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 4

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, Chapters 3 & 4

0. **Collaboration and discussion.** Please list the names of all the students with whom you discussed these homework problems.

1. Kleppner & Kolenkow, Problem 3.7 [10 points]

2. Kleppner & Kolenkow, Problem 3.11 [10 points]

3. Kleppner & Kolenkow, Problem 3.13 [10 points]

4. Kleppner & Kolenkow, Problem 3.14 [10 points]

5. Kleppner & Kolenkow, Problem 3.15 [10 points]

6. Kleppner & Kolenkow, Problem 3.16 [5 points]

7. Kleppner & Kolenkow, Problem 3.18 [10 points]

8. Kleppner & Kolenkow, Problem 3.20 [10 points]

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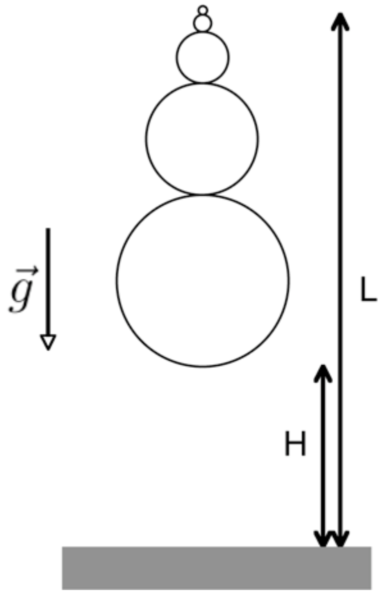

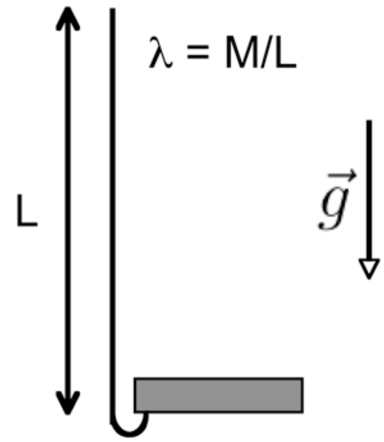

9. **The super-astro-blaster.** [15 points]

   In class we demonstrated how the astroblaster (a set of elastic bouncing balls released from rest and rebounding from the floor) can launch the smallest and topmost ball to considerable distance. Let's push this to the test. Assume we have n balls of mass (left figure above) m_1, m_2, m_3, ..., m_n where $m_1 >> m_2 >> m_3 >> ... > m_n$. The most massive ball is at bottom and starts at rest at a height H = 1 meter above the ground. Assume that all balls bounce elastically, that constant gravitational acceleration $\vec{g}$ points downward, and that air resistance and realistic limits in the elasticity of the balls can be ignored.

   (a) (10 points) In terms of n, to what height does the top ball bounce? How many balls do you need to reach 1 kilometer?

   (b) (5 points) How many balls do you need to achieve escape velocity? You will need to determine an expression for escape velocity from the Earth, which is possible (to within an order of magnitude) through dimensional analysis.

10. **A falling chain.** [10 points]

   You hold a chain of mass M, length L and uniform mass density λ from one end above a fixed table (right figure above). The chain falls under constant gravitational acceleration. Ignore any swinging or bouncing in the chain and assume that it moves purely in a vertical direction until it comes to rest hanging straight down below the table.

   (10 points) What is the support force from the table, F_S, as a function of time after the chain is released?