Assignment 1
Math 810 - Spring 2003
Prof. John A. Pelesko

(1) The motion of a bead of mass m sliding on a rotating wire hoop of radius r is governed by

$$mr\ddot{\phi} + b\dot{\phi} + mg\sin(\phi) - mr\omega^2\sin(\phi)\cos(\phi) = 0$$

where here ω is the angular velocity of the hoop, b is the damping coefficient, g is the gravitational acceleration, and ϕ is the angular position of the bead. (See Figure 1)
(a) Nondimensionalize this equation in such a way that one dimensionless parameter sits in front of the $\ddot{\phi}$ term.
(b) In part (a) the dimensionless parameter you should have found is $\epsilon = \frac{m^2gr}{b^2}$. Give a physical interpretation of this parameter. When would ϵ be small?
(c) In the case where ϵ is small, is it correct to simplify the system by taking $\epsilon \longrightarrow 0$? (Hint: Think about initial conditions.)

(2) Go to the course web page and download the movie clip from Apollo 15. Using the movie and dimensional analysis estimate the gravitational constant for the moon. Look up the correct constant and compare.

(3) Some cookbooks say that a roast should be cooked x minutes per pound; others say x_1 minutes per pound for small roasts and x_2 minutes per pound for large roasts. Discuss.

(4) Consider an arbitrarily shaped two dimensional plate of fixed area A. Assume that the boundary of the plate is held at temperature T_A and that a constant heat source, Q, heats the plate internally. For what shape plate will the maximum temperature of the plate be maximized? That is, if you want to obtain the hottest possible hot spot, what shape should you make your plate? Use dimensional analysis to justify your conclusion.

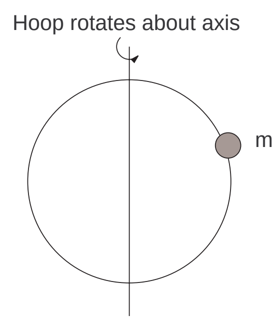

Figure 1: The bead on a hoop.