Chapter 10: Waves

Did you read chapter 10 before coming to class?
A. Yes  
B. No

The Test
- Average score: 25/30
http://ps100.byu.edu/Syllabus.aspx

Wave concepts
- Waves are a "disturbance" that travels (usually through a material).
- They carry energy away from a source.
- The disturbance and associated energy move along, the material does not.

Types of Waves: Surface Waves
- Come from compressing atoms (or molecules) close together and then pulling them apart.
- The oscillations are parallel/antiparallel to the direction of travel.

Types of Waves: Compression Waves
- Compression waves can travel through solids and fluids.

Multiple Choice Scores

Frequency

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Types of Waves: Transverse waves
- The oscillations in a transverse wave are perpendicular to the direction of travel.
  - Mechanical transverse waves (shear waves) require rigid bonds, so they only travel through solids.

Wave Properties: Wavelength
- Wavelength is the distance between two similar parts of the wave.

Wave Properties: Amplitude
- Amplitude is the amount of displacement from the rest position.
  - Associated with the energy of the wave:
    - loudness (sound)
    - brightness (light)

Wave Properties: Frequency
- Frequency is the number of wave crests which pass a point per second.
  - sound: pitch, 20 to 20,000 Hz
  - light: color, $10^{15}$ Hz
  - earthquake: 10 to 1,000 Hz
  - radio: kHz (AM) to MHz (FM)

Wave Properties: Speed
- Speed = frequency $\times$ wavelength
  - Speed usually depends almost exclusively on the medium.
  - However, frequency/wavelength can play an extremely minor role in special cases.
    - This is how we get rainbows.

You hear the thunder five seconds after seeing the lightning.
How far away is the lightning?
If you double the frequency of a wave, the speed will

- a) Double
- b) Be cut in half
- c) Remain essentially unchanged

Speed = frequency × wavelength.

Sound

- A compression wave in a fluid (air, water, etc).
- Long wavelength, low frequency ➔ low pitch
- Short wavelength, high frequency ➔ high pitch

Visible Light

- A transverse wave (but what is waving?)
- Long wavelength, low frequency ➔ red light
- Short wavelength, high frequency ➔ blue light
- Speed is the same for all colors in vacuum/air. Small dependence on color in dense material like water/glass

Wave Behavior

- All waves will
  - Reflect
  - Refract
  - Diffract
  - Interfere

Reflection

Refraction

The bending of a wave as it enters a medium with different properties so that the wave speed changes.
**Diffraction**

- The wave fans out when it encounters an obstacle or opening.
- The amount of diffraction depends on the relationship between wavelength and size of opening:
  - Most when wavelength is similar to opening
  - Small when wavelength is much smaller than opening.

**Interference**

- When two or more waves meet:
  - Constructive interference: two crests add together
  - Destructive interference: crest and trough cancel

**Standing waves**

- Points of the medium that are permanently at rest are called Nodes
- Points of the medium that have maximum oscillation are called Anti-Nodes
- Only certain frequencies produce standing waves in a given system. These are called resonance frequencies.
- The energy of a wave is associated with its frequency.
- We can create one-dimensional standing waves using a rope:

**Higher Dimensions**

- Standing waves are possible in two dimensions as well
The Doppler Effect

- When the source and/or the observer are in motion relative to one another, the observed frequency can change.
- If the source and observer are moving towards each other, frequency increases.
- If they are moving apart, frequency decreases.

Bonus material: Shock waves

- If a source is moving faster than the speed of the wave, shock waves form.