Physics 1240: Sound and Music

Today (7/26/19): Woodwinds, Brass Instruments

Next time: Percussion: Vibrating Rods

Review

Types of Instruments
(Hornbostel–Sachs classification)

- Chordophones: vibrating strings

- Aerophones: vibrating columns of air

- Idiophones: vibrating the whole instrument

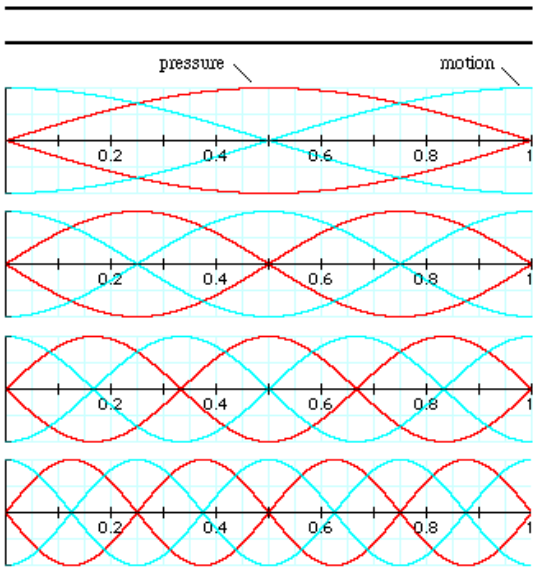
- Membranophones: vibrating membrane/skin

- Electrophones: vibrating loudspeaker

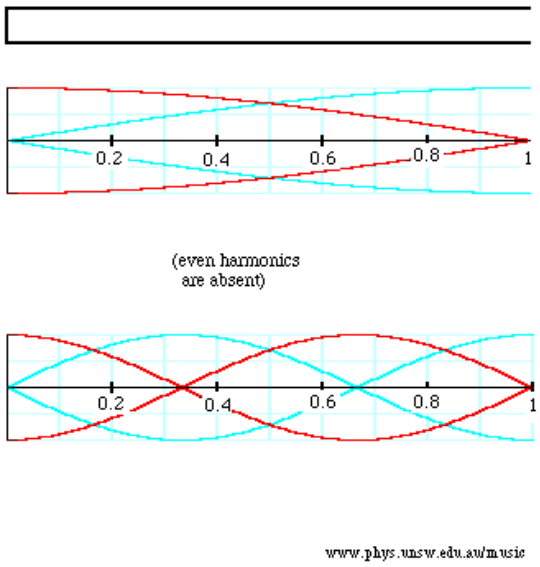
Review

Aerophones

- Free
  (no standing waves)
- Flute-type
  (edge tones)
- Reed-type
  (vibrating reed/lips)

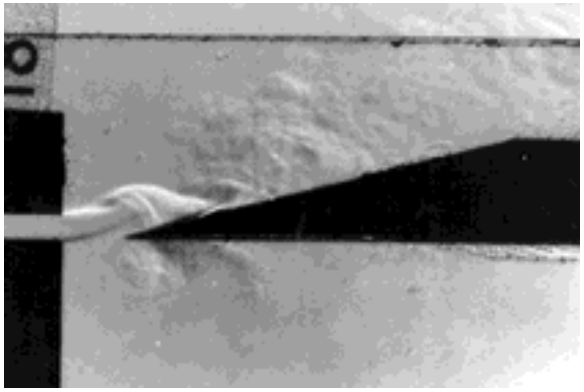


$$f_n = n\frac{v}{2L}$$



$$f_n = n\frac{v}{4L}$$

- How to create waves: edge tones, reeds



BA

Clicker Question 13.1

A flute (open-open tube) playing its lowest note is shown in the spectrum A ($f_{1,\text{flute}}$ refers to the fundamental of the flute). Which spectrum best matches a clarinet (open-closed tube) of equal length playing *its* lowest note?

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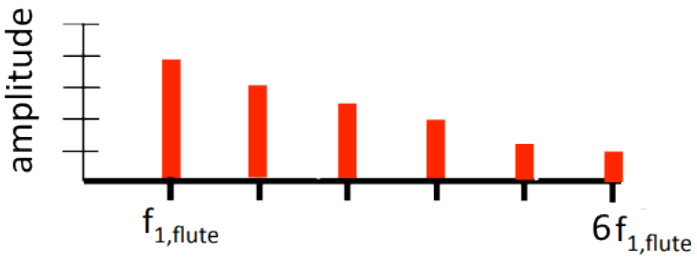

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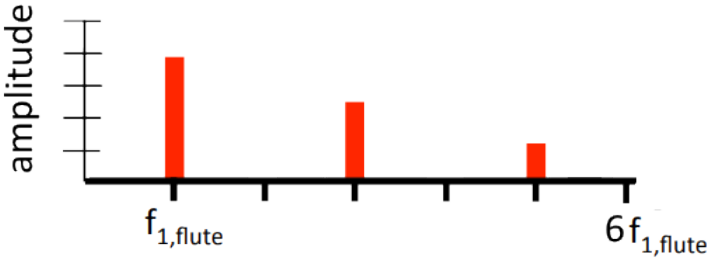

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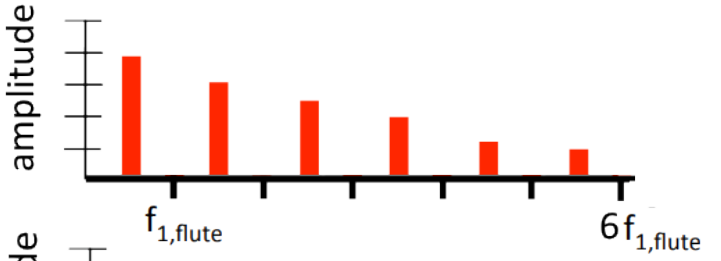

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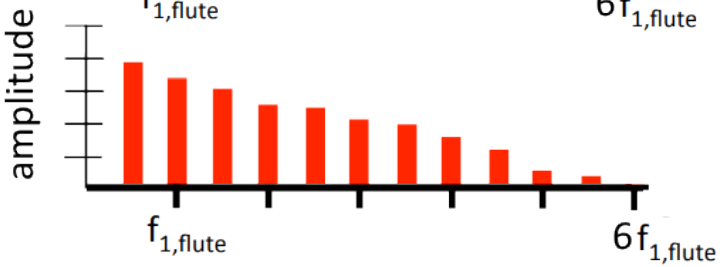

E) None of these look right

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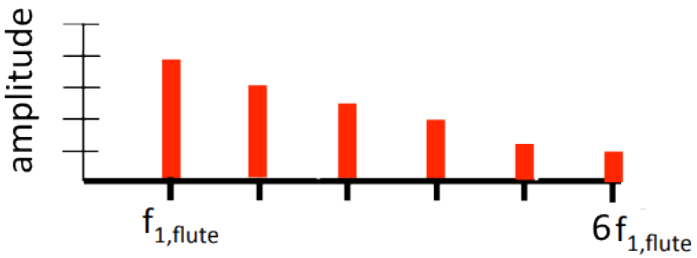

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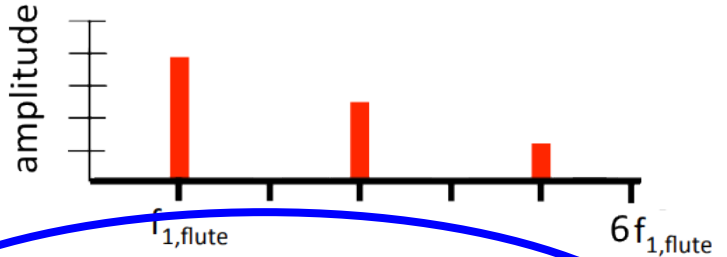

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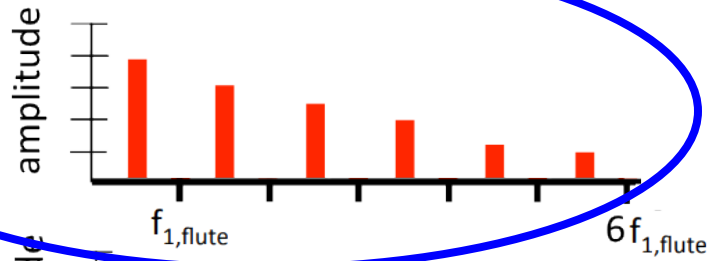

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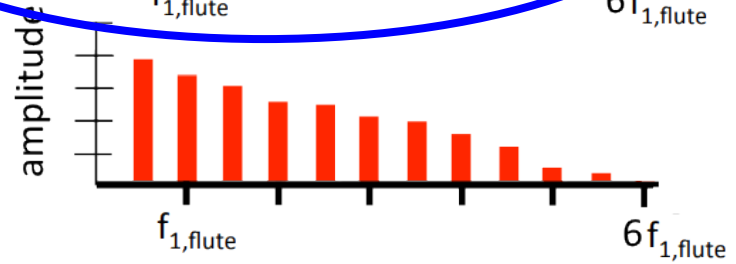
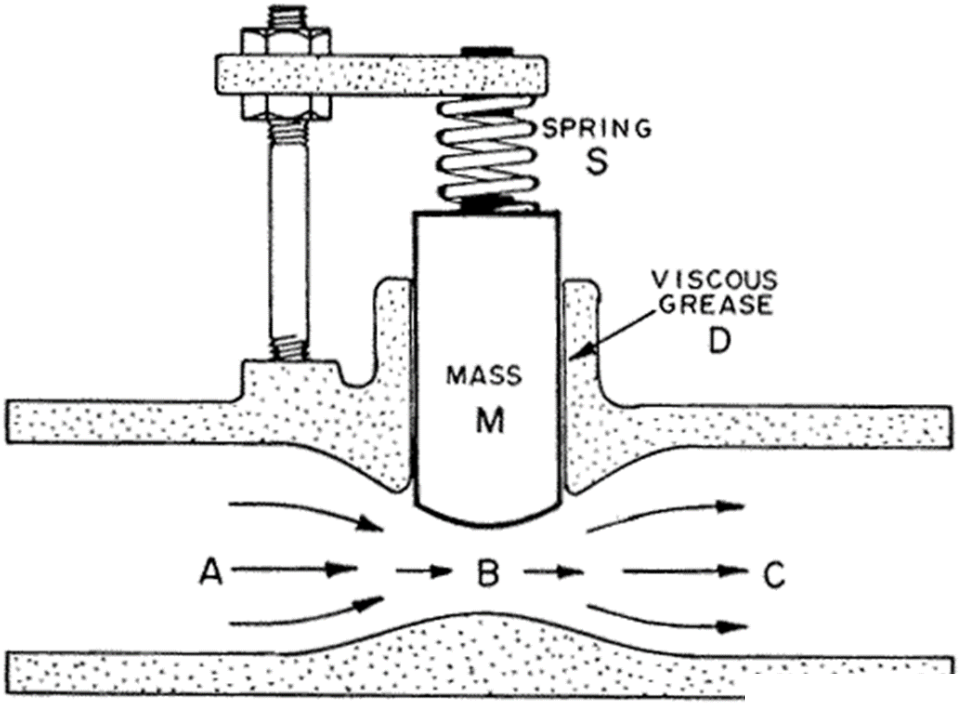


E) None of these look right

Aerophones

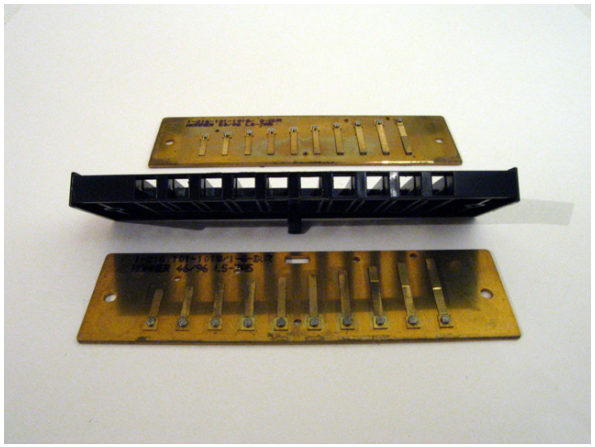
- Sound production: edge tones,
  vibrating reeds (⇒ Bernoulli effect)

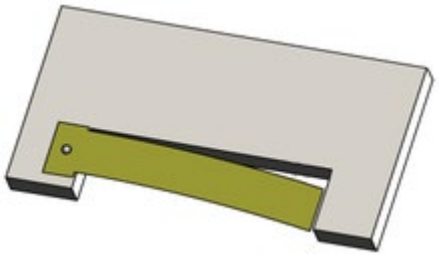
- Bernoulli effect: faster air ⇒ lower pressure
  ⇒ mass lowers (blocking airflow), building up more pressure
  ⇒ simple harmonic motion

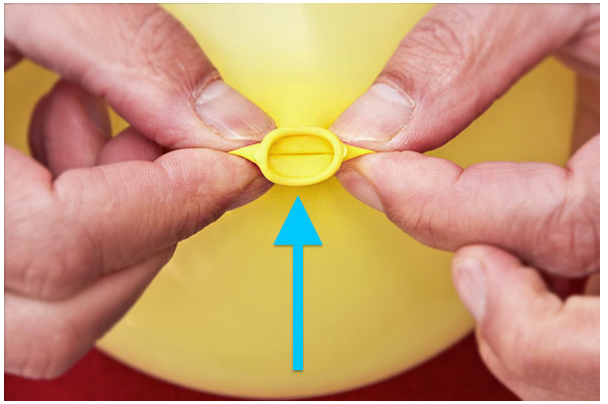


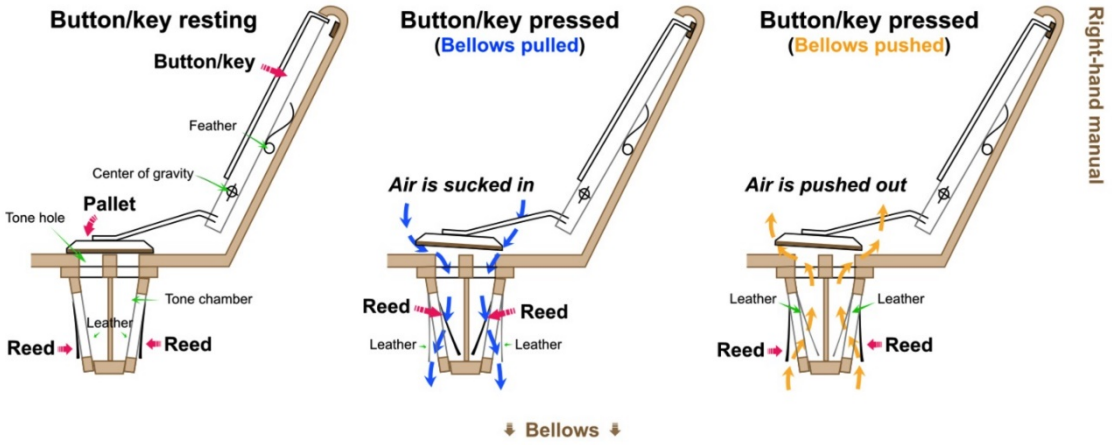
Free Aerophones

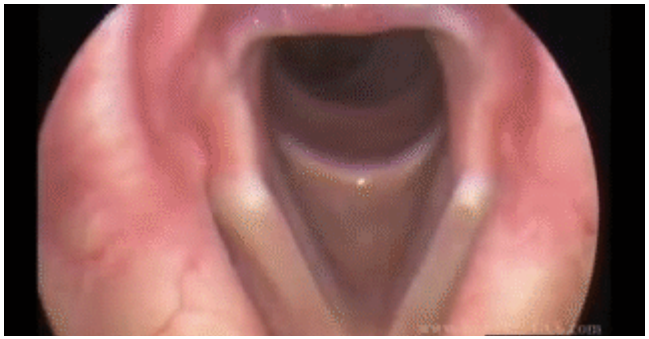
- Sound production: edge tones, vibrating reeds
- Free-reed aerophones: harmonicas, accordions, reed organs







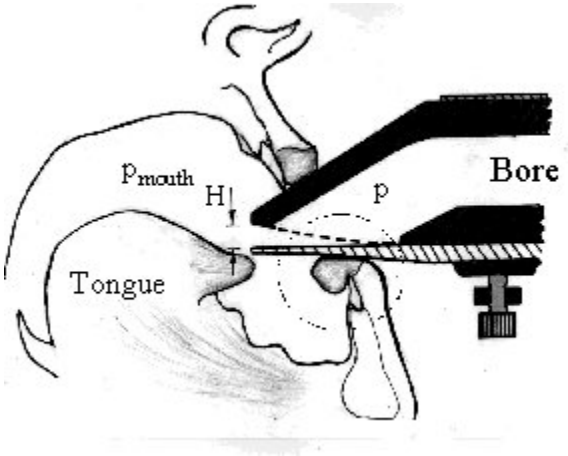


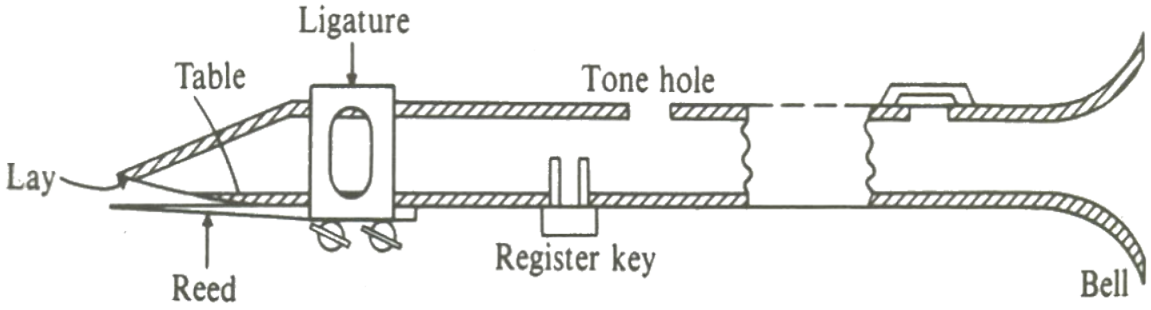


Reed-type Aerophones

Sound production: reeds/brass mouthpiece (Bernoulli effect)

- Reed woodwinds:



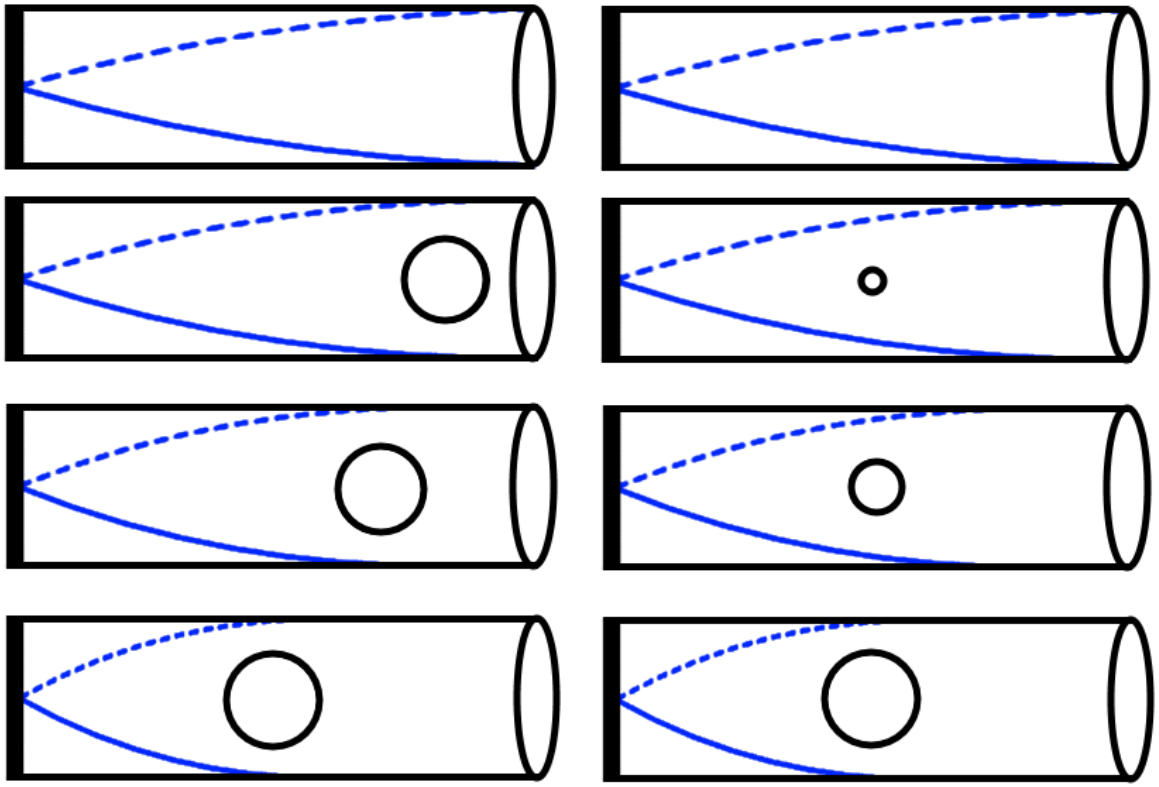


Reed Woodwinds

- Single reed: clarinet, saxophone
- Double reed: oboe, bassoon
- Quadruple…

Reed Woodwinds

- Tone holes decrease the effective length
- The larger the hole, the closer it is to a velocity antinode

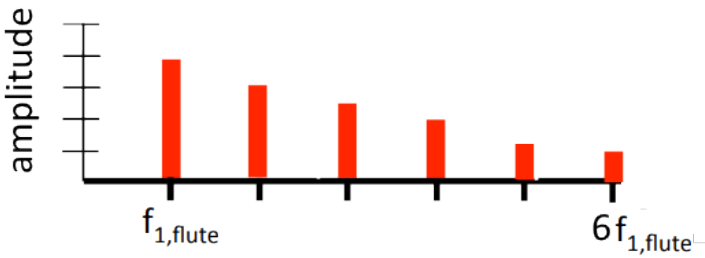


BA

Clicker Question 13.2

A flute with large tone holes plays a note with all tone holes covered, yielding spectrum A. Which choice best matches the spectrum produced when the tone hole in the middle of the instrument is uncovered?

A)



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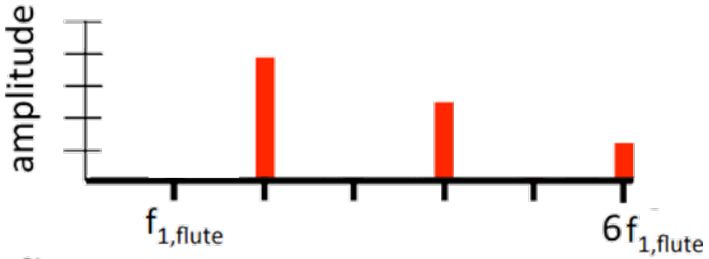
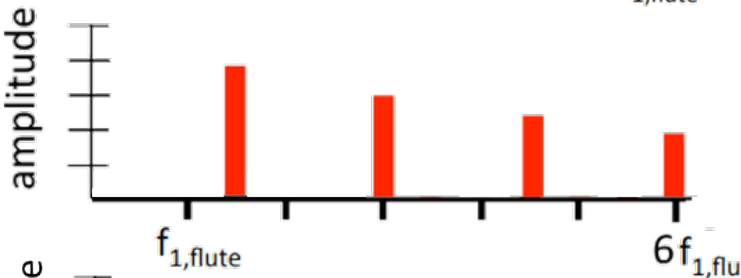


C)



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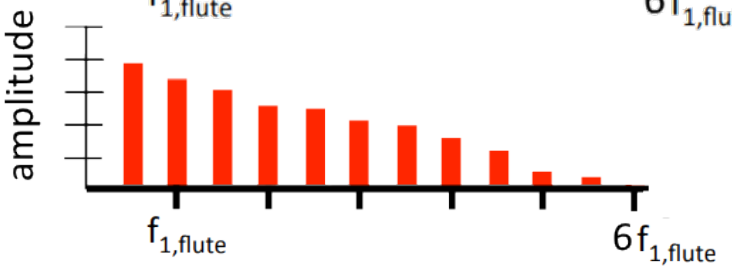

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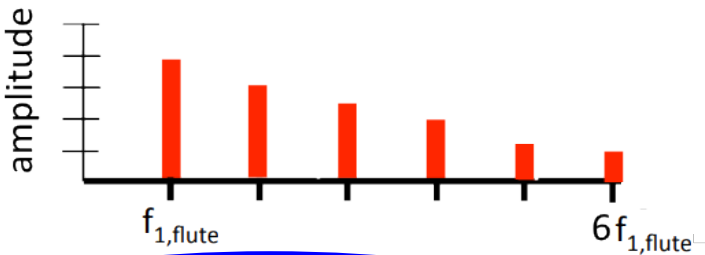

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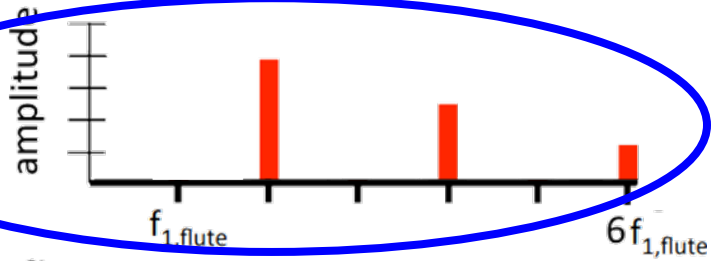

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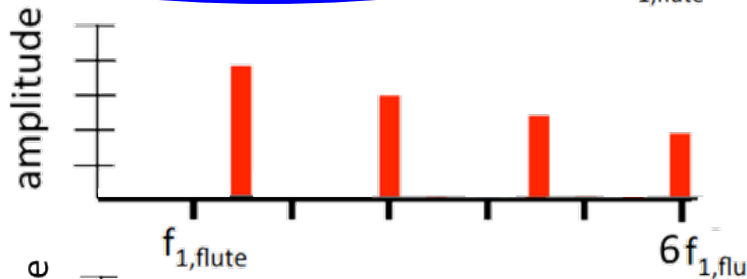

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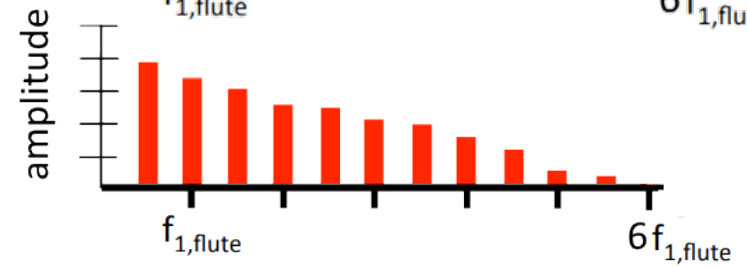

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Clicker Question 13.3

What would happen in the previous question if the tone holes were much smaller than the flute's ends? (Identify the spectrum of an open-open tube with a small hole in the center uncovered.)

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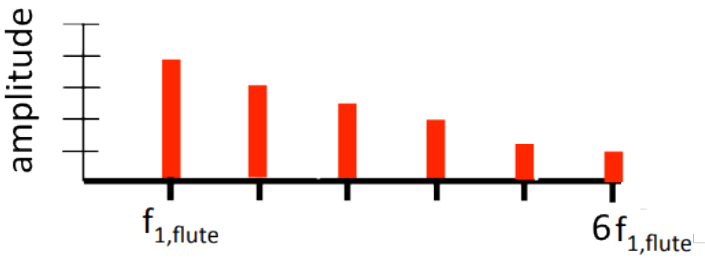

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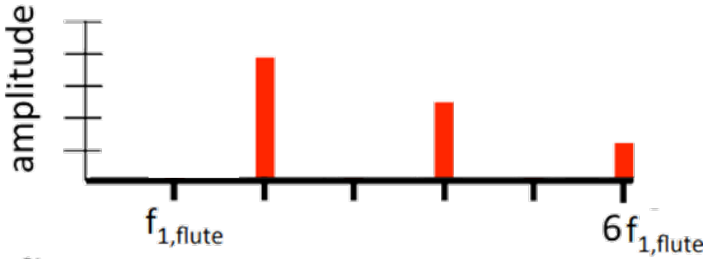

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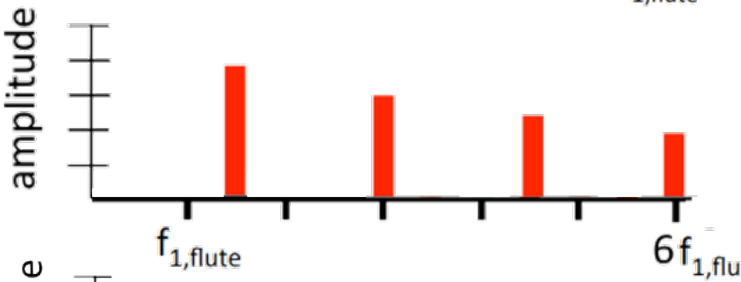

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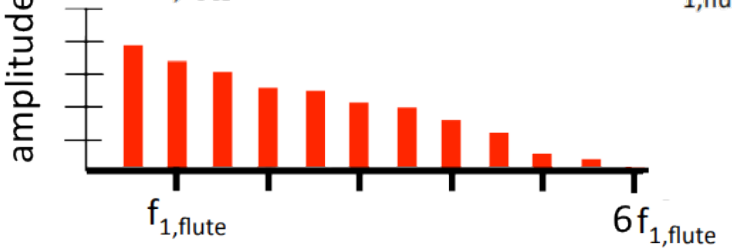

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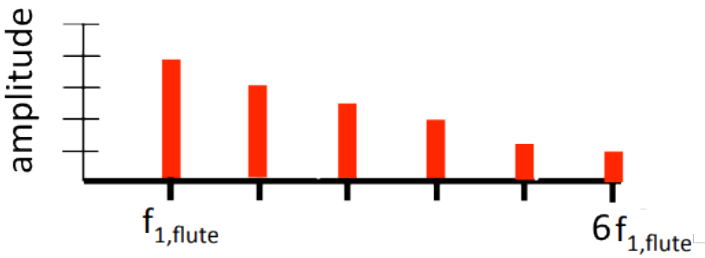

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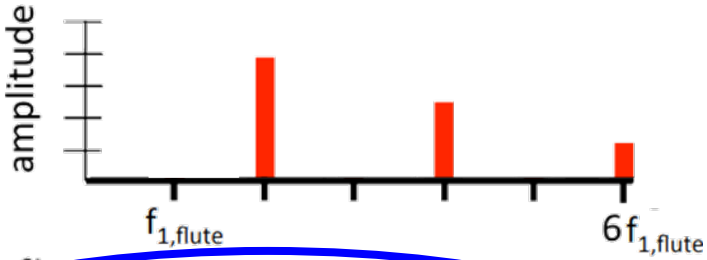

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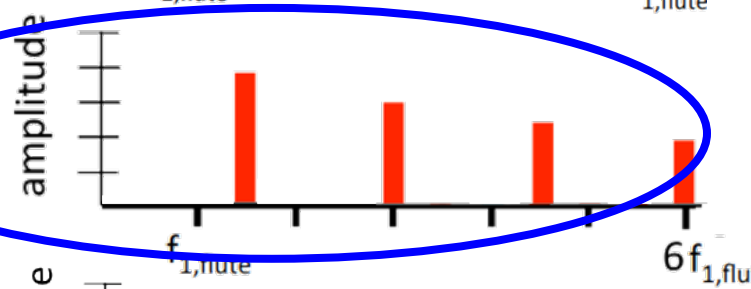

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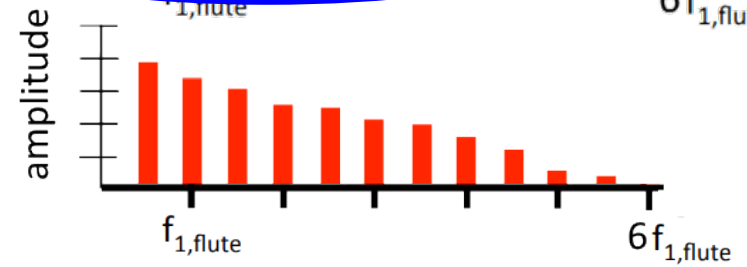


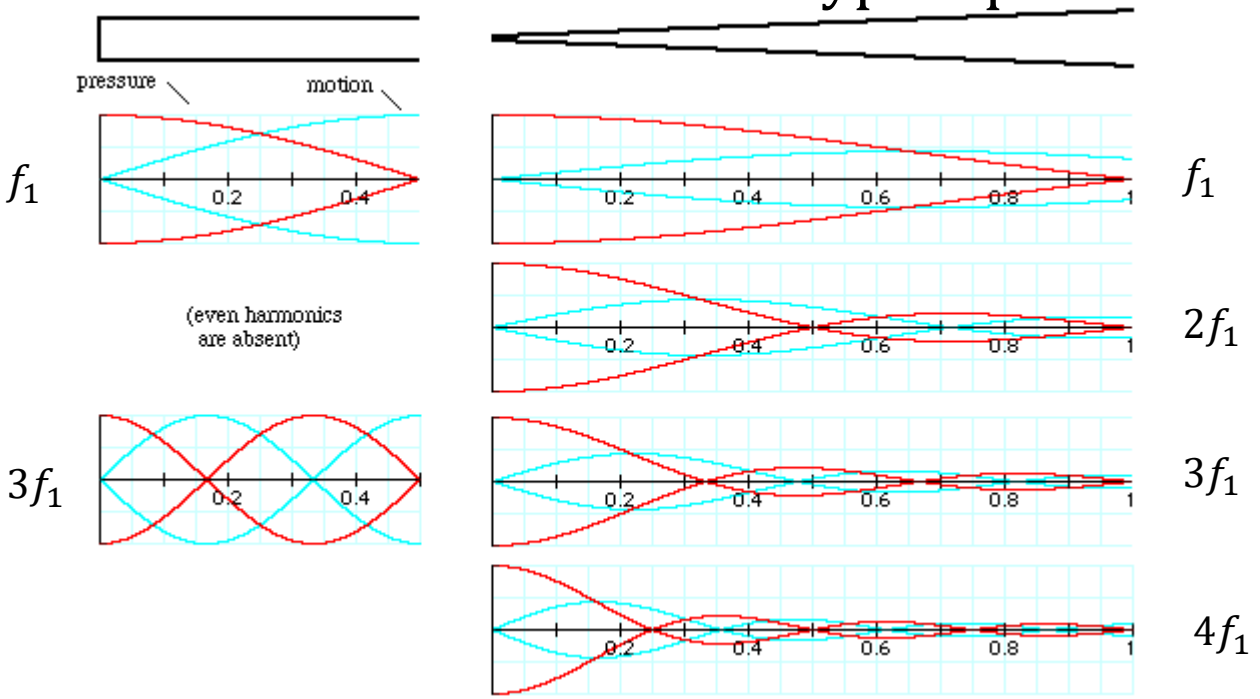
E) None of these look right

Reed Woodwinds

- Shapes: cylinder open at one end (clarinet)
  cone open at one end (saxophone, oboe, bassoon)

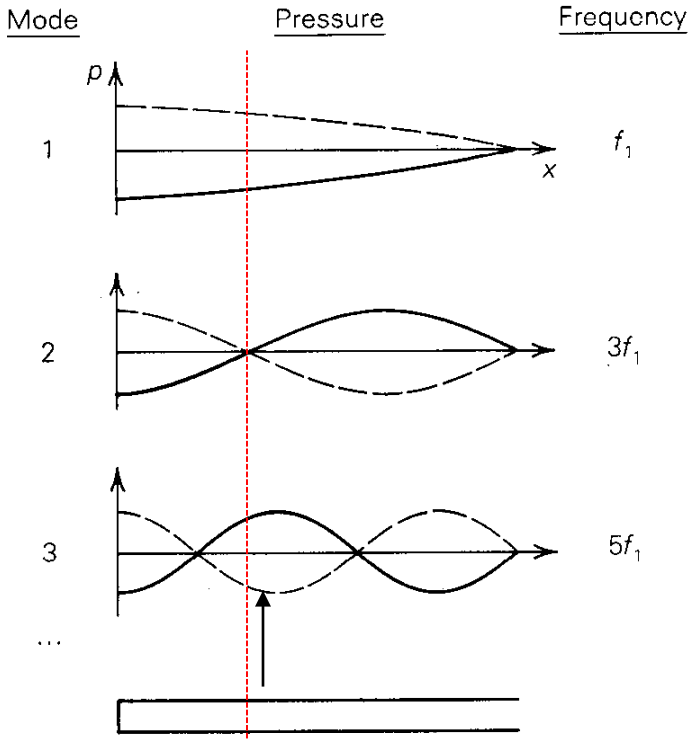
(bends in instrument don't affect too much)

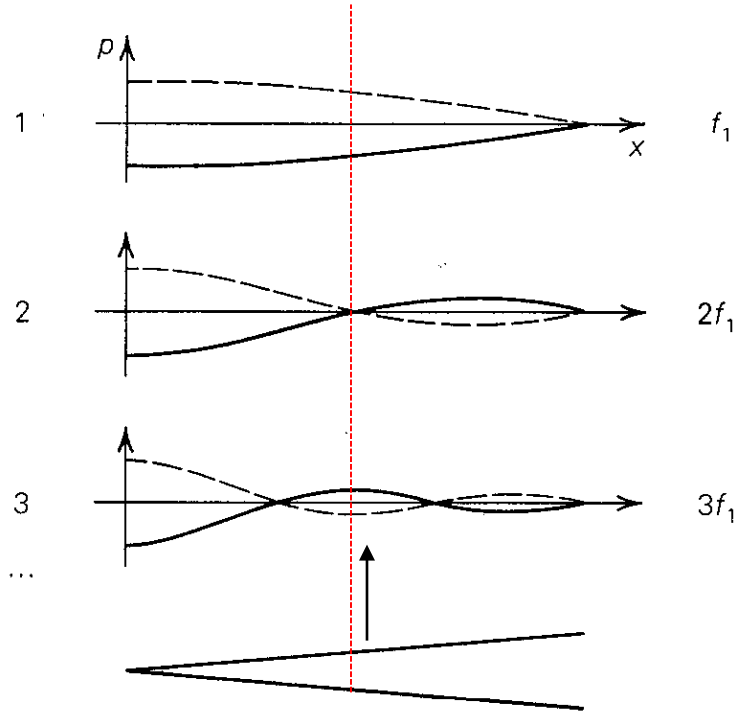
Type equation here.



Reed Woodwinds

- Register holes, octave holes: force harmonics





"register hole" here

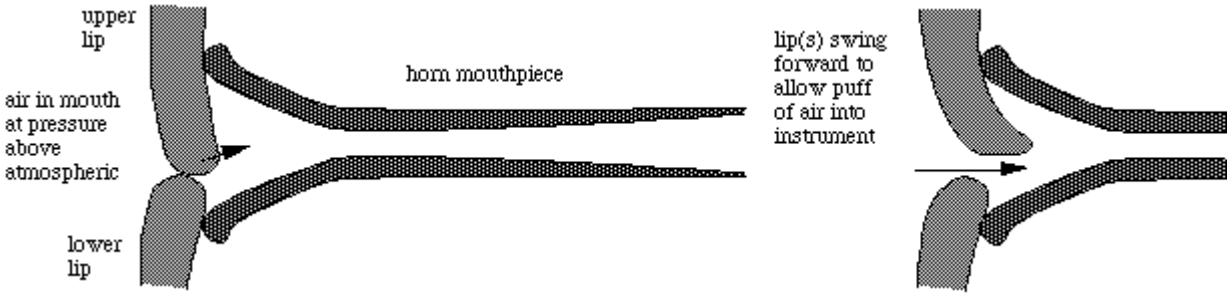
(forces $3f_1$ harmonic in clarinet)

octave hole here

(forces $2f_1$ harmonic in saxophone)

Brass

- Instead of reeds vibrating, the player's lips vibrate



Brass

- Shape: flared bell at end, mouthpiece constriction
- Partials are nearly harmonic, except first partial
- Lips control which partial is emphasized

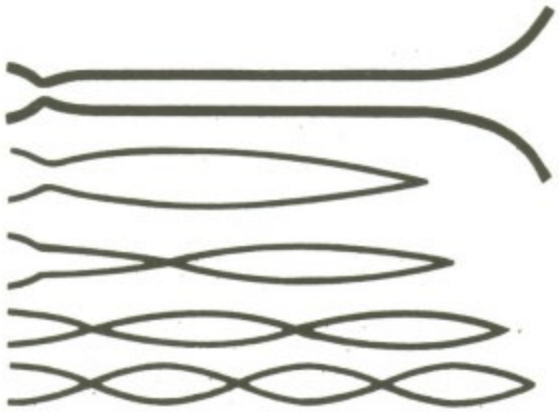
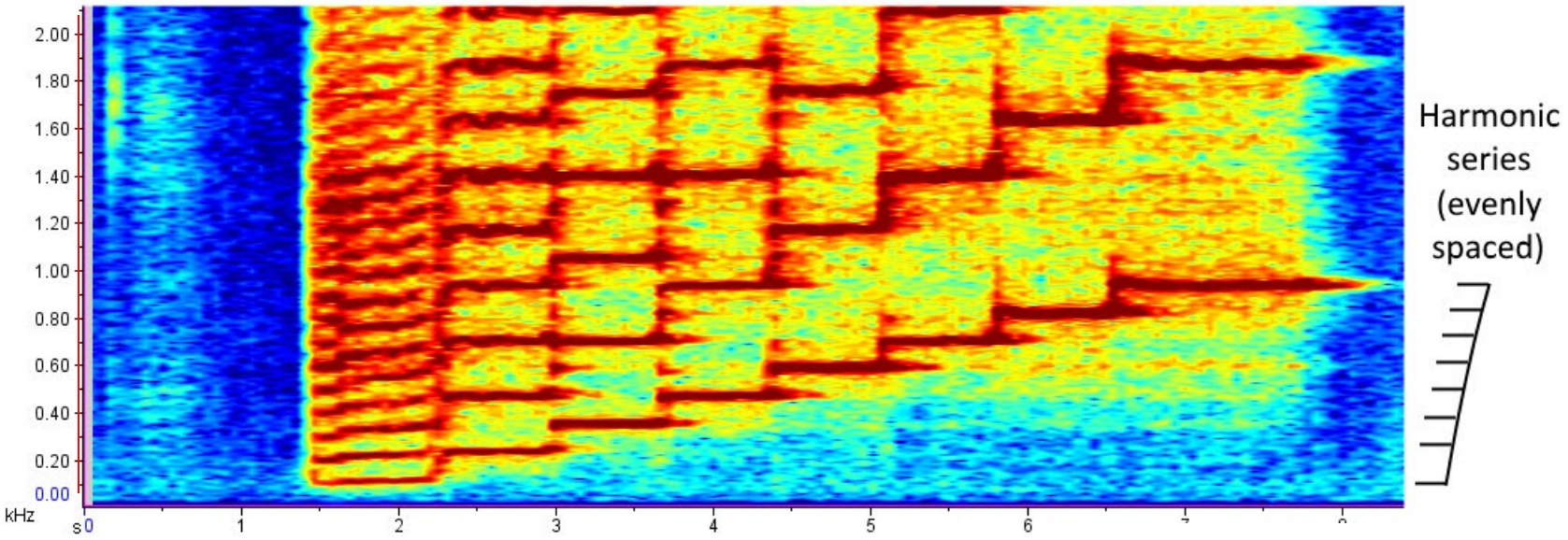


FIG. 11.8
Approximate pressure distribution for the first four modes in a trumpet. Note that the "turning point" moves outward in the bell as the frequency increases. Mode frequencies are nearly in the ratios 0.8 : 2 : 3 : 4.

Brass


2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
kHz
s 0
1
2
3
4
5
6
Harmonic series (evenly spaced)

Brass

- Changing pitch: no tone holes, but valves change length