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8.012 Physics I: Classical Mechanics
Fall 2008

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Physics

Physics 8.012: Physics (Mechanics) I **Fall Term 2008**

PROBLEM SET 9

Collaboration policy: You are encouraged to freely discuss homework problems with other 8.012 students and teaching staff. However, **you must write up your solutions completely on your own**—do not simply copy solutions from other students. You are **forbidden from consulting solutions from previous years or from the web.** Violations of this policy may result in disciplinary action.

Reading: Kleppner & Kolenkow, Chapter 8

0. **Collaboration and discussion.** Please list the names of all the students with whom you discussed these homework problems. Also be sure to write down your name and recitation section clearly on the first page.

1. Kleppner & Kolenkow, Problem 7.5 [10 points]

2. Kleppner & Kolenkow, Problem 7.7 [10 points]

3. Kleppner & Kolenkow, Problem 7.9 [10 points]

4. Kleppner & Kolenkow, Problem 7.11 [5 points]

5. Kleppner & Kolenkow, Problem 8.1 [10 points]

6. Kleppner & Kolenkow, Problem 8.3 [10 points]

7. Kleppner & Kolenkow, Problem 8.4 [10 points]

8. Kleppner & Kolenkow, Problem 8.5 [10 points]

9. Kleppner & Kolenkow, Problem 8.6 [10 points]

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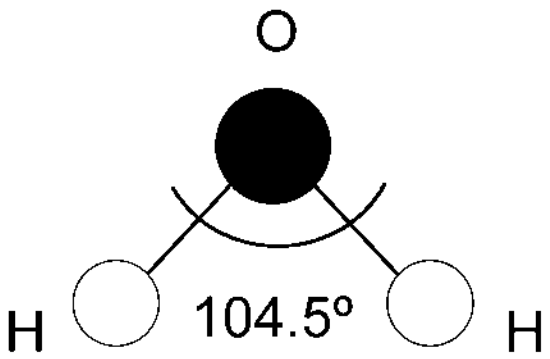
10. **Moment of Inertia of a Water Molecule.** [15 points]



The water molecule, H_2O, is composed of 2 atoms of hydrogen (molecular weight 1 amu = 1.66×10^{-27} kg) each bonded to one atom of oxygen (molecular weight 16 amu) in a triangular arrangement. The oxygen-hydrogen bonds have a length $r = 9.6\times10^{-11}$ m and are set apart by an angle of 104.5^o. Treat each atom as a point mass.

(a) [10 pts] Determine the center of mass position of the water molecule, and find the principal axes that pass through this center of mass. Confirm these axes by calculating the moment of inertia tensor in the principal axes frame. You can write your answer in terms of bond length r and hydrogen mass m_H.

(b) [5 pts] About which axis is torque-free rotation unstable (i.e, will lead to tumbling motion)?