



### Exhibit message

The longer, thicker strings on a piano give lower notes than the shorter, thinner strings.

### Quick Fact

The overtones from a piano are not exact harmonics, that is, they are not whole number multiples of the fundamental frequency. As a result all of the overtones are slightly sharp.

### Graphic panel text

**Which string makes the lowest note?**

#### The long and short of it

Plucking a string forces it to **vibrate** (move up and down). **Short strings** give higher notes than long strings because short strings vibrate faster. The speed of the vibration is called the **frequency**.

#### Many sounds from one string

Although you hear a **single note** when you pluck a string, many different frequencies are present. A string makes its lowest sound when vibrating at its **slowest (fundamental) frequency**.

Higher sounds (**overtones**) are produced by faster vibrations. Some overtones will be louder depending on where and how a string is plucked.

#### Same note, different sound

Different musical instruments produce **different overtones** (even when playing the same note). This is one reason why different instruments sound different.

### Want to know more about how piano strings vibrate and make music?

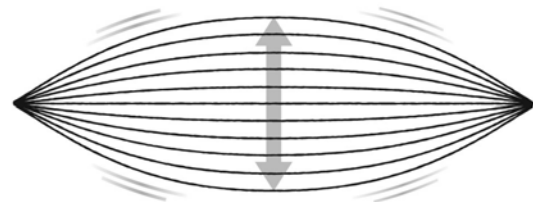
Plucking a string forces it to move up and down quickly, that is, to **vibrate**. The speed of the vibration is called the **frequency**.

**Frequency** is the number of times a vibration occurs in one second (hertz or Hz). Fast vibrations have high frequencies and produce high notes. Vibrations of about 260 Hz produce a note around middle 'C'.

The frequency of a vibrating string depends on its length. A short string vibrates faster (has a higher frequency) and therefore produces a higher note than a long string. When you pluck a long string, you get a low note. The highness or lowness of a sound is called its **pitch**.

Although you hear a single note when you pluck the string, many different frequencies are present. This is because a string usually vibrates at many different frequencies at the one time.

The lowest frequency at which a string can vibrate is called the **fundamental frequency**. A piano string vibrating at the fundamental frequency remains still at each end and vibrates the most in the middle.



A string can also vibrate at twice the frequency of the fundamental. This is called the **first overtone**. A piano string vibrating at the first overtone is stationary at each end and in the centre, and vibrates the most one quarter of the way in from each end.

The same string could also vibrate at 3, 4, 5 or more times the fundamental frequency. All

these extra vibrations are called overtones and make the string vibrate in a very complex fashion. Because the piano strings are fixed at both ends, they will always be still at the ends.

Depending on **where** and **how** a string is plucked or forced to vibrate some of the overtones will be louder than others. Plucking a string in the middle will make a note which is purest and loudest at its fundamental frequency. While plucking a string close to an end will produce louder overtones.

The fundamental will always be present. It is usually the loudest note and corresponds to the note we attribute to it. The overtones are usually softer and contribute to the quality of the note and instrument.

Different musical instruments produce different mixtures of overtones, even when playing the same note. This is one of the reasons why different instruments sound different. The combination of different overtones is called ‘timbre’.

The **volume (loudness)** of the sound is different from its pitch. It is the size of the vibration, not its speed, that determines the volume of a note. The bigger the vibration the louder the note will be.

### Extra for experts

The **wavelength** of a wave is the distance between two crests, troughs or similar phases. The frequency of a vibrating string is directly related to its wavelength.

The length of the wavelength ( $\lambda$ ) of the fundamental frequency is twice the length ( $L$ ) of the string. This is shown in the equation as:  $\lambda = 2L$ . So, a 60 cm long string would have a wavelength corresponding to the fundamental frequency of 120 cm long (1.2 m).

The wavelength of a string vibrating at the first overtone (twice the fundamental frequency) is the same as the length of the string. As the wavelength shortens, the frequency increases. The wavelength of the first overtone is half that of the fundamental.

Starting with a shorter string produces a shorter wavelength and therefore a higher frequency and note.

The length of string is not the only thing that can affect the pitch of the note it produces.

The tension and thickness of string also affects the pitch of the note. Increasing the tension of a string, that is, making the string tighter, makes the resulting note higher, without changing the length. A thicker string, on the other hand, results in a lower note. By using thickness and tension to affect the pitch of a string, pianos can have a large range of notes without having to have strings that are extraordinary long or short.

### Helpful terms

**Frequency:** The number of times a vibration occurs in one second (hertz or Hz). Fast vibrations have high frequencies and produce high notes or pitches.

**Harmonic:** An overtone that is a whole number multiple of the fundamental frequency. All harmonics are overtones, but not all overtones are harmonics.

**Overtone:** Frequency produced by a note from a musical instrument that is above the fundamental frequency. May be a whole number multiple of the fundamental frequency or not.

**Pitch:** How high or low a tone seems. Perceptual aspect of sound corresponding to physical aspect of frequency.

**Timbre:** The distinctive mixture of overtones that gives the characteristic quality to instruments; pronounced ‘tom-ber’.

**Vibration:** A single object or particle moving backwards and forwards (or up and down) rapidly.

### Further information

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- ✪ *Jacaranda Physics 2*. G Lofts, et al, 2004. John Wiley & Sons, Milton, Qld.
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- ✦ Strings, standing waves and harmonics.  
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- ✦ *Overtone series*. Acoustics Lab, UNSW,  
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