Exam 1

- **Deadline:** Mon Sept., 11:00 am (5$ late: rest of Mon & Tues. Sept. 29 all day)
- 30 multiple choice problems (1 pt. each)
- 1 Essay question (5 pts)
- closed book
- Test your ability to apply science concepts

Review sessions

- **Adrian Rockwell:**
  Tuesday 29th (late day) noon to 2 pm. 381 CB
Quiz: Have you read Chapters 1 – 10?

A. Yes, all of them
B. Most of them
C. Some of them
D. None of them
Some definitions

- A wave is a “disturbance” that travels (usually through a medium).
- They carry energy away from a source.
- The *disturbance* travels while the material does not. The material may move some, but it wants to come back to its original state.
  - Example: slinky
Kinds of Waves

1. Surface Waves
Kinds of Waves

1. Surface Waves
2. Compression Waves
Kinds of Waves

1. Surface Waves
2. Compression Waves
Kinds of Waves

1. Surface Waves
2. Compression Waves
3. Transverse
Kinds of Waves

1. Surface
2. Compression
3. Transverse
4. Torsion
Compression vs. Shear Waves

- **Compression (Longitudinal)**
  - Come from compressing atoms close together and pulling them apart
  - Can travel through any material state

- **Shear (Transverse)**
  - Come from pulling an atom perpendicular to the bonds holding it to other atoms
  - Requires rigid bonds
  - Only travels through solids
Wave Properties

1. Wavelength

- The distance between wave crests

Shear

Compression

\( \lambda \)
Wave Properties

2. Amplitude

- The amount of displacement from the rest position
- A measure of the wave energy.
- Related to loudness (sound) or brightness (light)
Wave Properties

3. Frequency

- 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: set the dial: kHz to MHz
3. Speed

- Speed = frequency × wavelength
- Speed depends on the medium the wave travels through, not frequency or wavelength.
- The speed of sound is 340 m/sec. So...

<table>
<thead>
<tr>
<th>speed (m/sec)</th>
<th>frequency (Hz)</th>
<th>wavelength (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>340</td>
<td>100</td>
<td>3.4</td>
</tr>
<tr>
<td>340</td>
<td>34</td>
<td>10</td>
</tr>
<tr>
<td>340</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>340</td>
<td>0.34</td>
<td>1000</td>
</tr>
</tbody>
</table>
Quiz:
If the frequency of a wave is doubled,

A. the amplitude is doubled.
B. the amplitude is halved
C. the wavelength is doubled
D. the wavelength is halved
A compression wave in air.

- Long wavelength → low pitch
- Short wavelength → high pitch
Light

- A transverse wave (but what is waving?)
- Long wavelength $\rightarrow$ red light
- Short wavelength $\rightarrow$ blue light

Frequency increasing $\rightarrow$
Wavelength decreasing $\rightarrow$
Speed stays the same!
Wave Behavior

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

The bending of a wave as it enters a medium of different density.
Mirages are due to refraction
Interference

- When two or more waves meet.
- **constructive interference:** two crests add together
- **destructive interference:** crest and trough cancel
- **Example:** two loudspeakers
Diffraction

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

- We can create one dimensional standing waves using a rope

- One wave: No good. No standing wave will form.

- Three waves: Antinodes and nodes form the standing wave pattern.
The vocabulary of **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 or **modes** produce standing waves. These are called **resonance frequencies**.
- The energy of a wave is associated with its frequency.
  - Higher frequencies have higher energy.
  - Example: wave machine
Higher Dimensions

- Standing waves are possible in two dimensions as well
Video: Standing waves in soap bubbles

Rectangular frame holding a soap film.

SOAP FILM
Standing Wave Modes in 2 Dimensions
Quiz: The **distance labeled A** in the picture is called

A. Wave Amplitude  
B. Wave Frequency  
C. Wavelength  
D. Wave Speed  
E. Wave Interference
Quiz: Waves arrive at point B because of which of the following?

A. Diffraction of waves
B. Wave interference
C. Refraction of waves
D. Reflection of waves
E. The speed of light in empty space is a constant
The Tacoma narrows bridge revisited

Nodes

Anti-Nodes

Nodes
The Doppler Effect