Happy New Year !

Physics 2D Lecture Slides
Lecture 1: Jan 3 2005

Vivek Sharma
UCSD Physics

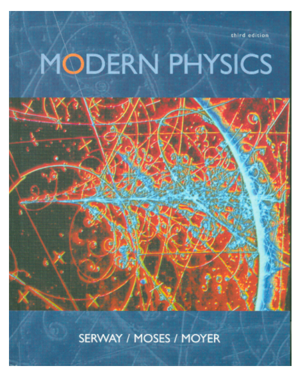
Modern Physics (PHYS 2D)

- 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

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

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

$$\textbf{Speed of Light, c} = \mathbf{3.0 \times 10^8 m/s}$$

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$

$$x' = \gamma(x - vt)$$

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

$$V'_x = \frac{V_x - v}{1 - \frac{V_x v}{c^2}}$$

$$p = \frac{mV_x}{\sqrt{1 - V_x^2/c^2}}$$

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

$$\nu_{obs} = \frac{\sqrt{1 + v/c}}{\sqrt{1 - v/c}} \nu_{source}$$

$$\vec{F} = m\vec{a}$$

$$a = \frac{d^2x}{dt^2}$$

$$\vec{F} = q(\vec{v} \times \vec{B})$$

$$Sin^2\theta + Cos^2\theta = 1$$

All constants will be provided
No need to memorize them

Course Grade

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

Total Score	Grade
> 85	A+
> 75	A
> 60	B
> 45	C
< 30	F

- 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 6^{th} 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 every thing for the week before exam !!
- All-nighters don't work in this course: Get decent sleep before Quiz or Finals

Week 1 Schedule

Physics 2D : Winter 2005 Weekly Schedule

Week 1 Starts Monday 3th Jan 2005

Confused ? Send Prof. Sharma an E-mailfor clarification

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

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

Describe on Black board

- 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 ← 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')

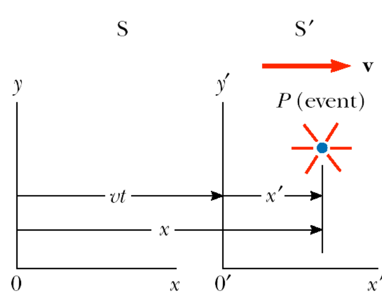
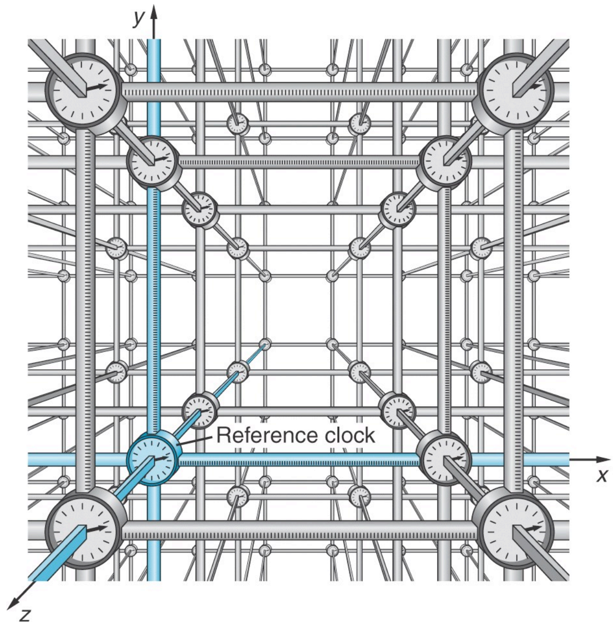
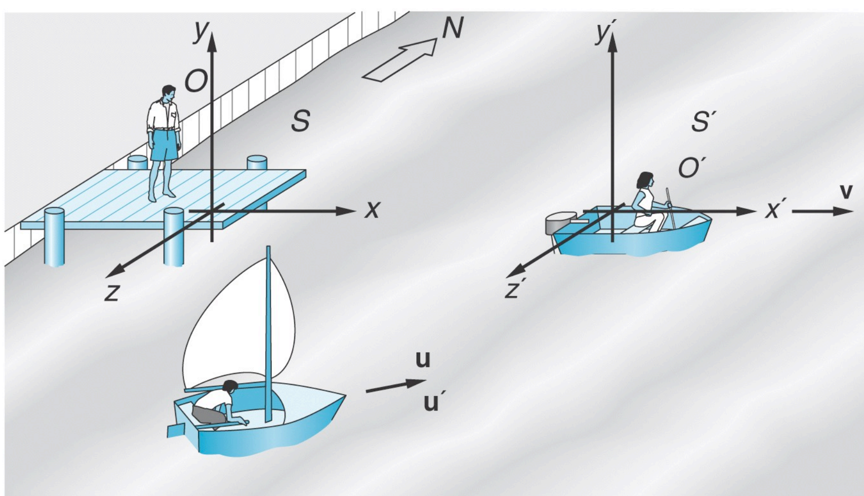


Figure 39.2 An event occurs at a point P. The event is seen by two observers in inertial frames S and S′, where S′ moves with a velocity **v** relative to S.

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 references
⇒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 ABSOLTUTE motion thru scape is meaningless
⇒There is no such thing as a preferred frame of reference

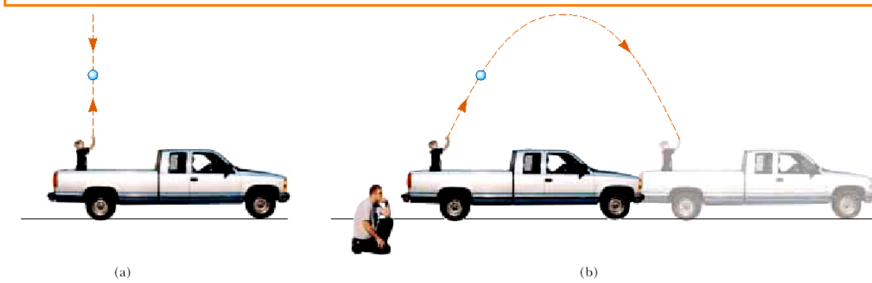


Figure 39.1 (a) The observer in the truck sees the ball move in a vertical path when thrown upward. (b) The Earth observer sees the path of the ball as a parabola.

Galilean Transformation of Coordinates

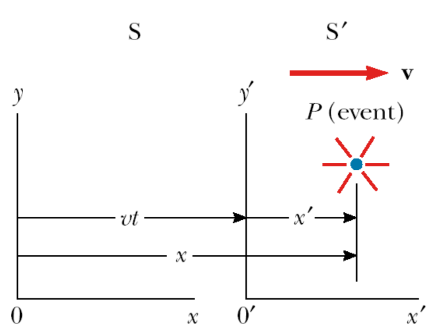


Figure 39.2 An event occurs at a point *P*. The event is seen by two observers in inertial frames S and S′, where S′ moves with a velocity **v** relative to S.

Galilean Rules of Transformation

$$x' = x - vt$$

$$y' = y$$

$$z' = z$$

$$t' = t$$

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

$$\boxed{dx' = dx - v\,dt}$$

$$\boxed{dt = dt'}$$

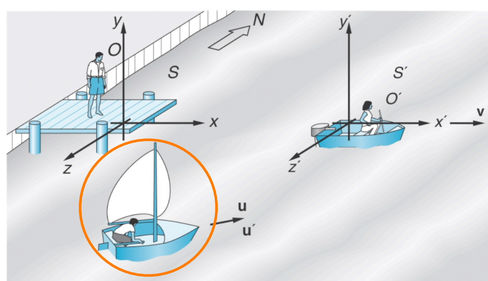
$$\Downarrow$$

$$\frac{dx'}{dt'} = \frac{dx}{dt} - v$$

$$\Downarrow$$

$$u_x' = u_x - v$$

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



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:

$$\oint_S \mathbf{E}\cdot d\mathbf{A} = \frac{Q}{\epsilon_0}$$

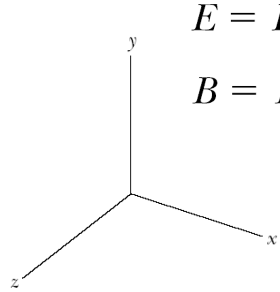
$$\oint_S \mathbf{B}\cdot d\mathbf{A} = 0$$

$$\oint \mathbf{E}\cdot d\mathbf{s} = -\frac{d\Phi_B}{dt}$$

$$\oint \mathbf{B}\cdot d\mathbf{s} = \mu_0 I + \mu_0\epsilon_0\frac{d\Phi_E}{dt}$$

$$\frac{\partial^2 E}{\partial x^2} = \mu_0\epsilon_0\frac{\partial^2 E}{\partial t^2}$$

$$\frac{\partial^2 B}{\partial x^2} = \mu_0\epsilon_0\frac{\partial^2 B}{\partial t^2}$$

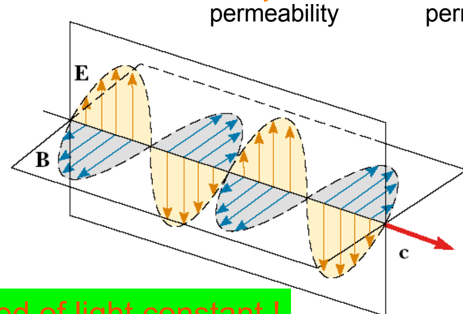


$$E = E_{\max}\cos(kx-\omega t)$$

$$B = B_{\max}\cos(kx-\omega t)$$

$$\boxed{c = \frac{1}{\sqrt{\mu_0\epsilon_0}}}$$

permeability permittivity



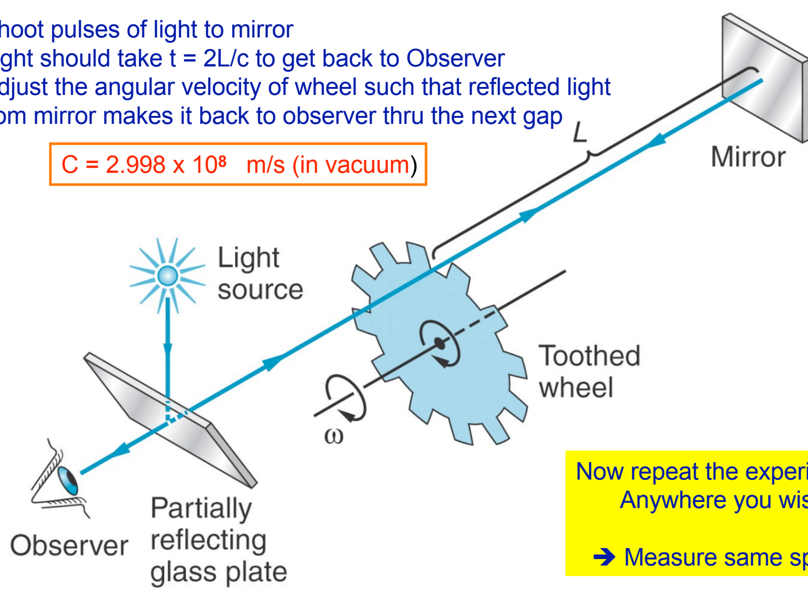
Speed of light constant !

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

$\boxed{C = 2.998 \times 10^8 \text{ m/s (in vacuum)}}$

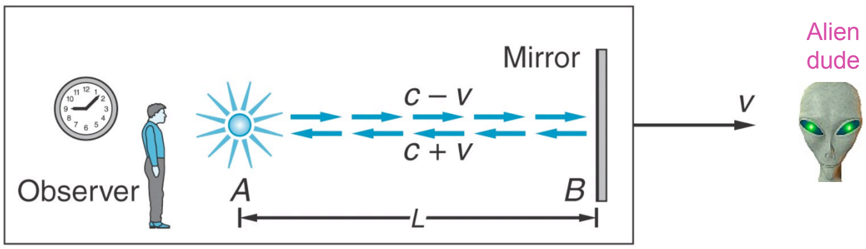


Now repeat the experiment
Anywhere you wish

→ Measure same speed

Newtonian Relativity & Light !

Light source, mirror & observer moving thru some medium with velocity V
Galilean Relativity ➔
• 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 → 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!