

Watch “**Equations for Strings and Pipes, Resonant Wavelengths**”

<https://www.youtube.com/watch?v=ah9a-bmeM1g>

Resonance, Harmonics, & Standing Waves of Guitar Strings

1. A guitar’s **low E string (E2)** is plucked and the **string’s vibrating length is 0.65 m**. Draw the string and find the **standing wavelength** of the fundamental vibration on the string.
2. The **low E string of a guitar (E2)** has a **fundamental frequency of 82.4 Hz**. Draw the string and calculate the **frequencies of the 2nd and 3rd harmonics** of the low E string.
3. A **guitar’s low E string** has a **vibrating length of 0.65 m**, and a **wave speed of 650 m/s**. Draw the string and find the **standing wavelength of the 2nd harmonic**.
4. Harmonics can be produced at **various nodes along the string**, but typically, the **highest playable harmonic is the 5th harmonic**. Draw the string and find the frequency of the last clearly playable harmonic (5th harmonic) on the E string. Determine the standing wavelength of this harmonic.

Guitar Strings

1. A **guitar string** produces a **fundamental frequency of 110 Hz**. Draw a picture, then calculate the **standing wavelength** of the guitar string.
2. A guitarist wants to tune a string so that its **2nd harmonic** produces a frequency of **392 Hz (G4)**. Draw a picture, then calculate the standing wavelength.
3. A **guitar string** has a **fundamental frequency of 82.4 Hz**. Calculate the **frequency of the 3rd harmonic**. Draw a picture, then calculate the **standing wavelength** of the guitar string.
4. A **guitar string** with a **fundamental frequency of 110 Hz** is plucked. Draw a picture, then calculate the frequencies of the **4th harmonic** of this string.
5. A guitarist plays an **string with a fundamental frequency of 330 Hz (E4)**. If the guitarist presses down at the **12th fret (which halves the vibrating length)**. Draw a picture, then find the new frequency of the string?

9. A **closed pipe** and an **open pipe** of **equal length** are played. If the **closed pipe's** fundamental frequency is **150 Hz**.
- Draw a picture of both pipes with one node.
 - Calculate the wavelength of the closed pipe using $v = f\lambda$. Assume the speed of sound is **343 m/s**.
 - Determine the required closed pipe length to produce that frequency.
 - Determine the wavelength produced by the open pipe.
 - Find the **fundamental frequency of the open pipe**?
10. A **guitar string** with a vibrating length of **0.65 m** is tuned to a **fundamental frequency of 196 Hz (G3)**. A **closed pipe** of length **0.437 m** is played alongside the string.
- Draw a picture of both the guitar string and the closed pipe.
 - Find the frequency at each of the first five harmonics for the guitar string.
 - Determine the fundamental wavelength produced by the closed pipe.
 - Determine the fundamental frequency of the closed pipe. Assume the speed of sound is **343 m/s**.
 - Find the frequency at each of the first five harmonics for the closed pipe.
 - Determine the first common harmonic frequency where both the guitar string and the closed pipe will resonate together.