Unified Engineering I Fall '03
Problem U2 (Unified Concepts)

Dimensions and units are fundamental to the language of engineering. This question is an exercise in this important topic. You may have to use common sense and perhaps a little research to answer some of the questions. The tables in the front of Crandall, Dahl, and Lardner should be helpful. The SI, British, and other unit systems all have well-defined units and symbols, Answers which are not accompanied by the correct symbol or unit are not eligible for full credit, in this question and in the rest of Unified.

a) **Conversion.** A strong cyclist is generating a steady 0.4 hp. How much power is this in SI and British units?

b) **Estimation.** The cyclist also generates waste heat at a rate of three times the mechanical power. If the cyclist's body wasn't being continuously cooled, roughly how long could he maintain this power output?
Hint: Assume the human body has the same heat capacity as water.

c) **Analysis.** You will learn in Fluids that the aerodynamic lift L and pitching moment M on a wing depend on the air density ρ, air velocity V, wing area S, and wing chord c. Good approximations to measured data are found to be:

$$\begin{aligned} L &= \frac{1}{2}\rho V^2\, S\, C_L \\ M &= \frac{1}{2}\rho V^2\, S\, c\, C_M \end{aligned}$$

What are the dimensions of the lift coefficient C_L and the pitching moment coefficient C_M?

d) **Scaling.** If the wing in c) is geometrically scaled down by a factor of 1/2, and is operated in the same airflow conditions as the full-size wing, how much do you expect the lift and the moment to change?