Conservation of Energy

The **Law of Conservation of Energy** states that:

The total energy is neither increased nor decreased in any process. Energy can be transformed from one form to another, but the total amount remains constant.

In other words:

The total energy of a system is constant.

This concept is useful in solving a variety of problems involving the motion of objects.

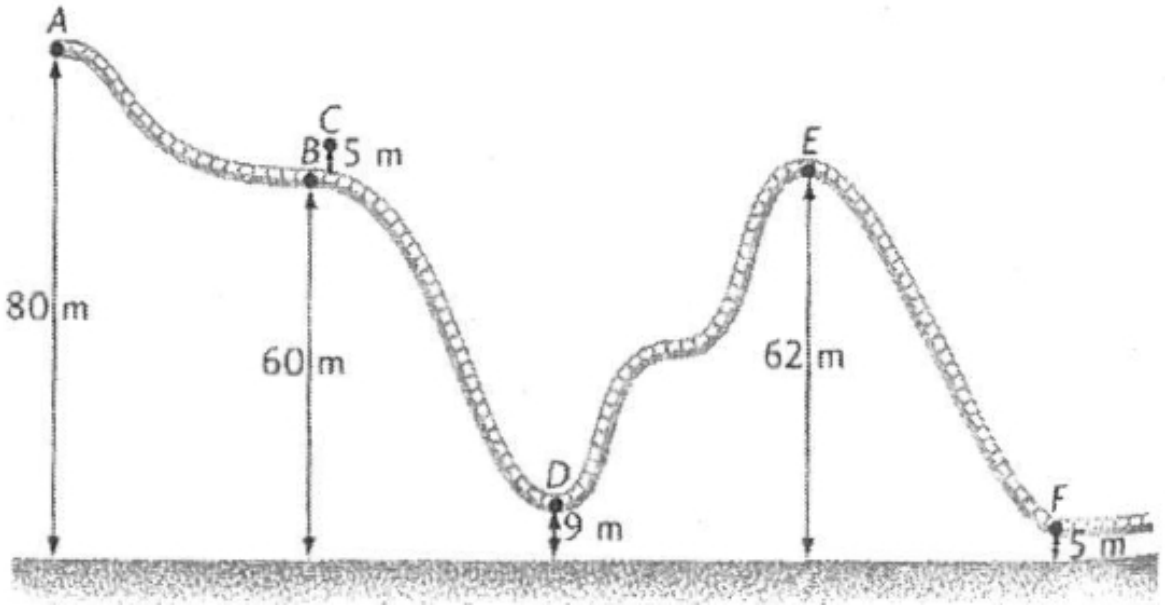
Example 1
A car is at rest atop a $40\ m$ tall hill. If the car rolls down the hill, determine:

a) the velocity of the car at the bottom of the hill.

b) at what height it will have half this velocity.

Example 2
A 6.0 *m* rope is tied to a tree limb and used as a swing. A person starts from rest with the rope held taut horizontally. How fast will the person be moving at the lowest point of their swing?

Example 3
A 1000 *kg* roller coaster car starts from rest at point A on a frictionless track as shown.



a) At which point on the track is the car's gravitational potential energy the greatest? the least?

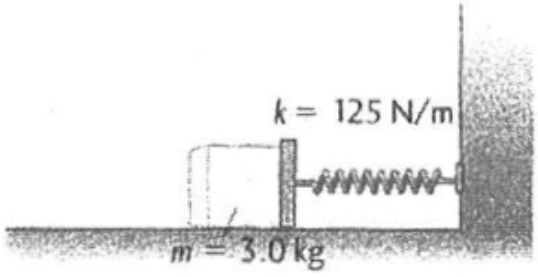
b) What is the car's maximum speed?

c) What is the speed of the roller coaster car at point E?

d) What constant braking force would have to be applied to bring the coaster car at point F to a stop in $5.0\ m$?

Example 4

A 3.0 *kg* block of ice held against a spring with a force constant of 125 *N* / *m* , as shown. The spring is compressed by 12 *cm* . The ice is released across a horizontal plank with a coefficient of friction of 0.10.



a) Calculate the velocity of the ice just as it leaves the spring. Assume the friction between the plank and the ice is negligible until the moment the ice leaves the spring.

b) Determine the distance the ice travels after it leaves the spring.

Energy Worksheet #4

1. A spring bumper, whose force-compression relationship is given by $F = 50x$, is compressed $0.20\ m$. A $0.40\ kg$ cart is placed against the compressed spring on a horizontal, frictionless plane, and the system is released. With what velocity will the cart leave the spring? ($2.24\ m/s$)

2. The spring in a toy gun has a force constant of $500\ N/m$. It is compressed $5.0\ cm$, and a ball of mass $10\ g$ is placed next to it in the barrel. What is the ball's maximum velocity, when the trigger releases the spring? Assume there is no friction, and that the gun barrel is level. ($11.2\ m/s$)

3. A horizontal spring with a force constant of $350\ N/m$ is compressed $12\ cm$ by a $3.0\ kg$ mass. How fast is the mass moving after only $10\ cm$ of the spring is released? ($1.28\ m/s$)

4. A $1.0\ kg$ lead sphere is suspended from the ceiling by a wire $5.0\ m$ long. The ball is pulled sideways and up, until the wire is horizontal, and then released. Find

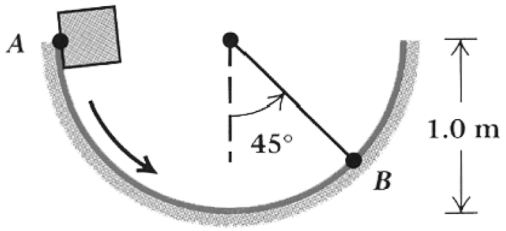
   a) the maximum velocity acquired by the ball. ($9.9\ m/s$)

   b) The tension in the wire at the lowest point in the swing. ($29.4\ N$)

5. A carpenter drops a hammer off the roof of a house. If the hammer falls a distance of $6.46\ m$, what is its speed just before striking the ground? Neglect air resistance. ($11.25\ m/s$)

6. An ice cube slides from rest without friction down a long inclined ramp that makes an angle of $37.5°$ with the horizontal. What is the speed of the cube after it slides $1.27\ m$ down the plane? ($3.89\ m/s$)

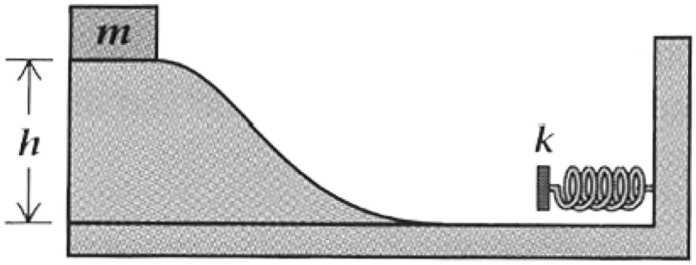
7. A block slides on a semicircular frictionless track, as shown below. If it starts from rest at position *A*, what is its speed at the point marked *B*? ($3.72\ m/s$)



8. An egg falls from a nest at a height of $3.08\ m$. What speed will it have when it is $0.50\ m$ from the ground? Neglect air resistance. ($7.11\ m/s$)

9. A baseball is thrown almost straight up at a speed of $12.3\ m/s$ and falls back on the roof of a building $5.42\ m$ above the height from which the ball was thrown. What is the speed of the ball just before it reaches the roof? ($6.71\ m/s$)

10. A block of mass $m = 750\ g$ is released from rest and slides down a frictionless track of height $h = 55.2\ cm$. At the bottom of the track the block slides freely along a horizontal table until it hits a spring attached to a heavy, immovable wall (as shown below). The spring compressed by $2.64\ cm$ at the maximum compression. What is the value of the spring constant k? ($11643\ N/m$)



11. Suppose the roller coaster car in the diagram below starts from rest at point A and moves without friction.

    a) How fast is it going at points B, C, and D? ($11.7\ m/s$, $8.9\ m/s$, $9.9\ m/s$)

    b) What constant deceleration must be applied at D to have it stop at E? ($-1.63\ m/s^2$)