THE UNIVERSITY OF BRITISH COLUMBIA

Science 1 Physics

Assignment # 5:

Advanced Mechanics

Wed. 11 Oct. 2000 — finish by Wed. 18 Oct.

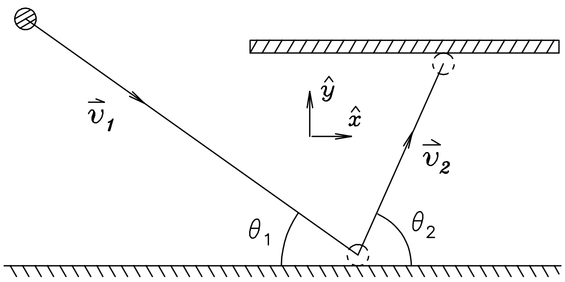

Figure 1 : **Superball**

A "superball" is a hard rubber ball with a nearly perfect coefficient of restitution and a huge coefficient of static friction with hard, smooth surfaces. As a result, when it bounces off such a surface we may treat the collision as perfectly elastic (no loss of energy) and assume that the point (of the ball) in contact with the surface during the collision *does not slip*, no matter how acute the angle θ of its trajectory. To simplify the problem, we will also assume that the following experiment is done in a weightless environment, although the qualitative results are unchanged by gravity.

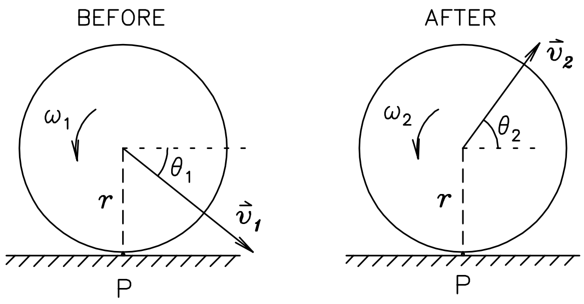

Figure 2 : **First Bounce:**

The ball is thrown at the floor with an initial velocity $\vec{v}_1$ making an angle θ_1 with the positive $\hat{x}$ direction or with the floor.[1] The ball is *not rotating* initially ($\omega_1 = 0$). After the collision we expect ω_2 to be negative.[2]

Assuming that the ball is a uniform solid sphere, calculate the angle θ_2 and the speed v_2 in terms of θ_1 and $v_1 \equiv |\vec{v}_1|$.

[1] By convention, angles are measured counter-clockwise from the reference axis, so technically θ_1 is negative; this makes no difference to its cosine. Thus $v_x = v\cos\theta$ is initially positive and $v_y = v\sin\theta$ is initially negative.

Under the Table:

If the ball was thrown under a table, as shown, with the smooth, dry underside of the tabletop parallel to the floor, *show that it will always return* to the thrower's hand along the same trajectory it followed in the first two bounces (shown in the figure).

Superball Design:

Does it matter if the ball is really a uniform solid sphere? If it were a hollow sphere or a rubber sphere with a lead centre, would you still obtain the same qualitative result? What criteria are important? Explain.

... *and* Tipler Ch. **8**:

(4^{th} Edition) problems **9**, **86**, **97** and **124**

... *and* Tipler Ch. **9**:

(4^{th} Edition) problems **5**, **31**, **53**, **86** and **92**

[2] Again the convention is to treat counter-clockwise rotations as positive; by inspection we can see that ω_2 must be clockwise, so $\omega_2 < 0$. As long as a consistent notation is used, it doesn't matter if the direction shown is opposite to the actual direction; the answer will always come out of any correct calculation with the required minus sign.