Themed: 02-02

Resonance & Standing Waves

Resonance

- Definition: represents increasing amplitude from periodic external forces that match the natural frequency
- If you've ever pushed someone on a swing, you know resonance
- If you didn't know WHEN to push the swing, you'd slow it down as often as you'd speed it up
- A swing has a natural frequency, match it and you make the swing go higher – bigger AMPLITUDE

Resonance

- Definition: represents increasing amplitude from periodic external forces that match the natural frequency
- How does length and tension affect the natural frequency?
  - Longer ruler or Dilly Bopper (higher f or lower f?)
  - Tighten (increase tension) of a rubber band. How does f change?
- Do the different Orange Dilly Boppers have different NATURAL FREQUENCIES?
- Do the corresponding Dilly Boppers vibrate?
- Why would being blind folded make you bad at pushing your little brother on a swing?

Resonance and more
dealing with confusing definitions

- **resonance** represents increasing amplitude from periodic external forces that match the natural frequency;
- **harmonics** are the naturally occurring frequencies of a system;
- **sympathetic vibration** is when a system initially at rest begins vibrating due to the vibration of a nearby system with the same natural frequency;
- **forced vibrations** occur any time a periodic external force causes a system to vibrate (can be at system's natural frequency or not)

Demos: Slinky, Orange Dilly Boppers, Paired Tuning Forks

- Goals - Can you recognize:
  - Which harmonic is being demonstrated?
  - How many nodes and antinodes?
  - How/why this is a standing wave?
  - How does resonance makes this demo possible?
  - How can you push with air and get metal to vibrate?
  - Why does one Dilly Bopper develop a big amplitude, but not the other?

Standing waves - intro

- Standing waves are the basis for all music and are voices – not just interesting slinky patterns!
- To understand standing waves, you need to understand:
  - Pulse waves & reflection
  - Interference
  - Timing and tie all this knowledge together
  - Look at this simulation: http://www.walter-fendt.de/html5/phen/standingwavereflection_en.htm

Standing waves – Pulse waves & reflection

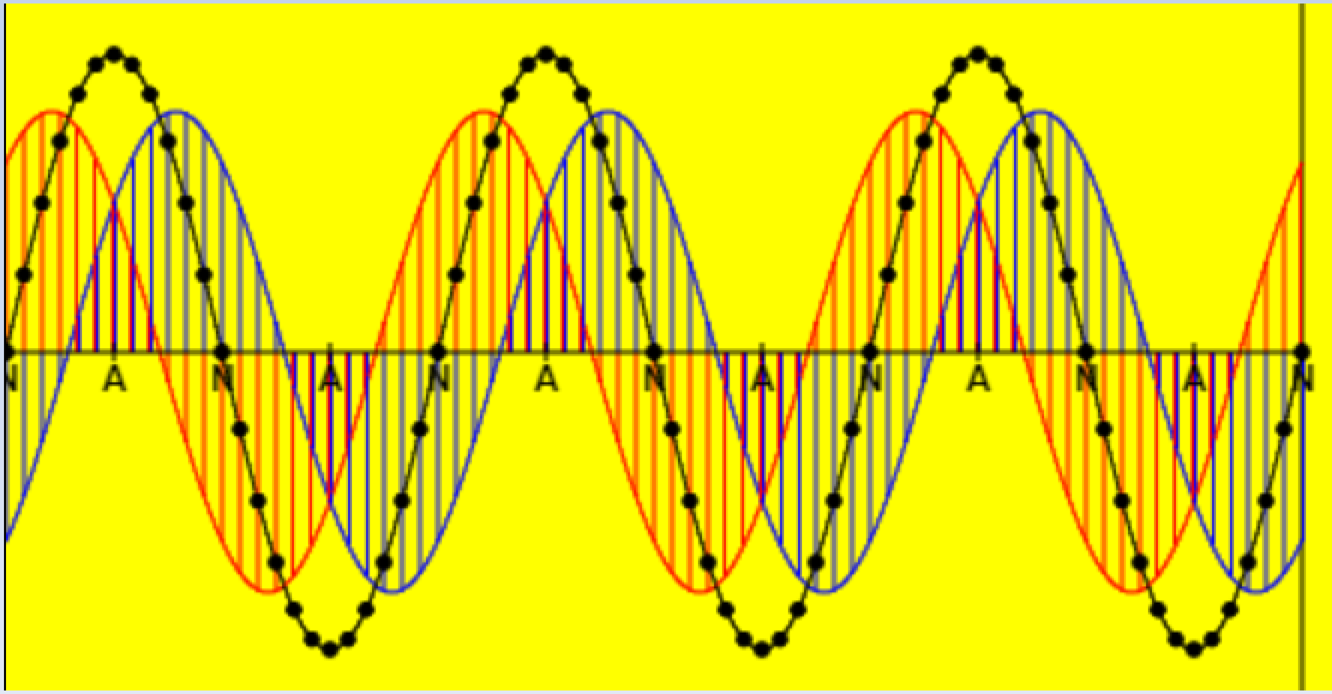
- Pulse waves are single waves (single wrist snap)
- Continuous waves are a series of pulse waves
- Pulse waves are easy to observe
- Slinky: fixed end reflection (opposite side: vertical AND horizontal reflection)
- Fixed end examples: Slinky, Guitar string
- Free end reflection (same side, horizontal reflection only)

Standing waves – Interference

- Just like football – receiver and cornerback try to occupy same space at same time – PENALTY!
- Waves are energy - can occupy same space at same time – INTERFERENCE
- Each wave adds its influence to the medium (yanks slinky in a particular direction)
- Both waves yank slinky same way? Constructive interference (add amplitudes = Superposition Principle)
- Each wave tugs each other opposite way? Destructive interference (Also Superposition Principle)

Standing waves – Tying it together

- Computer sim and slinky demo?
- Standing waves:
  - Reflected waves along medium
  - With right timing:
    - Certain locations ALWAYS have destructive interference (nodes)
    - Certain locations ALWAYS have constructive interference (antinodes)
- Waves are reflecting back and forth, but LOOKS like wave is STANDING still (reason call standing wave)



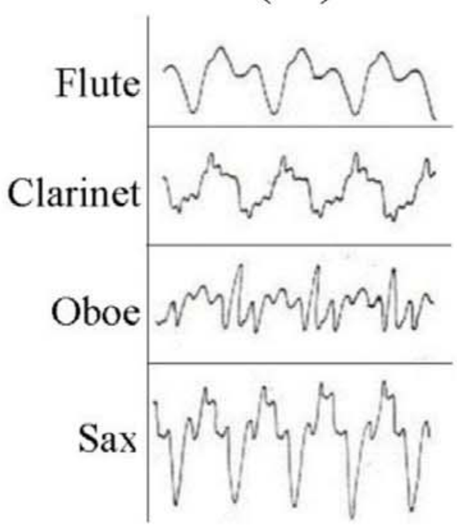
Harmonics and Timbre: You sound like you and guitars don’t sound like pianos!

A. The “*same*” note sounds different on different musical instruments or from different voices

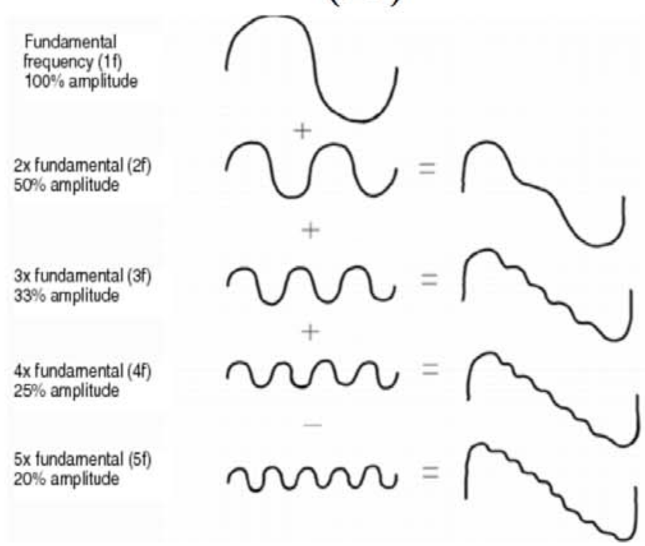
B. The note is produced by multiple standing waves simultaneously vibrating along a string or air tube. Different harmonics have different amplitudes. The fundamental is usually the “loudest” in the mix. The mixture of amplitudes is called “timbre”

C. The resulting wave is produced by interference. Notice how the fundamental’s amplitude is most and the complex wave that results.

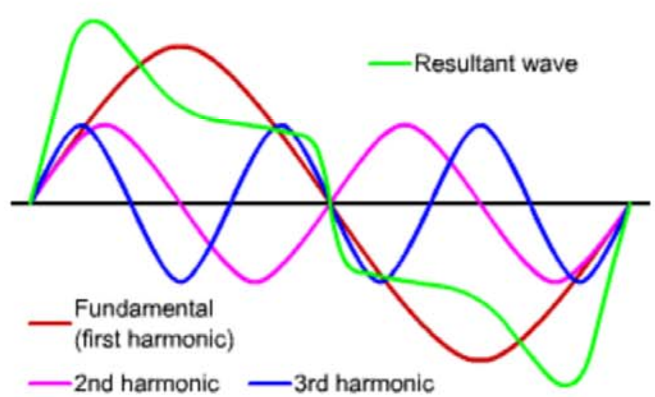
(A)



(B)

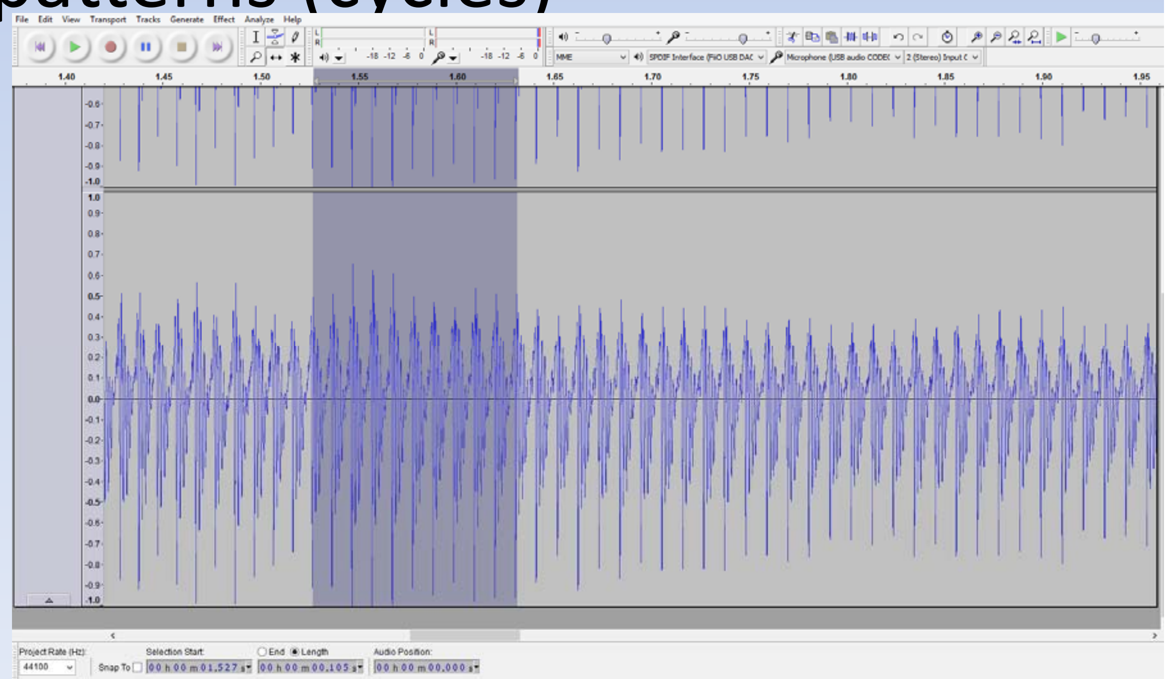


(C)

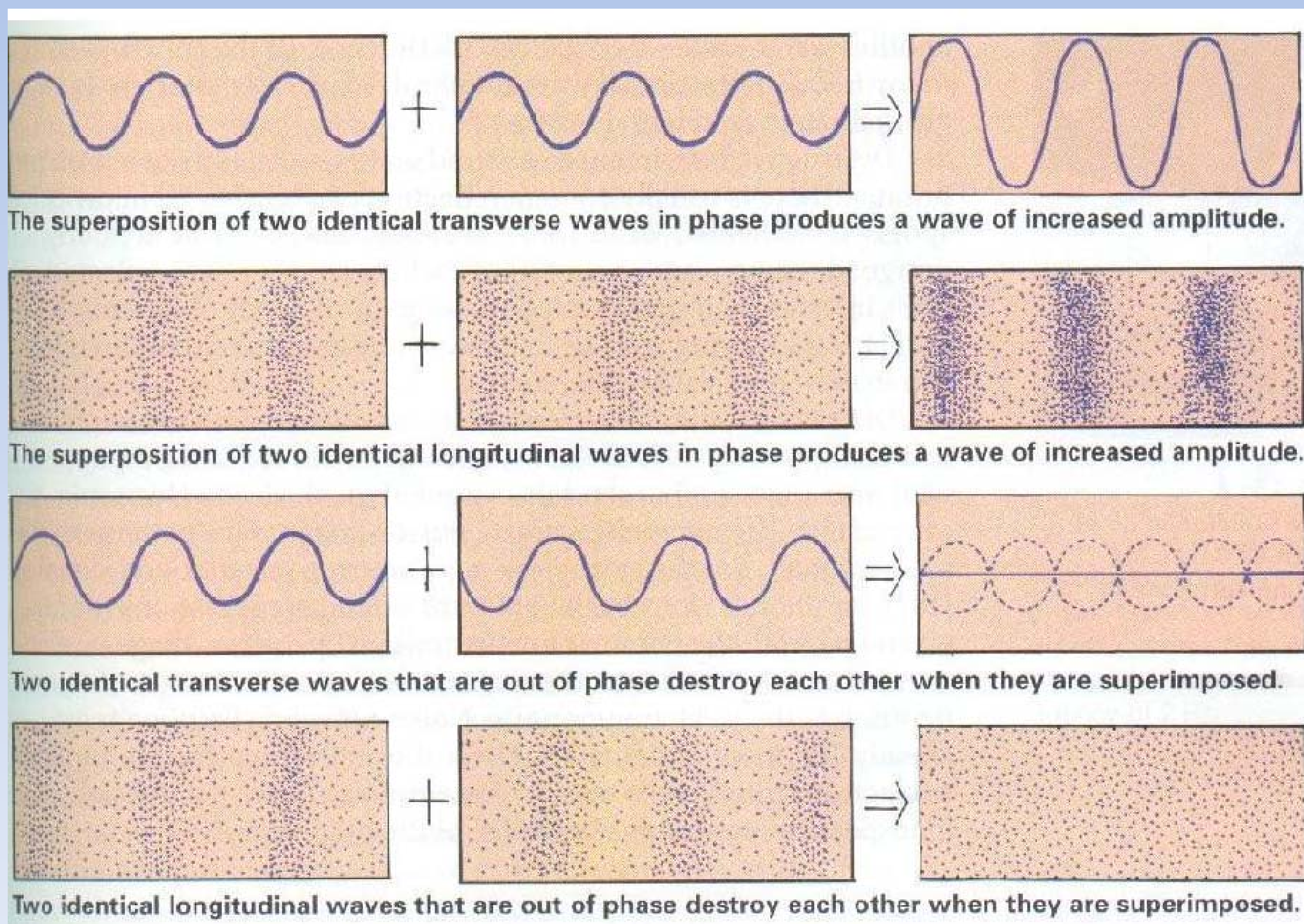


Audacity Introduction

- Records air pressure variations (sound!)
- Y-axis is pressure/sound energy/amplitude
- X-axis is time
  - Look at sig figs in time measurements, this limits the precision of your frequency measurements
- Look for repeating patterns (cycles)
  - f = cyc/sec



Understanding What Audacity Really Does Interference & Superposition Principle for REAL sound waves



The superposition of two identical transverse waves in phase produces a wave of increased amplitude.

The superposition of two identical longitudinal waves in phase produces a wave of increased amplitude.

Two identical transverse waves that are out of phase destroy each other when they are superimposed.

Two identical longitudinal waves that are out of phase destroy each other when they are superimposed.

Audacity Introduction

- Some program highlights