Physics 115 Lecture 6

Sound waves

February 2, 2018

Sound Wave Generation

- Production of sound waves
  - Any disturbance in a medium creates an outgoing sound wave.
  - The disturbance can be enhanced (producing a more intense sound wave) by means of a *resonator*. A resonator amplifies the disturbance by causing a greater amount of the medium to vibrate. (Example: Tuning fork placed on a tabletop.)

Sound Wave Propagation

- Sound waves propagate by means of "neighbor-to-neighbor" interactions.
  An air molecule, for example, strikes a neighboring air molecule, which in turn strikes another, etc. Watch animation
- A propagating sound wave diminishes in intensity as its distance from the source increases.
  - ☞In 1 dimension, this is due to frictional losses.
  - ☞In 2 or 3 dimensions, this is due to frictional losses and also to geometrical effects.

Sound is a pressure wave

- Pressure is force/area

$$P = \frac{\text{force}}{\text{area}} = \frac{F}{A} = \frac{\text{N}}{\text{m}^2} = \text{Pascal (Pa)}$$

- Atmospheric pressure is defined as 101,325 Pa = 101 kPa, about 14.7 lb/in^2 (psi)
- Sound pressures are tiny, only a fraction of a pascal

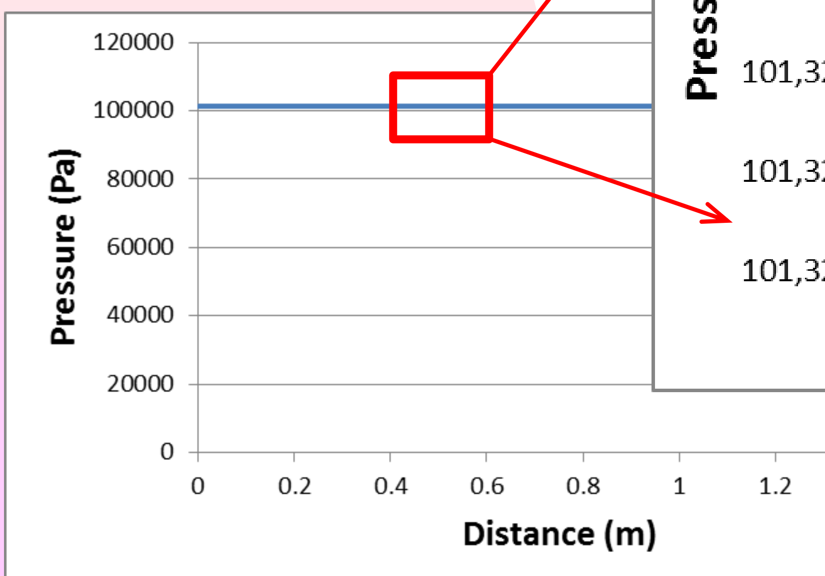
Sound is a pressure wave

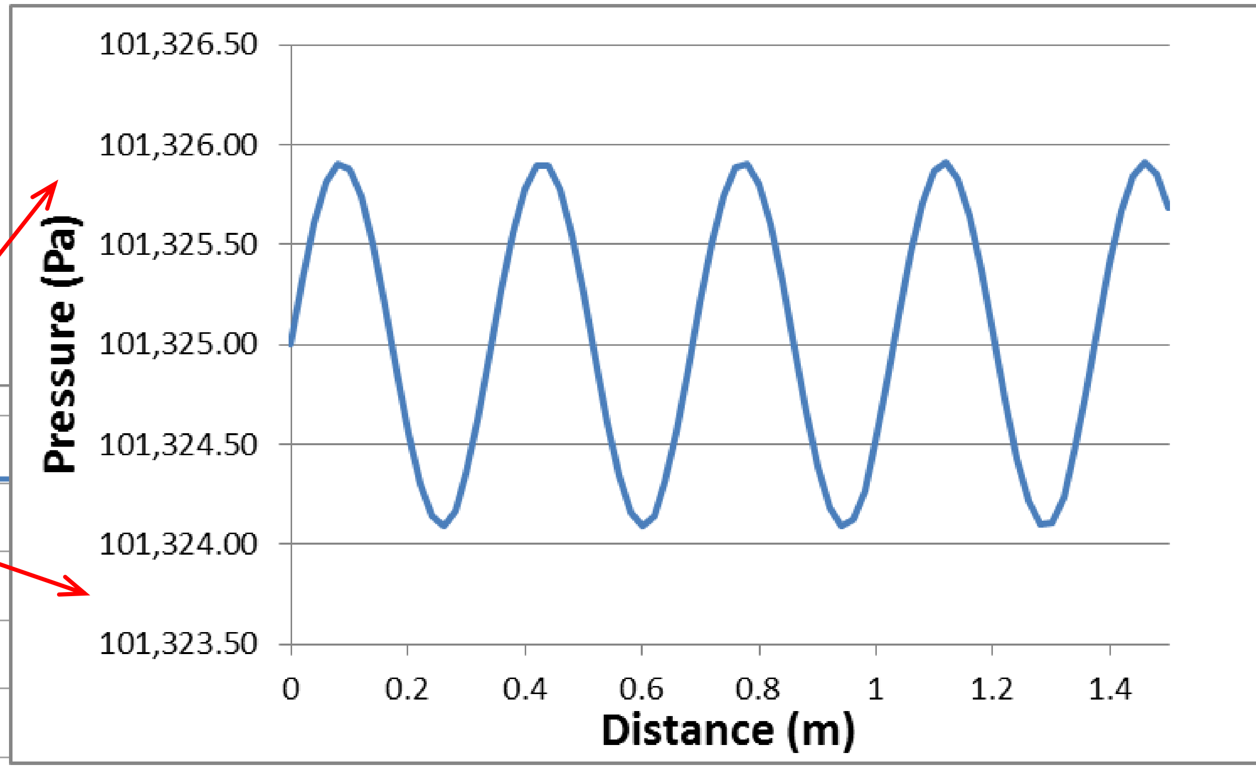
- Waves oscillate in space and time

$$k = \frac{360^\circ}{\lambda} \begin{cases} \text{phase change} \\ \text{with distance} \end{cases}$$

$$\omega = \frac{360^\circ}{T} \begin{cases} \text{phase change} \\ \text{with time} \end{cases}$$

$$p = p_0 \sin(k\,x - \omega t)$$

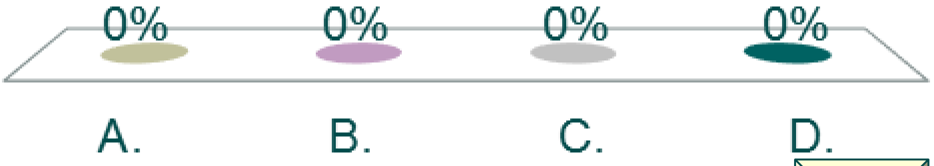




A loud 90-dB sound has a pressure amplitude of p_0 = 0.907 Pa

How much force can a 2.0-in diameter suction cup hold? It has an area of 0.00203 m^2, and works by removing all the air from one side while the atmospheric pressure of 101 kPa acts on the other side.

A. 2.05 N
B. 0.00205 N
C. 205,000 N
D. 205 N



Response Counter

90

How much force can a 2.0-in diameter suction cup hold? It has an area of 0.00203 m², and works by removing all the air from one side while the atmospheric pressure of 101 kPa acts on the other side.

A. 2.05 N

B. 0.00205 N

C. 205,000 N

D. 205 N

$$P = \frac{F}{A}$$

$$F = P\,A = \left(101{,}000\ \text{Pa}\right)\left(0.00203\ \text{m}^2\right)$$

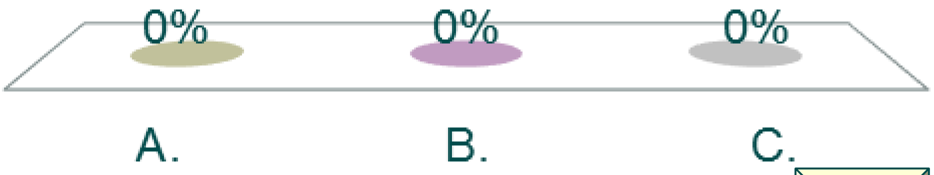
$$= \boxed{205\ \text{N}} \times \frac{1\ \text{lb}}{4.45\ \text{N}} = 46.1\ \text{lb}$$

Sound waves are longitudinal

- Watch animation
- They can travel through any material except vacuum
- The stiffer the medium, the larger the effective “spring constants” that connect the atoms, and the faster the wave propagates.

A sound wave travels through wood into aluminum, a stiffer medium than wood. The wave speed in aluminum will be _____ than the speed in wood.

A. higher than
B. the same as
C. lower than



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A sound wave travels through wood into aluminum, a stiffer medium than wood. The wave speed in aluminum will be _____ than the speed in wood.

A. **higher than**
B. the same as
C. lower than

A stiffer medium means higher spring constants, faster oscillations, and faster wave propagation