Final Report

Name: ——————————————————— Course: ———————————————————

This report is part of the course evaluation. Students may work on it together. Each student should turn in his or her own handwritten copy.

The report consists of 4 parts: multiple-choice questions, definitions of terms, a problem, and a short essay.

Multiple-choice questions

Mark the answer that you think is closest to the correct answer.

An electron is moving with a relativistic factor $\gamma = 10$. Its momentum is

☐ 1 MeV/c   ☐ 2 MeV/c   ☐ 4 MeV/c   ☐ 5 MeV/c   ☐ 10 MeV/c

The magnetic rigidity of a 200-GeV proton is

☐ 2 T·m   ☐ 6.68 T·m   ☐ 20 T·m   ☐ 200 T·m   ☐ 668 T·m

In a fixed-target experiment, if the target density is doubled while other parameters are left unchanged, then the luminosity

☐ is unchanged   ☐ quadruples   ☐ doubles   ☐ halves   ☐ is reduced to 1/4

In a detector with total efficiency $\varepsilon = 10\%$, the event rate is $R = 1$ kHz for events with a known cross section $\sigma = 1\ \mu$b. The luminosity is

☐ 10^{32} cm^{-2}s^{-1} ☐ 10^{34} cm^{-2}s^{-1} ☐ 10^{36} cm^{-2}s^{-1} ☐ 10^{38} cm^{-2}s^{-1} ☐ 10^{40} cm^{-2}s^{-1}

In a synchrotron, if the rf voltage is multiplied by 4, the synchrotron frequency for small-amplitude oscillations changes by a factor

☐ 4   ☐ 2   ☐ 1/2   ☐ 1/4   ☐ 1/8

In a synchrotron with slip factor η, as the amplitude of the synchrotron oscillations increases, the synchrotron tune

☐ increases   ☐ doesn't change   ☐ decreases   ☐ increases if $\eta > 0$ ☐ decreases if $\eta > 0$

The horizontal profile of a Gaussian beam has a standard deviation of 3 mm at a location where the amplitude function is 6 m. The rms geometrical emittance of the beam is

☐ 0.5 μm   ☐ 1.0 μm   ☐ 1.5 μm   ☐ 3.0 μm   ☐ 6.0 μm

In a collider like the LHC (relativistic factor $\gamma = 7000$), the amplitude function at the interaction region is $\beta = 60$ cm and the normalized rms beam emittance is $\varepsilon = 2\ \mu$m. The standard deviation of the transverse beam size in the interaction region is

☐ 1.1 μm   ☐ 13 μm   ☐ 1.2 mm   ☐ 12 mm   ☐ 1.1 m

Consider the self fields in a long bunch of charged particles. If the energy of the beam is increased by a factor 10, the intensity of the transverse space-charge force

☐ increases by 100   ☐ increases by 10   ☐ is unchanged   ☐ decreases by 1/10   ☐ decreases by 1/100

Definitions

Define the following terms using less than 100 words each.

<u>Transition energy</u>

<u>Nonlinear dynamics</u>

Problem

Consider the transverse linear motion of a charged particle in a focusing channel called *FODO cell*. The particle traverses first a focusing lens with focal length F; second, a drift of length L; then, a defocusing lens with focal length F; finally, another drift of length L.

(a) Calculate the 2×2 transfer matrix M for this cell.

(b) Find the condition of stability that F and L have to satisfy if this cell is repeated a large number of times.

(c) Calculate the eigenvalues and eigenvectors of matrix M. Are they real or complex? What is the physical meaning of complex eigenvalues?

Short essay

- Choose a topic related to accelerator physics (examples: luminosity; design of interaction-region focusing; measurement of beam emittance; the beam-beam force; applications of synchrotron light; hadron therapy; etc.).

- E-mail your topic to the lecturers for feedback and approval.

- Gather information about the topic from reliable sources, such as textbooks, experts in the field, journals.

- Within these two pages, summarize what you believe are the main aspects of the topic, including relevance, concepts, results, and challenges.