USPAS summer 2025, Grad Accelerator Physics

Instructors: Georg Hoffstaetter de Torquat, David Sagain
TAs: Matt Signorelli, Joseph Devlin

August 6, 2025

Homework #8

Exercise (Beta Measurement)
Assume you are able to change the strength of all optical elements in a storage ring individually, and that you can measure its tunes ν_x and ν_y accurately.
(a) How can you measure β_x and β_y in a quadrupole.

(b) How can you measure the beam position in a sextupole?

(c) Assuming there is a BPM just next to a horizontal correction dipole. How can you measure the horizontal beta function at that position?

(d) You have a beam position monitor next to a sextupole. How can you measure the beta functions at the sextupole?

(e) If you can measure the beam position next to a quadrupole, how can you find the beam position for which the beam goes through the center of the quadrupole?

(f) A common technique to find a closed orbit that goes through the center of all quadrupoles is the following: slowly move the tune as close as possible to an integer while correcting the close orbit so that beam exertions do not become too large. Explain why the orbit is close to quadruple centers when the tune is very close to an integer.

Exercise (Beta Beat for Quad Errors in a Ring)
The first quadrupole after an interaction region typically has a very large vertical beta function.
(a) Use thin lens approximation to find β_y in this quadrupole for $\beta_y^* = 1\text{cm}$ and a distance of 1.5m from quadrupole to interaction point.
(b) If this quadrupole has a focal strength of 0.5m^{-1} and its current changes accidentally by 1%. How many percent of beta-beat ($\Delta\beta/\beta$) would you expect for a tune of $\nu = 0.52$? Note that you need to use the beta beat for a periodic system, not that for a one-pass system.

(c) What tune shift would you expect?