US PARTICLE ACCELERATOR SCHOOL and THE UNIVERSITY OF TEXAS AT AUSTIN

1992 Course Descriptions

Week 1

PHYSICS 396TA Accelerator Modelling
1-1/2 Semester Hours
Dr. Richard M. Talman - Cornell University

The principles of modelling are presented, including the representation of accelerators and storage rings and the representation of beams and their oscillations by super particles. The emphasis will be on numerical methods and the optimization of computation. Beam simulation and particle tracking are studied. An analysis of adjustment algorithms is presented: for closed orbit smoothing, for tune and chromaticity control and for coupling minimization. The impact on the adjustment algorithms of the presence of random and systematic field errors is discussed. Also presented in the course is a study of the representation of beam diagnostic procedures, including the Fourier Analysis of signals and the beam transfer function.

PHYSICS 396TB Physics and Technology of Ion Sources
1-1/2 Semester Hours
Dr. Ian G. Brown - Lawrence Berkeley Laboratory

This course will present an overall picture of the field as well as a detailed understanding of some specific kinds of ion sources. Some basic plasma physics will be reviewed, including plasma formation and confinement techniques and the plasma physics of ion beam formation. The essential features common to all ion sources will be discussed and some simple sources conceptually designed as examples. Typical electrical systems, vacuum and mechanical aspects, and beam diagnostics will be outlined. A brief survey of different kinds of ion sources will be presented, and the characteristics of the beams produced will be compared. Fundamentals of beam transport will be discussed. Limits to source performance will be considered, with some discussion of possible future developments.

PHYSICS 396TC Superconducting Magnets
1-1/2 Semester Hours
Dr. Arnaud Devred - Superconducting Super Collider Laboratory

This course introduces the technologies involved in designing and fabricating superconducting particle accelerator magnets. Subjects studied are methods of field calculation; field measurement techniques; assembly techniques; mechanical properties of the magnet through cool down and excitation; helium properties and cryogenics; magnet stability problems; quench performance and quench protection; and the effects of superconductor magnetization on field quality. Examples and problems are presented throughout.

PHYSICS 396TD Introduction to Linear Accelerators
1-1/2 Semester Hours
Dr. Thomas P. Wangler - Los Alamos National Laboratory

This introduction to the theory of rf linear accelerators will treat rf accelerating structures and linac beam dynamics. The emphasis will be on the underlying principles. We will study the basic properties of single and coupled cavities, including cavity-mode characteristics, stored energy, quality factor, shunt impedance, and dispersion curves. The principles of operation of the most common linac-accelerating structures will be presented, including drift-tube linacs, coupled-cavity linacs, and the radiofrequency quadrupole. We will discuss focusing and defocusing effects in a linac, and the longitudinal and transverse beam dynamics both for noninteracting particles and high-intensity beams. We will treat such topics as phase space, rms emittance, the rms-envelope equation, space-charge dominated beams, and emittance-growth mechanisms, all of which are important for modern high-intensity linacs.

PHYSICS 396TE RF Systems for Electron Linacs and Storage Rings
1-1/2 Semester Hours
Perry B. Wilson - Stanford Linear Accelerator Center

The emphasis in this course is on basic physical principles and general engineering considerations for rf systems providing high peak pulsed power to electron linacs and continuous (cw) power to electron storage rings. Some of the topics covered are: properties of pulsed and cw klystron rf power sources; modulators and pulse transformers for driving pulsed klystrons; rf pulse compression for enhancing peak power; principles of acceleration in standing-wave (sw) cavities and traveling-wave (tw) structures; beam loading in sw cavities and tw structures; feedback and phase stability considerations for storage ring cavities; single bunch and transient beam loading in linacs and storage rings; introduction to higher mode and wakefield effects.

Week 2

PHYSICS 396TF Numerical Methods, Maxwell and Newton
1-1/2 Semester Hours
Dr. Richard K. Cooper - Los Alamos National Laboratory

This course will cover the methods used in the numerical solution of Maxwell's equations and the self-consistent motion of charged particles in electromagnetic fields, using the particle-in-cell (PIC) approach. The time- and frequency-domain formulations in three dimensions will be covered. The numerical methods covered will include linear system solvers including multigrid methods; the solution of large sparse-matrix eigenvalue problems; and numerical integration of particle equations of motion. Available software will be reviewed, and hands-on computer experience is anticipated as part of the instruction.

PHYSICS 396TG Experimental Techniques for High Energy Electron Accelerators
1-1/2 Semester Hours
Dr. John T. Seeman - Stanford Linear Accelerator Center

This course deals with experimental techniques used during beam dynamics studies of high energy electron accelerators. These techniques are important in designing practical and imaginative instrumentation and measurement systems. General reviews and many detailed examples are given. Subjects include phase space, transport line components, beam position measurements, trajectory correction, tune monitoring, energy and energy spectrum control, bunch length and transverse profile measurements, phase space (emittance) determination, practical synchrotron radiation, wakefield produced nongaussian profiles, and an introduction to feedback. Participants should familiarize themselves with the linear Courant-Snyder parameters and TRANSPORT notation, which will be included in the pre-course review material.

PHYSICS 396TH Superconducting Materials
1-1/2 Semester Hours
Dr. David C. Larbalestier - University of Wisconsin-Madison
Dr. William H. Warnes - Oregon State University

Superconducting devices form crucial elements of modern particle accelerators, in RF cavities, in bending and focusing magnets and in detector magnets. This course will describe the basic physical principles of superconductivity, the principal properties of superconducting materials (type I and type II, low temperature and high temperature superconductors), principles of design of superconducting composites for superconducting magnets.

PHYSICS 396TI Intense Charged Particle Beams
1-1/2 Semester Hours
Dr. Ronald C. Davidson - Princeton University

The equilibrium and stability properties of intense electron and ion beams are investigated at sufficiently high beam current and density that the electric and magnetic self fields play an important role in determining the detailed properties of beam propagation, collective oscillations, and instability behavior. The statistical models used to describe collective processes in intense charged particle beams are based on the Vlasov-Maxwell equations, or the fluid-Maxwell equations, as appropriate. Equilibrium properties, collective oscillations, and instabilities are analyzed from first principles for beam propagation in a solenoidal focusing field, periodic (alternating-gradient) strong focusing field, and (high-current) modified betatron configurations. Lectures and problems are based on topics selected from Chapters 2, 4, 9, and 10 of Physics of Nonneutral Plasmas (Addison-Wesley, 1990) by Ronald C. Davidson.

PHYSICS 396TJ Optical Systems for Synchrotron Light Beams
1-1/2 Semester Hours
Dr. Malcolm R. Howells - Lawrence Berkeley Laboratory

The aim of this course is to provide the tools needed to design and build optical systems to exploit synchrotron light sources. Presented are the theory and practice of optical design for the vacuum ultraviolet/soft x-ray spectral region. Basic physics and engineering are emphasized. Examples are used throughout. Subjects studied are the basic principles of optics, the theory and measurement of coherence and the synchrotron as a source for optical systems. The treatment of optical systems includes reflection, polarization, polarimetry and surfaces. Examples are given of the design of real mirror systems, diffraction gratings and monochromators. A critical review is given of existing designs of optical systems, of past failures and of future best bets. The course concludes with a study of x-ray imaging, including basic ideas, technology and new ideas for the future.