Introduction To Plasmas And Plasma Dynamics With Reviews Of Applications In Space Propulsion Magnetic Fusion And Space Physics

The physics of emission, absorption and interaction of light in astrophysics and in laboratory plasmas is developed from first principles and applied across various fields, from quantum mechanics, electricity and magnetism, to statistical physics. This text links undergraduate level atomic and radiation physics with the advanced material required for postgraduate study and research.
This compact and well-organized text provides an introduction to plasma physics and shows the interaction of plasmas without any external magnetic fields. It deals with the concepts, processes, and characteristic features associated with plasmas. The interaction of magnetic fields on plasma is purposely excluded in this introductory text to help students grasp the basics first, which makes the understanding of the effects of the magnetic fields easier in the subsequent courses. The book begins with a review of the concepts of kinetic theory of gases, collision phenomena in ionized gases and motion of charged particles. It goes on to give a discussion on the characteristic properties of plasmas and conditions to be satisfied for an ionized gas to show plasma behaviour. In addition, the text covers such topics as transport processes, plasma oscillations, and plasma as a dielectric medium, as a charged fluid, and as a many-body system. Finally, it provides a systematic analysis of important instabilities for an unmagnetized plasma, as well as a discussion on the radiation processes. The organization is systematic and the style lucid, with more physical insight and only relevant mathematics. The text is well illustrated, and the References and Bibliography at the end of the book should stimulate those students who have a desire to study the subject deeper. It is a one-semester text and is designed for the undergraduate, postgraduate and research students of science and engineering who wish to choose plasma physics, astrophysics or space physics as their special areas of study.
This book provides the ideal introduction to this complex and fascinating field of research, balancing the theoretical and practical and preparing the student for further study.
A good working knowledge of fluid mechanics and plasma physics is essential for the modern astrophysicist. This graduate textbook provides a clear, pedagogical introduction to these core subjects. Assuming an undergraduate background in physics, this book develops fluid mechanics and plasma physics from first principles. This book is unique because it presents neutral fluids and plasmas in a unified scheme, clearly indicating both their similarities and their differences. Also, both the macroscopic (continuum) and microscopic (particle) theories are developed, establishing the connections between them. Throughout, key examples from astrophysics are used, though no previous knowledge of astronomy is assumed. Exercises are included at the end of chapters to test the reader's understanding. This textbook is aimed primarily at astrophysics graduate students. It will also be of interest to advanced students in physics and applied mathematics seeking a unified view of fluid mechanics and plasma physics, encompassing both the microscopic and macroscopic theories.
Confinement, Transport and Collective Effects
The Physics of Fluids and Plasmas
Introduction to High-Frequency Discharges
An Introduction to Alfven Waves,
Introduction to Plasma Physics

Introduction to Plasma Physics presents the latest on plasma physics. Although plasmas are not very present in our immediate environment, there are still universal phenomena that we encounter, i.e., electric shocks and galactic jets. This book presents, in parallel, the basics of plasma theory and a number of applications to laboratory plasmas or natural plasmas. It provides a fresh look at concepts already addressed in other disciplines, such as pressure and temperature. In addition, the information provided helps us understand the links between fluid theories, such as MHD and the kinetic theory of these media, especially
propagation. Presents the different phenomena that make up plasma physics Explains the basics of plasma theory Helps readers comprehend the various concepts related to plasmas
Provides a complete introduction to plasma physics as taught in a 1-year graduate course. Covers all important topics of plasma theory, omitting no mathematical steps in derivations. Covers solitons, parametric instabilities, weak turbulence theory, and more. Includes exercises and problems which apply theories to practical examples. 4 of the 10 chapters do not include complex variables and can be used for a 1-semester senior level undergraduate course.
This book grew out of lecture notes for an undergraduate course in plasma physics that has been offered for a number of years at UCLA. With the current increase in interest in controlled fusion and the wide spread use of plasma physics in space research and relativistic as trophysics, it makes sense for the study of plasmas to become a part of an undergraduate student's basic experience, along with subjects like thermodynamics or quantum mechanics. Although the primary purpose of this book was to fulfill a need for a text that seniors or juniors can really understand, I hope it can also serve as a painless way for scientis
fields-solid state or laser physics, for instance to become acquainted with plasmas. Two guiding principles were followed: Do not leave algebraic steps as an exercise for the reader, and do not let the algebra obscure the physics. The extent to which these opposing aims could be met is largely due to the treatment of a plasma as two interpenetrating fluids. The two-fluid picture is both easier to understand and more accurate than the single-fluid approach, at least for low-density plasma phe nomena.
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 book looks at non-relativistic, fully ionized, nondegenerate, quasi-neutral, and weakly coupled plasma. Intended for the student market, the text provides a concise and cohesive introduction to plasma physics theory, and offers a solid foundation for students wishing to take higher level courses in plasma physics. Mathematically Rigorous, but Driven by Physics This work conta
exercises—carefully selected for their pedagogical value—with fully worked out solutions available in a separate solutions manual for professors. The author provides an in-depth discussion of the various fluid theories typically used in plasma physics. 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, plasma fluid theory, electromagnetic waves in cold plasmas, electromagnetic wave propagation through inhomogeneous plasmas, magnetohydrodynamical fluid theory, and kinetic
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 WKB theory illustrated by the investigation of radio wave propagation in the earth's ionosphere Studies the MHD theory illustrated by the investigation of solar wind, dynamo theory, magnetic reconnection, and MHD shocks Plasma Physics: An Introduction addresses applied areas and advanced topics in the study of plasma physics, and specifically demonstrates the behavior of ionized gas.
With Space, Laboratory and Astrophysical Applications
An Introduction to Plasma Physics and Its Space Applications, Volume 2
Introduction to Plasma Physics and Controlled Fusion
Plasma Physics
Introduction to Plasma Technology

Introduction to Plasmas and Plasma Dynamics provides an accessible introduction to the understanding of high temperature, ionized gases necessary to conduct research and develop applications related to plasmas. While standard presentations of introductory material emphasize physics and the theoretical basis of the topics, this text acquaints the reader with the context of the basic information and presents the fundamental knowledge required for advanced work or study. The book relates theory to relevant devices and mechanisms, presenting a clear outline of analysis and mathematical detail; it highlights the significance of the concepts with reviews of recent applications and trends in plasma engineering, including topics of plasma formation and magnetic fusion, plasma thrusters and space propulsion. Presents the essential principles of plasma dynamics needed for effective research and development work in plasma applications Emphasizes physical understanding and supporting theoretical foundation with reference to their utilization in devices, mechanisms and phenomena Covers a range of applications, including energy conversion, space propulsion, magnetic fusion, and space physics.
A wide-ranging introduction to the theoretical and experimental study of plasmas and their applications.
Plasma Physics: Confinement, Transport and Collective Effects provides an overview of modern plasma research with special focus on confinement and related issues. Beginning with a broad introduction, the book leads graduate students and researchers – also those from related fields - to an understanding of the state-of-the-art in modern plasma physics. Furthermore, it presents a methodological cross section ranging from plasma applications and plasma diagnostics to numerical simulations, the latter providing an increasingly important link between theory and experiment. Effective references guide the reader from introductory texts through to contemporary research. Some related exercises in computational plasma physics are supplied on a special web site
TO THE SECOND EDITION In the nine years since this book was first written, rapid progress has been made scientifically in nuclear fusion, space physics, and nonlinear plasma theory. At the same time, the energy shortage on the one hand and the exploration of Jupiter and Saturn on the other have increased the national awareness of the important applications of plasma physics to energy production and to the understanding of our space environment. In magnetic confinement fusion, this period has seen the attainment 13 of a Lawson number nTE of 2 x 10 cm -3 sec in the Alcator tokamaks at MIT; neutral-beam heating of the PL T tokamak at Princeton to KTi = 6. 5 keV; increase of average ß to 3%-5% in tokamaks at Oak Ridge and General Atomic; and the stabilization of mirror-confined plasmas at Livermore, together with injection of ion current to near field-reversal conditions in the 2XIIß device. Invention of the tandem mirror has given magnetic confinement a new and exciting dimension. New ideas have emerged, such as the compact torus, surface-field devices, and the EßT mirror-torus hybrid, and some old ideas, such as the stellarator and the reversed-field pinch, have been revived. Radiofrequency heat ing has become a new star with its promise of dc current drive. Perhaps most importantly, great progress has been made in the understanding of the MHD behavior of toroidal plasmas: tearing modes, magnetic VII VIII islands, and disruptions.
Plasma Atomic Physics
Space Physics
Basic Equations and Applications
An Introduction to the Atomic and Radiation Physics of Plasmas
Introduction to Plasma Dynamics

This book is a brief introduction to plasma physics. The book is divided into two parts, focusing initially on molecular collisions, before moving on to examine the physical description of plasmas as a system of interacting particles. Basic concepts are introduced in a simple way and mathematical developments and demonstrations are covered thoroughly. The fundamental processes in a plasma at the atomic and molecular level are discussed, with updated experimental data sets provided. Each chapter concludes with references and commentaries for further insight in the essential points. Two important applications of plasma physics in aerospace technology are introduced in the last chapters: the electric propulsion in space and low-pressure microwave electric discharges, currently denominated multipactor and corona. The book is for Master and undergraduate courses of aerospace engineering and physics. It is also aimed at both non-specialists and professionals involved in laboratory testing for space qualification.
Colloidal plasmas - a still emerging field of plasma physics - enable the study of basic plasma properties on a microscopic kinetic level and allow the visualization of collective plasma phenomena, like oscillations and waves. Moreover, a vast number of novel phenomena are found in these systems, ranging from Coulomb crystallization to new types of forces and waves. Last but not least, they shed a new light on various traditional aspects of plasma physics such as shielding or the mechanism of acoustic waves in plasmas, thus providing new insight into the basic foundations of plasma physics.These course-based and self-contained lecture notes provide a general introduction to this active and growing field to students and nonspecialists, requiring only basic prior knowledge in plasma physics. ?
A practical introduction to microwave plasma for processing applications at a variety of pressures In Microwave Plasma Sources and Methods in Processing Technology, an award-winning team of researchers delivers a comprehensive introduction to microwaves and microwave-generated plasmas. Ideal for anyone interested in non-thermal gas discharge plasmas and their applications, the book includes detailed descriptions, explanations, and practical guidance for the study and use of microwave power, microwave components, plasma, and plasma generation. This reference includes over 130 full-color diagrams to illustrate the concepts discussed within. The distinguished authors discuss the plasmas generated at different levels of power, as well as their applications at reduced, atmospheric and higher pressures. They also describe plasmas inside liquids and plasma interactions with combustion flames. Microwave Plasma Sources and Methods in Processing Technology concludes with an incisive exploration of new trends in the study and application of microwave discharges, offering promising new areas of study. The book also includes: A thorough introduction to the basic principles of microwave techniques and power systems, including a history of the technology, microwave generators, waveguides, and wave propagation A comprehensive exploration of the fundamentals of the physics of gas discharge plasmas, including plasma generation, Townsend coefficients, and the Paschen curve Practical discussions of the interaction between plasmas and solid surfaces and gases, including PVD, PE CVD, oxidation, sputtering, evaporation, dry etching, surface activation, and cleaning In-depth examinations of microwave plasma systems for plasma processing at varied parameters Perfect for researchers and engineers in the microwave community, as well as those who work with plasma applications, Microwave Plasma Sources and Methods in Processing Technology will also earn a place in the libraries of graduate and PhD students studying engineering physics, microwave engineering, and plasmas.
Introducing basic principles of plasma physics and their applications to space, laboratory and astrophysical plasmas, this new edition provides updated material throughout. Topics covered include single-particle motions, kinetic theory, magnetohydrodynamics, small amplitude waves in hot and cold plasmas, and collisional effects. New additions include the ponderomotive force, tearing instabilities in resistive plasmas and the magnetorotational instability in accretion disks, charged particle acceleration by shocks, and a more in-depth look at nonlinear phenomena. A broad range of applications are explored: planetary magnetospheres and radiation belts, the confinement and stability of plasmas in fusion devices, the propagation of discontinuities and shock waves in the solar wind, and analysis of various types of plasma waves and instabilities that can occur in planetary magnetospheres and laboratory plasma devices. With step-by-step derivations and self-contained introductions to mathematical methods, this book is ideal as an advanced undergraduate to graduate-level textbook, or as a reference for researchers.
An Introduction to Laboratory, Space, and Fusion Plasmas
Microwave Plasma Sources and Methods in Processing Technology
Introduction to Dusty Plasma Physics
Introduction to Plasmas and Plasma Dynamics: With Reviews of Applications in Space Propulsion, Magnetic Fusion and Space Physics
Eine Einführung in die experimentellen und theoretischen Grundlagen

This book is an outgrowth of courses in plasma physics which I have taught at Kiel University for many years. During this time I have tried to convince my students that plasmas as different as gas dicharges, fusion plasmas and space plasmas can be described in a uni ed way by simple models. The challenge in teaching plasma physics is its apparent complexity. The wealth of plasma phenomena found in so diverse elds makes it quite different from atomic physics, where atomic structure, spectral lines and chemical binding can all be derived from a single equation—the Schrödinger equation. I positively accept the variety of plasmas and refrain from subdividing plasma physics into the traditional, but arti cially separated elds, of hot, cold and space plasmas. This is why I like to confront my students, and the readers of this book, with examples from so many elds. By this approach, I believe, they will be able to become discoverers who can see the commonality between a falling apple and planetary motion. As an experimentalist, I am convinced that plasma physics can be best understood from a bottom-up approach with many illustrating examples that give the students con dence in their understanding of plasma processes. The theoretical framework of plasma physics can then be introduced in several steps of re nement. In the end, the student (or reader) will see that there is something like the Schrödinger equation, namely the Vlasov-Maxwell model of plasmas, from which nearly all phenomena in collisionless plasmas can be derived.
A comprehensive introductory graduate textbook illustrating specialised topics in current physics.
Introduction to Plasma Physics is the standard text for an introductory lecture course on plasma physics. The text's six sections lead readers systematically and comprehensively through the fundamentals of modern plasma physics. Sections on single-particle motion, plasmas as fluids, and collisional processes in plasmas lay the groundwork for a thorough understanding of the subject. The authors take care to place the material in its historical context for a rich understanding of the ideas presented. They also emphasize the importance of medical imaging in radiotherapy, providing a logical link to more advanced works in the area. The text includes problems, tables, and illustrations as well as a thorough index and a complete list of references.
Introduction to Dusty Plasma Physics contains a detailed description of the occurrence of dusty plasmas in our Solar System, the Earth's mesosphere, and in laboratory discharges. The book illustrates numerous mechanisms for charging dust particles and provides studies of the grain dynamics under the influence of forces that are common in dusty plasma environments.
Plasma Physics: An Introductory Course
Complex Plasmas
With Reviews of Applications in Space Propulsion, Magnetic Fusion and Space Physics
Introduction to Complex Plasmas
Introduction to Plasma Theory

Plasma Atomic Physics provides an overview of the elementary processes within atoms and ions in plasmas, and introduces readers to the language of atomic spectra and light emission, allowing them to explore the various and fascinating radiative properties of matter. The book familiarizes readers with the complex quantum-mechanical descriptions of electromagnetic and collisional processes, while also developing a number of effective qualitative models that will allow them to obtain adequately comprehensive descriptions of collisional-radiative processes in dense plasmas, dielectronic satellite emissions and autoionizing states, hollow ion X-ray emissions, polarized atoms and ions, hot electrons, charge exchange, atomic population kinetics, and radiation transport. Numerous applications to plasma spectroscopy and experimental data are presented, which concern magnetic confinement fusion, inertial fusion, laser-produced plasmas, and X-ray free-electron lasers' interaction with matter. Particular highlights include the development of quantum kinetics to a level surpassing the almost exclusively used quasi-classical approach in atomic population kinetics, the introduction of the recently developed Quantum-F-Matrix-Theory (QFMT) to study the impact of plasma microfields on atomic populations, and the Enrico Fermi equivalent photon method to develop the "Plasma Atom", where the response properties and oscillator strength distribution are represented with the help of a local plasma frequency of the atomic electron density. Based on courses held by the authors, this material will assist students and scientists studying the complex processes within atoms and ions in different kinds of plasmas by developing relatively simple but highly effective models. Considerable attention is paid to a number of qualitative models that deliver physical transparency, while extensive tables and formulas promote the practical and useful application of complex theories and provide effective tools for non-specialist readers.
This rigorous explanation of plasmas is relevant to diverse plasma applications such as controlled fusion, astrophysical plasmas, solar physics, magnetospheric plasmas, and plasma thrusters. More thorough than previous texts, it exploits new powerful mathematical techniques to develop deeper insights into plasma behavior. After developing the basic plasma equations from first principles, the book explores single particle motion with particular attention to adiabatic invariance. The author then examines types of plasma waves and the issue of Landau damping. Magnetohydrodynamic equilibrium and stability are tackled with emphasis on the topological concepts of magnetic helicity and self-organization. Advanced topics follow, including magnetic reconnection, nonlinear waves, and the Fokker-Planck treatment of collisions. The book concludes by discussing unconventional plasmas such as non-neutral and dusty plasmas. Written for beginning graduate students and advanced undergraduates, this text emphasizes the fundamental principles that apply across many different contexts.
Although based on lectures given for graduate students and postgraduates starting in plasma physics, this concise introduction to the fundamental processes and tools is as well directed at established researchers who are newcomers to spectroscopy and seek quick access to the diagnostics of plasmas ranging from low- to high-density technical systems at low temperatures, as well as from low- to high-density hot plasmas. Basic ideas and fundamental concepts are introduced as well as typical instrumentation from the X-ray to the infrared spectral regions. Examples, techniques and methods illustrate the possibilities. This book directly addresses the experimentalist who actually has to carry out the experiments and their interpretation. For that reason about half of the book is devoted to experimental problems, the instrumentation, components, detectors and calibration.
Most of the visible matter in the universe exists in the plasma state. Plasmas are of major importance for space physics, solar physics, and astrophysics. On Earth they are essential for magnetic controlled thermonuclear fusion. This textbook collects lecture notes from a one-semester course taught at the K.U. Leuven to advanced undergraduate students in applied mathematics and physics. A particular strength of this book is that it provides a low threshold introduction to plasmas with an emphasis on first principles and fundamental concepts and properties. The discussion of plasma models is to a large extent limited to Magnetohydrodynamics (MHD) with its merits and limitations clearly explained. MHD provides the students on their first encounter with plasmas, with a powerful plasma model that they can link to familiar classic fluid dynamics. The solar wind is studied as an example of hydrodynamics and MHD at work in solar physics and astrophysics.
Physics Of Space Plasmas
Physics of Dusty Plasmas
An Introduction to Plasmas and Particles in the Heliosphere and Magnetospheres
Science, Engineering, and Applications
Fundamentals of Plasma Physics

Designed as a textbook for both graduate and advanced undergraduate students, Introduction to Plasma Physics is organized into six Units which lead the reader comprehensively through the fundamentals of modern plasma physics. Units on single-particle motion, plasmas as fluids and collisional processes in plasmas lay the groundwork for the understanding of the subject. The text then moves on to apply this understanding to waves and instabilities in a fluid plasma, and finally introduces the kinetic theory of plasmas and re-examines waves and instabilities from the kinetic viewpoint. Many problems of varying levels of difficulty complement the book. In addition, two computer programs (included in both Macintosh and IBM formats) allow the student to examine and experiment with theoretical models of complex plasma phenomena -- making this an invaluable modern teaching resource. The Princeton Plasma Physics Laboratory has long been home to some of the most exciting and important developments inplasma physics and, through its association with Princeton University, sponsors a highly regarded undergraduate and graduate educational program
Alfven waves permeate the universe. They have been observed in the Sun, in the magnetosphere, as low frequency fluctuations in the Earth's magnetic field, and they are easily generated in laboratory plasmas. Alfven waves serve as a useful diagnostic tool to probe plasma conditions in both space and laboratory plasmas. In the quest for nuclear fusion they have been used with spectacular success to heat tokamak plasmas to temperatures exceeding 50 million Kelvin. This book aims to provide an introduction to the physics of Alfven wave propagation for postgraduate physicists and astrophysicists who are entering research on laboratory or space plasmas. In the early chapters the basic properties of Alfven waves are derived for homogeneous plasmas, using the ideal magnetohydrodynamic fluid equations. The essential differences between torsional and compressional wave types are highlighted by an examination of phase and group velocity surfaces, and by a discussion of recent experimental results obtained with small, 'point-source', antennae. Later chapters deal with cylindrical plasmas, Alfven waves in a plasma with two or more ion species, effects of plasma current, resistive damping and inhomogeneous plasmas. There are also two chapters about numerical and experimental techniques, topics which are often neglected in other books.
The growing number of scientific and technological applications of plasma physics in the field of Aerospace Engineering requires that graduate students and professionals understand their principles. This introductory book is the expanded version of class notes of lectures I taught for several years to students of Aerospace Engineering and Physics. It is intended as a reading guide, addressed to students and non-specialists to tackle later with more advanced texts. To make the subject more accessible the book does not follow the usual organization of standard textbooks in this field and is divided in two parts. The first introduces the basic kinetic theory (molecular collisions, mean free path, etc.) of neutral gases in equilibrium in connection to the undergraduate physics courses. The basic properties of ionized gases and plasmas (Debye length, plasma frequencies, etc.) are addressed in relation to their equilibrium states and the collisional processes at the microscopic level. The physical description of short and long-range (Coulomb) collisions and the more relevant collisions (elementary processes) between electrons' ions and neutral atoms or molecules are discussed. The second part introduces the physical description of plasmas as a statistical system of interacting particles introducing advanced concepts of kinetic theory, (non-equilibrium distribution functions, Boltzmann collision operator, etc). The fluid transport equations for plasmas of electron ions and neutral atoms and the hydrodynamic models of interest in space science and plasma technology are derived. The plasma production in the laboratory in the context of the physics of electric breakdown is also discussed. Finally, among the myriad of aerospace applications of plasma physics, the low pressure microwave electron multipactor breakdown and plasma thrusters for space propulsion are presented in two separate chapters.
This complete introduction to plasma physics and controlled fusion by one of the pioneering scientists in this expanding field offers both a simple and intuitive discussion of the basic concepts of this subject and an insight into the challenging problems of current research. In a wholly lucid manner the work covers single-particle motions, fluid equations for plasmas, wave motions, diffusion and resistivity, Landau damping, plasma instabilities and nonlinear problems. For students, this outstanding text offers a painless introduction to this important field; for teachers, a large collection of problems; and for researchers, a concise review of the fundamentals as well as original treatments of a number of topics never before explained so clearly. This revised edition contains new material on kinetic effects, including Bernstein waves and the plasma dispersion function, and on nonlinear wave equations and solitons. For the third edition, updates was made throughout each existing chapter, and two new chapters were added; Ch 9 on "Special Plasmas" and Ch 10 on Plasma Applications (including Atmospheric Plasmas).
An Introduction to the Linear Theories and Methods of Electrostatic Waves in Plasmas
Introduction to Plasma Spectroscopy
The Physics of Plasmas
An Introduction to Plasma Physics and Its Space Applications, Volume 1
Scientific Challenges and Technological Opportunities

This text is an introduction to the physics of collisional plasmas, as opposed to plasmas in space. It is intended for graduate students in physics and engineering . The first chapter introduces with progressively increasing detail, the fundamental concepts of plasma physic. The motion of individual charged particles in various configurations of electric and magnetic fields is detailed in the second chapter while the third chapter considers the collective motion of the plasma particles described according to a hydrodynamic model. The fourth chapter is most original in that it introduces a general approach to energy balance, valid for all types of discharges comprising direct current(DC) and high frequency (HF) discharges, including an applied static magnetic field. The basic concepts required in this fourth chapter have been progressively introduced in the previous chapters. The text is enriched with approx. 100 figures, and alphabetical index and 45 fully resolved problems. Mathematical and physical appendices provide complementary information or allow to go deeper in a given subject.
This textbook was developed to provide seniors and first-year graduate students in physical sciences with a general knowledge of electrodynamic phenomena in space. Since the launch of the first unmanned satellite in 1957, experiments have been performed to study the behavior of electromagnetic fields and charged particles. There is now a considerable amount of data on hand, and many articles, including excellent review articles, have been written for the specialists. However, for students, new researchers, and non-specialists, a need still exists for a book that integrates these observations in a coherent way. This book is an attempt to meet that need by using the theory of classical electrodynamics to unify space observations. The contents of this book are based on classroom notes developed for an introductory space physics course that the author has taught for many years at the University of Washington. Students taking the course normally have had an undergraduate course in electricity and magnetism but they come with very little knowledge about space.
Modern plasma physics, encompassing wave-particle interactions and collec tive phenomena characteristic of the collision-free nature of hot plasmas, was founded in 1946 when 1. D. Landau published his analysis of linear (small amplitude) waves in such plasmas. It was not until some ten to twenty years later, however, with impetus from the then rapidly developing controlled fusion field, that sufficient attention was devoted, in both theoretical and experimental research, to elucidate the importance and ramifications of Landau's original work. Since then, with advances in laboratory, fusion, space, and astrophysical plasma research, we have witnessed important devel opments toward the understanding of a variety of linear as well as nonlinear plasma phenomena, including plasma turbulence. Today, plasma physics stands as a well-developed discipline containing a unified body of powerful theoretical and experimental techniques and including a wide range of appli cations. As such, it is now frequently introduced in university physics and engineering curricula at the senior and first-year-graduate levels. A necessary prerequisite for all of modern plasma studies is the under standing oflinear waves in a temporally and spatially dispersive medium such as a plasma, including the kinetic (Landau) theory description of such waves. Teaching experience has usually shown that students (seniors and first-year graduates), when first exposed to the kinetic theory of plasma waves, have difficulties in dealing with the required sophistication in multidimensional complex variable (singular) integrals and transforms.
As the twenty-first century progresses, plasma technology will play an increasing role in our lives, providing new sources of energy, ion-plasma processing of materials, wave electromagnetic radiation sources, space plasma thrusters, and more. Studies of the plasma state of matter not only accelerate technological developments but also improve the understanding of natural phenomena. Beginning with an introduction to the characteristics and types of plasmas, Introduction to Plasma Dynamics covers the basic models of classical diffuse plasmas used to describe such phenomena as linear and shock waves, stationary flows, elements of plasma chemistry, and principles of plasma lasers. The author presents specific examples to demonstrate how to use the models and to familiarize readers with modern plasma technologies. The book describes structures of magnetic fields—one- and zero-dimensional plasma models. It considers single-, two-, and multi-component simulation models, kinetics and ionization processes, radiation transport, and plasma interaction with solid surfaces. The text also examines self-organization and general problems associated with instabilities in plasma systems. In addition, it discusses cosmic plasma dynamic systems, such as Earth's magnetosphere, spiral nebulas, and plasma associated with the Sun. This text provides wide-range coverage of issues related to plasma dynamics, with a final chapter addressing advanced plasma technologies, including plasma generators, plasma in the home, space propulsion engines, and controlled thermonuclear fusion. It demonstrates how to approach the analysis of complex plasma systems, taking into account the diversity of plasma environments. Presenting a well-rounded introduction to plasma dynamics, the book takes into consideration the models of plasma phenomena and their relationships to one another as well as their applications.
Volume 1: Plasma Physics
An Introduction to Plasma Astrophysics and Magnetohydrodynamics
Introduction to Plasmas and Plasma Dynamics
Fundamentals and Elementary Processes
An Introduction for Astrophysicists

Written by a university lecturer with more than forty years experience in plasma technology, this book adopts a didactic approach in its coverage of the theory, engineering and applications of technological plasmas. The theory is developed in a unified way to enable brevity and clarity, providing readers with the necessary background to assess the factors that affect the behavior of plasmas under different operating conditions. The major part of the book is devoted to the applications of plasma technology and their accompanying engineering aspects, classified by the various pressure and density regimes at which plasmas can be produced. Two chapters on plasma power supplies round off the book. With its broad range of topics, from low to high pressure plasmas, from characterization to modeling, and from materials to components, this is suitable for advanced undergraduates, postgraduates and professionals in the field.
Observations and physical concepts are interwoven to give basic explanations of phenomena and also show the limitations in these explanations and identify some fundamental questions. Compared to conventional plasma physics textbooks this book focuses on the concepts relevant in the large-scale space plasmas. It combines basic concepts with current research and new observations in interplanetary space and in the magnetospheres. Graduate students and young researchers starting to work in this special field of science, will find the numerous references to review articles as well as important original papers helpful to orientate themselves in the literature. Emphasis is on energetic particles and their interaction with the plasma as examples for non-thermal phenomena, shocks and their role in particle acceleration as examples for non-linear phenomena. This second edition has been updated and extended. Improvements include: the use of SI units; addition of recent results from SOHO and Ulysses; improved treatment of the magnetosphere as a dynamic phenomenon; text restructured to provide a closer coupling between basic physical concepts and observed complex phenomena.
This book provides the reader with an introduction to the physics of complex plasmas, a discussion of the specific scientific and technical challenges they present and an overview of their potential technological applications. Complex plasmas differ from conventional high-temperature plasmas in several ways: they may contain additional species, including nano meter- to micrometer-sized particles, negative ions, molecules and radicals and they may exhibit strong correlations or quantum effects. This book introduces the classical and quantum mechanical approaches used to describe and simulate complex plasmas. It also covers some key experimental techniques used in the analysis of these plasmas, including calorimetric probe methods, IR absorption techniques and X-ray absorption spectroscopy. The final part of the book reviews the emerging applications of microcavity and microchannel plasmas, the synthesis and assembly of nanomaterials through plasma electrochemistry, the large-scale generation of ozone using microplasmas and novel applications of atmospheric-pressure non-thermal plasmas in dentistry. Going beyond the scope of traditional plasma texts, the presentation is very well suited for senior undergraduate, graduate students and postdoctoral researchers specializing in plasma physics.
Complex plasmas differ from traditional plasmas in many ways: these are low-temperature high pressure systems containing nanometer to micrometer size particles which may be highly charged and strongly interacting. The particles may be chemically reacting or be in contact with solid surfaces, and the electrons may show quantum behaviour. These interesting properties have led to many applications of complex plasmas in technology, medicine and science. Yet complex plasmas are extremely complicated, both experimentally and theoretically, and require a variety of new approaches which go beyond standard plasma physics courses. This book fills this gap presenting an introduction to theory, experiment and computer simulation in this field. Based on tutorial lectures at a very successful recent Summer Institute, the presentation is ideally suited for graduate students, plasma physicists and experienced undergraduates.
Physics of Collisional Plasmas
INTRODUCTION TO UNMAGNETIZED PLASMAS
An Introduction to the Theory of Astrophysical, Geophysical and Laboratory Plasmas
Atom- und Quantenphysik
An Introduction