

Solutions to Chen's Plasma Physics

Kalman Krizhnik

1-1. Compute the density (in units of m^{-3}) 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 1×10^{-3} cubic meters. Thus, the number per cubic meter is $N_A/n = 6.022 \times 10^{23}/(22.4 \times 10^{-3}) = 2.66 \times 10^{25} m^{-3}$. Thus, the Loschmidt number is 2.66×10^{25} $\square$

b) Using $PV=NkT$, we obtain (with $R = 1.4 \times 10^{-23} \text{ J } K^{-1}$ and 1 Torr = 133 Pa):

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

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

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

such that

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

This one is straightforward. Just integrate:

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

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

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

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

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

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

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

$$n_i = n_0 e^{-e\phi/kT_i} \quad (7)$$

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

$$\lambda_D^{-2} = \frac{ne^2}{\epsilon_0} \left(\frac{1}{kT_e} + \frac{1}{kT_i} \right) \quad (8)$$

Show that λ_D is determined by the temperature of the colder species.

We'll use Poisson's equation

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

Solution Manual For Fundamentals Of Plasma Physics

**Thirumalaisamy P.
Velavancorresponding**



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Advance Elements of Laser Circuits and Systems Ofer Aluf, 2021-03-09 This book on Advance Elements of Laser circuits and systems Nonlinearity applications in engineering addresses two separate engineering and scientific areas and presents advanced analysis methods for Laser circuits and systems that cover a broad range of engineering and scientific applications The book analyzed Laser circuits and systems as linear and nonlinear dynamical systems and there limit cycles bifurcation and limit cycle stability by using nonlinear dynamic theory Further it discussed a broad range of bifurcations related to Laser systems and circuits starting from laser system differential equations and their bifurcations delay differential equations DDEs are a function of time delays delay dependent parameters followed by phase plane analysis limit cycles and their bifurcations chaos iterated maps period doubling It combines graphical information with analytical analysis to effectively study the local stability of Laser systems models involving delay dependent parameters Specifically the stability of a given steady state is determined by the graphs of some functions of which can be expressed explicitly The Laser circuits and systems are Laser diode circuits MRI system Laser diode circuitry Electron photon exchanges into VCSEL Ti Sapphire laser systems Ion channel and long wavelength lasers Solid state lasers Solid state laser controlled by semiconductor devices microchip solid state laser Q switched diode pumped solid state laser Nd YAG Mid Infrared and Q switched microchip lasers Gas laser systems copper vapor laser CVL circuitry Dual wavelength laser systems Dual wavelength operation of a Ti sapphire laser Diode pumped Q switched Nd YVO₄ yellow laser Asymmetric dual quantum well lasers Tm₃ doped silica fibre lasers Terahertz dual wavelength quantum cascade laser The Book address also the additional areas Laser X guiding system Plasma diagnostics Laser Beam shaping Jitter and crosstalk Plasma mirror systems and High power Laser Target diagnostic system optical elements The book is unique in its emphasis on practical and innovative engineering and scientific applications All conceptual Laser circuits are innovative and can be broadly implemented in many engineering applications The dynamics of Laser circuits and systems provides several ways to use them in a variety of applications covering wide areas This book is aimed at electrical and electronics engineers students and researchers in physics as well It is also aimed for research institutes in lasers and plasma physics and gives good comprehensive in laser and plasma systems In each chapter the concept is developed from basic assumptions up to the final engineering and scientific outcomes The scientific background is explained at basic and advance levels and closely integrated with mathematical theory Many examples are presented in this book and it is also ideal for intermediate level courses at graduate level studies It is also ideal for engineer who has not had formal instruction in nonlinear dynamics but who now desires to fill the gap between innovative Laser circuits systems and advance mathematical analysis methods

Fundamentals of the Optics of Materials Vladimir I. Gavrilenko, Volodymyr S. Ovechko, 2023-10-19 This textbook showcases the rapidly developing field of materials optics It is aimed at a broad audience as the readers require only university entry level knowledge of physics chemistry and optics It

overviews the basics of optical engineering and the typical and widely used applications of materials optics with the first general chapters corresponding to the standard university courses targeting bachelor s and master s degrees in physics The next few chapters present the modern developments in materials optics such as nano plasmonics nano photonics and optical properties of nano sized materials intended for readers familiar with the basic elements of quantum mechanics Some more specialized chapters address recent developments in fields such as optics of solid surfaces plasma optics optics of composites alloys and metamaterials optics of anisotropic materials optics of organic and biological materials and relativistic effects in optics The appendices present a more advanced description of selected topics with important reference materials subject index and extended list of publications as well as numerous examples and problems to better orient readers interested in gaining further knowledge of the subject

Radio Wave Propagation Fundamentals, Second Edition Artem

Saakian,2020-12-31 This completely updated second edition of an Artech House classic provides a thorough introduction to the basic principles of electromagnetic wave propagation of radio frequencies in real world conditions fully updated by including new achievements in theory and technology It serves as an invaluable daily reference for practitioners in the field and as a complete organized text on the subject This comprehensive resource covers a wide range of essential topics from the classification of radio waves electromagnetic wave theory and antennas for RF radio links to the impact of the earth surface on the propagation of ground waves atmospheric affects in radio wave propagation and radio wave reception The book explores the propagation of the ground radio waves namely the waves that propagate in vicinity of the earth s surface e g guided by that interface without involvement of any atmospheric effects Specifics of the high frequency HF radio propagation due to reflections from ionospheric layers is studied based on commonly used models of the ionospheric vertical profiles Scattering of the radio waves of UHF and higher frequency bands from the random variations of the tropospheric refraction index from tiny air turbulences are also considered by using the principles of statistical radio physics Analysis of propagation conditions on real propagation paths including analysis of the power budget of the VHF UHF link to assure its stability percentage of availability within observation time frame terrestrial broadcast mobile and satellite RF links are presented The engineering design of the cellular networks including LTE 4G 5G and upcoming higher generations is explored HF propagation predictions for extremely long range links design for commercial and military applications are explained Packed with examples and problems this book provides a theoretical background for astrophysical aeronomy and geophysical instrumentation design

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