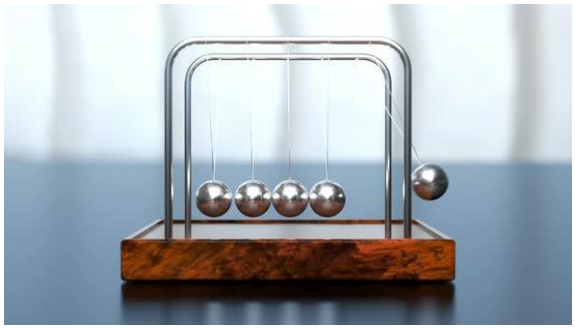


Newton's Cradle

Introduction

What Students Do in this Activity?

Students are introduced to the physical principal of conservation of momentum found in many aspects of the day to day life and used in all the areas of engineering and physical sciences. Students will build their own Newton's Cradle with simple materials and test what happens when they lift one end of the Newton's Cradle at different heights.

Concepts

The Newton's Cradle is a desk toy named by one of the most important scientists, Sir Isaac Newton. It demonstrates the scientific idea of momentum and the principal of conservation of momentum in impacts (also called collisions) by moving one ball at the end at a certain height and letting go to hit the other balls. Momentum can be defined as a "mass in motion" and it measures the motion of an object. As an object with a certain mass moves at greater velocities it has greater momentum or you can compare two objects of different masses moving at the same velocity, the object that has greater mass will have a greater momentum. For example, if Ball A has a mass of 10 lbs and Ball B has a mass of 20 lbs, and both balls are moving at 10 mph, Ball B will have a greater momentum than Ball A. The equation for momentum is:

$$\text{Momentum} = \text{Mass} \times \text{Velocity}$$

Now the principal of conservation of momentum is one of the most fundamental principals in science and engineering. This principal states that the momentum in a collision must be the same before the impact and after. In the case of the Newton's Cradle each time the balls on the ends strike the ones in the middle a force is transmitted through each ball until it reaches the one on the opposite end that is free and it moves some distance. In an ideal world the motion is never ending, since there are no external forces acting to reduce the momentum. In our case in the real world the momentum decreases as each impact occurs, this is due to energy being taken away by factors like friction, in the strings and the interactions between each ball in the Newton's Cradle. The basic equation for the principal of conservation of momentum is:

$$m_i \times v_i = m_f \times v_f$$

The variables in the equations represent physical parameters of the object under study. The variable m_i represents the initial mass of the object or system, the variable m_f represents the final mass of the object of system. The variable v_i is the initial velocity and v_f is the final velocity of the object or system. Depending on if the collision whether the object strikes and bounces back the initial and final mass of the object or system stays the same and does not change; if the object strikes and are stuck together the final mass of the system is the sum of both objects.

Objectives

Students will:

- Build their own Newton's Cradle
- Learn about the principal of conservation of momentum
- Experiment with a Newton's Cradle
- Contemplate the uses of this principal in science or engineering

Questions before the activity

- What is an example of the principal of conservation of momentum found in a normal day?
- What will have more momentum: A ball of 10 lbs rolling at 5 ft/s or a ball of 5 lbs rolling at 15 ft/s?
- What is a use of the principal of momentum in a game?

Time

30-45 minutes

Materials

To complete this activity students will need:

- 6 marbles (preferably medium or large in size)
- 20 jumbo craft sticks
- Scissors
- Glue
- String
- Tape
- A pencil
- Hot glue
- Ruler

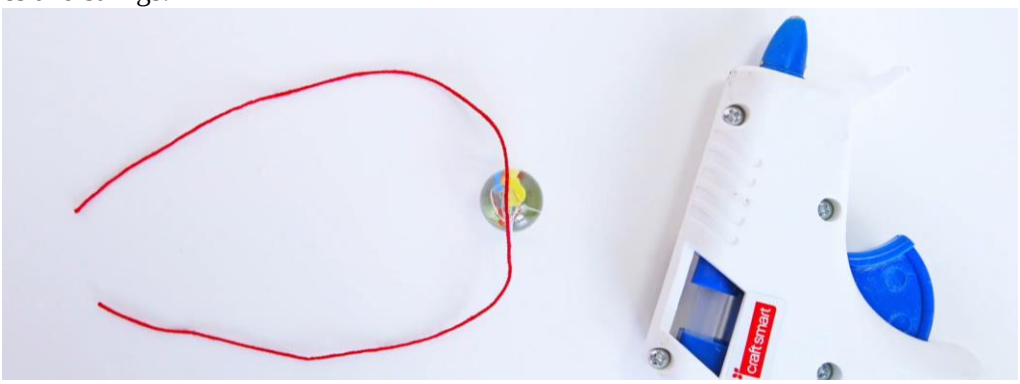
Activity

Steps to build the Newton's Cradle

To construct the Newton's Cradle the following steps are needed:

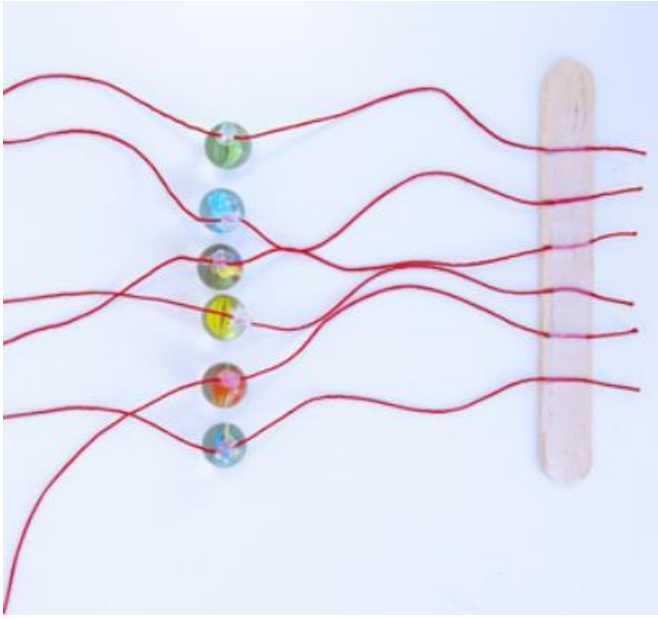
1. Glue four craft sticks at each corner to make the shape of a square. Repeat this step with four more craft sticks. Leave the sticks to dry. These will be the sides of your frames.

2. Measure the string to be approximately 8 inches in length and cut. This step is repeated to have 6 strings of equal lengths.
3. Use the hot glue to glue the marble at the center of the string. Repeat this step with the other five marbles and strings.



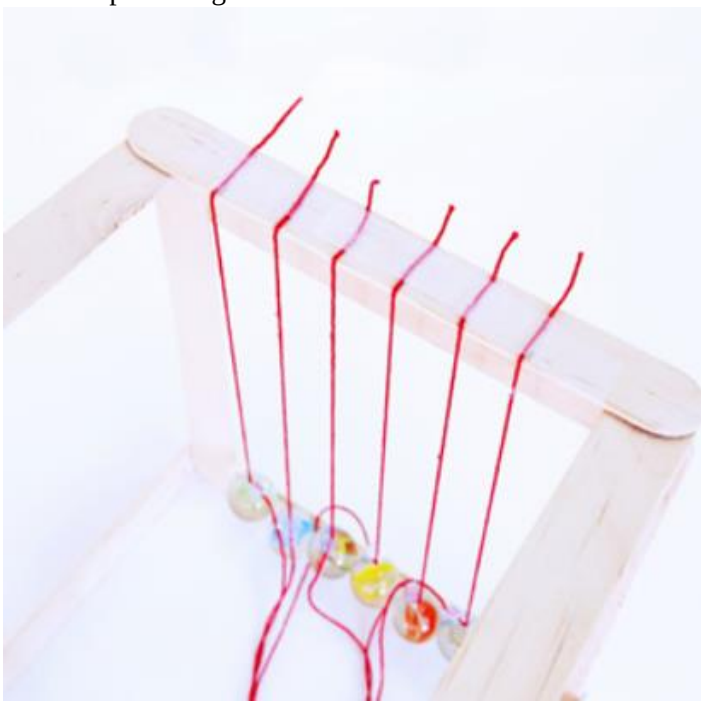
4. Use the ruler and pencil to make 6 marks along two craft sticks ever ½ inches. Leave a space of ½ inch at the corners of the craft sticks. Be careful to make the marks at the center of the sticks.

5. Place the strings with the marbles attached on each of the marks on the sticks and use tape to attach the string to the stick. After completing this step set aside the part.

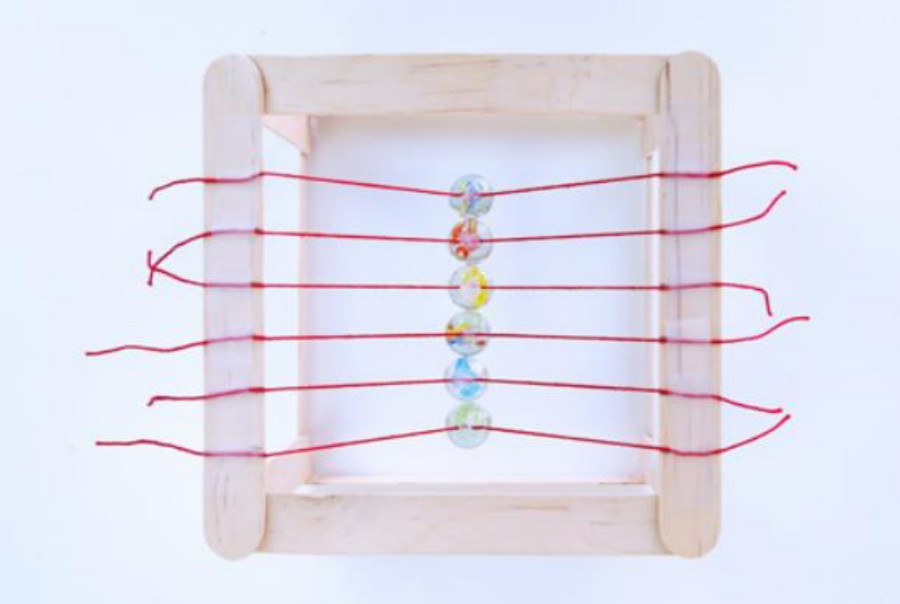


6. Attached the 2 sides of the frame (assembled in step 1) together, by hot gluing two wooden sticks perpendicular to each corner of the frame on the bottom, and two sticks on the top of the frame.

7. Attach craft stick with the taped strings and marbles to one side of the frame with hot glue.



8. Glue the second marked craft stick on the opposite side of the frame and tape the loose end of each string with the marble attached to each mark on the stick. Pull on each string to make sure that each marble is align with each other.
   Note: the marbles should be aligned horizontally when viewed from above



9. After completing the Newton's Cradle perform experiment by pulling one of the outside marbles back to different heights.

Experiment

Test

To observe how the momentum changes, vary the height of the marble that is pulled back and let go. Start by pulling back one marble a little bit, then increase the distance that the marble is pulled back and answer these questions:

- What happens with the marble at the opposite end of the Cradle? How much does it move?

- What is the difference in the speed at which it moves?

Questions after building and testing the Newton's Cradle

- What would happen to the motion of the marble if bigger ones are used? And what if smaller marbles are used?

- What do would happen if you pullback one marble and instead of letting go you push it a little and give it some speed?

- What would happen if you hold the marble at the other end when you let go of the marble? What would you feel?

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