Physics 401 – Fall 2007

Practice Exam 2

Please budget your time in solving these problems. Make sure you attempt each problem in order to maximize partial credit. *Please show your work in your blue book.* Do not spend excessive time on any single part of a problem. There are 3 problems and 100 points possible.

1. (30 points) A steel ball is dropped from rest at height h onto a steel floor. The coefficient of restitution between the ball and the floor is ϵ where $0 \leq \epsilon < 1$ (see section 9.8 of the text). Treat the floor as infinitely massive relative to the ball, neglect air resistance when the ball is in the air, and neglect the time of contact between the ball and floor on each bound..

   (a) (25 pts) Find an algebraic expression for the time required for the ball to come to rest with no remaining energy.

   (b) (5 pts) Find the ratio of your result for $\epsilon = 0.9$ to the completely inelastic case ($\epsilon = 0$).

2. (30 points) Consider a central force law of the form:

$$F(r) \quad = \quad -\frac{k}{r^2}\, \exp^{-r/a}$$

   where a and k are constant parameters.

   (a) (20 pts) Find an upper limit $R_{\max}$ on the range of radii r for which *stable* circular orbit is possible.

   (b) (10 pts) For a circular orbit of radius $\frac{1}{2}R_{\max}$, find an expression for the kinetic energy in terms of k, a, and dimensionless constants.

3. (40 points) A hoop of radius ρ is constrained to roll without slipping on the lower half of the inner surface of a hollow cylinder of inside radius $R = 2\,\rho$. Find an algebraic expression for the angular frequency ω of small oscillations about equilibrium. [This problem can be solved 1) by using a Lagrangian function of two coordinates related by an explicit constraint; 2) by using a Lagrangian function of one coordinate; or 3) by using a purely Newtonian approach. Choose the approach with which you feel most comfortable.]