Corpuscular optics: exercises

Exercise 1. We consider a $^{12}C^{4+}$ ion. Its kinetic energy is 800 MeV/nucleon. The energy at rest for the nucleon will be 0.94 GeV. Give the numerical value of the Lorentz β and γ coefficients and the magnetic rigidity of the particle.

Exercise 2. A system is made of a focusing thin lens (focal length f) followed by a drift space (length L) followed by a defocussing lens (focal length f).

- Give the transfer matrix of the whole system
- Give the expression of the object focal length F_O versus L and f
- Give the position of the principal planes
- Suppose now L=1m, f=0.5m. Draw a schematic picture of the system (at the right scale) with the positions of the principal planes and the position of the Object focal point.
- Is this system equivalent to a thin lens?

Exercise 3. Consider a magnetic quadrupole. The beam rigidity is 10 Tm, the field gradient is 5T/m in the quadrupole

- If the inner radius of the quadrupole is 50mm, give the value of the field (B) on the poles
- We wish a focal length equal to 4m. What is the length of the quadrupole?
- Give the numerical value (3 digits are enough) of the transfer matrix in the focusing plane (using the length calculated before).

Exercise 4. We consider a non-accelerating system. The transfer matrix is $M = \begin{bmatrix} -1 & L \\ -\frac{4}{L} & X \end{bmatrix}$.

Give the value of X (obvious!)

Exercise 5. We consider a thin converging lens, f is its focal length. A beam enters the lens with emittance parameters $(\alpha_0, \beta_0, \gamma_0)$. The lens is followed by a drift space (length L).

- The incomimg beam is supposed to be divergent. What is the sign of α_0?
- What is the general relation between the émittance parameters α, β and γ?
- What are the emittance parameters α and β at the exit of the thin lens versus $(\alpha_0, \beta_0, \gamma_0)$?
- We suppose now $\alpha_0 = 0$.What must be the length of the drift space to get a waist ($\alpha = 0$). Check it is for L positive (ie: downstream). This length will be given only versus f and β_0 (use the second question of the exercise to eliminate γ_0.