Homework PHY 554 #4.

HW 1 (3 points): Cavities filled with ferrite material are used for RF system requiring large frequency tuning range. The frequency is controlled by applying external magnetic field, B_{ext}, to the ferrite material and by doing so to change it magenta permeability $\mu(B_{ext})$. A 300 m in circumference AGS synchrotron accelerates polarized protons from total energy of 2.5 GeV to 25 GeV.

(a) Calculate the range of the beam revolution frequency in AGS;
(b) Assuming 100% filling by ferrite, what should be ratio of μ_{max} to μ_{min}. Where μ should have maximum value?

Note: RF systems operate on a fixed integer harmonic of the revolution frequency.

HW 2 (2 points): In RF cavity operating at 500 MHz, amplitude of the magnetic field at the part surface is 500 Gs or 500 Oe. Find power losses per square meter of the surface for:

(a) Cu cavity*
(b) SRF cavity with surface resistance, $R_s = 5\ 10^{-9}$ Ohm.

How much water you can heat from 20 C^o to 40 C^o in one hour (3,600 second) by cooling such Cu cavity?

*Hint: you may use the conductivity of Cu or scale R_s from results shown in Lecture 11. Thermal capacitance of water is 4,179 J/kg/ C^o.

HW 3 (4 points): Superconducting RF pillbox cavity operating at 2K temperature would quench when the surface magnetic field reaches above 0.1 T (e.g. 1,000 Gs or 1,000 Oe).

(a) For such pillbox cavity operating in fundamental TM_{010} mode find maximum attainable accelerating electric field on axis of the cavity.
(b) For Rs = 5 nanoOhm, calculate thermal losses in such cavity operating at 20 MV/m (Hint do not forget side walls!)

HW 4 (6 points): For SRF Nb cavity the London penetration depth is equal to 40 nanometers.

(a) What is the density of superconducting electrons, n_s?
(b) For surface magnetic field of 500 Gs or 500 Oe, find the density of surface current.
(c) For frequency of 1 GHz, find value of electric field on the surface of the superconductor.

(d) Assuming conductivity on normal component (non-superconducting electron) of Nb is 3 x 10^8 S/m (e.g., conductivity of 6x 10^6 S/m at room temperature multiplied by RRR of 50), find what is the value of the normal component of the surface current.

Hint: assume that the superconducting conductivity is significantly higher than normal part.