7.3 Conservation of Energy

The law of conservation of energy tells us that energy can never be created or destroyed—it is just transformed from one form to another. The total energy after a transformation (from gravitational potential to motional kinetic energy and ***IGNORING FRICTION***!) is equal to the total energy before the transformation. We can use the Law of Conservation of Energy to solve real-world problems, as shown in the examples below.

Example:

A 0.50-kilogram ball is tossed upward with a kinetic energy of 100 joules. How high does the ball travel?

1. Looking for: The maximum height of the ball.

2. Given: The mass of the ball, 0.50 kg, and the kinetic energy at the start: 100 joules

3. Relationships: $E_{MKE} = \frac{1}{2} mv^2$; $E_{GPE} = mgh$

4. Solution: The gravitational potential energy at the top of the ball's flight is equal to its motional kinetic energy at the bottom (just after it was thrown up). Therefore,

$E_{GPE} = mgh = 100$ joules.

Substitute into the equation m = 0.50 kg and g = 9.8 m/s^2.

$100 = mgh = (0.50)(9.8)h = 4.9\ h$

Solve for h.

$100 = 4.9\ h$

$100/4.9 = \cancel{4.9}h/\cancel{4.9}$

$\boxed{20\text{m} = h}$

Practice:

1. A 3.0-kilogram toy dump truck moving with a speed of 2.0 m/s starts up a ramp. How high does the truck roll before it stops assuming we ignore motional kinetic energy converted to thermal energy from friction?

2. A 2.0-kilogram ball rolling along a flat surface starts up a hill. If the ball reaches a height of 0.63 meters, what was its initial speed?

3. A 500kg roller coaster starts from rest (v=0m/s) at the top of an 80.0m hill. What is its speed at the bottom of this hill assuming we ignore motional kinetic energy converted to thermal energy from friction?

4. Find the gravitational potential energy of this roller coaster when it is halfway down the hill.

5. A 2.0kg ball is tossed straight up with a motional kinetic energy of 196 joules. How high does it go assuming we ignore motional kinetic energy converted to thermal energy from air friction?

6. A 50kg rock rolls off the edge of a cliff. If it is traveling at a speed of 24.2 m/s when it hits the ground, what is the height of the cliff assuming we ignore motional kinetic energy converted to thermal energy from air friction?

7. Challenge! Make up your own energy conservation problem. Write the problem and the answer on separate index cards. Exchange problem cards with a partner. Solve the problems and then check each other's work using the answer cards. If your answers don't agree, work together to find the source of error.

7.3 Conservation of Energy

① A 3.0 kg toy dump truck moving with a speed of 2.0 m/s starts up a ramp. How high does the truck roll before it stops?

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

$= \frac{1}{2}(3.0\text{ kg})(2.0\text{ m/s})^2$

$= 6\text{ J}$

$PE = mgh$

$h = \frac{PE}{mg} = \frac{6\text{ J}}{3.0\text{ kg} \cdot 9.8\text{ m/s}^2}$

$h = .2\text{M}$

② A 2.0 kg ball rolling along a flat surface starts up a hill. If the ball reaches a height of 0.63M, what was the initial speed?

$PE = mgh$

$= (2.0\text{ kg})(9.8\text{ m/s}^2)(0.63\text{M})$

$= 12.35\text{ J}$

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

$v^2 = \frac{KE}{\frac{1}{2}m} = \frac{12.35\text{ J}}{\frac{1}{2}(2.0\text{ kg})}$

$v^2 = 12.35\text{ m}^2/\text{s}^2$

$v = 3.51\text{ m/s}$

3. A 500 kg roller coaster starts from rest at the top of an 80 m hill. What is the speed at the bottom?

$PE = mgh$

$= (500\text{ kg})(9.8\text{ m/s}^2)(80\text{ m})$

$= 392{,}000\text{ J}$

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

$v^2 = \frac{KE}{\frac{1}{2}m} = \frac{392{,}000\text{ J}}{\frac{1}{2}(500\text{ kg})}$

$v^2 = 1568\text{ m}^2/\text{s}^2$

$v = 39.60\text{ m/s}$

4. Find the potential energy of the coaster halfway down the hill?

$PE = mgh$

$= 500\text{ kg}(9.8\text{ m/s}^2)(40\text{m})$

$= 19{,}6000\text{ J}$

5. A 2.0 kg ball is tossed straight up with a KE of 196 J. How high does it go?

$PE = mgh$

$h = \frac{PE}{mg} = \frac{196\text{ J}}{(2.0\text{ kg})(9.8\text{ m/s})}$

$h = 10\text{M}$

6. A 50kg rock rolls off the edge. If its traveling @ a speed of 24.2m/s when it hits the ground, what is the cliff's height.

$KE = \frac{1}{2}mv^2 = \frac{1}{2}(50\text{kg})(24.2\text{m/s})^2$

$= 14{,}641\text{J}$

$h = \frac{PE}{mg}$ $h = \frac{14{,}641\text{J}}{50\text{ kg}(98\text{m/s})}$

$h = 29.88\text{M}$