USPAS Graduate Accelerator Physics Homework 10/madx Lab

Due date: Tuesday February 9, 2021

1 $\pi/2$ Insertion in madx

a) (5 points) Download a $\pi/2$ insertion with the parameters given on slide 20 of the Friday Feb 5 class notes in `madx`: $L_l = 7.95\,\mathrm{m}$, $L_2 = 8.75\,\mathrm{m}$. This lattice is located at `http://www.toddsatogata.net/2021-USPAS/lab/piovertwo.madx`. Calculate the quadrupole focal lengths, where $f = 1/(K1 \cdot L)$. Are they "thin" or "thick" quadrupoles?

b) (3 points) What are the periodic Twiss function boundary conditions of this $\pi/2$ insertion? Hint: You can find these easily by using the TWISS command without specifying the initial values of the Twiss parameters. Include a plot of the Twiss parameters for this insertion. Use the "interpolate" option of the PLOT command to make the beta function graphs show as curved in the long drift sections.

c) (2 points) Are these values consistent with the design constraints of the $\pi/2$ insertion from slide 20 of the Friday Feb 5 class notes?

2 Dogleg in madx

A dogleg (as illustrated on slide 14 of the Monday Feb 8 lecture) is a pair of opposite-bend dipoles separated by a drift section. In the FODO `madx` lab, you learned all the tools to build such a dogleg (with only three elements) in `madx`. An example SBEND dipole element in `madx` is

```
MYDIPOLE: SBEND, L=2.0, ANGLE=0.052359877;
```

where the length L is $2.0\,\mathrm{m}$, and the angle is given in radians.

a) (5 points) Construct a weak dogleg with 3° SBEND (sector bend) elements of length $2.0\,\mathrm{m}$, with a drift length of $6.0\,\mathrm{m}$ between them. Track $\eta_x = 0, \eta'_x = 0$ through the dogleg and compare the results to the class slides. Note that `madx` twiss table entries for horizontal dispersion are DX and DPX. Provide your input file.

b) (5 points) Construct a strong dogleg with 30° SBEND (sector bend) elements of length $2.0\,\mathrm{m}$, with a drift length of $6.0\,\mathrm{m}$ between them. Track $\eta_x = 0, \eta'_x = 0$ through the dogleg and compare the results to the class slides. What is the requirement for the weak dogleg approximation to apply? Provide your input file.

c) (5 points) Build an achromatic dogleg with four $\pi/2$ insertions instead of the drift to see that the dogleg indeed moves the beam without dispersion. Plot the dispersion for this achromatic dogleg in `madx` to see that it closes, similar to the plot on slide 20 of the Monday Feb 8 class notes.

3 Double Bend Achromat in madx

a) (5 points) Construct a double bend achromat with the parameters given on slide 32 of the Monday Feb 8 class notes in `madx`: $L = l = 2\,\mathrm{m}, \theta = 0.01\,\mathrm{rad}, f = (L{+}2l)/4 = 1.5\,\mathrm{m}$, $(KL)_{\mathrm{quad}} = 0.677\,\mathrm{m}^{-1}$. Provide your input file.

b) (3 points) Use Twiss with input conditions $\eta_x = 0, \eta_x' = 0$ through the achromat and demonstrate that it is an achromat by reproducing the figure of η_x vs s on slide 32.

c) (3 points) Can a system like this be periodic in both β_x and β_y? That is, can you construct an achromatic bending "cell" out of just a DBA?

d) (4 points) Add an extra defocusing quadrupole on each end of the DBA of a "reasonable" strength (e.g. with focusing length on the order of 2–3 times the spacing of the elements to avoid overfocusing), then a drift and a half a focusing quadrupole (with the same strength as the defocusing quadrupole) to each end. Use `madx` to find the periodic cell boundary conditions. Plot the periodic lattice functions $(\beta_x, \beta_y, \eta_x)$ for your new DBA lattice cell.