JUAS 2014 exam

The following constant will be used in the exercises

velocity of light	$c = 2.998 \cdot 10^8$ m/s
reduced Planck constant	$\eta = h/2\pi = 1.05 \cdot 10^{-34}$ Kg m^2/ s
vacuum dielectric constant	$\varepsilon_0 = 8.854 \cdot 10^{-12}$ F/m
electron rest energy	0.511 MeV
proton rest energy	938 MeV
classical electron radius	$r_e = 1/(4\pi\varepsilon_0)\, e^2/(mc^2) = 2.81 \cdot 10^{-15}$ m

Ex. 1:
The LHC is a proton synchrotron with

proton beam energy (at injection):	450 GeV
proton beam energy (at collision):	7 TeV
LHC dipole bending radius:	2803.9 m

a) compute the critical energy of the synchrotron emission for the LHC proton beam at collision energy;

b) the energy is ramped from the injection energy to the collision energy. Is there a value of the energy during the ramp such that the synchrotron emission is peaked on the blue light (2.8 eV)?

Ex. 2:
The diamond synchrotron stores a 3 GeV electron beam of 300 mA. Knowing that

diamond dipole bending radius:	7.1 m
diamond average radius:	89.4 m

a) compute the energy loss per turn for a single electron;

b) compute the total power lost by a stored beam of 300 mA; what should be the energy of a proton beam with 300 mA in order to radiate the same synchrotron power?

c) assume the RF trips off. Knowing that the maximum horizontal dispersion is 25 cm and the horizontal aperture is ±2 cm. Compute the number of turns the beams survives in the ring before hitting the wall.

Ex. 3:
Consider again Diamond with the data in exercise 2. Assume we add a wiggler with peak field 3.5 T and length 2 m.

a) Compute the new value for the total energy loss per turn per electron

b) Assuming the RF voltage is set to 3 MV, What is the corresponding shift of the synchronous phase?

c) Assuming $J_x \sim 1$, compute the transverse damping time with and without the wiggler.

Ex. 4: low emittance lattices

Describe the physical causes that determine the emittance of an electron beam. What are the basic strategies to build a low emittance lattice (<1 page)?