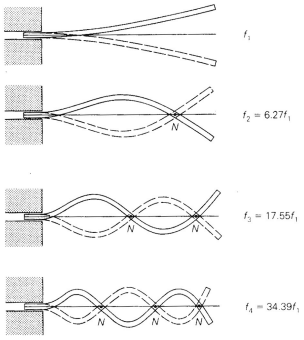
Physics of Musical Sound

Class 21
Read Chapter 31
Sections 1-10.
Quiz Wednesday.

Clamped Bar Modes



Normal Modes Reminder

- Normal Mode: all parts of system oscillate with same frequency.
- Every motion of the system can be written as a sum of the normal modes.
- If we analyze the sound spectrum then we shall only find frequencies corresponding to the normal modes.
- The amount of each normal mode depends on the way that the motion was started.
  - Modes whose shape is similar to the starting shape will be strongly excited, those with different shapes will be weakly excited.
  - When the initial shape is produced by striking or plucking the system then those modes with anti-nodes closest to the striking point will be strongest and those with nodes closest to the striking point will be weakest.

Clamped Bar Modes

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  - Iannis Xenakis invented an instrument called the Sixxen that uses clamped plates struck with mallets. Because the sound is non-harmonic the pitch of each note is not perfectly clear but there are clearly higher and lower notes .

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  - Iannis Xenakis invented an instrument called the Sixxen that uses clamped plates struck with mallets. Because the sound is non-harmonic the pitch of each note is not perfectly clear but there are clearly higher and lower notes.
  - Heard in person these instruments are very loud! When Les Percussions de Strasbourg came last year I measured sound levels midway in Wellin Hall of over 100dB.

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Tuning Bar Modes

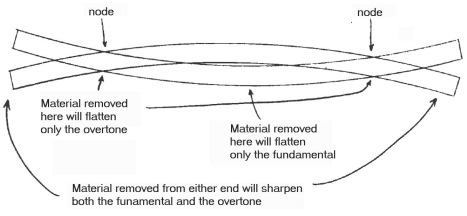

FIGURE 1 -- FUNDAMENTAL VIBRATION MODE OF A XYLOPHONE BAR

Image From http://www.mmdigest.com/Gallery/Tech

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    - Sitting the bar on carefully placed dampers allows only modes mode that have nodes near the suspension point to survive. Modes that involve much motion of the suspensions points are damped and decay away quickly.

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  - By controlling the hardness and shape of the mallets the player can exert a certain amount of control over the tone quality of the instrument.

Marimba Bar

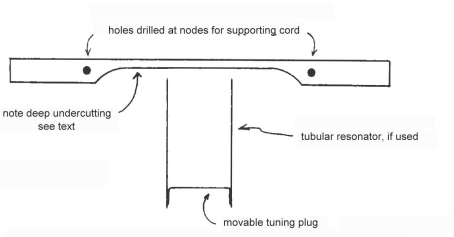

FIGURE 2 -- CROSS-SECTION OF A TYPICAL VIBRAHARP OR MARIMBA BAR

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  - Mallets made from hard materials stay in contact with the bar only a very short length of time. They can excite the highest frequency modes.

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- Cymbal is a circular sheet that is supported in the center and free to move at the edges.
  - Raised center section of Cymbal and general shallow dish shape modify real cymbals from the simple sheet somewhat but the general features remain. The actual shape is guided by experience.

Cymbal Modes

- Can visualize normal modes of a circular sheet with free edges using the Chladni plate.
  - Note that the Ch is pronounced like K--Kladni.
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  - Find normal modes with shapes that are basically circles and ones with more complex pie shaped modes.
  - Frequencies are very non-harmonic.
  - Cymbals are made from a hard brass alloy that has very little internal friction. This makes the vibrations last for a long time and be very sharp in frequency. The resulting sound has no clear pitch but is very full of non-harmonic partials.

Exciting Cymbal Modes

- Details of which modes are excited depends on how the cymbal is struck.
  - As with the Glockenspiel, narrow hard sticks/mallets can excite high frequency, short wavelength modes and so produce a very bright sound.
  - Larger sticks and softer sticks cannot excite the high frequencies so well and so result in a richer, less bright sound.

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  - Where the cymbal is struck will also affect the sound. You can only excite modes with anti-nodes near the strike point.
  - Brushes produce a new quality of tone by providing many small excitations randomly over a small region of the cymbal. The sound is less intense (less energy per blow) and usually lacking in low frequencies. It is more of a shimmery sound.