

Exercises for Space Plasma Physics:

III. Single particle motion

1. Under which conditions is the test-particle approach a suitable approximation?
2. What are constants of motions? What are adiabatic invariants?
3. What conditions have to be fulfilled that the motion of charged particles can be described as Drift?
4. How do gyro-radius and frequency change with the magnetic field strength, particle mass, charge and temperature?
5. How do electrons (charge $-e$, mass m_e) and ions (charge $+e$, mass m_i) move under the influence of a constant homogeneous magnetic field $\vec{B} = B_0 \vec{e}_z$ and
 - (a) A constant homogeneous electric field $\vec{E} = E_0 \vec{e}_x$
 - (b) A homogenous, but slowly temporal varying electric field

$$\vec{E} = E(t) \vec{e}_x$$

Hint: In the moving frame (Lorentz transform of E) a free particle does not feel an electric field $\vec{E}' = \vec{E} + \vec{v} \times \vec{B} = 0$ and you can average over the gyroperiod assuming that the temporal changes of the electric field are much slower than the gyro-frequency.

- (c) Do these drift motions produce electric currents? If yes, calculate them.