Applied Physics – Problem set #5

1. An air pipe filled with helium is closed down at one end and open at the other end. The fundamental frequency now is 525.5Hz. Filling the pipe with a different gas, the fundamental frequency changes to 235Hz. The speed of sound in helium is 610m/s.
(a) What is the speed of sound in the unknown gas?
(b) What is the length of the pipe?
(c) What is the frequency of the first harmonic for the two gases?

2. A 22-gram bullet traveling 240m/s penetrates a 2kg block of wood and emerges going at 130m/s. If the block is stationary on a frictionless surface when hit, how fast does it move after the bullet emerges?

3. A 450-gram soccer ball flying at 12m/s collides head-on with a 1.5kg fitness ball traveling at 5m/s in the opposite direction. What will be their velocities after colliding, if the coefficient of restitution is 0.4?

4. A fully fueled rocket has a mass of 21000kg, of which 15000kg is fuel. The burned fuel is spewed out the rear at a rate of 190kg/s with a speed of 2800m/s relative to the rocket. If the rocket is fired vertically upward from the surface of Earth calculate: (a) the thrust of the rocket; (b) the net force on the rocket at blastoff, and just before burnout (when all the fuel has been used up); (c) the rocket's velocity as a function of time, and (d) its final velocity at burnout. Ignore air resistance and assume the acceleration due to gravity is constant at g=9.8m/s^2.

5. A novice player rolls the 5.44kg bowling ball at 5m/s initial speed with a backspin of 2rpm. The ball has a radius of 0.108m, and the coefficient of friction is 0.05 between the ball and the oiled lane. What will be the speed of the ball once it starts to roll without slipping, and how far does it travel down the lane by then?

<u>Homework #5</u>

1. A spacecraft of total mass 3180kg is traveling in outer space with a velocity of 125m/s. To alter its course by 35°, its thrusters can be fired very briefly in a direction perpendicular to its original motion. If the rocket gases are expelled at a speed of 1750m/s, how much mass must be expelled?

2. A rocket traveling at 1950m/s away from the Earth at an altitude of 6371km fires its engines, which eject gas at a speed of 1200m/s (relative to the rocket). If the mass of the rocket at this moment is 25000kg and an acceleration of 1.5m/s^2 is desired, at what rate must the gases be ejected?

3. A homogeneous disk with 4kg mass and 50cm radius can freely rotate around a fixed horizontal axis going through its center. There is a string with negligible mass rolled up on this disk, while the other end of the string is connected to a 2kg object sliding down a 60^o slope. What will be the acceleration of the object, if the coefficient of friction between the slope and the object is 0.2? (For a disk: $I = \frac{1}{2}MR^2$).