Happy New Year!

Physics 2D Lecture Slides
Lecture 1: Jan 3 2005

Vivek Sharma
UCSD Physics
Modern Physics (PHYS 2D)

- Exploration of physical ideas and phenomena related to
  - High velocities and acceleration (Einstein’s Theory of Relativity)
  - Sub Atomic structure and Dynamics (Quantum Physics)
  - The very small (quarks) and the Very large (cosmos)

- A glimpse of the cutting edge of thought in Physics and technology that it is generating

- A different kind of course:
  - Exciting (Gee Whiz stuff) BUT intense
  - About 40 Nobel Prize winning ideas/experiment in course (~4 / week!)
  - Non-intuitive (how do you figure how electrons act inside an atom)
    - Will require abstract thought
    - Fountainhead of Chemistry, Biology, Electronics, Computing
  - Foundation for tomorrow’s technology, chemistry and medicine

Introduction to Modern Physics (2D)

- Course Text: Modern Physics, Serway, Moses, Moyer
  - 3rd Ed, published by Saunders/BrooksCole

- Instructor: Prof. Vivek Sharma
  - Email: modphys@hepmail.ucsd.edu
  - 3314 Mayer Hall, Phone: (858) 534 1943
  - Office Hours:
    - Mon & Tuesday 2:30-3:30 PM in 3314 Mayer
    - Weekends or other times by (email) appointment

- TA: Chris Schroeder
  - Email: crs@physics.ucsd.edu
  - 4430 Mayer Hall, Phone: (858) 822 1376
  - Office Hours: Wed (TBA pm) & Thursday (TBA pm)

- Course Web Page: http://modphys.ucsd.edu/2dw05
  - Walk thru the web site now
  - Please make sure you can access it and check all site links
  - Send mail to modphys@hepmail.ucsd.edu if have problems
Weekly Class Schedule

<table>
<thead>
<tr>
<th></th>
<th>Day</th>
<th>Time</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>Monday</td>
<td>11:00-11:50 am</td>
<td>WLH 2005</td>
<td>Prof. Sharma</td>
</tr>
<tr>
<td>Prof. Office Hour</td>
<td>Monday</td>
<td>2:30 - 3:30 pm</td>
<td>Mayer 3314</td>
<td>Prof. Sharma</td>
</tr>
<tr>
<td>Lecture</td>
<td>Tuesday</td>
<td>5:00-5:50 pm</td>
<td>Petersen 110</td>
<td>Prof. Sharma</td>
</tr>
<tr>
<td>Prof. Office Hour</td>
<td>Tuesday</td>
<td>2:30-3:30 pm</td>
<td>Mayer 3314</td>
<td>Prof. Sharma</td>
</tr>
<tr>
<td>Lecture</td>
<td>Wednesday</td>
<td>11:00-11:50 am</td>
<td>WLH 2005</td>
<td>Prof. Sharma</td>
</tr>
<tr>
<td>Discussion</td>
<td>Wednesday</td>
<td>3:00-3:50 pm</td>
<td>PCYNH 106</td>
<td>C. Schroeder/ V.Sharma</td>
</tr>
<tr>
<td>TA Office Hour</td>
<td>Wednesday</td>
<td>3:00-4:00 pm</td>
<td>Mayer 2106</td>
<td>Chris Schroeder</td>
</tr>
<tr>
<td>TA Office Hour</td>
<td>Thursday</td>
<td>4:00-5:00 pm</td>
<td>Mayer 2106</td>
<td>Chris Schroeder</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>Thursday</td>
<td>7:00-8:50 pm</td>
<td>WLH 2005</td>
<td>Chris Schroeder</td>
</tr>
<tr>
<td>Quiz</td>
<td>Friday</td>
<td>11:00-11:50 am</td>
<td>WLH 2005</td>
<td>Weekly (starts Jan 14 )</td>
</tr>
<tr>
<td>Prof. Office Hour</td>
<td>Weekend</td>
<td>By Appointment</td>
<td>Mayer 3314</td>
<td>Prof. Sharma</td>
</tr>
</tbody>
</table>

Make sure you can attend the discussion and problem sessions.

Quizzes, Final and Grades

- **Course score = 60% Quiz + 40% Final Exam**
  - 8 quizzes (every Friday starting Jan 14th), best 6 scores count
    - Two problems in each quiz, 40 minutes to do it
      - One problem HW like, other more interesting
    - Closed book exam, some formulae will be provided
      - No “CHEAT SHEETS” please
    - Blue Book required, Code numbers will be given at the 1st quiz. Bring calculator, check battery!
    - No makeup quizzes / See handout for Quiz regrade protocol
- **Final Exam : Week of Monday 14th March, date TBA**
- **Inform me of possible conflict within 2 weeks of course**
  - Don’t plan travel/vacation before finals schedule is confirmed!
    - No makeup finals for any reason
What to Expect / Not Expect on the Quiz / Final Handout

Some Useful Numbers, Equations and Identities

Speed of Light, \( c = 3.0 \times 10^8 \text{m/s} \)

\[
\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}
\]

\[
x' = \gamma (x - vt)
\]

\[
t' = \gamma (t - \frac{xv}{c^2})
\]

\[
V'_x = \frac{V_x - v}{1 - \frac{xv}{c^2}}
\]

\[
p = \frac{mV_x}{\sqrt{1 - \frac{V_x^2}{c^2}}}
\]

\[
E = \frac{mc^2}{\sqrt{1 - \frac{V_x^2}{c^2}}} = K + mc^2
\]

\[
\nu_{obs} = \frac{\nu + \frac{x}{c}}{\sqrt{1 - \frac{\nu}{c}}} \nu_{source}
\]

All constants will be provided
No need to memorize them

Course Grade

- Our wish is that everybody gets an A! So no curve
- Grading on an absolute scale. Roughly it looks like this:

<table>
<thead>
<tr>
<th>Total Score</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 85</td>
<td>A+</td>
</tr>
<tr>
<td>&gt; 75</td>
<td>A</td>
</tr>
<tr>
<td>&gt; 60</td>
<td>B</td>
</tr>
<tr>
<td>&gt; 45</td>
<td>C</td>
</tr>
<tr>
<td>&lt; 30</td>
<td>F</td>
</tr>
</tbody>
</table>

- Hint: don’t miss the early quizzes, they are easier (less calculus)
Expected Prior Knowledge: Brush up!

- Concepts learnt in Phys 2A, 2B and 2C will be used in 2D
- Familiarity with Vector Calculus & Differential Equation
- Knowledge of PHYSIC 2C material
  - Will need to know concepts in Waves: Interference & Diffraction
    - Chapters 17-18, 33, 36-37 in Fundamentals of Physics by Halliday/Resnick/Walker 6th Ed (On Reserve for this course)
    - Hard to appreciate ideas in Modern Physics without them
  - Notes on 2C concepts needed are posted on class web site
  - TA has video recorded easy to follow lectures (2) which are available for your viewing via Video-on-demand (streaming Video) at the UCSD computer labs (CLICS, Geisel etc)
  - Please start this week with the summary notes at web site
  - Consult TA or me if you need extra help
    - We can help you over weekends but pl. contact us early!!

How To Do Well In This Course

- Don’t rely on your intuition! Always think thru the concept
- Read the assigned text BEFORE lecture to get a feel of the topic
- Attend lecture (ask questions during/before/after lecture) and discussion. Review lecture & discussion material using video-on-demand
- Attempt all homework problems yourself
  - Before looking at the problem solutions (available on web every Tuesday afternoon)
  - Before attending Problem Solving session
  - Work in sets of 2-3 to share ideas and problem solving approaches
- Do not try to memorize complicated formulae or Homework problems! Do not just accept a concept without understanding the logic
- Quarter goes fast, don’t leave everything for the week before exam!!
- All-nighters don’t work in this course: Get decent sleep before Quiz or Finals
  - Don’t skip the TA lecture and Don’t TA’s office hours (they don’t bite!!)
Week 1 Schedule

Physics 2D : Winter 2005 Weekly Schedule

Week 1 Starts Monday 3rd Jan 2005

Confused ? Send Prof. Sharma an E-mail for clarification

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Read</th>
<th>Topic</th>
<th>HW problems for the week</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>11:00 am</td>
<td>Ch 1</td>
<td>Relativity</td>
<td></td>
<td>WLH 2005</td>
</tr>
<tr>
<td>Tuesday</td>
<td>5:00 pm</td>
<td>Ch 1</td>
<td>Relativity</td>
<td>Ch 1: 2, 3, 4, 5, 6, 7, 8</td>
<td>WLH 2005</td>
</tr>
<tr>
<td>Wednesday</td>
<td>11:00 am</td>
<td>Ch 1</td>
<td>Relativity</td>
<td>Ch 1: 10, 12, 14, 16, 17, 18</td>
<td>WLH 2005</td>
</tr>
<tr>
<td>Wednesday</td>
<td>3:00 pm</td>
<td>-----</td>
<td>Discussion</td>
<td>Read text before coming to Discussion</td>
<td>PCYNH 106</td>
</tr>
<tr>
<td>Thursday</td>
<td>7:00-8:50 pm</td>
<td>-</td>
<td>Problem Session</td>
<td>Do problems yourself before coming to PS session</td>
<td>WLH 2005</td>
</tr>
<tr>
<td>Friday</td>
<td>11:00 am</td>
<td>-</td>
<td>Relativity</td>
<td>Ch 1</td>
<td>WLH 2005</td>
</tr>
</tbody>
</table>

2005 is World Year of Physics

In Celebration of Albert Einstein’s (3) revolutionary Ideas published in 1905

You will see all of them in this course
Lecture 1: Relativity

- Describing a Physical Phenomenon
  - Event (s)
  - Observer (s)
  - Frame(s) of reference (the point of View !)
    - Inertial Frame of Reference
    - Accelerated Frame of Reference

- Newtonian Relativity and Inertial Frames
  - Laws of Mechanics and Frames of Reference
  - Galilean Transformation of coordinates
    - Addition law for velocities

- Maxwell’s Equations & Light
  - Light as Electromagnetic wave
  - Speed of Light is not infinite!
  - Light needs no medium to propagate

---

Event, Observer, Frame of Reference

- Event : Something happened => (x,y,z,t)
  - Same event can be described by different observers
- Observer(s) : Measures event with a meter stick & a clock
- Frame of Reference : observer is standing on it
  - Inertial Frame of reference \( \leftrightarrow \) constant velocity, no force
- An event is not OWNED by an observer or frame of reference
- An event is something that happens, any observer in any reference frame can assign some \((x,y,z,t)\) to it
- Different observers assign different space & time coordinates to same event
  - S describes it with \((x,y,z,t)\)
  - S’ describes same thing with \((x’,y’,x’,t’)\)

![Diagram](image)

**Figure 39.2** An event occurs at a point \(P\). The event is seen by two observers in inertial frames \(S\) and \(S'\), where \(S'\) moves with a velocity \(v\) relative to \(S\).
The Universe as a Clockwork of Reference Frames

“Imagining” Ref Frames And Observers
Newtonian/Galilean Relativity

Inertial Frame of Reference is a system in which a free body is not accelerating.

Laws of Mechanics must be the same in all Inertial Frames of References
⇒ Newton’s laws are valid in all inertial frames of reference
⇒ No Experiment involving laws of mechanics can differentiate between any two inertial frames of reference
⇒ Only the relative motion of one frame of ref. w.r.t other can be detected
⇒ Notion of ABSOLUTE motion through space is meaningless
⇒ There is no such thing as a preferred frame of reference

Galilean Transformation of Coordinates

Galilean Rules of Transformation

\[
\begin{align*}
x' &= x - vt \\
y' &= y \\
z' &= z \\
t' &= t
\end{align*}
\]
Quote from Issac Newton Regarding Time

Absolute, true and mathematical time, of itself, and from nature, flows equably without relation to anything external

\[ t = t' \]

There is a universal clock

Or

All clocks are universal

Galilean Addition Law For Velocities

This rule is used in our everyday observations (e.g. driving a car) and is consistent with our INTUITIVE notions of space and time

\[ dx' = dx - v \, dt \]

\[ dt = dt' \]

\[ \frac{dx'}{dt'} = \frac{dx}{dt} - v \]

\[ u'_x = u_x - v \]

But what happens when I drive a car very fast!!

How fast: \((v = ?)\)

- As fast as light can travel in a medium !!!
Light Is An Electromagnetic Wave (2C)

- Maxwell’s Equations:

\[
\begin{align*}
\oint E \cdot dA &= \frac{Q}{\varepsilon_0} \\
\oint B \cdot dA &= 0 \\
\int E \cdot ds &= -\frac{d\Phi_E}{dt} \\
\int B \cdot ds &= \mu_0 I + \mu_0 \varepsilon_0 \frac{d\Phi_B}{dt}
\end{align*}
\]

\[
\begin{align*}
\frac{\partial^2 E}{\partial x^2} &= \mu_0 \varepsilon_0 \frac{\partial^2 E}{\partial t^2} \\
\frac{\partial^2 B}{\partial x^2} &= \mu_0 \varepsilon_0 \frac{\partial^2 B}{\partial t^2}
\end{align*}
\]

\[E = E_{\text{max}} \cos(kx - \omega t)\]
\[B = B_{\text{max}} \cos(kx - \omega t)\]

\[c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}\]

Measuring The Speed Of Light

High Technology of 1880’s: Fizeau’s measurement of speed of light

1. Shoot pulses of light to mirror
2. Light should take \(t = 2L/c\) to get back to Observer
3. Adjust the angular velocity of wheel such that reflected light from mirror makes it back to observer thru the next gap

\[C = 2.998 \times 10^8 \text{ m/s (in vacuum)}\]
Newtonian Relativity & Light!

Light source, mirror & observer moving thru some medium with velocity $V$
Galilean Relativity $\Rightarrow$
- If the alien measures velocity of light = $c$
- Then observer must measure speed of light = $c-v$ when it is leaving him
  = $c+v$ when it is reflected back

But Maxwell’s Eq $\Rightarrow$ speed of light is constant in a medium??

Must it be that laws of Mechanics behave differently from E&M in different inertial frames of references? … if so how inelegant would nature be!