

Introduction to Plasma Physics (409.307A)

Midterm Examination

11 April, 2019

1. (10 points) Discuss whether the state of a bright gas inside a fluorescent lamp is a plasma or not.

2. Answer the following questions.

(1) (10 points) Calculate the pitch of the helix (Δz in figure 1), moving distance along the magnetic field line after making a cycle motion in the xy -plane.

(2) (10 points) Draw the trajectory of the particle with initial velocity \mathbf{v}_0 when both magnetic fields and ∇B are applied in z -direction as shown in figure 2.

(3) (5 points) What is the force which the particle in figure 2 feels as it is moving to the $+z$ direction?

(4) (15 points) Find the criterion of a charged particle to be confined in the mirror device as shown in figure 3.

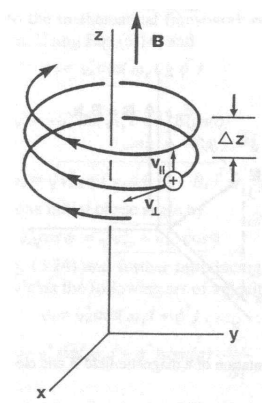


Figure 1

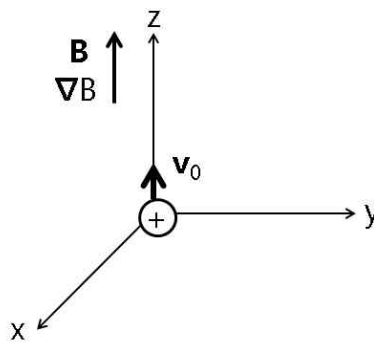


Figure 2

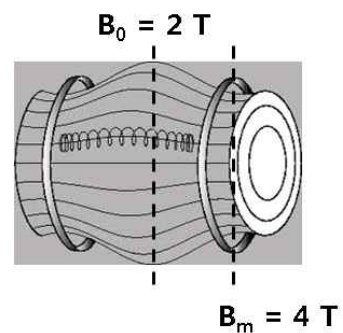


Figure 3

3. If electrons in a plasma have the Maxwellian distribution $f(c)$ of speed in one dimension;

$$f(c) = A \exp\left[-\frac{1}{2}mc^2 / kT\right], \quad n = \int_0^{\infty} f(c)dc$$

(1) (15 points) Find A

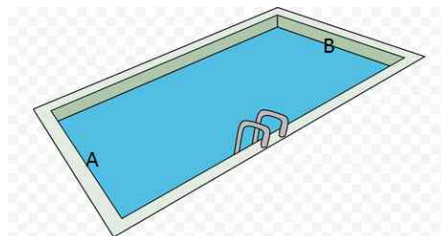
(2) (15 points) Calculate the average kinetic energy of the electrons using the formulae below if needed.

$$\int_0^{\infty} c^{2n} e^{-ac^2} dc = \frac{1 \cdot 3 \cdot 5 \cdots (2n-1)}{2^{n+1} a^n} \sqrt{\frac{\pi}{a}}$$

$$\int_0^{\infty} c^{2n+1} e^{-ac^2} dc = \frac{n!}{2a^{n+1}} \quad (a > 0)$$

(3) (10 points) If the mean value of c^2 of the electrons is $3 \times 10^5 \text{ m}^2/\text{s}^2$, Calculate the electron pressure in the KSTAR tokamak where the electron mass and the number density is $1 \times 10^{-30} \text{ kg}$ and $1 \times 10^{20}/\text{m}^3$, respectively.

4. (10 points) A boy is playing in the outdoor swimming pool, 50 m long. A temperature sensor is attached on his body to measure the time variation of the temperature. If the temperature difference is 10 K between A and B in the swimming pool (see the figure below), calculate the temperature change in the sensor while he swims from A to B. Assume that the temperature increases linearly along his swimming path from A to B and he swims at constant speed of 2 m/s. The temperature rise rate of the swimming pool by sunshine is constant as 0.1 K/s.



"Your commands make me wiser than my enemies, for they are ever with me.

I have more insight than all my teachers, for I meditate on your statutes.

I have more understanding than the elders, for I obey your precepts." (Psalms 119:98-100)