

# *Newton's Cradle*

## *An Example of Three Levels of Explanation*

### **Primary:**

Raise the metal ball and then let go of it.

What happens to the second ball that was hit?

What happens to the first ball that you released?

The second ball should move forward and the first ball should stop. This is because the first ball gives energy to the second ball and the second ball takes energy from the first ball.

This is like when your foot kicks a soccer ball – your foot gives energy to the soccer ball. The soccer ball moves forward while your foot stops. What would happen if instead of kicking a soccer ball you were to kick a tennis ball?

Go to the second cradle and raise the big ball to the same height you raised it in the first cradle. Let go of the big ball.

What happens to the small ball?

How is this different than what happened before?

The light ball should move further in this cradle than in the first cradle.

This is like when you kick a tennis ball. The tennis ball moves further than the soccer ball because it is lighter. Instead of saying that the tennis ball is lighter, scientists say that the tennis ball has less mass than the soccer ball. Mass is how scientists measure how much “stuff” an object has. A soccer ball is made of more “stuff” than a tennis ball, so it is harder to move.

### **Secondary:**

Raise the first ball and release it and let it hit the second ball. What happens? Let the two balls swing back and forth. What eventually happens?

When you raise the first ball you are doing work to it. You give it a type of energy that physicists call “Potential Energy”. When you let go of the ball it starts to move because gravity is pulling it down. When objects move they have a type of energy called “Kinetic Energy”. When objects move they also have what physicists call “Momentum”. As the ball moves faster it gains Kinetic Energy and momentum.

When the two balls collide, the first ball transfers its kinetic energy to the second ball. This is because of a law called the “Conservation of Energy”. This law states that energy cannot be destroyed but only exchanged. The second ball “takes” the energy from the first ball.

In the same way, the first ball transfers its momentum to the second ball. This because of a law called “Conservation of Momentum.” The second ball takes the momentum of the first ball. The first ball has lost its energy and momentum to the second ball, and it the first ball stops.

You'll notice, as the balls swing back and forth, that they eventually come to a stop. Why is this? Why don't the balls swing back and forth forever?

The balls lose energy to many things – they lose energy to the air as they move through it (air friction), they make sound energy when they collide, and they lose energy to heat upon collision. Each of these factors “takes away” energy from the ball – as the ball loses energy it slows down and eventually stops.

Now go to the second cradle and raise and release the bigger ball. What happens? Let the balls swing back and forth and pay attention to what happens.

The small ball moves further than the big ball did in the first cradle. This is because the small ball has less mass than the big ball. Kinetic energy and momentum both depend on two things – mass and speed. Because the small ball has less mass than the big ball, most of the energy and momentum it receives from the big ball is in the form of speed. Because it has more speed, it moves further.

Notice how, as you let the balls go back and forth, there is chaotic movement to the balls. There are some complicated reasons for this, but in short it has to do with the fact that both the momentum and energy have to be conserved at the same time. Because the balls have different masses the movement of the two balls is more irregular than the first cradle.

**Cultural: (NB: This is adapted from Wikipedia – and is very unreliable! It is a first swipe at research, and serves only as an example of a “type”. You would be required to do research that included references from reputable books and journals.)**

Newton's cradle demonstrates conservation of momentum and energy. Newton's was invented in 1967 by English actor Simon Prebble. At first, a wood cradle version was sold by Harrods of London and later a chrome design was created by the sculptor Richard Loncraine.

In schools, Newton's used to present the concepts Conservation of Momentum, Conservations of Energy, Newton's Second Law, and Newton's Third Law. The largest Newton's cradle is on public display in Kalamazoo, Michigan. It is used for demonstrations and consists of 20 bowling balls, each weighing 15 pounds. The balls are hung from cables in the ceiling. The cables are 20 feet long and the balls are 3 feet off the floor.

*I also found a reference to Abbé Mariotte in the 17<sup>th</sup> century. This is a lead that overthrows the story above, and provides a fruitful avenue of research. There seems to be a great story here about scientific invention and scientific credit.*