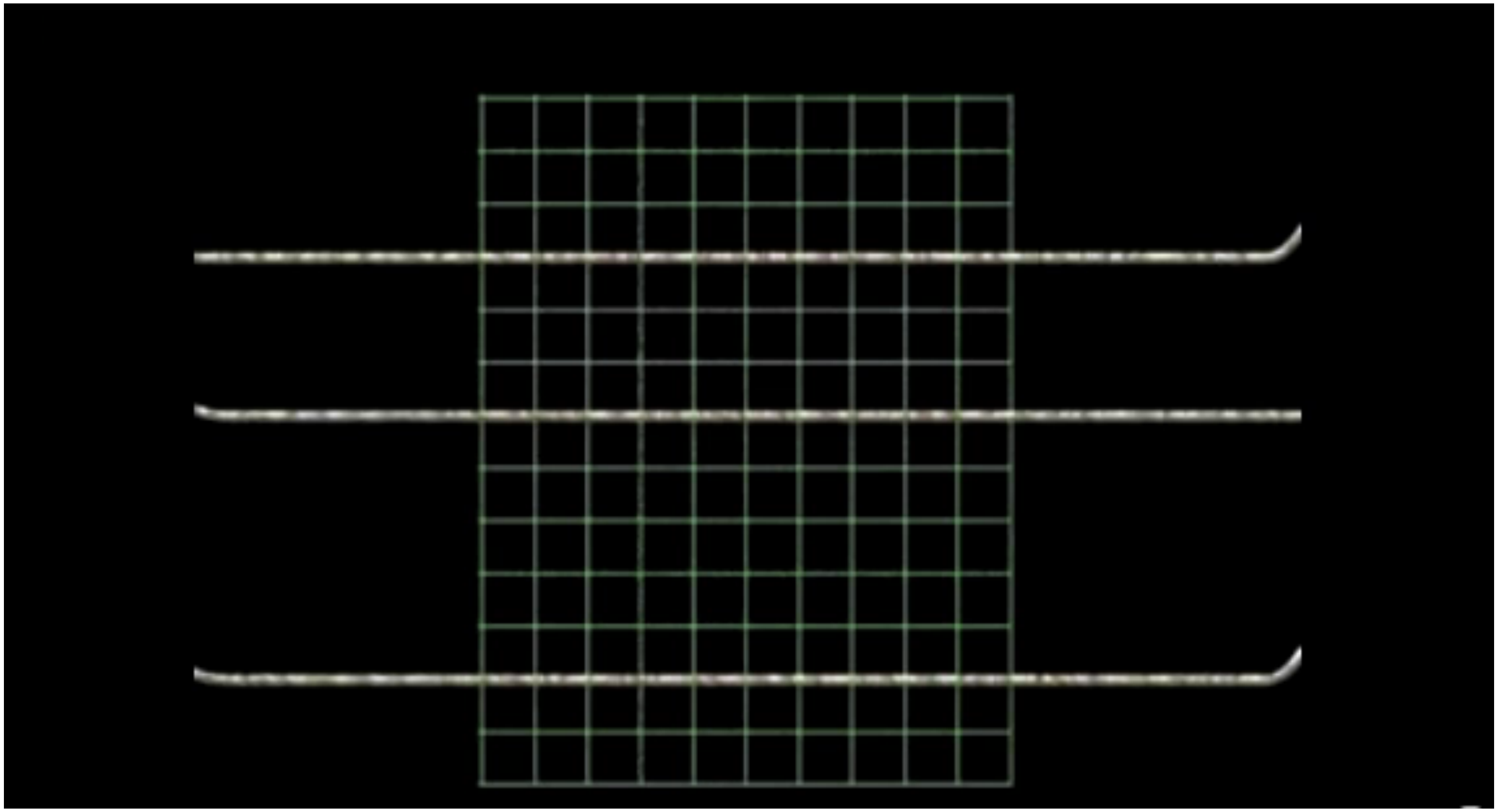
Superposition and Standing Waves

Pre-Class Questions

Problem Set (due next time)
Ch 12 - 15b, 16, 25, 30

Lecture Outline

1. The Principle of Superposition
2. Standing Waves on a String
3. Standing Sound Waves in Pipes

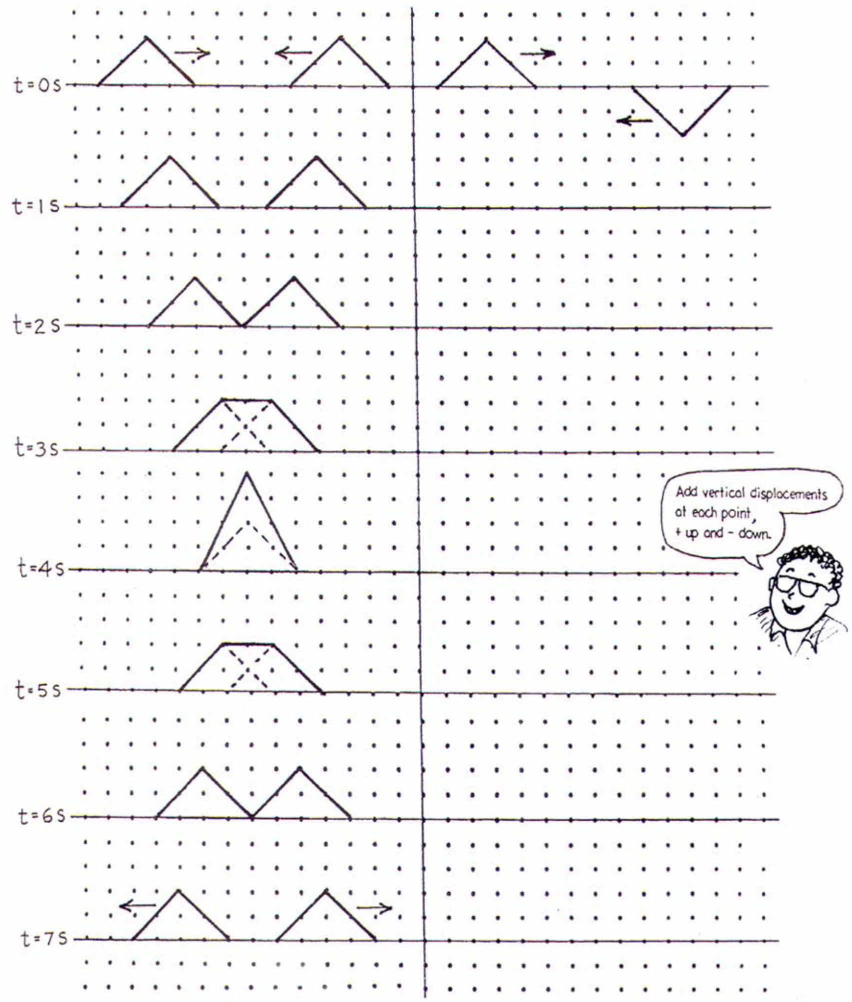


http://www.youtube.com/watch?v=3d2gfk1ih5E

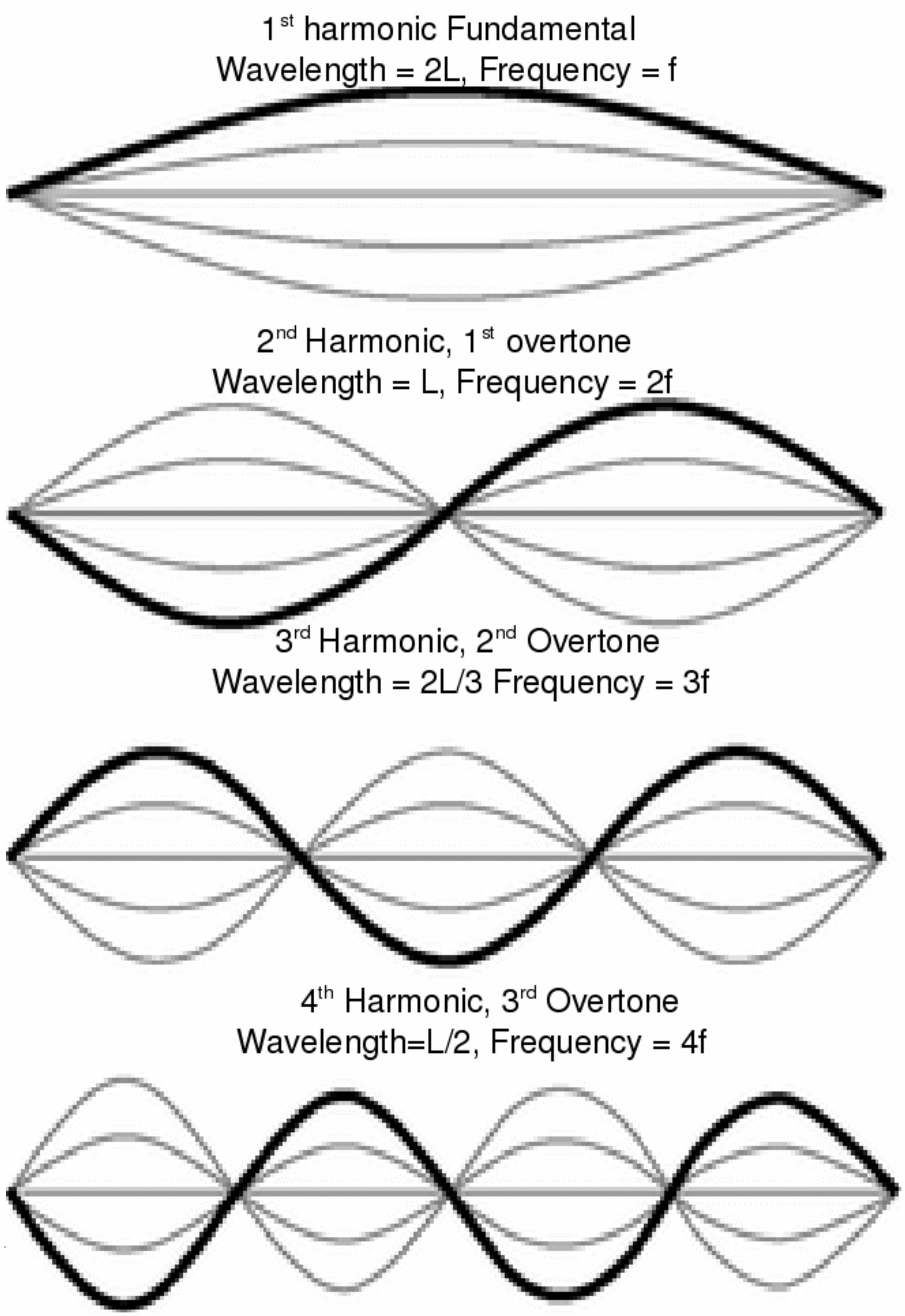
CONCEPTUAL **Physics** PRACTICE PAGE

Chapter 20 Sound
Wave Superposition

A pair of pulses travel toward each other at equal speeds. The composite waveforms, as they pass through each other and interfere, are shown at 1-second intervals. In the left column note how the pulses interfere to produce the composite waveform (solid line). Make a similar construction for the two wave pulses in the right column. Like the pulses in the first column, they each travel at 1 space per second.



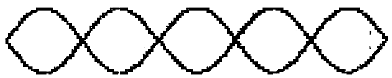
thanx to Marshall Ellenstein


1st harmonic Fundamental
Wavelength = 2L, Frequency = f
2nd Harmonic, 1st overtone
Wavelength = L, Frequency = 2f
3rd Harmonic, 2nd Overtone
Wavelength = 2L/3 Frequency = 3f
4th Harmonic, 3rd Overtone
Wavelength=L/2, Frequency = 4f

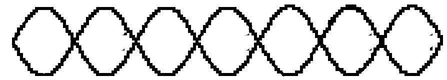
The figures below show systems of standing waves set up in strings, fixed at both ends, under tension. All of the strings are identical except for their lengths and are under the same tension. The variables in these situations, in addition to the lengths (L) of the strings, are the amplitudes (A) at the antinodes and the number of nodes.

Rank these systems, from greatest to least, on the basis of the wavelengths of the waves.

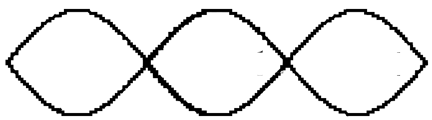
A A = 12 cm L = 25 cm



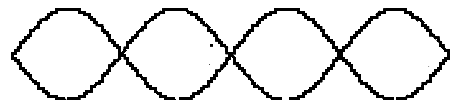
B A = 12 cm L = 28 cm



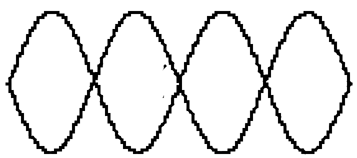
C A = 18 cm L = 27 cm



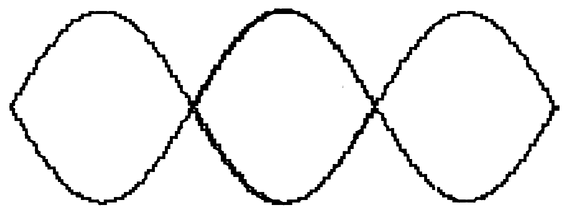
D A = 16 cm L = 28 cm



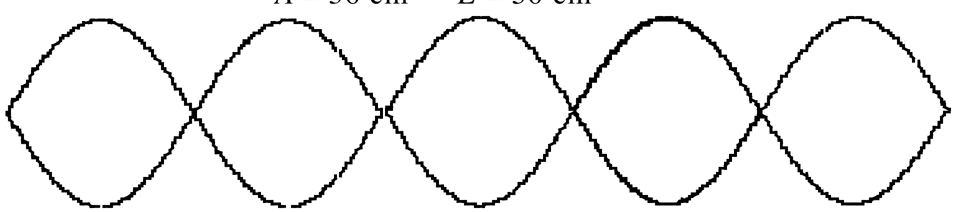
E A = 24 cm L = 20 cm



F A = 36 cm L = 30 cm



G A = 36 cm L = 50 cm



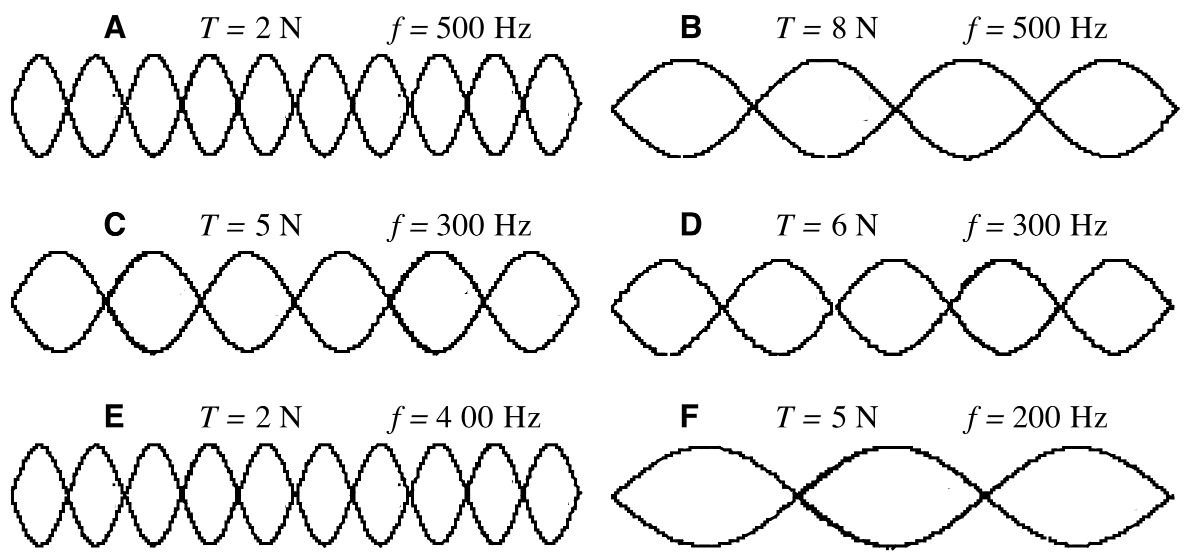
Greatest 1_______ 2_______ 3______ 4_______ 5_______ 6______ 7 ________ Least

Or, all of these systems have the same wavelength. _________

Please carefully explain your reasoning.

Shown below are six standing wave systems in strings. These systems vary in frequency of oscillation, tension in the strings, and number of nodes. The systems are also set up in various strings. The specific values for the string tensions and the frequencies of oscillation are given in each figure. All of the strings have the same length.

Rank these systems, from greatest to least, on the basis of the speeds of the waves in the strings. That is, put first the system whose waves have the greatest speed in their string and put last the system whose waves are traveling slowest in their string.



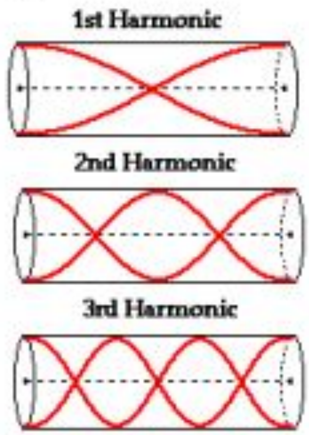
Greatest 1________ 2________ 3________ 4________ 5________ 6_______ Least

Or, all of the waves in these systems have the same speed. _______

Please carefully explain your reasoning.

Example 1: The E-string on the guitar has a fundamental frequency of 330HZ and is 60cm long. Find the frequencies and wavelengths of the first four harmonics.

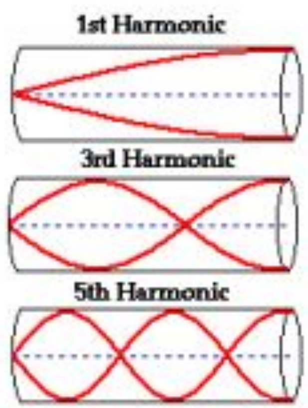
Open at Both Ends



Harmonic	Wavelength λ	Frequency f
1[st]	$2L$	f_1
2[nd]	L	$2f_1$
3[rd]	$2L/3$	$3f_1$

Odd and Even Harmonics

Closed at One End

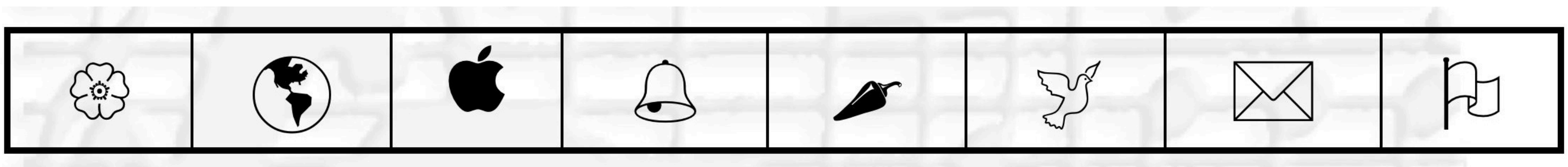


1[st]	$4L$	f_1
3[rd]	$4L/3$	$3f_1$
5[th]	$4L/5$	$5f_1$

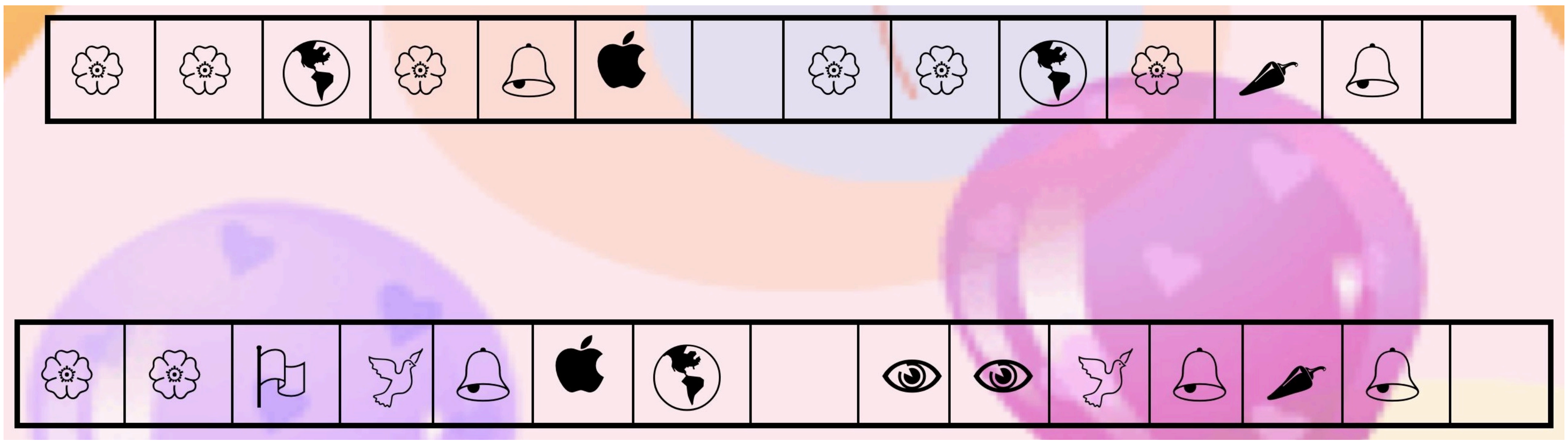
Odd Harmonics

Example 2: A clarinet is 72.0cm long. Find the frequencies and wavelengths of the first four harmonics.

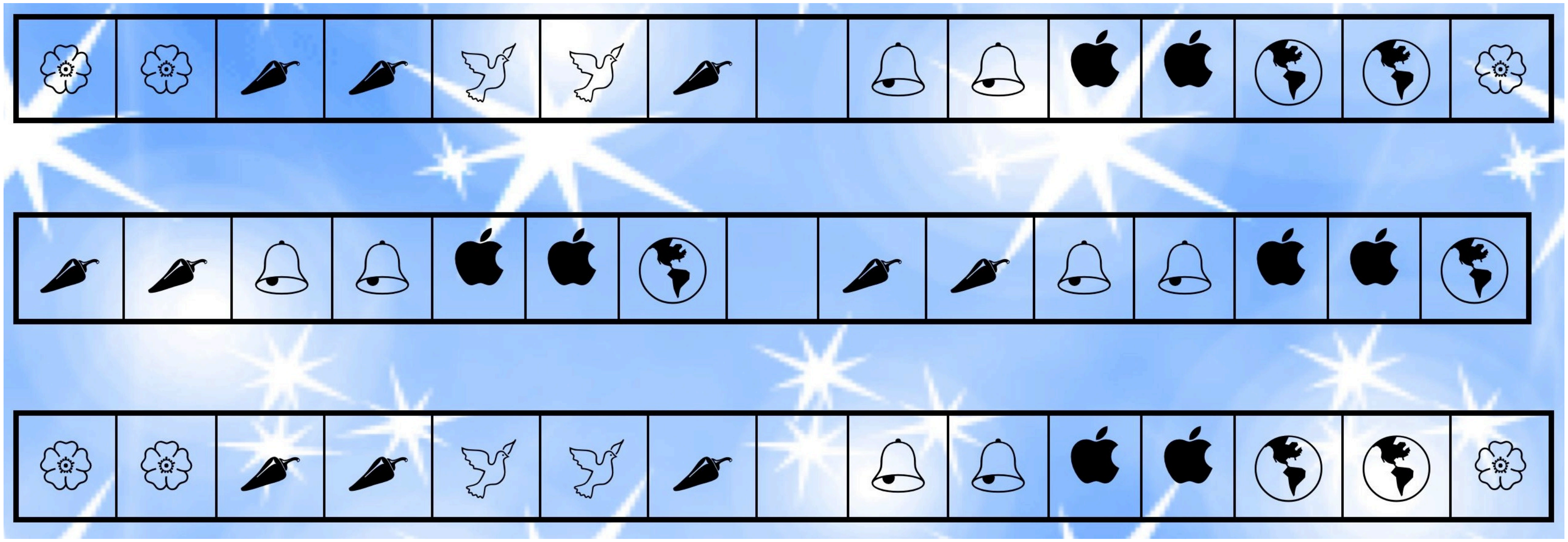
Major Scale



Happy Birthday



Twinkle Twinkle



Lecture 31- Summary

Principle of Superposition: Waves add point by point.

Standing Waves

String	$\lambda_n = \frac{2L}{n}$	$f_n = nf_1$
Pipes open at both ends	$\lambda_n = \frac{2L}{n}$	$f_n = nf_1$
Pipes closed at one end	$\lambda_n = \frac{4L}{n}$	$f_n = nf_1$ odd n only