Theory

Pre-lab Question: A piece of music on a staff consists of four quarter notes followed by one whole note.
Assume:
- each quarter note plays for 0.5 seconds
- each whole note plays for 2 seconds
- Each line on the staff represents a frequency, there are 96 distinct note frequencies (corresponding to potential vertical positions of notes on staff).

1. What is the duration (in seconds) of the sound represented?
2. Assuming 16-bit samples and 48KHz sampling frequency (similar to Lab 2), how many bytes would it take to produce this sound?
3. Consider, instead, encoding the notes on the staff into a digital representation that the computer can understand. How would you represent the different frequencies? The different types of notes? How many bytes does it take to represent the information on the musical staff shown above? (State any further assumptions you need to make.)
4. What is the compression ratio achieved by modeling the notes as in question 3 vs capturing the raw audio as in question 2?

Analysis

Exploring the Frequency Domain

Question 1: What happens to the sine wave as you change the frequency, amplitude and phase? Describe what you observe in both the time and frequency domain as well as what you hear.

Question 2: How does the sine wave differ from the other three (triangle, square and sawtooth) waves. I.e. What do the other three waves have in common that the sine wave does not?

Question 3: The triangle wave shows multiple spikes in the frequency domain graph.

- For a triangle wave at a frequency of 180Hz, what are the ratios of the higher frequency spikes to the frequency of the first spike (you should use the cursor to get estimates of the frequency of each spike)? Round your ratios to the nearest integer value. Remember to look at the frequency (on the abscissa) and not the amplitude (on the ordinate).
• What happens to the relative horizontal distance between spikes as you sweep the frequency slider back and forth between 180Hz and 380Hz (going above 380 will show a strange “mirroring” effect in the frequency domain, the reason for this will become clear in week 6)?
• How are the frequency values of the higher frequencies changing with respect to the value of the primary frequency defined by the frequency slider?

Analyzing Sound Waves

Question 4: Using what you’ve learned from lecture and the harmonic information, quantitatively describe the four .wav files.

Building Sounds

Question 5: For the two pure tones you created:

a. What happens when the frequencies of the two pure tones are close together?

b. What happens when the frequencies of the two pure tones are far apart?

c. How does the wave change when you change the phase of one of the two tones?

Building a Synthesizer

Question 6: Present the values that you wrote down for the different instruments in this section.

Conclusion

Question 7: In lecture 3, we saw the idea of saving space by having a lookup table that allows the Kindle to store the shape of each character once and look it up whenever it needs to draw a character. How can you use a similar space saving idea when talking about notes on a staff and synthesized instruments?

Question 8: In this question, you will extend your model from the prelab (question 3) to include what you need to represent the synthesized instruments we created so that a computer can take the digital representation of the music and the digital representation of the instrument and play the song using the instrument.

a. How would you encode the instruments you modeled above? How many bytes do you need to describe your model? (State your assumptions; the course has not given you a way to give a unique, precise answer, however, it has given you enough background that you can make ballpark estimates).
b. Adding this additional model information to the information you identified in question 3 of the prelab, how does this impact the compression ratio as compared to the results from question 4 in the prelab?

c. How would it impact the compression ratio for an entire 3 minute song? (State necessary assumptions.)