Traditional: 11-05
Themed: 01-05

Wave speed math, echo problem, Doppler (shock waves/bow waves), mach (shape)

Final slinky tips

- Have fun
- Understand what your doing as the curious scientist we both know you are
- Think about the notes for this you are demonstrating:
  - Fixed end reflection
  - Wave speed's independence of amplitude and frequency be the first student ever to read the TITLE of part 3 and win a prize! (my bad sense of humor again)
  - Standing waves
  - Longitudinal vs. Transverse waves (please NOTICE the vibration direction and the wave motion's direction!)
  - Harmonics (the natural frequencies that produce standing waves)
- Have fun (did I already say that?)

Wave speed equation

- Wave speed equation
  - $V = f\lambda$
  - f is “frequency”: big f means waves pass by very often (short time between subsequent waves)
  - Frequency is measure in Hertz (Hz). 1 Hz, is 1/sec or a “per second”
  - The time in seconds between waves is given it’s own name and symbol: Period and the symbol is T (T stands for “time” between waves)
  - λ (lamda) is wavelength, measure in meters
  - Wave speed must be in m/s….see how the units makes sense?

Clicker question

- Pick the pair of units matching the following variables: f, λ (in the same order as f, λ)

a) Hz, m/sec

b) 1/sec, m

c) m, Hz

d) Hz, 1/sec

e) m/sec, 1/sec

Wave speed equation

- Frequency and period
  - They're opposites (inverses)
  - Big frequency (like 1000 Hz) means 1000 waves per second, or small time interval between waves
  - Small frequency (like 0.5 Hz) means 0.5 waves per second, or lots of time between waves
- Mathematically, they're relationship is

$f = 1/T$

Sample problems

- If you time 10 waves in 1 minute, what's the frequency? What's the period? *(0.167 Hz), (6 seconds)*
- If you measure the above waves move at 4 m/s then what's the wavelength *(24 m)*
- How long does it take the above wave 100 m from the shore to reach the shore? *(25 s)*

Echo problem and V(T) in air

- Speed of sound in air depends on temperature
  - High temp = fast moving air molecules
  - Fast moving air molecules = more frequent collisions
  - More frequent collisions = faster moving waves
  - V(T) = 331 m/s + 0.6T (where T is centigrade temp. of air)
- Sample: How fast is the speed of sound in 15°C air?(340 m/s)

Echo problem and V(T) in air

- Walking down a cold -12°C Bavarian mountain, Hans spots Rita. She's very pretty and Hans yodels to get her attention. He hears his echo 2.0 seconds later. How far is Hans from Rita?
- (323.8 m)

Sound/Doppler

- Sound: *A longitudinal vibration traveling through a physical medium*
- Surface water waves are not sound, they’re not longitudinal; light waves are not sound since they don’t require a physical medium
- Sound cannot pass though a vacuum, it can pass through media like steel, water, etc.

Sound/Doppler

- Humans can hear sounds between 20 Hz and 20,000 Hz
  - Infrared means light with frequencies too low to see; infrasonic means sound with frequencies too low to hear (below 20 Hz)
  - Ultraviolet means light with frequencies too high to see; infrasonic means sound with frequencies too high to hear (greater than 20,000 Hz)
- Radio waves are light. They are **NOT** sound!

Waves Notes

Doppler/interference – bow waves, shock waves

- When the "source" moves faster than the wave speed, waves line up and interference makes very large amplitudes
- Doppler works for light too (basis for Big Bang Theory is "red shift")
- In two-dimensions (water surface): bow waves
- In three-d, shock waves (sonic boom)
- Sonic boom is CONTINUOUS and unheard by pilot and passengers (they outrun the sound!)

Waves Notes
Shock waves

- Shape of shock wave cone tells how fast plane is moving compared to speed of sound
- More pointed = faster, more blunt = slower
- Mach speed is ratio of source speed (plane) compared to speed of sound

$$M = V_{\mathbf{0}}/v_{\mathbf{sound}}$$

- Example: How fast does a plane moving Mach 3 go? (assume speed of sound is 340 m/s)
  - Answer: 1020 m/s