Newton's cradle

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Newton's cradle[1] is a device that demonstrates conservation of momentum and energy using a series of swinging spheres. When one sphere at the end is lifted and released, it strikes the stationary spheres, transmitting a force through the stationary spheres that pushes the last sphere upward. The last sphere swings back and strikes the still nearly stationary spheres, repeating the effect in the opposite direction. In this experiment, we will verify energy conservation laws using video tracking.

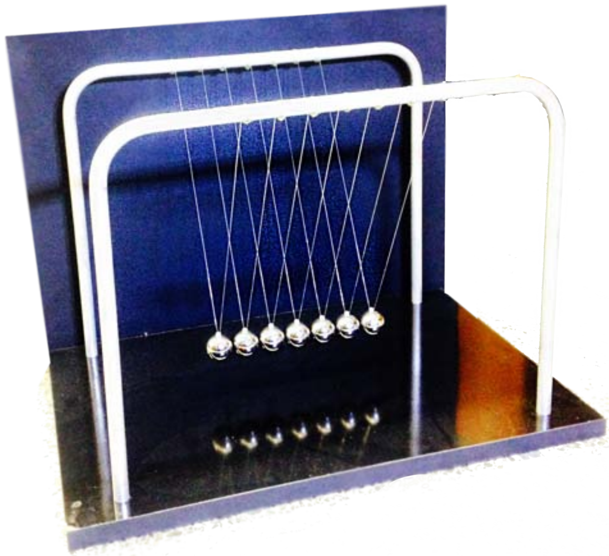


Figure 1: Newton's cradle consists of aligned spheres.

Major specifications of Newton's cradle

Number of spheres	07
Radius of each sphere	1.25 cm
Mass of each sphere	66.1 g

[1]The device is named after the 17th-century English scientist Sir Isaac Newton. It is also known as Newton's Balls or Executive Ball Clicker.

1 Objectives

In this experiment, we will,

1. track the motion of Newton's cradle, by recording video a camera, in the following configurations:
   (a) The far right ball is pulled away and let go.
   (b) The far right and the far left balls are simultaneously pulled away and let go.
   (c) A set of two balls from the far right are pulled away and let go.
2. Further more, using recorded videos of these experiments, we will obtain graphs of:
   (a) K.E. of all balls,
   (b) P.E. of all balls,
   (c) velocities of all balls, and
   (d) acceleration of all balls.

Your instructor will guide you on which experimental configurations will you be required to test.

2 The Experiment

The experimental configuration is shown in Figure 2. This experiment employs video based tracking using PhysTrack—our MATLAB based solution for videos tracking. The video should be recorded with high frame rate (i.e. 240 frames per second). The latest version can be downloaded from the website http://bit.ly/PhysLab_PhysTrack. Interpret your data and discuss with the instructor.

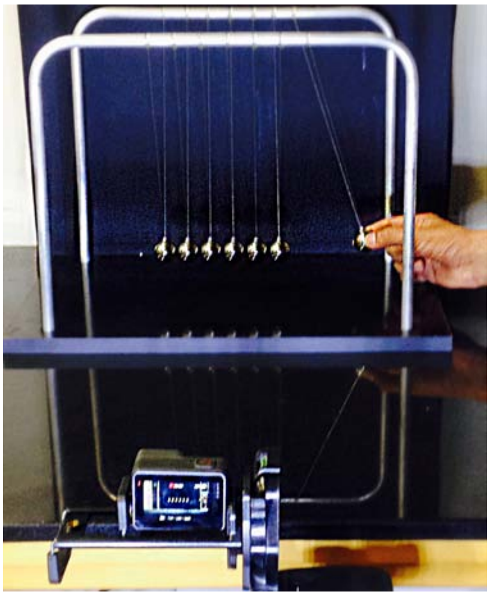
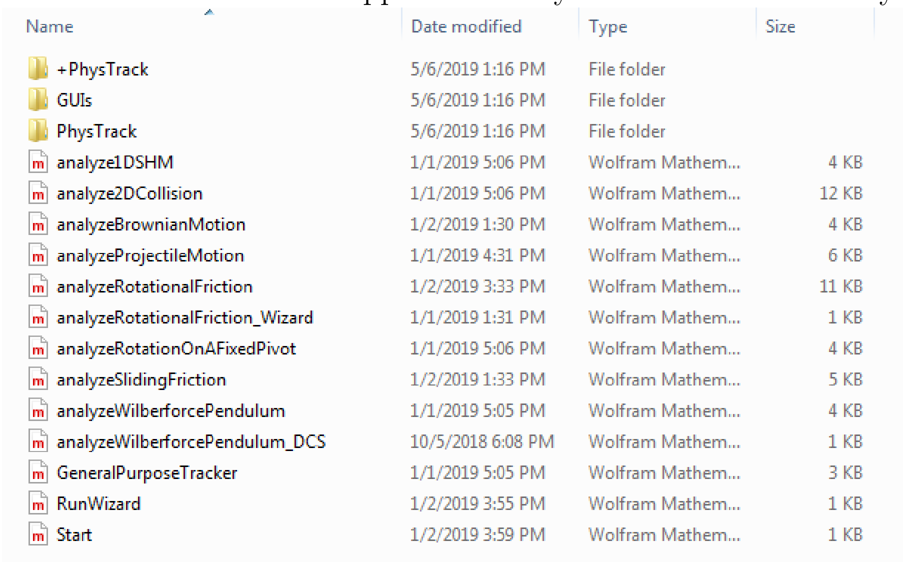


Figure 2: Releasing the right most sphere in Newton's cradle.

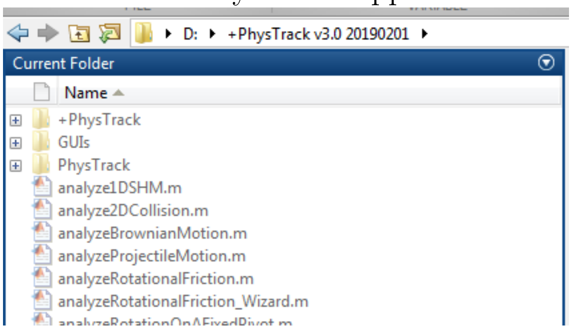
3 Tracking the Recorded Videos

The heart of this experiment is to extract the kinematics from recorded videos. At this point, we expect that you have recorded the video. By going through the following steps, you can extract the experimental data from the video using `PhysTrack`:

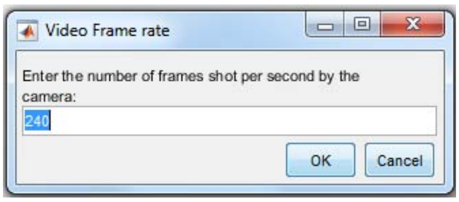
1. Download the Phystrack (the zipped file) from the url `http://bit.ly/PhysLab_PhysTrack`
2. Extract the downloaded zipped file into your PC's local directory.



3. Run `MATLAB` and change it's current folder to the same directory where you have extracted the PhysTrack zipped file.



4. In the command window, type "GeneralPurposeTracker" and press Enter .
5. A new option will pop up to select the desired video, pick the video to be processed.
6. After selecting the video, a option will appear asking for the frame rate of the selected video, write proper frame rate and click on OK .

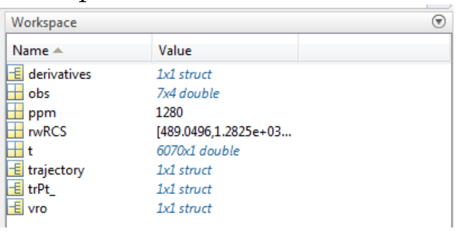


7. Video trimming option will emerge; pick the proper `mark--in` and `mark--out` frame and click on Close .

8. The "Object Selector Option" will pop up. Mark all the spheres as an object by clicking on "Manually mark an object" and then select the spheres one by one. After that, click on Close .

9. Now, KLTGUI named option will pop up, click on the button Begin and wait for the process to complete.

10. After completing these steps, the script will generate a lot of useful variables in the workspace of MATLAB that can be used as required.



11. Following are the variables that will be used in this experiment:

List of useful variables	
t	time (s)
trajectory.tp1.x	x profile of first sphere
trajectory.tp1.y	y profile of first sphere
trajectory.tp2.x	x profile of second sphere
trajectory.tp2.y	y profile of second sphere
⋮	⋮

12. **Numerical Differentiation**: For speeds and accelerations, we need to determine numerical derivatives. For this purpose, one could use the following command.
`[xd, yd] = PhysTrack.deriv(xdata, ydata, order)`