Idaho State University – Department of Physics
PHYS 499 / PHYS 630 Accelerator Physics — Spring 2009
6 May 2009

Final Exam

Name: _____

Major: _____ ISU ID: _____

Definitions (6 points)

Define the following terms using less than 100 words.

Admittance

Synchrotron radiation

Multiple-choice questions (8 points)

In a synchrotron, if the rf voltage is multiplied by 4, the synchrotron frequency changes by a factor

☐ 4 ☐ 2 ☐ 1/2 ☐ 1/4 ☐ 1/8

In a synchrotron, 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 elements of the transfer matrix for a periodic structure are $a = 0.80$, $b = 2$ m, $c = -0.26$ m^{-1}, and $d = 0.60$. The amplitude function β is

☐ 55 m ☐ 32 m ☐ 10 m ☐ 4.0 m ☐ 2.8 m

In a straight section of length 4 m, the initial values of the Courant-Snyder parameters are $\alpha = 0$ and $\beta = 4$ m. The final value of the amplitude function β is

☐ 0.5 m ☐ 1.0 m ☐ 2.0 m ☐ 4.0 m ☐ 8.0 m

If the betatron tune of a circular machine is 4.667, then the machine is operating near a resonance of order

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4

In a circular machine, the average value of the ratio between dispersion and radius of curvature is $\langle D/\rho \rangle = 0.01$. The transition 'energy' γ_t is

☐ 5 ☐ 10 ☐ 20 ☐ 50 ☐ 100

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 '1σ' beam emittance is

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

A circular machine has revolution frequency 700 kHz and phase-slip factor equal to 0.025. At a particular location, it is observed that an increase in revolution frequency of 35 Hz produces a displacement of the closed orbit of 12 mm towards the inside of the machine. At this location, the dispersion function is

☐ 1 m ☐ 2 m ☐ 3 m ☐ 6 m ☐ 9 m

Problem (8 points)

(a) It is possible to calculate the size of the beam in a transport line or in a periodic machine if the amplitude function β and the beam emittance are known. How?

Estimate the maximum value of the beta function $\hat{\beta}$ by studying the differential equation that the amplitude function must obey, i.e. $2\beta\beta'' - (\beta')^2 + 4\beta^2 K = 4$, where K is the normalized gradient. To study the equation, follow these steps:

(b) Show that a local maximum can only occur in a region where $K > 0$.

(c) Find $\hat{\beta}$ as a function of K and β''.

(d) Show that $\hat{\beta} > 1/\sqrt{K}$ and that $\hat{\beta} > |\beta''|/(2K)$.

(e) Find an expression for $\hat{\beta}$ in the following three special cases: $K \ll (\beta'')^2$, $K \simeq (\beta'')^2$, and $K \gg (\beta'')^2$.

Short essay (8 points)

Choose and describe one use of particle accelerators in pure or applied science. Make sure you mention the most important aspects of the topic. Aim your essay at someone who is knowledgeable about science, but does not know accelerators in detail. Limit the length of your essay to these two pages.