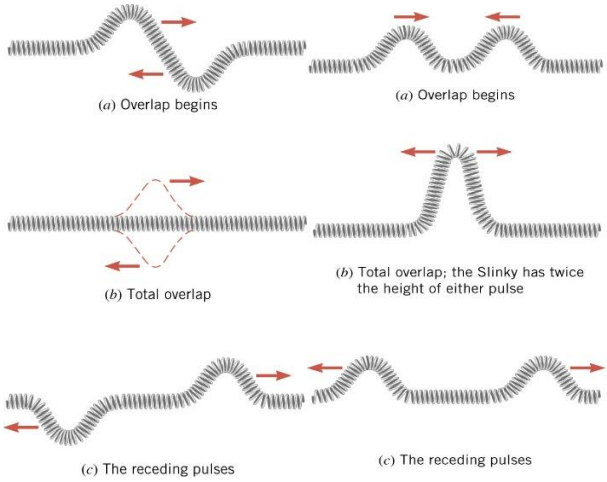
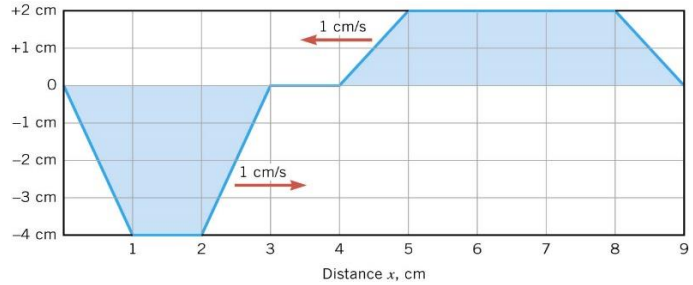
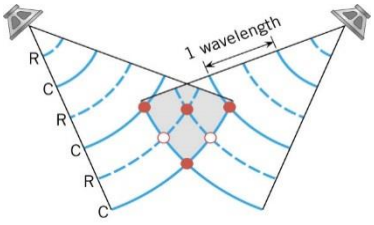
Superposition

- Often _____ or more wave _____ move through the same _____ at once
- When two or more waves are present _____ at the same place, the _____ disturbance is the _____ of the disturbances from _____ waves



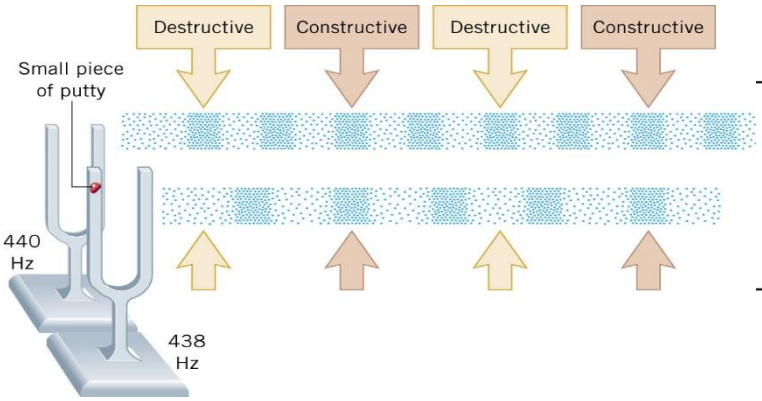


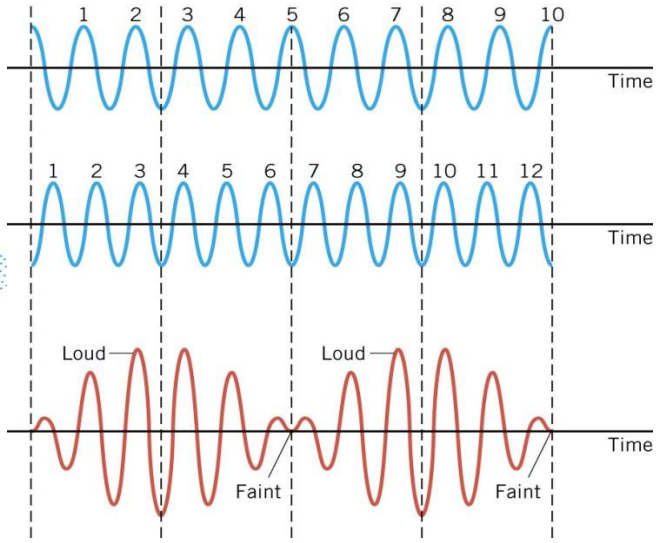
After 2 seconds, what is the height of the resultant pulse at x = 2, 4, and 6 cm?



Beats

- When two _____ are the _____
- Constructive and Destructive Interference give _____ the amplitude or _____ amplitude
- What if the two frequencies are just slightly _____?





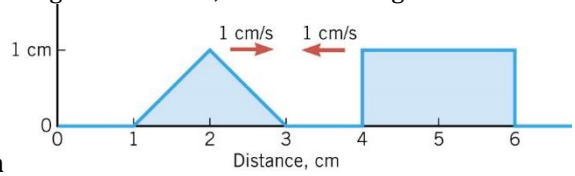
- Beat Frequency = _____ of the two _____ frequencies

$$Beats = |f_1 - f_2|$$

Two car horns have an average frequency of 420 Hz and a beat frequency of 40 Hz. What are the frequencies of both horns?

Homework

1. Speakers in stereo systems have two color-coded terminals to indicate how to hook up the wires. If the wires are reversed, the speaker moves in a direction opposite that of a properly connected speaker. Explain why it is important to have both speakers connected the same way.
2. Does the principle of linear superposition imply that two sound waves, passing through the same place at the same time, always create a louder sound than either wave alone? Explain.
3. A tuning fork has a frequency of 440 Hz. The string of a violin and this tuning fork, when sounded together, produce a beat frequency of 1 Hz. From these two pieces of information alone, is it possible to determine the exact frequency of the violin string? Explain.
4. A car has two horns, one emitting a frequency of 199 Hz and the other emitting a frequency of 203 Hz. What beat frequency do they produce? (OpenStax 16.57) **4 hz**
5. The middle-C hammer of a piano hits two strings, producing beats of 1.50 Hz. One of the strings is tuned to 260.00 Hz. What frequencies could the other string have? (OpenStax 16.58) **261.50 Hz, 258.50 Hz**
6. Two tuning forks having frequencies of 460 and 464 Hz are struck simultaneously. What average frequency will you hear, and what will the beat frequency be? (OpenStax 16.59) **462 Hz, 4 Hz**
7. Twin jet engines on an airplane are producing an average sound frequency of 4100 Hz with a beat frequency of 0.500 Hz. What are their individual frequencies? (OpenStax 16.60) **4099.750 Hz, 4100.250 Hz**
8. Three adjacent keys on a piano (F, F-sharp, and G) are struck simultaneously, producing frequencies of 349, 370, and 392 Hz. What beat frequencies are produced by this discordant combination? (OpenStax 16.62) **21 Hz, 22 Hz, 43 Hz**
9. Two pulses are traveling toward each other, each having a speed of 1 cm/s. At t = 0 s, their positions are shown in the drawing. When t = 1 s, what is the height of the resultant pulse at (a) x = 3 cm and at (b) x = 4 cm? (Cutnell 17.1) **2 cm, 1 cm**



10. Two speakers, one directly behind the other, are each generating a 245-Hz sound wave. What is the smallest separation distance between the speakers that will produce destructive interference at a listener standing in front of them? The speed of sound is 343 m/s. (Cutnell 17.2) **0.700 m**
11. Two out-of-tune flutes play the same note. One produces a tone that has a frequency of 262 Hz, while the other produces 266 Hz. When a tuning fork is sounded together with the 262-Hz tone, a beat frequency of 1 Hz is produced. When the same tuning fork is sounded together with the 266-Hz tone, a beat frequency of 3 Hz is produced. What is the frequency of the tuning fork? (Cutnell 17.16) **263 Hz**
12. A 440-Hz tuning fork is sounded together with an out-of-tune guitar string, and a beat frequency of 3 Hz is heard. When the string is tightened, the frequency at which it vibrates increases, and the beat frequency is heard to decrease. What was the original frequency of the guitar string? (Cutnell 17.18) **437 Hz**
13. A tuning fork vibrates at a frequency of 524 Hz. An out-of-tune piano string vibrates at 529 Hz. How much time separates successive beats? (Cutnell 17.20) **0.2 s**