Quiz No. 01 (Spring 2018)

PHYS 510: Classical Mechanics

Date: 2018 Jan 17

1. (**20 points.**) A mass m_1 is placed on a frictionless floor. Another mass m_2 is placed on top of mass m_1. See Figure. The surfaces of m_1 and m_2 in contact leads to a coefficient of static friction μ_s between them.

   (a) Determine the magnitude and direction of the force of friction on the (top) mass m_2.

   (b) Find the maximum force F one can exert on the (bottom) mass m_1 such that the (top) mass m_2 does not move relative to mass m_1.

2. (**20 points.**) You construct a pulley system shown in Figure. Assume massless pulley and massless rope. You exert a constant force F on the free end of the rope. The total mass hanging on the other end of the rope (including your mass) is m.

   (a) What is the minimum force you need to exert on the free end of the rope such that the mass m does not fall.

   (b) Determine the acceleration with which you move up when you exert a force larger than this minimum force.

3. (**20 points.**) (Based on Problem 12 in Goldstein.) The escape velocity of a particle on Earth is the minimum velocity required at Earth's surface in order that the particle can escape from Earth's gravitational field. Neglecting the resistance of the atmosphere, the system is conservative. Calculate the escape velocity for Earth.

4. (**20 points.**) A solid sphere of mass M, radius R, and moment of inertia $I = 2MR^2/5$, starts from rest at a height h on an incline. Rolling motion without slipping or sliding corresponds to the constraint

$$x = R\theta \qquad \text{or} \qquad v = \omega R, \tag{1}$$

   where θ is the angular displacement describing rolling, $\omega = d\theta/dt$ is the angular speed, x is the distance along the incline, and $v = dx/dt$ is the linear speed along the incline.

   (a) Determine the velocity of the sphere at the bottom of the incline.

   (b) How much energy is lost due to friction.

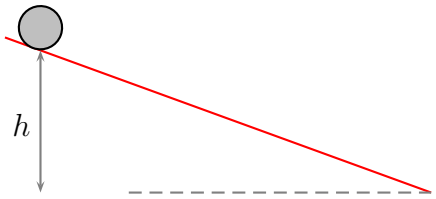

Figure 1: Problem 4