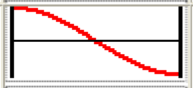
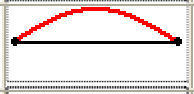
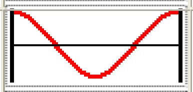
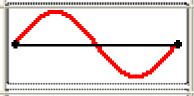
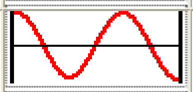
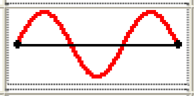
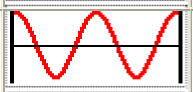
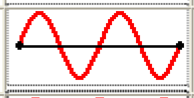
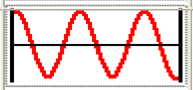
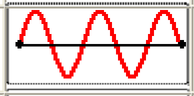
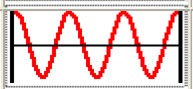
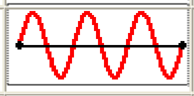
Room Modes and Vibrations of Strings

German Version: Raummoden und Saitenschwingungen http://www.sengpielaudio.com/RaummodenUndSaitenschwingungen.pdf

UdK Berlin
Sengpiel
10.2012
Tutorium

1. Standing waves are called room modes when looking at hard sound reflecting parallel walls.
2. Standing waves and acoustical resonance of strings. That are no room modes.

1. Room modes as Sound pressure patterns — 2. Standing waves as amplitude patterns

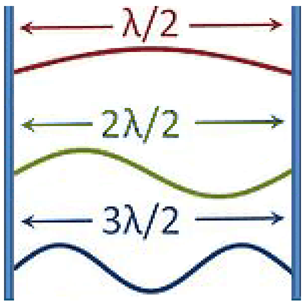
Harmonics	Number of nodes	Number of antinodes	Sound pressure patterns room walls	Length relationship	Harmonics	Number of nodes	Number of antinodes	Displacement patterns of a string	Length relationship
1.	1	2		$L = 0.5 \cdot \lambda$	**1.**	2	1		$\lambda = 2 \cdot L$
2.	2	3		$L = 1 \cdot \lambda$	**2.**	3	2		$\lambda = 1 \cdot L$
3.	3	4		$L = 1.5 \cdot \lambda$	**3.**	4	3		$\lambda = 2/3 \cdot L$
4.	4	5		$L = 2 \cdot \lambda$	**4.**	5	4		$\lambda = 1/2 \cdot L$
5.	5	6		$L = 2.5 \cdot \lambda$	**5.**	6	5		$\lambda = 2/5 \cdot L$
6.	6	7		$L = 3 \cdot \lambda$	**6.**	7	6		$\lambda = 1/3 \cdot L$
***n*.**	***n***	***n* + 1**	---	$L = (n/2) \cdot \lambda$	***n*.**	***n* + 1**	***n***	---	$\lambda = 1/(n/2) \cdot L$

The left figure is the sound pressure of a sine wave and its harmonics represented between two totally sound reflective, i.e. reverberant walls. It is important that in the event of resonance at each wall of the room there is always located a maximum sound pressure level (SPL antinode).

Many representations for explaining the spatial modes an inaccurate showing of the string vibration is used, where at each end always is a fixed node, such as here:

This is **not** the representation of **sound pressure** vibrations between walls in a small room.

These are vibrations of a string (displacement amplitudes).



A typical wrong figure with nodes at the wall. Showing the air displacement is not wanted.

Top right: A string is clamped between two "fixed ends". At the ends there appears a wave knot.

Top left: A sound pressure between two hard walls is viewed with "loose ends". Therefore the sound pressure appears on the sides of the wall as wave maximum - that is an antinode.

The room resonances that build up between the boundary surfaces of a room are called "standing waves", room eigenmodes, or room modes. They occur when a multiple of half the wavelength ($\lambda/2$) fits between the boundary surfaces of a room. Requirement for a room mode is a standing wave.

Sound engineers should mainly be interested in the frequency-dependent response of the sound pressure variations because its effect moves our eardrums and the microphone diaphragms, see:

Sound pressure and Sound power – Effect and Cause http://www.sengpielaudio.com/SoundPressureAndSoundPower.pdf

Room modes are nothing more than standing sound pressure waves that develop in any room more or less at low frequencies below 300 Hz. Non-parallel walls are not a cure.

The formation of standing waves in the room at sound hard walls (room modes) is clearly to be distinguished to the string vibrations (displacement amplitudes) between two tightly clamped points.

"Standing waves and acoustic resonance in ideal strings":
http://www.sengpielaudio.com/StandingWaves.htm

"Calculate the three modes (Room Eigenmodes) - room resonances of rectangular rooms":
http://www.sengpielaudio.com/calculator-roommodes.htm

With a wall distance of 1/4 wavelength of the standing wave there is a place where the sound pressure is constantly zero - independent of the instantaneous phase angle of the waves. The sound of the wave can not be heard there.