Second exam: Monday November 5, 2001
12:05 lecture: Room 1300 Sterling
1:20 lecture: Room 125 OLD Biochem Bldg
420 Henry Mall (corner Univ Ave)

the exam covers: Homework 4-7
Lab 5-8
Study Guide

the material refers to p. 71-138 in "The Science of Sights and Sounds" on reserve at Helen C. White and at Physics library

- Review Sessions in Room 3335 Sterling
- Emre 1-3 pm Saturday, November 3
- Santhosh 1-3 pm, Sunday, November 4
- Eva **6:15-8:15 pm** Sunday, November 4

CHANGED

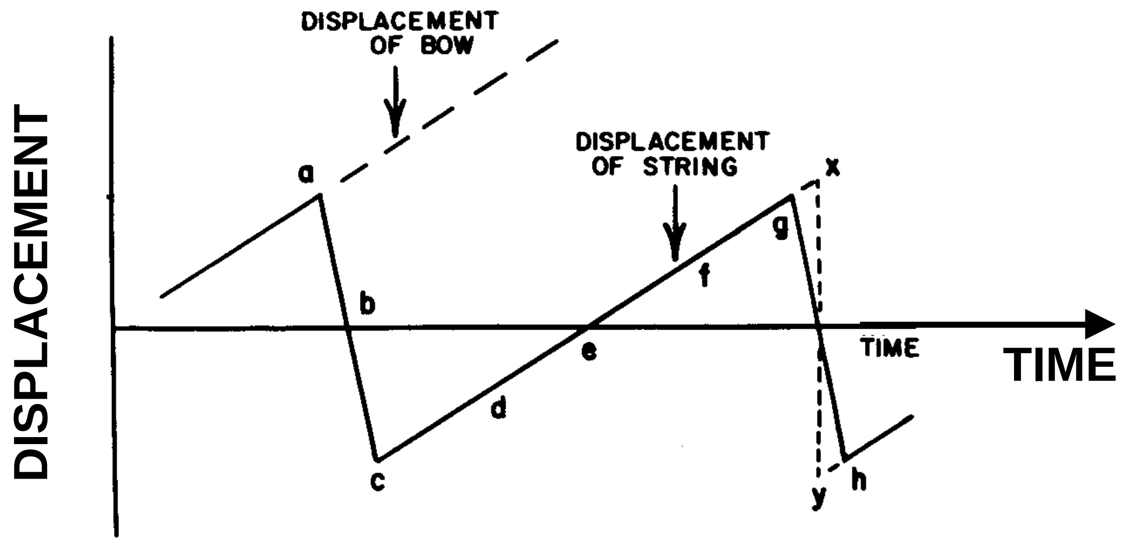
Excitation of Instruments - Making a Steady Tone

driving force must be kept in step with the natural frequency (resonance) – HOW is it done?

FEEDBACK between instrument and musician

a) Bowed String:

sticky rosin on bow pulls string aside. Reflected pulse loosens string at right time- string snaps back after round trip time of pulse.



b) Woodwind:

Flute, recorder, organ pipes: Blowing across an edge makes turbulent flow.

Pulse reflected from end of flute deflects air stream

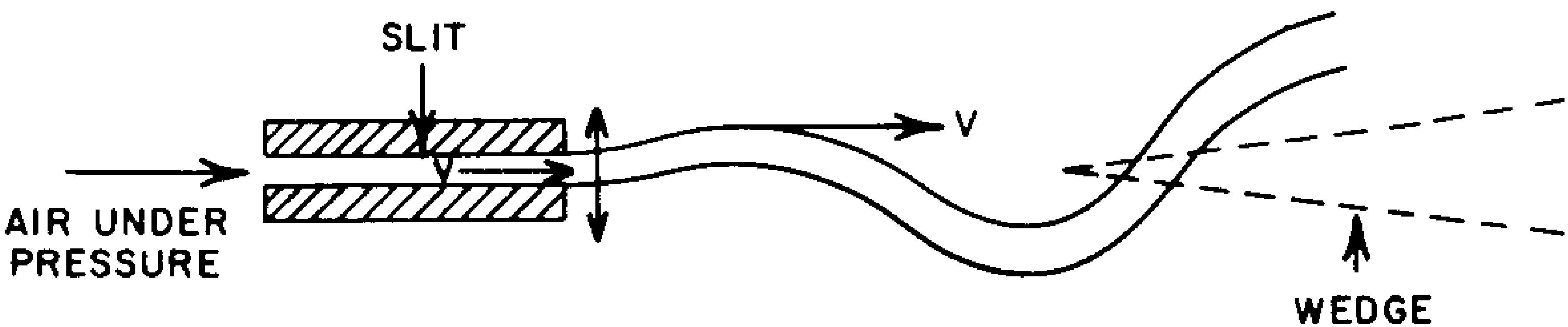


FIG. 1. An oscillating air stream.

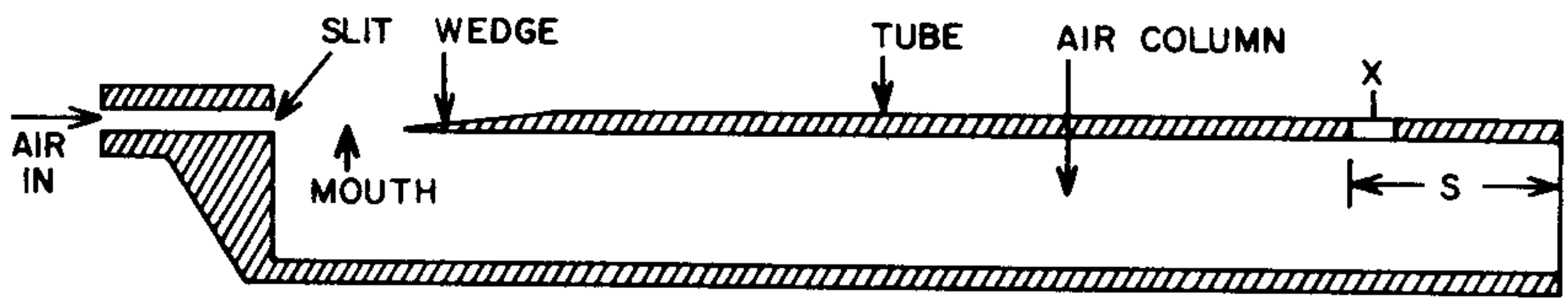


FIG. 2. Oscillating air stream system connected to an air column.

Reed wind instruments:

Clarinet, Oboe, Saxophone, Bassoon etc.

player alters reed frequency with lip pressure and rate of air flow

reflected wave locks reed frequency to one of the modes

c) Brass:

Player buzzes lips at about the right frequency.

Reflected wave locks lip frequency to one of the modes

Formants of Voice

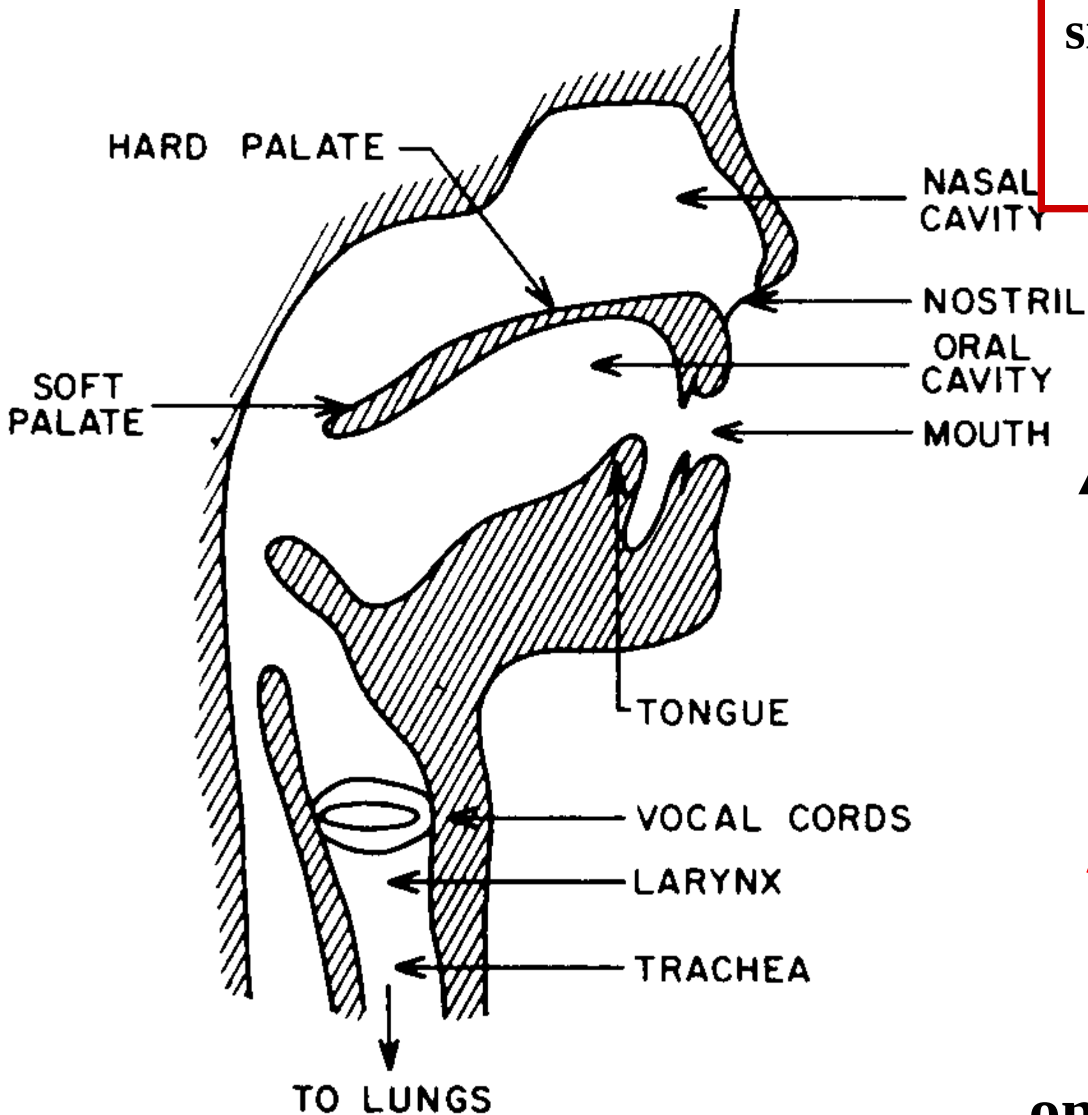


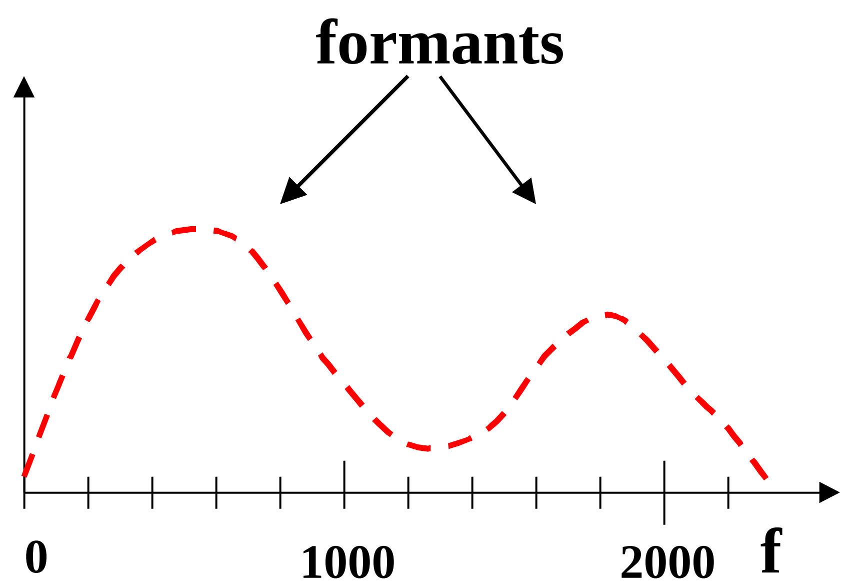
FIG. 21. The vocal tract.

difference to wind instruments

singer can adjust **two variables**

vocal cord frequency

formants (oral resonance)



one example of resonance curve of oral cavity

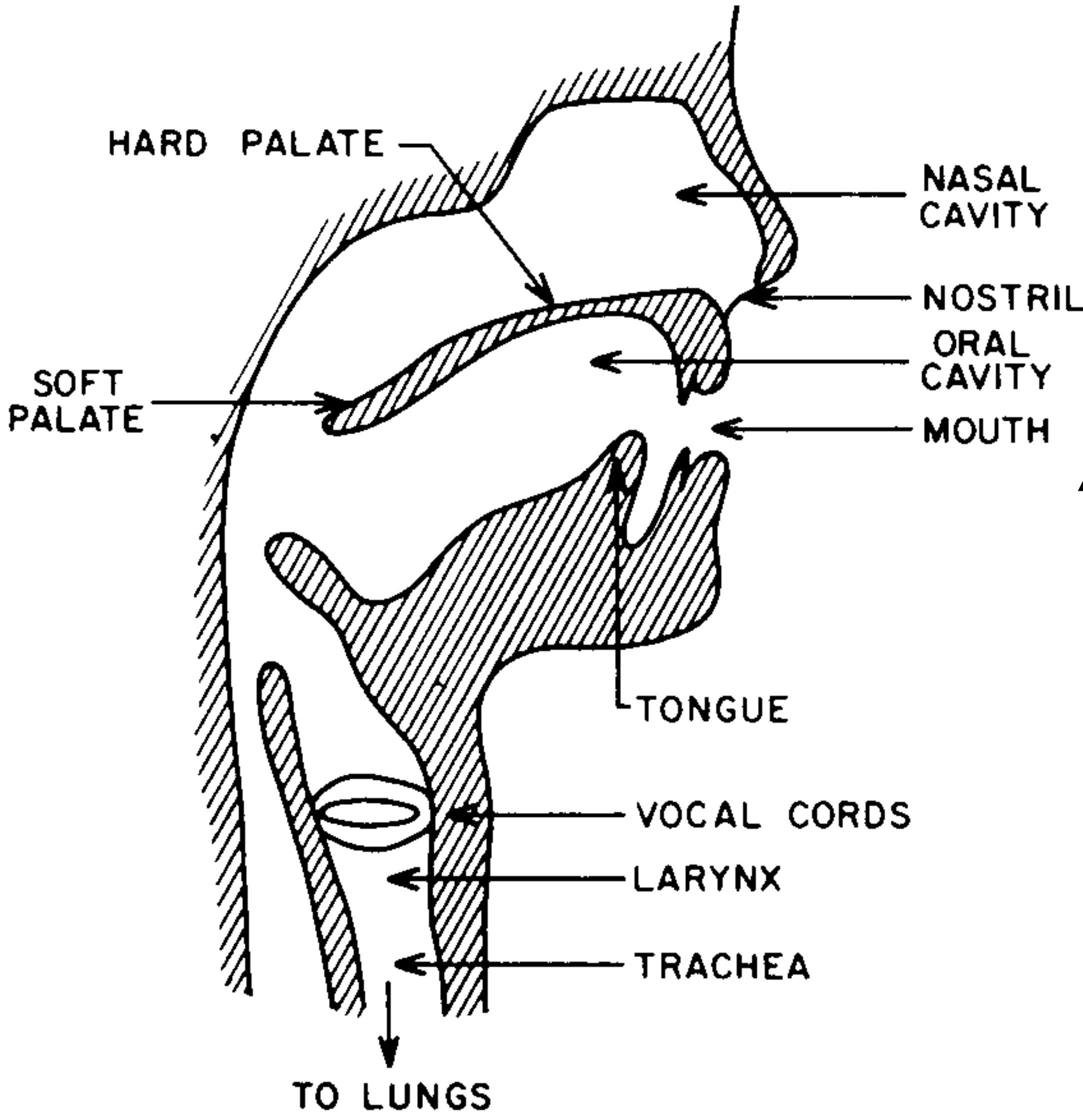
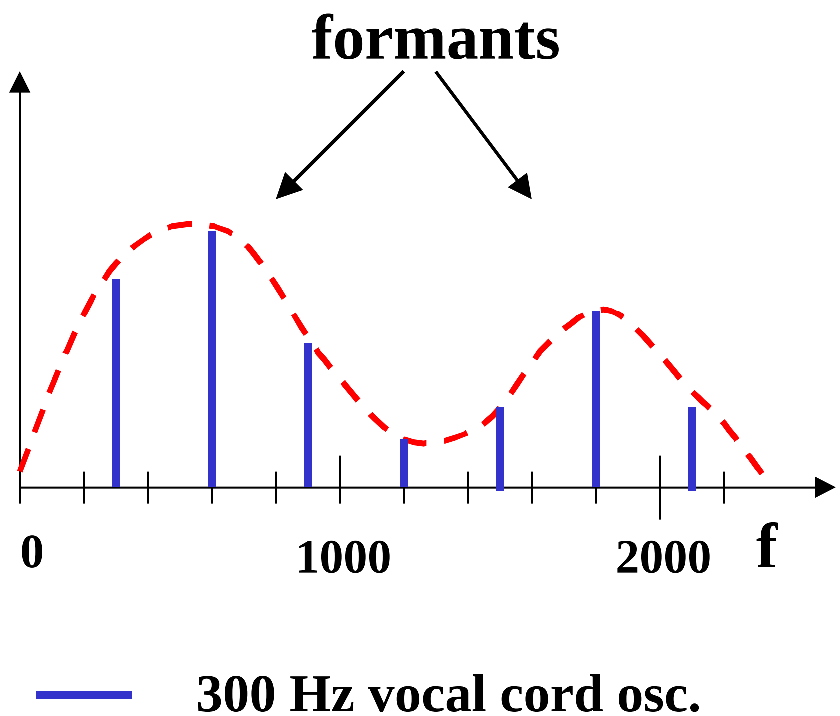
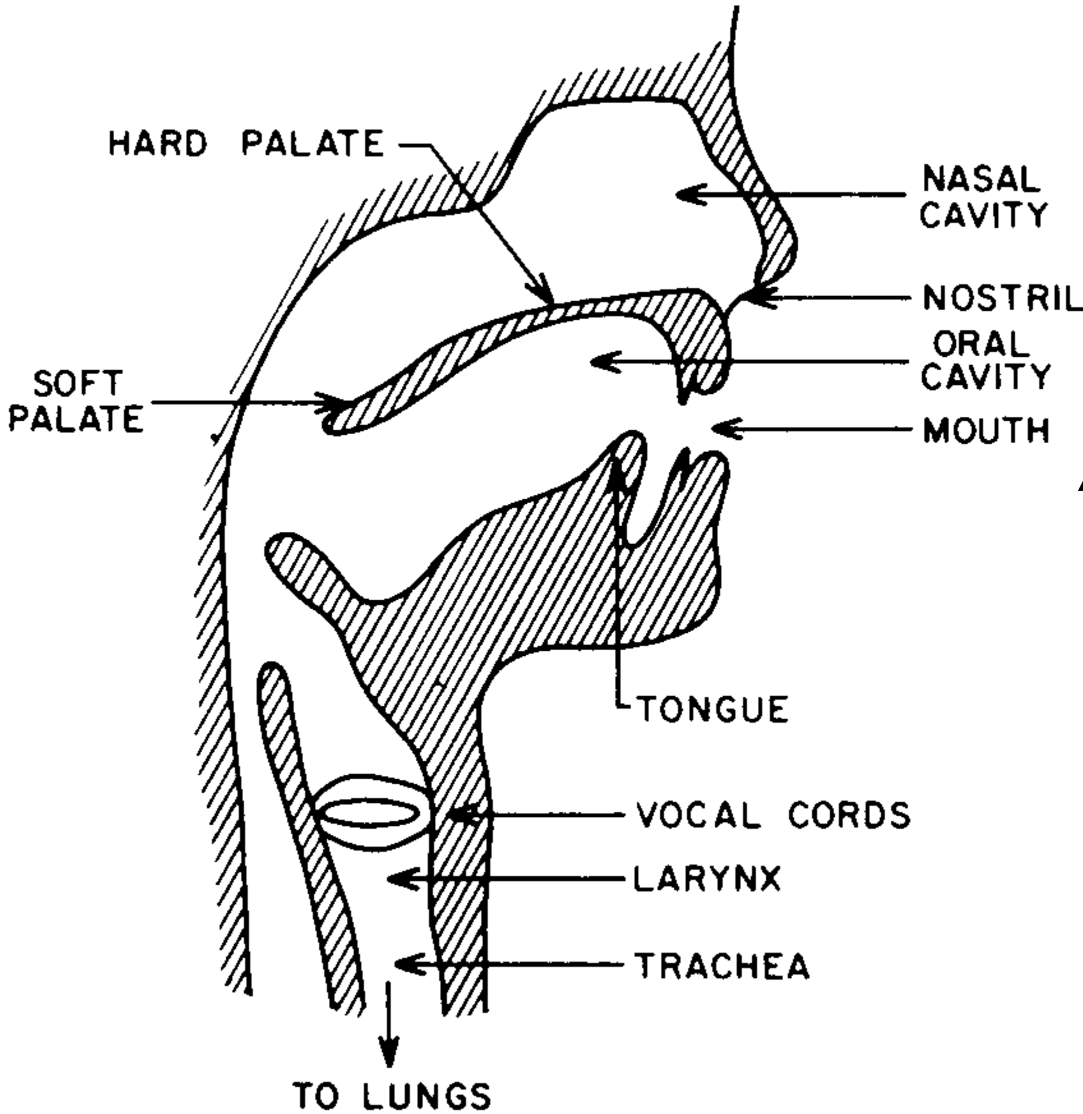


FIG. 21. The vocal tract.





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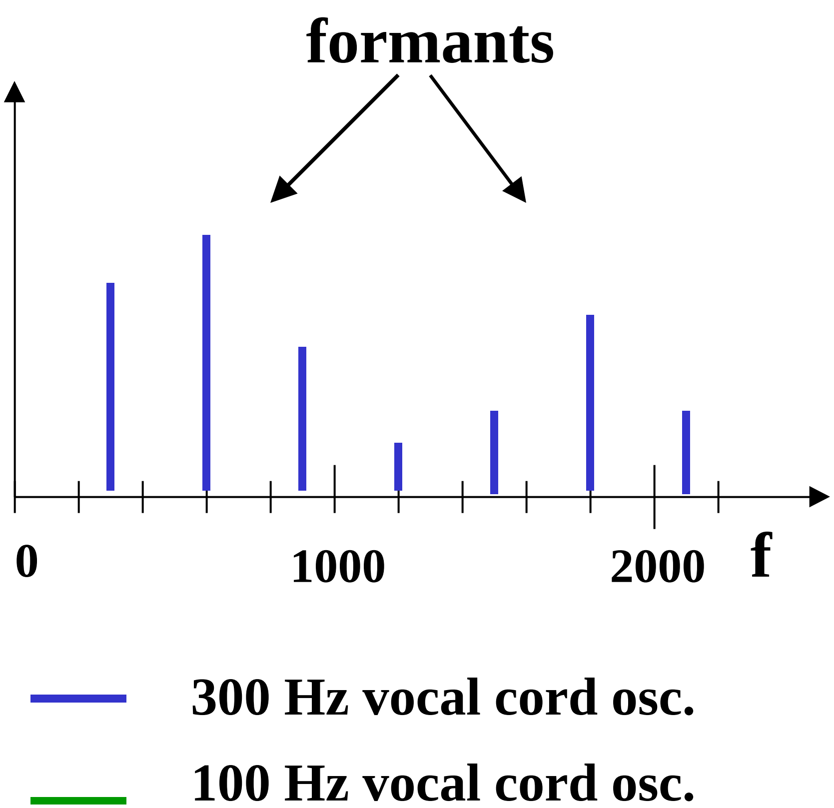


Piano and Piano Tuning

Sound board: large wooden plate with a wooden bridge over top of the plate - strings pass over bridge. On grand piano sound board 1000 pound downward pressure of 200 strings.
note: a given hammer of the piano hits 3 (or 2) strings

Bridge is notched for the strings.

Felt hammers are made of two types of felt for inside (stiff felt) and outside (softer felt)

Cast iron plate is being fit into piano

Piano Tuning:

Principle:

listen to beats between harmonics

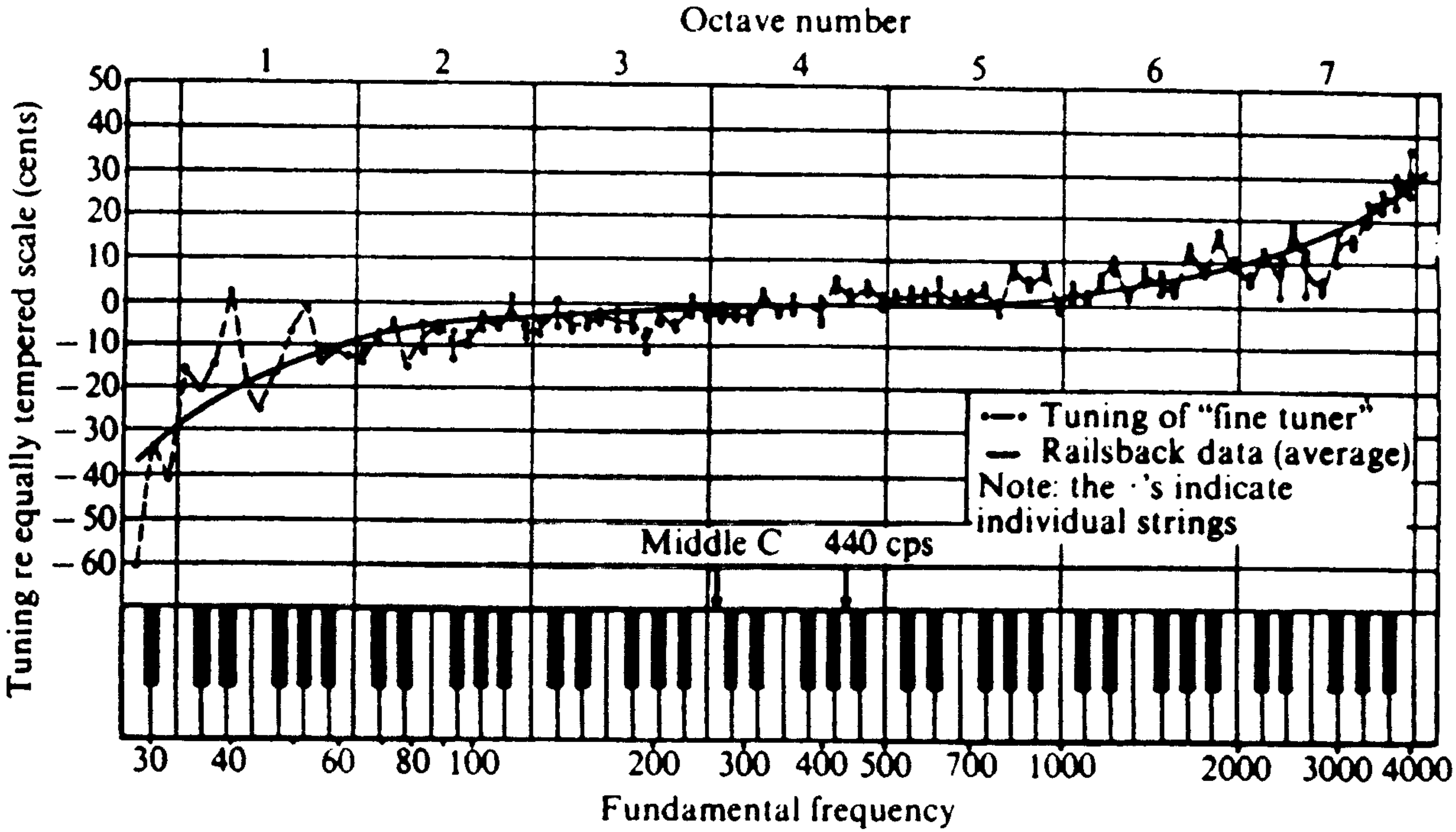
Piano tuner knows correct number of beats for tempered intervals.

example:
after tuning A_4 to 440 Hz, tune D_4:
Since tempered fifth is not exact, there will be some beats between third harmonic of D and second harmonic of A.
Calculation gives 0. 98 beats/sec.

Octaves are tuned so there are no beats.

But first overtone of A_4= 440 Hz is not exactly 880 Hz,
but is sharp because of stiffness of string - say it is 882 Hz

Result: a "stretched octave" - slightly larger than 2:1 ratio



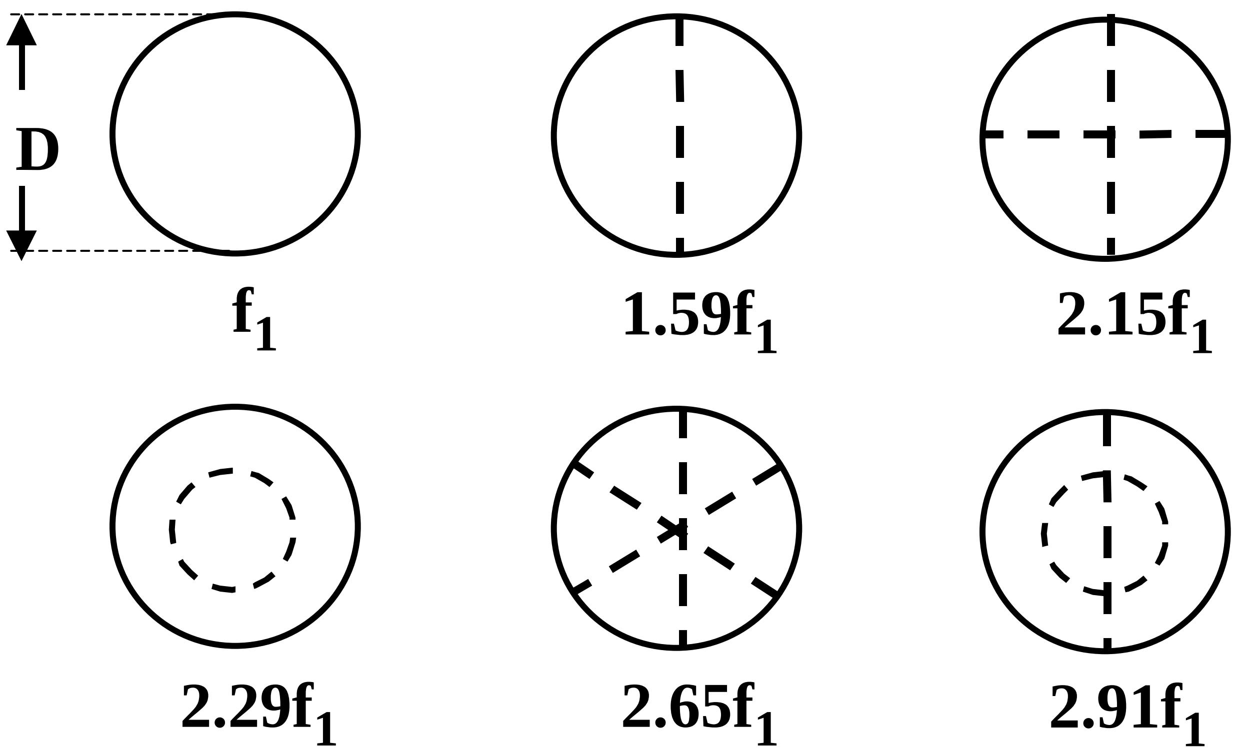
Deviations from tempered tuning in a piano (master tuner)

note: one <u>semitone</u> deviation is called <u>100 cents</u>

Instruments with non-harmonic overtones:

harmonic: strings, pipes (one-dimensional)

non-harmonic: drums, bells, xylophone, marimba



$$f_1 = \frac{0.766}{D}\sqrt{\frac{T}{\sigma}}$$

HEARING

<u>Large frequency range</u> of hearing

(50 Hz to 20,000 Hz)

<u>Vast loudness range</u> of hearing

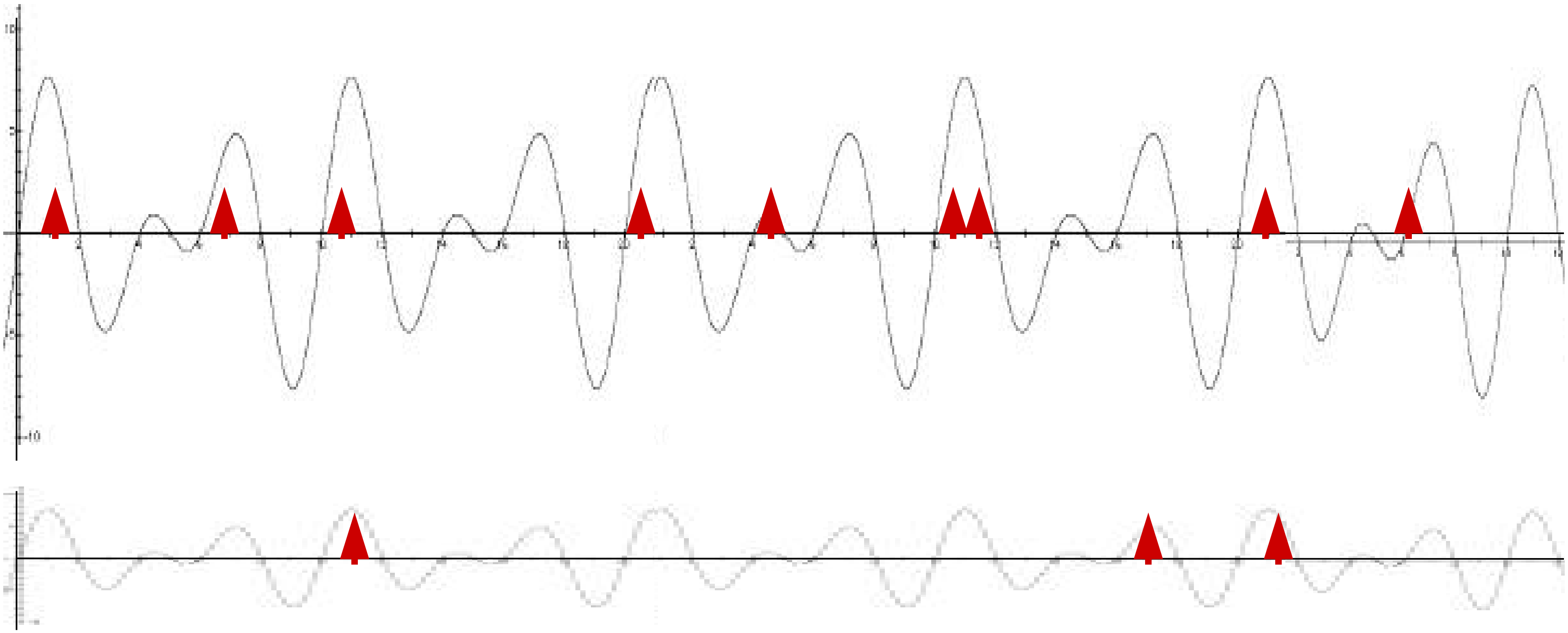
(sound pressure varies by 10^6 from threshold of hearing to threshold of pain).

How can auditory system accommodate this range? (Nerve signals are about 10 mV = 0.01 V. Multiplied by 10^6 would require 10,000 V!)

Rather, nerves make fixed discharges (pulses) whose time distribution reflects the tone you hear.

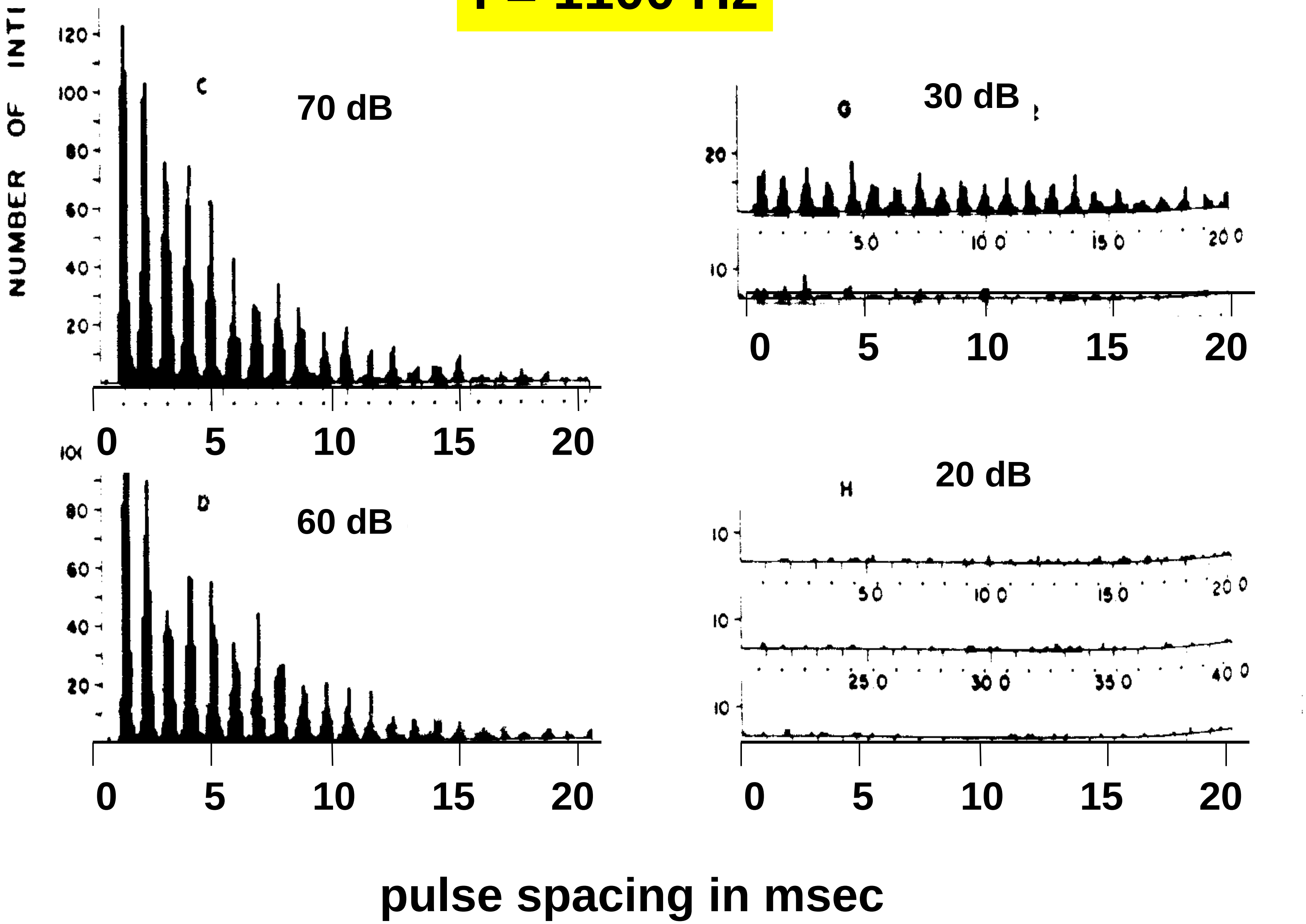
curve: sound pressure vs. time

nerve discharges (pulse)



nerve impulses: only when pressure is +
probability of occurrence prop to log of amplitude

f = 1100 Hz


70 dB
60 dB
30 dB
20 dB
NUMBER OF INTI
0
5
10
15
20
pulse spacing in msec