Investigation of Parameters in Oscillations of Newton's Cradle

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ABSTRACT

This is a problem related to oscillations of a Newton's cradle which will gradually decay until the spheres come to the rest. The effect of several parameters such as number, material and alignment of the spheres on the rate of decay in this research have been investigated. The collision between two balls was our initial observation and then it was extended to a higher number of balls. A comparison between middle and side ball and the effect of number of the releasing balls and alignment are investigated theoretically which shows the decay in collisions and also increasing the number of the balls will cause increasing the rate of decay too. It also shows that as we use more elastic materials, the rate of decay decreases in our experiment.

Key Words: *oscillation, Newton's cradle, collision, elastic materials*

1 Introduction

Newton's cradle is constructed from a series of pendulums (usually five in number) abutting one another. Each pendulum is attached to a frame by two strings of equal length angled away from each other. If these strings were not same in length, the balls would then be unbalanced. This string arrangement restricts the pendulums' movements to the same plane. In Newton's cradle when the first ball is released, it hits the second ball then transfers its momentum and energy to the last ball through the middle balls. This process repeats in reverse until the spheres come to the rest and all of the energy is dissipated. The behavior of the pendulum follows from the conservation of momentum and kinetic energy only in the case of two pendulums (Fig.1) [1].

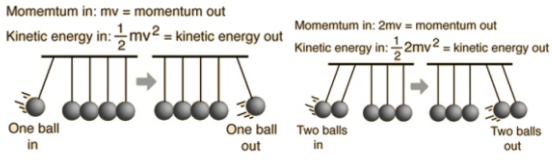

Fig.1: Demonstration of conservation of momentum and conservation of energy in Newton's cradle [2]

The phenomenon causes swinging pendulums to synchronize when they are close together, but if we have a number of pendulums, there are unknown parameters to be calculated from the initial conditions.

2 Materials, Devices and Method

2-1 Materials and Devices

When a ball on one end of the cradle is pulled away from the others and then released, it strikes the next ball in the cradle, which remains motionless. But the ball on the opposite end of the row is thrown into the air, then swings back to strike the other balls, starting the chain reaction again in reverse (Fig.2).

Two cradles in different materials, steel and copper, with 2 up to 5 number of balls, are used in this experiment.

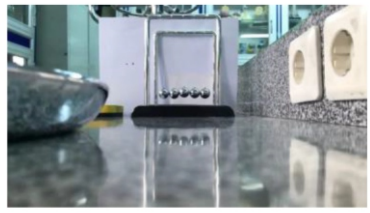

FIg 2: A Newton's Cradle setup

2-2 Methods and Modeling

This is started with modeling the collisions between two balls in the perfectly elastic condition. For perfectly elastic collision between two spheres, elasticity and ratio between two spheres' masses is equal to 1. When the first ball hits the second ball, all of its momentum and energy is transferred to the next ball and it starts moving with the first ball's initial velocity. When the first ball collides with the second, the first ball stops, and its momentum is transferred to the second ball until it reaches the last ball. In perfectly elastic collision between two balls, we have (Eq. 1) (Fig.3 a and b).

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