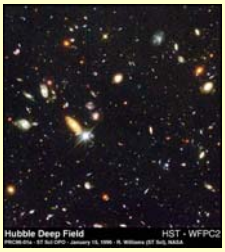
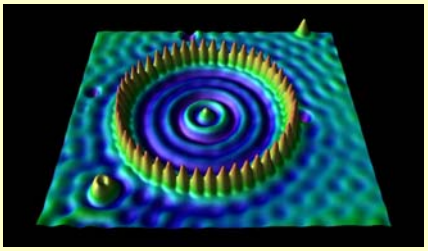
Lecture 1

Welcome to Physics 150!



Deep Field image from the Hubble Telescope
in a tiny region of the sky where no stars are visible to the naked eye - showing distant galaxies behind stars in our Milky Way

Welcome to Physics 150!



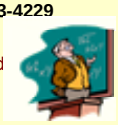
Observation of atoms, electron waves
with Scanning Tunneling Microscope

Today

- Information on Course
- Questionnaire
- Overview and Outline of Course
- Demonstrations
  Hands on activities to bring out the ideas
- Start First Part of Course:
  Scientific Knowledge: What is it?

Teaching Staff

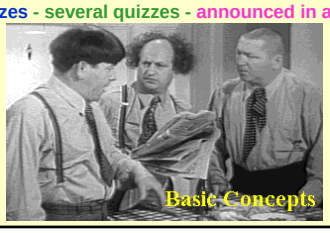
- Richard M. Martin (rmartin@uiuc.edu)
  2129 ESB (Engineering Sciences Bldg), 333-4229
  - Office Hours: Just after class
    - MW 10:30 - 11:00 (longer if needed
    - And by appointment



- Joseph Jun (jun1@uiuc.edu)
  4129 Eng. Sci. Building, 333-4736
  - Office hours:
    - TBA
    - And by appointment
- Both of us can be reached most easily by e-mail
  - We will try to answer promptly and can set up appointments

Course Format

- Course Meetings: 9:00 - 10:20 am MW
  - Lecture (Total of 45-60 minutes) - questions encouraged!
  - Demonstrations - with active participation by you!
  - "Active Learning" Exercises: Usually questions posed to you concerning concepts just presented in lecture. Participation important !
  - Quizzes - several quizzes - announced in advance



Course Exams, Grades, …

- Grades (approximate figures - may vary somewhat)
  - two in-class hour exams, 2 x 15 % = 30%
  - one final exam 30%
  - report 20%
  - homework, quizzes, participation 20%
- Homework:
  - Assigned throughout course
  - Linked on Web pages
  - Important part of course!

Lecture 1

Report

- **Report**
  - To be handed in before the end of the semester. See links on Web page and material passed out today. Topics suggested throughout the semester.
  - Each student can choose a person, persons or subject matter (theme) from any area of physics
    - Discuss the conceptual basis and development of the physical ideas.
    - The effect of the ideas on sciences and culture
    - Historical context (scientific as well as cultural).
  - Before starting the student should consult with the instructor concerning the topic.

Text and References

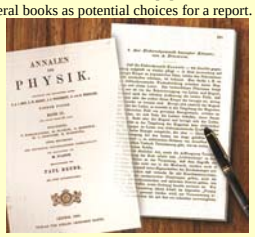
The **required texts** for this course are:

***Physics for Poets*, Robert H. March, fifth edition**

***Great Ideas in Physics*, Alan Lightman**.

Additional material from ***Six Easy Pieces* by R. Feynman** will be given during the course, and in a few other texts available in the Physics Library.

Many other references are on reserve in the Physics Library, 204 Loomis, as listed in "Books on Reserve". Several are also available as paperbacks in bookstores. Prof. Martin will make available several books as potential choices for a report.



Math

- **Mathematics is the natural language of physical science**
- **How much is necessary?**
  - Minimal -- but non-zero
    - The PURPOSE of this course is NOT to prepare you to DO PHYSICS CALCULATIONS, but rather to have an understanding of the workings of science.
    - At various times during this course (esp. relativity) it will be necessary to use minimal mathematical calculations.
    - What is "minimal?"
      - See "Basic Math Sheet"
- **We will help! We do not want math to be an impediment!**

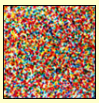
Web Resources

Much of the course material will be available via the World-Wide-Web (WWW) on the class site **http://online.physics.uiuc.edu/courses/phys150/fall03/**

The Home Page contains current information on the class, and links to other pages that contain the basic information for the course, the homework, gradebook, and the syllabus that will be updated during of the course. The syllabus will also have links to the lecture slides, notes, and homework. A separate page of Links to Web resources is linked to the main page. Many of these are excellent resources for history, beautiful and instructive images of natural phenomena, working Java demonstration programs, etc.

http://www.powersof10.com/





http://www.calacademy.org/exhibits/powers_of_ten/

Animated applet
http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/
Good site with vast range
http://microcosm.web.cern.ch/Microcosm/P10/english/welcome.html

Science Events

- **Programs, ….. (yesterday – repeated Aug. 28 3AM)**
  Also Book – *Crystal Fire* by M. Riordan and L. Hoddeson

- **Natural events**

Questionnaire

- **Reminder to fill out questionnaire**

Lecture 1

Physics 150 Overview

- What is it?
  - A Course for non-scientists
  - NOT a non-scientific course!!
- What is the purpose of the course?
  - To discover what physics is about, i.e., how do we understand the world?
  - Physics as a paradigm for science
  - Science as part of our culture and society
  - How scientific knowledge was (and is!) created
  - Conceptual understanding stressed … with minimum mathematics and problems
    No knowledge of calculus is required
  - Discovery that nature is stranger than any person has imagined

Theme(s) of the course

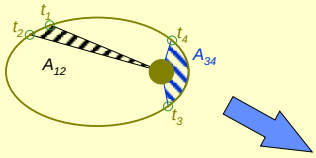
- To discover what science (physics) is about
  - Is it objective discovery of facts about nature?
  - Is it human invention of ways to describe what we see around us?
  - What are the great ideas of science (physics)?
  - How does science (physics) affect our world view?
- The approach we will take is to describe the conceptual structure of physics in a historical perspective (following the texts with additions)
  - How has physics evolved?
  - Revolutions in science – in human thought
  - How has it affected world views?

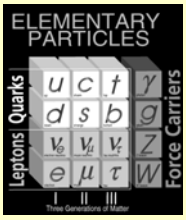
Revolutions in Human Thinking

- The same laws apply to:
  - The points of light we see in the sky
  - The motion of a stone thrown on earth
  - The source of power that drives the sun
  - The ideas that made possible electronic computers, the internet, …
- What is a law? A law of science?
  - How have laws come to be accepted?
  - How do laws come to be accepted?
  - How do they affect our world views?

What are the revolutionary ideas?

Observation of motion:
planets, ordinary objects





Current ideas of the smallest particles to the entire universe

Some questions:

- To be answered
  - Does the Earth go around the Sun or vice-versa?
  - What did Einstein show to be relative?
  - What did Heisenberg show to be uncertain?
  - How do we know that particles act like waves?
- To be somewhat answered
  - What is the evidence for the Big Bang? When was it?
  - Why does water freeze?
  - What is a black hole? Is it really black?
  - What is Schrodinger's cat?
- To be addressed
  - What sort of mysterious goings-on are to be found in nature at the smallest scale: particles, nuclei, atoms, quantum electronics, …
  - Aspects of experiments that attempt to resolve current questions about the nature of quantum mechanics

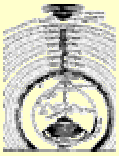
Progression of Course

- Scientific Knowledge: ≈1 week (& revisited)
  - How is scientific knowledge obtained (created)?
  - Early knowledge of astronomy & physics
- Classical Physics: ≈5 weeks
  - "The Scientific Revolution": Copernicus → Newton
  - "Classical Physics" ruled until cracks developed ~ 1900
- First Modern Revolution, Relativity: ≈3 weeks
  - Einstein & the revolution in concepts of space, time, and matter
- Second Revolution, Quantum Mechanics: ≈3 weeks
  - The atomic nature of matter
  - Particle-wave duality → unpredictability, strange causation, etc.
- The smallest particles to the Universe: ≈2 weeks
  - Quantum Mechanics and the matter around us
  - The Universe: Black Holes, the Big Bang, ...

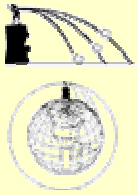
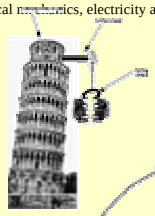
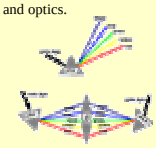
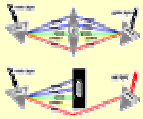
Lecture 1

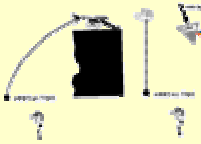
Ancient physics:
We begin with ancient Greek science (and before) , give credit to the golden age of Islam when Europe was in its dark ages, and progress through the 18th-19th centuries



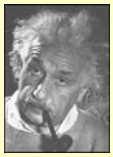
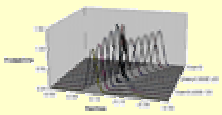



Classical Physics:
The world-view that evolved from Newtonian mechanics culminated in "classical" physics at the end of the 19th century, and this system was thought to be a comprehensive description of the physical world. We will survey the state of knowledge and general interpretations of different areas of physics at that time, such as classical mechanics, thermodynamics, statistical mechanics, electricity and magnetism and optics.

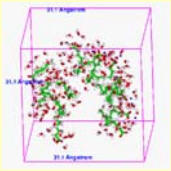
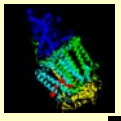
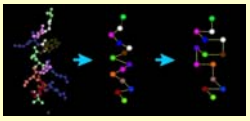
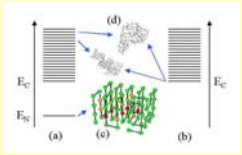





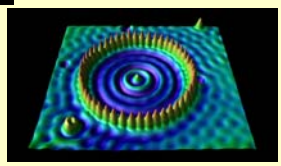


Quantum Physics and Relativity:
At the turn of the century this classical description was profoundly shaken and revised by the fundamental principles of relativity and quantum mechanics. These revolutionary descriptions of the physical world has had major consequences not only on our scientific understanding, but their influence extends into many other areas of intellectual pursuit, technology, culture and even politics. The conceptual development and consequences of these physical ideas will be explored.

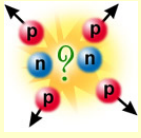

Physics in other science disciplines and in our world view :
The role of physics in other scientific disciplines, such as chemistry and biology, will also be discussed.

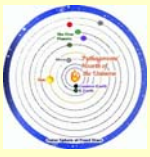







Particles and Cosmology:
The last part of the course will include a short introduction to current understanding of elementary particles and the present view of the universe and cosmology.


Crab Nebula



Demonstrations

- **Demonstrations will be a part of each class**
  - **Meant to illustrate the concepts and ideas**
  - **Today a sample**
- **Periodic motion of balls in a "Newton's Cradle"**
  - **Simple – but surprising - motion**
- **What about complex systems?**
  - **The notion of the increase of entropy (the arrow of time)**
  - **Demonstrated by a deck of cards**

Demonstrations Continued

- Sparks from a "Tesla Coil"
  - Causes sparks in nearby coil
  - Light emitted from fluorescent and neon gas tubes
  - What causes the effects?
- What is the light that is emitted?
  - Look through a grating at the colors
  - Illustrates Quantum Mechanics of the atoms in the gas
  - Despite the "uncertainty principle" the light from atoms like neon is the standard for the measuring time agreed by the nations of the world!
- Not Magic - part of the fabric of modern physics

Demonstrations Continued

- Counts detected by a "Geiger Counter"
  - What causes the effect?
- Illustrates:
  - the energy that powers the sun
  - The uncertainty principle of Quantum Mechanics
- Part of the fabric of modern physics – but still the most mysterious phenomenon in physics

First Part of Course Scientific Knowledge:

- What is it?
- Is it different from other knowledge?
- How is it developed?

Science plays an important role in history and culture

- Technological importance: the output of science
- Cultural importance: the concepts of science
- What is meant by a "scientific approach" or "scientific knowledge"?

Starting Questions

- Who was the first president of the United States?
- How do you know?
- Is aspirin effective in relieving headaches?
- How do you know?
- Does the sun circle the earth?
- Or does the earth circle the sun?
- How do you know?

Further Questions

- Have you ever seen an electron?
- John's answer: No. No one can see anything as small as an electron.
- Jane's answer: Yes. I calculate that I see at least 10^{12} every day just looking at my computer monitor.
- Who do you think is right?
- How does one decide the answer to such questions?

Feynman's Answers to some questions

- "The test of all [scientific] knowledge is experiment." This is the test of any scientific law. (*Six Easy Pieces*, p 2)
- "But what is the source of [this] knowledge? Where do the laws that are to be tested come from? Experiment …. gives hints. But also needed is imagination, to create from these hints the great generalizations ….." (p 2)
- "If a thing is not a science, it is not necessarily bad. For example, love is not a science. … If something is said not to be a science, it just means that it is not a science." (p 47)

Power's Answers to a question

- What is the greatest idea of the last 1,000 years ?
  (Written for New York Times series for the millennium)
- It lies beyond all reasonable doubt that no single idea has had a more profound or ubiquitous impact on what the human race has become, or what it has worked upon the face of the planet, than the vesting of authority in experiment.
- …. set in motion by a man named Abu Ali al-Hasan Ibn al-Haytham, born around the year 965 in Basra, in what is now Iraq

Next Time

- Scientific Knowledge
  - What is it?
  - How is it created?
- Description of motion
  - Position, time, velocity
  - View of Galileo vs. Aristotle
- Demonstrations
  - Falling bodies
  - Galileo's "diluted falling"
- Reading
  - March: Introduction, Ch. 1; Lightman, Introduction
  - Article by Richard Powers on the most important concept of the last millleniuм