

Week 2 Challenge Homework

Average Quantities and Graphical Analysis

Submit a digital copy (PDF, jpg, etc.) to gradescope.com. Please use the Gradescope interface to associate each page of your submission with the corresponding question number! It makes grading much easier.

Every page should be labeled on the top left with the question number and there should be only be one solution per page. If a solution takes more than one page, be sure to label that it is a continuation of the previous page's solution. If data is needed to complete a problem, be sure to cite the source you've acquired your data from. See the course website for further details.

You will be asked to apply sense-making in some problems. Use the list below as a reference to the different sense-making techniques. More information about sense-making can be found on the BoxSand menu under Math Tools => [Sense-making](#).

- *Sign*: Check the **sign** of each quantity makes sense.
- *Dimensionality*: Check the **dimensionality** and units of each quantity makes sense.
- *Order of Magnitude*: Check the **order of magnitude** of the final answer and other important quantities is within a factor of 10 of what you think it should be.
- *Graphical Analysis*: Use a **graph** to see if the behavior of a solution makes sense.
- *Proportionality*: Using a symbolic solution, check the behavior of the answer when you change a given quantity on which it is dependent. Does the answer vary **proportionally** to what you expect?
- *Special Cases*: Check the behavior of a derived equation in limiting (**special**) cases makes sense, e.g. as x goes to 90 degrees in $\sin(x)$.
- *Self-consistency*: Check derived equations, functions, or values, are **self-consistent**, e.g. check that the slope of a derived position plot matches the values of the given velocity plot
- *Known Values*: Compare given or derived quantities with common well **known values**.
- *Related Quantities*: Compare the relative magnitude of two **related quantities**.

Question 1:

During the middle of a family picnic, Barry Allen received a message that his friends Bruce and Hal needed to be saved. Barry promised his wife Iris that he would be back in exactly 5 minutes. From that picnic location, Barry runs at a speed of 600 m/s for 2 minutes at a heading of 35° north of west to save Bruce. He then changed his heading to 30° west of north, slows down to 400 m/s and runs for 1 minute to save Hal. (The changes in speed are essentially instantaneous and not part of solving this problem).

- Draw a physical representation of the displacement during Barry's full trip.
- Use the *Related Quantities* sense-making technique to compare Barry's total distance traveled to the magnitude of his displacement.
- What average velocity (magnitude and direction) does Barry need to return back to the picnic in order to keep his promise to Iris?

Question 2:

The graph shows the speed as a function of time for a corvette as it accelerates from rest to its top speed of about 202 mph on a straight horizontal road.

- About how many seconds does it take this corvette to go from 0 mph to 60 mph.
- About what percentage of the total time does the corvette spend in each gear?
- Estimate the average acceleration in 1st gear.
- What is the speed of the corvette at 11 seconds?
- Estimate the total distance the corvette travels from its starting location to the location when it reaches the top speed (end of curve).
- Use the *Order of Magnitude* sense-making technique to check your answer to part (e).

