Assignment8

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December 2025

1 Cycling

In the last assignment, the cyclist's velocity increases indefinitely, which is unrealistic. In this problem, I add other forces to the system that influence the cyclist's velocity. I added two different drag forces and the force from gravity, introducing path that has hills.

1a) Drag forces

For drag forces, I considered two terms: 1) the force due to the act of pushing the air out of the way as the rider plows through it, and 2) the effect of viscous interactions between the surrounding air molecules.

The first drag term I added was the pressure force, with C_D as the drag coefficient, A as the area of the cyclist, ρ as the denisty of air at standard conditions, and v as the velocity. CD depends on the aerodynamics of the system.

$$F_d = -\frac{1}{2}C_D \rho A v^2 \tag{1}$$

The second term I added was the viscous force, η as the viscosity, A as area of the cyclist, v as velocity, and h as the effective thickness of the fluid layer.

$$F_v = -\eta A \frac{v}{h} \tag{2}$$

I added these equations as functions and input them into my dvdt function. With my new dvdt function, I updated velocity over time. I then plotted the results in Figures 1 and 2. Figure 1 shows velocity as a function of time with only the pressure drag force and Figure 2 shows velocity as a function of time with both drag forces.

1b) Hills

To make my cyclist's path more interesting, I had them go up and down a few hills. I wanted the hills to be fixed on a coordinate system,not related to velocity, so I created an x-axis that updated along with the velocity. I then created a new force term, $F_g = mgsin(\theta)$, that will account for the gravity force in the x-direction. To find the angle,θ, I played around with a few equations, eventually coming up with $\theta = arctan(0.08(0.15sin(0.015x + 3) + 0.6sin(0.025x + 5) + 0.3sin(0.009x)))$. I added this force term to my dvdt function and updated velocity with all three new forces. I plotted the new fucntion v vs. t in Figure 3.

2 Random walk: 1 walker

I created a program called random.py which simulates a single random walk of n steps using python's random module. Each step is 1 unit in length but can be forward, backwards, or no step is taken. The walker starts at a position of 0, and their position is plotted for 100 steps, as seen in Figures 4 and 5.

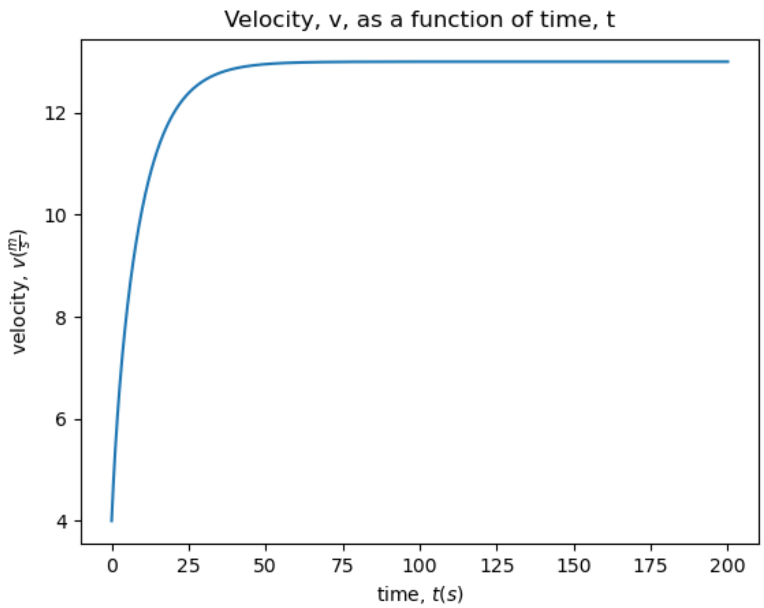

Figure 1: Velocity, v, as a function of time, t, containing one drag force.

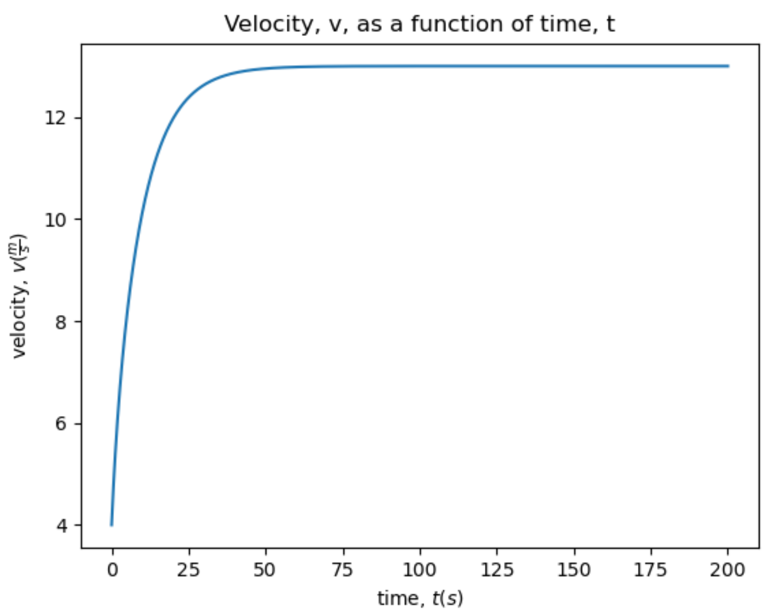

Figure 2: Velocity, v, as a function of time, t, containing two drag forces.

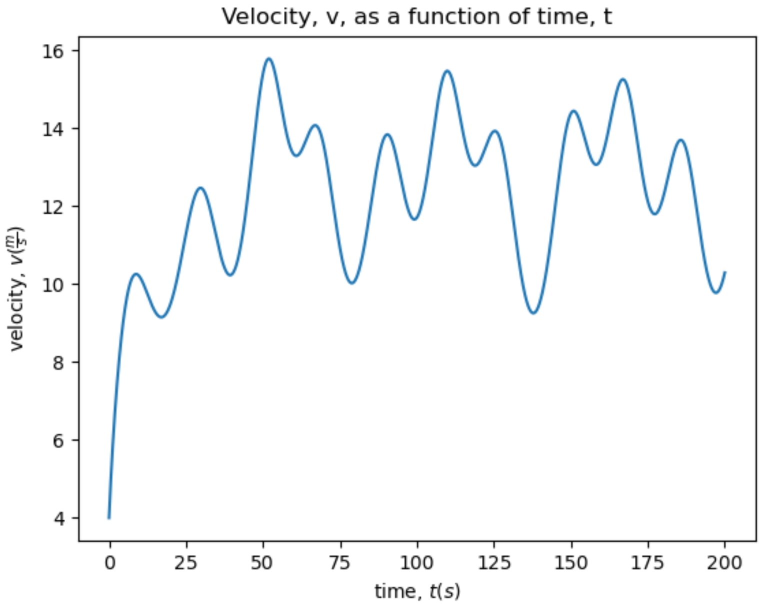

Figure 3: Velocity, v, as a funciton of time, t, with two drag forces and the gravitational force from a hilly path.

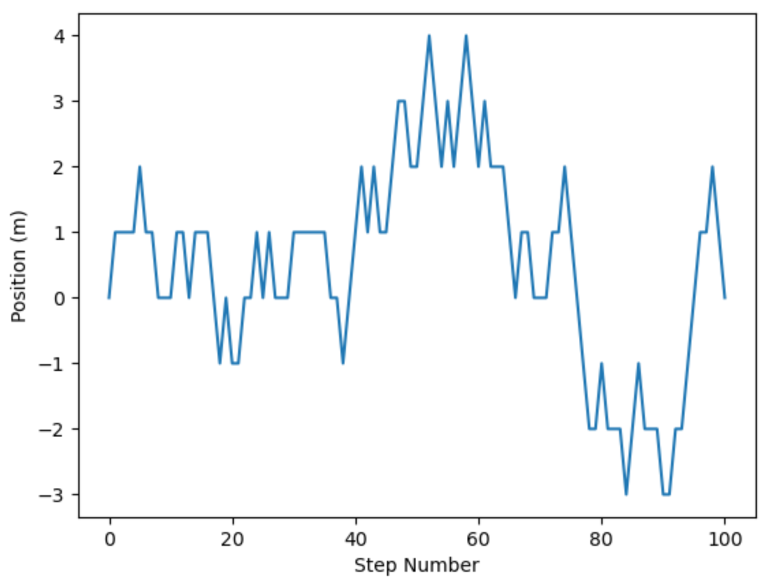

Figure 4: Position of a walker taking 100 random steps.

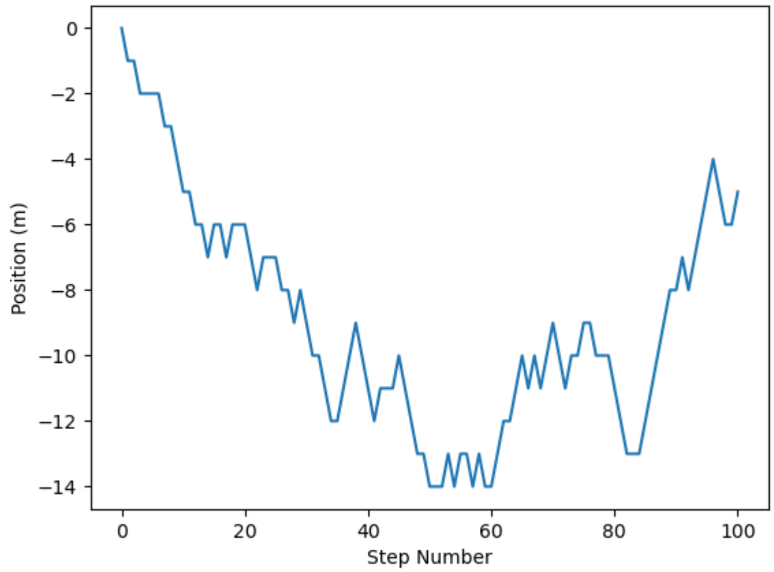

Figure 5: Position of a walker taking 100 random steps.

3 Random walk: 500 walkers

Here, I modified random1.py so that you it solved for 500 walkers. I recorded the displacement for each step for each walker and calculated the mean displacement for each step, x_n, and the mean displacement squared, x_n^2, to denote taking the mean over all walkers. I plotted the squared displacement as a function of step number in Figure 6.

It is clear to see that the mean and the squared value for each step is close to zero. This makes sense as it used random numbers -1, 0, and 1. The average, for a large sample would be around zero. As seen in Figure 6, the squared average doesn't get larger than 0.3.

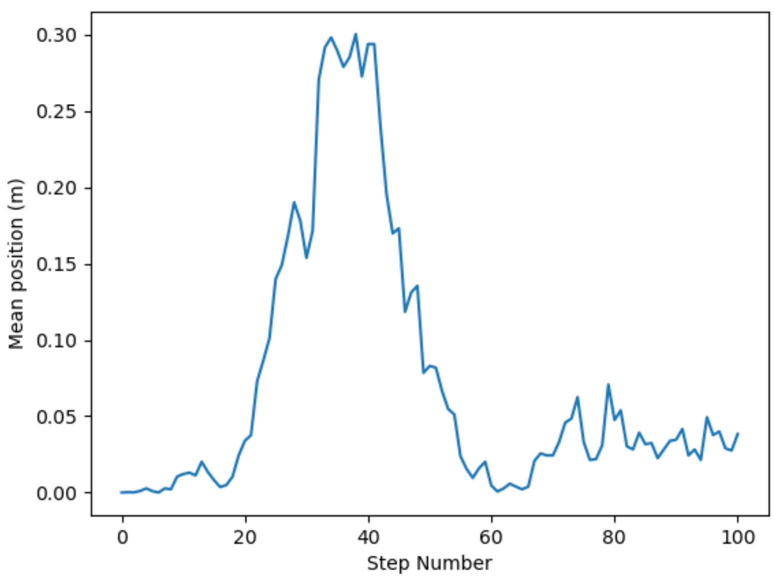

Figure 6: Mean displacement squared as a function of step number.