Problem Set 11: Angular Momentum, Rotation and Translation

Design Engineering Challenge: "The Big Dig" 2.007 Contest
Paddle Spinning Concepts

PROBLEM 1:

If the system is pure elastic when the spring collides with the hockey ball, and hockey ball with the paddle then energy is conserved. But if the collision is inelastic, then energy is not conserved and you will not transfer the full amount of energy from the spring.

In the second case the spring pushes directly onto the hockey ball to launch it, therefore all its energy given that's its elastic will be transferred to the ball.

PROBLEM 2:

Idea 1: Make a funnel that you can dump all the balls in. At the end of the funnel is a tube that directs the balls in a vertical motion.

Idea 2: Angle the ball loader so that only one ball is loaded at a time.

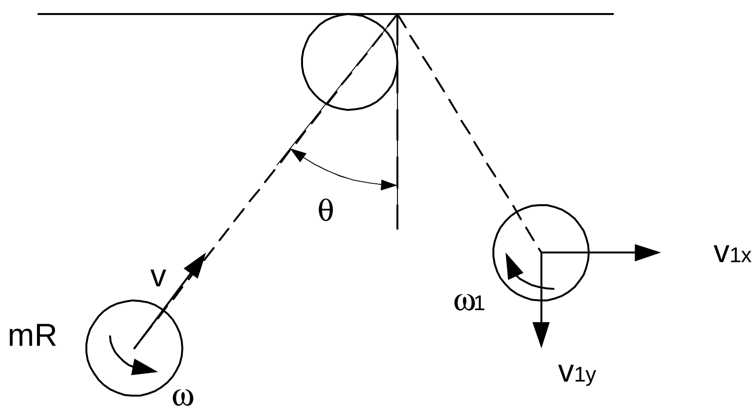
Idea 3: Balls are aligned in a channel. As the first ball reaches the end of the channel it is knocked into the paddle wheel.

PROBLEM 3:

a) If the impact with the deflector is elastic then $m_1v_1=m_2v_2$ and the velocities are the same. If the impact is inelastic then $v_2 = ev_1$ where e is the elasticity constant. Looking at it energy wise, and assuming there is no nonconservative force like friction at the wall, the final velocity can be determined by

$$KE_1 + PE_1 = KE_2 + PE_2$$
$$\frac{1}{2}mv_1^{\ 2} + mgy_1 = \frac{1}{2}mv_2^{\ 2} + mgy_2$$
$$\Rightarrow v_2 = \sqrt{v_1^{\ 2} + 2g(y_1 - y_2)}$$

One other advanced method is modeling the problem like an impact problem and considering the rotation of the ball as it hits the deflector, see the below figure. Assuming no energy losses while the ball is in air and assuming an elastic collision



$$mRw_0 \sin q_0 + \frac{1}{2} mR^2 = \frac{1}{2} mR^2 w_1 + mRq_1 x$$

$$=> v_{1x} = \frac{2}{3} v \sin q + \frac{1}{3} Rw$$

No slip at wall so $\begin{array}{l} v_{1x} = Rw \\ v_{1y} = v \cos q \end{array}$

where R is the radius and m the mass of the ball.

b) The ball has an initial speed going into the slide but unlike a), friction slows down the ball. If we neglect friction then $v_1 = v_2$. If not we have to account for the frictional loss by using the change in kinetic energy due to nonconservative forces as the ball rolls around the curved track. The calculation looks something like:

$$-fs = \frac{1}{2} m v_f{}^2 - mgy_i$$

where f is the coefficient of friction, s it the distance traveled, m is mass, v_f is the final velocity, and y_i is the initial height of the ball.

PROBLEM 4:

A deflector will likely be the easiest to manufacture and does not run the risk of jamming. A curved track will ensure that all balls enter the scoring bin.