Handout 1 - Sound Waves

All sound is vibration. When a drummer strikes a cymbal, a batter hits a ball or you speak, ripples--sound waves--are created in and carried by the air to your ears. There, the sophisticated machinery in your ear canal converts those sound waves into the signals your brain registers as “sound.” Without the air or some other substance to carry sound waves, there is no sound.

The earliest attempts to combine electricity and music instruments in an effort to manipulate the transmission of sound waves date to the mid-18th century. In both Europe and the United States, several pioneering inventors created “hybrid” electronic instruments in which electricity was used to modify the sound created by an acoustic instrument in some way. Many hybrid instruments, such as electric string instruments like the electric guitar and electric bass, remain in use today. Around the turn of the 20th century, the period in which the technologies for telephones, radios and sound recording were all pioneered, the first instruments that relied *completely* on electricity--”pure” electronic instruments--were created. While working on new circuitry for telephones, American inventor Elisha Gray discovered he had also created a “tone generator.” Gray patented his rudimentary “oscillators” in 1876 and, until the onset of digital technology in the early 1980s, the tones of nearly all “pure” electronic instruments had some version of oscillators at their core.

All sounds travel as waves, but the human ear only hears some of those waves as having a “pitch” in the musical sense. Beginning in the early 20th century, the oscilloscope enabled the measurement and visualization of sound waves, allowing us to see the different shapes that we hear as either “noise” or “notes.” Prior to the oscilloscope, there was no such way to “see” music.

Figure 1 is a sound wave created by an oscillator known as a “sine wave.” Figure 2 is a sound wave created by an open guitar string. In both diagrams the volume of the tone is represented vertically while the length of the tone is represented horizontally. The images below represent a tiny fraction of a second. The lower a note is in pitch, the longer its wave stretches.

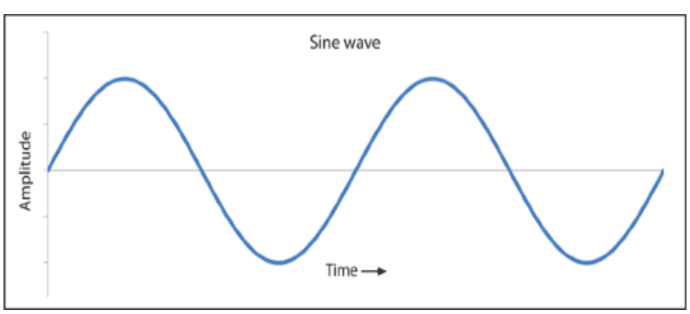

Figure 1

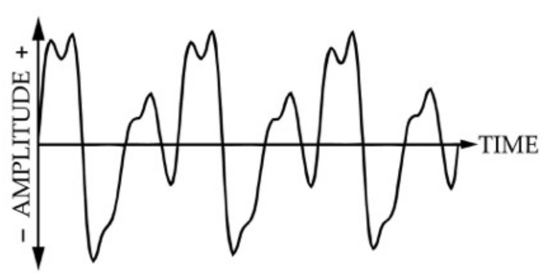

Figure 2

- How might you describe the shape of the sine wave?
- How does the shape of the guitar's wave differ from the sine wave?

Open the *Soundbreaking Sound Wave TechTool*. Notice that there are four possible sound wave types. Select "sine wave" and use the color-coded keyboard at the bottom to play through the notes (it is a major scale). Try playing a simple melody using the keyboard.

- How would you describe the sound of a sine wave?
- How do you think the shape of the sine wave relates to the sound that you hear?
- Do you think you could make a sound like a sine wave with your voice or an instrument? What would be the same or different?
- No acoustic instruments create sine waves, they can only be generated electronically. Why do you think this might be?

Now switch to the "square wave" waveform and play the same notes.

- How would you describe the square wave? How is it different from the sine wave?
- The display of the waveform shows the duration of the note moving from left to right. What is different about the starting and ending points of the the square and sine waves?
- How do you think this might affect the sound you hear?

The sine wave is smooth, and to many a pleasing sound because one does not hear the "attack," or beginning, and "decay," or the gradual end, of the note, as much as with the square wave, in which the right angles show a "harsh" sudden attack and decay. Now try the same song on both the "sawtooth" and "triangle" waves. Compare them to the sine and square waves you've already heard and consider how their shapes affect the sounds the make.

Synthesizers allow users to take the basic wave shapes found on the *Soundbreaking Sound Wave TechTool* and process them through various filters that modify them from their "perfect" forms into shapes more like the guitar string sound wave of Figure 2. Synthesis allows musicians to imitate the sounds of other instruments and also to create sounds, such as some of those from Clip 1, that no instrument had ever made.

Though soundwave synthesis existed throughout the early 20th century, most required expert knowledge to operate as well as massive machinery such as that Malcolm Cecil is using in the photo to the right. Robert Moog shrunk the basic elements of the synthesizer into a portable, suitcase sized keyboard such as the one seen to the right.