**Trajactory Simulation of Billiard Ball**

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**Abstract**

We chose billiard ball's trajectory motion simulation as our team project title. In real world, billiard balls rarely proceed without spins. So, we decide to add a spin-considered model to express it more realistically. Basically, we want to configure the field through a 2-d array and assume a situation in which hitting the ball by cue stick. The physical concepts we will apply are impulse-momentum, momentum conservation, angular momentum conservation, energy conservation. And the variables to be considered include hitting position, hitting force, strike time, restitution coefficient on the wall, and friction. First, we will construct the model of the simulation for the theoretical situation without friction and spin, and secondly, we will construct the model of the simulations for situations with spin. In addition, we want to simulate the shape of billiard tables not only in rectangles but also regular-triangle, circle, ellipses, and case of with obstacles.

**Introduction**

We often find physical phenomena related to collisions around us. We can see the collision directly in a billiard game. We proceeded with this project because we wanted to learn what physical phenomena are applied to billiard balls and how they are involved in the movement of balls by implementing the collision phenomenon that we had only learned from theory in code. Our simulations will simulate like the moment when a cue stick hits a billiard ball for similar a real situation. To do so, we thought billiard balls were not just a dot, but rather a ball of size and volume. Also, we want to describe the trajectory of billiard balls by considering the position of hitting, strength, and hitting time as variables. In addition, if there are trajectories, obstructions in various shapes of billiards, and if there is a spin in the billiard ball that is identical to the actual situation, we will simulate any trajectory.

In the main body section, we will describe the initial conditions of billiard game. The initial conditions will start the trajectory of the ball by specifying the initial position of the ball, the position of the ball hitting with the cue stick, and the speed of the strike as the initial variables. And we will indicate the trajectory of the ball by considering the law of conservation of momentum, the friction between the ball and the billiard table.

**Main body**

The simulation procedure is divided by two steps.

**1) Initialization**: create the table, set the ball’s position, hit point and speed of cue.

The variables about hitting are two types; the hit point- () and the cue properties- (). For preventing jump shot, the hitting angle should be limited by . And using the conservation of momentum, we can derive the ball’s state, linear/angular velocity right after hitting.

**2) Record the Trajectory.**

The motion of the ball is divided into sliding and rolling according to the relative velocity between the center and floor. Because the coefficients of friction by rolling and sliding are not same, we must construct the computation by different way.

While recording trajectory, we should detect collision by obstacles (include rails). If there is an obstacle at the distance from the center to Rb, using the coefficient of restitution and friction, we must control the collision.

Through the above process, we will express the trajectory of the ball on a two-dimensional plane and analyze the distance of travel, the number of collisions, according to various variables.

**Summary**