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Beats Teacher Notes

Essential Question: What is the relationship between two frequencies played at once and the observed beat?

Materials:

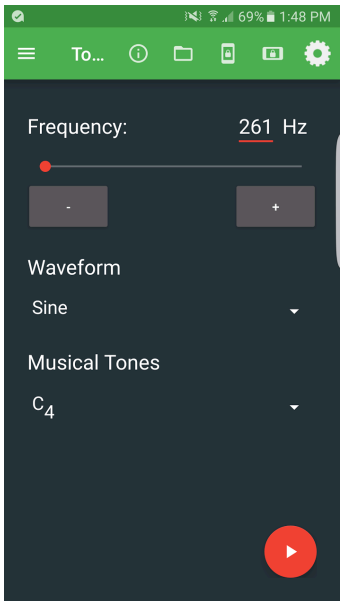
- Three mobile devices
  As two devices will be used to mix sound, it is preferential to have the two devices producing the sound be either similar devices or have similar sound systems.
- Physics Toolbox Sensor Suite: Tone Generator mode
- Physics Toolbox Sensor Suite: Oscilloscope mode

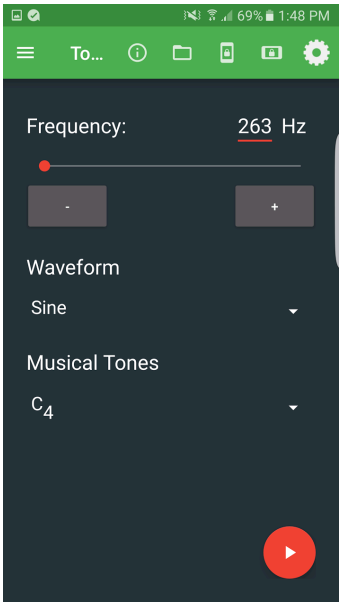
Learning Progression:

1. Using the first mobile device, use the **Tone Generator** mode to play a tone at the default **261** Hz.

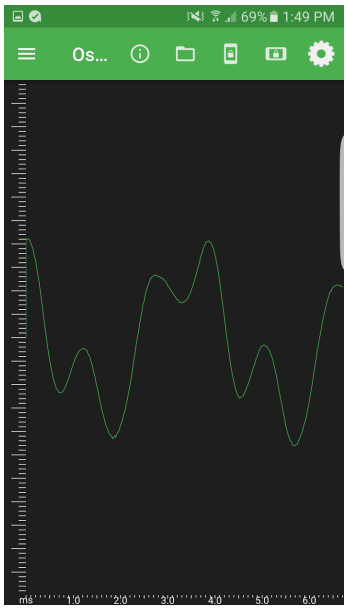
2. At the same time, using the second mobile device, play a tone at the default **261** Hz. What do you observe?
   Collectively, the sound is louder than when a tone is played by the single mobile device.

3. While still playing the **261** Hz tone on the first device, modify the tone on the second mobile device so that it plays a tone at **263** Hz. What do you observe?
   The sound appears to get louder and quieter, producing “beats.”





4. Make a prediction about what you think the sound wave is actually doing when the **261** and **263 Hz** are played simultaneously. Provide a rationale.
   Predictions will vary.



5. Again play the two tones simultaneously, and use a third mobile device to observe changes in the sound wave using the **Oscilloscope** mode. Based upon your observations of the wave, explain what causes the sound beats.
   The overall sound wave appears to pulsate in sync with the beats. The wave's amplitude is increased during the loud part of the beat, and the wave's amplitude is decreased during the quiet part of the beat.

6. Make a prediction about what you will observe when playing a **263** Hz and a **265** Hz tone at the same time. Explain your reasoning, then check! If your observation differed from your prediction, include that below.
   Predictions will vary. What should be observed is that while the tone is slightly higher than before, the beat frequency is the same.

7. Perform an investigation to measure the frequency of the observed beat when playing **263** and **265** Hz tones. List the measured value, and explain how you achieved it.
   The beat frequency is 2 Hz. This was accomplished by counting the number of beats (60) during a 30 second interval. 60 beats / 30 seconds is equivalent to 2 beats/s, or 2 Hz.

8. Make a prediction about what you will observe when playing at **263** Hz and a **264** Hz tone at the same time. Explain your reasoning, then check! If your observation differed from your prediction, include that below.
   Predictions will vary. The beat frequency is significantly slower.
9. Perform an investigation to measure the frequency of the observed beat when playing **263** and **264** Hz tones. List the measured value, and explain how you achieved it.
   The beat frequency is 1 Hz. This was accomplished by counting the number of beats (30) during a 30 second interval. 30 beats / 30 seconds is equivalent to 1 beat/s, or 1 Hz.

10. Using words or algebra, devise a rule for predicting the beat frequency observed when two slightly different tones are played simultaneously.
    Beat frequency = |tone 1 frequency - tone 2 frequency|

11. Make a prediction about what you will observe when playing at **263** Hz and a **273** Hz tone at the same time. Explain your reasoning, then check! If your observation differed from your prediction, include that below.
    Predictions will vary. The beat frequency is significantly faster.

12. When playing two tones with differences greater than a few Hz, it can be very difficult to count the beats. However, our ears are very sensitive, and the beats can still be observed even if not counted. What is the maximum difference in tones that still allow you to observe beats?
    Answers will vary. Most people can distinguish beats for a difference of up to 20 Hz between the two tones.