

## Music 170 assignment 5

*It's hard to see how to assign exercises to this chapter which is mostly descriptive. Instead, these exercises serve as a cumulative review of Chapters 1-5.*

1. Suppose a signal is a sum of three sinusoids, each with peak amplitude 1, at 300, 400, and 500 Hz. What is the signal's average power?
2. What is the period of the signal of exercise 1?
3. How many barks wide is the spectrum of the signal of exercise 1?
4. What is the name of the interval from the lowest to the highest of the component sinusoids?
5. How many half-steps is the lowest of the component sinusoids above middle C?
6. By how many dB does this signal's power exceed the power of its lowest component (i.e., of a 300 Hz. sinusoid of peak amplitude 1)?

**Project:** multiplying sinusoids. This project is a demonstration of my Fundamental Law of Computer Music (last formula of Section 2.3).

First, make a "sinusoid" object and connect it both to an "output" (so you can hear it) and to a "spectrum" (so you can see it). To start with, tune the sinusoid to 500 Hz. and turn the spectrum object on (turn on the "repeat" toggle and optionally increase the rate, say to 5 or 10 Hz). With the scale control at 100 you should see a peak at 500 Hz. on the horizontal scale and just reaching the top of the graph (0 dB.) (Really, I should be reporting the RMS power as -3 dB; I'll fix this next release, but no matter for now.)

Now bring out a second oscillator at 100 Hz. and multiply it by the first one you have (using a "multiply" object). Disconnect the first oscillator from the spectrum object and connect the output of the multiply object instead; do the same with the output object so you hear the product of the two sinusoids. What are the frequencies and amplitudes of the resultant sinusoids? (To measure the amplitude I used the "scale" control to scale them back up to 0dB; that told me the relative amplitude in dB compared to the original sinusoid.)

Now repeat the process to make a product of *three* sinusoids: disconnect the output of the multiplier, and introduce a third sinusoid and a second multiply object; multiply the new sinusoid by the product you already made of the first two. Set the third sinusoid to 50 Hz. and connect the output of the multiplier (the product of the three sinusoids) to the output and spectrum objects. What frequencies and amplitudes do you see now?

Now that you've done this you're welcome to change the frequencies of the three oscillators and see how the result behaves. If you find that interesting (I do!) try multiplying by a fourth sinusoid in the same way and enjoy.