Physics in the classroom

Lecture 5

Sound Waves

- Speed of sound = 340 m/s in air.
- Sound waves are compressional waves.
- Sound must have a medium to travel in. (air, solid objects, etc.) Sound can not travel in a vacuum

Review

- Amplitude of wave: displacement from equilibrium.
- Period: time for one complete oscillation.
- Frequency: number of oscillations per second.
- Wavelength: distance between identical points on a wave

Review (cont.)

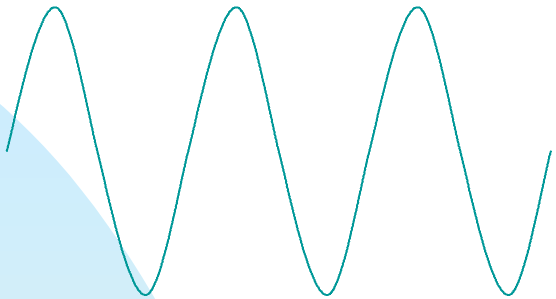
- $v = f \lambda$
- Constructive interference: two or more waves add together in a constructive way.
- Destructive interference: two or more waves add together in a destructive way.

$v = f\lambda$

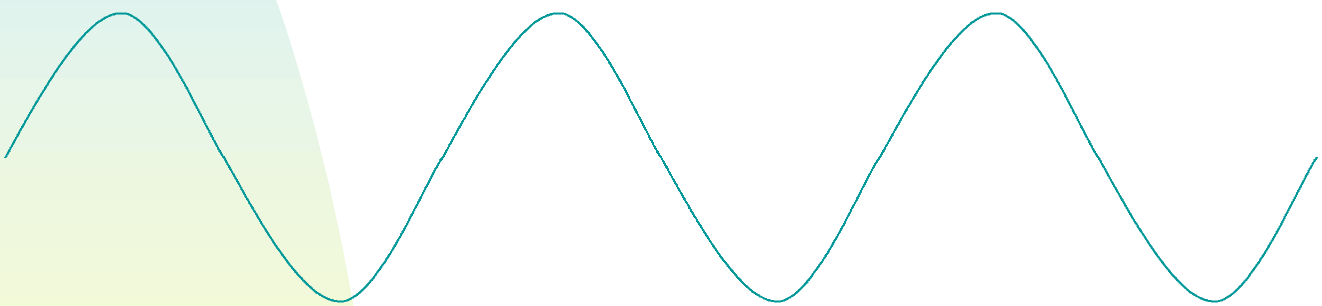
- v is speed (velocity) in m/s
- f is frequency in Hz (1/s)
- λ is wavelength in meters
- The speed is constant!
- The speed is constant!
- The speed is constant!

$v = f \times \lambda$

- If frequency increases then the wavelength must decrease in order to keep the speed constant.
- Or, if the frequency decreases then the wavelength must increase in order to keep the speed constant.



high frequency
short wavelength

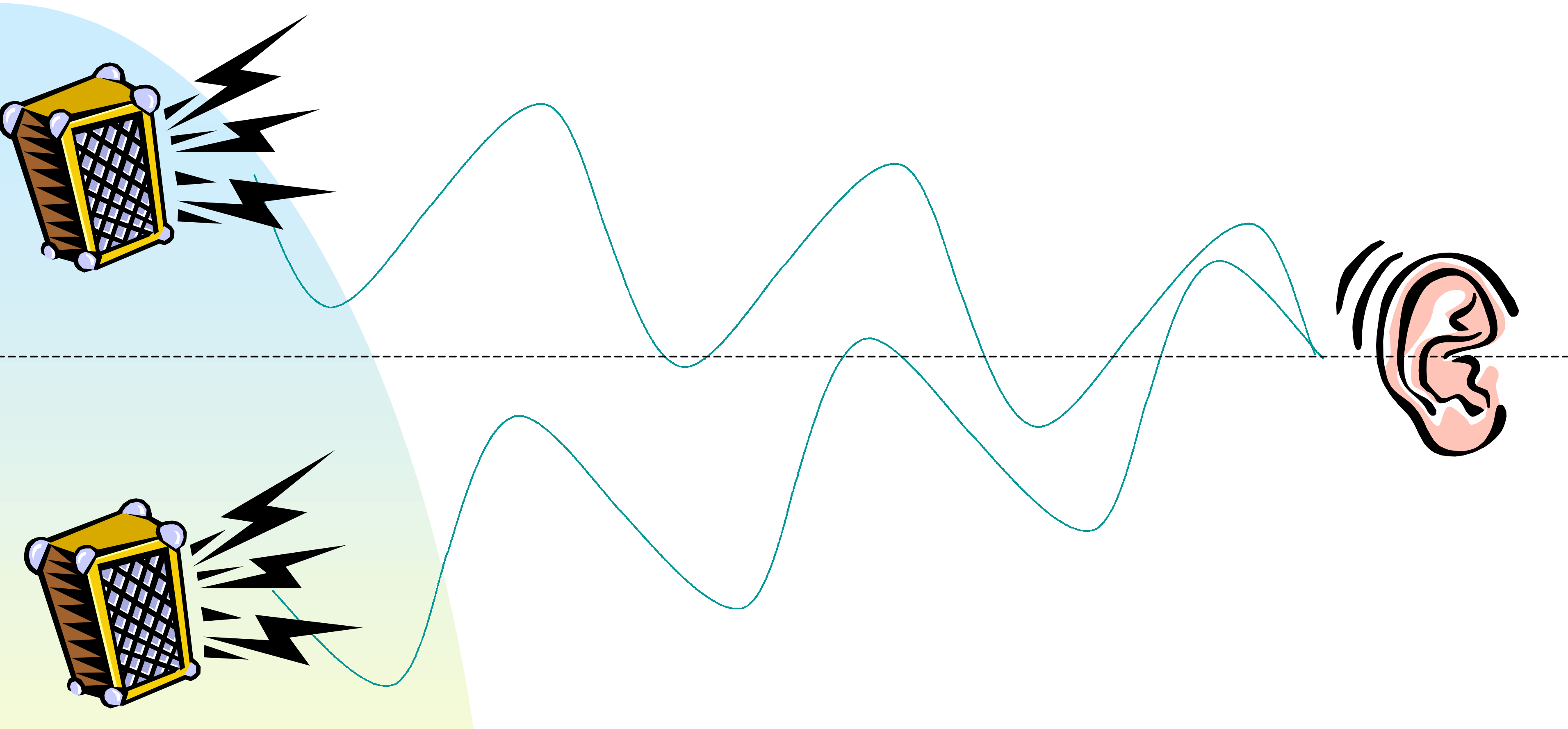


low frequency
long wavelength

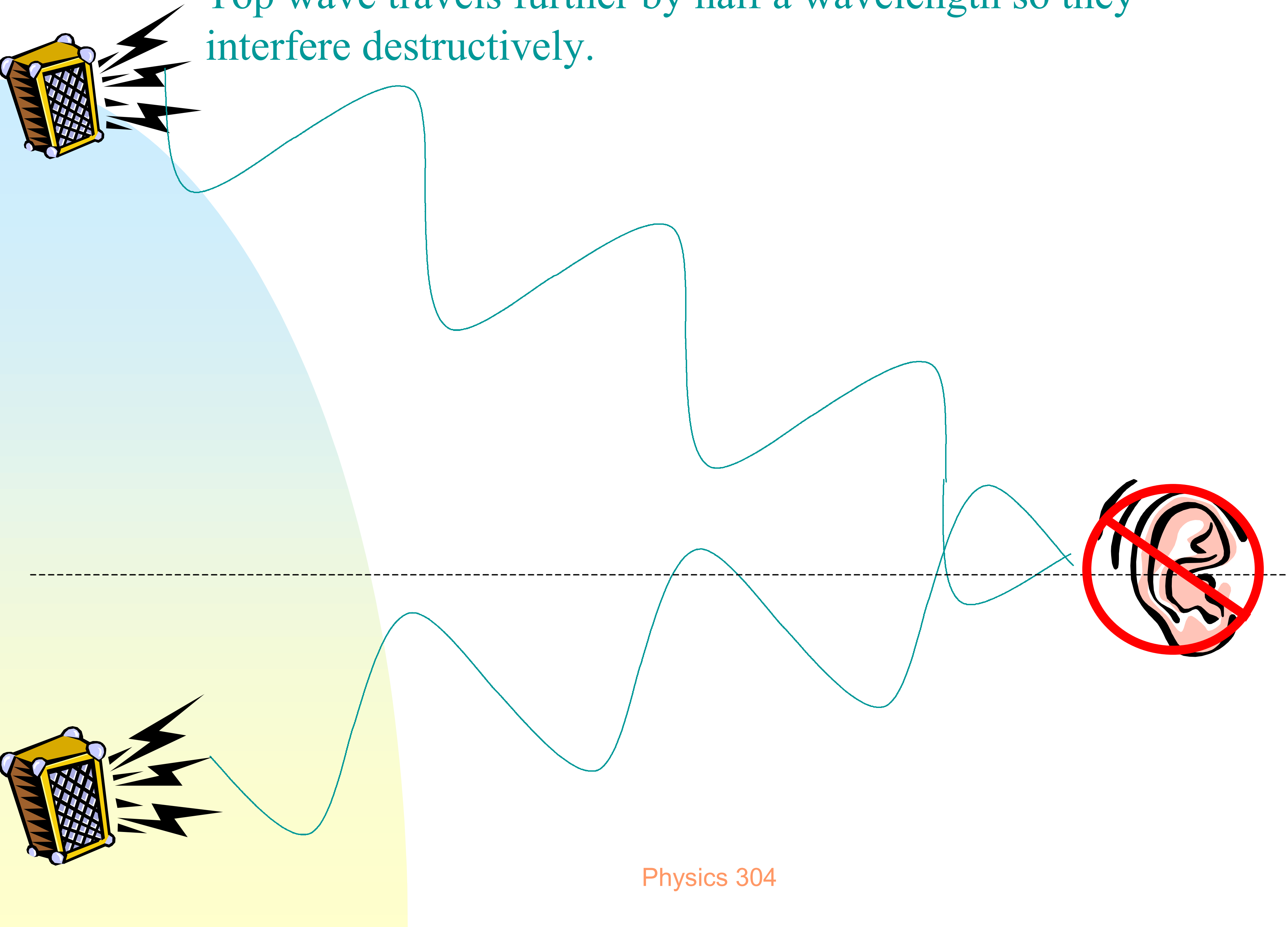
Interference

- Constructive interference
- Destructive interference

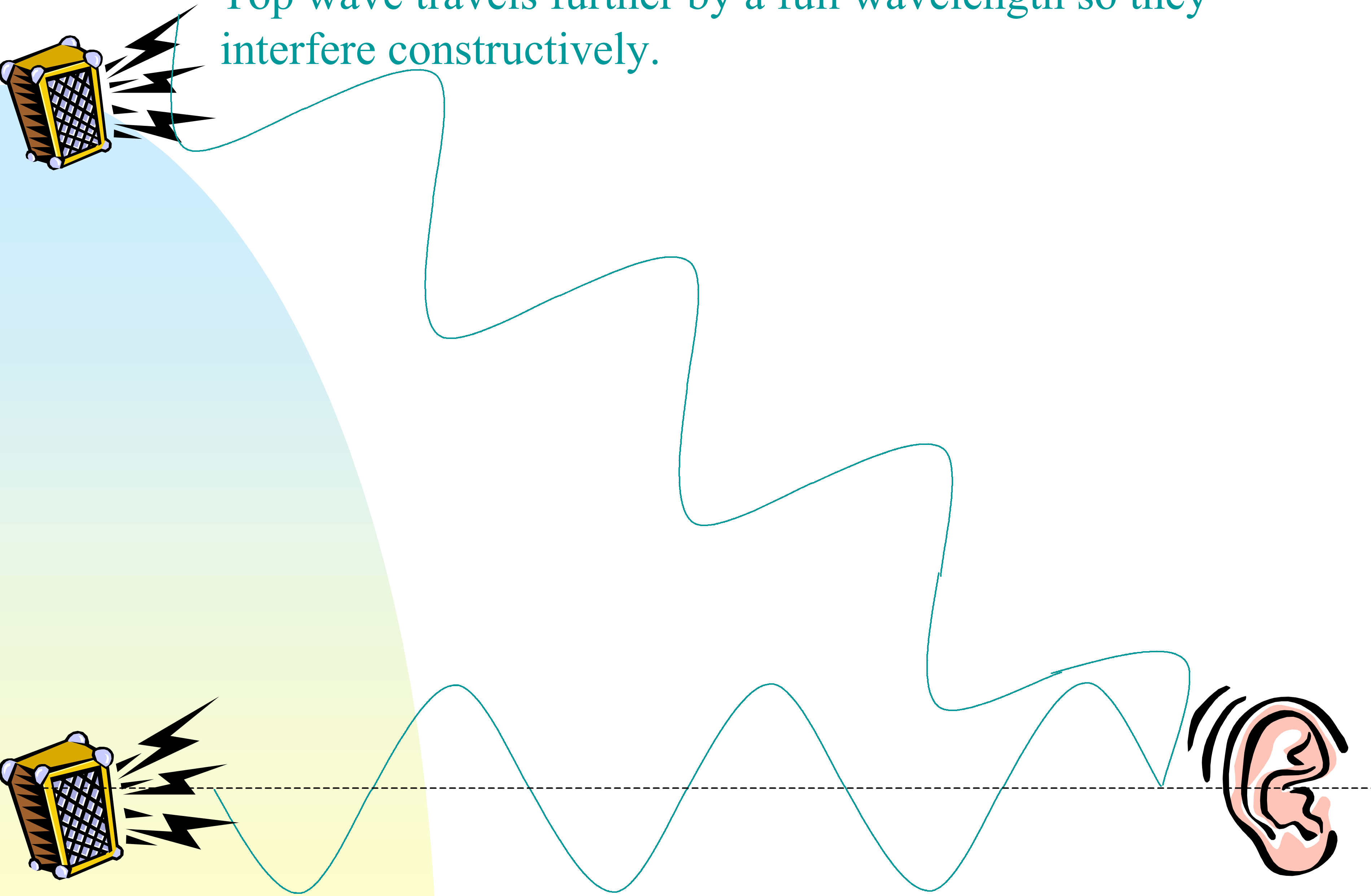
Waves travel same distance, so they interfere constructively



Top wave travels further by half a wavelength so they interfere destructively.



Top wave travels further by a full wavelength so they interfere constructively.



Constructive and destructive interference of sound waves.

- Move around the room and listen for “dead” spots, which are places of destructive interference. Also, listen for “hot” spots, which are places of constructive interference.

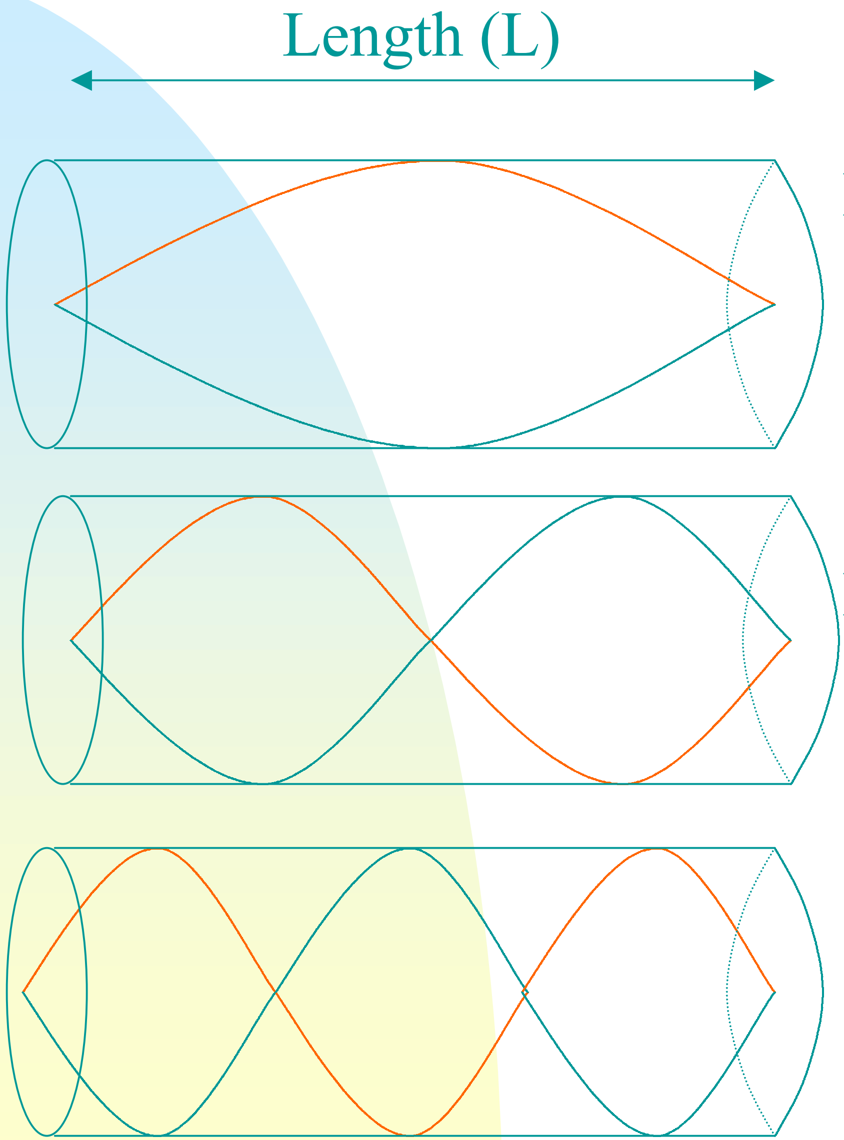
Sound waves in a tube

- Many musical instruments are essentially tubes which are either open or closed at each end.
- Waves reflect off the closed ends and the open ends of tubes.
- Reflected waves traveling back and forth inside a tube interfere, producing standing waves.

Standing waves inside a tube.

- Very similar to waves on a string.
- A node (no vibration) must exist at the open end of a tube.
- An antinode (maximum vibration) must exist at the closed end of a tube.

Standing waves in tube open at both ends



$L = (1/2)\,\lambda_1$ ⟶ $\lambda_1 = 2L$

$f_1 = f_1$

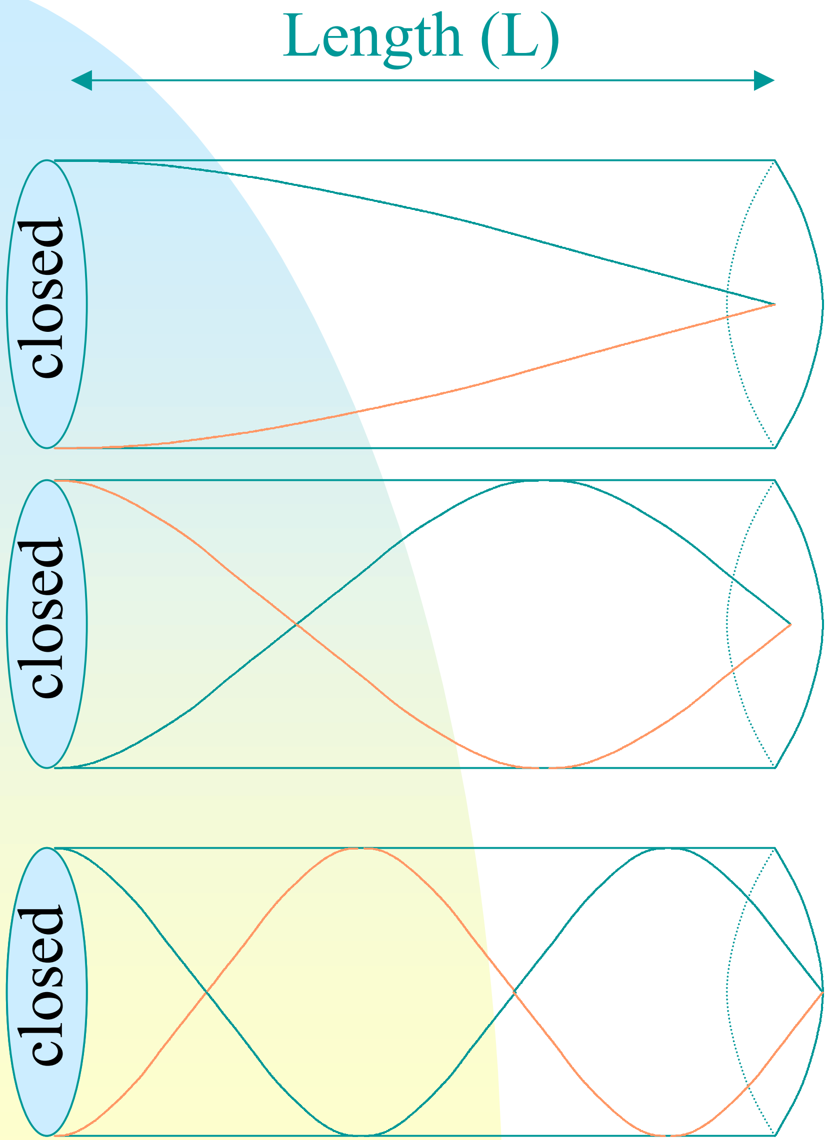
$L = (2/2)\,\lambda_2$ ⟶ $\lambda_2 = L$

$f_2 = 2f_1$

$L = (3/2)\,\lambda_3$ ⟶ $\lambda_3 = (2/3)L$

$f_2 = 3f_1$

Standing waves in tube open at one end and closed at the other end. (only odd harmonics)



$L = (1/4)\,\lambda_1 \longrightarrow \lambda_1 = 4L$

$f_1 = f_1$

$L = (3/4)\,\lambda_2 \longrightarrow \lambda_2 = (4/3)L$

$f_2 = 3f_1$

$L = (5/4)\,\lambda_3 \longrightarrow \lambda_3 = (4/5)L$

$f_2 = 5f_1$

Standing waves in a tube demonstration.


Questions?