NEEP 602 -- Engineering Problem Solving II
Homework Set 2
Due Tuesday 2/22/05

4. Skydiver (15 points)

An 80-kg skydiver jumps from a plane at an altitude of 600 m. After 5 s her parachute opens. The skydiver's altitude as a function of time y(t) is given by

$$y'' = -g + \alpha(t)/m$$
$$y(0) = 600\ m$$
$$y'(0) = 0\ m/s$$

where g is the acceleration due to gravity. The drag, or air resistance, $\alpha(t)$ is proportional to the square of the velocity, and is of course different before and after the parachute opens:

$$\alpha_1(t) = K_1 y'(t)^2, \quad t < 5\ s$$

$$\alpha_2(t) = K_2 y'(t)^2, \quad t \geq 5\ s$$

If $K_1 = 1.25$ and $K_2 = 25.5$, use Matlab solver `ode45` and its event location feature to determine the altitude at which her chute opens, the time it takes her to land, and her vertical velocity at landing. Your script should clearly display this information in the command window, and produce a labeled plot showing the skydiver's altitude vs. time.

5. Long Jump (15 points)

The 1968 Summer Olympics were held in Mexico City. There, Bob Beamon set a world record for the long jump with a distance of 8.90 m, which was 0.8 m longer than the previous mark. After this record-setting jump, which has only been beaten once since 1968, some suggested that the lower air density at Mexico City's altitude of 2250 m was a contributing factor. This problem will look a the effect of air density, and also the jumper's initial velocity.

The jumper's initial velocity has a magnitude of v_0 and makes an angle of θ_0 with respect to the horizontal. After the jump, the only forces acting on the jumper are gravity and aerodynamic drag D, which is proportional to the square of the magnitude of the velocity. The equations of motion are

$$x' = v\cos\theta, \quad y' = v\sin\theta$$

$$\theta' = -\frac{g}{v}\cos\theta, \qquad v' = -\frac{D}{m} - g\sin\theta$$

and the drag is given by

$$D = \frac{c\rho s}{2}\left(x'^2 + y'^2\right)$$

where $c = 0.72$ is the drag coefficient, $s = 0.50\text{m}^2$ is the jumper's cross sectional area, and the initial takeoff angle θ_0 is 22.5º. For sea level, take the air density to be $\rho = 1.29$ kg/m^3, and for Mexico City, use $\rho = 0.94$ kg/m^3.

Use Matlab `ode45` and event location to plot and display the jumper's distance for both sea level and Mexico City conditions, using an initial velocity of 10 m/s. Then use a loop to determine the initial velocity that Beamon would have had to reach a distance of 8.90 m in Mexico City. Determine how far he would have jumped at sea level. Which makes a greater difference: the air density or a jumper's initial velocity?