

## Exam on Linear Imperfections - JUAS 2013

Consider a proton synchrotron with kinetic energy of **3GeV**. The proton rest energy is **938MeV**. The horizontal tune is  $Q_x = 6.25$ . Three identical sextupoles with magnetic length of  $l_s = 0.3\text{m}$  are powered in series (i.e. they provide the same magnetic strength) and are used to control the horizontal chromaticity in locations where the horizontal dispersion  $D_x$  is **0.5**, **2** and **0.5m**, respectively. The horizontal beta function  $\beta_x$  in these location is **15**, **30** and **15m**, respectively.

- a. If the natural horizontal chromaticity  $\xi_x$  normalized by the tune is **-1.2**, compute its un-normalised value.
- b. Compute the normalized sextupoles' strength (in  $\text{m}^{-3}$ ) in order to set the horizontal chromaticity to 0.
- c. Assuming that there is a **1mm** horizontal offset in the first sextupole, compute the resulting normalized quadrupole (in  $\text{m}^{-2}$ ) and dipole fields (in  $\text{m}^{-1}$ ) feed-downs. What is the integrated normalized quadrupole gradient and dipole kick? Do these values depend on the energy of the ring?
- d. Compute the resulting horizontal tune-shift  $\delta Q_x$  given by the displaced sextupole. Assuming that there is no change in the dispersion function, is there a significant chromaticity change due to this quadrupole distortion? (please give a conceptual answer, do not calculate anything).
- e. Compute the orbit distortion in all three sextupoles, assuming a horizontal phase advance of  $90^\circ$ , between consecutive sextupoles.
- f. What are the resulting normalized quadrupole fields in all three sextupoles due to this orbit distortion? Is the orbit change significant for providing an additional horizontal tune-shift? (please give a conceptual answer, do not calculate anything).
- g. By how much should the last sextupole be displaced in order to cancel the orbit distortion at the first and the last sextupole? In that case, how much will be the orbit distortion in the second sextupole? How much will be the total tune-shift?
- h. What is the advantage of having the horizontal tune at 6.25? What will happen if the tune is moved towards 6.5? What will happen if the tune is moved towards 6.0? (please give a conceptual answer, do not calculate anything).