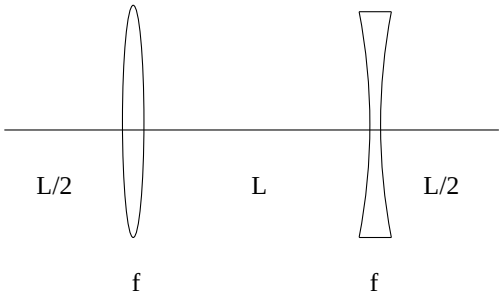
Last Homework

Exercise 1



Consider the quadrupole doublet shown above. Let $\frac{L}{f} = \sqrt{2}$.

a) Using the thin lens approximation, find the horizontal transfer matrix for the three drifts and two quadrupoles shown in the figure above.

b) What is the transfer matrix for the motion in the vertical plane?

c) Write all matrix elements in terms of L, eliminating f. Does this combination focus in the horizontal plane, the vertical plane, or both?

Exercise 2

In a small proton accelerator, a transverse beam size measurement is done when the machine is at the injection energy, 400 MeV. The momentum spread of the beam is $\frac{\Delta p}{p} = 1 \times 10^{-3}$. A horizontal beam sigma of $\sigma_x = 10$ mm is measured at a location where the amplitude function is a maximum, $\beta_{max} = 34$ m, and the dispersion, D, is 4 m.

a) What is the 39% beam emittance? (The 39% beam emittance encompasses 39% of the beam, which may be considered Gaussian.)

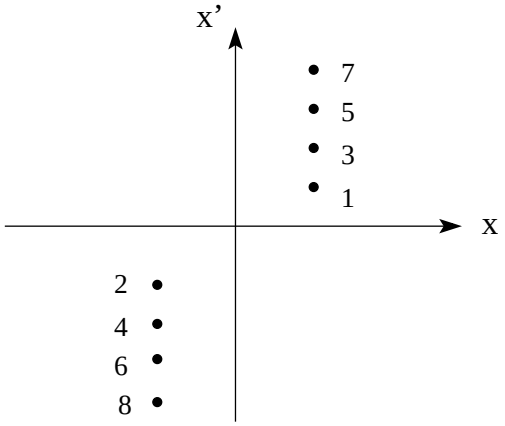
b) A measurement of σ_x is also done at a minimum beta location, where $\beta_{min} = 5$ m, and $D = 1$ m. What is the value of σ_x measured there?

c) What is the normalized horizontal emittance, ε_N, of the beam?

Exercise 3

A FODO cell has $\beta_{Hmax} = 100$ m, $\beta_{Hmin} = 25$ m, and the focal length of both quadrupoles is $f = 25$ m. In the vertical plan also $\beta_{Vmax} = 100$ m, $\beta_{Vmin} = 25$ m. What are the natural chromaticities, ξ_H and ξ_V, of the FODO cell? If there are 70 FODO cells making up the lattice of the machine, what are the machine chromaticities?

Exercise 4



A storage ring is brazenly attempting to operate at a half-integer tune. Alas, there is a gradient error in the machine. A particle is tracked for eight turns, and its phase space evolution at the location of the gradient error is shown in the figure above. The numbers indicate which successive turn corresponds to each point. Explain the phase space plot.