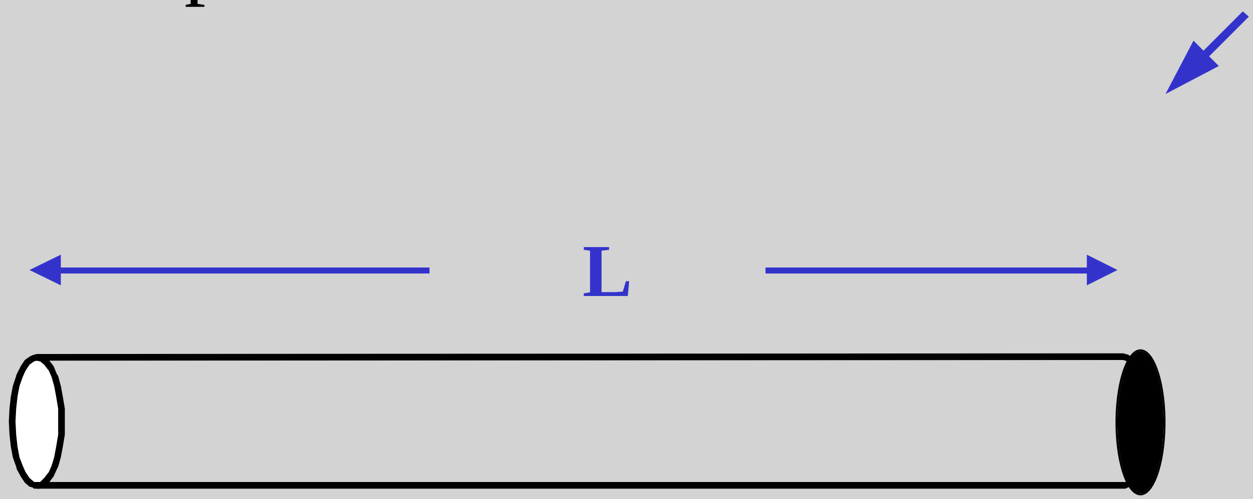
Closed Pipe

Pipe closed at ONE end:



$$L = \lambda/4$$

fundamental frequency of closed pipe:

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

note: this is half the frequency of an open pipe of same length (octave below)

open end: **pressure NODE** (motion antinode)
closed end: **pressure antinode** (motion node)

example:

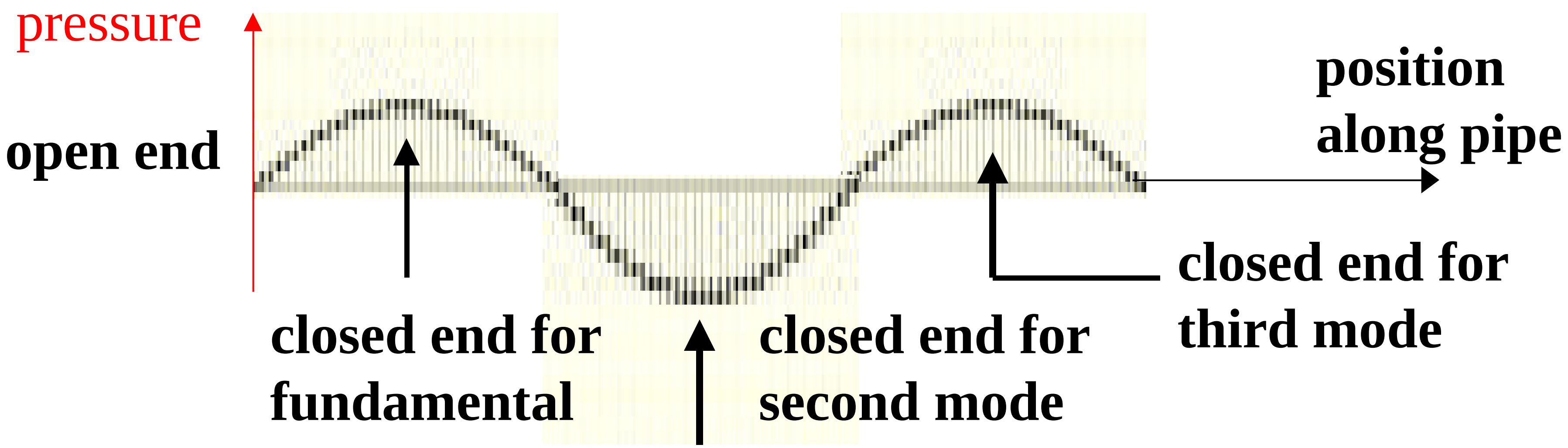
how long is a CLOSED organ pipe that plays A_1 = 55 Hz? (note: $A_1 \rightarrow A_4$ = 3 octaves)

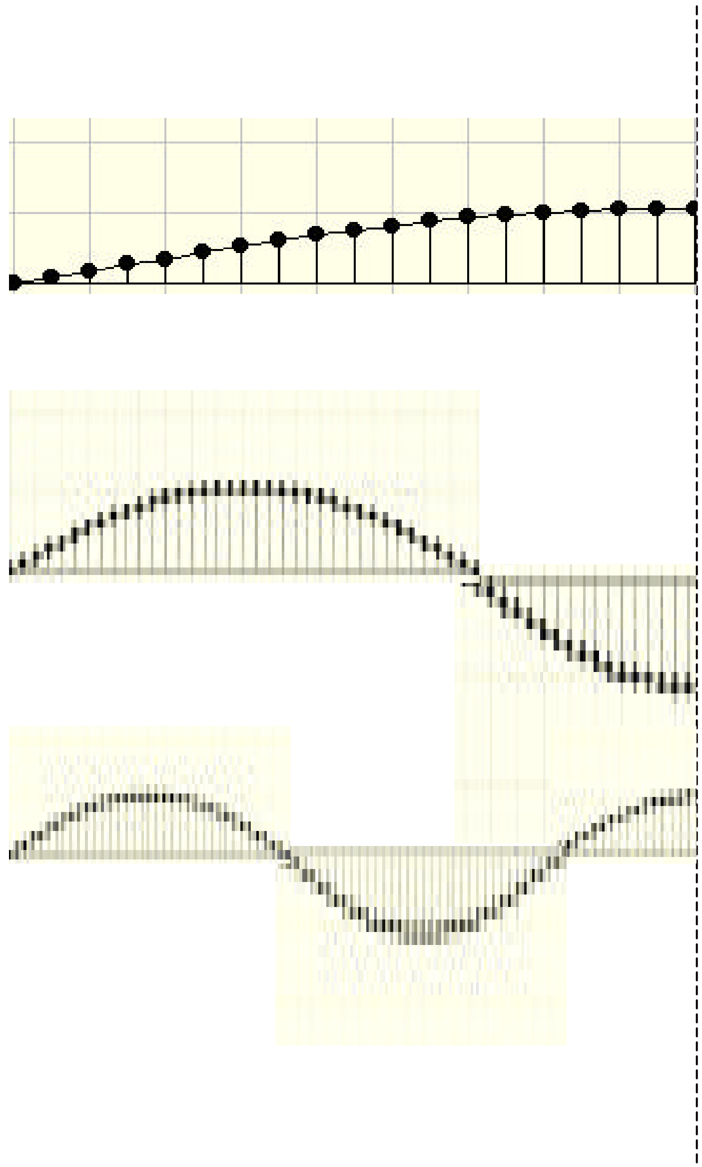
$L = v/4f = (340/220)\ m =$ **1.55 = 5 ft**

Higher modes of closed pipe:

need pressure NODE at open end

need pressure BELLY at closed end





higher modes (overtones) of closed pipe

Only ODD multiples of fundamental

f_1 first mode (fundamental)

$3f_1$ second mode (first overtone)

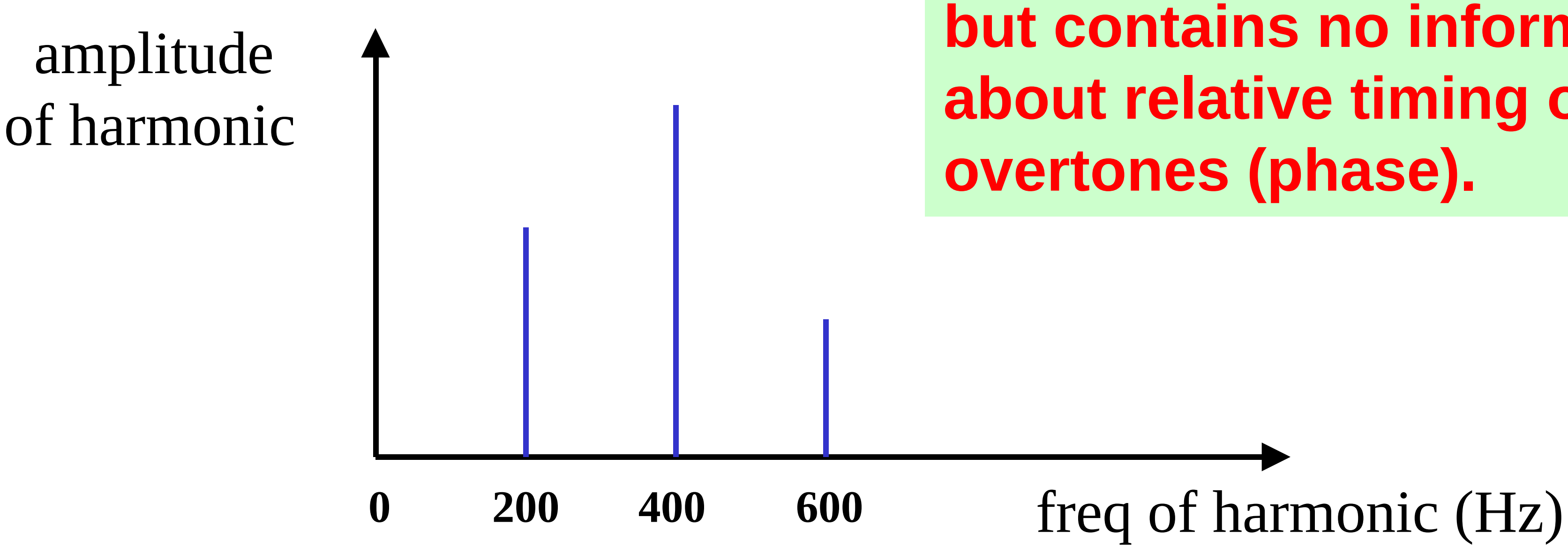
but third harmonic!

$5f_1$ third mode (second overtone)

but fifth harmonic!

Sound Spectrum (Fourier Spectrum)

Fourier: represent complicated periodic oscillation (period T) as sum of sinusoidal oscillations of frequencies f_1= (1/T) and harmonics $f_2=2f_1$, $f_3=3f_1$ etc.



easy visualization of harmonic content (timbre) but contains no information about relative timing of overtones (phase).

Fourier Synthesizer….. produces frequencies

f_1, $2f_1$, $3f_1$, $4f_1$, $5f_1$ $6f_1$, $7f_1$ etc

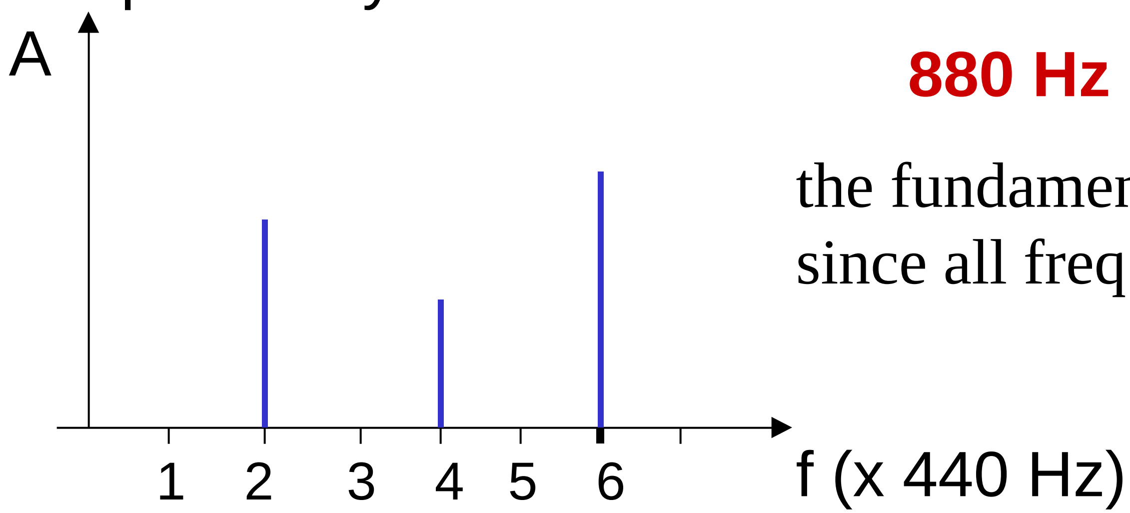
of adjustable amplitude and phase .

e.g. f_1 = 440 Hz = A_4 can synthesize <u>any</u> oscillation of period T=1/440 sec.

Pitch perception

listen to the following combination of harmonics:

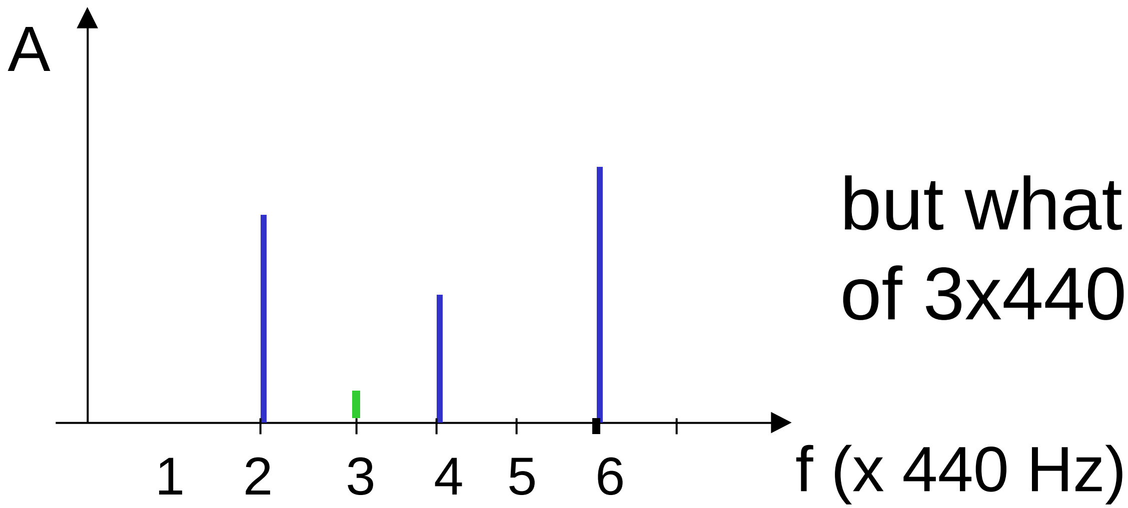
what pitch do you hear?



880 Hz = A_5

the fundamental is 880 Hz since all freq multiples of 880

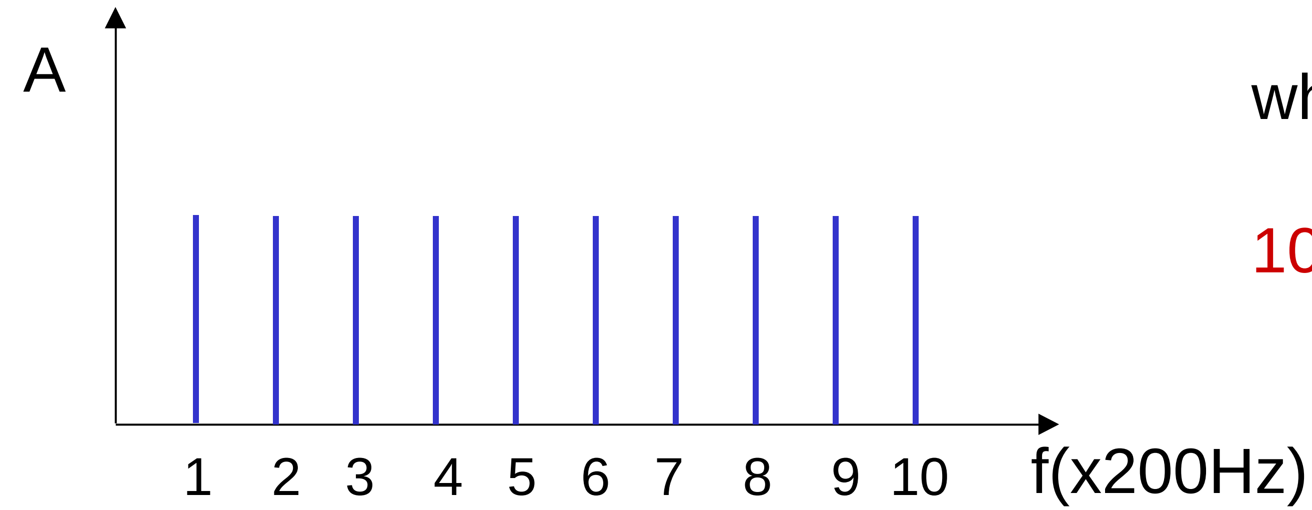
but….



but what if we add a bit of 3x440Hz??

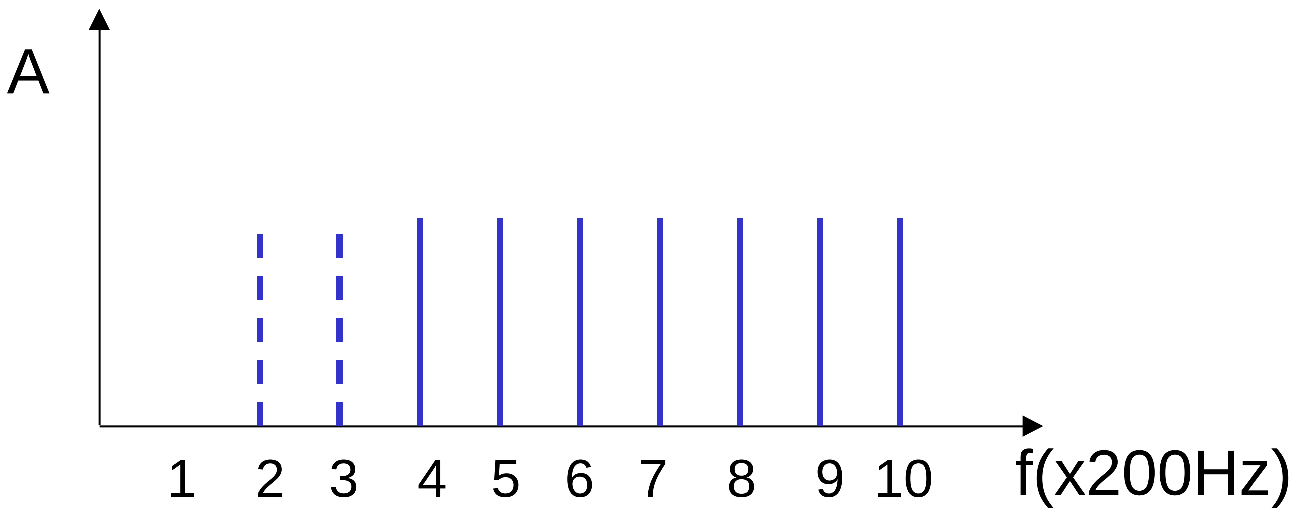
now suddenly the (theoretical) fundamental is 440 Hz
but what do we hear?

Demo: in some situations (missing or almost missing fundamental) there may be an ambiguity in perceived pitch



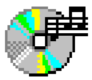
what do you hear?

100 Hz of course!



and now?

DEMO



Tone Quality (Timbre)

In acoustic theory, what exactly is “timbre”? Timbre is that attribute that differentiates two tones of same loudness and same pitch.

The Fourier Spectrum (frequencies and intensities of overtones) is only one aspect of timbre……..

Other aspect of tone quality: rise and decay

An example of two tonal presentations which show importance of the tone envelope (attack and decay)