

Week 5

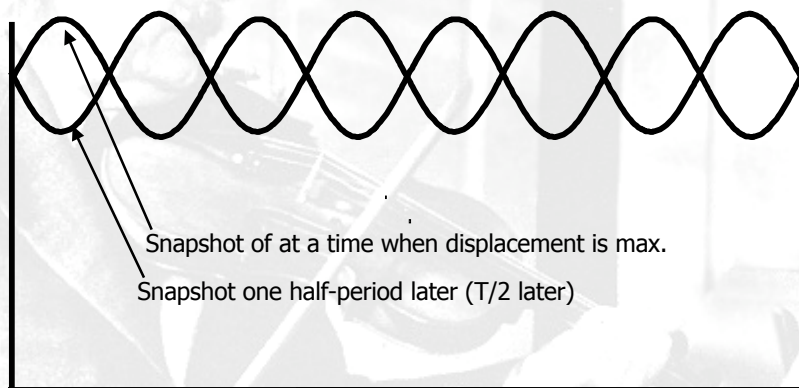
Standing waves in Air Columns

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1

Standing Waves in the Bathtub

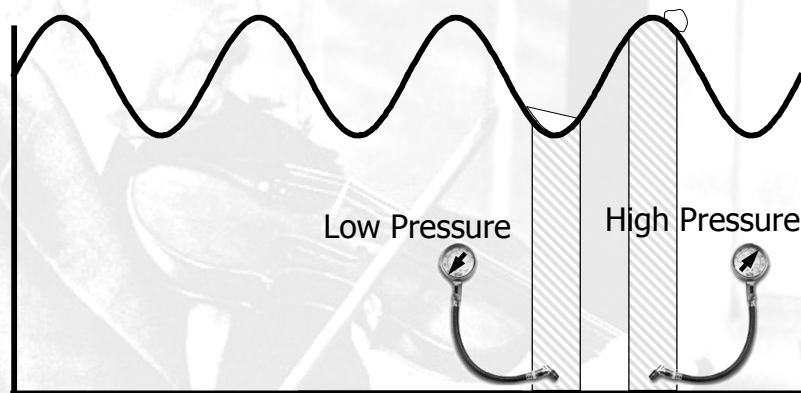


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2

Standing Waves in the Bathtub

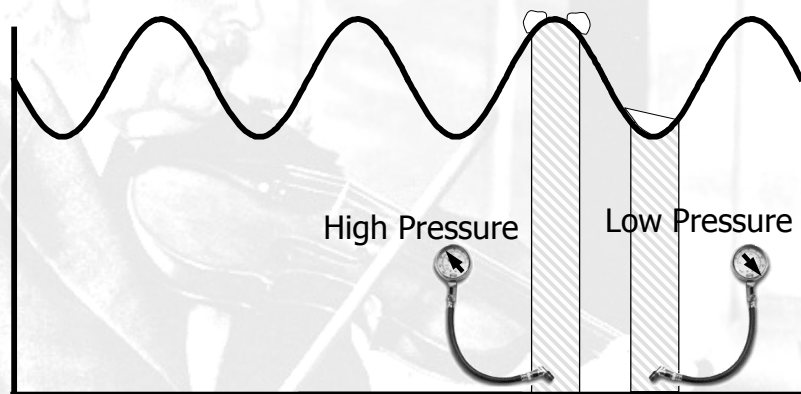


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Standing Waves in the Bathtub

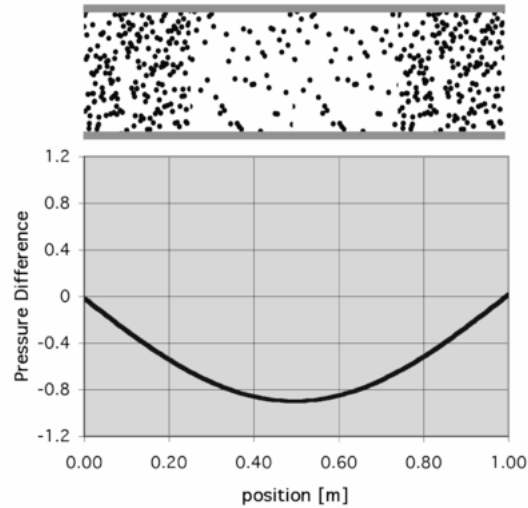


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Both Ends Open: 1. Mode

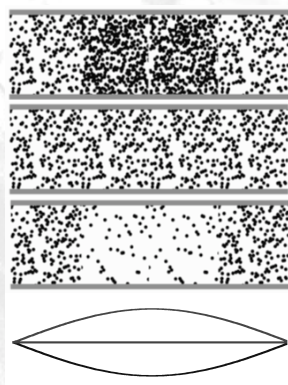


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5

Both Ends Open: 1. Mode



phase

$0 \text{ \& } T$

$\frac{1}{4}T \text{ \& } \frac{3}{4}T$

$\frac{1}{2}T$

wavelength

$$\lambda_1 = 2L$$

frequency

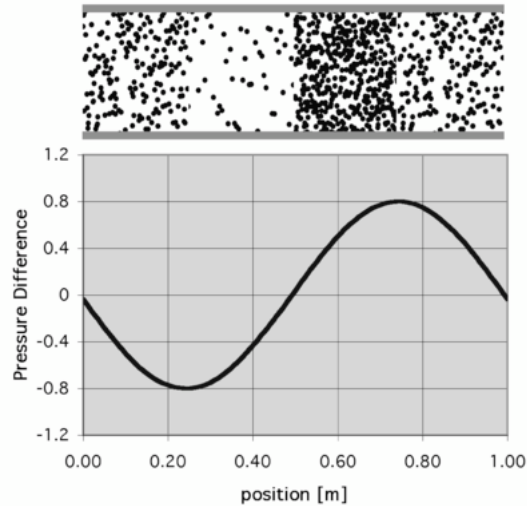
$$f_1 = \frac{v}{2L}$$

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Both Ends Open: 2. Mode

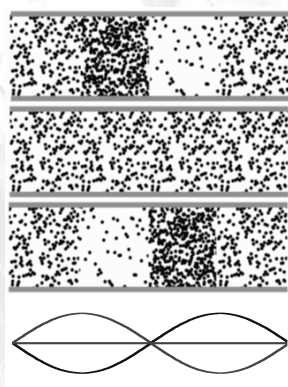


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Both Ends Open: 2. Mode



phase

$0 \text{ \& } T$

$\frac{1}{4}T \text{ \& } \frac{3}{4}T$

$\frac{1}{2}T$

wavelength

$$\lambda_2 = L = \frac{1}{2} 2L$$

frequency

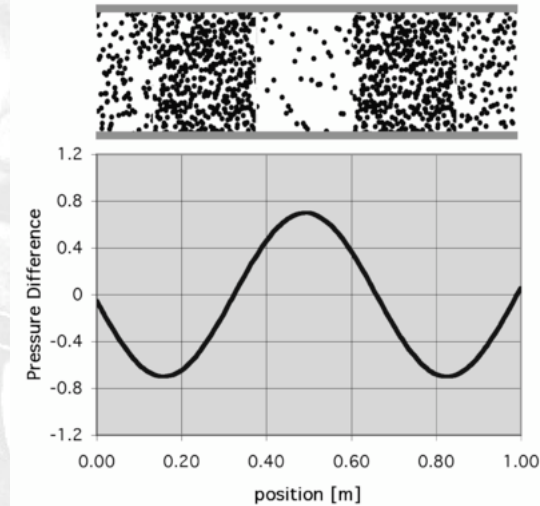
$$f_2 = 2 \frac{v}{2L} = 2f_1$$

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Both Ends Open: 3. Mode

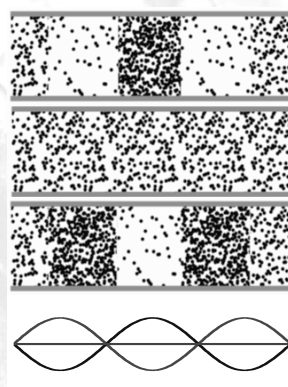


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Both Ends Open: 3. Mode



phase

$0 \text{ \& } T$

$\frac{1}{4}T \text{ \& } \frac{3}{4}T$

$\frac{1}{2}T$

wavelength

$$\lambda_3 = \frac{1}{3}2L$$

frequency

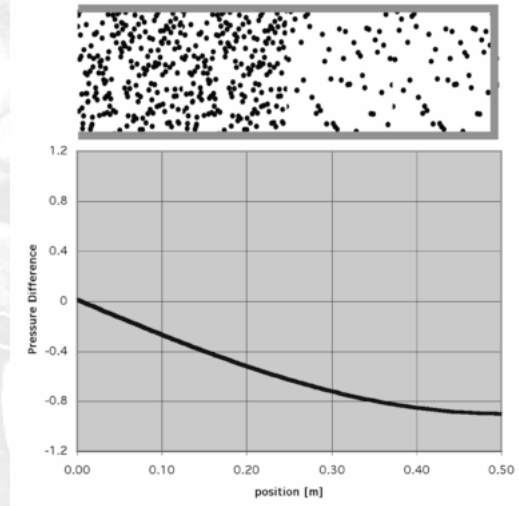
$$f_3 = 3\frac{v}{2L} = 3f_1$$

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One End Closed: 1. Mode

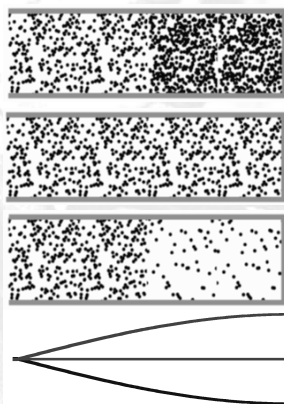


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One End Closed: 1. Mode



phase

$0 \text{ \& } T$

$\frac{1}{4}T \text{ \& } \frac{3}{4}T$

$\frac{1}{2}T$

wavelength

$$\lambda_1 = 4L$$

frequency

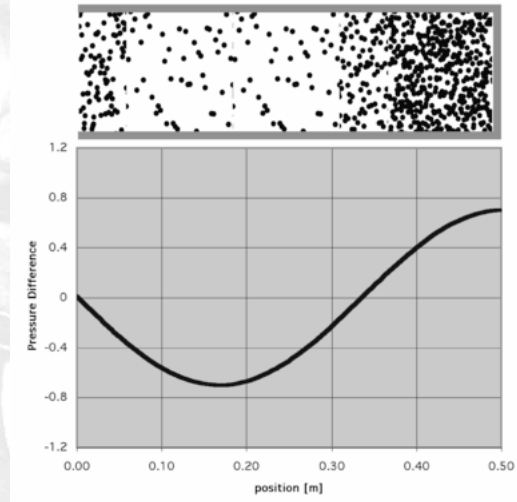
$$f_1 = \frac{v}{4L}$$

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One End Closed: 2. Mode

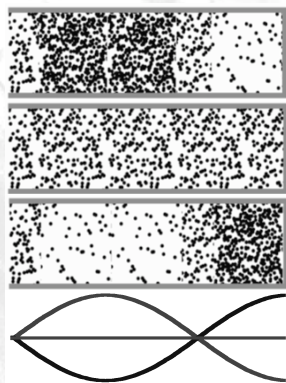


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One End Closed: 2. Mode



phase

$0 \text{ \& } T$

$\frac{1}{4}T \text{ \& } \frac{3}{4}T$

$\frac{1}{2}T$

wavelength

$$\lambda_2 = \frac{4}{3}L$$

frequency

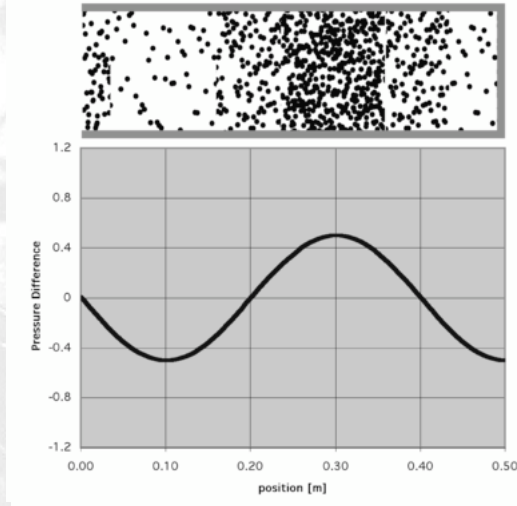
$$f_2 = 3 \frac{v}{4L}$$

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One End Closed: 3. Mode

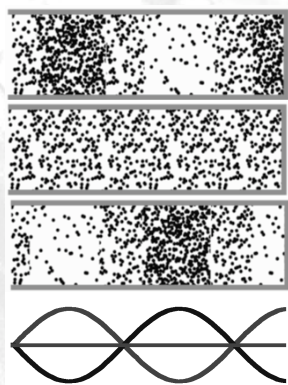


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One End Closed: 3. Mode



phase

$0 \text{ \& } T$

$\frac{1}{4}T \text{ \& } \frac{3}{4}T$

$\frac{1}{2}T$

wavelength

$$\lambda_3 = \frac{4}{5}L$$

frequency

$$f_3 = 5 \frac{v}{4L}$$

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Strings, Rods, and Air Columns

Strings (both ends fixed)	$\lambda_n = \frac{1}{n} 2L$	$f_n = n \frac{v}{2L}$	(n=1,2,3...)
Thin Rod (one end fixed)	$\lambda_n = \frac{1}{2n-1} 4L$	$f_n = (2n-1) \frac{v}{4L}$	(n=1,2,3...)
Air Column (both ends open)	$\lambda_n = \frac{1}{n} 2L$	$f_n = n \frac{v}{2L}$	(n=1,2,3...)
Air Column (one end closed)	$\lambda_n = \frac{1}{2n-1} 4L$	$f_n = (2n-1) \frac{v}{4L}$	(n=1,2,3...)

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What do they have in common?

Loose string/rod and *closed* end of pipe
must have an antinode

Fixed string/rod and *open* end of pipe
must have a node

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Strings, Rods, and Air Columns

Strings (both ends fixed)

$$\lambda = 2L, \frac{1}{2}2L, \frac{1}{3}2L, \frac{1}{4}2L...$$

Air Column (both ends open)

$$f = 1\frac{v}{2L}, 2\frac{v}{2L}, 3\frac{v}{2L}, 4\frac{v}{2L}...$$

Rod (one end fixed)

$$\lambda = 4L, \frac{1}{3}4L, \frac{1}{5}4L, \frac{1}{7}4L...$$

Air Column (one end closed)

$$f = 1\frac{v}{4L}, 3\frac{v}{4L}, 5\frac{v}{4L}, 7\frac{v}{4L}...$$

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Some Consequences...

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Short Blades – Long Blades

The shorter the blade, the higher the resonance frequency

$$f_1 = \frac{v}{4L}$$

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Clarinet vs. Flute Playoff

Same length (nearly) but clarinet is much lower



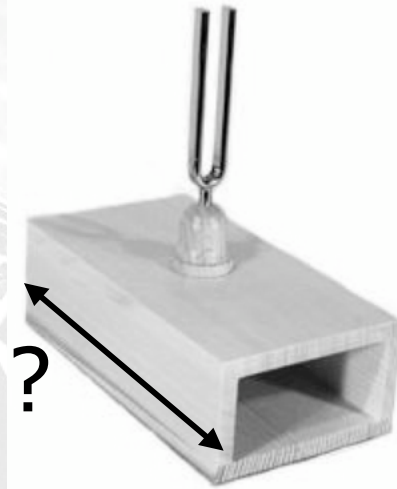
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Tuning Fork Resonator

How Long?

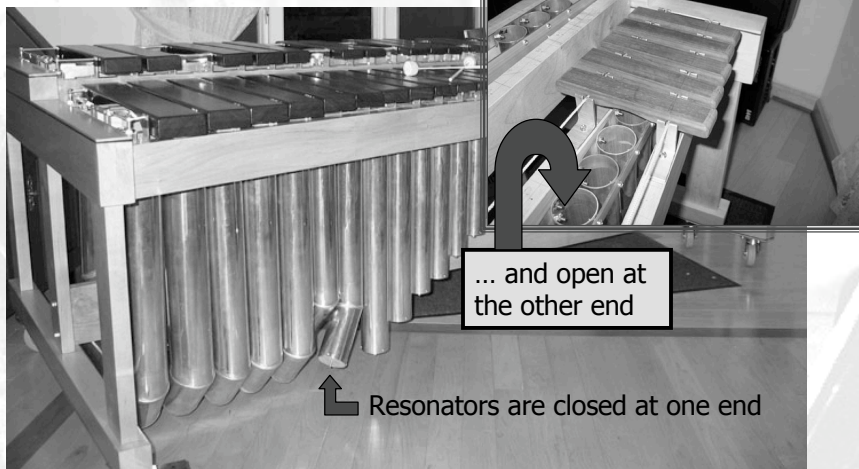


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Resonators on a Marimba



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Resonators on a Marimba

This Resonator Tube is 63 cm long

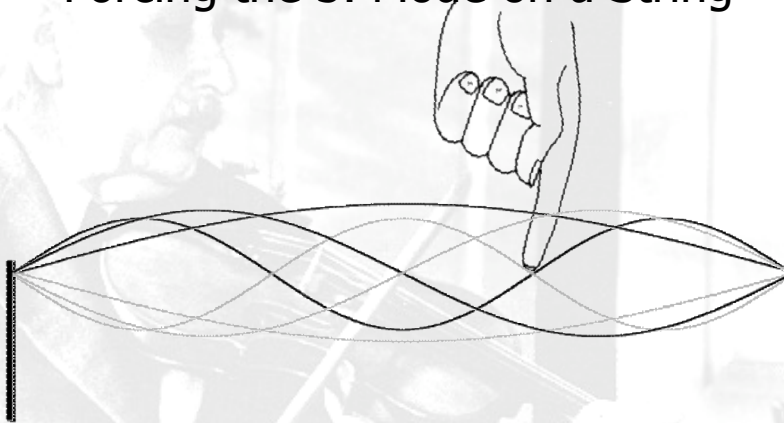


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Forcing the 3. Mode on a String



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