Course Descriptions

PHYSICS 6938A — Introduction to RF Systems in Accelerators
1-1/2 Semester Hours
Shane Koscielniak and Richard Baartman - TRIUMF

The course will contain an introduction to longitudinal dynamics in cyclic accelerators and elaborate the standard methods of closed-loop beam control in synchrotrons in the low current regime. The course continues with an account of commonly used cavity structures and modes and will then study beam loading of the fundamental mode. Robinson instability and compensation techniques will be discussed. Longitudinal coupled-bunch modes and parasitic resonance crossing for a swept frequency cavity will be treated after introducing the beam coupling impedance. The course problem sets will include applications to proposed medium energy proton synchrotrons.

PHYSICS 6938B — Magnetic Systems
1-1/2 Semester Hours
Klaus Halbach - Lawrence Berkeley Laboratory

After establishing the theoretical basis for the discussion of magnets, and describing the most frequently used conventional magnets, their design, and their properties, emphasis will be placed on a variety of particular magnets and methods. This includes devices (e.g. septum magnets, permanent magnet systems with and without iron, and permanent magnet assisted electro magnets), and their properties (e.g. consequences of small perturbations and assembly errors, and various consequences of eddy currents) as well as methods that are useful for understanding and designing magnets (e.g. direct and orthogonal analog models, use of magnetic charges to get insight into properties of magnets, and conformal mapping).

PHYSICS 6938C — Computer Methods in Particle Tracking
1-1/2 Semester Hours
Martin Berz - Michigan State University

Using differential algebraic (DA) techniques, it is possible to conveniently describe the properties of arbitrary beam physics systems with high order maps. After a brief introduction of DA methods and their use, we will describe various applications of the maps: direct and symplectic tracking, determination of parameters including energy dependent fixed points, lattice functions, and efficient methods of chromaticity correction. Finally we will discuss the DA formulation of normal form theory, which will allow the computation and correction of amplitude dependent tune shifts and resonance strengths, and provide a general and practical tool to obtain insight into the specifics of weakly nonlinear motion. The lectures will be accompanied by problems as well as computer work which will be performed with the general arbitrary order DA code COSY INFINITY, and which will be based on realistic problems that typically occur in the study of nonlinear repetitive accelerators.

PHYSICS 6938D — Introduction to Synchrotron Radiation Sources
1-1/2 Semester Hours
James B. Murphy - Brookhaven National Laboratory

The course will introduce the fundamentals of electron storage rings as synchrotron radiation sources. The properties of the electron beam and the emitted light will be examined. A brief outline follows: 1) Basic accelerator physics: betatron & synchrotron motion, closed orbit, injection 2) Physics of electron storage rings: radiation damping, emittance, & lifetime 3) Light source lattices: double bend achromat (DBA), triple bend achromat (TBA), chromaticity correction 4) Overview of hardware: magnets, vacuum system, RF system, etc 5) Synchrotron radiation: spectrum, intensity & polarization 6) Undulators & wigglers: properties of the light & device design.

PHYSICS 6938E — Introduction to High Current Beam Transport
1-1/2 Semester Hours
George J. Caporaso and Yu-Jiuan Chen, Lawrence Livermore National Laboratory

1) Introduction: applications of high current beams. 2) Transport limits: beam envelope equations and dynamics. 3) Discussion of various focusing systems: continuous and alternating solenoids, quadrupoles, foils, resistive wires, ion channels, magnetic multipole lens arrays. 4) Introduction to transport instabilities: cumulative beam breakup, transverse resistive wall, transverse ion-hose, longitudinal instability of a heavy ion beam, effects of phase mix damping. 5) Chromatic aberration and its control, "corkscrew" growth, simple dynamic alignment algorithm for focusing elements.

PHYSICS 6938F Experimental Methods
1-1/2 Semester Hours
Stephen D. Holmes and Gerald P. Jackson - Fermilab

A review of particle accelerator diagnostic devices: operating principles, signal processing, interpretation of data, diagnosis of problems, and strategies for enhancement of accelerator performance. Representative topics to be covered include: beam position, beam loss, profile monitors, Schottky detectors, wide and narrow band pickups, dampers, feedback, data acquisition, and the use of such devices in understanding accelerator performance characteristics.

PHYSICS 6938G Superconducting RF
1-1/2 Semester Hours
H. Alan Schwettman - Stanford University

The development of rf superconductivity as a technology for accelerator physics will be reviewed, including discussion of both theoretical and practical limitations. Topics covered will include the limitations on field and Q value and the design of couplers and structures. Special attention will be given to problems encountered in the use of rf superconducting techniques in high current storage rings, linear colliders, and Free Electron Lasers.

PHYSICS 6938H Electromagnetic Fields and Their Computation
1-1/2 Semester Hours
Richard W. Ziolkowski and Andreas C. Cangellaris - University of Arizona

This course will cover the basic principles of Maxwell's equations with an emphasis on how to calculate electromagnetic field effects. It will include discussions into the concepts of static, quasi-static, and dynamic electromagnetic fields. Both time domain and frequency domain concepts will be addressed. Basic discrete and integral equation methods will be reviewed. Finite difference and finite element approaches to the solution of electromagnetic field problems will be stressed. Available software will be reviewed. Hands-on computer experience in a workstation environment is anticipated as part of the instruction.

PHYSICS 6938I Introduction to Strong Field Radiation
1-1/2 Semester Hours
Pisin Chen - SLAC

This course will introduce the physics of radiation by a relativistic charged particle under the influence of a strong external electromagnetic field. We review the classical theory of synchrotron radiation. We discuss the need for a quantum description and then develop the quantum theory of strong field radiation. Using a quasi-classical formalism, we calculate the radiation power spectrum, the number spectrum, and the Sokolov-Ternov self-polarization effect. Finally, we describe the process of e+e- pair creation by a photon traversing a strong external field. Throughout the course, we will apply the theory to examples in accelerators, such as synchrotron, wiggler and undulator radiation for light sources; spin polarization in high energy storage rings; and beamstrahlung during beam-beam interactions in linear colliders. A variety of problems will be given. Prerequisites: Electrodynamics and Quantum Mechanics at the first year graduate level.

PHYSICS 6938J Topics in Radiation Damage
1-1/2 Semester Hours
A. Lincoln Read and J. Donald Cossairt - Fermilab

Radiation problems at High Energy Accelerators will be studied. The first part of the course will address the optimization of accelerator radiation safety programs. Regulatory requirements will be reviewed. The major emphasis will be on the technical basis for these programs. Problem-solving sessions will emphasize techniques for addressing real life issues. Some attention will be devoted to the conceptual design of experiments to address technical issues in accelerator radiation protection. The second part of the course will deal with issues concerning radiation damage to components of accelerators and experimental apparatus. It will include a tutorial on the physical processes which result in radiation damage as well as a review of the various types of damage which occur. The existing data on this subject will be reviewed. Problem-solving sessions will emphasize the solution of some of the practical problems facing individuals who desire to design the next generation of experimental apparatus and accelerator diagnostic instrumentation.