Physics 1240: Sound and Music

Today (7/30/19): Percussion: Vibrating Membranes

Next time: The Human Voice, Language

Review

Types of Instruments
(Hornbostel–Sachs classification)

- Chordophones: vibrating strings

- Aerophones: vibrating columns of air

- Idiophones: vibrating the whole instrument

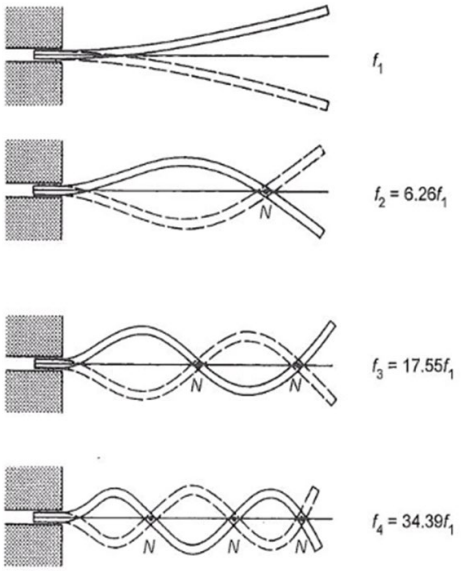
- Membranophones: vibrating membrane/skin

- Electrophones: vibrating loudspeaker

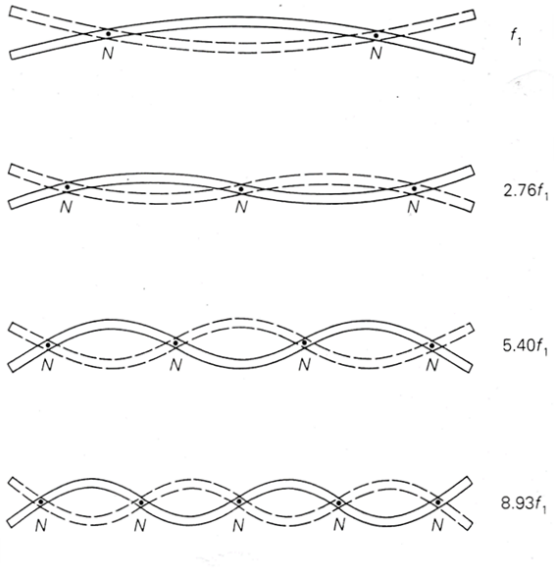
Review

Idiophones

Clamped-free beam



Free-free beam



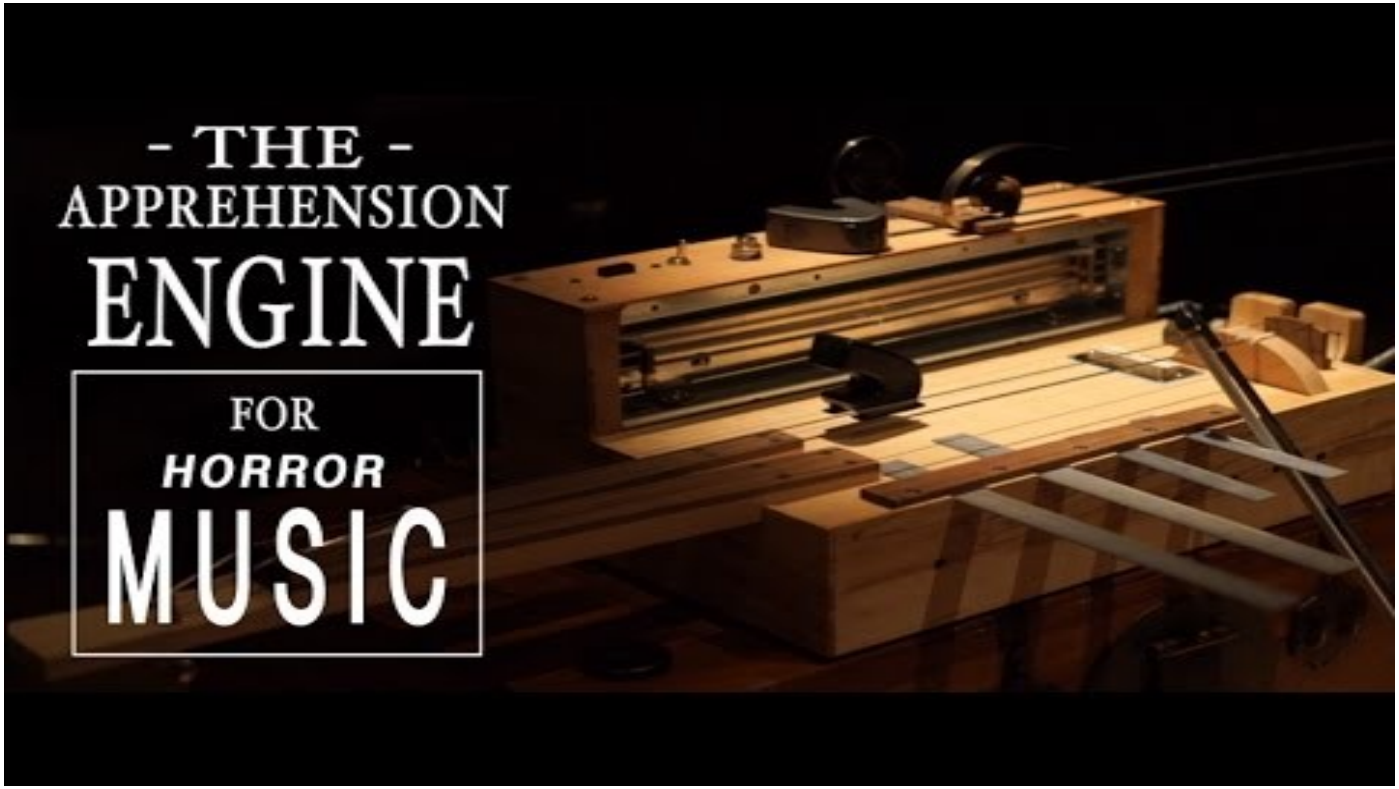
- Striking an object at any given point will sound each natural mode in proportion to how much that mode involves motion of that point
- Fixing an object to any given point will sound each natural mode that has a node at that point

Musical Saw

(https://www.youtube.com/watch?v=Qm8BuOQwX4c)

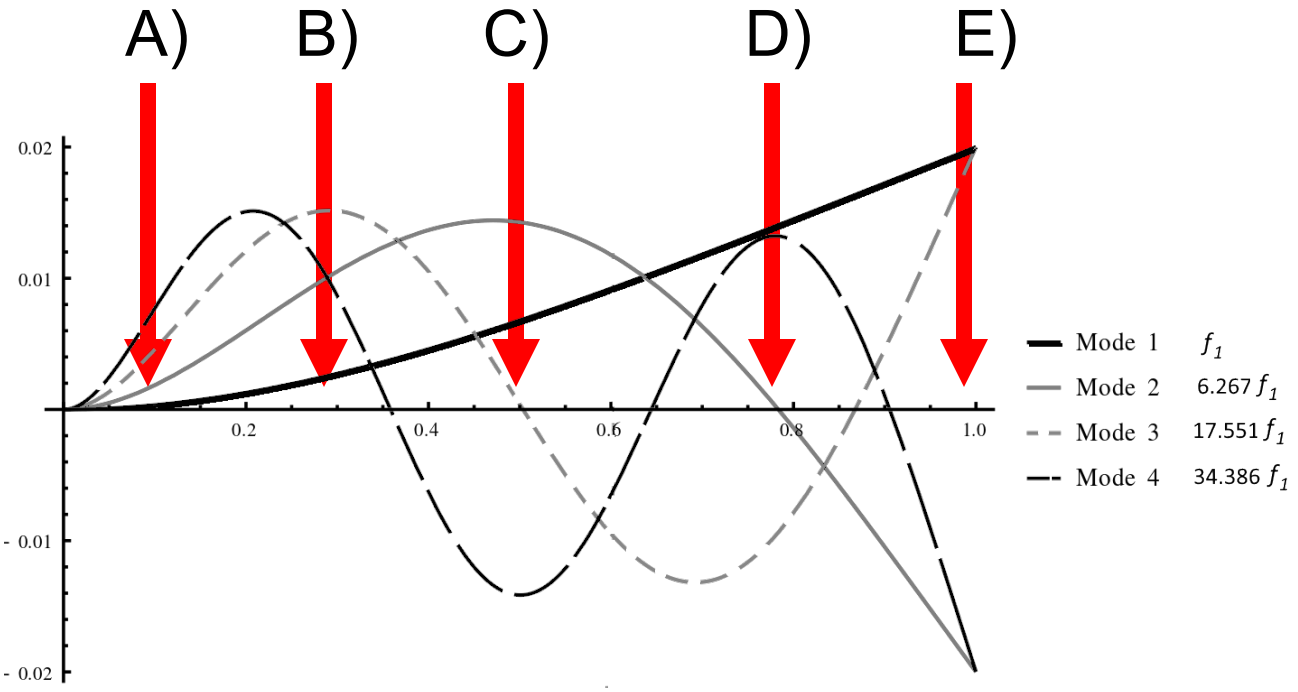
https://www.youtube.com/watch?v=QhTdBrOxteU

https://www.youtube.com/watch?v=lzk-l8Gm0MY



Clicker Question 15.1

If a musical saw is played by rubbing a bow along its side while NOT holding the free end, where should the bow be placed to most effectively remove the second natural mode?



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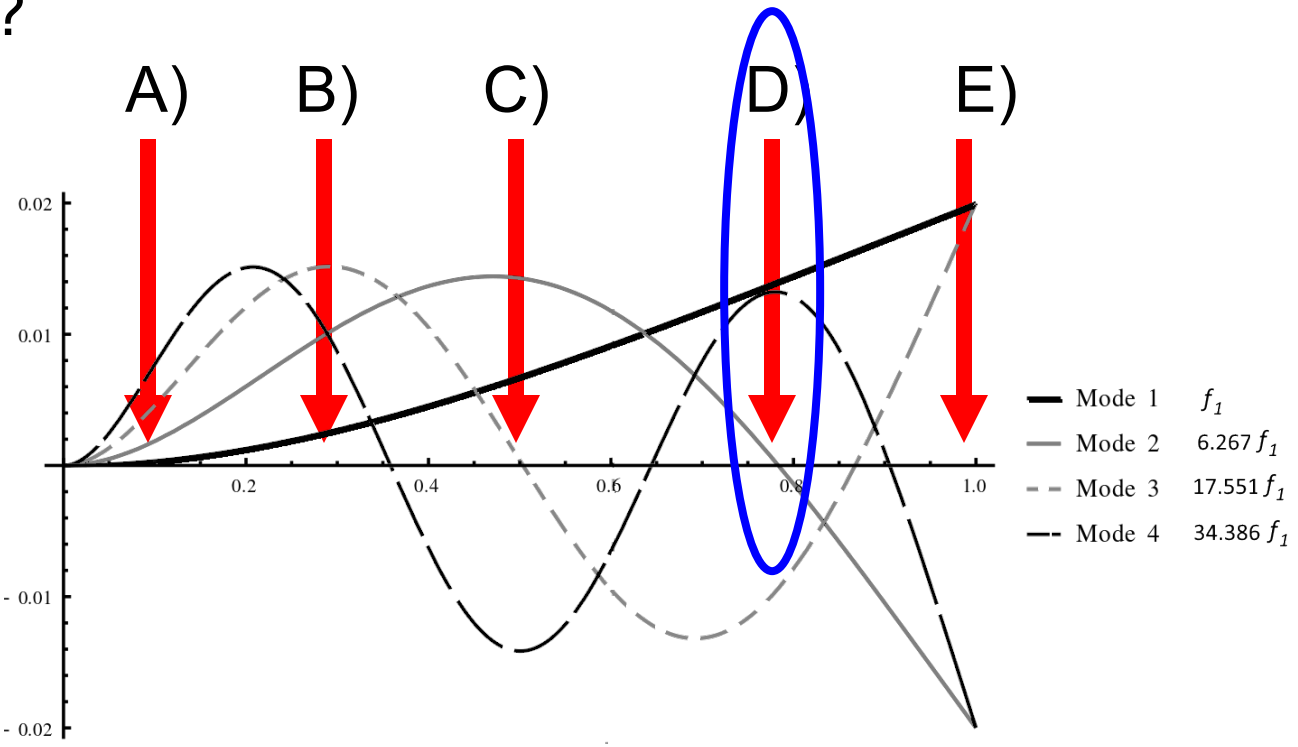


What about other percussion instruments?

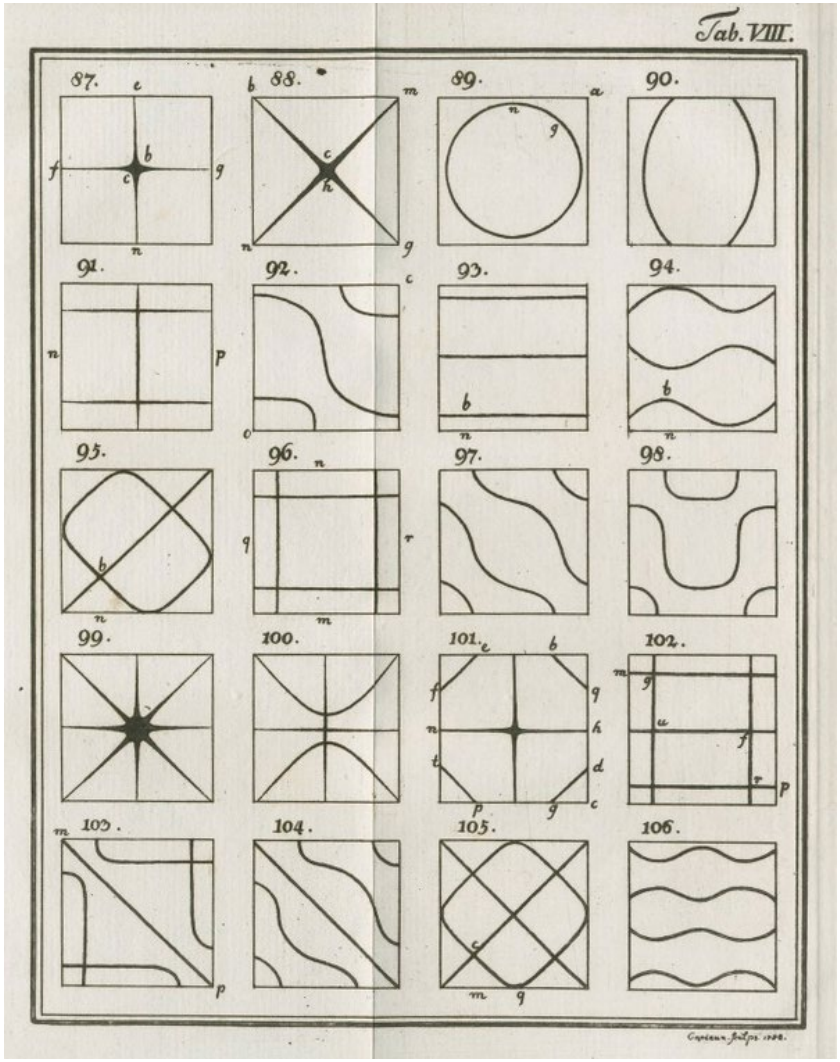
Stonehenge

(https://www.youtube.com/watch?v=ppnhKwXXL40)

Chladni Figures

- Ernst Chladni (1787) (studied law & philosophy at University of Leipzig)

- Demonstrated the natural modes of vibration for a square plate



Clicker Question 15.2

For a particular natural mode on a Chladni plate, what do the spots with sand show?

A) nodes
B) antinodes
C) something else

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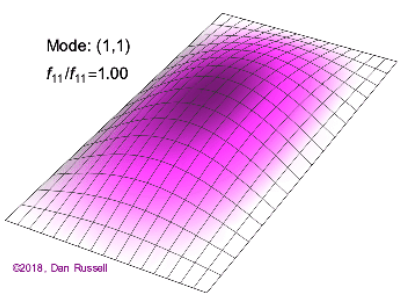
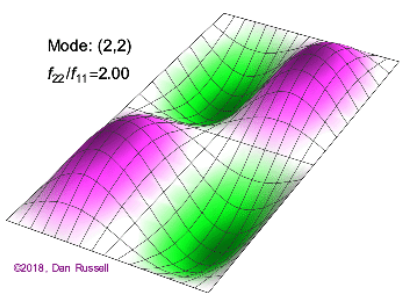
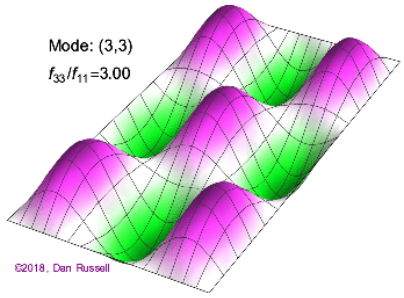
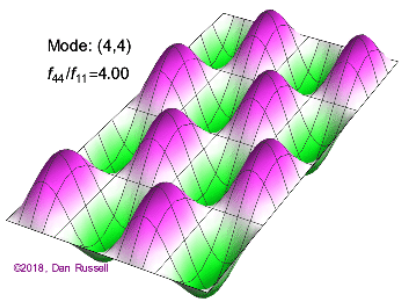
Chladni Figures

- Vibrations of 2D systems: nodes/antinodes are lines/curves instead of points
- Modes labelled with 2 numbers instead of 1
  - e.g. Mode (1,1), Mode (1,3), Mode (2,4), etc.
- Modes with the same number twice have integer-multiple frequencies; others do not



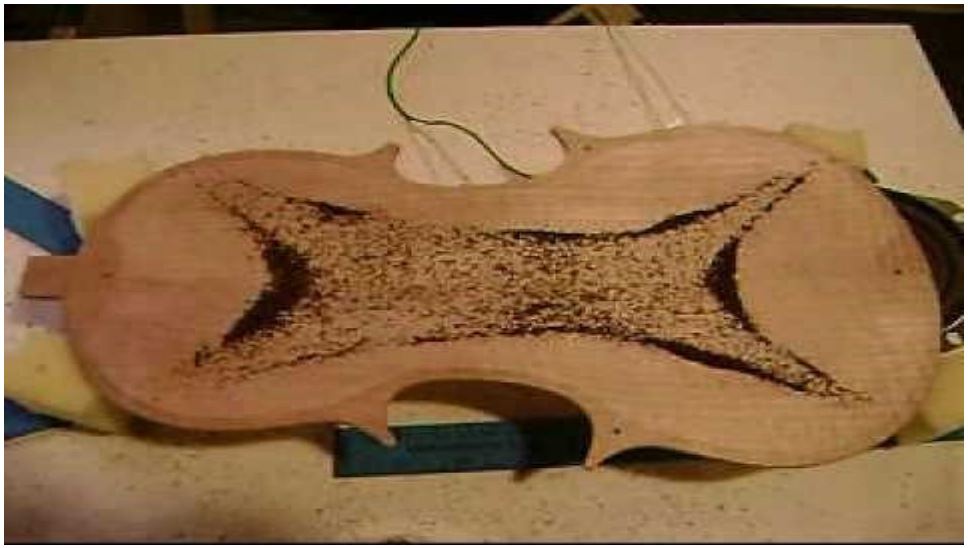


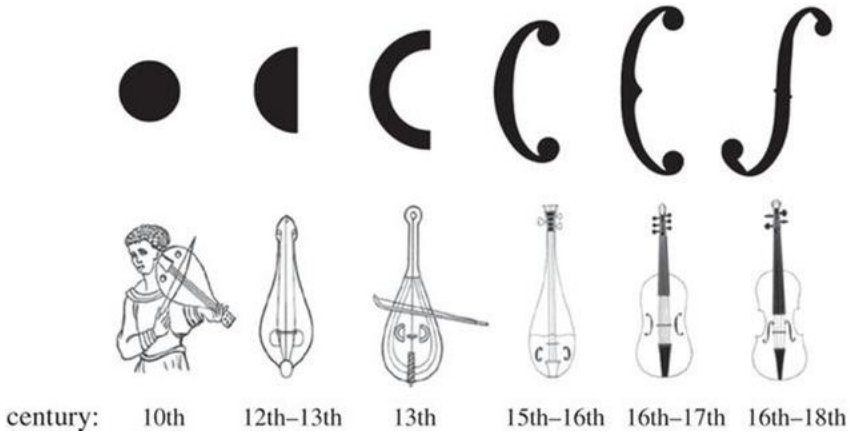




Violin

(https://www.youtube.com/watch?v=3uMZzVvnSiU)

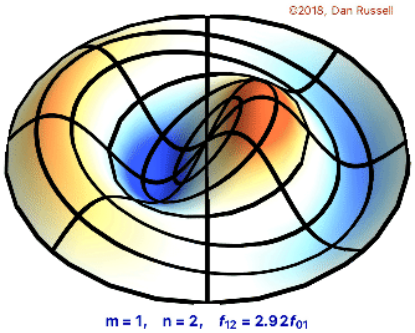


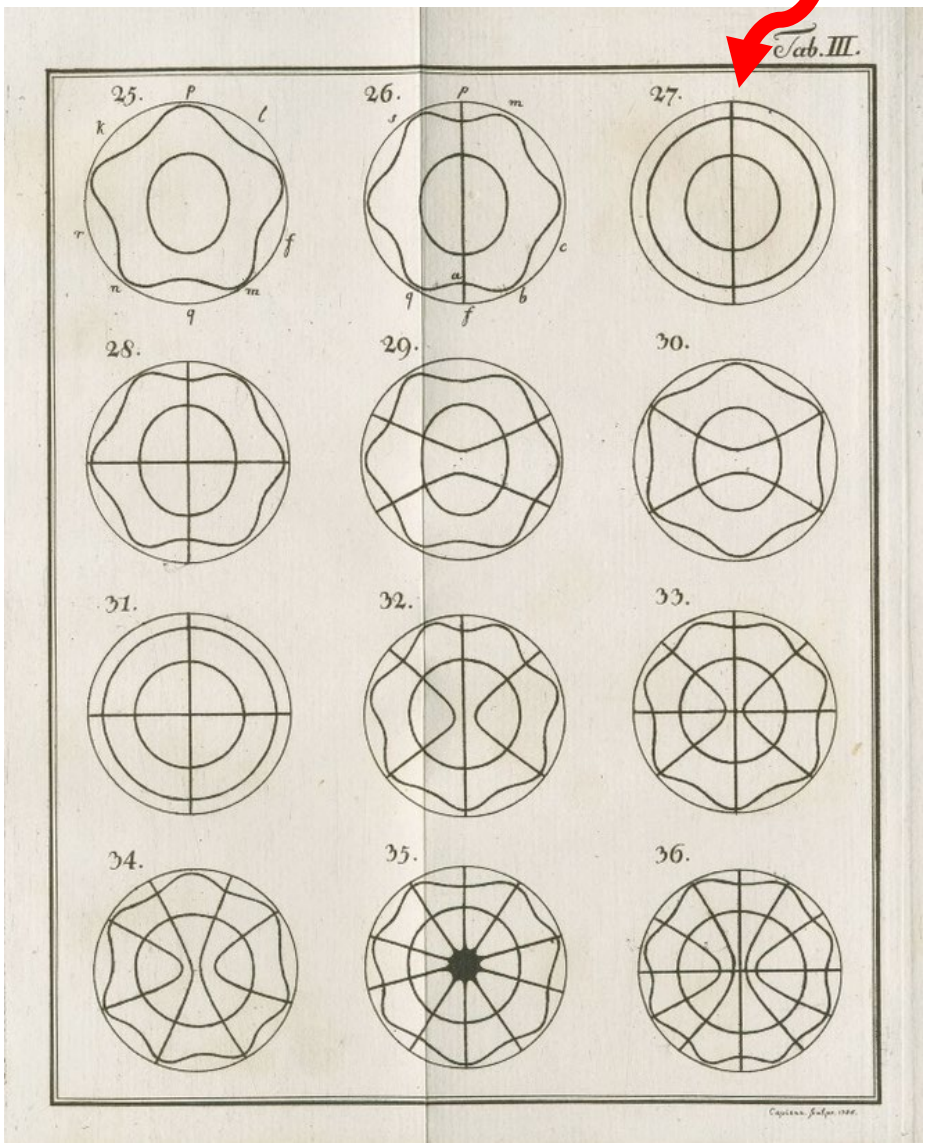


Chladni Figures: circular modes

(1,2)

- Modes labelled by number of linear and circular nodes



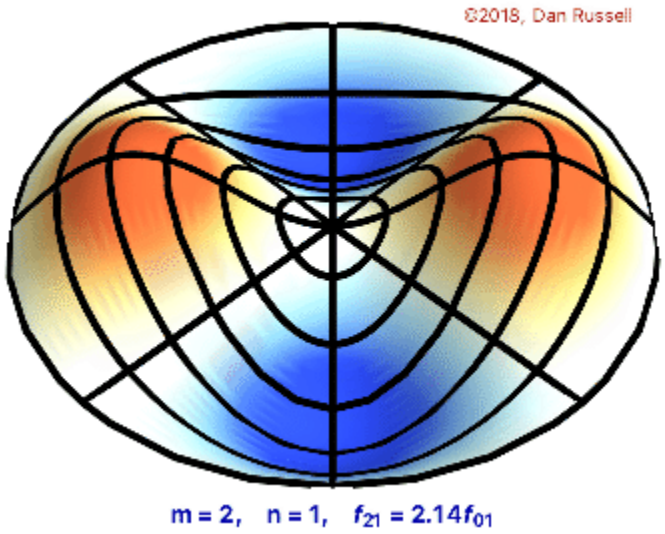


BA

Clicker Question 15.3

Which natural mode is shown in the image below? Circular membrane modes are labelled as (# linear nodes, # circular nodes)

A) (0,1)
B) (1,1)
C) (2,1)
D) (3,1)



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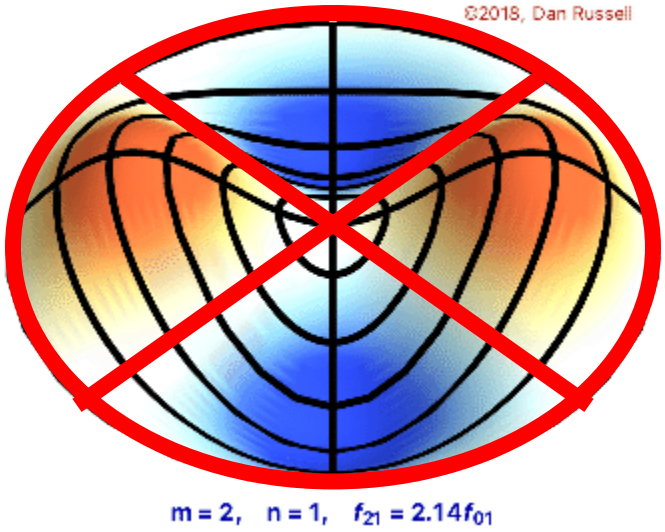
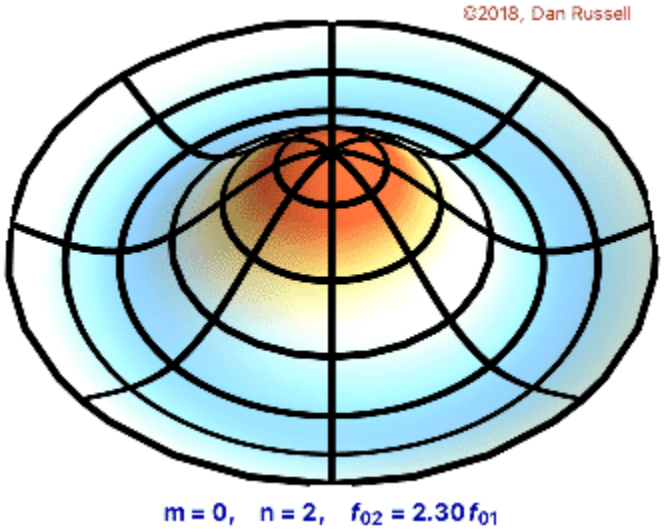


BA

Clicker Question 15.4

Which natural mode is shown in the image below?

A) (0,1)
B) (0,2)
C) (1,1)
D) (1,0)
E) (2,2)



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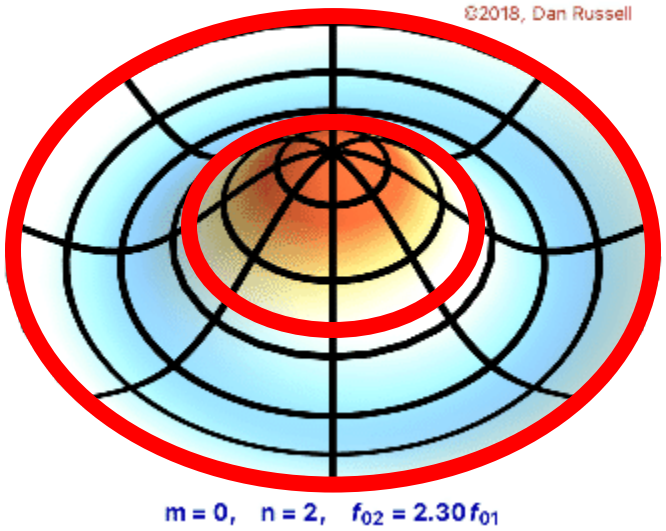


Vibrating Sheets/Membrane

- Instrument examples: thunder sheet, gongs, cymbals, bells, drums

- An Alpine Symphony by Richard Strauss https://www.youtube.com/watch?time_continue=2443&v=eQa9mW8ygAE

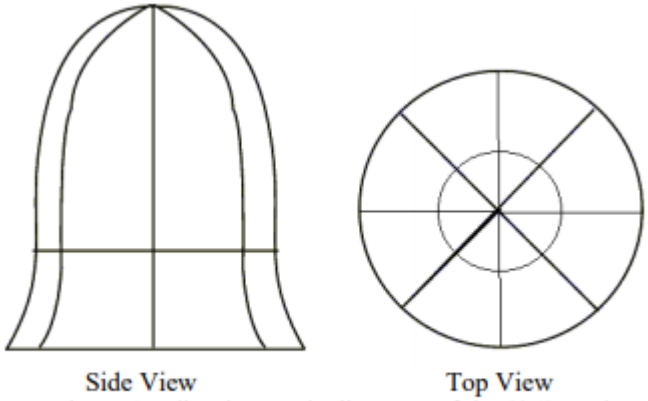
Cymbal / Gong

https://www.youtube.com/watch?v=kpoanOlb3-w

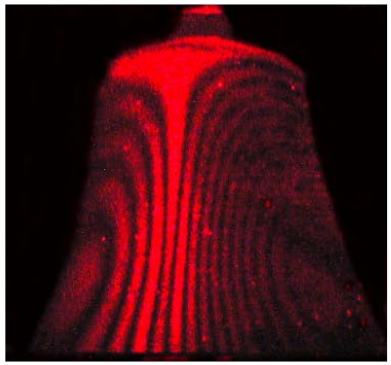
Bells

- Same as a circular sheet, but bent

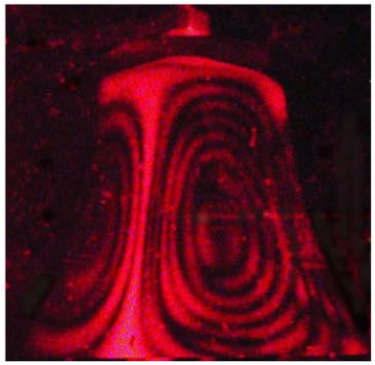
(frequencies slightly different)



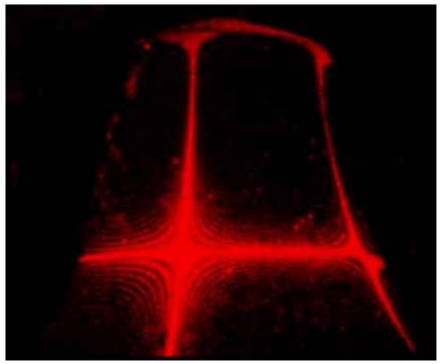
(4,1) Mode for a handbell



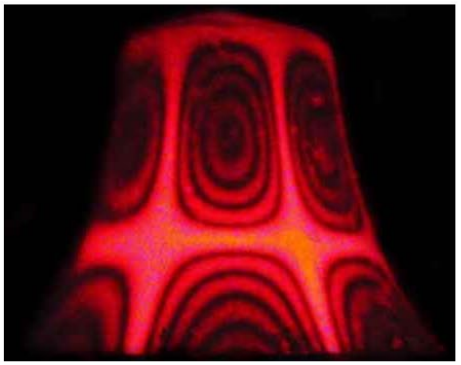
(2,0) mode: 261.8 Hz



(3,0) mode: 770.9 Hz



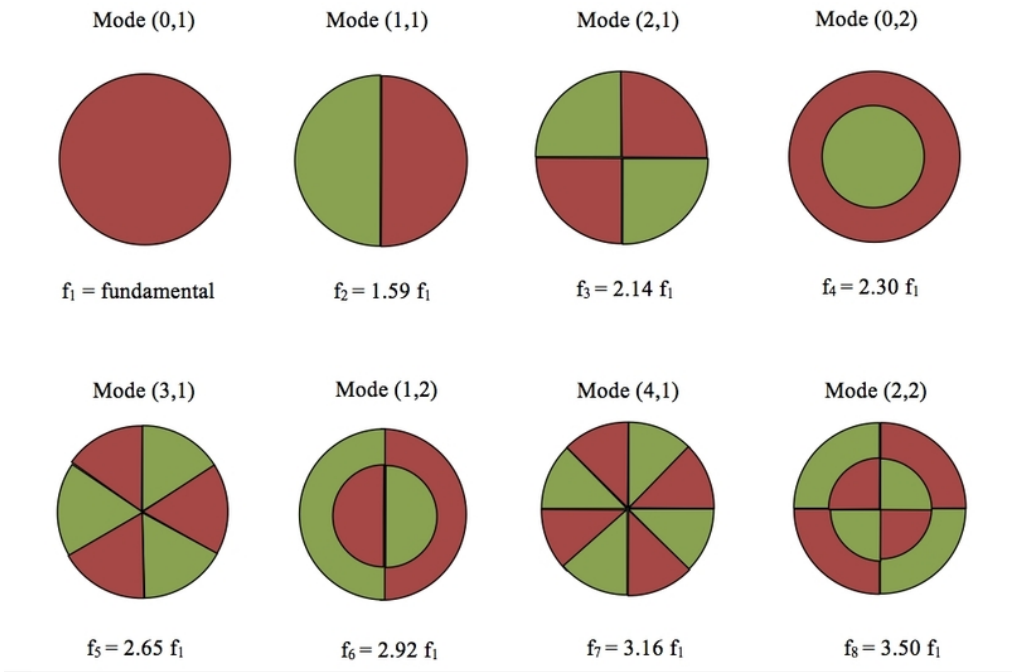
(3,1) mode: 1250.6 Hz



(4,1) mode: 1334.5 Hz

Drum Modes

- Same as circular sheet, but with one restriction
  - Edge must be a circular node



Drum Modes

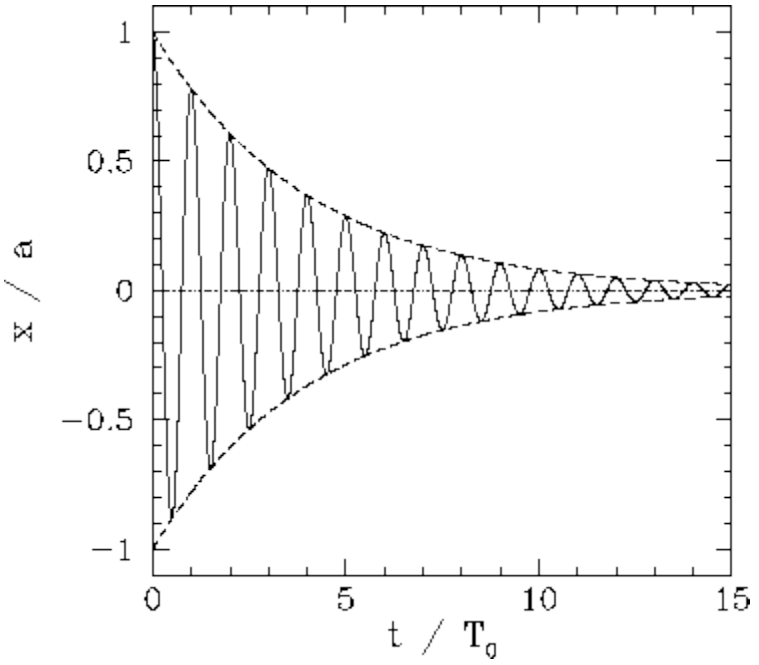
- What about the timpani?

https://www.youtube.com/watch?v=wgcMG4EijSo

  - Membrane has to move air
  - f_n depends on bowl shape
  - Fundamental damps away quickly
  - Striking point damps out many modes

Damping time

- Damping time: time it takes for a sound to vanish
- Sound will never completely vanish—damping time measures how long it takes to drop 60 dB



BA

Clicker Question 15.5

How much (by what factor) does the intensity of a sound drop if it decays 60 dB?

A) 1/60
B) 1/100
C) 1/2
D) 1/1,000
E) 1/1,000,000

BA

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How much (by what factor) does the intensity of a sound drop if it decays 60 dB?

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C) 1/2
D) 1/1,000
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Steel Drum

https://www.youtube.com/watch?v=Ne4eutIKH7Q


YAMAHA
CPA
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