

### 3.10.2.1: Plucked String

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Generally strings are either plucked or bowed. In both cases the string does not undergo the simple scenario of harmonics described above. Plucking a string at the center does not cause a nicely shaped sinusoidal wave; instead you start with a triangle shape on the string.

But we know from Fourier's work that any repeating shape can be formed from a series of sine waves. Plucking a string at the center emphasizes the fundamental but many other harmonics will be included. Plucking the string at a location one fourth of the way along the string makes the second harmonic a bit louder but other harmonics will still be present. The result of plucking (starting with a triangle shape) and plucking at different locations means the spectrum is not uniform; where you pluck the string determines which harmonics are emphasized.

In the plucked case the triangle shape immediately converts into a combination of sines and cosines, some of which die away quickly. If the string is bowed, however, the triangle wave is maintained since the bow continues to pull the string to one side at the point of contact. The triangle shaped wave travels to the bridge, reflects, and returns to the bow contact location. When the point of the triangle shape returns to the bow it causes the string to break loose from the bow. The wave continues and reflects off the fret end, returning to the bow again, now causing the string to stick to the bow. This slip-stick mechanism maintains a triangle shaped wave moving on the string, reflecting from each end. Once again, changing the location of the bow contact determines which harmonics are emphasized.

#### Video/audio examples:

- A YouTube of a [standing waves on a driven string](#).
- Wikipedia on [string resonance](#) (lists many types of stringed instruments).
- A few stringed instruments, such as the Indian sitar have sympathetic strings. These are extra strings that are not normally played by the musician but vibrate due to resonance because they are tuned to the strings that are plucked or bowed.
- Slow motion YouTube of a [bowed string](#).
- Slow motion YouTube of a [plucked string](#).

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