Mechanics of the Bounce of a Ball off an Edge

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Abstract

A table tennis ball was dropped vertically from rest onto the sharp edge of an aluminium cube and the rebound angle was measured as a function of the separation between the ball's centre and the edge. A Vpython simulation was made by modelling the collision of the ball against the edge using conservation of linear momentum and by treating the collision to be perfectly elastic. The rebound angles predicted by the simulation matched the measurements within the measurement uncertainties. The relationship between the rebound angle and separation between the ball's centre and the edge of the aluminium cube was also derived analytically and confirmed by the measurement data.

Introduction

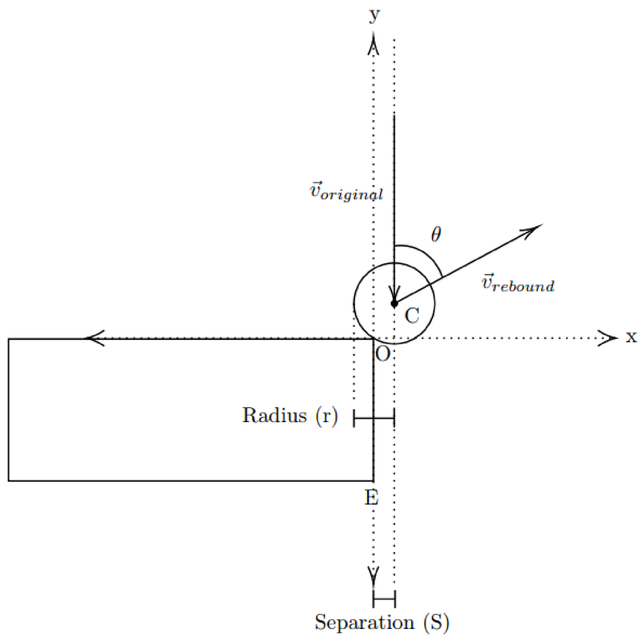

Figure 1: *The Separation S and Rebound Angle θ at the instant of collision.*

Research Question: How does the rebound angle of a ball's bounce off an edge vary with its separation from the edge?

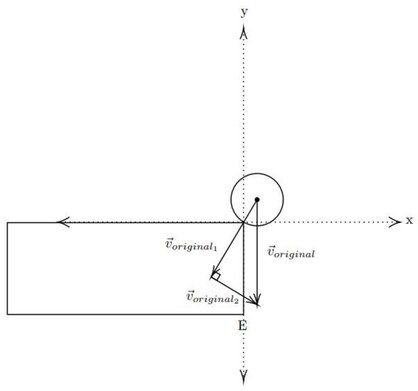

Figure 2: *Components of the original velocity along and perpendicular to the line of action from the edge to the centre of the ball.*

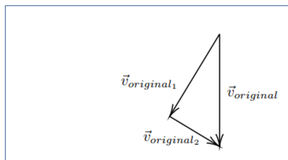

Figure 3: *Components of the original velocity (simplified).*

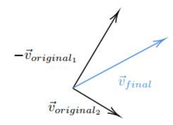

Figure 4: *The final velocity as the sum of two vectors.*

Methods and Materials

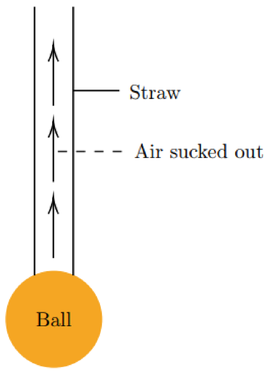

Figure 5. Mechanism to release the Ball from known separation.

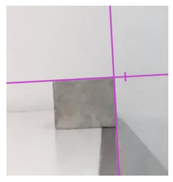

Figure 6. Defining the axes in TRACKER.

Figure 7. Defining the diameter of the ball in TRACKER..

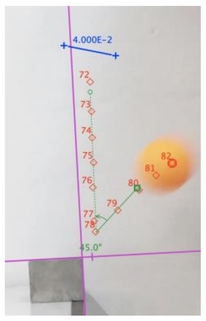

Figure 8. Measuring the rebound angle using protractor tool in TRACKER.

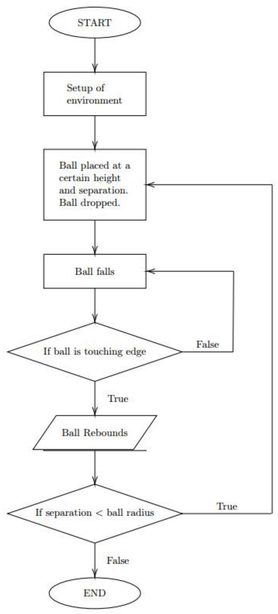

Figure 9. Flowchart illustrating the logic of the simulation

Results and Discussion

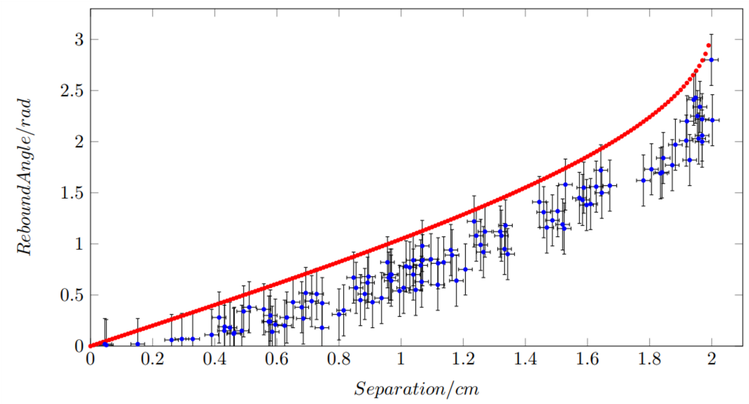

Figure 10. Comparison of experimental data (blue) with simulation data (red).

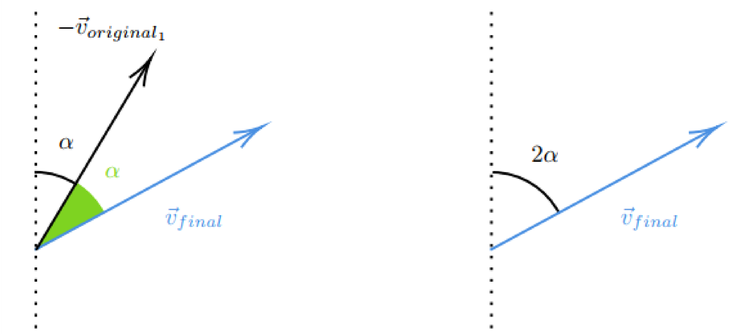

Figure 11. The rebound angle

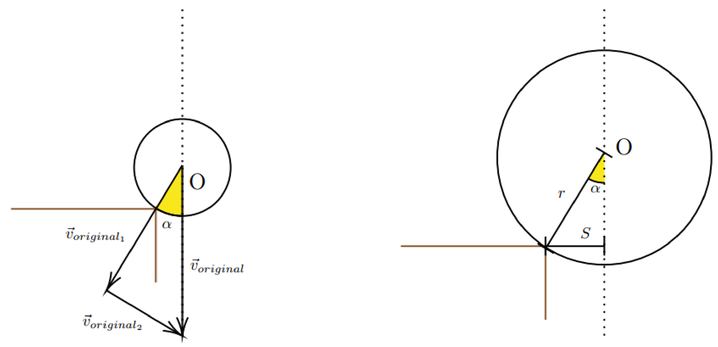

Figure 12. $\sin\alpha = \frac{S}{r}$

Using geometry, it was derived that the rebound angle must depend on the separation as $\theta = 2\alpha = 2\arcsin\left(\frac{S}{r}\right)$

Conclusions

The relationship between the Rebound Angle θ; the radius of the ball r, and the Separation S was derived and confirmed by experiment and simulation to be $\theta = 2\arcsin\left(\frac{S}{r}\right)$.

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References

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