1) A parallel beam of electrons of $\mathrm{E}=500 \mathrm{GeV}$ enters a beamline. It is necessary to focus this beam into a point at a 3 m distance from the edge of the last quadrupole. Estimate the necessary parameters of a quadrupole system (gradients, lengths) that can perform this task.
2) Beam of electrons with energy as in the previous task has the following vertical rms sizes and angular spread just in front of the final focusing quadrupole: $\sigma_{\mathrm{y}}=30 \mu \mathrm{~m}$ and $\sigma_{\mathrm{y}^{\prime}}=0.6 \mathrm{nrad}$. Take the parameters of the final quadrupole (length and gradient) as estimated in the previous task. Estimate the vertical beam size at the IP, assuming that the energy spread in the beam is zero; and also estimate the increase of the beam size due to the $1 \mathrm{E}-3$ energy spread.
3) Before arriving to the final quadrupole, the electron beam mentioned above, passes through horizontal bending magnet with field $B=0.2 \mathrm{~T}$ and length $\mathrm{L}_{\mathrm{B}}=20 \mathrm{~m}$. Synchrotron radiation in this bend result in the average energy loss and additional energy spread in the beam. Estimate:
a. Longitudinal shift of the beam waist due to the average energy loss
b. Increase of the vertical beam size in the waist due to energy spread
4) For the above mentioned beam and final doublet design
a. Estimate increase of the vertical beam size at the IP due to synchrotron radiation in the final quadrupole
b. Estimate, at what beam energy, with all other conditions the same, the beam size would about double due to synchrotron radiation in the quadrupole
5) The beam described above has population $\mathrm{N}=1 \mathrm{e} 10$ electrons and horizontal size at IP $\sigma_{x}{ }^{*}=200 \mathrm{~nm}$. For the particle of incoming positron bunch, estimate the number of emitted beamstrahlung photons per particle when:
a. The oncoming e+ bunch has 3 nm vertical offset with respect to e- bunch;
b. The oncoming e+ bunch has 30 nm vertical offset with respect to e- bunch;
c. Estimate the length $\sigma_{z}$ of the beam that would be optimal for the travelling focus regime
6) The beam described above enters detector solenoid with horizontal angle with respect to its axis equal $\theta_{c}=10 \mathrm{mrad}$. Half-length of the detector is $\mathrm{L}=5 \mathrm{~m}$ and its longitudinal magnetic field is $\mathrm{B}=4 \mathrm{~T}$. In the assumption of hard edge solenoid, estimate the vertical orbit deviation and the vertical angle of the beam at the exit from solenoid. (Ignore any final focusing elements).
7) Analyze and describe any scientific or technical (possibly, related to accelerator science) invention/discovery in terms of the TRIZ and AS-TRIZ approaches, identifying a contradiction and an inventive principle that were used (could have been used) in this invention or discovery.
