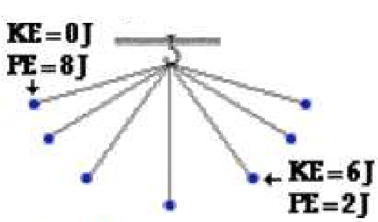
Why or why not?______________________________

______________________________________________


TME Conserved? _________

Why or why not?______________________________

______________________________________________



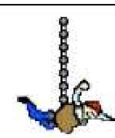

TME Conserved? __________

Why or why not?______________________________

______________________________________________

For each statement, identify which forces ($F_{grav}$; $F_{norm}$; $F_{frict}$; $F_{air}$; $F_{app}$; $F_{tens}$; and $F_{spring}$) are doing work. Then state whether the total mechanical energy will be conserved.

a. A bungee jumper rapidly decelerates as he reaches the end of his spring-like bungee chord. Ignore the effect of air resistance.



Forces doing work? ____________________

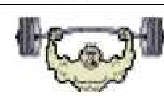
TME Conserved? Yes No

b. A girl releases a softball from rest from a height of 2 meters above the ground; the ball free-falls to the ground.

Forces doing work? ____________________

TME Conserved? Yes No

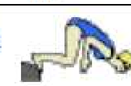
c. A weightlifter briskly raises a 200-pound barbell above his head.



Forces doing work? ____________________

TME Conserved? Yes No

d. A swimmer pushes off the blocks to accelerate forward at the beginning of a race.



Forces doing work? ____________________

TME Conserved? Yes No

Consider the falling and rolling motion of the ball in the following two friction-free situations. In one situation, the ball falls off the top of the platform to the floor. In the other situation, the ball rolls from the top of the platform along the staircase-like pathway to the floor. For each situation, indicate what types of forces are doing work upon the ball. Indicate whether the energy of the ball is conserved and explain why. Finally, fill in the blanks for the 2-kg ball.

A._______ D._______ G._______ J._______

B._______ E._______ H._______ K._______

C._______ F._______ I. _______