AE 252: Introduction to Aerospace Dynamics
Spring 2007

Homework #10

Due Thursday, April 12, at 5PM in the "AE252" box in the mailroom. Please start every problem on a new sheet of paper, and put your name on the *back* of each page.

1. Text problem 17.129.

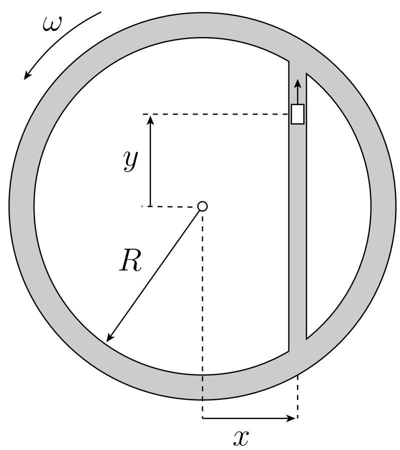
2. Text problem 17.141.

3. Text problem 18.5.

4. Do the "space station" problem on the following page.

5. A motionless "space-walking" astronaut can change her orientation without using thrusters, momentum wheels, etc. How is this possible? (Why might you think it was impossible?) For that matter, why do cats always land on their feet? (And how are these two problems related?

Problem 4. Designing a space station transport system.



You are designing a large circular space station of radius $R = 1000$ m. It will rotate counter-clockwise at a constant rate. A transport system will carry passengers in a car through a glass-plated tube from one side of the station to another. The car is capable of exerting a thrust of maximum magnitude $T_{\text{max}} = 7000$ N. The glass-plated tube is capable of withstanding a force of maximum magnitude $N_{\text{max}} = 9000$ N before breaking. Assume the car has mass $m = 1000$ kg. Also assume that the car travels at constant speed $v = 5$ m/s. Your job is to pick reasonable values of ω and x.

a. Find ω so occupants of the space station will feel an acceleration outward of magnitude $g = 9.81$ when they are walking along the ring at radius R.

b. Write an expression for the acceleration of the car with respect to an inertial frame, assuming that the center of the space station is fixed.

c. Write the equations of motion of the car, assuming that the only forces acting on it are the thrust force (along the tube) and the normal force (perpendicular to the tube).

d. The restriction $|T| \le T_{\text{max}}$ results in a lower bound $x_{\text{min}} \le x$. Similarly, the restriction $|N| \le N_{\text{max}}$ results in an upper bound $x_{\text{max}} \ge x$. Find both x_{min} and x_{max}.

e. Choose a value of x satisfying your design constraints. Report the maximum values of T and N for your design, and say where they occur. What rationale did you use for picking a particular x? Sketch the trajectory followed by the car, as observed by someone in an inertial reference frame.

f. **BONUS (2 pts):** Assume that the car accelerates from zero velocity at a rate $a = 0.05$ m/s^2 until reaching $y = 0$, then decelerates at the same rate until reaching the end of the tube. For the x that you chose, does the car still satisfy the constraints on T and N? (Show that it does or does not.)