Physics 303/573

Homework 2 due Wednesday, September 19.

From Taylor: Problems 2.16, 2.36. For 2.36, use quadratic drag and $x = \dot{x} = 0$. You can use the solution of the general case in the book or the results of problem (3) below.

Other problems:

1. Consider a body with a cross-sectional area A moving with speed $|v|$ through a fluid with density ρ. We showed using dimensional analysis that this gave rise to a drag force proportional to $\rho A|v|^2$.

a) At what rate does the body encounter the fluid, that is how much mass per second does it hit?

b) To accelerate all this fluid to the body's speed $|v|$, what force needs to be exerted?

In reality, the body doesn't accelerate all the fluid it encounters to its own speed, but this gives a rough measure of the drag force. For a sphere, it turns out that the force is about $\frac{1}{4}\rho A|v|^2$. In air at room temperature and pressure (STP), $\rho \approx 1.3 kg/m^3$.

c) Find the constant c in equation (3.35) of the notes in terms of the diameter D of the sphere. How does this result compare to (2.6) in the book?

2. For one-dimensional motion along the z-axis, if $F_z = f(z)$ for an arbitrary function f, write the general solution relating v_z and z in terms of an integral (hint–multiply the equation through by $v_z \equiv \dot{z}$).

3. For one-dimensional motion along the z-axis, if $F_z = f(v_z)$ for an arbitrary function f, write the general solution relating t and v_z in terms of an integral.

4. For quadratic drag, suppose $\dot{z}_0 = 0$.

a) What is the initial slope w_0 in this case? What is the integration constant A (not an area!) in equation (3.44) of the notes?

b) The mass falls; after some time, $v_x = -v_z$. Use (3.38) of the notes, the definition of the slope w, and (3.43) to find what the velocity is. Notice how this simplifies when the drag $c = 0$; what is the physical reason for this?

c) More generally, use (3.38), the definition of the slope w, (3.43), and (3.44) to write down the exact relation between v_x and v_z for arbitrary $\dot{x}_0$ and $\dot{z}_0$–this is a complicated equation relating $v_x, v_z, \dot{x}_0, \dot{z}_0$; I do not expect you to solve it.