Music

Music is a "pleasant" sound (longitudinal) wave.

The pitch is the frequency of the wave.

The loudness is the amplitude of the wave.

Music is made by producing a large variety of waves and making a certain set of them louder by using resonance.

Resonance is the result of constructive interference caused by making an object vibrate at it's natural frequency.

Resonance

When the object vibrates at it's natural frequency it will cause constructive interference with other waves of the same or integer multiple frequency making that particular note (pitch, sound) louder.

The lowest pitch is called the fundamental tone, the integer multiples are called harmonics or overtones.

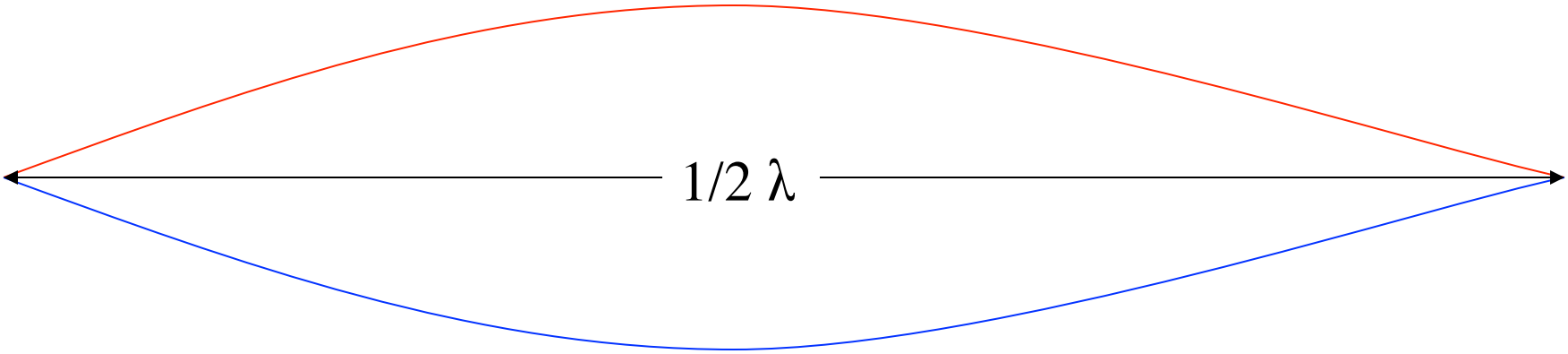
The constructive interference is the result of a standing wave pattern. The standing wave is produced when one wave reflects almost perfectly from one end of an instrument and then reinforces the next wave as it travels back to the source.

String Instruments

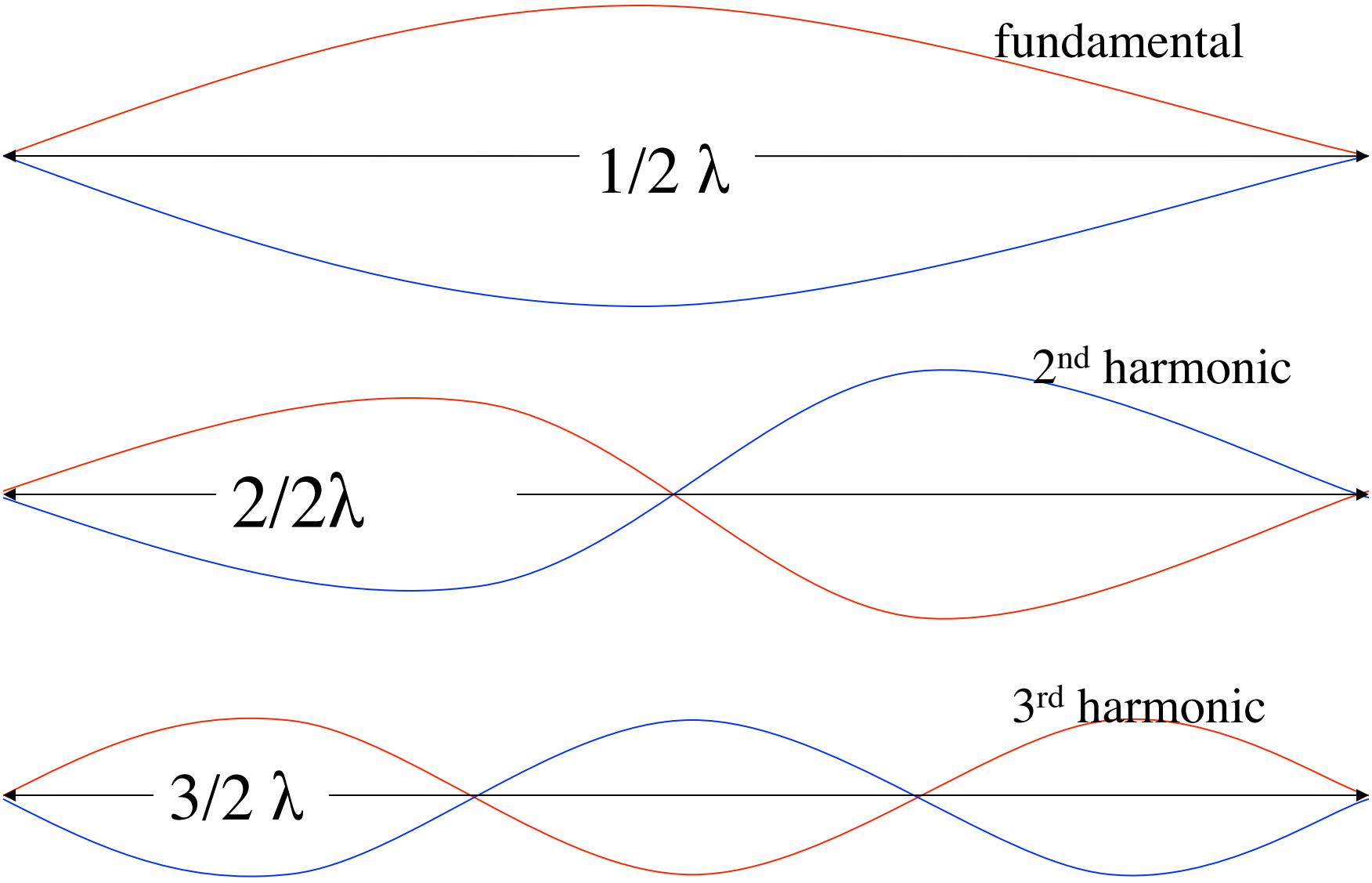
A disturbance applied to a string will make the string begin to vibrate. The velocity of the resulting wave will depend on the density and tension of the string but the wavelength will depend on the length of the string.

Standing Waves in Strings

Remember that when a wave is reflected it becomes inverted. In order this to happen in a string the reflection must happen at a node. This means that in order for there to be resonance in a string there must be a node at each end. The length of the string then determines the wavelength of the sound produced.



Strings



Notes From Strings

The note we hear from a string is controlled by three factors:

1. The length of the string $l=n(1/2\lambda)$.
2. The tension of the string (higher tension means more velocity)
3. The properties of the string (materials, density, etc).

The first two factors are connected to the equation $v=f\lambda$

String instruments

Pipe Instruments

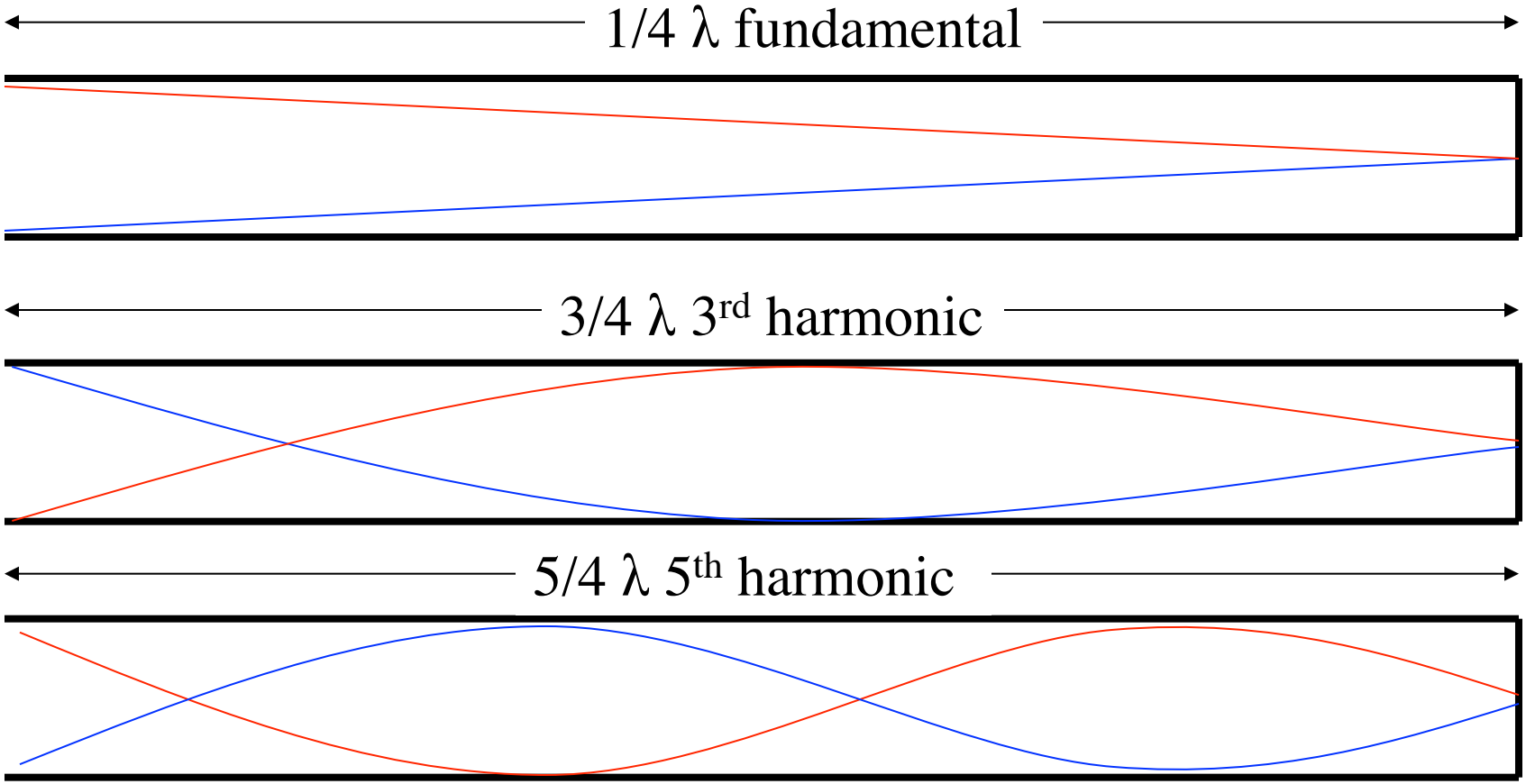
In a pipe the thing that is vibrating is a column of air. The velocity of a sound wave in air depends on the temperature and the humidity. We generally cannot control these factors but can only adjust for them with the length of the pipe.

There are two kinds of pipes, those that are closed at one end (closed end pipes) and those that are open at both ends (open end pipes).

The key to resonance in pipes is that an anti-node must occur at the open ends of the pipe. To get the most sound these open ends must vibrate as much as possible.

Pipe closed at one end

For a pipe that is closed at one end we must then have an anti-node at the open end and a node at the closed end.



Closed End Pipes

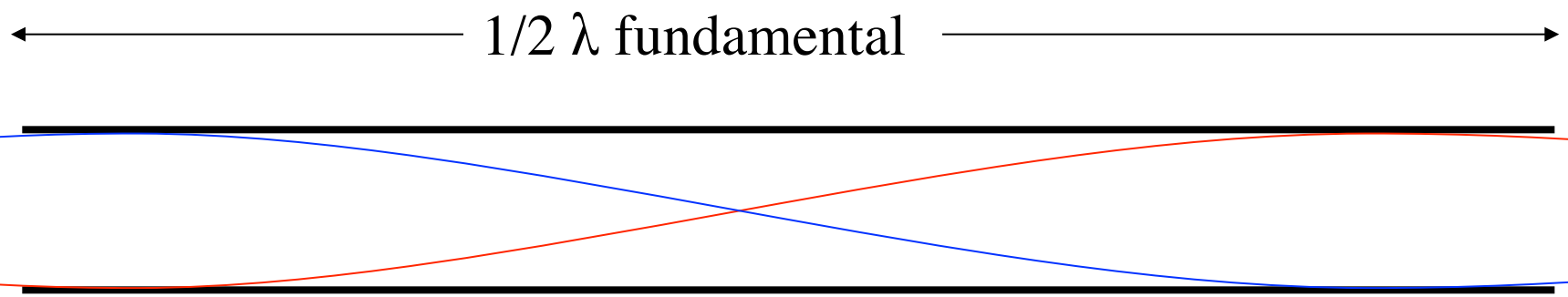
Notice that for pipes that are closed at one end only the odd numbered harmonics can result in a standing wave. The standing wave is necessary to get the natural frequency constructive interference to produce the audible sound.

Also notice that I have drawn the waves as transverse waves but sound travels as a longitudinal wave. It is very difficult to draw a longitudinal standing wave.

Sound waves in musical instruments

Pipes open at both ends

Pipes that are open at both ends must have an anti-node at each end.



Open End Pipes