Name _____ Date _____ Period _____

ZornScience
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Standing Waves Virtual Lab

Physics

Open **activities.zornscience.org/standing-waves-lab/** and follow each step. Use g = 9.81 m/s^2. Show your work with units.

Objective

Relate the **frequency**, **wavelength**, and **speed** of waves on a string, and find how **tension** and **density** change the speed.

NGSS alignment: HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

Practices and concepts: Using mathematics; Analyzing and interpreting data; Patterns; Cause and effect.

Meet the simulation

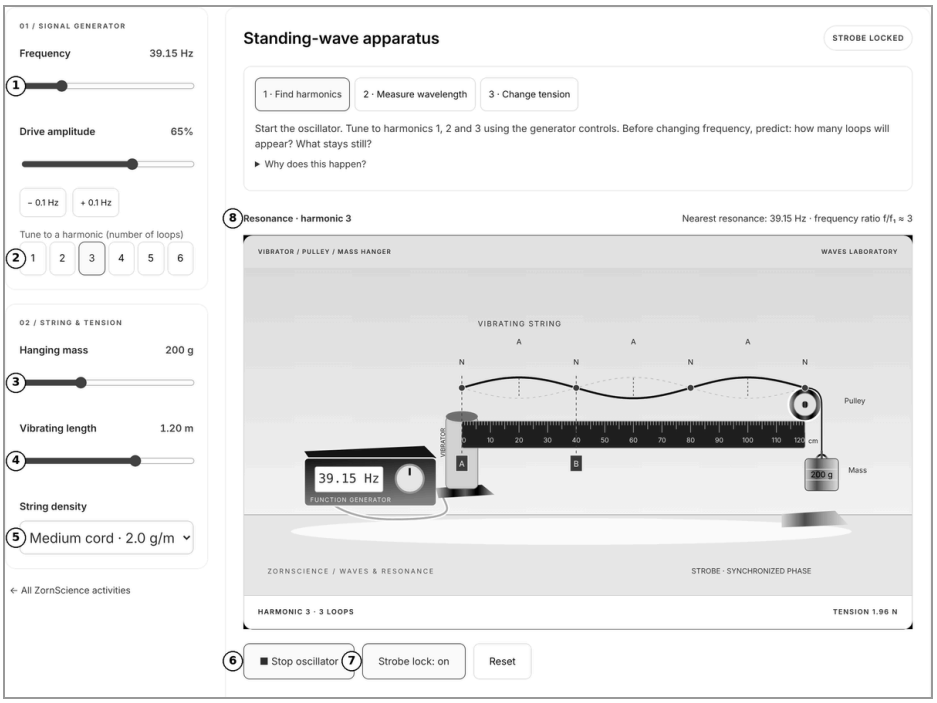


Figure 1. Harmonic 3 with nodes (N) and antinodes (A) labeled. Scene inverted for printing.

1. Generator frequency (Hz).
2. Harmonic buttons: tune exactly to 1 to 6 loops.
3. Hanging mass. Tension T = mg.
4. Vibrating length of the string.
5. String density (mass per meter).
6. Starts and stops the vibrator.
7. Strobe lock freezes the view.
8. Tells you when the string is at resonance.

Pre-lab

1. In a standing wave, what is a **node**? What is an **antinode**? How far apart are two neighboring nodes, in wavelengths?

2. A 200 g mass hangs from a string with density μ = 0.0020 kg/m. Calculate the tension, T = mg. Then calculate the wave speed, v = √(T/μ).

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Part A. Find the harmonics

1. Use the starting settings: hanging mass **200 g**, length **1.20 m**, **Medium cord · 2.0 g/m**, drive amplitude 65%. (Select **Reset** if you changed anything.)
2. Select **Start oscillator**, then **Strobe lock**, and check **Label nodes & antinodes**.
3. Select each harmonic button below. Record the frequency and count the nodes and antinodes (include both ends as nodes).
4. Select **Place cursors on adjacent nodes** (marker 1 in Figure 2). Record the cursor separation Δx (marker 2).

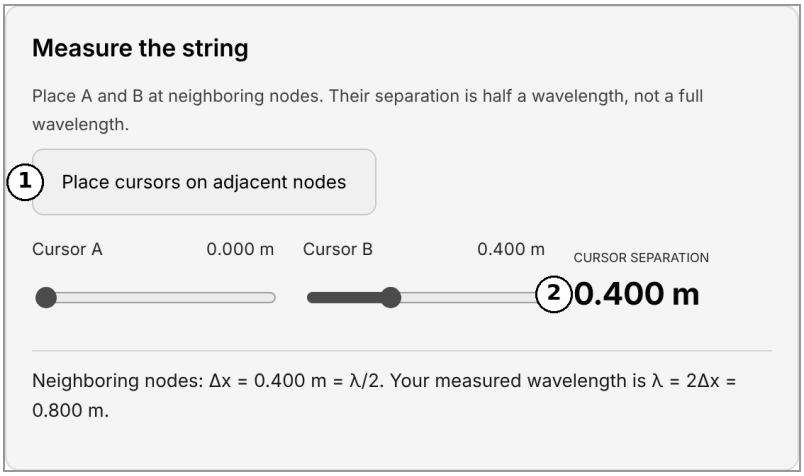


Figure 2. Cursor separation at harmonic 3.

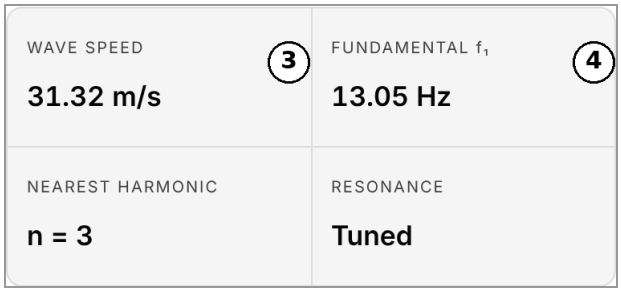


Figure 3. Readouts: (3) wave speed, (4) fundamental f_1.

Harmonic n	Frequency f (Hz)	Nodes	Antinodes	Node spacing Δx (m)	Wavelength λ = 2Δx (m)	f × λ (m/s)
1						
2						
3						
4						
5						
6						

3. Describe two patterns in your table. How is each harmonic's frequency related to the first one (f_1)? How is the wavelength related to the string length L = 1.20 m?

4. Show the f × λ calculation for harmonic 4. Compare the last column to the **Wave speed** readout. What does f × λ equal, and why does it stay the same?

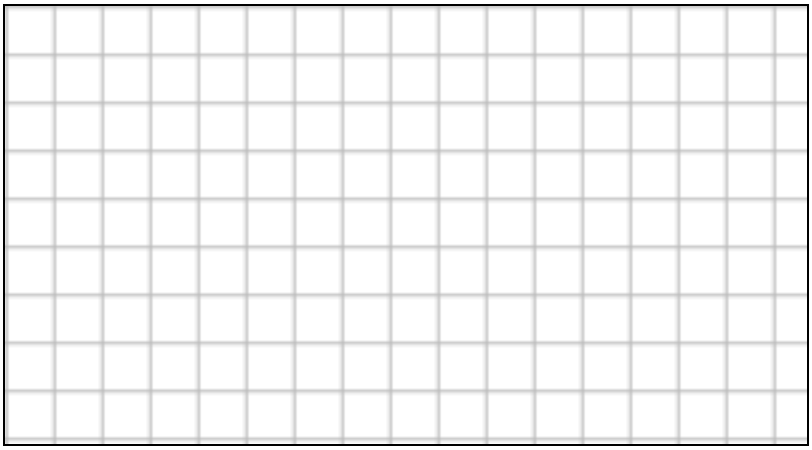
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Part B. Change the tension

1. Keep the oscillator on, length 1.20 m, and Medium cord. Set each hanging mass below.
2. Select harmonic button **2** each time. Record the tension (bottom right of the scene), the frequency, and the wave speed.
3. Calculate v^2. Round to 1 decimal place.

Hanging mass (g)	Tension T (N)	Frequency for harmonic 2 (Hz)	Wave speed v (m/s)	v^2 (m^2/s^2)
50				
100				
200				
400				
500				

5. Graph v^2 (y-axis) against tension (x-axis). Label both axes with units and draw a line of best fit. Calculate the slope.



6. Squaring $v = \sqrt{(T/\mu)}$ gives $v^2 = T/\mu$, so the slope equals $1/\mu$. Use your slope to calculate the string density μ in kg/m. Does it match the Medium cord setting?

7. Compare the 100 g and 400 g rows. The tension became 4 times larger. By what factor did the wave speed change? Why did the frequency for harmonic 2 change by the same factor?

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Part C. Change the string density

1. Set the hanging mass back to **200 g** (length 1.20 m). Choose each cord below.
2. Select harmonic button **1** each time. Record the frequency and the wave speed.

String density	μ (kg/m)	Fundamental frequency f_1 (Hz)	Wave speed v (m/s)
Light cord · 1.0 g/m			
Medium cord · 2.0 g/m			
Heavy cord · 4.0 g/m			

8. How does a heavier string change the wave speed? Use the Light and Heavy rows to describe the pattern with numbers.

9. Use $v = f\lambda$ to predict the frequency of harmonic 3 on the Heavy cord (200 g, 1.20 m). Then check your answer with the harmonic 3 button.

10. Turn off Strobe lock and drag the Frequency slider to about 30 Hz (between harmonics) on the Medium cord. What happens to the string? Then name one way a real string lab differs from this ideal model.

Conclusion

11. Write a claim that answers the objective: how are frequency, wavelength, and wave speed related, and what controls the wave speed? Support it with evidence (specific numbers) and explain your reasoning with $v = f\lambda$ and $v = \sqrt{(T/\mu)}$.

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