

Sound and Sound Waves
Honors Physics: Class Examples

Example 11

A particular string on a piano is 1.50 m long and has a tension of 400.0 N. It vibrates with a fourth-harmonic frequency of 110.0 Hz.

- A. What is the mass of this string?
 B. What are the first three harmonics of this string?

$L = 1.50 \text{ m}$
 $F_T = 400 \text{ N}$
 $f_4 = 110 \text{ Hz}$

$f_4 = 110 \text{ Hz}$
 $f_4 = 4 \cdot f_1$
 $110 = 4 \cdot f_1$
 $f_1 = 27.5 \text{ Hz}$

A.) $v = \sqrt{\frac{F_T}{m/L}}$
**missing mass*

$f_n = \frac{n \cdot v}{2L}$
 $f_1 = \frac{1 \cdot v}{2(1.50)}$
 $27.5 = \frac{v}{3}$
 $v = 82.5 \text{ m/s}$

B.) $f_1 = 27.5 \text{ Hz}$
 $f_2 = 2 \cdot f_1 = 55 \text{ Hz}$
 $f_3 = 3 \cdot f_1 = 82.5 \text{ Hz}$
 $f_4 = 110 \text{ Hz}$

Standing Waves - Pipes Open at Both Ends

Fundamental

1st Harmonic



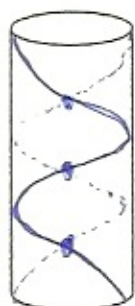
$\frac{1}{2} \lambda$

2nd Harmonic



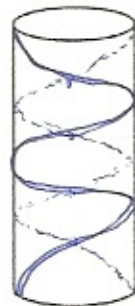
λ

3rd Harmonic



$\frac{3}{2} \lambda$

4th Harmonic

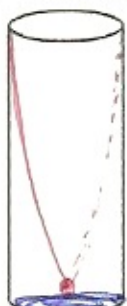


2λ

Standing Waves - Pipes Open at One End

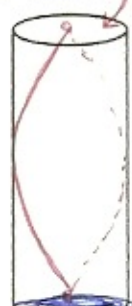
Fundamental

1st Harmonic



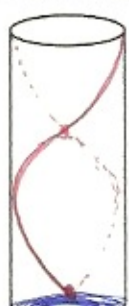
$\frac{1}{4} \lambda$

Node - can't hear
 2nd Harmonic



$\frac{1}{2} \lambda$

3rd Harmonic



$\frac{3}{4} \lambda$

Node - can't hear
 4th Harmonic



λ

5th Harmonic



$\frac{5}{4} \lambda$

ODD harmonics - can be heard
 EVEN harmonics - can't be heard