Physics/Astro 562/ Peterson: Problem Set #3
Due: Tuesday, 2/27/2024
Intro to High Energy Astrophysics

1) **Bremsstrahlung:** The total power emitted from thermal bremsstrahlung we said was

$$\frac{dE}{dVdt} = \frac{32\pi e^6}{3hmc^3}\left(\frac{2\pi k_B}{3m}\right)^{\frac{1}{2}} Z^2 n_e n_i o n T^{\frac{1}{2}}$$

(ignoring the Gaunt factor). Now the energy per unit volume of a thermal plasma is nk_BT. What is the cooling time of a plasma due to Bremsstrahlung (i.e. the time it takes the plasma to lose its energy due to radiation)? How long does it take a $10^8 K$ plasma with number density 10^{-2} cm^{-3} to cool down (typical of plasma in a cluster of galaxies)?

2) **Synchrotron Radiation:** : Given that the synchrotron power for a single electron in a magnetic field is:

$$\frac{dE}{dt} = \frac{4}{3}\sigma_T c \beta^2 \gamma^2 u_B$$

calculate the time it takes an electron to cool from synchrotron emission. How does it depend on energy? How long does it take a 1 keV electron to cool down in a 1 μG magnetic field (typical of our own Galaxy)?