Problem Set 10: Torque, Rotational Dynamics, Physical Pendulum, Angular Momentum

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

***PROBLEM 1*:**

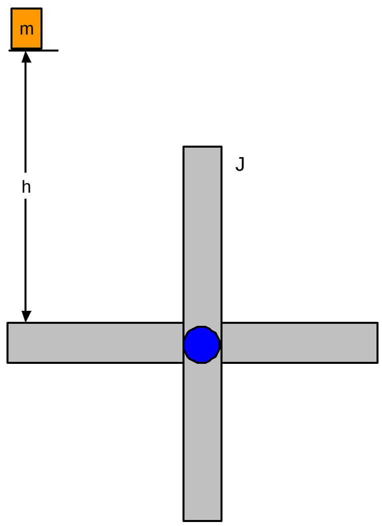

Figure 1: FBD of the two wheeled car

Conservation of Energy:

$$mgh = \frac{1}{2}Jw^2 \Rightarrow w = \sqrt{\frac{2mgh}{J}}$$

Since $W = Fd = mgh, KE = \frac{1}{2}Jw^2$

***PROBLEM 2*:**

Height and/or mass of object can be increased to avoid an additional Force. To make it worth while, a substantial force must be added since angular velocity is proportional to the square root of work. $w a \sqrt{W} \Rightarrow$ To double angular velocity, force musr be quadrupled, $w = \sqrt{\frac{2W}{J}} \Rightarrow 2w = \sqrt{\frac{8W}{J}}$

***PROBLEM 3*:**

The work above represents an elastic collision. Accounting for friction of the paddle wheel would reduce angular velocity.

***PROBLEM 4*:**

Dropping the balls one after another maintains angular velocity, but does not increase it; it does not allow friction to bring the paddle to a stop. The terminal velocity is:

$$w = \sqrt{\frac{2mgh}{J}}$$

To increase angular velocity, more balls should be dropped together (at once):

$$w = \sqrt{\frac{2\times(m_1 + m_2 + ... + m_n)h}{J}}$$

In this case, angular velocity will be limited by the space between the paddles (i.e. how many balls can fit between paddles to increase angular velocity)

***PROBLEM 5*:**

$$\mathrm{P} = \Gamma w, T = FR = mgR, w = \frac{\mathrm{P}}{mgR}$$

where,
m : mass of paddle
R : length of paddle

***PROBLEM 6*:**

It is best to drop a heavy object into the mass scoring bin to and accelerate a hockey ball onto the paddle wheel to spin it up; since the angular velocity of the paddle is proportional to the square root of the work, it is not very advantageous to focus on increasing work.