**A Tale of Two (Velo)Cities**

**Estimating the Distance Between Two Objects**

**Background:**

If you have taken calculus based kinematics in a physics class, you know that the velocity of an object can be calculated as the derivative of the position. In fact, we have worked through many examples of this in class. Conversely, this also means that the integral (anti-derivative) of the velocity of an object can provide you with the position.

Assume now that we have two objects traveling in the same direction, but at different speeds. These two objects should then have different positions. We are able to capture measurements of the velocity of these two objects, but we need to know how far apart they are. We can do this by using integration and finding the area between the two velocity curves!

We know from calculus that taking the integral is equivalent to finding the area underneath a curve. In this case, finding the area underneath the velocity curve will tell us the position of the object at the end of the time interval.

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| Velocity Measurements v1(t) for Object 1 | Position of object 1 at t = 4: |
| Velocity Measurements v2(t) for Object 2 | Position of object 2 at t = 4: |

We can use this same idea of finding the position using the area underneath the velocity curve to determine the distance between the two objects. If you have two objects at known positions, you can calculate the distance between them simply by finding the difference in their locations. For instance, object 1 is sitting at x = 5m and object 2 is sitting at x = 2m, taking the difference shows us that object 1 is 3m away from object 2.

Since the area underneath the velocity curve is the current position of the object, the area between the two curves (position of object 1 – position of object 2) will tell us the distance between the two objects.

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|  | Distance between object 1 and object 2 at t = 4: |

If you have mathematical functions describing the velocities for the two objects, performing this operation is somewhat trivial. However, if all you have are the velocity measurements collected during the experiment, you will need to use one of the numerical estimates for the integral in order to estimate the distance between the objects.

**Assignment:**

Download the Velocity\_Data.mat file. This file contains 6 vectors describing the data collected during two runs of an experiment:

1. run1\_vel\_ob1 – the velocity measurements for object 1 during the first experiment
2. run1\_vel\_ob2 – the velocity measurements for object 2 during the first experiment
3. run1\_time – the times at which the velocity measurements were acquired during the first experiment
4. run2\_vel\_ob1 – the velocity measurements for object 1 during the second experiment
5. run2\_vel\_ob2 – The velocity measurements for object 2 during the second experiment
6. run2\_time – the times at which the velocity measurements were acquired during the second experiment

***Write a script*** that will use the velocity measurements to estimate the distance between the two objects over the course of their travels, using Simpson’s Rule. Your function should produce the following:

1. Your estimate for the final distance between the two objects
2. A graph of the estimated positions of both objects over the length of their travels.
3. A graph of the estimated distance (compute distance as object 2 – object 1) between the two objects over the length of their travels.

Run your program for each set of data (run 1 and run 2) and record the results.

**Questions for Thought:**

Do your results for each experiment make sense given the velocity data? Why or why not?

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What could you do to improve the accuracy of the results?

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What is one of the potential drawbacks when using Simpson’s Rule if you were trying to analyze the data in real-time (i.e. as you are collecting it) when compared to other estimation methods?

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