**Principles of Physics I (PHY 111)**

Practice Exam 3

**Question 1** (4 points) Explain, in words, the conditions under which the mechanical energy of an object is conserved. Explain, in words, the conditions under which the momentum of a system of objects is conserved.

**Question 2** (4 points) Two objects collide and stick together. Is the mechanical energy of the system of two objects conserved? Is the momentum of the system of two objects conserved? How do you know?

**Question 3** (4 points) A hard rubber ball is dropped from a height of 1 m above a smooth, hard floor. It bounces up and down for quite a while. Let's just say that there's no friction and it bounces up and down *forever*. Discuss three different types of energy that this ball has, and identify the times (or the places during its motion) when it has the most of each type. (Hint: In order to bounce, the ball must be a bit elastic and compress a little bit.)

**Question 4** (4 points) It's been a bad day, and you find yourself out in space with nothing but a bowling ball. Your space ship is about 50 meters away and seems to be slowly moving farther away. Or maybe it's you that's moving. Who cares. But you know that those people down at mission control are really going to be upset if you don't get back to that ship and continue with whatever public-relations-oriented mission they had planned. So, what can you do? And why does it work?

**Problem 1** (8 points) A spring with spring constant $k = 10,000$ N/m is attached to a wall. A block (mass 20 kg) is pushed against the spring so that the spring compresses a distance $x$ from its equilibrium position. The block is held in this position for a moment, then released, and it shoots across the floor (coefficient of kinetic friction 0.15) for a distance of 10m before climbing a frictionless ramp to a height of 1.7 m before sliding down again. What was the distance $x$ that the spring was compressed?

**Problem 2** (8 points) The force needed to hold a particular spring compressed an amount $x$ from its normal length is given by

$$F = kx + ax^3 + bx^4.$$

How much work must be done to compress it by a distance $x_0$, starting from the equilibrium position at $x = 0$? Express your result in terms of $k$, $a$, $b$, and $x_0$.

**Problem 3** (8 points) Consider a ballistic pendulum, like the one you investigated in lab. We have a ball with mass 0.1 kg that we shoot (horizontally) into a socket with mass 0.7 kg. The ball and socket together rise to a height that is 0.08 m above the spot at which the collision occured. Find (a) the speed of the ball-socket system just after the collision, and (b) the speed of the ball just before the collision?