PHY 554. Homework 2.

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Electronic copies accepted at kshih@bnl.gov

HW 1 (4 pts). Magnet kicker (dipole)

Using the transfer matrix M to show that, when a particle is kicked at s1 by angle θ, the displacement at a downstream location s2 is

$$\Delta x_2 = \theta\sqrt{\beta_1\beta_2}sin\mu,$$

Where β_1 and β_2 are values of betatron functions at s1 and s2 respectively, and μ is the betatron phase advance between s1 and s2. The quantity $\sqrt{\beta_1\beta_2}sin\mu$ is usually called the kicking arm. In the scenario of designing a magnet kicker (which kicks the beam for injection/extraction or other orbit change), to obtain the maximum kick (or minimum kicker strength), what are the requirements for choosing the kicker location?

HW 2 (6 pts). FODO cells

An accelerator is made of 20 FODO cells with circumference of 200 m. The betatron tunes (phase advance per revolution divided by 2π) Qx/Qy are 5/4.8 respectively. What are the maximum/minimum betatron functions (x and y) and where are they located at?

Given the RMS beam emittance ε is 2 mm-mrad, what is the minimum vacuum chamber size to house such beam without losing particles.

HW 3 (10 point): localized orbit correction

The closed orbit can be locally corrected by using steering dipoles. A commonly used algorithm is based on the "three-bumps'' method, where three steering dipoles are used to adjust local-orbit distortion.

Let θ_1 , θ_2 and θ_3 be the three bump angles. For the orbit distortion to be localized between first and third dipoles, show that these angles must be related by

$$\theta_2 = -\theta_1\sqrt{\frac{\beta_1}{\beta_2}}\frac{\sin\psi_{31}}{\sin\psi_{32}}, \qquad \theta_3 = \theta_1\sqrt{\frac{\beta_1}{\beta_3}}\frac{\sin\psi_{21}}{\sin\psi_{32}},$$

where β_1, β_2 and β_3 are the beta functions at local bumps and ψ_{ij} is the phase advance between ith and jth steering dipoles.

Show under what condition, the "three-bumps" method can become "two-bumps" method, i.e., only two steering dipoles are used for local orbit distortion.