KOÇ UNIVERSITY

College of Engineering

DEPARTMENT OF MECHANICAL ENGINEERING

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MECH 534 PROJECT #2

FINAL REPORT

Berke Ataseven

54326

Instructor: Çağatay Başdoğan

Introduction and Abstract

In this project, we were asked to simulate a rigid body. Different from the first project, we now have to account for the rotation of the body. As shown in figure 1, the rigid body's position is bounded by the box that surrounds it. The rigid body should bounce from the walls inside the box.

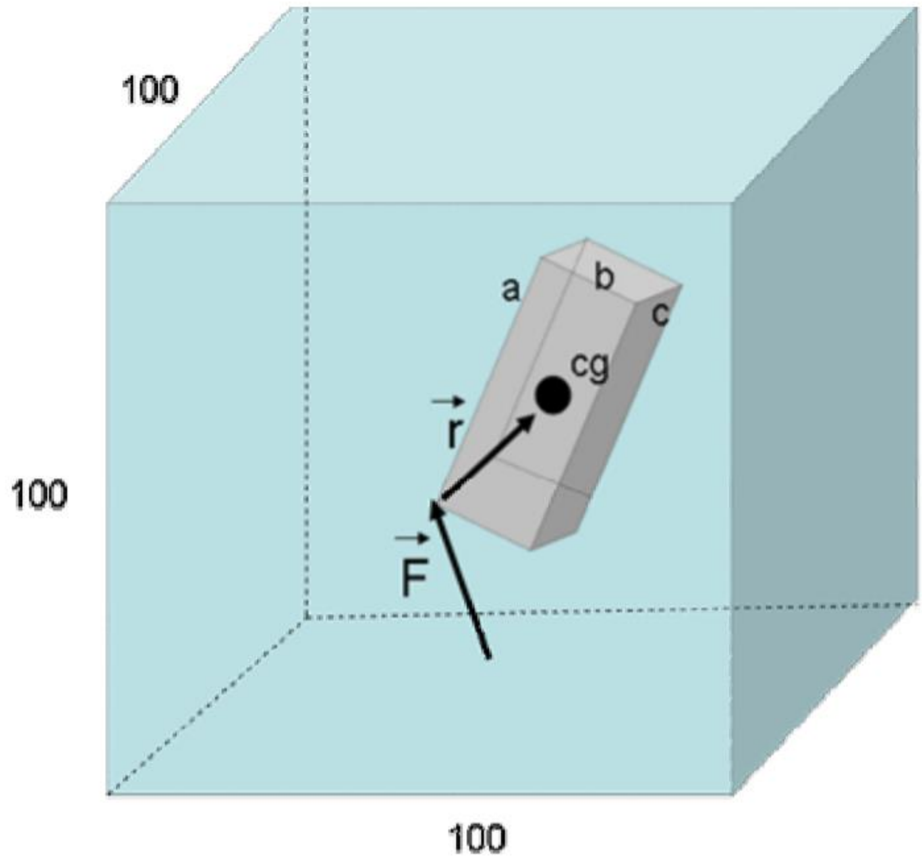

Figure 1 Rigid Body Inside the Box

Methodology

When the program runs, the rigid body stays stationary. Pressing the spacebar applies a random force and a random moment to the rigid body. When a force is applied to the object it causes the body to accelerate according to Newton's law (F = ma). Velocity is calculated by integrating the acceleration. Then, the position is updated by integrating the velocity. Likewise, when a moment is applied to the body, it causes an angular acceleration. Angular acceleration can be calculated using the following formula:

$$\sum M = I\alpha$$

Where M is the moment, I is the inertia matrix, α is the angular acceleration. Inertia matrix of a symmetric solid cuboid can be calculated as:

$$I = \begin{bmatrix} I_{xx} & 0 & 0 \\ 0 & I_{yy} & 0 \\ 0 & 0 & I_{zz} \end{bmatrix}$$

$$I_{xx} = \frac{m(b^2 + c^2)}{12}, I_{yy} = \frac{m(a^2 + c^2)}{12}, I_{zz} = \frac{m(a^2 + b^2)}{12}$$

Where a, b, c are the side lengths along the x, y, z axes, respectively.

By integrating the angular acceleration, angular velocity is obtained. Finally, rotation of the object is obtained by integrating the angular velocity. To dampen the movements of the rigid body, a drag force and drag moment is applied. These calculations are made in each time step dt.

Collision Check

Coordinates of the corners of the rigid body are calculated in every time step using a transformation matrix. X, Y, Z components of these coordinates are checked against the boundaries of the room to determine if the body collides with the walls of the room. If the body is in collision, the component of the velocity vector which is parallel to the normal vector of the collision surface (of the wall) is negated. To prevent multiple negations of the velocity vector (this phenomenon is caused by multiple corners hitting the surface at the same time), a boolean flag is used. This flag is set to “true” after the center of mass (CoM) of the body passes the CoM of the room. On the other hand, the flag is set to “false” immediately after the velocity component is negated. After a collision, the object loses 10 percent of its velocity.

Collision check is also used to constrain the position of the rigid body. After the position calculation, if a corner turns out to be outside of the room, we move the rigid body slightly so that the corner is on the wall. Without this functionality, the body leaves the room when the gravity is turned on. However, this approach is still flawed as it may still stuck on the surface.

By default, gravity is turned off. The user can follow the instructions in the console to control the simulation.