Assignment 8

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1 Cycling With Drag

Previously, we had solved for the velocity as a function of time for a cyclist that experienced no drag forces. This resulted in an unrealistic plot that showed an infinitely increasing velocity. To improve upon this model, we have now added a drag force $F_{drag} \approx -\frac{1}{2}C_D\rho A v^2$ with the drag coefficient $C_D = 0.9$, the surface area of the cyclist $A = 0.33\ \mathrm{m}^2$, the density of air $\rho = 1.225\ \mathrm{kg/m}^3$, and v is the velocity. The result of adding this term is plotted in Figure 1.

For improved accuracy, we can also add the viscous drag force $F_{drag,viscous} = -\eta A\frac{v}{h}$ with the viscosity of air $\eta = 2 \times 10^{-5}\ \mathrm{P \cdot s}$, and $h = 2$ m. As seen in Figure 2, the effect of the addition of this term is negligible for our situation.

We can also easily include the effect of a slope on this cyclist by including a term $F_{gravity,x} = F_g \sin\theta$ for the x-component of the force due to gravity. Here, $\theta = \arctan G$ is the angle of inclination with the slope grade of 10 percent corresponding to $G = 0.1$. The result is plotted in Figure 3

2 Random Walk

A random walk of 100 steps was simulated where the walker could increase or decrease their position by one each step. The results for two trials can be seen in Figures 4 and 5.

The mean displacement and the mean displacement squared of 500 walkers was calculated and plotted for each step all the way to 100 steps. The results of this can be seen in Figure 6. As expected, the mean displacement remains around zero, and the mean displacement squared follows a linear trend with a slope of 1.

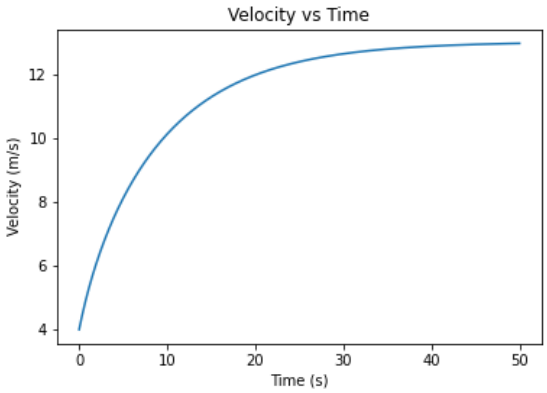

Figure 1: Velocity vs Time for a cyclist experiencing only the quadratic term of the drag force.

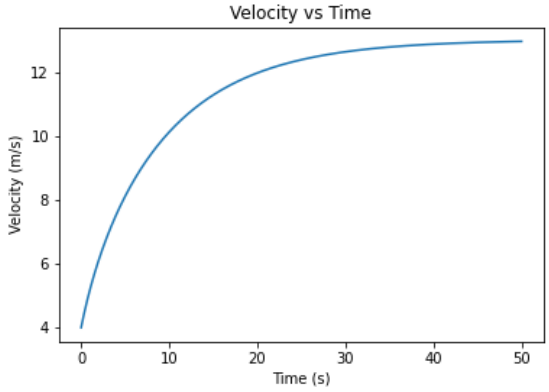

Figure 2: Velocity vs Time for a cyclist experiencing both the linear and the quadratic term of the drag force.

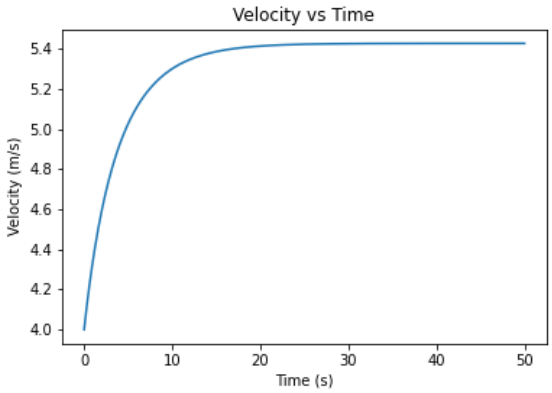

Figure 3: Velocity vs Time of a cyclist experiencing drag forces as well as additional horizontal acceleration that arises due to riding on a sloped surface.

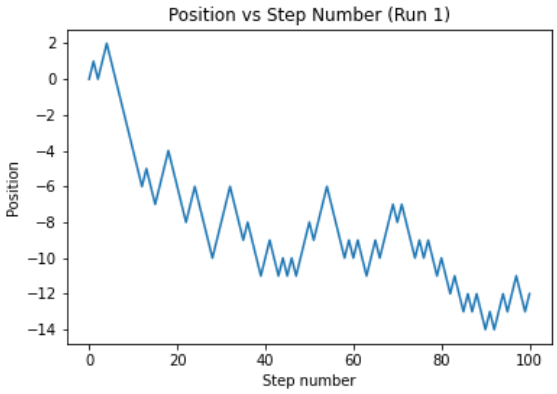

Figure 4: The position for each step in a simulated random walk (Trial 1).

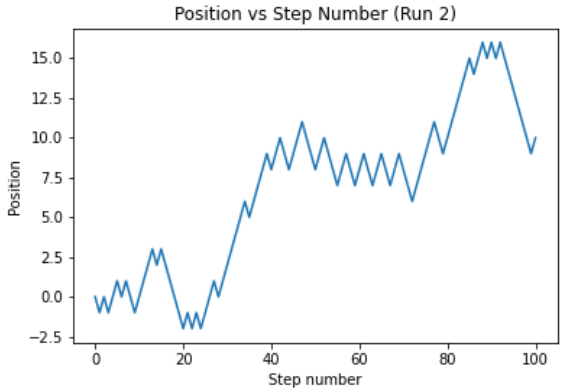

Figure 5: The position for each step in a simulated random walk (Trial 2).

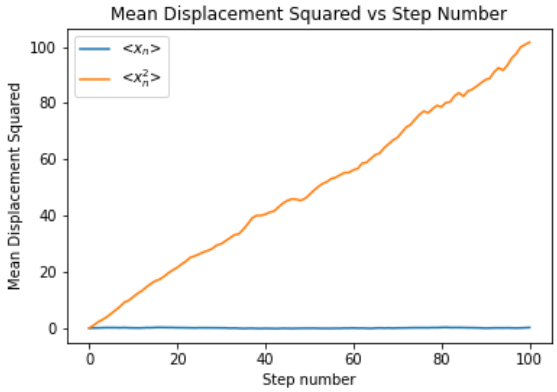

Figure 6: The mean displacement of 500 walkers for each step plotted in blue, and the mean displacement squared of 500 walkers for each step plotted in orange.