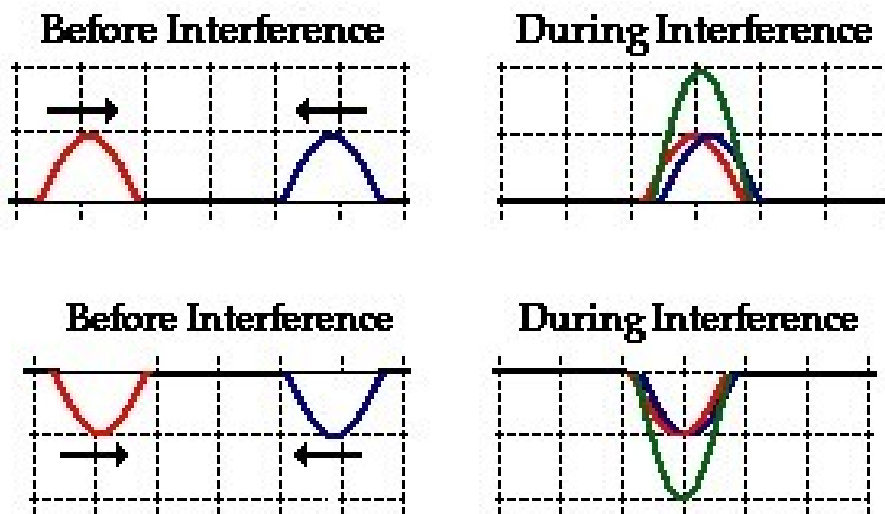


⇒ Principle of Superposition: The resultant displacement of a given particle is equal to the sum of the displacements that would have been produced by each wave acting independently.

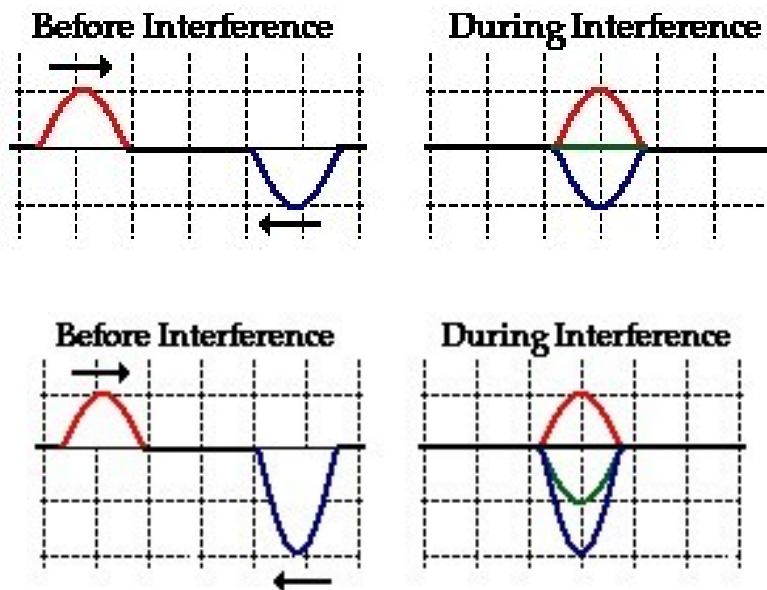
- Constructive interference results when two or more waves interfere to produce a resultant displacement greater than the displacement caused by either wave itself.



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- Destructive Interference is when the resultant displacement is smaller than the

displacement that would be caused by one wave by itself.

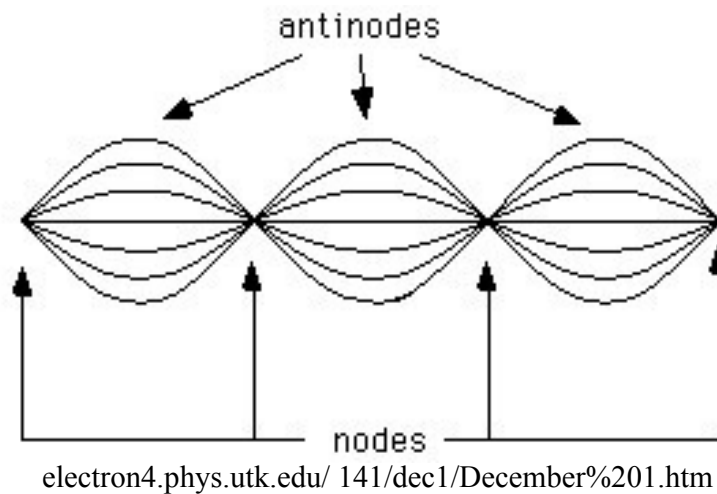


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Standing Waves: Interference in One Dimension

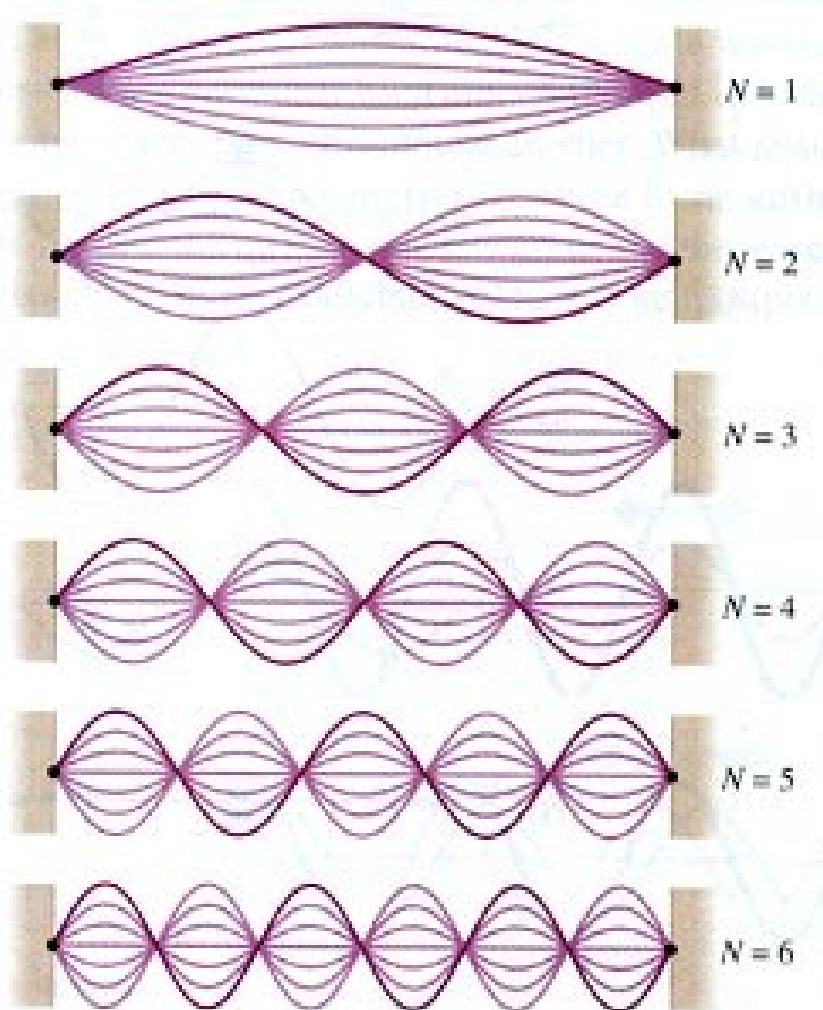
⇒ A standing wave interference pattern occurs if interfering waves have the same amplitude, wavelength, frequency, and are traveling in opposite directions.

- Called a standing wave for short.



- ⇒ The node, or nodal point, is where crests and troughs of equal amplitude interfere destructively. For one-dimensional waves the fixed ends are nodal points.
- ⇒ The antinodes, or loops, are areas of constructive interference.
- ⇒ The number of nodal points for a given medium depends on the physical structure of that medium, thus only certain frequencies will produce a standing wave pattern. Such frequencies are resonance frequencies for that medium.

⇒ If one antinode were created with a certain frequency, say f_1 , then to create two or three antinodes (etc.) the frequency would have to be $2f_1$, or $3f_1$ respectively. Note the decrease in amplitude as more antinodes are created.



- ⇒ The distance between two successive nodes in a vibrating string is $\frac{1}{2}\lambda$.
- ⇒ The point of maximum displacement from a node is $\frac{1}{4}\lambda$.

Examples

1. What is the wave speed of a standing wave containing 4.5 waves in 50 cm and waves are created 62 times each second?

$$v = ?$$

$$f = 62 \text{ Hz}$$

$$\lambda = ?$$

$$50 \text{ cm} = 4.5 \lambda$$

$$\lambda = 11.1 \text{ cm}$$

$$v = f \lambda$$

$$= (62)(11.1)$$

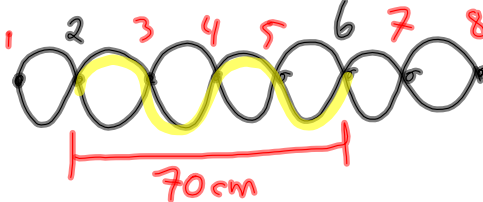
$$v = 688 \text{ cm/s}$$

2. A standing wave pattern contains 8 nodes (with a node at the beginning and end.) The distance between the second and 6th node 70 cm. The wave speed is 102 cm/s. What frequency is necessary to observe 3 antinodes?

$$v = 102 \text{ cm/s}$$

$$7 \text{ antinodes}$$

$$f_3 = ?$$

$$\text{Find } f_7 \Rightarrow$$


$$70 \text{ cm} = 2 \lambda$$

$$35 \text{ cm} = \lambda$$

$$v = f_7 \lambda$$

$$102 = f_7 (35)$$

$$\underline{2.9 \text{ Hz}} = f_7$$

$$f_3 = 3 f_1$$

$$f_1 = \frac{f_7}{7}$$

$$f_3 = \frac{3 f_7}{7} \leftarrow$$

$$f_3 = \frac{3(2.9)}{7} = \boxed{1.24 \text{ Hz}}$$

Problems 27 - 33
Pg 18-19 Ans: Pg 22

PRACTICE PROBLEMS

MHR: Pg. 341 # 1-4.

1. A metronome beats 54 times over a 55 s time interval. Determine the frequency and period of its motion.
2. Most butterflies beat their wings between 450 and 650 times per minute. Calculate in hertz the range of typical wing-beating frequencies for butterflies.
3. A watch spring oscillates with a frequency of 3.58 Hz. How long does it take to make 100 vibrations?
4. A child swings back and forth on a swing 12 times in 30.0 s. Determine the frequency and period of the swinging.

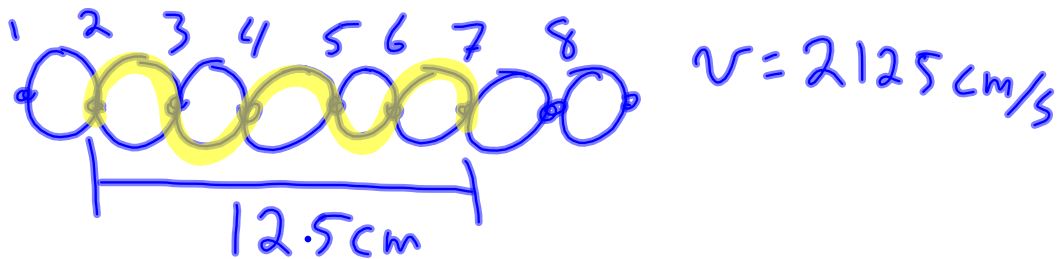
PRACTICE PROBLEMS

Pg. 349 # 5 – 9.

5. A longitudinal wave in a 6.0 m long spring has a frequency of 10.0 Hz and a wavelength of 0.75 m. Calculate the speed of the wave and the time that it would take to travel the length of the spring.
7. Tsunamis are fast-moving ocean waves typically caused by underwater earthquakes. One particular tsunami travelled a distance of 3250 km in 4.6 h and its wavelength was determined to be 640 km. What was the frequency of this tsunami?
8. An earthquake wave has a wavelength of 523 m and travels with a speed of 4.60 km/s through a portion of Earth's crust.
 - (a) What is its frequency?
 - (b) If it travels into a different portion of Earth's crust, where its speed is 7.50 km/s, what is its new wavelength?
6. Interstellar hydrogen gas emits radio waves with a wavelength of 21 cm. Given that radio waves travel at 3.00×10^8 m/s, what is the frequency of this interstellar source of radiation?
 - (c) What assumption(s) did you make to answer part (b)?
9. The speed of sound in air at room temperature is 343 m/s. The sound wave produced by striking middle C on a piano has a frequency of 256 Hz.
 - (a) Calculate the wavelength of this sound.
 - (b) Calculate the wavelength for the sound produced by high C, one octave higher than middle C, with a frequency of 512 Hz.

Problems for Understanding Chapter Review Pg. 372 # 21 – 28.

21. A pendulum takes 1.0 s to swing from the rest line to its highest point. What is the frequency of the pendulum?
22. By what factor will the wavelength change if the period of a wave is doubled?
23. A wave with an amplitude of 50.0 cm travels down a 8.0 m spring in 4.5 s. The person who creates the wave moves her hand through 4 cycles in 1 second. What is the wavelength?
24. A sound wave has a frequency of 60.0 Hz. What is its period? If the speed of sound in air is 343 m/s, what is the wavelength of the sound wave?
25. Water waves in a ripple tank are 2.6 cm long. The straight wave generator used to produce the waves sends out 60 wave crests in 42 s.
 - (a) Determine the frequency of the wave.
 - (b) Determine the speed of the wave.
26. A rope is 1.0 m long and the speed of a wave in the rope is 3.2 m/s. What is the frequency of the fundamental mode of vibration?
27. A tsunami travelled 3700 km in 5.2 h. If its frequency was 2.9×10^{-4} Hz, what was its wavelength?
28. A storm produces waves of length 3.5 m in the centre of a bay. The waves travel a distance of 0.50 km in 2.00 min.
 - (a) What is the frequency of the waves?
 - (b) What is the period of the waves?



$$12.5 \text{ cm} = 2.5 \lambda$$

$$5 \text{ cm} = \lambda$$

$$v = f \lambda$$

$$(2125) = f (5)$$

$$425 \text{ Hz} = f$$

$f_8 = \text{freq to}$

observe 8

anti-nodes

$$f_3 = 3f_1 \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} f_3 = \frac{3f_8}{8}$$

$$f_1 = \frac{f_8}{8}$$

$$= \frac{3(425)}{8} = \boxed{159 \text{ Hz}}$$