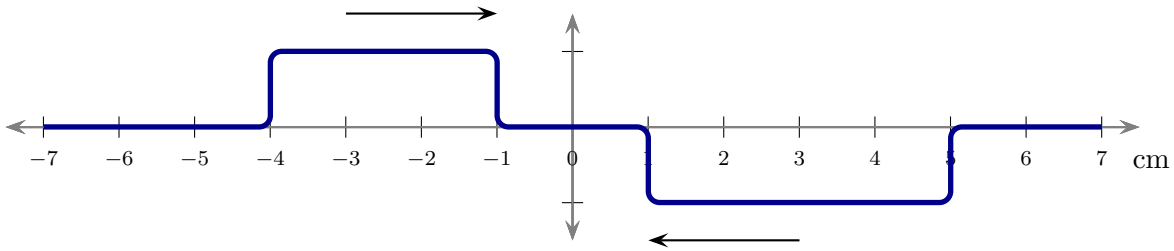
Concepts of Physics: Homework 9

Due: 10 November 2023

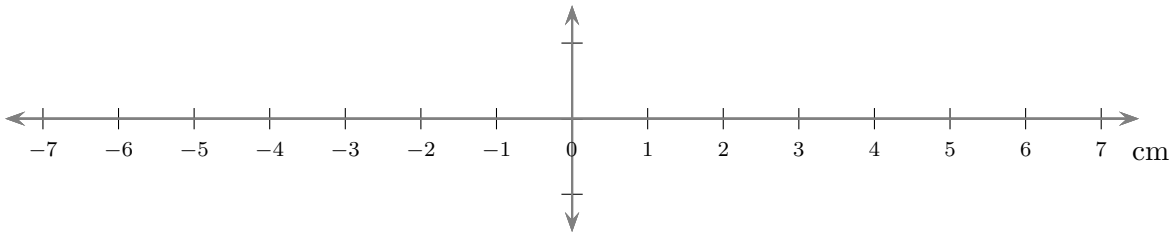
1 Interference of waves on a string

Two rectangular wave pulses move along a string with speeds 1 cm/s. Initially the string appears as illustrated.

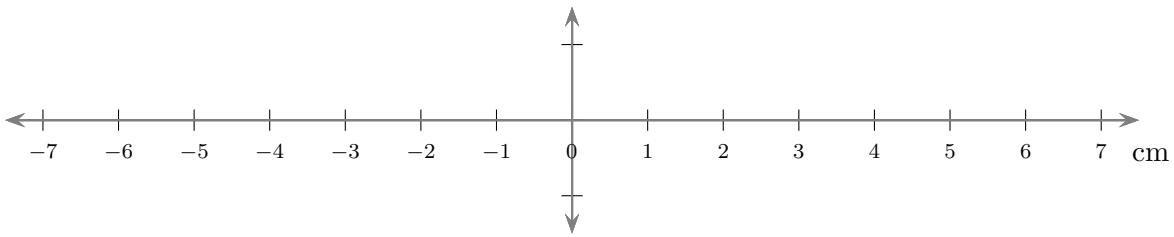


In the following questions the times refer to the time after this instant.

a) Illustrate the appearance of the string after 2 s has passed. Use the axes below to do this.

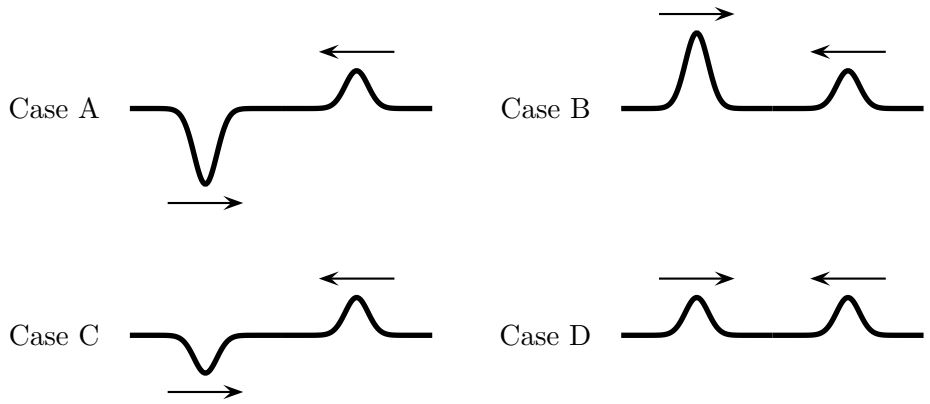


b) Illustrate the appearance of the string after 3 s has passed. Use the axes on the attached sheet to do this.



2 Interference of pulses

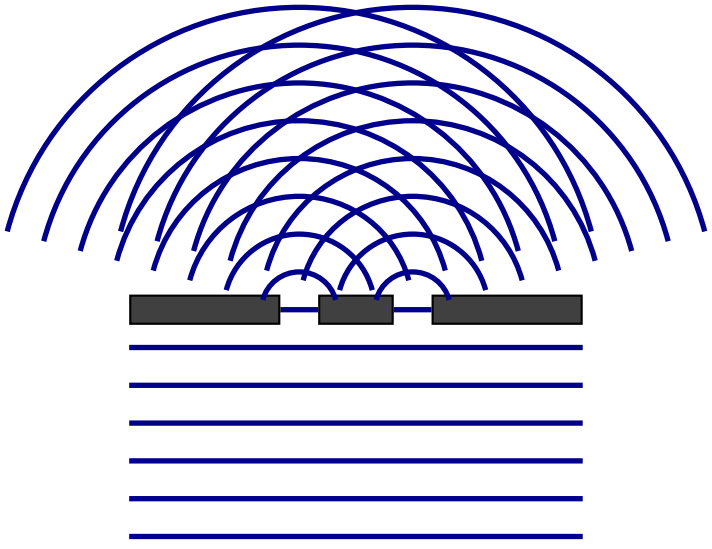
Various pulses approach each other as illustrated. The pulses overlap and interfere; when each does so there will be a point of maximum displacement away from the horizontal.



Rank the situations in order of increasing maximum displacement away from the horizontal during interference (indicate any ties in the ranking). Explain your answer.

3 Interference from two slits

The following diagram illustrates the crests of circular waves that pass through each of two slits.

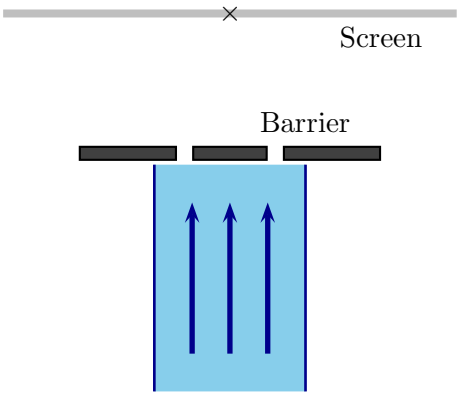


a) Indicate the lines along which constructive interference occurs and the points at which bright spots will appear on the screen.

b) Use a similar diagram to indicate the changes in the locations of the bright spots when the wavelength of the light increases. Are they further apart, closer together or do they have the same spacing as a result of the change in wavelength?

4 Light passing through two slits: competing models

Consider light that arrives at a barrier with two slits. The intensity of the light could be observed at the point on the screen (×) directly opposite to the midpoint of the barrier and slit arrangement.



a) Consider a model of light in which light consists of small particles that travel in straight lines. What would this model predict for the intensity that would be observed at the marked point on the screen? Explain your answer.

b) Consider a model of light in which light consists waves. What would this model predict for the intensity that would be observed at the marked point on the screen? Explain your answer.

c) Explain *how* you could use such a barrier and slit arrangement to decide which model of light is correct. *Note: you do not need to say which is known to be correct. You do need to provide a procedure (list of steps) that you could use to check. You need to state what the possible results of the procedure are and how you would use these to decide which model is correct.*

5 Interference patterns and wavelengths

Both red and green light produce interference patterns when incident on a double slit arrangement. It is observed that the interference pattern produced by the green light is narrower than that produced by the red light (i.e. the bright spots are closer together). Based on this, is the wavelength of the red light larger or smaller than that of the green light? Explain your answer.

6 Electromagnetic spectrum

a) An electromagnetic wave has frequency 3.0×10^{13} Hz. In which part of the spectrum (e.g. visible, ultraviolet,...) does this fall?

b) Is the frequency of ultraviolet light larger than or smaller than the freqeucny of infrared light?

7 Reading exercise: photons

Read section 12.2 of chapter 12 (pages 277–281). The following exercises are intended to give you an understanding of the concepts presented in the text.

a) You learned that the double slit experiment provided evidence for the wave nature of light. Consider Fig. 12.3 and the accompanying text ("How do we know light is quantized?"). Does this experiment still provide completely compelling evidence for the wave nature of light?

b) According to the text, is a photon truly like a particle, in the sense that it occupies exactly one location in space at any single moment?

c) Do Concept Check 1. After you have done it check the answer at the end of the text.

d) Do Conceptual Exercise 7 on page 292. After you have done it check the answer at the end of the text.