Damping Rings - Homework II

1. The CLIC damping ring has a circumference of 430m, and contains 100 dipole magnets (without quadrupole gradient), each of length 0.5 meter. The beam energy is 2.86 GeV. Ignoring the damping wigglers calculate:
   a. the bending radius of each dipole;
   b. the second and third synchrotron radiation integrals
   c. the energy loss of each particle per turn through the ring
   d. the horizontal, vertical and longitudinal damping times
   e. the equilibrium energy spread
2. Show that, for small phase advance μ_x in a FODO cell, the natural emittance of a FODO lattice is given approximately by

$$\varepsilon_0 \approx 8C_q\gamma^2\left(\frac{\theta}{\mu_x}\right)^3$$

where θ is the bending angle of one dipole in the cell, and γ is the relativistic factor

Storage ring	Lattice type	Beam energy	Number of dipoles
SRS	72° FODO	2 GeV	16
SRS (HBL)	140° FODO	2 GeV	16
APS	DBA	7 GeV	80
DIAMOND	DBA	3 GeV	48
ALS	TBA	1.9 GeV	36

3. Given data on a number of storage ring lattices estimate the natural emittance for each ring, assuming that the lattice is tuned for the minimum emittance in each case (with zero dispersion in the straight sections of the achromats). Note: use the small phase advance approximation for the FODO lattices – even though this may not be very accurate in these cases! Explain why the emittances for the achromat lattices are likely to be somewhat larger in practice than the values you have calculated.