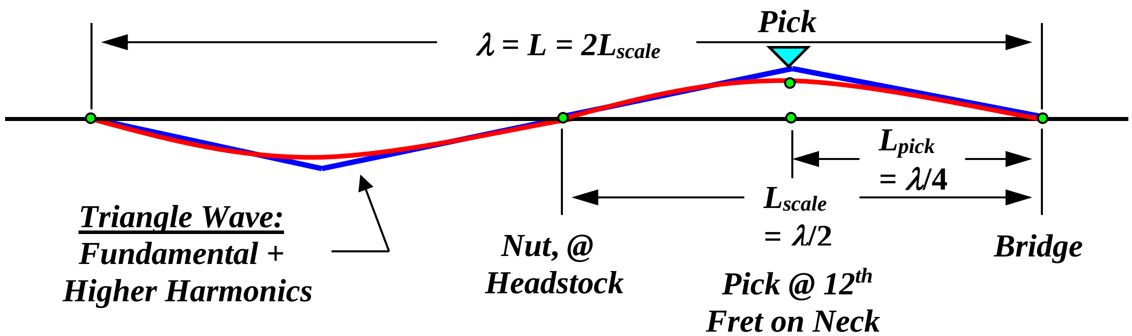
vibrate (to a first approximation). These *boundary conditions* mandate *sine* wave-type solutions!

Vibration of the Fundamental of a Guitar String



As indicated in the above figure, when an open string vibrates in the fundamental mode, this occurs only on a half-length of the fundamental (here the right-hand half) – the left-hand half of the fundamental doesn't physically exist in stringed instruments.

The pick (here) is used to excite an open guitar string at its *midpoint* – at the 12th fret (i.e. 1st octave location), which is an *anti-node* of the fundamental (i.e. a point of maximum *transverse* displacement). This position is a distance of $L_{pick} = \lambda/4$ from the bridge of the guitar. At this loction, the pick stretches the string transversely from its zero-displacement equilibrium position. Before the pick is released from stretching the string, the energy associated with the stretching of the string into this shape is entirely in the form of mechanical *potential* energy. At the precise instant the pick disengages from the stretched string, the shape of the string *is* a symmetric (i.e. isosceles) triangle. Immediately after the pick releases the string, the string begins to vibrate, converting the mechanical potential energy back and forth into kinetic energy (and also radiating some of this energy away as sound waves). However *because* of energy conservation, all the energy initially contained in each of the harmonics is also preserved (see Parseval's theorem) and thus, the initial shape of the string at the instant it was released from the disengagement of the pick is also preserved. In other words, the transverse *shape* of the string the instant before it is released *dictates* its harmonic sound-content afterward!

Guitar players do not normally play at this location on the guitar, because picking the strings of the guitar with the fingerboard/fretboard immediately underneath is difficult. However, those guitarists who *have* tried playing there know that the resulting sound output from the guitar is quite mellow, because picking the strings at this location predominantly excites the fundamental at frequency, f. The second harmonic, one octave above at frequency, $2f$ is *completely* absent in picking the strings at this location on the guitar, because the second harmonic has a *node* at $L_{pick} = \lambda/4$ - i.e. it *cannot* be excited by picking here! In fact *none* of the even-n harmonics - at $2f$, $4f$, $6f$, $8f$, $10f$, ... etc. can be excited by picking at $L_{pick} = \lambda/4$ because they *all* have nodes at this point! In addition to the fundamental, only the odd-n harmonics of the fundamental can be excited by playing at the 12th fret of the guitar - in fact the odd-n harmonics all have anti-nodes at this point!