PHYS 684.1
October 15, 2003

Homework #5

Due: October 22.

1. Read the note RHIC/AP/106. Compute exactly the RHIC slip factor and the longitudinal beta function for gold ions of 100 GeV per nucleon and with Qs=0.001.

2. Find the ratio R/L of a pillbox cavity for which the shunt impedance

$$R_s = \frac{Z_0^2}{\pi \rho_s} \frac{L}{R} \frac{T^2}{(1 + (R/L)) J_1^2(2.4050)} \tag{1}$$

(Edwards and Syphers 2.23, p. 27) of the cavity is a maximum. If the shunt impedance per unit length is defined by $r_s \equiv R_s/L$, find the ratio of R/L for which r_s is a maximum.

3. For many years, surface breakdown fields in RF cavities under cw (continuous wave) conditions have been estimated with an empirical criterion called the Kilpatrick criterion, established when untrapped oil diffusion vacuum pumps were used. The criterion can be written in the form

$$f = 1.64\ E_k^2\ \exp(-8.5/E_k). \tag{2}$$

Here the frequency f is in MHz and the electric field E_k is in MV/m. Nowadays it is reasonable to design for fields above the Kilpatrick limit by nearly a factor of two. Using a maximum surface field of 1.7 E_k, find the energy gain possible for the pillbox RF cavity examined in the text and the previous problem. If a synchrotron is to produce acceleration at the rate of 3 MeV per turn, how many cavities are required and what is their total power dissipation?

4. One common method of adjusting the closed orbit using steering dipoles is called *three-bumps*, where a local orbit distortion is made with three steering dipole correctors. If the three steering corrector angles are θ_1, θ_2, and θ_3, then demonstrate that the three-bump is closed (no orbit offsets exist outside these three correctors) when

$$\theta_2 \ = \ -\theta_1 \left(\frac{\beta_1}{\beta_2}\right)^{1/2} \frac{\sin(\psi_3 - \psi_1)}{\sin(\psi_3 - \psi_2)} \qquad\qquad \theta_3 \ = \ -\theta_1 \left(\frac{\beta_1}{\beta_3}\right)^{1/2} \frac{\sin(\psi_2 - \psi_1)}{\sin(\psi_3 - \psi_2)} \tag{3}$$

Hint: Use a previous homework's result for the downstream orbit offset of a single dipole corrector kick.