PHY 121: Mechanics: Mid Term Examination

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Monday, June 6th, 2011
Duration: 2 hour 15 mints

1. At a certain instant, a fly ball has velocity $\vec{v} = 25\hat{i} - 4.9\hat{j}$ (the x axis is horizontal, the y axis is upward, and $\vec{v}$ is in metres per second). Has the ball passed the highest point of its trajectory?

2. The force $\vec{F}$ as in Figure 1. keeps a 6.40 kg block and pulleys in equilibrium. The pulleys have negligible mass and friction. Calculate the tension T in the upper cable.

3. A 12 N horizontal force $\vec{F}$ pushes a block weighing 5.0 N against a vertical wall (Figure 2). The coefficient of static friction between the wall and the block is 0.60, and the coefficient of kinetic friction is 0.40. Assume that the block is not moving initially. (a) Will the block move ? (b) In unit-vector notation, what is the force on the block from the wall?

4. Figure 3, shows a spherical hollow inside a lead sphere of radius R ; the surface of the hollow passes through the center of the sphere and "touches" the right side of the sphere. The mass of the sphere before hollowing was M. What is the mass of the hollowed-out sphere? With what gravitational force does the hollowed-out lead sphere attract a small sphere of mass m that lies at a distance d from the center of the lead sphere, on the straight line connecting the centers of the spheres and of the hollow? What is the gravitational field prodeced at this point (position of the center of the sphere of mass m) due to the hollowed-out sphere ?

5. A geostationary satellite hovers continuously over a certain spot above the Earth. Draw a free body diagram showing all the forces acting

on this satellite from a non-inerial frame of reference. Give the reason why such a satellite can remain only over a special latitute. What is the altitude of its orbit (called a *geosynchronous orbit*) ? Express the result in terms of R (the readius of Earth), M (the mass of Earth) and ω (angular speed of rotation of Earth).

6. In Figure 4, two long barges are moving in the same direction in still water, one with a speed of 10 km/h and the other with a speed of 20 km/h. While they are passing each other, coal is shoveled from the slower to the faster one at a rate of 1000 kg/min. How much additional force must be provided by the driving engines of (a) the fast barge (b) the slow barge if neither is to change speed? Assume that the shoveling is always perfectly sideways and the frictional forces between the barges and the water do not depend on the mass of the barges.

7. A body of mass 2.0 kg makes an elastic collision with another body at rest and continues to move in the original direction but with one-fourth of its original speed. (a) What is the mass of the other body? (b) What is the speed of the two-body center of mass if the initial speed of the 2.0 kg body was 4.0 m/s ?

8. Figure 5, shows a thin rod, of length L and negligible mass, that can pivot about one end to rotate in a vertical circe. A heavy ball of mass m is attached to the other end. The ball is pulled aside through an angle θ and released. As the ball descends to its lowest point, (a) how much work does the gravitational force do on it and (b) what is the change in the gravitational potential energy of the ball-Earth system? (c) If the gravitational potential energy is taken to be zero at the lowest point, what is its value just as the ball is released? (d) Do the magnitudes of the answers to (a) through (c) increase, decrease, or remain the same if angle θ is increased?