

Beats & combinations of tones →

1) Beats (Acoustic Beats) →

Beats occur when two tones of slightly different frequencies are played together.

- * If one tone is 440 Hz and another is 444 Hz, you won't hear two separate notes.
- * Instead, you hear a single tone that pulses in loudness.
- * The pulse rate (beat frequency) equals the difference between the two frequencies.

Beat frequency formula.

$$f_{\text{beat}} = |f_1 - f_2|$$

Example →

$$440 \text{ Hz} + 444 \text{ Hz}$$

$$\text{Beat frequency} = 4 \text{ Hz}$$

You hear the sound getting louder and softer 4 times per second.

Why Beats Happen → when sound waves combine.

- * Sometimes they reinforce each other (constructive interference)
- * Sometimes they partially cancel (destructive interference)
- * This alternating reinforcement and cancellation creates the pulsing effect.

Practical use →

- * Musicians use beats to tune instruments.
- * Piano tuners listen for beats between strings to adjust pitch precisely.

2) combination Tones (Tartini Tones) →

When two tones are played together at higher volumes, the ear itself produces additional perceived tones.

These are called combination tones

Two main Types.

(1) Difference Tone

$$f_{\text{difference}} = f_1 - f_2$$

(2) Summation Tone

$$f_{\text{sum}} = f_1 + f_2$$

The most noticeable is usually the difference tone.

Example →

If you play:

1000 Hz and 1200 Hz

You may hear

- * A difference tone at 200 Hz

This effect was studied by the violinist and composer Giuseppe Tartini, which is why they're sometimes called Tartini tones.