Welcome to Physics 201

Today’s Topics

- The Physics 201 Team
- Course Formality and Course Overview
- Q&A
- Ch 1: Physics and Measurement

Physics 201 Homepage
http://www.physics.wisc.edu/undergrads/courses/fall2017/201/

Physics Department Homepage
http://www.physics.wisc.edu
The Physics 201 Team

➢ Faculty (lectures):
  ☺ Instructor: Prof. Yibin Pan (me), yibinpan@wisc.edu 4283 CH. 262-9569

➢ Teaching Assistants (labs, discussions):
Brown, Jonathan  jhbrown2@wisc.edu  302 305
Das, Diptaranjan  ddas5@wisc.edu  303 309
Gold, David  dcgold@wisc.edu  310 312
Li, Ping-Yu  pli69@wisc.edu  301
Oxholm, Trevor  oxholm@wisc.edu  311 313
Vega, Cristian Santiago  csvega@wisc.edu  304 314
Walker, Justin  jwwalker2@wisc.edu  306 307
Physics 201 Course Composition

- **Text:** “Physics for Scientists and Engineers, 9th ed”. Serway/Jewett
- **Lectures:** TR 9:55 am
- **Discussion Sessions:** 2/week. (Grading: quizzes, participation, etc.)
- **Labs:** Mandatory. Each missing lab = - 1 letter grade level (A→AB, AB→B...)
- **Homework:** ~10 problems/week online via Webassign.net
- **Exams:** (3 middle-terms + final)
- **Office Hours.** (Yibin Pan: 2:00-4:00pm Thursdays, other time by appointments, TAs: as scheduled, see course page)
- **Your home time:** > 5 hours/week + homework.
- **Honor credit:** see email announcement (to be sent soon)
- **Grading:**
  - **Homework:** 100 pts
  - **Laboratory:** 50 pts (plus missing lab penalty)
  - **Discussion:** 50 pts = quizzes(20) + discussions(30).
  - **Midterms:** 100 pts each
  - **Final Exam:** 200 pts

  (Final grades are based on curved and weighted component scores)
  
  Typical curve: 20% A, 35% (AB,B), 40% (BC,C), 5% D + very few F’s
Lectures

- **Style:**
  - PPT + white board + demos

- **Subjects:**
  - Key concepts.
  - Tricky issues
  - Interactive problem solving

- **Lectures are NOT meant to be complete.**
  - It is a supplement to your own learning
  - Do read materials BEFORE the lecture.
    - Our lectures are designed with the assumption that you’ve read the corresponding sections!
  - Review materials after the lectures.
    - Lecture notes will be posted after each lecture

**Effectiveness = Preview + Lecture + Review**
Exams and Exam Policy

- **Exam Dates:**
  - Midterms (5:30-7:00 pm, rooms TBA)
    - Exam 1: Monday, Oct 2
    - Exam 2: Monday, Oct 23
    - Exam 3: Monday, Nov 20
  - Final: Thursday, Dec 21 (2:45-4:45 pm, rooms TBA), cumulative.

- If you have a conflict with above midterm exam dates, inform your professor (me) asap, normally at least 2 weeks before the scheduled date. Alternative exam arrangements are granted only for valid reasons. Given the size of the class, our flexibility is very limited.

- Popular excuses:
  - Academic/athletic conflicts: can be considered
  - Medical emergency: can be considered
  - Attending wedding/visiting friends/Family reunion plans: **NOT** to be considered.

* Final Exam has much less flexibility to adjust. (I will be very strict)
Some Practical Issues

- Course Web:

- When sending me emails:
  - Include phrase “Phy201” somewhere in the subject line.
  - Mentioning your section # is helpful.

- Homework assignments are posted each Wednesday evening and due by 11 pm of the following Wednesday.

- Lecture notes will be posted after each lecture on the same day. A draft will be available the night before (can be late). Follow the links on course web.

- Discussion sessions start on Thursday this (first) week
- First lab starts next week (i.e. 2nd week)
- Please all sign up for WebAssign. ([www.webassign.net](http://www.webassign.net))
  - Your TAs have for section keys. (You still need to purchase access code)
Physics 201 and 202

201

202

Light and Optics
Electro-Magnetism
Thermodynamics
Heat, Temperature, Pressure, Entropy,..
Oscillation and Waves
Classical Mechanics
Laws of motion
Force, Energy, Momentum,…

Cosmology
Sub-Sub-Atomic: Elementary Particles
Sub-Atomic: Nuclear Physics
Many-Atoms: Molecules, solids
Atomic Structure
Quantum Theory
Relativity

Classical
Modern
Math Background Requirements

- High school math
  - Basic formulas, linear and quadratic equations,…
  - Sine, cosine, tangent,….
- Vectors
- Some calculus

Calculus evaluation: Are you comfortable with these?

*Notations:*
\[
\frac{df(x)}{dx}, \frac{d^2f(x)}{dx^2}, \int_a^b f(x)dx, \int f(x)dx, \sum_i f(x_i)\Delta x_i
\]

*Definitions:*
\[
\frac{df}{dx} = \lim_{\Delta x \to 0} \frac{\Delta f}{\Delta x}, \quad \int f(x)dx = \lim_{\Delta x_i \to 0} \sum_i f(x_i)\Delta x_i
\]

*Formulas:*
\[
\frac{d}{dx} \left( \frac{1}{2} ax^2 \right) = ax, \quad \int axdx = \frac{1}{2}ax^2, \quad \frac{d}{dx} \left( \sin(x) \right) = \cos(x)
\]

*Equations and solutions:*
\[
\frac{df^2(x)}{dx^2} = -\omega^2 x \quad \Rightarrow \quad f(x) = A \cos(ax + \phi)
\]
Physics and Physical Quantities

- Physics is a branch of Science that covers “everything” at the very fundamental level

Physics: Theory $\leftrightarrow$ Observations
- Theory: Mathematical Relationship of Physical Quantities
- Observations: Measurements of Physical Quantities

- A Physical Quantity (e.g. time, mass, length...) is expressed by Numerical Value(s) + Unit

$\rightarrow$ A Physical Quantity without value or unit are meaningless.
Units of Time, Length, and Mass

- Time (T), length (L), and mass (M) are three fundamental physical quantities in mechanics.
  - From which other physical quantities can be defined (next page)
- International standard (SI) units for them.

<table>
<thead>
<tr>
<th></th>
<th>SI Main</th>
<th>SI alternative</th>
<th>Non-SI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>s</td>
<td>ms, µs,...</td>
<td>day, hour,...</td>
</tr>
<tr>
<td>Length</td>
<td>m</td>
<td>km, cm, mm,...</td>
<td>ft, yd, in,...</td>
</tr>
<tr>
<td>Mass</td>
<td>kg</td>
<td>g, t,...</td>
<td>lb, ounce,...</td>
</tr>
</tbody>
</table>

- How are they defined?

<table>
<thead>
<tr>
<th></th>
<th>Original</th>
<th>Modern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Solar day</td>
<td>Atomic oscillation</td>
</tr>
<tr>
<td>Length</td>
<td>Meter Bar in France</td>
<td>Distance light travels</td>
</tr>
<tr>
<td>Mass</td>
<td>Kilogram Block in France</td>
<td></td>
</tr>
</tbody>
</table>
Derived Units

Basic units can be used to construct derived units for other quantities:

- Area = $L_a \times L_b \rightarrow m^2$, Volume = $L_a \times L_b \times L_c \rightarrow m^3$
- Speed = distance/time $\rightarrow m/s$
- Density = mass/volume $\rightarrow kg/m^3$
- Force $\rightarrow kg \text{ m/s}^2$ (≡ Newton)
- Energy $\rightarrow kg \text{ m}^2/\text{s}^2$ (≡ Joule)
- Power $\rightarrow kg \text{ m}^2/\text{s}^3$ (≡ Watt)
- ...

Units reflect dimensions of corresponding quantities:

- e.g. $m^2 \rightarrow L^2$, $m^3 \rightarrow L^3$, $kg/m^3 \rightarrow M/L^3$, ...
- Further reading “dimensional analysis”

Please practice unit conversion (section 1.4) after class.
Significant Figures (Sig. Figures)

- Every measurement has errors, one needs to be precise, but not excessively-precise.
  - Question: A ruler has smallest scale of 1 cm. When used to measure a string of ~36 cm long, which of the following readings are improper?
    - 36.2 cm
    - 36.0 cm
    - 36.4 cm
    - 36. cm
    - 36.22 cm
  - Answer: 
    - 36 is too inaccurate $\rightarrow$ one more digit can be estimated
    - 36.22 is over accurate $\rightarrow$ the last digit can not be estimated
    - 36.2, 36.4, 36.0 cm are all possibly OK (depending on reading).
    - Note 36 cm $\neq$ 36.0 cm!

- In measurements and in calculations only keep significant figures.
Rules On Sig. Figures

- **Rule 1:**
  - In direct measurement, keep all “sure” digits plus only one estimated digit. e.g. 41.2 cm, 23.5 s, ...
  - These (“sure” + “estimated”) digits are called significant figures (sig. figure), with the estimated one being called least sig. figure.

- **Rule 2:**
  (Definition). Number of sig. figures = number of significant digits not counting leading zeros
  e.g. 41.2 \( \rightarrow \) nSigFig = 3, 0.0032 \( \rightarrow \) nSigFig. = 2, 3.20 \( \rightarrow \) nSigFig = 3.

- **Rule 3:**
  In additions or subtractions, the least significant figure of the final result can not be more accurate than that of any operands. e.g. 13.8 m +2.05 m -0.062 m (=15.788 m) =15.8 m (be sure to use same unit!)

- **Rule 4:**
  In multiplication or division, the N of sig. figures of the final result equals the lowest num. of sig. figures among all operands.
  e.g. 13.8 m x 2.05 m x 0.062 m (=1.75398) = 1.8 m³
  Always keep all digits until final result and then perform rounding.
Order Of Magnitude Estimation

- Often, a rough “guesstimation” on the physics quantities before detailed measurement is useful (and possible.)

Quick quiz:
How many sand grains in a palm?
- 100
- 1000
- millions
- billions

Quick estimation:
\[ N = \frac{\text{total volume}}{\text{sand size}} \]
\[ \sim 10 \text{ cm}^3 / (0.01 \text{ cm})^3 \]
\[ \sim 10 \text{ million} \]
A solid block of iron has a volume measured as 2.2 cm$^3$, how many iron atoms in this block? (known: $\rho = 7.86$ g/cm$^3$, Atomic mass of iron = 55.93 u, 1u = 1.6606 x 10$^{-27}$ kg, 1g = 10$^{-3}$ kg)

A: 20
B: 20,000
C: 2x10$^{23}$
D: 2x10$^{33}$

Solution:

- Method 1: use order of magnitude estimation.
  (hint: ever heard of Avogadro’s number? 6.022x10$^{23}$?)
- Method 2: detailed calculation
  - The block has mass $m = \rho V = 7.86$ g/cm$^3$ * 2.2 cm$^3$ = 17 g
  - Mass of iron atom = 55.93 u = 55.93 * 1.6606x 10$^{-27}$ kg/u = 92.88 x 10$^{-27}$ kg
  - Number of iron atoms in the block
    \[ = \frac{17 \text{ g}}{92.88 \times 10^{-27} \text{ kg}} = 17 \text{ g} \times \frac{10^{-3} \text{ kg/g}}{92.88 \times 10^{-27} \text{ kg}} \]
    \[ = 1.8 \times 10^{23} \]

The correct answer is C: 2x10$^{23}$.
A Challenging Quiz

Measured data:

<table>
<thead>
<tr>
<th>Mass of Atoms (in unit $u$)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>1.01</td>
</tr>
<tr>
<td>Helium</td>
<td>3.02</td>
</tr>
<tr>
<td>Oxygen</td>
<td>15.99</td>
</tr>
<tr>
<td>Sodium</td>
<td>22.99</td>
</tr>
<tr>
<td>Aluminum</td>
<td>26.98</td>
</tr>
<tr>
<td>Iron</td>
<td>55.93</td>
</tr>
<tr>
<td>U 238</td>
<td>238.05</td>
</tr>
</tbody>
</table>

Challenge

- Anything special?
  - All masses are (near) full numbers!
- This strongly suggests?
  - Atoms are made of particles with mass = $u$.

Facts

- Atom is made of: protons + neutrons + electrons
  - $M_{\text{proton}} \sim M_{\text{neutron}} \sim 1 \text{ u}$
  - $1u = 1.6605 \times 10^{-27} \text{ kg}$
  - $M_{\text{electron}} \ll 1u$
Resources

- Your Instructor (me) and your TAs

- Practicing Engineering Problem Solving (PrEPS) for Physics 201 offered by the Engineering School. (More on this later).

- The Physics Club: http://ups.physics.wisc.edu/drupal/