HW 2: The Euler Method and Drag Force

# 1d Case

1. Write a function that performs the Euler method on a function f satisfying the first order differential equation f’(t)=g(t) where the function depends on t, f and g only.
2. Write a program using that function that numerically solve the differential equation

dv/dt = g – bv (which models free fall with air resistance) where b is given in terms of the drag coefficient, density of air, mass and cross-sectional area.

1. Assuming that a = 9.8 and b = 1 for what initial velocities (assuming you never have to worry about it hitting the ground) does the velocity function approach a horizontal asymptote? Show this analytically.

(I’m sure there’s probably a prettier way but that’s a later problem)

1. Turn in a labeled graph of velocity vs. time using the values of a and b given in #4 and an initial velocity that results in the graph having a horizontal asymptote.
2. (\*) Include a function in the program that checks that the horizontal asymptote is reasonably close to the accepted value for the terminal speed a/b regardless of choice of b. - My program shows that as b increases, the error increases at a seemingly square root function, using the same time step, so for a larger b, a smaller dt would be necessary
3. (\*) Provide sufficient evidence that your program converges to the correct solution as the step size becomes smaller. Determine the maximum step size in order to be within 1% of the correct solution at all times. - 0.02905638428514
4. (\*\*) The time to rise and the time to fall (to the same initial height) for a particle that is projected straight upwards are equal in the absence of air resistance. Explain conceptually why this is not true in the presence of the drag force, and then numerically compute the two times showing that they are indeed unequal. - The direction of drag force is not constant but rather is opposite the motion so going up, the drag works with gravity, accelerating the object faster than g, but going down it works against gravity, accelerating slower than g

# 2d Case

1. (\*) Use the Euler method to write a program to solve for the trajectory in the presence of air resistance dependent upon initial speed, starting angle, positions, drag coefficient, cross-sectional area and mass.
2. (\*\*) Choose a realistic object and research appropriate values to use in your program and then use it to plot at least one trajectory (y vs. x). Also produce a plot of range versus starting angle. Compare and contrast these two plots to the frictionless case.
3. Compare your results with your classmates, how do they compare? (you all have to use different objects) – Some objects have more distortion than others. Objects with smaller surface areas, like an iPhone, or smaller drag coefficients, like a soccer ball, have less distortion than others. The initial velocity also affects the distortion but only when it is very fast, like Brennan’s 9000 m/s soccer ball.