intermediate-level courses in electromagnetism and classical mechanics. The main theme of the book is showcasing role of fields in mediating action-at-a-distance interactions. Suitable technical machinery is developed to explore at least some aspect of each of the four known fundamental forces in nature. Beginning with the physically-motivated introduction to field theory, the text covers the relativistic formulation of electromagnetism in great detail so that aspects of gravity and the nuclear interaction not usually encountered at the undergraduate level can be covered by using analogies with familiar electromagnetism. Special topics such as the behavior of gravity in extra, compactified dimensions, magnetic monopoles and electromagnetic duality, and the Higgs mechanism are also briefly considered.

This monograph is devoted to the systematic and encyclopedic presentation of the foundations of quantum field theory. It represents mathematical problems of the quantum field theory with regard to the new methods of the constructive and Euclidean field theory formed for the last thirty years of the 20th century on the basis of rigorous mathematical tools of the functional analysis, the theory of operators, and the theory of generalized functions. The book is useful for young scientists who desire to understand not only the formal structure of the quantum field theory but also its basic concepts and connection with classical mechanics, relativistic classical field theory, quantum mechanics, group theory, and the theory of functional integration.

In recent years, gauge fields have attracted much attention in elementary particle physics. The reason is that great progress has been achieved in solving a number of important problems of field theory and elementary particle physics by means of the quantum theory of gauge fields. This refers, in particular, to constructing unified gauge models and theory of strong interactions between the elementary particles. This book expounds the fundamentals of the quantum theory of gauge fields and its application for constructing unified gauge models and the theory of strong interactions. In writing the book, the authors aimed at being three-fold: firstly, to outline the basic ideas underlying the unified gauge models and the theory of strong interactions; secondly, to discuss the major unified gauge models, the theory of strong interactions and their experimental implications; and, thirdly, to acquaint the reader with a rather special mathematical approach (path-integral method) which has proved to be well suited for constructing the quantum theory of gauge fields. Gauge fields are a vigorously developing area. In this book, we have select ed for presentation the more or less traditional and commonly accepted material. There also exist a number of different approaches which are presently being developed. The most important of them are touched upon in the Conclusion.

Contemporary quantum field theory is mainly developed as quantization of classical fields. Therefore, classical field theory and its BRST extension is the necessary step towards quantum field theory. This book aims to provide a complete mathematical foundation of Lagrangian classical field theory and its BRST extension for the purpose of quantization. Based on the standard geometric formulation of theory of nonlinear differential operators, Lagrangian field theory is treated in a very general setting. Reducible degenerate Lagrangian theories of even and odd fields on an arbitrary smooth manifold are considered. The second Noether theorems generalized to these theories and formulated in the homology terms provide the strict mathematical formulation of BRST-extended classical field theory. The most physically relevant field theories are the gauge theory on principal bundles, gravitation theory on natural bundles, theory of spinor fields and topological field theory are presented in a complete way.

This book is designed for theoreticians and mathematical physicists specializing in field theory. The authors have tried to provide the necessary mathematical background, thus making the exposition self-contained.

The book describes Maxwell's equations first in their integral, directly testable form, then moves on to their local formulation. The first two chapters cover all essential properties of Maxwell's equations, including their symmetries and their covariance in a modern notation. Chapter 3 is devoted to Maxwell theory as a classical field theory and to solutions of the wave equation. Chapter 4 deals with important applications of Maxwell theory. It includes topical subjects such as metamaterials with negative refraction index and solutions of Helmholtz' equation in paraxial approximation relevant for the description of laser beams. Chapter 5 describes non-Abelian gauge theories from a classical, geometric point of view, in analogy to Maxwell theory as a prototype, and culminates in an application to the U(2) theory relevant for electroweak interactions. The last chapter 6 gives a concise summary of semi-Riemannian geometry as the framework for the classical field theory of gravitation. The chapter concludes with a discussion of the Schwarzschild solution of Einstein's equations and the classical tests of general relativity (perihelion precession of Mercury, and light deflection by the sun).

Cosmology in Gauge Field Theory and String Theory focuses on the cosmological implications of the gauge theories of particle physics and of string theory. The book first examines the universe's series of phase transitions in which the successive gauge symmetries of the higher-temperature phase were spontaneously broken after the big bang, discussing relics of these phase transitions, more generic relics (baryons, neutrinos, axions), and supersymmetric particles (neutralinos and gravitinos). The author next studies supersymmetric theory, supergravity theory, and the constraints on the underlying field theory of the universe's inflationary era. The book concludes with a discussion of black hole solutions of the supergravity theory that approximates string theory at low energies and the insight that string theory affords into the microscopic origin of the Bekenstein-Hawking entropy. Cosmology in Gauge Field Theory and String Theory provides a modern introduction to these important problems from a particle physicist's perspective. It is intended as an introductory textbook for a first course on the subject at a graduate level.

Cosmology in Gauge Field Theory and String Theory focuses on the cosmological implications of the gauge theories of particle physics and of string theory. The book first examines the universe's series of phase transitions in which the successive gauge symmetries of the higher-temperature phase were spontaneously broken after the big bang, discussing relics of these phase transitions, more generic relics (baryons, neutrinos, axions), and supersymmetric particles (neutralinos and gravitinos). The author next studies supersymmetric theory, supergravity theory, and the constraints on the underlying field theory of the universe's inflationary era. The book concludes with a discussion of black hole solutions of the supergravity theory that approximates string theory at low energies and the insight that string theory affords into the microscopic origin of the Bekenstein-Hawking entropy. Cosmology in Gauge Field Theory and String Theory provides a modern introduction to these important problems from a particle physicist's perspective. It is intended as an introductory textbook for a first course on the subject at a graduate level.

Cosmology in Gauge Field Theory and String Theory focuses on the cosmological implications of the gauge theories of particle physics and of string theory. The book first examines the universe's series of phase transitions in which the successive gauge symmetries of the higher-temperature phase were spontaneously broken after the big bang, discussing relics of these phase transitions, more generic relics (baryons, neutrinos, axions), and supersymmetric particles (neutralinos and gravitinos). The author next studies supersymmetric theory, supergravity theory, and the constraints on the underlying field theory of the universe's inflationary era. The book concludes with a discussion of black hole solutions of the supergravity theory that approximates string theory at low energies and the insight that string theory affords into the microscopic origin of the Bekenstein-Hawking entropy. Cosmology in Gauge Field Theory and String Theory provides a modern introduction to these important problems from a particle physicist's perspective. It is intended as an introductory textbook for a first course on the subject at a graduate level.

Cosmology in Gauge Field Theory and String Theory focuses on the cosmological implications of the gauge theories of particle physics and of string theory. The book first examines the universe's series of phase transitions in which the successive gauge symmetries of the higher-temperature phase were spontaneously broken after the big bang, discussing relics of these phase transitions, more generic relics (baryons, neutrinos, axions), and supersymmetric particles (neutralinos and gravitinos). The author next studies supersymmetric theory, supergravity theory, and the constraints on the underlying field theory of the universe's inflationary era. The book concludes with a discussion of black hole solutions of the supergravity theory that approximates string theory at low energies and the insight that string theory affords into the microscopic origin of the Bekenstein-Hawking entropy. Cosmology in Gauge Field Theory and String Theory provides a modern introduction to these important problems from a particle physicist's perspective. It is intended as an introductory textbook for a first course on the subject at a graduate level.
theory is constructed. And then there is the bold theoretical proposal of a field-field interaction from James Clerk Maxwell. This textbook presents the theory of classical fields as a mathematical structure based solidly on laboratory experiments. Here the student is introduced to the beauty of classical field theory as a gem of theoretical physics. To keep the discussion fluid, the history is placed in a beginning chapter and some of the mathematical proofs in the appendices. Chapters on Green’s Functions and Laplace’s Equation and a discussion of Faraday’s Experiment further deepen the understanding. The chapter on Einstein’s relativity is an integral necessity to the text. Finally, chapters on particle motion and waves in a dispersive medium complete the picture. High quality diagrams and detailed end-of-chapter questions enhance the learning experience.

Translated from the 6th Russian edition, this latest edition contains seven new sections with chapters on General Relativity, Gravitational Waves and Relativistic Cosmology, where Professor Lifshitz’s interests lay. The text of the 3rd English edition has been thoroughly revised and additional problems inserted.

Several significant additions have been made to the second edition, including the operator method of calculating the bremsstrahlung cross-section, the calculation of the probabilities of photon-induced pair production and photon decay in a magnetic field, the asymptotic form of the scattering amplitudes at high energies, inelastic scattering of electrons by hadrons, and the transformation of electron-positron pairs into hadrons.

Like any books on a subject as vast as this, this book has to have a point-of-view to guide the selection of topics. Naber takes the view that the rekindled interest that mathematics and physics have shown in each other of late should be fostered, and that this is best accomplished by allowing them to cohabit. The book weaves together rudimentary notions from the classical gauge theory of physics with the topological and geometrical concepts that became the mathematical models of these notions. The reader is asked to join the author on some vague notion of what an electromagnetic field might be, to be willing to accept a few of the more elementary pronouncements of quantum mechanics, and to have a solid background in real analysis and linear algebra and some of the vocabulary of modern algebra. In return, the book offers an excursion that begins with the definition of a topological space and finds its way eventually to the moduli space of anti-self-dual SU(2) connections on S4 with instanton number -1.

Scheck’s successful textbook presents a comprehensive treatment, ideally suited for a one-semester course. The textbook describes Maxwell’s equations first in their integral, directly testable form, then moves on to their local formulation. The first two chapters cover all essential properties of Maxwell’s equations, including their symmetries and their covariance in a modern notation. Chapter 3 is devoted to Maxwell’s theory as a classical field theory and to solutions of the wave equation. Chapter 4 deals with important applications of Maxwell’s theory. It includes topical subjects such as metamaterials with negative refraction index and solutions of Helmholtz’ equation in paraxial approximation relevant for the description of laser beams. Chapter 5 describes non-Abelian gauge theories from a classical, geometric point of view, in analogy to Maxwell’s theory as a prototype, and culminates in an application to the U(2) theory relevant for electroweak interactions. The last chapter 6 gives a concise summary of semi-Riemannian geometry as the framework for the classical field theory of gravitation. The chapter concludes with a discussion of the Schwarzchild solution of Einstein’s equations and the classical tests of general relativity. The new concept of this edition presents the content divided into two tracks: the fast track for master’s students, providing the essentials, and the intensive track for all wanting to get in deep knowledge of the field. Clearly labeled material and sections guide students through the preferred level of treatment. Numerous problems and worked examples will provide successful access to Classical Field Theory.

The book assumes a knowledge of relativistic quantum mechanics, but not of quantum field theory. The topics covered form a foundation for a knowledge of modern relativistic quantum field theory, providing a comprehensive coverage with emphasis on the details of actual calculations rather than the phenomenology of the applications.

Introduction to Gauge Field Theory provides comprehensive coverage of modern relativistic quantum field theory, emphasizing the details of actual calculations rather than the phenomenology of the applications. Forming a foundation in the subject, the book assumes knowledge of relativistic quantum mechanics, but not of quantum field theory. The book is ideal for graduate students, advanced undergraduates, and researchers in the field of particle physics.

Quantum Field Theory has become the universal language of most modern theoretical physics. This introductory textbook shows how this beautiful theory offers the correct mathematical framework to describe and understand the fundamental interactions of elementary particles. The book begins with a brief reminder of basic classical field theories, electrodynamics and general relativity, as well as their symmetry properties, and proceeds with the principles of quantisation following Feynman’s path integral approach. Special care is used at every step to illustrate the correct mathematical formulation of the underlying assumptions. Gauge theories and the problems encountered in their quantisation are discussed in detail. The last chapters contain a full description of the Standard Model of particle physics and the attempts to go beyond it, such as grand unified theories and supersymmetry. Written for advanced undergraduate and beginning graduate students in physics and mathematics, the book could also serve as a reference for active researchers in the field.

Covers principal fiber bundles and connections; curvature; particle fields, Lagrangians, and gauge invariance; inhomogeneous field equations; free Dirac electron fields; calculus on frame bundle; and unification of gauge fields and gravitation. 1981 edition

An expanded and up-dated book examining gauge theories and their symmetries.

Classical field theory predicts how physical fields interact with matter, and is a logical precursor to quantum field theory. This introduction focuses purely on modern classical field theory, helping graduates and researchers build an understanding of classical field theory methods before embarking on future studies in quantum field theory. It describes various classical methods for fields with negligible quantum effects, for instance electromagnetism and gravitational fields. It focuses on solutions that take advantage of classical field theory methods as opposed to applications or geometric properties. Other fields covered includes fermionic fields, scalar fields and Chern–Simons fields. Methods such as symmetries, global and local methods, Noether theorem and energy momentum tensor are also discussed, as well as important solutions of the classical equations, in particular soliton solutions.

Comprehensive graduate-level text by a distinguished theoretical physicist reveals the classical underpinnings of modern quantum field theory. Topics include space-time, Lorentz transformations, conservation laws, equations of motion, Green’s functions, and more. 1984 edition.

Classical Theory of Gauge FieldsPrinceton University Press

Based on his own work, the author synthesizes the most promising approaches and ideas in field theory today. He presents such subjects as statistical mechanics, quantum field theory and their interrelation, continuous global symmetry, non-Abelian gauge fields, instantons and the quantum theory of loops, and quantum strings and random surfaces. This book is aimed at postgraduate students studying field theory and statistical mechanics, and for research workers in continuous global theory.

This book develops a novel approach to perturbative quantum field theory: starting with a perturbative formulation of
classical field theory, quantization is achieved by means of deformation quantization of the underlying free theory and by applying the principle that as much of the classical structure as possible should be maintained. The resulting formulation of perturbative quantum field theory is a version of the Epstein-Glaser renormalization that is conceptually clear, mathematically rigorous and pragmatically useful for physicists. The connection to traditional formulations of perturbative quantum field theory is also elaborated on, and the formalism is illustrated in a wealth of examples and exercises. Annotation Classical field theory is employed by physicists to describe a wide variety of physical phenomena. These include electromagnetism, fluid dynamics, gravitation and quantum mechanics. The central entity of field theory is the field which is usually a multi component function of space and time. Those multi component functions are usually grouped together as vector fields as in the case in electromagnetic theory and fluid dynamics, in other cases they are grouped as tensors as in theories of gravitation and yet in other cases they are grouped as complex functions as in the case of quantum mechanics. In order to know the value of the field one needs to solve a set of coupled partial differential equations with given boundary and initial conditions. The book covers a selection of recent advances in classical field theory involving electromagnetism, fluid dynamics, gravitation and quantum mechanics. Advances in Classical Field Theory will benefit readers by saving them the effort to read through numerous journal articles which would be needed to obtain a coherent picture of classical field theory otherwise. The book is unique in its aim and scope and is not similar to any existing publication. Geometrical notions and methods play an important role in both classical and quantum field theory, and a connection is a deep structure which apparently underlies the gauge-theoretical models in field theory and mechanics. This book is an encyclopaedia of modern geometric methods in theoretical physics. It collects together the basic mathematical facts about various types of connections, and provides a detailed exposition of relevant physical applications. It discusses the modern issues concerning the gauge theories of fundamental fields. The authors have tried to give all the necessary mathematical background, thus making the book self-contained. This book should be useful to graduate students, physicists and mathematicians who are interested in the issue of deep interrelations between theoretical physics and geometry. keywords:Lagrangian Field Theory;Hamiltonian Field Theory;Classical Mechanics;BRST Formalism;Topological Field Theories;Non-Commutative Geometry;Theoretical Physics;Mathematical Physics;Fibre Bundle;Connection;Jet Manifold;Gauge Theory;Gravitation;Theory;Quantum Field;Geometric Quantization;Supergeometry;BRST;Theory “this book certainly offers a valuable supplement to the existing literature on the impact of connection theory on theoretical physics.” Mathematical Reviews This book introduces a rapidly growing new research area — the study of dynamical properties of elementary fields. The methods used in this field range from algebraic topology to parallel computer programming. The main aim of this research is to understand the behavior of elementary particles and fields under extreme circumstances, first of all at high temperature and energy density generated in the largest accelerators of the world and supposed to be present in the early evolution of our Universe shortly after the Big Bang. In particular, chaos is rediscovered in a new appearance in these studies: in gauge theories the well-known divergence of initially adjacent phase space trajectories leads over into a quasi-thermal distribution of energy with a saturated average distance of different field configurations. This particular behavior is due to the compactness of the gauge group. Generally this book is divided into two main parts: the first part mainly deals with the “classical” discovery of chaos in gauge field theory while the second part presents methods and research achievements in recent years. One chapter is devoted entirely to the presentation and discussion of computational problems. The major theme, returning again and again throughout the book, is of course the phenomenon with a thousand faces — chaos itself. This book is intended to be a research book which introduces the reader to a new research field, presenting the basic new ideas in detail but just briefly touching on the problems of other related fields, like perturbative or lattice gauge theory, or dissipative chaos. The terminology of these related fields are, however, used. Exercises are also included in this book. They deepen the reader's understanding of special issues and at the same time offer more information on related problems. For the convenience of the fast reader, solutions are presented right after the problems. Contents:IntroductionChaotic DynamicsChaos in Gauge TheoryTopological Field TheoriesLattice Gauge TheoryHamiltonian Lattice Gauge TheoryComputing SU(2) Gauge TheoryChaos in Lattice Gauge TheoryApplications and ExtensionsBeyond the Classical TheoryChaos and Confinement Readership: Nonlinear scientists, high energy physicists, mathematicians and engineers. keywords:Non-Abelian Gauge Fields;Periodic Orbits;Lyapunov Exponents;Classical and Quantum Yang-Mills Mechanics;Higgs Mechanism;Self-Thermalization via Chaos;Chaos and Confinement;Quark-Gluon Plasma;Lattice Gauge Theory;Monte Carlo Methods;Physics;Field Theory;Chaos;Gauge;Lattice;Thermalization;Entropy;Computing “This book is a good place to approach the research area of chaos applied to gauge field theories.” Mathematical Reviews This book is a systematic study of the classical and quantum theories of gauge systems. It starts with Dirac's analysis showing that gauge theories are constrained Hamiltonian systems. The classical foundations of BRST theory are then laid out with a review of the necessary concepts from homological algebra. Reducible gauge systems are discussed, and the relationship between BRST cohomology and gauge invariance is carefully explained. The authors then proceed to the canonical quantization of gauge systems, first without ghosts (reduced phase space quantization, Dirac method) and second in the BRST context (quantum BRST cohomology). The path integral is discussed next. The analysis covers indefinite metric systems, operator insertions, and Ward identities. The antifield formalism is also studied and its equivalence with canonical methods is derived. The examples of electromagnetism and abelian 2-form gauge fields are treated in detail. The book gives a general and unified treatment of the subject in a self-contained manner. Exercises are provided at the end of each chapter, and pedagogical examples are covered in the text.