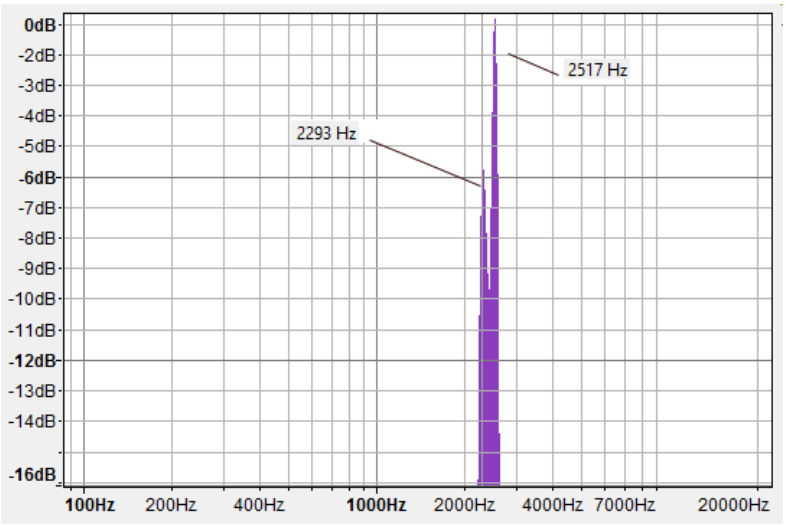
Beats: demonstrations with a cup and a weighted bowl

A resonating cup

The ceramic cup is tapped a few cm below the rim with the handle of the rubber hammer. Tapping opposite the handle gives a note of a particular pitch. Tapping on either side at 90º from the handle gives a note of the same pitch. Tapping between these two points at 45º from the handle gives a note of a higher pitch.

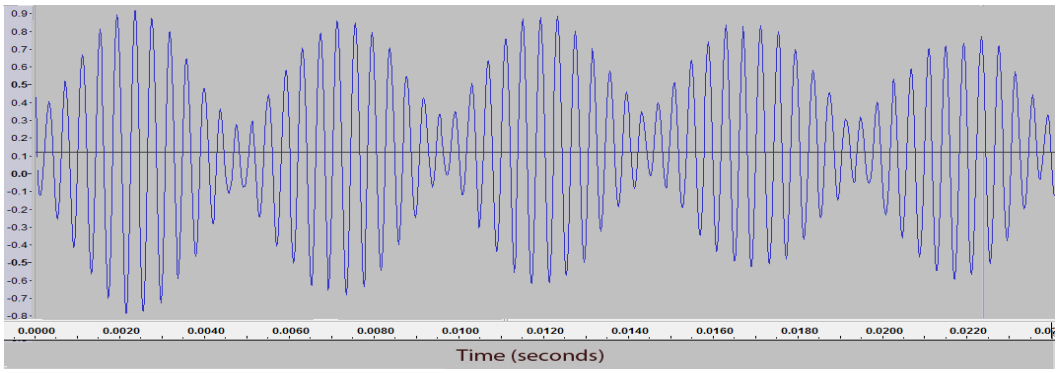
Fig 1

The FFT frequency spectrum in Audacity is shown below in graph 1 when the cup is tapped at 22.5º from the handle. Both resonances are excited and the peak is double.



Graph 1 - FFT plot showing two frequencies when the cup is tapped at 22.5º.

The two resonant frequencies are about 224 Hz apart. The beat frequency from the graph below is 5.00/0.0230 = 217 Hz, within errors, equal to the frequency difference above.



Graph 2 - cutting a small section of sound data from the recording in Audacity gives the beat frequency as 217 Hz.

The high frequency beat is interpreted by the human auditory system as *dissonance*, a harsh grating sound.

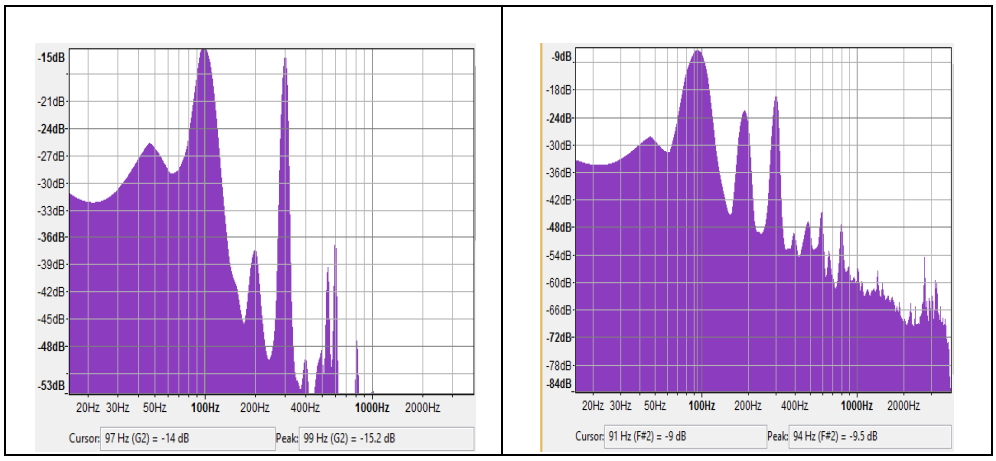
Note: the handle adds mass to the oscillation at an antinode when the cup is tapped at 90, 180 and 270 degrees from the handle. When tapping between these positions the handle is at an antinode and has less effect.

A weighted bowl

A clamp is attached to the large brass bowl used elsewhere to demonstrate transverse standing waves on a circular ring. The clamp acts as the handle of a cup and splits the lowest harmonic on the bowl into two components.

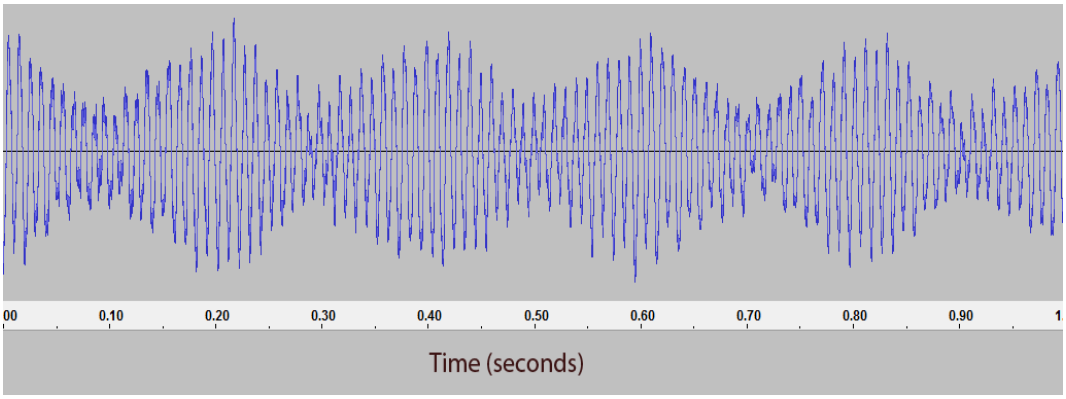
Fig 2 – bowl, clamp and microphone.

Exciting one mode at a time by hitting the bowl as above identifies the mode frequencies as 93 Hz and 98 Hz.



Graph 2 – the two resonant frequencies of the large brass bowl.

Note: set the Project rate to 8000 Hz for the low frequency bowl oscillations and use the log scale. The decibel scale may be confusing for students. A more intuitive sound pressure FFT spectrum can be done in Logger Pro. The bowl is now hit half way between the points with the rubber hammer (at 22.5º see above). Both modes are excited at the same time and the sound is heard to beat. For the demonstration a microphone is held in the bowl.



Graph 3 - Audacity gives the beat frequency as 5 Hz.

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The beat frequency is again the difference in frequencies …

$$f_B = f_1 - f_2$$

The sound combination is heard as a single pitch at the intermediate frequency.