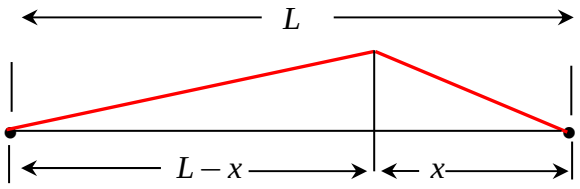
Complex Vibrations & Resonance

Simple vibrating systems have only ***one*** frequency (the fundamental).
Few such systems exist in real life (*n.b.* they are also musically less interesting/boring..).

Real vibrating systems are "complex" – rich structure of harmonics/overtones.
Overtone structure may also change/shift with time – not constant – more interesting!

Vibrating Strings - Standing Waves:

Consider a stretched string of length L, vibrating from fixed (*i.e.* rigid) end supports:



fixed endpoints (rigid)

Plucking the string at position x launches two ***counter-propagating traveling*** waves:

* One traveling wave moves to the ***right***, the other traveling wave moves to the ***left***.

* When the traveling wave(s) hit the rigid/fixed ends at $x = 0$ and $x = L$, they are reflected;
  A polarity flip (= phase change of 180°) also occurs there.

Compare this situation to that for two counter-propagating traveling waves reflected from ***free*** ends - ***no*** polarity change (*i.e.* ***no*** phase shift) occurs!

The ***superposition*** {*i.e.* the ***linear*** addition $y_{tot}(x,t) = y_1(x,t) + y_2(x,t)$} of two ***counter-propagating*** traveling waves (one ***right***-moving, $y_1(x,t)$ and one ***left***-moving, $y_2(x,t)$) creates a ***standing*** wave on the string!