PHYSICS OF THE TWENTIETH CENTURY AND BEYOND
SYLLABUS CAS-PY 100

Instructor: Sheldon Lee Glashow

Communication: Advice or assistance will be gladly provided during my office hours: Tues and Thurs 10:30 – 11:30 AM, in PRB 567 (3 Cummington St.) or by appointment. E-mail queries are also encouraged: slg@bu.edu [Tel: 3-9099].

Lectures: Tuesdays and Thursdays 2:00–3:20, MCS-148. Attendance at lectures is mandatory. Questions during lectures are encouraged!

Required Textbooks:
(1) “Strange World of Quantum Mechanics,” D.F. Styer, and
(2) “Einstein for Dummies,” C.I. Calle.
(3) “Particle Physics—A very Short Intro.” Frank Close (Oxford) See also any college physics text, such as my ‘From Alchemy to Quarks’ [on Reserve at the Science library].

Grading:
25% — 1st Midterm Exam: Thursday, 21 Oct (in class)
25% — 2nd Midterm Exam: Tuesday, 23 Nov (in class)
25% — Homework Assignments & Class participation
25% — Term Paper (Book Review, or approved alternative)

Assignments will be graded by Jiayuan Luo, whose office location and hours will be provided. There will be no final examination in this course.

Homework assignments: Approximately 8 problem sets or essay questions will be assigned in class and/or be available on the web. They are to be submitted to me in class (or via the web) when due. Late problems CANNOT be accepted and will receive NO credit. Assignments may be discussed among yourselves, but they MUST be completed independently.

Midterm Exams: Makeup exams will NOT be provided. If ONE exam is missed for a DOCUMENTED medical reasons or family emergency, the second exam will count double. Otherwise, a missed midterm exam will have a devastating effect on your grade. Each Midterm Exam will be based on material thusfar presented in class and upon assigned readings from the texts. Note that the 2nd Midterm will be held on the Tuesday preceding the Thanksgiving break!
Website: This course does have a Blackboard web site to which you should have access.

Term Paper: One requirement for PY-100, which serves in lieu of a final examination, is to read and review a book having to do with 20th century physics. The review should by typed, double-spaced, and of length 8–10 pages. You should describe the content of the book and explain how it contributed to your understanding of the development or application of modern physics. The choice of a book to review must either be approved by Professor Glashow or listed below. Your review must be submitted in class (or via email) no later than the last day of class. Late submissions will not be accepted.

Strange Beauty; George Johnson
The Quark and the Jaguar; M. Gell-Mann
Inward Bound; A. Pais
Subtle is the Lord; A. Pais
QED, Richard Feynman
Beyond Smoke and Mirrors: Climate Change & Energy; B. Richter
Facts & Mysteries in Particle Physics, M. Veltman (World)
The Making of the Atomic Bomb; Richard Rhodes
Einstein, His Life & Universe; W. Isaacson
Quantum: Einstein, Bohr & the Great Debate; M. Kumar
Black Holes & Quantum Foam; J.A. Wheeler

Student Conduct: All students are expected to maintain high standards of academic honesty and integrity, as described in the Undergraduate Student Handbook.
A BRIEF SYLLABUS

Week 1 9/3,7 An Introduction to Mathematics, incl. Pythagorean Triplets, Prime Numbers, Methods of Mathematical Proof, Geometric (and other) series.

Week 2 9/9,14 How Physics differs from Mathematics: Units and Dimensions, the Ladder of Science, the Universe on Log Time, &c.

Week 3 9/16,21 Relativity according to Galileo, Newton and the Science of Motion on Earth & in the Heavens.

Week 4 9/23,28 Son & Lumi`ere: Wave phenomena from Newton to Einstein. Light as particles or waves?

Week 5 9/30,5 Electromagnetism underlies all we touch, smell, taste, see and smell! Coulomb’s Law and Maxwell’s Equations.

Week 6 10/7,14 Space & Time According to Einstein: his special and general theories treated lightly.

Week 7 10/19 Review and discussion.
  10/21 FIRST HOUR EXAM!

Week 8 10/26,28 Heat, energy and the Laws of Thermodynamics.


Week 10 11/9,11 Radioactivity and the birth of nuclear physics; mesons, neutrinos, positrons &c.

Week 11 11/16,18 Nuclear Fission & Fusion; Neutrinos on Earth & from the heavens; How the sun shines, and how it will die.

Week 12 11/23 SECOND HOUR EXAM!
  11/30 Particle Accelerators: from the cyclotron to the LHC.

Week 13 12/2,7 Today’s Standard Theory of Particle Physics, and a bit of Cosmology.

Week 14 12/9 What we have learned.
A Brief Discussion of the Class

‘Twentieth Century Physics & beyond’ deals primarily with the sciences lying at the extremes of the ladder of size:

- Particle Physics: the search for the basic building blocks of matter and the rules by which they combine. Once upon a time, atoms were thought to be the basic and indivisible constituents of matter. About a century ago, atoms were shown to consist of electrons and tiny atomic nuclei. Later on, nuclei were found to be made of neutrons and protons. Today we know that these particles (and many others not ordinarily found in Nature) are made up of quarks, and we have a remarkably successful although certainly incomplete ‘Theory of Almost Everything.’

- Cosmology and Astrophysics: which seek to understand the nature of stars and galaxies and their origin in the hot big bang. Again, we have a remarkably predictive model of the birth and evolution of the Universe, but again there are many vexing puzzles remaining to be solved.

Scientists have learned so much about the microworld and the larger structures in the cosmos through what has been called “the unreasonable effectiveness of mathematics.” So it is that Newton invented calculus, Maxwell used differential equations, Einstein used non-Euclidean geometry, and today’s physicists need to know all sorts of advanced math. However, the students in this course are not expected to know much math at all... although they should certainly be willing and able to learn a bit more! Thus the first week of the course will be devoted to various topics in (seemingly) pure mathematics.

Thereafter, our approach to the revolutionary discoveries of the past century will be largely (but not exclusively!) conceptual and methodological. There will, after all, be quantitative problems on home assignments and exams. We shall learn how experiments or observations, properly interpreted, can reveal the inner workings of the natural world. A central theme of the course is the universality of physics. The very same laws and principles describe the relationship between matter and energy on Earth and in the Heavens: from quarks to quasars, from neutrinos to neutron stars, and from the birth of the universe to its inevitable decline. In short, we will study the grandest unification of all: that of the incomprehensibly large and the incredibly small.
Zeroth Problem Set

These questions have nothing to do with 20th century physics. Ponder them, but do not submit your answers to me. Their intent is simply to get you to think about physics. We may discuss them in class (or on the web) if you wish.

1. Why can you see the Sun but not hear it?
2. Why is winter cold and summer hot, and why are the seasons reversed in the Southern Hemisphere?
3. Why are there usually two high tides each day?
4. Why do we see we only one side of the Moon?
5. Why does it take longer to boil an egg in Denver than Boston?
6. Why can you hear the parade long before you see it?
7. Why is moonrise about an hour later each day?
8. Why do the tails of comets point away from the Sun?
9. What is meant by ‘the hydrogen economy’?
10. How do we know the speed of light? ...the distance to the Sun? ...the age of the Earth?