

## Physics 6220/7220 Pre-Test

**Total points for the exam: 35**

1. A right circular cylinder of uniform mass density has a height  $h$ , radius  $R$ , and mass  $M$ .
  - a. Draw a figure with the cylinder and a Cartesian frame of reference with origin at the center of mass of the cylinder and the  $z$ -axis along the axis of the cylinder. [2 points]
  - b. Calculate the moment of inertia matrix  $I$  in this frame using cylindrical coordinates. [6 points]
  - c. Find the principal moments of inertia and unit vectors along the principal axes with the same origin. Express all answers only in terms of given quantities. [2 points]
2. A particle is sitting on top of a smooth, frictionless fixed hemisphere of radius  $a$ . The particle is disturbed slightly (see Figure 1).
  - a. What is the kinetic energy  $T$  and potential energy  $V$ ? [2 points]
  - b. Determine the speed of the particle as it slides down the hemisphere as a function of  $\theta$ . [4 points]
  - c. At what point will the particle leave the hemisphere? [4 points]

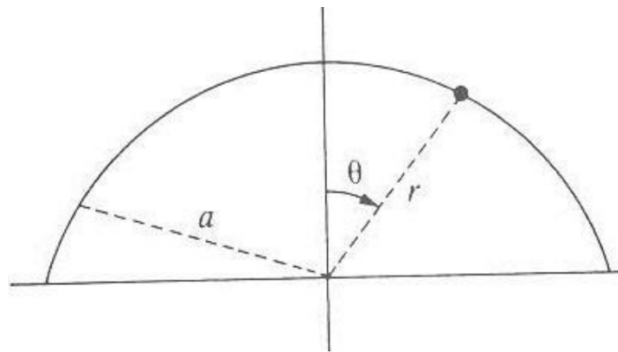


Figure 1

3. Starting from rest, a truck accelerates with an acceleration  $a$  in the horizontal direction, as shown in the diagram below.



- a. It is given that there is no friction, the mass  $m$  is initially at rest, and the spring is initially at its equilibrium position. What is the compression  $\delta$  of the spring while the truck accelerates? **[2 points]**
- b. The truck suddenly stops accelerating. As a result, the spring expands to its equilibrium position and the mass goes flying forward. What is its speed  $v$  in the reference frame of the truck once it has lost contact with the spring? **[3 points]**