Pendulum Waves and Newton's Cradle   
Simulation Report  
Computer Modelling CA1

Submitted by:  
Sylwia Calka  
N00146095  
29th February 2017  
Dún Laoghaire Institute of Art, Design+Technology

Contents

1. [Introduction 3](#_Toc476080546)
2. [Background information about pendulum 3](#_Toc476080547)

[2.2 Pendulum Wave 3](#_Toc476080548)

[2.3 Newton’s cradle 3](#_Toc476080549)

1. [Description of the physics and mathematics components 4](#_Toc476080550)

[3.1 Physics and Mathematics components 4](#_Toc476080551)

[3.2 Interactive elements 4](#_Toc476080552)

1. [Initial concept 4](#_Toc476080553)
2. [Overview of the implementation 5](#_Toc476080554)
3. [Results 5](#_Toc476080555)
4. [Conclusion 5](#_Toc476080556)
5. [References 5](#_Toc476080557)

Introduction This report discusses the implementation of the simulation made with JavaScript and HTML5 canvas. This simulation was developed as a part of Computer Modelling Module. This simulation represents a pendulum wave machine and Newton’s cradle. Those devices illustrate the nature of pendulum oscillations. I have chosen this subject because pendulums are nice and interesting devices to simply look at.

Background information about pendulum  
2.1 Simple gravity pendulum  
The simple pendulum is simplified real pendulum. It explains the construction of the pendulum. The mass is centred in the ball at the end of the string and the mass of the string is irrelevant. The ball moves back and forth in a single plane. The friction and drag are inconsequential. The only forces come from gravity and string tension and those are proportional to the mass of the ball. Thus, the period of the pendulum is independent. It means that it will always be the same way no matter what object is hanging at the end of the string.

|  |  |
| --- | --- |
| T – period L - length of the pendulum g- gravity | https://lh6.googleusercontent.com/3I4-cNUGQjkkXL91HhaVpF13x_xqOpIZKEMscC6EolswhjLyxYWQ0k7p0FsBG4ya1DzbKaTjO-mAo1AvsjttikbksbcxmCyvmbyS6XPlY92ec-iPfAT8pd2P4rbfjGG9y8V7tu89 |

2.2 Pendulum Wave  
Pendulum wave are simple pendulums hung next to each other. The length varies between them. The length of the longest pendulum is adjusted so it has 51 oscillations in one minute period. The length of following pendulums is shorter that each successive pendulum executes additional oscillation.

2.3 Newton’s cradleNewton’s cradle is a device that shows the conservation of momentum and energy. It uses balls which and swinging. When one of the balls is moved, it falls and then transmits the energy through the balls in the middle and pushes the last sphere up. The simplified solution depends on conservation of momentum and kinetic energy.

Description of the physics and mathematics components

## 3.1 Physics and Mathematics components

1. *Velocity* is a physical vector quantity. It is calculated with displacement divided by time. In my application, it is calculated for an x-direction velocity for Newton’s balls.

2. *Sine waves* are curves which represents repetitive oscillation and has the shape the same as sine function. Amplitude of the sine wave is a maximum distance it reaches from zero. The period of the sine wave is the time it completes one cycle. The frequency is the amount of cycles in one second. In the Pendulums Wave simulation, the frequency for each ball changes. All the pendulums start moving at the same time and immediately they fall out of sync. The phases changes because of the different periods of oscillation and this change is applied to the x-position of balls.

3. *Collision detection* was used to create the Newton’s Cradle simulation. Each time when the ball touches the ball next to it, in theory the kinetic energy is passed through the balls and the last ball is pushed up. In the code, it is checked if balls are touching and then according amount of balls is pushed up from the other side.

4. Mathematical components used

* Math.round – returns the value rounded to the nearest integer
* Math.PI – returns the ration of a circle’s circumference to diameter
* Math.cos – returns the cosine of a number

## 3.2 Interactive elements

There are two buttons on the left-side panel. Those buttons allow user to switch between two different canvases. In the first simulation, the user can change the number of balls and the colour of them. In the second animation, it is possible to switch between one ball and three balls swings.

Initial concept  
In the initial concept for developing the Newton’s Cradle the interaction was designed differently. It was planned to allow the user to drag the balls up and put them in motion when the user release the ball.

Overview of the implementation   
Representation of physics is usually difficult without usage of physics’ engines. In my simulations, the physics were simplified. In case of the Pendulum Wave the values for first frequency were calculated [1] and already provided in the code. In the Newton’s Cradle simulation, the user can see the cradle in motion, however the conservation of momentum and energy are faked.

Results  
In the end the simulations are displaying the desired motion. There are no run-time errors in the application.

ConclusionTo sum up, this project let me learn about the pendulums physics and Newton’s Laws. The idea for the project was developed just after the brief was given out. If I would be able to start again, I would start with a wider research of physics and after that start the implementation process. If I would have longer time to complete the project I would implement drag functionality for the Newton’s balls and improved the physics implementation involved.

References

[1] “Pendulum Waves,” Pendulum Waves. [Online]. Available: http://sciencedemonstrations.fas.harvard.edu/presentations/pendulum-waves.