#### Solutions to Chen's Plasma Physics

#### Kalman Knizhnik

1-1. Compute the density (in units of m<sup>-3</sup>) of an ideal gas under the following conditions:

a) At 0"C and 760 Torr pressure (1 Torr = 1mm Hg). This is called the Loschmidt number.

b) In a vacuum at  $10^{-3}$  Torr at room temperature (20°C). This number is a useful one for the experimentalist to know by heart ( $10^{-3}$  Torr = 1 micron).

a) Avogadro's number is  $N_A=6.022\times 10^{23}$ . One mole of gas at STP occupies 22.4 liters. 1 liter is  $1\times 10^{-3}$  cubic meters. Thus, the number per cubic meter is  $N_A/n=6.022\times 10^{25}/(22.4\times 10^{-3})=2.66\times 10^{25}~m^{-3}$ . Thus, the Loschmidt number is  $2.66\times 10^{25}~\Box$ 

b) Using PV=NkT, we obtain (with R= 1.4 × 10<sup>-23</sup> J K<sup>-1</sup> and 1 Torr = 133 Pa):

$$\alpha = \frac{N}{V} = \frac{P}{kT} = \frac{10^{-3} \times 133}{1.4 \times 10^{-23} \times (20 + 273)} = 3.3 \times 10^{19} m^{-3}$$
 
(1)

1-2. Derive the constant A for a normalized one-dimensional Maxwellian distribution

$$\hat{f}(u) = Ae^{-mu^2/2kT}$$
(2)

such that

$$\int_{-\infty}^{\infty} \hat{f}(u)du = 1$$
(3)

This one is straightforward. Just integrate:

$$1 - \int_{-\infty}^{\infty} Ae^{-mu^2/2kT} du = A\sqrt{\frac{2\pi kT}{m}} \rightarrow A = \sqrt{\frac{m}{2\pi kT}} \square$$
 (4)

1-4. Compute the pressure, in atmospheres and in  $tons/ft^2$ , exerted by a thermonuclear plasma on its container. Assume  $kT_c = kT_t = 20keV$ ,  $n = 10^{21}m^{-3}$  and p = nkT, where  $T = T_t + T_c$ .

This is just unit conversion, albeit with units that nobody really ever remembers. For reference,  $1 \text{ keV} = 1.6 \times 10^{-19} J$ , so

$$p = 10^{21} \times (20 keV + 20 keV) = 4 \times 10^{22} m^{-3} keV = 4 \times 10^{3} m^{-3} J = 4 \times 10^{3} N/m^{2}$$
 (5)

But 1  $atm = 10^5 N/m^2 = 1 ton/ft^2$ , so (Note: I think there is a mistake in Chen's solutions here. If I am mistaken, please let me know).

$$p = 0.04 \text{ atm} = 0.04 \text{ ton/}ft^2 \square$$
 (6)

1-5. In a strictly steady state situation, both the ions and the electrons will follow the Boltzmann relation

$$n_j = n_0 e^{-q_j \phi/kT_j}$$
(7)

For the case of an infinite, transparent grid charged to a potential c, show that the shielding distance is given approximately by

$$\lambda_O^{-2} = \frac{ne^2}{\epsilon_O} (\frac{1}{kT_c} + \frac{1}{kT_l})$$
 (8)

Show that  $\lambda_D$  is determined by the temperature of the colder species. We'll use Poisson's equation

$$\nabla^2 \phi = \frac{en_e - en_i}{\epsilon_0} = \frac{en_0}{\epsilon_0} \left(e^{\epsilon\phi/kT_e} - e^{-\phi\phi/kT_i}\right) \approx \frac{en_0}{\epsilon_0} \left(1 + \frac{e\phi}{kT_e} - 1 - \frac{-e\phi}{kT_i}\right) = \frac{e^2\alpha}{\epsilon_0} \left(\frac{\phi}{kT_e} + \frac{\phi}{kT_i}\right) \quad (9)$$

# **Solution Manual Of Plasma Physics**

O García

## **Solution Manual Of Plasma Physics:**

Solutions Manual for Controlled Fusion and Plasma Physics Miyamoto Kenro, Miyamoto Kenro Staff, 2006-07 Plasma Physics Richard Fitzpatrick, 2022-12-13 Encompasses the Lectured Works of a Renowned Expert in the Field Plasma Physics An Introduction is based on a series of university course lectures by a leading name in the field and thoroughly covers the physics of the fourth state of matter This textbook provides a concise and cohesive introduction to plasma physics theory and offers a solid foundation for students of physics wishing to take higher level courses in plasma physics Mathematically Rigorous but Driven by Physics The author provides an in depth discussion of the various fluid theories typically used in plasma physics presenting non relativistic fully ionized nondegenerate quasi neutral and weakly coupled plasma This second edition has been fully updated to include new content on collisions and magnetic reconnection It contains over 80 exercises carefully selected for their pedagogical value with fully worked out solutions available in a separate solutions manual for professors The material presents a number of applications and works through specific topics including basic plasma parameters the theory of charged particle motion in inhomogeneous electromagnetic fields collisions plasma fluid theory electromagnetic waves in cold plasmas electromagnetic wave propagation through inhomogeneous plasmas kinetic theory magnetohydrodynamical fluid theory and magnetic reconnection Features Discusses fluid theory illustrated by the investigation of Langmuir sheaths Explores charged particle motion illustrated by the investigation of charged particle trapping in the earth's magnetosphere Examines the MHD and WKB theories Plasma Kinetic Theory -Engineering Education ,1983 Solutions Manual Donald Gary Swanson, 2008-02-22 **Waves and Oscillations in** Plasmas Hans L. Pecseli, 2020-05-05 Waves and Oscillations in Plasmas addresses central issues in modern plasma sciences within the context of general classical physics The book is working gradually from an introductory to an advanced level Addressing central issues in modern plasma sciences including linear and nonlinear wave phenomena this second edition has been fully updated and includes the latest developments in relevant fluid models as well as kinetic plasma models including a detailed discussion of for instance collisionless Landau damping linear as well as non linear The book is the result of many years of lecturing plasma sciences in Norway Denmark Germany and also at the Unites States of America Offering a clear separation of linear and nonlinear models the book can be tailored for students of varying levels of expertise in plasma physics in addition to areas as diverse as the space sciences laboratory experiments plasma processing and more Features Presents a simple physical interpretation of basic problems is presented where possible Supplies a complete summary of classical papers and textbooks placed in the proper context Includes worked examples exercises and problems with general applicability Lectures on Numerical Methods for Non-Linear Variational Problems R. Glowinski, 2008-01-22 When Herb Keller suggested more than two years ago that we update our lectures held at the Tata Institute of Fundamental Research in 1977 and then have it published in the collection Springer Series in Computational Physics we thought at first that it would

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