

## Standing Waves

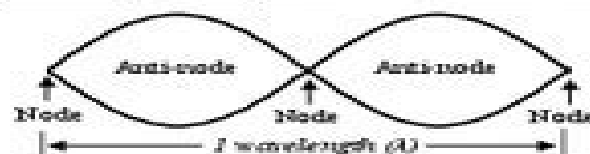
We know that waves move. Yet waves can be trapped between boundaries. These are known as *standing waves*.

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



To keep a standing wave going it needs to have a *driven end* and 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.

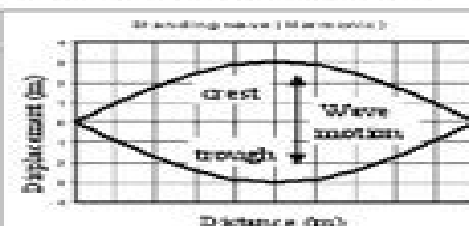
Standing waves are **TRAPPED** between boundaries, so we show both the crest and the trough in the same place at the same time. In reality, though, it alternates: going up and down, just like a jump rope.

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

$$1 \text{ Anti-node} = (1/2)\lambda$$

$$2 \text{ Anti-nodes} = \lambda$$

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.



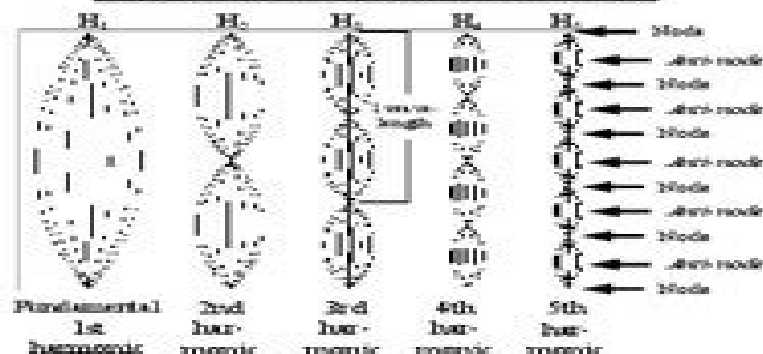
A graph of the fundamental wave for this distance.

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

### 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

$$\text{Frequency of harmonic } n \rightarrow f_{Hz} = f_1 (\infty) \leftarrow \begin{matrix} \uparrow \\ \text{Frequency of the} \\ \text{fundamental (in Hz)} \end{matrix} \leftarrow \begin{matrix} \leftarrow \\ \text{N of the} \\ \text{Harmonic} \end{matrix}$$

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

$$\begin{matrix} f_1 = 4 \text{ Hz} \\ n = 3 \\ f_{Hz} = ? \end{matrix} \quad \begin{matrix} f_{Hz} = f_1 (\infty) \\ f_{Hz} = (4 \text{ Hz}) \times (3) \\ f_{Hz} = \underline{12 \text{ Hz}} \end{matrix}$$

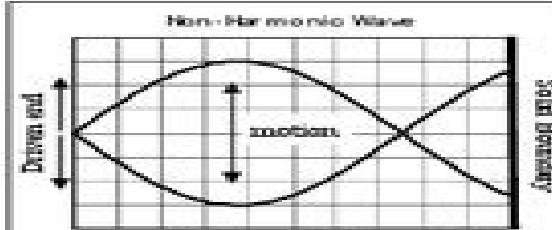
Ex. If the fifth harmonic has a frequency of 55 Hz, find the fundamental frequency.

$$\begin{matrix} f_{Hz} = 55 \text{ Hz} \\ n = 5 \\ f_1 = ? \end{matrix} \quad \begin{matrix} f_{Hz} = f_1 (\infty) \\ f_1 = f_{Hz} / n = 55 \text{ Hz} / 5 \\ f_1 = \underline{11 \text{ Hz}} \end{matrix}$$

#### Examples of Fundamentals and their Harmonics

$H_1$ (f)	$H_2$	$H_3$	$H_4$	$H_5$
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

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.



# Standing Waves Worksheet 3 Key

**Michael Hoelscher**

A red circular graphic with a gradient, appearing as a semi-circle or a partial circle, located to the right of the author's name.

### 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, 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.

The Top Books of the Year Standing Waves Worksheet 3 Key The year 2023 has witnessed a remarkable surge in literary brilliance, with numerous captivating novels enthralling the hearts of readers worldwide. Lets delve into the realm of bestselling books, exploring the fascinating narratives that have enthralled audiences this year. Standing Waves Worksheet 3 Key : Colleen Hoover "It Ends with Us" This touching tale of love, loss, and resilience has gripped readers with its raw and emotional exploration of domestic abuse. Hoover masterfully weaves a story of hope and healing, reminding us that even in the darkest of times, the human spirit can succeed. Standing Waves Worksheet 3 Key : Taylor Jenkins Reids "The Seven Husbands of Evelyn Hugo" This intriguing historical fiction novel unravels the life of Evelyn Hugo, a Hollywood icon who defies expectations and societal norms to pursue her dreams. Reids captivating storytelling and compelling characters transport readers to a bygone era, immersing them in a world of glamour, ambition, and self-discovery. Standing Waves Worksheet 3 Key : Delia Owens "Where the Crawdads Sing" This mesmerizing coming-of-age story follows Kya Clark, a young woman who grows up alone in the marshes of North Carolina. Owens weaves a tale of resilience, survival, and the transformative power of nature, captivating readers with its evocative prose and mesmerizing setting. These bestselling novels represent just a fraction of the literary treasures that have emerged in 2023. Whether you seek tales of romance, adventure, or personal growth, the world of literature offers an abundance of captivating stories waiting to be discovered. The novel begins with Richard Papen, a bright but troubled young man, arriving at Hampden College. Richard is immediately drawn to the group of students who call themselves the Classics Club. The club is led by Henry Winter, a brilliant and charismatic young man. Henry is obsessed with Greek mythology and philosophy, and he quickly draws Richard into his world. The other members of the Classics Club are equally as fascinating. Bunny Corcoran is a wealthy and spoiled young man who is always looking for a good time. Charles Tavis is a quiet and reserved young man who is deeply in love with Henry. Camilla Macaulay is a beautiful and intelligent young woman who is drawn to the power and danger of the Classics Club. The students are all deeply in love with Morrow, and they are willing to do anything to please him. Morrow is a complex and mysterious figure, and he seems to be manipulating the students for his own purposes. As the students become more involved with Morrow, they begin to commit increasingly dangerous acts. The Secret History is a exceptional and suspenseful novel that will keep you wondering until the very end. The novel is a warning tale about the dangers of obsession and the power of evil.

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