Physics 309, The University of Chicago, Winter 2003

INTRODUCTION TO ACCELERATOR PHYSICS

Instructor: Kwang-Je Kim (kwangje@aps.anl.gov)

Particle accelerators are becoming larger and more complex to satisfy the ever more challenging requirements of the beam properties, as can be seen from the recent development in high-energy colliders for elementary particle physics and in synchrotron radiation facilities for biology and material sciences. The study of beams in accelerators is thus becoming more challenging and exciting as more of the subtler beam phenomena must be understood with greater certainty.

We will start from basic beam dynamics topics: how to keep beams focused in long or circulating accelerator chambers, how to maintain stable acceleration, and some of mechanisms by which the beam motion could become unstable. We will then discuss two important examples of electron accelerators—the electron storage ring and the linear accelerator. In electron storage rings, the beams are naturally damped to smaller emittance, that is, to smaller size and angular spread. These properties are important for many applications, for example as synchrotron radiation sources. However, the performance of electron storage rings is also limited by synchrotron radiation. Linear accelerators must be employed to achieve either smaller emittance or higher energy, hundreds of GeV, not feasible with storage rings. The course will end with discussion on some future concepts of accelerators to achieve performances far exceeding the current state of the art.

Prerequisites:
Undergraduate E&M
Undergraduate Mechanics

Text Book:
An Introduction to Particle Accelerators by E. Wilson (Oxford University Press)

Reference Book:
An Introduction to the Physics of High Energy Accelerators by D. Edwards and M.J. Syphers (Wiley-Interscience)

Course Syllabus:

Part I: Basic Beam Dynamics (3.5 weeks)
1. Introduction
2. Beam description
3. Transverse motion
4. Nonlinearities and Imperfections
5. Acceleration and longitudinal motion

Part II: Electron Storage Rings (2.5 weeks)
1. Beam dynamics in electron storage rings
2. Synchrotron radiation facilities
3. B-factories

Part III: Electron Linear Accelerators (2.5 weeks)
1. RF cavities
2. Wakefields and beam breakup effects
3. Electron sources
4. Linear colliders

Part IV: Future accelerator concepts (1 week)
High power lasers, laser acceleration, wake-field acceleration