**Assignment Instructions**

 Up until now you have been creating audio clips and sonifications by manipulating sampled sounds. For this exercise, you will experiment with synthesis in Processing.

**Synthesizing the Sounds**

You will use WavePlayer UGens in Processing and additive synthesis to create several types of synthesized sounds. Additive synthesis is any type of sound-generating algorithm that combines sounds to build more complex sounds. Some form of additive synthesis can be found in virtually any synthesizer. Additive synthesis can be implemented in Processing with the Beads library by adding multiple WavePlayer UGens as inputs to a single Gain UGen. The wave generators (WavePlayers) will be summed by the Gain, thus accomplishing additive synthesis.

You will use 10 sine wave WavePlayer UGens, a fundamental sine wave at a particular frequency (i.e. 440 Hz) and a series of 9 harmonics, integer multiples of the fundamental frequency, to synthesize the following wave types: **square**, **triangle** and **sawtooth** waves.

An ideal **square wave** can be synthesized by summing an infinite series of **sine waves** composed of a fundamental frequency (n = 1) and odd-numbered (n = 3, 5, 7, …) harmonic partials with decreasing intensity of 1/n.

An ideal **triangle wave** can be synthesized by summing an infinite series of **cosine waves** composed of a fundamental (n = 1) and odd-numbered (n = 3, 5, 7, …) harmonic partials with decreasing intensity of 1/n2.

An ideal **sawtooth wave** can be synthesized by summing an infinite series of **sine waves** composed of a fundamental (n = 1) and all (n = 2, 3, 4, …) harmonic partials with decreasing intensity of 1/n.

Using Processing, Beads and ControlP5, create a Processing sketch with four radio-style buttons, one which, when clicked, starts playing the fundamental sine wave and one each which plays your square, triangle and sawtooth synthesized waves. Make sure you stop playing other waves when you click each button. You could achieve this radio button behavior in several ways, for example, by dynamically reconfiguring a UGen graph to switch between sounds or by dynamically setting the amplitudes of the 9 harmonic partials (i.e. play the fundamental wave only by setting the amplitudes (Gain UGens) of the 9 harmonics to zero).

Full functionality of the four wave playback buttons and correct additive synthesis of square, triangle and sawtooth waves will receive 90/100 points (+10 for correct submission format).

10 extra credit points: Using ControlP5, create a UI from a set of ten sliders and one mode button to implement a simple, interactive additive synthesizer. The mode button will switch sound playback to the interactive synthesizer (i.e. it can be fifth radio button). The first of ten sliders will change the fundamental sine wave frequency. Sliders 2 to 9 will change the amplitude of each of the first 9 harmonic partials of the fundamental frequency from 0 to 100 percent of the fundamental wave’s amplitude.

Here is a Processing sketch to get you started: [synthesis.zip](https://gatech.instructure.com/courses/360934/files/47565343/download)

This sketch demonstrates one method for creating a synthesized square wave.

Max grade = 110/100