Week 1 Challenge Homework

Two Source Interference and Wave Optics

Submission Details | Submit a digital copy (PDF, jpg, etc.) to Canvas. Include solutions to the metacognitive exercise and each question. Please use the interface to associate each page of your submission with the assignment. It makes grading much easier. Please clearly indicate which question is being solved. If data is needed to complete a problem, be sure to cite the source you've acquired your data from. Typed work will not receive credit. See the course website for further details.

Group Submissions | You may submit a group collaboration to Canvas. Add each group member to the submission. Each group member should contribute to the work. Clearly indicate which part of the submission is written by each member (color or labels are preferable).

Sensemaking | You will be asked to apply sensemaking in some problems. More information about sense-making can be found on the BoxSand Sensemaking page, which is linked on the Canvas homepage.

Metacognitive Exercise

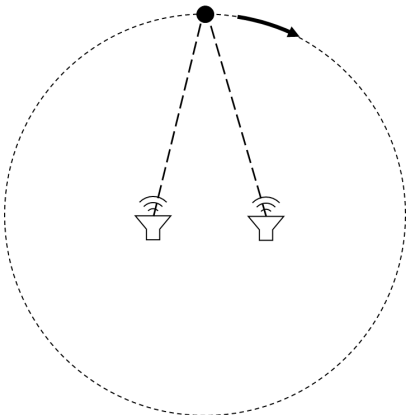
Each week will feature a metacognitive exercise, followed by one or two challenge problems to solve. The metacognitive exercise will usually ask you to reflect on your solution to the previous week's challenge problems.

Usually, you will be asked to review your solution from the previous week's Challenge Homework. Also, you may be asked to review a solution which will be posted to the BoxSand solutions archive (click here for a link). Solutions are posted a few days after the assignment is due. This week, there is no previous solution, so we will do something different!

(a) Please review the **Challenge Homework Rubrics and Guidelines for Grading** and **Example Challenge Homework and Solution**. In the table below, or a similar table, please grade the example solution using the rubric that will be used to grade your own challenge homework solutions (hint: it's a good idea to check over your own solutions using this rubric before you turn them in!)

Category	None, attempted, developing, meets, or exceeds expectations	Reasoning (briefly)
Metacognition		
Clarity of Communication		
Earnest Attempt		
Physical Representation		
Sensemaking		

Question 1.



Two spherical speakers are placed 5 meters apart. They emit a constant tone of 686 Hz. You are standing on the dot in the picture, equidistant from each speaker. The speed of sound in air is 343 m/s.

(a) What is the wavelength of the sound emitted by the speakers?

(b) Is your starting position a point of constructive or destructive interference? Explain.

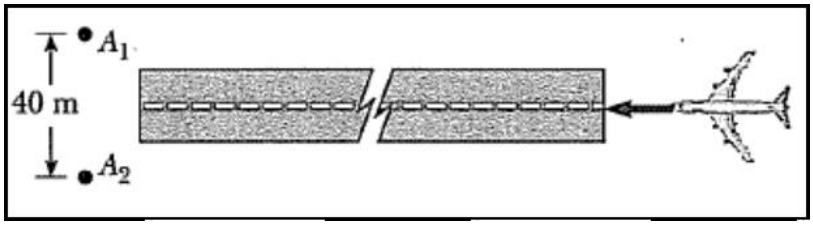
(c) How many spots of constructive interference do you experience if you walk in a complete circle around the speakers?

(d) Use covariational sensemaking to evaluate this situation by answering the following prompts:

- Make a prediction for how the number of constructive interference spots would change if the frequency were to increase.
- Explain your prediction using one or more algebraic relationships you used to solve part (c).
- Compare your prediction with the number of constructive interference spots observed if the frequency of the speakers is tripled.

Question 2.

Young's double-slit experiment underlies the instrument landing system used to guide aircraft to safe landings when the visibility is poor. Although real systems are more complicated than the example described here, they operate on the same principles. A pilot is trying to align her plane with a runway as suggested in the figure. Two radio antennas A_1 and A_2, separated by 40.0 m, are positioned adjacent to the runway. The antennas broadcast single frequency, 30.0 MHz, coherent radio waves.



(a) Find the wavelength of the waves. The pilot "locks onto" the strong signal radiated along an interference maximum and steers the plane to keep the received signal strong. If she detects the central maximum, the plane will have the right heading to land when it reaches the runway.

(b) Suppose instead that the plane is flying along the first side maximum, one maximum from the central. How far to the side of the runway centerline is the plane when it is 2.00 km from the antennas?

(c) It is possible to tell the pilot she is on the wrong maximum by sending out two signals from each antenna and equipping the aircraft with a two-channel receiver. The ratio of the two frequencies must not be the ratio of small integers (such as 3/4). Explain how this two-frequency system would work, and why it would not necessarily work if the frequencies were related by an integer ratio. In your explanation, make sure to draw a diagram (physical representation) of a system which uses two distinct frequencies (it's probably most helpful to draw this for two frequencies that ARE related by a ratio of small integers).