Accelerator Fundamentals Homework 7

1. The SLAC linac produced electron and positron beams of 45.6 GeV energy each (half the Z_0 mass). Calculate the average energy [eV] of the synchrotron radiation produced by this electron beam due to the bend caused by the Earth's magnetic field (about 0.5 Gauss). What is the wavelength associated with this mean energy [nm]? (note: this unexpected result once caused me a lot of problems).

2. Calculate the power lost to synchrotron radiation and the vertical synchrotron damping times for the following machines. Show the equations you use, but definitely use a spreadsheet to simplify the calculations. (You can just show the calculation once and then use a spreadsheet to calculate the other cases)

Machine	Particle type	Circumference	Bend radius of magnets	Beam Current	Energy (per beam)
LEP	Electrons	27 km	3.5 km	5 mA	45.6 GeV
					104 GeV[1]
LHC	Protons	27 km	3 km	600 mA	7 TeV
HE-LHC[2]	Protons	27 km	3 km	600 mA	16.5 TeV

3. In the case of the 45.6 GeV LEP energy, calculate
   a. The equilibrium energy spread.
   b. The equilibrium x emittance (use $v_x = 90.3$)

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[1] Highest energy reached during LEP II run.
[2] This would be an accelerator base on Nb3Sn dipoles, being considered for 2030 or later.