

I547: Homework 1

For each problem submit the R code you created with any necessary written annotations.

1. Using R, create a sine tone at 440 Hz (tuning a) sampling at 8KHz. Listen to the tone. Compare this with both a cosine wave also at 440 Hz and the sine wave at -440 Hz. Describe the similarities and differences between the sounds and explain their origin.
2. The `*` operation in R is pointwise multiplication between vectors (of the same length). Thus $(1:10) * (1:10)$ gives a vector of the 1st 10 squares. Use this idea to create a sine tone with “amplitude vibrato” — a periodic cycling of the (maximum) amplitude of the wave. Make the vibrato rate at 5 Hz.
3. Consider the `repeated_intervals.r` R program discussed in class with the sampling rate changed to 8KHz. Using the interval of an octave ($c = 2$), generate 8 notes starting at 440 Hz. What are the precise frequencies of the notes you hear? Explain how you arrived at your answer.
4. (a) Using the `repeated_intervals.r` program, create a sequence of 12 notes that divide the octave into 12 equal musical intervals. The result is called an equal tempered chromatic scale, as discussed in class.
(b) Alternatively, create a different 12-note chromatic scale in the following way: Begin with the same starting frequency, f_0 , you used in your chromatic scale above. Generate 12 more pitches by moving up by a “perfect fifth” (a $3/2$ ratio) between successive pitches, bringing each pitch back into the range $(f_0, 2f_0)$ by moving down by octaves, as necessary. The final pitch you generate should be about an octave above the initial pitch. Order the resulting 13 pitches in increasing order, and compare the two chromatic scales by listening. Comment on any differences you can hear.
5. Suppose we have the collection of rational numbers $S = \{0, \frac{1}{3}, \frac{1}{2}, \frac{2}{3}\}$ and a period length $p > 0$. We generate a periodic rhythm by tapping at the times $\{p(n + s) : n \in \mathbb{Z}^+, s \in S\}$ where $\mathbb{Z}^+ = \{0, 1, 2, 3, \dots\}$. When p is on the order of 1 second we hear a rhythm. Describe precisely what you would hear if $p = .005$ using standard terminology from this course.
6. Suppose you are given a starting frequency, f , and two operations that can be applied in any sequence desired.
 - (a) You can move up a perfect fifth
 - (b) You can move down an octaveShow that it is not possible to generate the frequency that is exactly an octave above your starting point.
7. **[Challenge]** Using a note at 440 Hz, create a “pitch vibrato” that changes the pitch by plus or minus 5 Hz at rate of 5 Hz by gradually varying the *frequency* of a sine tone.