PHY 250: FINAL PROJECT

Fall 2020

Death-line: December 18th

Submission Instructions

The project must be done in LaTeX, Libreoffice, Word, etc.

You must submit a zip file to moodle containing:

- The Octave codes.
- The pdf file with the theory development.
- The animated videos for the collisions.
- The sound files of exercise 2.
- This project can be made in teams of 2.

Exercise A

Solve a collision between an ellipse of mass M and a particle of mass m. Consider that the initial inclination of the ellipse axis is $0°$.

1. Given the initial conditions, find the final velocities of the particle $\vec{V}_1'$, the center of mass (CM) of the ellipse $\vec{V}_{CM}'$, and the angular velocity ω in terms of the initial velocities and the impulse $\vec{J}$.

2. Use the definition of the restitution coefficient to find the expression of $\vec{J}$ in therms of the initial velocities.

3. Write a code in Octave to calculate the final velocities of a collision for given initial conditions.

4. Plot the position of the particle, the ellipse and the position of the CM of the system for different times and build and animation.

Consider the following initial conditions:

- Initial velocity of the particle :$\vec{v}_1 = v_1\hat{\imath}$
- Initial velocity of the center of mass of the ellipse: $\vec{v}_{CM} = 0$
- Initial angular velocity: $\omega = 0$
- Restitution coefficient: e=1, e=0
- Relation between masses: $M = 2m$
- If the equation of the ellipse is $x^2/a^2 + y^2/b^2 = 1$, consider $b = 1.5a$

You can structure your code as follows:

Geometry
Define Space Mesh Build the ellipse
Set the Initial Conditions (IC) for the ellipse:
Mass, a, b Inertia Moment CM position CM velocity$\rightarrow$ $\vec{v}_{CM} = 0$ Inclination $\rightarrow$ $\theta_0 = 0$
Set the IC for the particle
mass initial position initial velocity
Set a value for the restitution coefficient
START TIME LOOP
motion of the particle at constant speed: $\vec{r}_p = \vec{r}_{p0} + \vec{V}_p\Delta t$ linear motion of the ellipse: $\vec{r}_{CM} = \vec{r}_{CM} + \vec{V}_{CM}\Delta t$ rotation of the ellipse: $\theta = \theta_0 + \omega\Delta t$ ellipse translated and rotated
DEFINE THE COLLISION CONDITION
If the condition is true $\rightarrow$ find contact point
Find the normal at the contact point Find the impulse Find the final velocities Find new positions
Generate a graph

Exercise B

1. Synthesize the sound of a Violin and a Clarinet.
    - Record the sound with "wavesurfer"[1] to obtain the spectrum [2] [3].
    - Extract the intensity corresponding to the first 16 harmonics and make a table.
    - Find an expression for the relative amplitude of the harmonics A/A_0 (where A_0 is the amplitude of the first harmonic) in terms of the intensity in dB.
    - Consider that the amplitude of the fundamental frequency is 1 and obtain the relative amplitudes for each one of the harmonics.
    - Generate a sound wave for those frequencies using Octave.
2. Make 4 plots:
    (a) Relative amplitudes vs. frequencies for the Violin (bars chart).
    (b) Resultant wave for the violin+the fundamental frequency.
    (c) Relative amplitudes vs. frequencies for the Clarinet (bars chart).
    (d) Resultant wave for the clarinet + the fundamental frequency.
3. Compare the spectrum for the violin and the clarinet. Which are the main differences?
4. Compare your sounds with the sources. What are the differences between your signals and the sources?
5. How could you improve the quality of the synthesized sounds?

[1] WaveSurfer is an open source tool for sound visualization and manipulation. (https://sourceforge.net/projects/wavesurfer/)

[2] Clarinet sound: https://www.youtube.com/watch?v=5Fi97H11KBc, from 4:39 to 4:40

[3] Violin sound: https://www.youtube.com/watch?v=j0FynYzQvcM