Review questions

Physics 2P20

1. A small ball of mass m is placed on top of a "superball" of mass M, and the two balls are dropped to the floor from height h. How high does the small ball rise after the collision? Assume that collisions with the superball are elastic, and that $m \ll M$. To help visualize the problem, assume that the balls are slightly separated when the superball hits the floor. Protect your eyes and breakables if you decide to test this experimentally.

2. A commonly used potential energy function to describe the interaction between two atoms is the Lennard-Jones (or, "6–12") potential

$$U(r) = \varepsilon \left[\left(\frac{r_0}{r} \right)^{12} - 2 \left(\frac{r_0}{r} \right)^{6} \right] .$$

   (a) Show that the radius at the potential minimum is r_0, and that the depth of the potential well is ε.

   (b) Reduce the equation to its dimensionless form, and use `physica` to plot the function.

   (c) Find the frequency of small oscillations about equilibrium for two identical atomes of mass m bound to each other by the Lennard-Jones interaction.

3. A uniform stick of mass m and length l is suspended horizontally with one end, A, on the edge of a table, and the other end, B, held by hand. Point B is suddenly released. At the instant of release:

   (a) what is the torque about A ?

   (b) what is the angular acceleration about A ?

   (c) what is the angular acceleration of the center of mass ?

   (d) and therefore, what is the vertical force at A ?

4. A solid uniform sphere of radius a has a spherical cavity of radius $a/2$ centered at a point $a/2$ from the center of the sphere. Find the moment of inertia of of this obect about an axis passing through the center of the sphere and the center of the cavity.

5. A uniform ladder of length l leans against a smooth vertical wall, making an initial angle θ_0 with the floor. It starts to slip downward without friction. Show that the top of the ladder loses contact with the wall when it is at two-thirds of its initial height or, equivalently, when the angle with the floor is $\theta = \arcsin\left(\frac{2}{3}\sin\theta_0\right)$.

   Hint: Only a single variable is needed to describe the system. Note the motion of the center of mass.