33-331 Physical Mechanics I. Fall Semester, 2009
Assignment No. 1 (Revised)
Due Friday, Sept. 4

READING

Thornton and Marion:

Ch. 1. Most of this you should have seen before, and you can review it when you need it. Glance through it to see what is there.

Ch. 2. All sections. However, in Sec. 2.4 omit the parts dealing with air resistance and motion in a magnetic field.

Ch. 3, Secs. 3.1 through 3.6

READING AHEAD:

Thornton and Marion Ch. 5 (Gravity)

EXERCISES:

Warning! This assignment is longer than the usual weekly assignment, so start on it early; do not leave it till the last minute!

1. Turn in at most one page, and not less than a third of a page, indicating what you have read, examples or exercises (apart from those assigned below) that you worked out, difficulties you encountered, questions that came to mind, etc. You may include complaints about the course. You will find a sample at the end of this problem set.

Answers to even numbered exercises in each chapter of Thornton and Marion are given at the back of the book. (It is rumored that not all of them are completely correct.) You must in any case provide an argument that leads to the final result.

2. Thornton and Marion 2-4.

3. Thornton and Marion 2-32.

4. Thornton and Marion 1-26.

5. A block of mass m is initially at rest at $x = -x_0,\ y = 0$, and slides without friction down a plane

$$y = -(x + x_0)\tan\theta,$$

where x and y are horizontal and vertical coordinates, and $\theta > 0$. Assume the linear dimensions of the block are negligible.

a) Find the x, y, and z components of the angular momentum $\mathbf{L}$ of the block relative to the origin $x = y = z = 0$ as a function of time.

b) Show that the rate of change of $\mathbf{L}$ is given by the torque, suitably defined with respect to the same origin.

c) Repeat (a) and (b) assuming an origin at $z = 0$ and (i) $x = 0, y = -x_0\tan\theta$, so the block passes through the origin on its way down the plane; (ii) $x = 0, y = -2x_0\tan\theta$, so the block passes above the origin on its way down the plane.

(continued)

6. A video camera of mass 5 kg is placed on a tripod with three legs of negligible mass on a horizontal floor in such a way that the points of contact form an equilateral triangle with edges 1 m on a side. Assume that a plumb bob suspended from the camera is either (i) directly over the center of the triangle or (ii) equidistant from two vertices, but 0.75 m from the third. Consider both cases in working out the following.

a) What are the forces which the floor exerts on each of the legs, assuming it is perfectly smooth, no friction? You can probably make a good guess, which is fine, but then justify your answer using the principles of static equilibrium. Is the answer unique? (Note that torque is a vector.)

b) Suppose that frictional forces can be present, i.e., the floor is not perfectly smooth. What can you say about these forces, assuming that the coefficient of static friction for each of the legs is 0.5? Are there some adjustable parameters, and if so how many? Explain your reasoning.

7. The professor dropped four nickels into the bottom of a pill bottle of outer diameter 2.5 cm. When it was floating nearly submerged in a bowl of water the frequency of vertical oscillations was measured to be 2.0 Hz. What is the mass of the bottle including the nickels? [Hint. There is something very much like this somewhere in Thornton and Marion.]

8. Thornton and Marion 3-15.

Sample answer to Exercise 1 by Willy Smart

A lot of this stuff is repeating the freshman course, so I didn't have much difficulty with it. On the other hand, some ideas in Sec. 2.4 weren't all that easy to follow. Are we really supposed to understand the motion of projectiles? You know I'm not in the ROTC program!

I worked through the examples in Ch. 2, which were mostly straightforward except for 2.9, which was a bit confusing. By the way, will we need to be able to write programs to do numerical things? If so, I much prefer Mathematica to MathCad. By the way, I am sceptical about Example 2.11: the why shouldn't the mouse arrive with some finite angular momentum contributing to that of the fan?

Complaints: Instructor tells too many jokes. Also, the pace of the course has been far too *slow*. Except for the stuff I'd never seen before, where it was hard to keep up; polar coordinates in particular. Why won't we be doing Ch. 4? It looks much more interesting than Ch. 3.