

Standing Waves

We know that waves move. Yet waves can be trapped between boundaries. These are known as *standing waves*.

A jump rope is a good example of a standing wave.



To keep a standing wave going, the ends have to have a driver that an end that gives energy to the wave. Jump ropes have two driven ends.

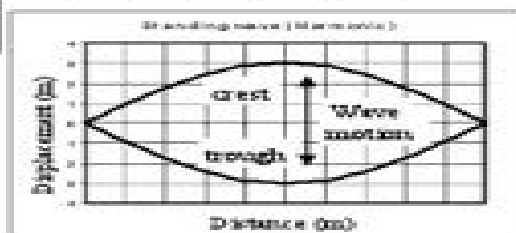
The places of no amplitude are called *nodes*. The places of greatest amplitude are called *anti-nodes*.



A moving wave.

Standing waves are **TRAPPED** between boundaries, so we show both the crest and the trough in the same place at the same time. In reality, though, it alternates: going up and down, just like a jump rope.

In a *moving wave*, the wave moves away from what drives it. Waves that move away from a rock in a pond are driven by the force of the rock pushing through the water.



A graph of the fundamental wave for this distance.

The largest wave that can be produced in a certain distance is called the *fundamental*. It is one-half of one wavelength long.

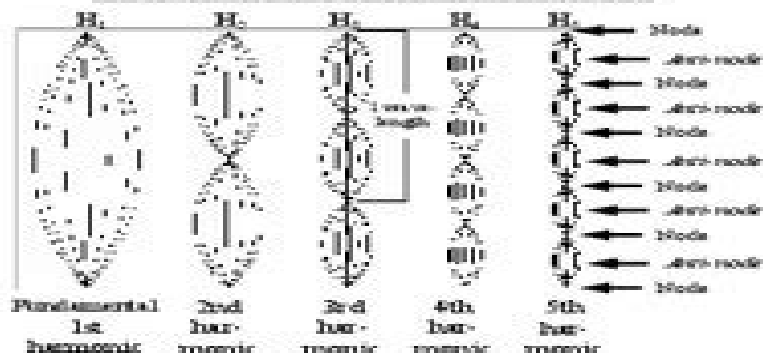
In a standing wave, each anti-node is one-half of a wavelength.

- 1 Anti-node = $(1/2)\lambda$
- 2 Anti-nodes = λ

Harmonics

Harmonics are waves that are whole number multiples of the fundamental. Harmonics sound louder, keep their energy longer, and take less energy to produce.

First 5 Harmonics of a Vibrating String



Frequency of Harmonics

$$\text{Frequency of harmonic } n \rightarrow f_{\text{nth}} = f_1 (n) \leftarrow \begin{matrix} \text{N of the} \\ \text{Harmonic} \end{matrix}$$

$$\uparrow$$

$$\text{Frequency of the fundamental (in Hz)}$$

Ex. Find the frequency of the third harmonic (H_3) of a 4 Hz fundamental.

$$f_1 = 4 \text{ Hz}$$

$$n = 3$$

$$f_{3\text{rd}} = ?$$

$$f_{3\text{rd}} = f_1 (n)$$

$$f_{3\text{rd}} = (4 \text{ Hz})(3)$$

$$f_{3\text{rd}} = 12 \text{ Hz}$$

Ex. If the fifth harmonic has a frequency of 55 Hz, find the fundamental frequency.

$$f_{5\text{th}} = 55 \text{ Hz}$$

$$n = 5$$

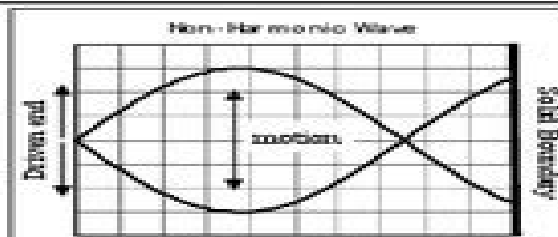
$$f_1 = ?$$

$$f_{5\text{th}} = f_1 (n)$$

$$f_1 = f_{5\text{th}}/n = 55 \text{ Hz}/5$$

$$f_1 = 11 \text{ Hz}$$

Non-harmonic waves can be forced into boundaries, too. The waves will die out quickly, sound quieter (if a sound wave), and take more energy to produce.



H_1 (f_1)	H_2	H_3	H_4	H_5
1 Hz	2 Hz	3 Hz	4 Hz	5 Hz
2 Hz	4 Hz	6 Hz	8 Hz	10 Hz
5 Hz	10 Hz	15 Hz	20 Hz	25 Hz
10 Hz	20 Hz	30 Hz	40 Hz	50 Hz

Standing Waves Worksheet 3 Key

Kathleen Armour



Standing Waves Worksheet 3 Key:

Cutnell & Johnson Physics John D. Cutnell, David Young, Kenneth W. Johnson, Shane Stadler, 2022 The newly revised Twelfth Edition of Cutnell's Physics delivers an effective and accessible introduction to college and university physics. It contains easy-to-follow explanations of critical math and problem-solving concepts. From kinematics to work and energy, temperature, heat, electricity, magnetism, and optics, as well as foundational concepts in more advanced subjects like special relativity. Physics is the ideal introductory text for students from any background. The greatest strength of the text is the synergistic relationship it develops between problem-solving and conceptual understanding. The book lays emphasis on building relevance of physics in day-to-day living and highlights the physics principles that come into play. A wide range of applications that are biomedical in nature and others that deal with modern technology. **Prentice Hall Science**

Explorer: Teacher's ed, 2005 *Sound and Light* Michael J. Padilla, Ioannis Miaoulis, Martha Cyr, Jay M. Pasachoff, 2002

Rhoades To Reading Fourth Edition, Level V Answer Key Jacqueline Rhoades, 2004 Reading program designed for adults grade 5 adult. Includes answers for activity sheets contained in the Level V Teacher Handbook. *Aviation Unit and Intermediate Maintenance Manual*, 1992 **The Physics of Sound and Music** Eric J. Pulver, 1998 **Fifth International**

Topical Meeting on Education and Training in Optics C. H. F. Velzel, 1997 *International Topical Meeting on Education and Training in Optics*, 1997 *Audio*, 1944 *Discourse Strategies for Science Teaching and Learning* Kok-Sing Tang, 2020-10-28 This engaging and practical volume looks at discourse strategies and how they can be used to facilitate and enhance science teaching and learning within the classroom context, offering a synthesis of research on classroom discourse in science education as well as practical discourse strategies that can be applied to the classroom. Focusing on the connection between research and practice, this comprehensive guide unpacks and illustrates key concepts on the role of discourse in students' thinking and learning based on empirical analysis of real conversations in a number of science classrooms. Using real-life classroom examples to extend the scope of research into science classroom discourse begun during the 1990s, Kok-Sing Tang offers original discourse strategies as explicit methods of using discourse to engage in meaning-making and work towards a specific instructional goal. This volume covers new and informative topics including how to use discourse to establish classroom activity and interaction, build and assess scientific content knowledge, organize and evaluate scientific narrative, enact scientific practices, coordinate the use of multimodal representations, and building on more than ten years of research on classroom discourse. *Discourse Strategies for Science Teaching and Learning* is an ideal text for science teacher educators, pre-service science teachers, scholars, and researchers.

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