Welcome to Phys 208!

- Duration: 4 Sep-Dec 15        15 Weeks
- Lectures: Tu, Th 12:05-12:55 pm
- Room: 2103 Chamberlin
- Honor lectures: Fri 12:05-12:55

Course Web page:
http://www.physics.wisc.edu/undergrads/courses/208-f07/index.html

Your Profs

- Mark Rzchowski rzchowski@physics.wisc.edu
  - Office: 5114 Chamberlin Hall Tel.: 265-2876 Office Hrs: Wed 1-2:30 pm
  - Research: Condensed Matter Physics
- Teresa Montaruli tmontaruli@icecube.wisc.edu
  - Office: 4112 Chamberlin Hall Tel.: 990-9901 Office Hrs: Mon 2-3:30 pm
  - Research: Research: High Energy Particle Physics and Astrophysics
  - IceCube Project http://icecube.wisc.edu/~tmontaruli

Your TAs

- acgault@wisc.edu Amanda Gault
- pohyland@wisc.edu Peter Hyland
- maili@wisc.edu Saurabh Maili
- szhang22@wisc.edu Siyuan Zhang

Meet them at the first discussion on Wed 5!

Labs start on Week 2
Check consultation hrs in
http://www.physics.wisc.edu/undergrads/courses/208-f07/consult.htm

Grading

<table>
<thead>
<tr>
<th>Part of the course work</th>
<th>Weight for your final grade</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labs</td>
<td>10% (-30% if 1 lost)</td>
<td>9/10 required to pass the course</td>
</tr>
<tr>
<td>DISC+Quizzes</td>
<td>10%</td>
<td>There will be one short (~15 min) quiz in discussion section each week, usually on Monday, and one group problem. Both will cover materials from the previous week's lecture.</td>
</tr>
<tr>
<td>HW</td>
<td>10%</td>
<td>Mastering Physics</td>
</tr>
</tbody>
</table>

Exams:
- MTE1 15%
- MTE2 15%
- MTE3 15%
- Final 25%

Exams are the main determining factor in the grade (70%)!!

More on Labs

http://www.physics.wisc.edu/undergrads/courses/208-f07/labs.htm
for each lab you need to fill out and hand in at the end of each lab a question sheet made available to you on this page.

9/10 Labs need to be completed to pass the course!!
If you complete only nine of them, the entire lab portion of your grade will be reduced by 30%

You can agree with your TA to make up labs with a good excuse (make-up week when exams scheduled and there are no labs)

Textbook and HWS

http://www.masteringphysics.com/

- Homeworks due each Thu at 11:59pm (HW0 for practice on Sep 10, HW1 on Sep 13 midnight)
 Contents

• Waves: interference & diffraction (Ch 20-22)
• Optics and Image Formation (Ch 23)
• Electricity and Magnetism (Ch 25-33)
• Electromagnetic Waves (Ch 33-34)
• Modern Physics (Ch 37-42)
• Friday Honor Lectures (modern physics and physics applied to biology and other human sciences), must attend for honors. Other students optional. Start next week (K. Forest - Biological Diffraction).

Waves (from P207)

Wave is a disturbance that propagates through a medium with a velocity determined by it. Energy and momentum propagate, not mass.

Mechanical waves: propagate in a medium where a restoring force acts (tension in a stretched string, gravitation on waves in a lake). Eg. Sound waves propagate in air.

Electromagnetic waves: oscillating electric and magnetic fields (no need of a material medium).

Matter waves: dual nature of particles like the photon (light wave and quantum of energy).

Sinusoidal Waves and Simple Harmonic Oscillator

Simple Harmonic oscillator

\[ F = -kx \text{ restoring force} \]
\[ -kx = m \frac{d^2x}{dt^2} \]

\[ x(t) = A \sin(\omega t + \Phi_0) \]

\[ \omega = \sqrt{\frac{k}{m}} \]
\[ v = \frac{\lambda}{T} = \lambda f \]

Sinusoidal Waves

At t=0

\[ D(x, t = 0) = A \sin\left(\frac{2\pi}{\lambda} + \Phi_0\right) \]

initial phase

Wave in motion

\[ D(x, t) = A \sin\left(\frac{2\pi}{\lambda} - \frac{vt}{\lambda} + \Phi_0\right) = A \sin\left(kx - \omega t + \Phi_0\right) \]

Phase difference for 2 waves with same frequency:

\[ \Delta \Phi = \Phi_2 - \Phi_1 = (kx_2 - \omega t_2 + \Phi_{02}) - (kx_1 - \omega t_1 + \Phi_{01}) = \]
\[ = \lambda \Delta x - \Delta \Phi_0 = \frac{2\pi}{\lambda} \Delta \lambda - \Delta \Phi_0 \]
**SOUND WAVES**

- **Audible waves**: within sensitivity of human ear 20 Hz - 20 kHz
- **Frequencies of Infrasonic (Ultrasonic) waves** < (>) audible range
- The speed of mechanical waves in a medium depends on the compressibility and the density of the medium. Sound wave velocity increases with temperature: at 0°C 331 m/s, at 20°C 343 m/s

<table>
<thead>
<tr>
<th>Gases</th>
<th>m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen (0°C)</td>
<td>1 286</td>
</tr>
<tr>
<td>Helium (0°C)</td>
<td>972</td>
</tr>
<tr>
<td>Air (20°C)</td>
<td>343</td>
</tr>
<tr>
<td>Air (0°C)</td>
<td>331</td>
</tr>
<tr>
<td>Oxygen (0°C)</td>
<td>317</td>
</tr>
<tr>
<td>Liquids at 25°C</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>1 495</td>
</tr>
<tr>
<td>Mercury</td>
<td>1 450</td>
</tr>
</tbody>
</table>

Ultrasonography: medical imaging technique for internal organs, used to visualize fetus.

Oscillators vibrating at MHz produce sound waves with speeds in water (main component of human body) corresponding to λ~0.5 mm suitable for small objects.

**LIGHT WAVES**

- Electromagnetic waves are oscillations of E-fields and B-fields traveling at speed of light in vacuum ~3x10^8 m/s
- Light slows down in a transparent medium v = c/n where n = index of refraction > 1

  \[ \lambda_{\text{new}} = \frac{v}{f_{\text{new}}} = \frac{c}{n_{\text{new}}} = \frac{c}{\lambda_{\text{old}}} \]

  when light travels from one medium to another v changes but ONLY λ does not.

- When light generates compression at the boundary of the media the frequency of the waves does not change in the second medium.

- Our eye is sensitive between 400-700 nm

**SUPERPOSITION OF WAVES**

2 waves or more waves traveling in the same direction. 

\[ \lambda \text{ increases with source distance increase} \]

**CONSTRUCTIVE**

In Phase: aligned crests to crests \( \Rightarrow \) maximum constructive interference

**DISTRACTIVE**

Out of Phase 180 degrees perfect destructive interference

**YOUNG’S DOUBLE SLIT EXPERIMENT (1801)**

Interference requirements or 2 or more waves:
- same wavelength (sources must be monochromatic)
- constant phase difference (sources are coherent)

Light emerging from 2 slits is coherent since a single source produces the original light beam.
The narrow slits $S_1$ and $S_2$ act as sources of waves. Waves emerging from slits originate from the same wave front, so they are always in phase. Bright and dark fringes on the screen correspond to constructive and destructive interference.

**Interference Pattern**

- The narrow slits $S_1$ and $S_2$ act as sources of waves.
- Waves emerging from slits originate from the same wave front, so they are always in phase.
- Bright and dark fringes on the screen correspond to constructive and destructive interference.

**Dark and Bright Fringes**

- The 2 waves travel the same distance, so they arrive in phase.
- The upper wave travels $1/2\lambda$ farther than the lower wave to point $R$, so the trough bottom wave overlaps the crest of the upper wave.

**Interference Max and Min**

- **Interference max:** $\Delta r = d\sin\theta = m\lambda$
  \[ y_{\text{max}} = \frac{\lambda L}{d} m \quad m = 0, \pm 1, \pm 2, \ldots \]

- **Interference min:** $\Delta r = d\sin\theta = (m+1/2)\lambda$
  \[ y_{\text{min}} = \frac{\lambda L}{d} \left( m + \frac{1}{2} \right) \quad m = 0, \pm 1, \pm 2, \ldots \]

- **Relation between Path and Phase difference:**
  \[ \Delta \Phi = \frac{2\pi}{\lambda} \Delta r \]
  \[ \text{Eg.:} \quad \Delta r = \lambda \implies \Delta \Phi = 2\pi \text{ rad} \]

**Question: Interference**

The distance between the slits in a double-slit experiment is increased by a factor of 4. If the distance between the fringes is small compared with the distance from the slits to the screen, the distance between adjacent fringes near the center of the interference pattern

- **A)** increases by a factor of 4.
- **B)** depends on the width of the slits.
- **C)** decreases by a factor of 2.
- **D)** decreases by a factor of 4.