Homework Set # 7
Introduction to Modern Physics
Due on Thursday, March 22, 2007

Reading: My notes: Chapters #6, #7, & #8
Rae: Chapters #1 & #2

1. Figure 1 shows the power output of warmblooded animals as a function of mass (note it is a “log - log” plot, and recall that $\log x^a = a \log x$). Humans appear at their proper spot, the wattage of a lightbulb.

   (a) Based on the data given in the plot of power output, how does power output scale with mass?

   (b) Now, forgetting the observed answer, do a dimensional analysis problem to find power output of a warmblooded creature as a function of mass and any other relevant dimensional parameters of those creatures.

   (c) Do the answers to 1a and 1b agree? If they do, fantastic... you’ve solved one of the great problems of nature. If not, think about it and see if you’ve left out something in part 1b which will change your results in the right direction.

2. In lecture, I talked about the problem of thermal contact and did not elaborate on its meaning. The phrase that I used was that “a fundamental law of thermodynamics is the two bodies in thermal contact will eventually come to the same temperature.” I also used this idea in conjunction with the use of temperature baths. What is a temperature bath and give at least three examples. In light of this discussion, discuss thermal contact and the human body. Discuss the feeling on a muggy summer day in the early evening when the pool temperature and the air temperature are the same. Do you cool off in the pool? Consider the operation of a fan in cooling you off. Are we in thermal contact with the sun? Are we at the same temperature as the sun? If the answer to these two questions is yes and no respectively why are we not at the temperature of the sun. Consider a magnifying glass. When used to start
a fire, what is the bright spot that you see? What temperature is it at? Why does it take some time to start the flame?

![Figure 2: Figure for problem #2](image)

3. We can model a cereal bowl as a hemisphere, see Figure 2. A particle is placed in the bowl. Consider the bowl and particle as frictionless. Show that for displacements as measured by the lateral distance from the bottom position and using usual energy considerations that this system for small enough displacements is simple harmonic. In other words, what is the action? Given a particle that starts at some place $x = x_0$ and a speed directed toward the neutral position of $v_0$. How far up the other side does it rise?

**Home experiment #7:** You will be given two polarizers. Look through one polarizer at several different light sources (glare from a water surface, a clear sky at different angles from the sun, a light bulb, and so on), each time rotating the polarizer through various angles. Describe what you see.

1. Put the two polarizers atop one another and look at the light bulb through both of them. Rotate the two polarizers together as before; then hold one still while you rotate the other. In all cases, describe what you see.

2. Get with a friend, put two polarizers atop one another, and rotate them relative to one another so that no light can be seen through them.

   (a) Place a third polarizer from your friend on top of the other two and rotate it through various angles. Describe what you see.

   (b) Now put the third polarizer between the other two and rotate it through various angles. Describe what you see.