Introduction to Nuclear Fusion as An Energy Source - Homework 1

2026/4/2

Due date: 2026/4/16

Note: Please provide the results, the description of your code and simulation results. Any programming language is allowed.

Please make codes for simulating particle trajectories and the magnetic field line that pass through the initial position of the particle in the following conditions. **Explanation of the result is required!**

1. [10 points in total] A uniform magnetic field $B_z = 0.1$ T. A proton with an energy of 1 keV. Initial position at the original. The initial velocity vector $v_z = 0$.

2. [10 points in total] A uniform magnetic field $B_z = 0.1$ T. A proton with an energy of 1 keV. Initial position at the original. The initial velocity vector $v_z \neq 0$.

3. [10 points in total] A spherical tokamak with a major radius $R = 45$ cm, a minor radius $a = 32$ cm, and an elongation of $\kappa = 2$. The toroidal field $B_T = 0.1$ T at 45 cm. The plasma current $I_p = 0$. A **proton** with an energy of 1 keV. Initial position at $R = 55$ cm.

4. [10 points in total] A spherical tokamak with a major radius $R = 45$ cm, a minor radius $a = 32$ cm, and an elongation of $\kappa = 2$. The toroidal field $B_T = 0.1$ T at 45 cm. The plasma current $I_p = 0$. An **electron** with an energy of 1 keV. Initial position at $R = 55$ cm. Please compare the result with condition 3.

5. [10 points in total] A spherical tokamak with a major radius $R = 45$ cm, a minor radius $a = 32$ cm, and an elongation of $\kappa = 2$. The toroidal field $B_T = 0.1$ T at 45 cm. The plasma current $I_p = 0$. A electric field $E_z = -1000$ V/m in $\hat{z}$. A **proton** with an energy of 1 keV. Initial position at $R = 55$ cm.

6. [10 points in total] A spherical tokamak with a major radius $R = 45$ cm, a minor radius $a = 32$ cm, and an elongation of $\kappa = 2$. The toroidal field $B_T = 0.1$ T at 45 cm. The plasma current $I_p = 0$. A electric field $E_z = -1000$ V/m in $\hat{z}$. An **electron** with an energy of 1 keV. Initial position at $R = 55$ cm. Please compare the result with condition 5.

7. [10 points in total] A spherical tokamak with a major radius $R = 45$ cm, a minor radius $a = 32$ cm, and an elongation of $\kappa = 2$. The toroidal field $B_T = 0.1$ T at 45 cm. The plasma current $I_p = 100$ kA. A **proton** with an energy of 1 keV. Initial position at $R = 55$ cm.

8. [10 points in total] A spherical tokamak with a major radius $R = 45$ cm, a minor radius $a = 32$ cm, and an elongation of $\kappa = 2$. The toroidal field $B_T = 0.1$ T at 45 cm. The plasma current $I_p = 100$ kA. An **electron** with an energy of 1 keV. Initial position at $R = 55$ cm. Please compare the result with condition 7.

9. [20 points in total] Please compare and explain results from condition 3 to 8.