Week 10 Challenge Homework

Sound Intensity Level, Doppler Effect, Beats

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 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:

You're convinced the opera is almost over because of the large person singing a loud vibrato.

(a) If the sound intensity level (dB) increases from one note to the next by 1 dB, what is the percent increase in the intensity?
(b) The singer comes over to your side of the stage, only 10 m away, and your phone applet tells you the sound intensity level is 85 dB. What is the power coming from their voice?
(c) All of the sudden 4 more identically loud people come out of nowhere and join the first person. You think to yourself, will it ever end. Three of them are standing next to the first person and the fourth is on the other side of the stage, twice as far from you as the group of singers. What is the sound intensity level now?

Question 2:

A stationary professor Farnsworth is trying to determine who will win the intergalactic go-kart race. The only two contenders left are Leela and Fry, with Leela trailing Fry by 50 m and Fry 50 m from the finish line. Both engines produce identical 600 Hz tones. Fry thought if pushing one of the pedals down made him go fast, then pushing them both down would make him go faster. As a consequence he is pressing down on both the brake and the gas and is traveling slower than Leela. Fry maintains a steady pace of 10 m/s traveling away from the professor, as shown in the figure. The professor uses his "frequency-O-meter" to determine that there is a 54 Hz sound at his location in addition to the sound from the engines. This additional sound is coming from the beat frequency generated by hearing both Leela and Fry's Doppler shifted sounds at the same time. Whenever two different frequency sounds are present at the same time there will be a third frequency generated called the beat frequency. This frequency is equal to absolute value of the difference in the two other frequencies.

(a) How fast is Leela traveling at that time?
(b) If both racers maintain a constant speed, who will win the race? Show your work.