



Problem Set 9

Due: 18 July 2019, 12.30 p.m.

**Problem 1.** Based on measurements of rotational energy levels of a HF molecule, its moment of inertia about the axis perpendicular to the line connecting both atoms, passing through the center of mass of the system, has been estimated at  $1,37 \cdot 10^{-47} \text{ kg} \cdot \text{m}^2$ . Find the distance between the H and the F atoms if their masses are  $m_{\text{H}} = 1,67 \cdot 10^{-27} \text{ kg}$ ,  $m_{\text{F}} = 3,17 \cdot 10^{-26} \text{ kg}$ , respectively.

(2 points)

**Problem 2.** Justify the following statement that we mentioned in class when we were discussing the moment of inertia of a disk: *For a planar object, the moment of inertia about an axis perpendicular to the plane is the sum of the moments of inertia about two perpendicular axes through the same point in the plane of the object.*

It is known as *the perpendicular axis theorem*.

(3 points)

**Problem 3.** Find the moment of inertia of a hollow cylinder with inner radius  $R_1$ , outer radius  $R_2$ , and height  $H$ , about the axis of symmetry. The cylinder is not uniform and the bulk density of mass depends on the distance  $r$  from the axis of symmetry as  $\alpha r$  with  $\alpha > 0$ .

(3 points)

**Problem 4.** What is the moment of inertia of the cylinder from Problem 3 about the axis parallel to the axis of symmetry, and tangential to the outer side wall.

(1 point)

**Problem 5.** A yo-yo is made of two identical cylinders of radius  $R$  attached at their centers to a cylindrical axle with radius  $r < R$ . All three cylinders have the same height and are made of the same material (with constant density of mass). A string is attached to and wrapped around the axle. Holding the free end of the string firm, we release the yo-yo.

Find the acceleration of the center of mass of the yo-yo. Assume that the string does not slip while unwinding.

(3 points)

