Homework 1 - reminder of Newtonian mechanics

To be handed in: **ETH:** Sun 27-09-09 **UNI:** Wed 30-09-09

1. **Geostationary space station:** An orbiting space station is observed to remain always vertically above the same point on the earth.

   a) Where on earth is the observer? Describe the orbit of the space station.

   b) What is the distance between the space station and the observer?

2. **Circling particle:** A mass m moves in a circle on a smooth (frictionless) horizontal plane with velocity v_0 at radius R_0. The mass is attached to a string which passes through a hole in the plane (as shown in Fig. 1).

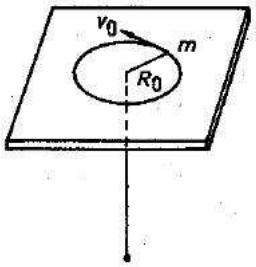

Figure 1: Circling particle on a string.

   a) What is the tension in the string?

   b) What is the angular momentum and the kinetic energy of m?

   c) The tension in the string is increased gradually until m moves in a circle of radius $R_0/2$. What is the final circular velocity v_1?. Why is it important that the string is pulled gradually?

3. **Fast rotating planet:** Consider a rotating spherical planet. The velocity of a point on its equator is v. The effect of rotation of the planet is to make g at the equator $1/2$ of g at the pole. What is the escape velocity for a polar particle on the planet expressed as a multiple of v?

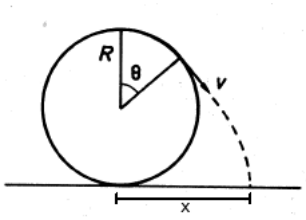

Figure 2: Particle falling from a sphere.

4. **Sphere:** A smooth sphere rests on a horizontal plane. A point particle slides frictionlessly down the sphere, starting at the top. Let R be the radius of the sphere.

   a) What is the velocity v when the particle leaves the surface of the sphere?

   b) At what distance x the particle lands on the plane?

5. **Enjoying wine in a train:** You return home to Zürich from a nice hike in Wallis. You took the oppertunity to buy a crate of wine from the region and would now like to enjoy some of it in the train. The just opened bottle of wine is a bit unstable as the train shakes the table. How much of the wine do you have to drink in order to get maximum stability? Of course drinking the whole bottle also solves this, and many other problems, but it is not the solution we are looking for.

   Assume that an empty 75 cl glass bottle weighs $\sim 450\,g$ and that wine has density similar to water. For simplicity, approximate the whole system with a thin rod.