# Slinky Physics: Equilibrium and Energy Exchange

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Concept: Equilibrium and Energy Exchange (Conservation of energy and momentum)
Model: Slinky toy

## Introduction

Most people have played with the slinky toy at one point of their life. Created by accident when naval engineer Richard James was researching on a meter to monitor horsepower on naval battleships, the slinky is a simple helical spring where its natural resting state has all its coils touching each other.

## Principles

Stable Equilibrium: An object in a state of stable equilibrium will return to its original position when it undergoes a small movement or displacement.
Conservation of Energy: The total energy in a conservative system at two different times or positions is the same.
Conservation of Momentum: The momentum of a conservative system at two different times is the same when there is zero external forces acting on the system.

Video for both situations here: http://www.youtube.com/watch?v=RhA2bfsnggc

## Slinky Moving Down Steps

When a Slinky is placed at the top of a flight of stairs or a stack of books, it will remain in a state of equilibrium. As it is not moving when placed, the Slinky is in a state of stable equilibrium. If the slinky is slightly disturbed, it will not change its position unless the force acting on it is large. Once a large force causes the Slinky to tip over, the Slinky will ‘walk’ down the steps. This can be explained through the concept of energy exchange specifically conservation of energy.

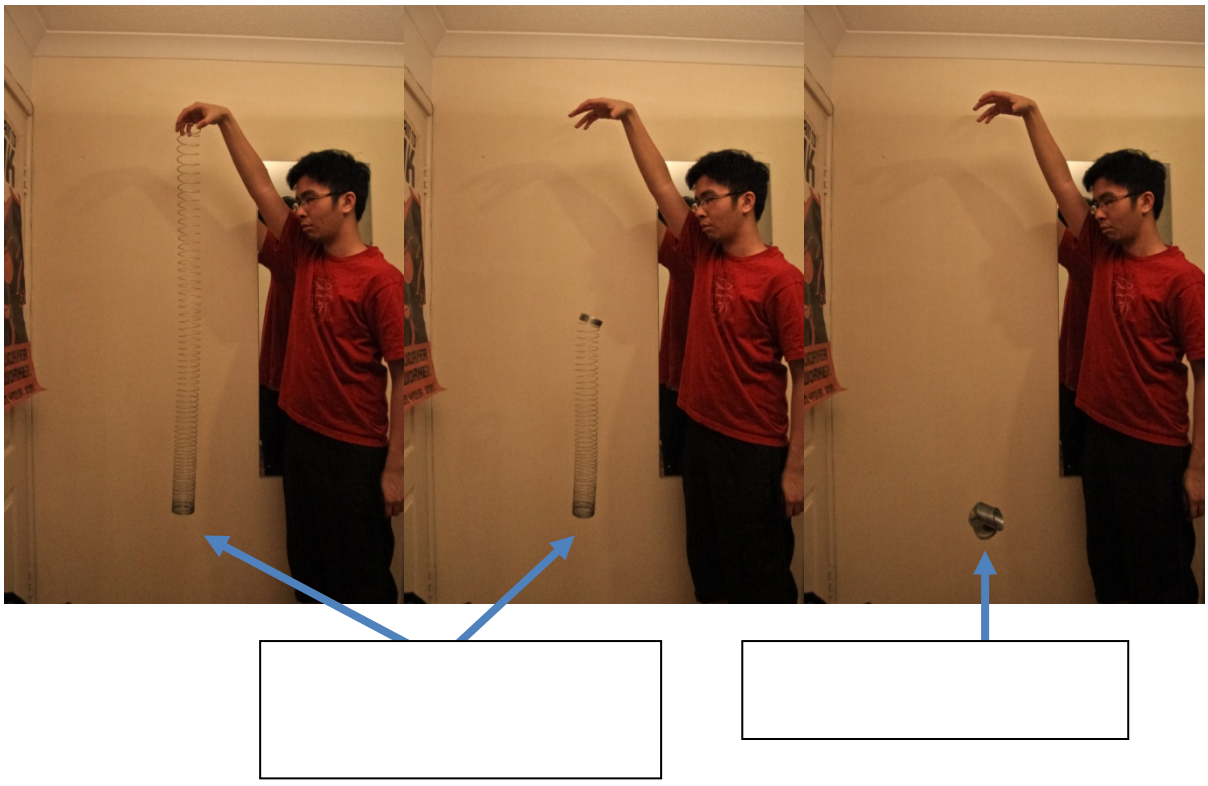
When placed at the top of a stack of books, the Slinky will have potential energy stored in it due to its mass being at an elevated position. Once the Slinky is tipped over the edge, the potential energy is converted to kinetic energy as the Slinky starts moving down the first step. Energy is continuously converted back and forth between potential energy and kinetic energy as the Slinky moves down each step. This conservation of energy enables the Slinky to move down each step on its own.

The moving Slinky also has momentum as it moves down the first step. As it reaches the first step, the momentum is conserved and travels back the opposite direction which causes the Slinky to tip over and move down the next step. In an ideal situation, this conservation of momentum and energy will propel the Slinky to continuously move down until it reaches the bottom of a flight of stairs or steps. In reality, external forces such as frictional and damping forces causes the system to lose its energy and momentum after each subsequent step and would therefore stop after several steps. Theoretically, the Slinky will forever move down an upward escalator.

The Levitating Slinky

When a Slinky is suspended in mid air, the Slinky will stretch out and be in a state of equilibrium. The Slinky stretches out due to the action of gravity pulling its mass downwards. The Slinky is in a state of equilibrium because the external force of gravity is balanced by the internal tension force in the Slinky that pulls it upwards thus allowing the stretched Slinky to be suspended as long as it is held up. The Slinky is in a state of unstable equilibrium. Once the top of the held Slinky is released, the top will fall down first as shown in the set of pictures below. As the top falls down, the bottom of the Slinky remains relatively stationary in mid-air as if it is levitating.

This phenomenon can be explained by the concept of equilibrium. Once the top is released, there is no longer a tension force in the Slinky that reacts against the pull of the gravitational force thus the Slinky collapses and compresses. This compression force travels as a wave downwards as the Slinky moves downwards. It takes time for this compression wave to travel to the bottom thus the bottom remains at rest until it the compression wave reaches it. This provides a brief moment for the levitation of the Slinky's bottom.



References


- http://courses.ncssm.edu/hsi/miniterm2000/fallingslinky/mslinkyphys.htm
- http://up-ship.com/blog/?p=11917
- http://www.portageinc.com/community/pp/slinky.aspx