CH21-3 – Standing Waves

Important Ideas

- When two waves are add to give a larger wave, it is called **constructive** interference. When the two waves add and give a smaller wave, it is called **destructive** interference.
- A wave that reflects from a fixed boundary is inverted. A wave that reflects from a free boundary is not inverted.
- For standing waves on a string that is fixed at both ends:

$$\begin{aligned} \lambda &= \frac{2L}{n} \\ f_n &= \frac{n}{2L}v \\ f_n &= nf_1 \end{aligned}$$

1. If these two waves add together, will the result be constructive or destructive interference?

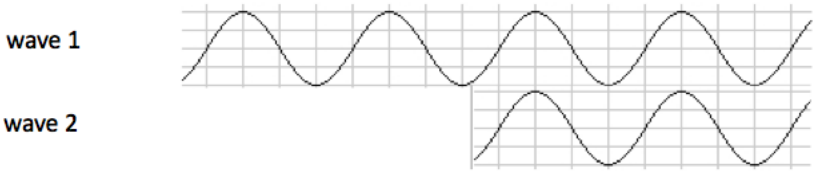


Figure 1: Superposition of two sinusoidal waves.

2. If these two waves add together, will the result be constructive or destructive interference?

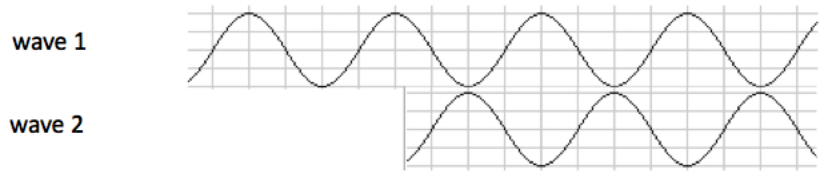
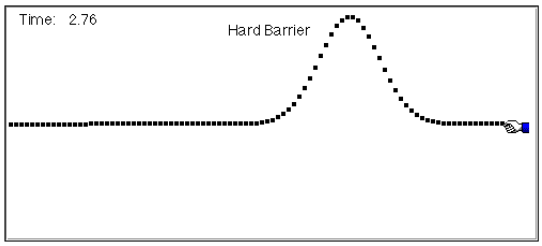
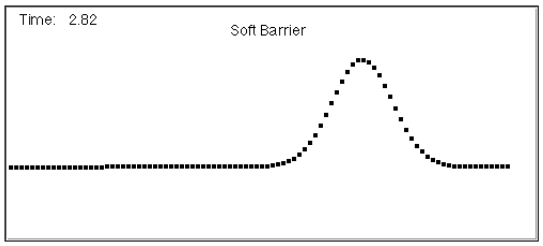


Figure 2: Superposition of two sinusoidal waves.

3. A pulse travels to the right and reflects off the right end where it is held fixed. Sketch the reflected pulse.



4. A pulse travels to the right and reflects off the right end which is free to move. Sketch the reflected pulse.



5. Sketch the first four harmonics for a standing wave on a string that is fixed at both ends. Label each graph with the harmonic (n). If the length of the string is 1 m, write the wavelength for each harmonic.

6. The fundamental standing wave occurs for a frequency 5 Hz. Predict the frequencies for the second, third, and fourth harmonic.

   - $n = 2$: $f_2 =$
   - $n = 3$: $f_3 =$
   - $n = 4$: $f_4 =$

7. The harmonic (n) is equal to the number of _____ of a standing wave.

   (a) nodes + 1
   (b) nodes
   (c) antinodes
   (d) antinodes -1
   (e) none of the above

8. What harmonic (n) is a standing wave with this shape?

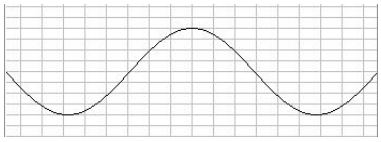


Figure 3: A standing wave at an instant t.

   (a) 2
   (b) 3
   (c) 4
   (d) 5

9. A standing wave at a certain instant of time is shown below.

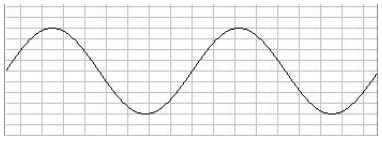


Figure 4: A standing wave at an instant t.

How many nodes and antinodes does the standing wave have?

(a) 5 nodes, 4 antinodes
(b) 4 nodes, 4 antinodes
(c) 3 nodes, 2 antinodes
(d) 6 nodes, 5 antinodes

10. If the length of the string is 2 m, what is the wavelength of the wave in Figure 3?

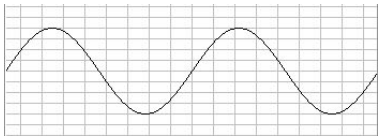


Figure 5: A standing wave at an instant t.

(a) 0.5 m
(b) 1.0 m
(c) 1.5 m
(d) 2.0 m

11. In an experiment, transverse standing waves on a string are produced by an oscillator. The frequency of the oscillator is constant. As you increase the tension:

(a) Does the harmonic (n) increase, decrease, or stay the same?
(b) Does the wavelength of the standing waves increase, decrease, or stay the same?
(c) Does the speed of a wave on the string increase, decrease, or stay the same?

12. In an experiment, transverse standing waves are produced on a long spring. The tension is kept constant. You find that a frequency of 2 Hz is sufficient to produce the fundamental standing wave. What frequency is required for the second harmonic and third harmonic?

13. If the spring in the previous question has a length of 3 m, what is the speed of a wave on the spring?

14. On a guitar string (or piano string or violin string), the spring approximately oscillates as a standing wave with $n = 1$ (i.e. the fundamental). So, this stays constant, regardless of other variables. If you increase the tension of the string:

    (a) Does the wavelength increase, decrease, or stay the same?

    (b) Does the frequency increase, decrease, or stay the same?

    (c) Does the speed of a wave on the string increase, decrease, or stay the same?

15. Suppose that the "top" string on a guitar and the "bottom" string on a guitar have the same tension.

    (a) Which string has a greater linear density (mass/length)?

    (b) Which string has the greater fundamental frequency?

16. If you decrease the length of a guitar string by pressing on one of the frets with your finger, the frequency will

    (a) Increase

    (b) Decrease

    (c) Remain constant

17. Suppose that an A-string on a guitar has a length of 0.765 m and linear mass density of 2 g/m. What tension is required for the A string of a guitar to produce a sound of 110 Hz?