Exam # 3 – Physics 151

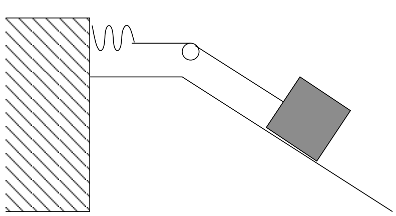
November 8, 2008

Be sure to include pictures, coordinate systems, etc. where reasonable.

1. An ammonia (NH_3) molecule is shaped like a pyramid. The base consist of three hydrogen (H) atoms arranged in an equilateral triangle; each H is $9.4x10^-11m$ **from the center of the triangle**. The nitrogen atom is at the apex of the pyramid. Other relevant pieces of information include the nitrogen-hydrogen bondlength $10.14x10^-11m$, the ratio of one N to one H atom is $m_N/m_H = 13.9$. Determine the center of mass of the molecule. You may find it convienient to center your coordinate system on the nitrogen atom.

2. A box is attached to a spring in the manor shown below. The very long ramp is frictionless. The spring has a spring constant $k = 20.0N/m$, the box a mass $M = 3.0kg$, the ramp an angle $\theta = 40^o$ with respect to the ground. The box initially has a speed of $v = 1.5m/s$ moving down the ramp and the spring is not stretched.
   (a) What is the farthest point down the ramp the box will slide to?
   (b) The block and spring are then transferred to a new ramp **with friction** that makes the same angle with the ground. The box starts with the same initial velocity and stops $1.5m$ down the ramp from where it started. What is the work done by friction?
   (c) What is the coefficient of kinetic friction for the ramp in part b.

3. A child ($30kg$) tows a sled ($2kg$) behind her by pulling on a rope at an angle 20^o above the level ground with a force of strength $8.0N$. The sled moves a distance of $3.0m$ along the ground with a constant speed of $5.0m/s$. In which ever order you find to be appropriate find



- the work done by the child on the sled,
- the work done by gravity on the sled,
- the work done by friction on the sled,
- the work done by the normal force on the sled,
- and the net work from all of these forces on the sled.

You should also calculate the power exerted by the child to keep the sled moving.

4. This year you have a summer job working for the National Park Service. Since they know that you have taken physics, they start you off in the laboratory which tests possible new equipment. Your first job is to test a small cannon. During the winter, small cannons are used to prevent avalanches in populated areas by shooting down heavy snow concentrations overhanging the sides of mountains. In order to determine the range of the cannon, it is necessary to know the velocity with which the projectile leaves the cannon (muzzle velocity). The cannon you are testing has a weight of 700 lbs and shoots a 40-lb projectile. During the lab tests the cannon is held hor izontally in a rigid support so that it cannot move. Under those conditions, you measure the magnitude of the muzzle velocity to be 400 m/s. When the cannon is actually used in the field, however, it is mounted so that it is free to move (recoil) when it is fired. Your boss asks you to calculate the projectile's speed leaving the cannon under field conditions, when it is allowed to recoil. She tells you to take the case where the cannon is fired horizontally using cannon shells which are identical to those used in the laboratory test.

5. Super Dave has just returned from the hospital where he spent a week convalescing from injuries incurred when he was "shot" out of a cannon to land in an airbag which was too thin. Undaunted, he decides to celebrate his return with a new stunt. He intends to jump off a 100-foot tall tower with an elastic cord tied to one ankle, and the other end tied to the top of the tower. This cord is very light but very strong and stretches so that it can stop him without pulling his leg off. Such a cord exerts a force with the same mathematical form as the spring force. He wants it to be 75 feet long so that he will be in free fall for 75 feet before the cord begins to stretch. To minimize the force that the cord exerts on his leg, he wants it to stretch as far as possible. You have been assigned to purchase the cord for the stunt and must determine the elastic force constant which characterizes the cord that you should order. Before the calculation, you carefully measure Dave's height to be 6.0 ft and his weight to be 170 lbs. For maximum dramatic effect, his jump will be off a diving board at the top of the tower. From tests you have made, you determine that his maximum speed coming off the diving board is 10 ft/sec. Neglect air resistance in your calculation – let Dave worry about that.