PHYS 105

In-class exercise 8.1

2-D Motion with Dissipation

Let's apply what we have learned about dissipation to 2-D motion by including the effect of air resistance into a projectile problem. We will do this in several stages.

1. Start with the version of the projectile (predictor–corrector) program without dissipation, provided on the web page.

2. We will begin by including a dissipative acceleration of the first form:

$$\mathbf{a}_{diss} = -\alpha\ \mathbf{v}$$

   (use the symbol ALPHA in your program). Note that now $\mathbf{v} = (v_x, v_y)$ is a 2-D vector, so $\mathbf{a}_{diss}$ also has two components. Note too that you will have to modify the calculation of the acceleration components to include velocities as well as positions as arguments.

3. First things first... Verify that setting ALPHA = 0 preserves the "Physics 1" projectile motion solution! Choose an initial velocity of 100 m/s at 60 degrees to the horizontal, take a time step of 0.1 s, and confirm that the range (the linearly interpolated value of x when $y = 0$) and time of flight (linearly interpolated value of t when $y = 0$) agree with the analytic result.

4. How does the trajectory of the projectile vary as you increase ALPHA? Specifically, determine the (interpolated) range and time of flight for

$$\text{ALPHA} = 0.01,\ 0.02,\ 0.05,\ 0.1,\ 0.2,\ 0.5,$$

   using the same initial velocity as in the original program. Plot both quantities as functions of ALPHA.

5. For the case ALPHA = 0.1, how much faster must the projectile be fired (keeping the angle constant) to hit the same spot on the ground as in the case ALPHA = 0? Compare the three trajectories (ALPHA = 0, ALPHA = 0.1, and ALPHA = 0.1 with the increased initial velocity) by plotting them on the same graph. By what factor does the initial kinetic energy have to increase to overcome the effects of air resistance?