

LAB 5: Wave Interference

REQUIRED READINGS: Waves p. 35-42, Properties of Waves p.45-49

Part 1: Fourier Transforms

Equipment:

You will need a Fourier synthesizer, an oscilloscope, a speaker and several connector wires. DO NOT plug the speaker into the wall socket; instead connect it to the 8Ω output of the synthesizer. To do this portion of the lab, connect the oscilloscope to the $10K$ output of the synthesizer. WITHOUT disturbing the phase knobs and buttons on the synthesizer reduce all of the amplitudes to zero. You may now plug in the synthesizer and oscilloscope and turn them on.

Procedure:

First, turn up the amplitude of the fundamental and adjust the amplifier so that you can comfortably hear the sound coming from the speaker. Now, look at the oscilloscope and make sure you are seeing a simple sine wave. If you are not seeing anything call a TA over to help adjust the oscilloscope. If you are seeing a sine wave, but it is bumpy make sure all the other amplitudes are turned to zero. Once you can see the simple sine wave you should be able to turn off the fundamental, and turn on any other harmonic, and see another sine wave.

- 1) What is the difference between the fundamental and any other harmonic? (Be quantitative!)

Now try turning on several harmonics at the same time. By varying the amplitude and number of harmonics you should be able to generate graphs of varying shapes. Remember that the most pleasing sounds will correspond to the most pleasing shapes! DO NOT TOUCH THE PHASE KNOBS!

- 2) Generate a saw-tooth wave. (It doesn't need to be exact, but you can get very close.) Sketch the graph and write down the harmonics and their relative amplitudes that generated the graph. Is there anything musically significant about these harmonics?

- 3) Generate a square wave. (It doesn't need to be exact, but you can get very close.) Sketch the graph and write down the harmonics and their relative amplitudes that generated the graph. Is there anything musically significant about these harmonics?
- 4) Generate any other pleasing shape you can. Sketch the graph and write down the harmonics and their relative amplitudes that generated the graph. Is there anything musically significant about these harmonics?
- 5) Vary the phase of the different harmonics. Does the phase affect the waveforms on the oscilloscope?
- 6) Does the phase affect what you hear?
- 7) Turn off everything but the fundamental. Vary the waveform of the fundamental at the top of the synthesizer from a sine wave to a square wave or triangle wave. Does this affect the waveforms on the oscilloscope?
- 8) Does the waveform affect what you hear?
Turn all the amplitudes to zero before going on!

Part 2: Lissajous Figures

Equipment:

You will need an extra connector for this portion. By turning the oscilloscope to the "xy" mode you will be seeing both waveforms together. One of the waveforms will be graphed against the x-axis, the other against the y-axis. Start with one of the inputs in the fundamental.

Procedure:

Turn up the amplitude of whichever harmonic your plugs are in and turn off the amplitude of the harmonics that are not being used!

- 1) Place the both inputs in a first harmonic and play with the phase until you see a perfect circle. Are there any other configurations of the available harmonics that will give you a circle? If yes, then what are they? Test them to make sure.

- 2) Return one of the inputs to the fundamental and place the other input in the second harmonic. Vary the phase and sketch the most pleasing shape you see. Are there any other configurations of the available harmonics that will give you the same shape? If yes, then what are they? Test them to make sure.
- 3) Return one of the inputs to the fundamental and place the other input in the third harmonic. Vary the phase and sketch the most pleasing shape you see. Are there any other configurations of the available harmonics that will give you the same shape? If yes, then what are they? Test them to make sure.
- 4) Return one of the inputs to the fundamental and place the other input in the fourth harmonic. Vary the phase and sketch the most pleasing shape you see. Are there any other configurations of the available harmonics that will give you the same shape? If yes, then what are they? Test them to make sure.
- 5) Now, place one of the inputs in the second harmonic and the other in the third harmonic. Vary the phase and sketch the most pleasing shape you see. Are there any other configurations of the available harmonics that will give you the same shape? If yes, then what are they? Test them to make sure.
- 6) Choose any other configuration of the harmonics, vary the phase and sketch the most pleasing shape you see.

TURN ALL THE AMPLITUDES TO ZERO. TURN OFF THE OSCILLOSCOPE AND THE SYNTHESIZER.

Part 3: Optional: Laser Lissajous Figures

Equipment:

This part is optional as the equipment is homemade, and may not work. Connect a wave generator to each of the speakers. POINT THE FINAL LASER LINE TO THE CEILING.

Procedure:

Starting with frequencies around 100Hz try reproducing the Lissajous figures you found in Part 2.

- 1) Sketch any figure you reproduced and write down the frequencies that you used to reproduce the figure.