Physics 208, Spring 2008
http://www.physics.wisc.edu/undergrads/courses/spring08/208

- Waves: Interference and Diffraction (Chap. 20-22)
  - Colors in soap films, CDs, and butterfly wings
- Refraction of Light, and Optics (Chap. 23)
  - Telescopes, microscopes, and eyes
- Electricity and Magnetism (Chap. 25-32)
  - Capacitors & cell membranes, battery-less flashlights
- Electromagnetic Waves (Chap. 33-34)
  - Light and polarization
- Modern Physics (Chap. 37-42)
  - Radiation and matter, radioactivity, nuclear fission

Your Profs and TAs

<table>
<thead>
<tr>
<th>TAs</th>
<th>Office</th>
<th>Discussion</th>
<th>Lab (3254 Ch)</th>
</tr>
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<tbody>
<tr>
<td>Adam Daily</td>
<td>218 Ch</td>
<td>507-766-5100 pm (346 959-8199)</td>
<td>350 M 12-05 pm</td>
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<tr>
<td>Amanda Gauth</td>
<td>505-766-5100 pm (2156 Ch)</td>
<td>350 T 12-05 pm</td>
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<tr>
<td>Zeev Kharrazi</td>
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<tr>
<td>Wael Elbaba</td>
<td>243-0-1234</td>
<td>608-766-5100 pm</td>
<td>334 M 7-05 pm</td>
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<td>Di Loh</td>
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<td>Michael Sclafani</td>
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<td>Max Phillips</td>
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<td>Ahmad Aminian</td>
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Lectures

- Monday, Wednesday 8:50-9:40 am, 2103 Chamberlin
- Includes
  - Demonstrations
  - Examples
  - Quick questions
- Honors lecture / discussion
  - Friday 8:50-9:30, 2103 Chamberlin
  - All welcome, but required for those signed up for honors (B or better course grade also required for honors)

Discussions and Labs

Discussions
- Tuesday and Thursday (begin tomorrow, Jan. 24)
  - Weekly Q&A, group problem, quiz.
Labs
- Start next week (3254 Chamberlin).
- No lab notebook: question sheets distributed.
- 10 of 11 labs must be completed to pass the course.
- Complete only 10 -> lab grade reduced by 30%.

- If you must miss a lab:
  - Immediately contact your TA
  - Try to arrange for a different lab section that week
  - If not possible, lab missed (for a good reason) can be made up only during the immediately following exam week.

Text: (Same as Physics 207 last semester)

Homework: (Mastering Physics)
- Should be able to use your login from Physics 207
  - Follow email instructions for registering
- Assigned each Thursday, due the following Thursday at midnight.
- First assignment: HW1 on Jan. 24 due on Jan. 31 at midnight

Exams

- 1 1/2 hour midterm exams
- Typically 5-6 problems (old exams at web site)
  - Multiple choice
  - Short answer
  - Longer calculation

Exam 1: Wed. Feb. 20 5:30-7 pm
Exam 2: Wed. Mar. 26 5:30-7 pm
Exam 3: Wed. Apr. 23 5:30-7 pm
Cumulative Final Exam: Mon. May 12 12:25-2:25 pm

Exams make up most of your grade (70%)
### Grading

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<th>Comments</th>
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<tbody>
<tr>
<td>Labs</td>
<td>10%</td>
<td>10 of the 11 labs required to pass the course. Lab grade reduced 30% if only 10 labs completed.</td>
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<tr>
<td>Discussion</td>
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<td>Tue &amp; Thurs</td>
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<tr>
<td>Homework</td>
<td>10%</td>
<td>Mastering Physics</td>
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<table>
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<tr>
<th>Exam</th>
<th>Weight</th>
<th>Time</th>
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<tbody>
<tr>
<td>MTE1</td>
<td>15%</td>
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<tr>
<td>MTE2</td>
<td>15%</td>
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<tr>
<td>MTE3</td>
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<td>1:30 hrs</td>
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<tr>
<td>Final</td>
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<td>2:00 hrs</td>
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### Last semester: mechanical waves
- Examples: Sound waves, Water waves, Earthquake waves
- Medium required
- Wave describes displacement of medium

### This semester: electromagnetic waves
- Examples: Light waves, Radio waves, Microwaves, X-rays
- No medium required
- Can propagate in vacuum
- Wave describes local electric and magnetic fields

### Common wave properties

- **Reflection**: Shows constant time intervals
- **Superposition**

### Wave properties
- Wave has both space and time dependence
  - Shows constant time intervals

### Periodic wave
- Repeats continuously, moves in space
- Wavelength $\lambda$: distance to complete one cycle
- Period $T$: time to complete one cycle
- Frequency $f$: $1/Period$

- Crest

$A \sin \left( \frac{2\pi}{\lambda} \cdot x - \frac{2\pi}{T} \cdot t \right)$

### Moving wave crests
- Period = 1 second
- Propagation speed = $v$
Same period, slower wave velocity

- Period = 1 second
- Propagation speed = $v/2$

Freq., wavelength, velocity are related

- Period:
  - Time interval between crests at some location, or
  - Time for source to emit once cycle of the wave.
- Wavelength:
  - Spatial distance between crests.
  - Source emits a crest once every period $T$.
  - This crest propagates at velocity $v$.
  - By the time the source emits another crest $T$ seconds later, the first crest has moved $vT$.
  - So the distance between crests is $vT$.
    - This is the wavelength of the wave
- Wavelength = velocity $\times$ period

Equation form

- Velocity = Wavelength / Period
- $v = \lambda / T$, or $v = \lambda f$
- $f = \text{Frequency} = 1 / \text{Period} = 1/T$

Interference

- Water drop is a source of circular waves (two-dimensions here)
- When the waves overlap, they superimpose.
- In some areas they cancel, in others they reinforce.
- This is called interference

Destructive Interference in a String

- Two pulses are traveling in opposite directions
- The net displacement when they overlap the displacements of the pulses subtract
- Note that the pulses are unchanged after the interference

Destructive interference in a continuous wave

- Two waves, $a$ and $b$, have the same amplitude and frequency
- They are $1/2$ wavelength out of phase
- When they combine, the waveforms cancel
Setting up destructive interference

- Sound takes two paths to arrive at ear
- One path 1/2 wavelength longer than other
- Results in destructive interference

Destructive interference for frequencies such that path length difference is 1/2 wavelength.

Question

Two speakers each emit a 340 Hz sound wave. At what separation of these speakers would you hear a quieter sound by turning on one of the speakers? (sound velocity = 340 m/s)

A. 0.1 m  B. 0.25 m  C. 0.5 m  D. 1.0 m  E. 2.0 m

Interference of 2 speakers

A little more detail

Path-length difference \( \delta = (\text{Path 2}) - (\text{Path 1}) = 0 \)

Same distance, same phase

Other angles?

Path-length difference \( \delta = 0 \)

Interference:

Constructive: \( \delta = m\lambda \)

\( \delta = 0, \lambda, 2\lambda, 3\lambda, \ldots \)

Destructive: \( \delta = \frac{2m+1}{2}\lambda \)

\( \delta = \frac{1}{2}\lambda, \frac{3}{2}\lambda, \frac{5}{2}\lambda, \ldots \)

Interference engineering
Line array works by interference

- Off-axis sound canceled by interference on the vertical axis.
- Horizontal plane unaffected
- Total sound intensity drops off more slowly

Interference summary

- Important quantity is distance difference in number of wavelengths.
- A distance difference of a half wavelength leads to destructive interference.
- Whole wavelength differences lead to constructive interference.

*But destructive interference also for 3 half wavelengths, 5 half-wavelengths, etc.*

*Constructive interference also occurs at differences of 2 whole wavelengths, 3 whole wavelengths*

**Question**

In your room you have two speakers in different corners. At your desk you are exactly 1 meter from each, so that there is no interference. Your roommate moved one of your speakers 0.25 m further away from your desk. At what frequency will you hear destructive interference?

A. 170 Hz
B. 340 Hz
C. 680 Hz
D. 1000 Hz
E. 1350 Hz