PHY 103

Percussion: Drums

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Reading for this week:

- Hopkin, Chapter 7
- Fletcher and Rossing, Chapter 3 (for advanced background material)
Percussion Instruments

Percussion instruments are divided into two types:

- Membranophones
  - Drums

- Idiophones
  - Chimes, xylophones, marimbas, jaw harps, boos, tongue drums, bells, gongs

Could also be divided into instruments with pitch and instruments without pitch

Q: do drums have pitch?
Types of Membranophones

- **Struck**: vibrations produced by sticks, hands, etc.
  - Timpani/kettledrum, snare, taiko, tabla, bongo, …

- **String**: vibrating string attached to drumhead
  - Found in South Asia (Indian drum)

- **Friction**: rubbing motion causes drumhead to vibrate
  - Irish bodhrán, Brazilian cuica, etc.

- **Singing**: vibrating membrane modifies another sound
  - Kazoo
Drum Components

1. Drumhead
   - Animal skin, fabric, plastic, fiberglass
   - Light and thin: more overtones, “bright” sounding
   - Heavy and soft: lower tones, “darker” sound

2. Body
   - Frame for drumhead and resonant cavity

3. Attachment of head to body
   - Staples, screws, tape, rubber bands, etc.
Effect of the Drum Body

- The drum body (if there is one) provides a resonant cavity for the vibrating membrane

- What does this drum sound like?

- No enclosure, **no air resonance**

- Front and back of drumhead are **out of phase**, causing cancellation of low-frequency overtones

- Sound is loud but **lacks depth** due to cancellations
Effect of the Drum Body

- What does this drum sound like?

- Bigger enclosure than frame drum, *more resonance*
- Less cancellation from front/back of drumhead
- Fuller, *deeper sound*
Effect of the Drum Body

- What does this drum sound like?

- Strong air resonance in barrel, *very full sound*

- Drumhead tone can differ from resonance tone and both can be heard separately
Effect of the Drum Body

What does this drum sound like?

Air resonance has **broad frequency peak** and **higher range** than the narrower barrel drum.
Effect of the Drum Body

- What does this drum sound like?

- Tube has strong, narrow air resonance peak

- Drumhead resonance is likely far above the tube resonance (recall: $f \sim 1/D$)
Modes of Circular Membrane

- A circular drumhead several kinds of vibrational modes:
  - **Radial**: changes as a function of distance from center
  - **Azimuthal**: changes as function of angle

![Diagram of modes of circular membrane]

From HyperPhysics
Lowest Four Modes

- Note that the modes are \textit{inharmonic}

01: $f_1$

11: $1.59 \times f_1$

21: $2.14 \times f_1$

02: $2.30 \times f_1$

- We can observe these in a real membrane using a speaker and a strobe light
Predicted Frequencies

The frequencies of the membrane’s vibrational modes depend on the size, density, and tension of the membrane.

- Need to account for material properties
- Need to account for shape

**Fundamental frequency** of a circular membrane:

\[ f_1 \approx 0.766 \frac{\sqrt{T/\sigma}}{D} \]

- \( T \) = tension
- \( \sigma \) = surface density
- \( D \) = diameter

Like a string, the frequency **increases** with tension.
Struck Drum: Snare

- Adjustable tension using screws on the rim of the drum

- Played with drumsticks (or brushes and hands). Used historically in military drum corps; a key component of percussion in orchestral music, jazz, and rock music

“Chavala” (Buddy Rich)
Struck Drum: Tabla

- Main drum: wooden body, distinct high pitched sound

- Larger drum: steel body, dark sound. The drummer adjusts the tension in the membrane with the heel of his hand
African Talking Drum

- The talking drum has two drumheads connected by tension chords.

- The drummer squeezes the chords using his arm and body (or legs) to change the tension and pitch of the drum.

- The pitch of the drum is varied to mimic the tones of speech.

Ayan Bisi Adeleke (Nigeria)
Q: What is the Cymbal?

- Idiophone or membranophone? Explain your answer!
The Drum Set

- In case you were starting to worry that percussion is for men only...

Mi-Gu (Yuko Araki), Yo Gabba Gabba! (c) 2007
Friction Drum: Bhodrán

- Traditional Celtic drum... or a mid-20th Century invention

- Played by brushing the hand against the drumhead and damping from behind with the non-dominant hand. Can also be played with a tipper
Cuica (Brazil)

- Friction drum with a stick attached to the inside of the drumhead. A key component of samba.

- Rubbing the stick produces a vibration, whose pitch is changed by adjusting tension in the drumhead.

- You can make a cuica easily out of an empty coffee can.
Coffee-can cuica, from Hopkin Ch. 7, p. 104:

- Empty coffee can with plastic lid, 1/8” bamboo skewer, scrap of chamois or cotton rag, duct tape
- Drill 1/16” hole in center of plastic lid
- Push through skewer so that 1/2” protrudes and affix it with 1/2” strip of duct tape wrapped around the stick and snug against the lid

Wet the scrap of rag, hold the can with one hand, pinch the stick with the rag and rub back and forth

Greater pressure increases the tension in the lid, resulting in higher frequency
Summary

- **Membranophones** are percussion instruments based on the excitation of a drumhead under tension by striking, friction, or sympathetic vibration.

- The overtones in membranophones are *inharmonic* due to the complexities of the material and shape of the instrument, including the air cavity.

- Excitations can include:
  - **Azimuthal modes**, adjacent areas moving up/down.
  - **Radial modes**, circularly symmetric excitations.