US Particle Accelerator School and Indiana University

Course Descriptions

PHYSICS 570 Introduction to Accelerator Physics
3 credit hours
Helmut Wiedemann, Stanford University

The course is designed to give an introduction to the fundamentals of beam physics and accelerator technology. The course starts with an overview of basic principles for linear and circular accelerators and continues with a more detailed discussion of transverse beam dynamics including magnet design, linear beam optics, matrix formalism, elements of particle guiding and focusing, phase space motion, beam emittance and envelopes, betatron and dispersion functions followed by an introduction to actual magnet lattices like the FODO lattice. Minimizing magnetic field and alignment errors is critically important for the stability of particle beams and the effect of perturbations due to such errors on the closed orbit and resonant stability will be discussed. Longitudinal particle motion, stability criteria and notions of emittance, energy spread and bunch length will be discussed. Synchrotron radiation is important for electrons beams and the basic principles of synchrotron radiation will be introduced including energy loss, radiation power, spectrum, photon flux, brightness, spatial and temporal coherence, followed by a discussion of insertion devices. Finally, the properties of radiation emission allows the full determination of electron beam parameters and beam life times. A brief overview of collective effects and coherent beam instabilities is given. Textbook: "Particle Accelerator Physics" by H. Wiedemann, Springer Verlag 1993.

PHYSICS 671A Synchrotron Light Sources
3 credit hours
Samuel Krinsky and James B. Murphy, Brookhaven National Laboratory
Massimo Cornacchia, Stanford Synchrotron Radiation Laboratory

The course will introduce the fundamentals of electron storage rings as synchrotron radiation sources. The properties of the electron accelerator, the electron beam and the emitted light will be examined. An outline of the course is as follows: Basic Accelerator Physics: betatron & synchrotron motion, closed orbit, injection & chromaticity. Physics of Electron Storage Rings: radiation damping, emittance & lifetime. Light Source Lattices: double bend achromat (DBA), triple bend achromat (TBA), chromaticity correction. Synchrotron Radiation: spectrum, intensity & polarization. Undulators & Wigglers: properties of light and device design; FELs. Prerequisites: Classical Mechanics and Electromagnetism.

PHYSICS 671B Introduction to Beam Instabilities
3 credit hours
Ronald D. Ruth, Stanford University

Review of relativistic single particle motion in synchrotrons. Electromagnetic fields due to the beam-cavity interaction and the resistive wall. Wakefields and impedances. Coasting beam instabilities. Introduction to dispersion relations and Landau damping. Bunched beam instabilities, including single and multibunch instabilities. Coherent modes and beam signals. Linear and circular accelerators, the Vlasov equation and few-particle models. The course includes an introduction to mechanisms of beam instability and a survey of experimental observations. Prerequisites: Electromagnetism and some familiarity with introductory accelerator physics.

PHYSICS 671C Introduction to Theory and Design of Charged Particle Beams
3 credit hours
Martin Reiser, University of Maryland

This course presents a systematic introduction to the theory and design of charged particle beams for accelerators, low-energy beam transport systems, microwave tubes and other devices. It offers a broad review of focusing systems and a unifying thermodynamic description of beams with space charge that reveals the underlying physics and stresses the implications for practical design. Definitions of fundamental beam parameters and their relationships are given, and theoretical guidance is provided for the design of the high-quality beams required in modern devices. Topics include: beam optics and focusing systems without space charge; beam optics with space charge; beam transport, focusing and matching; self-consistent theory and modelling with 'equivalent linear beams'; beam cooling due to acceleration; transverse and longitudinal envelope equations; emittance growth due to beam mismatch, collisions and instabilities; equipartitioning in rf linacs. The problems given will stress the relevance for practical design and experiments. Textbook: M. Reiser, "Theory and Design of Charged Particle Beams," Wiley Series in Beam Physics and Accelerator Technology (Series editor, M. Month), John Wiley & Sons, Spring 1994.

PHYSICS 671D Accelerator Instrumentation and Beam Measurement Laboratory
3 credit hours
Jacob B. Flanz, Mass General Hospital; Gerald P. Jackson, Fermilab;
S.Y. Lee, Indiana University

This course of lectures and laboratory studies is an introduction to experimental methods in accelerator physics. Accelerator instrumentation and beam measurements are studied in both laboratory and control room environments. Instrumentation and techniques for transverse and longitudinal measurements from beam current and position monitors to phase space diagnostics are introduced. Impedance measurements of accelerator components are also included. This experience is applied to measurements of a variety of beam characteristics using the Indiana University Cyclotron Facility. Commercial audio, RF and microwave test equipment such as spectrum and network analyzers are used throughout the course. The student should have some familiarity with introductory accelerator physics and electrical circuits.

PHYSICS 671E Computations in Accelerator Physics
3 credit hours
Richard K. Cooper and Robert D. Ryne, Los Alamos National Laboratory

This course will provide an introduction to the numerical techniques and computational tools used in the design and analysis of particle accelerators and beam transport systems. Lectures and computations will cover the following topics: (1) Numerical integration of ordinary differential equations; (2) Beam dynamics calculations in linear and nonlinear beam transport systems, with an emphasis on Lie algebraic techniques; (3) Numerical simulations of intense beams using RMS equations and Particle-In-Cell techniques; (4) RF cavity and magnet calculations in two dimensions; (5) Wakefield calculations; and (6) three-dimensional electromagnetic field calculations. The course will provide an overview of these subjects, along with a more detailed treatment of selected areas of student interest. Students will write their own codes for some topics, while for other topics they will utilize the codes MARYLIE, POISSON/SUPERFISH, ARGUS and ABCI. Students taking this course should have some familiarity with Unix, since the course computations will be performed on Unix workstations.