Physics 221
Harmonics

1. Investigate how changing amplitude affects the wave *Fourier-Making Waves* (PhET.colorado.edu). Describe in your own words what the y-axis for wave graphs represents.

2. Investigate what harmonics are and describe in your own words what harmonic means.
    a. Use the *Wavelength* tool to determine a mathematical relationship between the wavelengths of each harmonic.
    b. Calculate the frequency of the **fundamental** –A_1, the second harmonic –A_2 and the third harmonic –A_3.
    c. What is the mathematical relationship between the frequencies of all 11 harmonics shown in the sim?

Auditory Perception:

3. Turn on the sound using the "Sound" checkbox.
    a. Set all Amplitudes to 1. Can you pick out A_5 from this sound? Now try turning A_5 to zero and then back up. Now can you hear it? Why do you think this might be?

4. (Taken from "The Science of Sound" 3rd Ed. by Rossing, Moore and Wheeler).
   Helmholtz demonstrated that the sounds of most musical instruments (including the vocal folds or cords) consist of harmonics that determine the timbre. Furthermore, he carefully described a way in which the ear could comprehend timbre. On the basis of his experiments, he formulated the following general rules:
   I. Simple tones, such as those of tuning forks and widely stopped organ pipes, have very soft, pleasant sound, free from roughness but dull at low frequencies.
    II. Musical tones with a moderately loud series of harmonics up to the sixth (such as those produced by the piano, the French horn, and the human voice) sound richer and more musical than simple tones, yet remain sweet and soft if the higher harmonics are absent.
    III. Tones consisting of only odd harmonics (narrow stopped organ pipes, clarinet) sound hollow and, if many harmonics are present, nasal. When the fundamental predominates, the quality of tone is rich; when the fundamental is not sufficiently strong, the quality of tone is poor.'
    IV. Complex tones with strong harmonics above the sixth or seventh are very distinct, but the quality of tone is rough and cutting.

   Create a series of investigations using the Harmonics on *Fourier: Making Waves* to verify the above claims. Describe exactly what you did for each and what you heard. If there are differences in what each lab member heard (which there very likely will be) describe the different perceptions.

Adding Waves:

Preset Functions:
1. Investigate the different preset functions. Describe what each is and how it's created.

2. Describe what happens to <u>each</u> of the different preset functions if you decrease the number of *harmonics*.

3. Use the simulation to make a *Sum Graph* that looks like the graph below using only 2 harmonics. It's important to match both the x and y axes. Print* your *Harmonics Graph,* record the Amplitudes that you used, and describe what you thought about as you tried to match the graph.
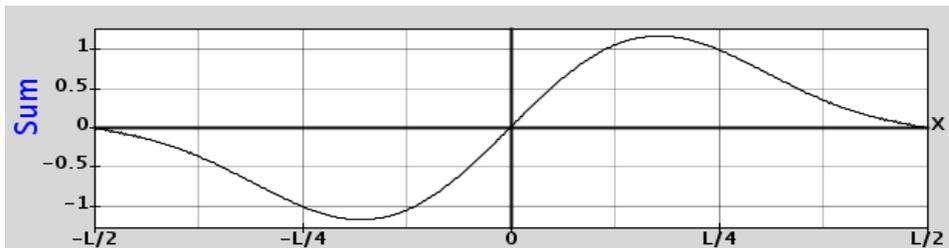
4. Draw what you think the Sum Graph will look like for the harmonics displayed below.
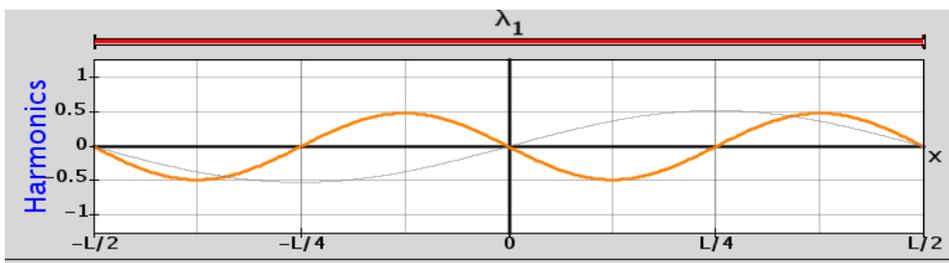
5. Use the simulation to test your prediction and make corrections with a different color pen. Record the amplitudes that you used and write a plan for how you could predict the sum of waves.

6. Use your predictions ideas to draw the sum of these waves.

7. Test your ideas using the simulation. Make corrections on the predicted graph with a different color pen. Correct your plans for prediction also.

8. Design a test for your ideas on wave addition. Explain in detail your experiment and the results. Include evidence that your prediction method is repeatable.

Printing Instructions: Press **shift-Print Scrn** and then **paste** into word or power point.

Lowest score wins!

1. Use the Level 1 for the beginning of the competition. Take turns:
   Press **New Game**, think about what should work, and then type in your guess in the Amplitude box.

   Keep score: **-5** points for correct on first try, **-3** for second and **-1** for third.

Name	Game 1	Game 2	Game 3	Game 4	total

2. In Level 2, you have to choose one of two harmonics. Take turns:
   Press **New Game**, decide which harmonic to use, think about what should work, and then type in their guess in the Amplitude box.

   Keep score: **-7** points for correct on first try, **-4** for second and **-1** for third.

Name	Game 1	Game 2	Game 3	Game 4	total

3. In Level 3, you have to choose one of eleven harmonics. Take turns:
   Press **New Game**, decide which harmonic to use, think about what should work, and then type in their guess in the Amplitude box.

   Keep score: **-10** points for correct on first try, **-5** for second and **-1** for third.

Name	Game 1	Game 2	Game 3	Game 4	total

4. In the other Levels, you have to choose more than one wave to add to make the SUM. Take turns:

Start the stopwatch as the player presses the **New Game** button. The seconds that it takes to match divided by the level number is the score. Design a spreadsheet to keep track of your scores.