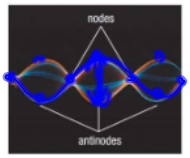
SPH3U 9.2 Waves at Media Boundaries

1. Standing waves

Standing wave:	a wave that looks like it's "standing still"
cause	waves interfere with their own reflections as they bounce up and down the medium.
nodes	points where particles aren't moving.
antinodes	points where particles move the most (up and down).



2. Standing waves – 2 fixed ends

Fixed end:	the end of the medium is held tight in place, so that it must have a node.
2 fixed ends	also called "fixed-fixed" (string instruments)

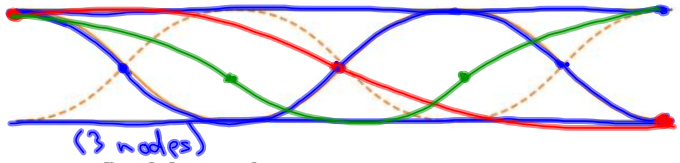
Symbol	Number of nodes between ends	Diagram	Harmonic (n)	Overtone
f_0	0	antinode; $n = 1$; $L_1 = \frac{1}{2}\lambda$	first	fundamental
f_1	1	node; $n = 2$; antinode; $L_2 = \lambda$	second	first
f_2	2	node, node; $n = 3$; antinode; $L_3 = \frac{3}{2}\lambda$	third	second
f_3	3	node, node, node; $n = 4$; antinode; $L_4 = 2\lambda$	fourth	third

$n = 4$

$n - 1$ nodes between ends.

3. Standing waves – 2 free ends

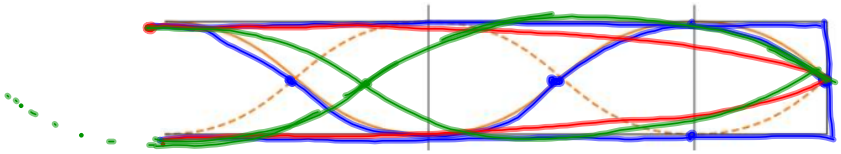
Free end:	the end of the medium can move freely – it will have an antinode (maximum).
2 free ends	also called "free-free" (brass instruments)



n = 1 (1st harmonic)
n = 2 (2nd harm.)
n = 3 (3rd harm.)

4. Standing waves – fixed-free ends

Fixed-free ends:	node on fixed, antinode on free (woodwind)



n = 1 (1st harm.)
n = 2 (2nd harm.)
n = 3 (3rd harm).

5. Equations

2 fixed or 2 free:	$L_n = \frac{n\lambda}{2} \Leftrightarrow \lambda_n = \frac{2L}{n}$.
Fixed-free:	$L_n = \frac{(2n-1)\lambda}{4}$, $\lambda_n = \frac{4L}{(2n-1)}$

The speed of a wave on a string with a fixed end and a free end is 350 m/s. The frequency of the wave is 200.0 Hz. What length of string is necessary to produce a standing wave with the first harmonic?

$n = 1$. $f = 200\,Hz$, $v = 350\,m/s$, $v = f\lambda$.

$\lambda = \frac{v}{f} = \frac{350}{200} = 1.75\,m$.

$L_n = \frac{(2n-1)\lambda}{4}$, $L_1 = \frac{(2-1)(1.75)}{4} = 0.44\,m$.

The sixth harmonic of a 65 cm guitar string is heard. If the speed of sound in the string is 206 m/s, what is the frequency of the standing wave?

$v = 206\,m/s$, $n = 6$, $L_6 = 0.65\,m$.

$L_n = \frac{n\lambda}{2}$. $L_6 = \frac{6\lambda}{2} \rightarrow 0.65 = 3\lambda$. $\rightarrow \lambda = \frac{0.65}{3} = 0.2167\,m$.

$v = f\lambda \rightarrow f = \frac{v}{\lambda} = \frac{206}{0.2167} = 950\,Hz$.

Homework: page 426: #5-7