

Homework 5

Wave models, interference and diffractions

Due Friday Nov 8 at 5pm

1. Term Project Part 2

Read the feedback that the instructor provided on Gradescope (Homework #4) and choose a subject/question to develop further. If your subject/question has not been endorsed yet by the instructor, please check with the instructor.

Develop your rich context homework question as much as you can. By completing a good draft this week, you will get plenty of feedback and guidance from the instructor.

The *minimum* requirement for this week is that you

- (a) Pose a well-defined question that has a quantitative answer,
- (b) Write down the necessary information to calculate an answer,
- (c) Write a paragraph outlining how you'd like to solve the question (write down the whole solution if you want).
- (d) Write a few sentences describing what challenges you foresee to complete the term project, and how you plan to address the challenges.

2. Uncertainty (long answer format)

The 2013 Prius is a model of car known for having good aerodynamics. When a 2013 Prius is driving at 30 m/s (on cruise control), it converts energy to the kinetic energy of moving air at a rate

$$\frac{1}{2}\rho C_D A v^3$$

where

$\rho = 1.20 \pm 0.06 \text{ kg/m}^3$ (depends on the ambient air pressure and temperature)

$C_D = 0.29 \pm 0.01$ (changes when the suspension is weighted, i.e. more/less cargo)

$A = 2.72 \pm 0.03 \text{ m}^2$ (changes when the suspension is weighted, i.e. more/less cargo)

$v = 30 \pm 0.3 \text{ m/s}$ (cruise control is accurate to within ~ 1 mph)

- a) Calculate the energy rate, and the uncertainty in this rate.
- b) Which factor(s) contribute most to the uncertainty?

3. Frequency and wavelength

Q1B.6 from Unit Q, 3rd Edition

A sinusoidal wave moving down a taut rope has an observed wavelength of 2.0 m and a period of 0.5 s. What are k and ω for this wave? What is this wave's phase speed?

4. Energy carried by waves

Q1B.9 from Chpt 1 of Unit Q, 3rd Edition

Pluto is roughly 40 times farther from the Sun than the Earth is. Ignoring atmospheric effects, the intensity of sunlight falling on Pluto's surface should be about what factor smaller than that falling on Earth?

5. Wave interference

Based on Q3M.2 from Unit Q, 3rd Edition

Two radio antennas are 60 m apart. One antenna is directly north of the other. They broadcast a synchronized signal with a frequency of 100 MHz. Imagine that we have a detector 5.0 km to the east of the two antennas. We move the detector along a north-south line, monitoring the intensity of the signal at 100 MHz. What is the separation between adjacent "bright spots" measured by the detector?

6. Wave interference

Based on Q3M.4 from Unit Q, 3rd Edition

When you connect stereo speakers to an amplifier, it is important that the speakers be connected in phase, so that if a signal from the amplifier pushes the cone of one speaker out at a given time, it pushes the cone of the other speaker out at the same time.

Reversing the red/black wires on the input terminals of speaker 1 (but not on speaker 2) will make it so that the cone of speaker 1 is pulled in when the cone of speaker 2 is pushed out. Explain why this could be a problem, or at least undesirable. Would you still be able to hear the music?