Accelerator Fundamentals Homework 7

(Corrected!)

1. The magnetic field of the Earth is about .5 Gauss. What energy electron beam would produce synchrotron light with critical wavelength of 500 nm (i.e. visible) when encountering this field[1]?

2. Calculate the total 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[2].

Machine	Particle type	Circumference	Bend radius of magnets	Beam Current	Energy (per beam)
LEP	Electrons	27 km	3.5 km	5 mA	45 GeV
					104 GeV[3]
LHC	Protons	27 km	3 km	600 mA	7 TeV
FCC	Protons	100 km	11 km	600 mA	100 TeV

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

---

[1] **Hint:** start with the expression for the critical wavelength from the notes, and express both ρ and γ in terms of energy (remember, this is ultra-relativistic).

[2] **Hint:** to get the total power, you will first need to convert current into the number of particles in the ring.

[3] Highest energy reached during LEP II run.