Second Year Physics

Special Relativity Dr S. Sarkar

Hilary Term, Weeks 5-8, 2001 (Wed 9/Thu 11, Lindemann Lecture Theatre)

This course will aim to summarize the experimental basis for special relativity, to develop the theory from Einstein's two postulates, to introduce appropriate mathematical tools, and to give examples of relativistic effects and calculations.

The material will be covered in 8 lectures, in the following order:

1. Introduction. Newton's Laws and Galilean Relativity. Non-Galilean invariant forces. Order of magnitude of relativistic effects. Einstein's two postulates. Experimental evidence for these.
2. Derivation of the Lorentz transformation. Minkowski diagrams. Fitzgerald contraction. Time dilation. Proper time.
3. Invariants. 4-vectors. Manifest covariance. Some mathematical tools.
4. Relativistic velocity, momentum, energy, mass, force. Why momentum is more useful than velocity?
5. Relativistic kinematics. CMS–Lab transformation. Invariant mass. Two body decays.
6. Compton scattering. Doppler effect (and the cosmic microwave background). Recoil shifts in emission and absorption of spectral lines. Use of Mössbauer spectroscopy.
7. Force and acceleration. Comoving approach. "Twin paradox". Examples.
8. Introduction to relativistic electromagnetism. Transformation of the fields. Magnetic field from Lorentz transformation of static electric field of a point charge. Lorentz force.

As the material of the first two lectures is largely revision of the 1st year's course it will be covered rapidly. Most applications of special relativity lie in astronomy and particle physics as reflected in the two problem sets accompanying the lecture notes. Several such examples will be discussed . . . in some cases the topic may well be beyond the syllabus.

The lecture notes and problem sheets can be downloaded from my webpage:
`http://www-thphys.physics.ox.ac.uk/users/SubirSarkar/SpecialRelativity.html`

. . . which is linked to the Physics Department Lecture Database at:
`http://www-nt.physics.ox.ac.uk/lectures/`

The key texts for this course are:

1. W. Rindler, *Introduction to special relativity, 2nd ed* (Oxford, 1991)
   — A succint mathematical treatment

2. J.D. Jackson, *Classical electrodynamics, 2nd ed*, (Wiley, 1975)
   — Chap 11 in particular

3. F.N.H. Robinson, *An introduction to special relativity and its applications* (World Scientific, 1995)

See also the books by Bowler, French, Muirhead, Rosser, and Taylor & Wheeler recommended for the first year course, and the chapters on relativity in the recommended text on electromagnetism by Lorrain & Corson.
The following books are suggested for those interested in the historical context of relativity and in its philosophical and cultural impact:

J. Stachel, *Einstein's miraculous year* (Princeton, 1998)
— the five papers he wrote in 1905 that changed the face of physics

A. Pais, *Subtle is the lord* (Oxford, 1986)
— superb scientific biography of Einstein

R.P. Feynmann, *Six not-so-easy pieces* (Allen Lane, 1998)
— characteristically original exposition of relativity, symmetry and space time

There is a lot of material on relativity on the World Wide Web, not all of it reliable! Here are some good sites (all hyperlinked to my web page) :

- Relativity FAQ
  `http://hepweb.rl.ac.uk/ppUK/PhysFAQ/relativity.html`
  - from the usenet newsgroup sci.physics.relativity

- Mathematical history of special relativity
  `http://www-history.mcs.st-and.ac.uk/~history/HistoryTopics.html`
  - on the St Andrews maths archive

- Biography of Einstein
  `http://www.aip.org/history/einstein/`
  - from the American Institute of Physics history project

- Dave's relativity page
  `http://www.svsu.edu/~slaven/relativity1.html`
  - basic introduction ... Dave Slaven, Saginaw Valley State University

- The Light Cone
  `http://www.phy.syr.edu/courses/modules/LIGHTCONE/index.html`
  - java animations . . . Rob Salgado, Syracuse University

- Special Relativity
  `http://casa.colorado.edu/~ajsh/sr/sr.shtml`
  - movies and more . . . Andrew Hamilton, Colorado University