

Elementary Music Synthesis

This lab is by Professor Virginia Stonick of Oregon State University.

The purpose of this lab is to construct physically meaningful signals mathematically in MATLAB using your knowledge of signals. You will gain some understanding of the physical meaning of the signals you construct by using audio playback. Also, we hope you have fun!

1 Background

In this section, we explore how to use simple tones to compose a segment of music. By using tones of various frequencies, you will construct the first few bars of Beethoven's famous piece "Symphony No. 5 in C-Minor." In addition, you will get to construct a simple scale and then play it backwards.

IMPORTANT: Each musical note can be simply represented by a sinusoid whose frequency depends on the note pitch. Assume a sampling rate of 8KHz and that an eighth note = 1000 samples.

Musical notes are arranged in groups of twelve notes called *octaves*. The notes that we'll be using for Beethoven's Fifth are in the octave containing frequencies from 220 Hz to 440 Hz. When we construct our scale, we'll include notes from the octave containing frequencies from 440 Hz to 880 Hz. The twelve notes in each octave are logarithmically spaced in frequency, with each note being of a frequency $2^{1/12}$ times the frequency of the note of lower frequency. Thus, a 1-octave pitch shift corresponds to a doubling of the frequencies of the notes in the original octave.

Table 1 shows the ordering of notes in the octave to be used to synthesize the opening of Beethoven's fifth, as well as the fundamental frequencies for these notes. When you do your scale, you will have to determine the frequencies of three of the higher notes on your own.

Note	Frequency (Hz)
<i>A</i>	220
<i>A</i> [♯] , <i>B</i> [♭]	$220 * 2^{\frac{1}{12}}$
<i>B</i>	$220 * 2^{\frac{2}{12}}$
<i>C</i>	$220 * 2^{\frac{3}{12}}$
<i>C</i> [♯] , <i>D</i> [♭]	$220 * 2^{\frac{4}{12}}$
<i>D</i>	$220 * 2^{\frac{5}{12}}$
<i>D</i> [♯] , <i>E</i> [♭]	$220 * 2^{\frac{6}{12}}$
<i>E</i>	$220 * 2^{\frac{7}{12}}$
<i>F</i>	$220 * 2^{\frac{8}{12}}$
<i>F</i> [♯] , <i>G</i> [♭]	$220 * 2^{\frac{9}{12}}$
<i>G</i>	$220 * 2^{\frac{10}{12}}$
<i>G</i> [♯] , <i>A</i> [♭]	$220 * 2^{\frac{11}{12}}$

Table 1: Notes in the 220-440 Hz Octave

A musical score is essentially a plot of frequencies (notes, on the vertical scale for you musician types) versus time (measures, on the horizontal scale). The musical sequence of notes to the piece you will synthesize is given in Figure 1. The following discussion identifies how musical scores can be mapped to tones of specific pitch and duration.

2 Note Frequency

In the simplest case, each note may be represented by a burst of a sinusoid followed by a shorter period of silence (a pause). The pauses allow us to distinguish between separate notes of the same pitch.

The horizontal lines in Figure 1 represent the notes E,G,B,D,F from the bottom to the top. The spaces between the lines are used to represent the notes F, A, C, and E, again from the bottom to the top. Note that A-G only yields seven notes; the additional notes are due to changes in pitch called sharps (denoted by the symbol ♯) or flats (denoted by the symbol ♭) that follows a given note. A sharp increases the pitch by $2^{\frac{1}{12}}$ and a flat decreases the pitch by $2^{\frac{1}{12}}$.

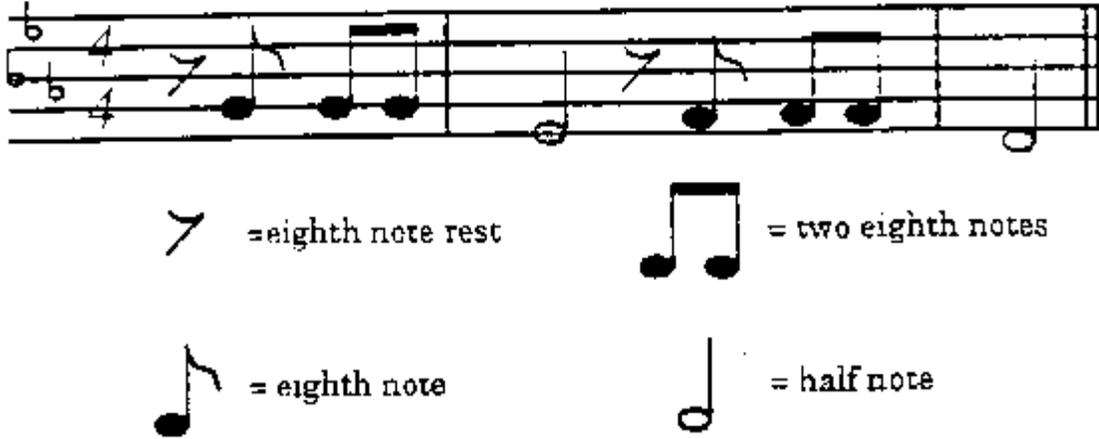


Figure 1: Musical Score for Beethoven's Fifth.

In the musical score in Figure 1, the first three eighth notes are all note G. The first half note is an E^b due to the inclusion of the three flat symbols at the left of the score, since we are in the key of C-minor. After the half note, the symbol is a rest of length equal to the duration of an eighth note. The next three eighth notes are all F, and the final half note is a D. You can get the fundamental frequencies for these notes from Table 1.

3 Note Durations

The duration of each note burst is determined by whether the note is a whole notes, half note, quarter note, eighth note, etc. Obviously, a quarter note has twice the duration of an eighth note, and so on. So your half notes should be four times the duration of your eighth notes. The short pause you use to follow each note should be of the same duration regardless of the length of the note.

4 To Do

1. Synthesize the piece appearing in Figure 1. Play it back using the SOUND command in matlab. Type HELP SOUND for more informa-

tion. You'll want to specify the sampling rate in the playback.

Save the entire music synthesis in a .m-file

Turn in a listing of your .m-file.

2. Synthesize a scale in the key of C. This is simply eight notes in order starting with C. They are

C D E F G A B C.

The key of C is simple because there are no sharps or flats. Here, you will have to define the frequencies for A, B, and the second occurrence of C since they do not appear in Table 1. What are the frequencies of the notes A, B, and the second occurrence of C? Save your scale in a .m file

The .m file should play the scale and then ALSO, PLAY IT BACKWARDS.

Turn in a listing of your .m file.