VISUAL CORTEX INSTRUMENTS

Lab 5: Collision Characterization

The Project: Spacecraft - Asteroid Collisions

Company X is working to develop a mission that will send unmanned spacecraft to explore a recently- discovered asteroid belt in another solar system. The density of asteroids in the belt is unusually high, and the asteroids themselves are moving, with a wide range of velocities that are similar in magnitude to the spacecraft velocity. As a result, the probability for collisions between the spacecraft and one or more asteroids is high.

The engineers who designed the spacecraft have constructed it such that it can withstand multiple asteroid collisions without damage. However, the influence of these collisions on the spacecraft's motion needs to be understood, so that the spacecraft's control software can be appropriately programmed to set the spacecraft back on its original course after it collides with an asteroid.

Your job is to provide a set of collision data that simulate the collisions that might happen between the spacecraft and an asteroid. Because both objects have similar rigid surfaces, spherical shapes, and similar masses, you decide to generate these simulated data by colliding two moving pucks on a frictionless air hockey table.

Your team has now been hired to run a series of simulated collisions, to build up a database of collision information that can guide engineers during the real mission.

Equipment:

- Tracking Camera
- Air hockey pucks
- Frictionless air hockey table.

The Requirements:

In order to demonstrate that you can accurately simulate and analyze collisions between two moving objects, we ask that you create a device to execute the following:

1. Collide two identical pucks on a frictionless air hockey table. The pucks should both be moving prior to the collision, and it should be possible to vary the collision angle.
2. Track the positions, velocities, and accelerations of two pucks before and after they collide.
3. Run a set of at least eight trial collisions with different initial angles between the colliding pucks.
    a. a. For each collision, collect information on the position, velocity, and acceleration of both pucks before and after the collision.
    b. b. One of the collisions should be "head on" (180^o angle between the velocity vectors of the pucks), and another should be at 90^o.
    c. c. The remaining six should include three angles from 180^o -> 90^o and three from 90^o -> 0^o.
4. Compare the resulting collision data with the theoretical expectations from conservation of momentum. Is momentum conserved in your collisions?
    a. a. Prepare a plot showing the deviation (positive or negative) from the theoretical expectation that momentum is conserved, as a function of collision angle. (Use the collision angle measured from your tracking camera data).
5. Analyze the total kinetic energy of the system before and after the collisions. Are these collisions elastic?

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Presentation of the solution: Your team must prepare a 2-3 page written report (including figures) summarizing the results of the project. The report must include the following:

- A description of the basic physics principles used in your project, including equations used to perform a theoretical analysis of the collision dynamics.
- A set of plots showing the momentum and kinetic energy of the puck(s) before and after the collisions.
- A discussion of your observations concerning momentum conservation, including a plot showing deviation from momentum conservation, as a function of collision angle.
- A discussion of your observations concerning kinetic energy conservation and whether or not the collisions are elastic.
- Discuss any sources of error or variance that are present in your measurements.