Momentum and Energy Problem Set #1

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This problem set will mainly focus on problems in momentum. However, there are a few energy problems too, a couple of which are directly from previous F=ma contests.

1. (F=ma 2010) A 5.0 kg block with a speed of 8.0 m/s travels 2.0 m along a horizontal surface where it makes a head-on, perfectly elastic collision with a 15.0 kg block which is at rest. The coefficient of kinetic friction between both blocks and the surface is 0.35. How far does the 15.0 kg block travel before coming to rest?

2. (F=ma 2009) Consider a completely inelastic collision between two lumps of space goo. Lump 1 has mass m and originally moves directly north with a speed v_0. Lump 2 has mass $3m$ and originally moves directly east with speed $v_0/2$. What is the final speed of the masses after the collision? Ignore gravity, and assume the two lumps stick together after the collision.

3. (F=ma 2008) A bullet of mass m_1 strikes a pendulum of mass m_2 suspended from a pivot by a string of length L with a horizontal velocity v_0. The collision is perfectly inelastic and the bullet sticks to the bob. Find the minimum velocity v_0 such that the bob (with the bullet inside) completes a circular vertical loop.

4. Prove that an inelastic collision in which two objects stick together results in the largest possible loss in kinetic energy.

5. A block of mass m slides towards a frictionless ramp of mass M, both of which are on a frictionless surface. How high does the block slide up the ramp, and what are the final velocities of the block and ramp?

6. For some odd reason, you decide to throw baseballs at a car of mass M that is free to move frictionlessly on the ground. You throw the balls at the back of the car at speed u, and they leave you rhand at a mass rate of σ kg/s. If the car starts at rest, find its speed and position aas a function of time, assuming that the balls bounce elastically directly backward off the back window.

7. Do the previous problem, except now assume that the back window is open, so that the balls collect inside the car.

8. A rocket that starts at rest with mass M ejects exhaust at a given speed u. What is the mass of the rocket (including unused fuel) when its momentum is maximum? What is the mass when its energy is maximum?

9. A mass M moving in the positive x direction collides elastically with a stationary mass m. The collision is not necessarily head-on, so the masses may come off at angles. Let θ be the angle of m's resulting motion. What should θ be so that m has the largest possible speed in the y direction?