Physics 3210, Spring 2010 HW#10 - due Wednesday, Mar. 31

For full credit, you must show all your work and explain your reasoning in complete sentences.

1) Consider a flat circular disk, like a coin, of mass \( M \) and radius \( R \). For the sake of argument, pretend that it is infinitely thin, like the sheet in problem 5 of HW#9.
   a) What are the principal axes of the coin, and their moments of inertia?
   b) The coin rotates about its center of mass with angular velocity \( \omega \). Show that the magnitude of \( \omega \) is constant.
   c) The coin is initially in a horizontal plane and you flip it, giving it components of angular velocity \( \omega_1 \) along a diameter through the coin, and \( \omega_3 \) along the principal axis perpendicular to the coin. If \( \omega_3 = 0 \), the coin just spins around its diameter, like an ordinary coin flip. However, if \( \omega_3 \neq 0 \), the coin precesses. What is the minimum value of \( \omega_3 / \omega_1 \) for which the precession is such that the same face of the coin is always exposed to an observer looking from above? (The wobble makes the coin look like it is flipping, even though you always know which side is up!)

2) Taylor, 10.44

3) An oxygen molecule consists of two oxygen nuclei, each of mass \( m = 2.7 \times 10^{-26} \) kg, separated by a distance \( 1.2 \times 10^{-10} \) m, and surrounded by a cloud of electrons of mass \( 9.1 \times 10^{-31} \) kg.
   a) Ignoring the small mass of the electron, what is the moment of inertia for rotation of the nuclei around their center of mass? If this rotation has angular momentum equal to \( \hbar \), that is, Planck’s constant divided by \( 2\pi \), what is the corresponding energy of rotation? Express your answer in units of electron volts, where \( 1 \text{ eV} = 1.6 \times 10^{-19} \) J.
   b) Suppose one of the electrons orbits in a circular orbit perpendicular to the axis joining the nuclei, with radius \( 1 \times 10^{-10} \) m. This motion contributes a moment of inertia of the molecule along the internuclear axis. How big is this moment of inertia? If the electron has angular momentum \( \hbar \), what is the corresponding energy of rotation, in eV? (This illustrates, very roughly, the discrepancy between electronic and rotational energy scales in molecules.)