8.012 Physics I: Classical Mechanics
Fall 2008

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Physics

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

PROBLEM SET 10 (OPTIONAL)

This problem set will be not be collected. Solutions will be posted online.

Reading: Kleppner & Kolenkow, Chapter 9

1. Kleppner & Kolenkow, Problem 8.8

2. Kleppner & Kolenkow, Problem 8.10

3. Kleppner & Kolenkow, Problem 8.11

4. Kleppner & Kolenkow, Problem 8.12

5. Kleppner & Kolenkow, Problem 9.1

6. Kleppner & Kolenkow, Problem 9.3

7. Kleppner & Kolenkow, Problem 9.4

8. Kleppner & Kolenkow, Problem 9.6

9. Kleppner & Kolenkow, Problem 9.12

10. **Spinning up Figure Skater.**
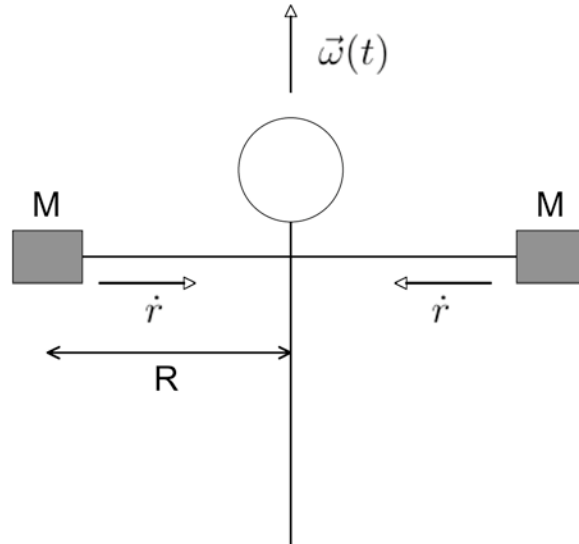
(a) The derivation of the rotational fictional forces we did in class (coriolis and centrifugal) assumed that the spin vector $\vec{\omega}$ was constant in time. Relax this constraint and derive an additional fictional force that depends on the $\dot{\vec{\omega}}$ (this is known as the azimuthal force).

(b) We found earlier that the spin up of an ice skater as she brings her hands in can be attributed to conservation of angular momentum (for different moments of inertia). Let's examine this in the skater's frame of reference. Assume our skater has hands of mass M extended initially at a radius R from her body, attached to effectively massless arms and an effectively massless body (think: spherical cow). She is initially rotating with spin vector $\vec{\omega}$ pointing upwards. Our skater moves her hands slowly toward the center of her body at a rate $\dot{r}$. Based on the fact that the skater does not spin up in her own frame of reference (always true!), and considering all fictional forces in her rotating frame of reference, derive an expression for $\dot{\omega}$ in terms of ω, R and $\dot{r}$.

(c) Derive this same expression by examining the evolution of angular momentum in the inertial reference frame.

(d) If the skater pulls her hands in to half their original radius, by how much does she spin up?