Next Generation Science Standards

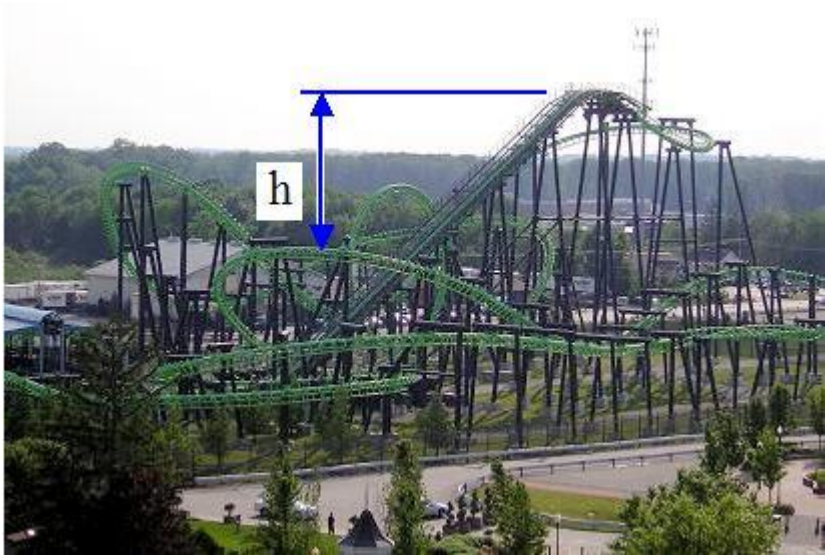
HS-PS3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).

Example Problem - Roller coaster

The typical roller coaster works by gravity. There are no motors used to power it during the ride. Starting from rest, it simply descends down a steep hill, and converts the (stored) gravitational potential energy into kinetic energy, by gaining speed. A small amount of the energy is lost due to friction, which is why it's impossible for a roller coaster to return to its original height after the ride is over.

The roller coaster uses a motorized lift system to return to its original position at the top of the initial hill, ready for the next ride.

The figure below illustrates the concept.



Source: Wikipedia via Chris Hagerman

Assuming no friction losses, when the center of mass of the roller coaster falls a vertical height *h* (from the initial hill) it will have a kinetic energy equal to the gravitational potential energy stored in the height *h*.

This can be expressed mathematically as follows.

Let *W* be the gravitational potential energy at the top of the hill.

Then,

$$W = mgh$$

where m is the mass of the roller coaster, and g is the acceleration due to gravity, which equals 9.8 m/s^2 on earth's surface.

The kinetic energy of the roller coaster is:

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

where v is the speed of the roller coaster.

If we assume no friction losses, then energy is conserved. Therefore,

$$W = KE$$

Thus,

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

mass cancels out, and

$$v = \sqrt{2gh}$$

This result is nice because it allows us to approximate the speed of the roller coaster knowing only the vertical height h that it fell (on any part of the track). Of course, due to friction losses the speed will be a bit less than this, but it is very useful nonetheless.