Course outline for Beam Physics (PHY 690C)

Physics 690C is a beam physics course designed to acquaint the student with theories and methods associated to the production, transport, manipulations and preservation of high-brightness beams.

A. **Introductory concepts:** beams and accelerators: applications; beam productions
B. **Charged particle dynamics:** Coordinate systems; Dynamics of a charged particle in external e.m. fields: Relativistic Lagrangian and Hamiltonian; Hamiltonian splitting; Transformations
C. **Beams:** phase spaces and trace spaces; the concept of emittance; concept of "equivalent beam" and the beam matrix
D. **Longitudinal single-particle beam dynamics:** acceleration; longitudinal motion in circular and linear accelerators
E. **Transverse single-particle beam dynamics:** paraxial equation of motion; transfer matrix and Twiss parametrization, bending, focusing elements and their transfer matrix; periodic motion; Courant-Snyder formalism
F. Space charge effects
G. **Self-consistent theory of beams:** Vlasov model, Maxwell-Boltzmann distributions, Beam envelope equations
H. **Emittance growth and control:** Mechanism of emittance growth and oscillation, Concept of free-energy, Theory of emittance compensation
I. **Collective effects and associated instabilities:** Wakefields (single and multi-

bunch) and beam-break-up; Space-charge induced instabilities; Electron bunch self-interaction via coherent synchrotron radiation: microbunching instability; application to single-pass free-electron laser

J. **Beam Manipulations:** Bunch compression, Beam cooling, Emittance converters

Bibliography:

M. Reiser, "Theory and design of charged particle beams", John Wiley and Sons Ed.,

A. Chao, "Physics of collective beam instabilities in high energy accelerators", John Wiley and Sons Ed., and

J.D. Lawson, "The Physics of charged-particle beams", Oxford Science Publications.

http://www.fieldp.com/educa.html

http://www.slac.stanford.edu/pubs/slacreports/slac-r-637.html

http://www.slac.stanford.edu/~achao/lecturenotes.html

http://www.slac.stanford.edu/~achao/wileybook.html

http://preprints.cern.ch/cernrep/1994/94-01/94-01_v1.html

http://www.kvi.nl/~brandenburg/courseinformation.htm

http://uspas.fnal.gov/lect_note.html