Integrated Optics: Theory and Technology-R. G. Hunsperger 2013-11-11 This book is an introduction to the theory and technology of integrated optics for graduate students in electrical engineering, and for practicing engineers and scientists who wish to improve their understanding of the principles and applications of this relatively new, and rapidly growing, field. Integrated Optics is the name given to a new generation of optoelectronic systems in which the familiar wires and cables are replaced by light waveguiding optical fibers, and conventional integrated circuits are replaced by optical integrated circuits (OIC's). In an OIC, the signal is carried by means of a beam of light rather than by an electrical current, and the various circuit elements are interconnected on the substrate wafer by optical wave guides. Some advantages of an integrated-optic system are reduced weight, increased bandwidth (or multiplexing capability), resistance to electromagnetic interference, and low loss signal transmission. Because of the voluminous work that has been done in the field of integrated optics since its inception in the late 1960's, the areas of fiber optics and optical integrated circuits have usually been treated separately at conferences and in textbooks. In the author's opinion, this separation is unfortunate because the two areas are closely related. Nevertheless, it cannot be denied that it may be a practical necessity.

Integrated Optics-Robert G. Hunsperger 2009-04-29 Integrated Optics explains the subject of optoelectronic devices and their use in integrated optics and fiber optic systems. The approach taken is to emphasize the physics of how devices work and how they can be (and have been) used in various applications as the field of optoelectronics has progressed from microphotonics to nanophotonics. Illustrations and references from technical journals have been used to demonstrate the relevance of the theory to currently important topics in industry. By reading this book, scientists, engineers, students and engineering managers can obtain an overall view of the theory and the most recent technology in Integrated Optics.

Integrated Optics-Robert Hunsperger 1995-10-09 Integrated Optics: Theory and Technology provides a comprehensive and thorough treatment suitable for use both as a classroom text (practice problems are included) and as a specialist's reference. Detailed descriptions of the phenomena, devices, and technology used in optical integrated circuits and their relationship to fiber optics are presented. In this fourth edition all chapters have been completely revised.

Integrated Optics; Theory and Applications-Tadeusz Pustelny 2005 Proceedings of SPIE present the original research papers presented at SPIE conferences and other high-quality conferences in the broad-ranging fields of optics and photonics. These books provide prompt access to the latest innovations in research and technology in their respective fields. Proceedings of SPIE are among the most cited references in patent literature.

Integrated Optics, Microstructures, and Sensors-Massood Tabib-Azar 1995-09-30 Controlling the mechanical, electrical, magnetic, and optical properties of materials by advanced fabrication methods (i.e., Molecular Beam Epitaxy and Metal-Organic Chemical Vapor Deposition) has become the new paradigm in our research era. Sensors, being the most vital part of the electronic data processing and decision making machines, stand to gain the most from engineering of the properties of materials. Microfabrication technology has already...
contributed significantly to the batch fabrication of micro-sensors with higher overall qualities compared to their counterparts that are fabricated using other methods. Batch fabrication of micro-sensors i) results in more uniform properties of co-fabricated devices, ii) nearly eliminates the need for characterization of individual sensors, and iii) eliminates a need for laborious alignment procedures. A less obvious benefit of using microfabrication methods is the possibility of precise control over the dimensions of the sensor. This control enables engineering of some of the properties of the material which affect the sensor’s operation. There are many examples of this in the literature. Optical sensors are known to have superior properties over their counterparts that use other (i.e.; electrostatic and magnetic) means of detection. To name a few, these advantages are: i) immunity to electromagnetic interferences, ii) higher sensitivities compared to the other types of sensors, iii) simplicity of operation principles, and iv) simplicity of overall construction.

Encyclopedic Handbook of Integrated Optics-Kenichi Iga 2018-10-03 As optical technologies move closer to the core of modern computer architecture, there arise many challenges in building optical capabilities from the network to the motherboard. Rapid advances in integrated optics technologies are making this a reality. However, no comprehensive, up-to-date reference is available to the technologies and principles underlying the field. The Encyclopedic Handbook of Integrated Optics fills this void, collecting the work of 53 leading experts into a compilation of the most important concepts, phenomena, technologies, and terms covering all related fields. This unique book consists of two types of entries: the first is a detailed, full-length description; the other, a concise overview of the topic. Additionally, the coverage can be divided into four broad areas: A survey of the basics of integrated optics, exploring theory, practical concerns, and the fundamentals behind optical devices. Focused discussion on devices and components such as arrayed waveguide grating, various types of lasers, optical amplifiers, and optoelectronic devices. In-depth examination of subsystems including MEMS, optical pickup, and planar lightwave circuits. Finally, systems considerations such as multiplexing, demultiplexing, 3R circuits, transmission, and reception. Offering a broad and complete treatment of the field, the Encyclopedic Handbook of Integrated Optics is the complete guide to the fundamentals, principles, and applications of integrated optics technology.

Semiconductor Integrated Optics for Switching Light-Charlie Ironside 2017-09-12 This book covers the technology of switching or modulating light in semiconductor optical waveguides. Currently a key function for optical communications systems is the conversion of data from an electrical signal to an optical signal for transmission in very low loss optical fibres and the converse process of optical to electrical conversion the O/E/O data conversion. This conversion between electronic and photonic signals imposes an energy consumption overhead on optical communication systems. So many research workers have been attracted to ultrafast all-optical switching of data in different formats. As a way of introduction to all-optical switching in semiconductor waveguides the book covers the electro-optic effect, electroabsorption and electrorefraction; effects that can be used in semiconductor optical modulation devices. But the book focuses on all-optical switching using second and third order optical nonlinearities in AlGaAs optical waveguides. It covers a variety of device configurations including integrated nonlinear couplers and Mach-Zehnder interferometers. Further, it provides design software in suit of Mathematica notebooks that can be used to explore the device design.

Integrated Optics-Reinhard Marz 1994 Here’s the only book to comprehensively address integrated optics from both the theory and practical modeling standpoints -- it reveals crucial design methods that decrease your overall device modeling effort.

Integrated Photonics-Ginés Lifante 2003-03-14 All integrated optical components and devices make use of "waveguides", where light is confined by total internal reflection. The elements in such "photonic chip" are interconnected through waveguides, and also the integrated optics components themselves are fabricated using waveguide configuration, such as couplers, switches, modulators, multiplexors, amplifiers and lasers, etc. These components are integrated in a single substrate, thus resulting in a compact and robust photonic device, which can be optically connected through optical fibres. With and increase in the number of integrated optical components and devices emerging from the research laboratories to the market place an up-to-date book is essential in collecting, summarizing and presenting the new developed photonic devices. This includes fundamental aspects, technical aspects (such as fabrication techniques and materials) and characterisation and performance. This is an advanced text aimed at specialists in the field of photonics, but who may be new to the field of integrated photonics. The fundamental aspects have been carefully considered, and all the topics covered by the book start at a medium level, making it highly relevant for undergraduate and post-graduate students following this discipline.

Microoptics-Karl-Heinz Brenner 2013-03-20 Microoptics is still an emerging field with a huge potential for a large number of applications. This monograph brings together the most recent developments in order to give a broad overview.
Optical Fiber Sensor Technology-L.S. Grattan 1999-04-30 Environmental and chemical sensors in optical fiber sensor technology The nature of the environment in which we live and work, and the precarious state of many aspects of the natural environment, has been a major lesson for scientists over the last few decades. Public awareness of the issues involved is high, and often coupled with a scepticism of the ability of the scientist and engineer to provide an adequate, or even rapid solution to the preservation of the environment before further damage is done, and to achieve this with a mini mum of expenditure. Monitoring of the various aspects of the environment, whether it be external or internal to ourselves and involving chemical, physical or biomedical parameters is an essential process for the well-being of mankind and of the individual. Legis lative requirements set new standards for measurement and control all around us, which must be met by the most appropriate of the technologies available, commensurate with the costs involved. Optical fiber sensor technology has a major part to play in this process, both to complement existing technologies and to promote new solutions to difficult measurement issues. The developments in new sources and detectors covering wider ranges of the electromagnetic spectrum, with higher sensitivity, allow the use of techniques that some time ago would have been considered inappropriate or lacking in sufficient sensitivity.

Integrated Photonics-Clifford Pollock 2013-06-29 From the beginning Integrated Photonics introduces numerical techniques for studying non-analytic structures. Most chapters have numerical problems designed for solution using a computational program such as Matlab or Mathematica. An entire chapter is devoted to one of the numeric simulation techniques being used in optoelectronic design (the Beam Propagation Method), and provides opportunity for students to explore some novel optical structures without too much effort. Small pieces of code are supplied where appropriate to get the reader started on the numeric work. Integrated Photonics is designed for the senior/first year graduate student, and requires a basic familiarity with electromagnetic waves, and the ability to solve differential equations with boundary conditions.

Electromagnetic Principles of Integrated Optics-Donald L. Lee 1986 Develops the fundamental electromagnetic concepts and principles of guided wave optics from Maxwell’s equations in a unified fashion. Analyzes many important building blocks of integrated optical systems. Discusses 2- and 3-dimensional optical waveguides, optical fibers, prism and dielectric waveguide couplers, waveguide filters, grating reflectors, and spectrum analyzers. The first introductory text to use optics rather than microwaves as a teaching vehicle, thus making the subject matter easily comprehensible. Numerous worked examples and homework problems included.

Introduction to Modern Optics-Grant R. Fowles 2012-04-25 A complete basic undergraduate course in modern optics for students in physics, technology, and engineering. The first half deals with classical physical optics; the second, quantum nature of light. Solutions.

Physics of Photonic Devices-Shun Lien Chuang 2009-01-20 The most up-to-date book available on the physics of photonic devices This new edition of Physics of Photonic Devices incorporates significant advancements in the field of photonics that have occurred since publication of the first edition (Physics of Optoelectronic Devices). New topics covered include a brief history of the invention of semiconductor lasers, the Lorentz dipole method and metal plasmas, matrix optics, surface plasma waveguides, optical ring resonators, integrated electroabsorption modulator-lasers, and solar cells. It also introduces exciting new fields of research such as: surface plasmonics and micro-ring resonators; the theory of optical gain and absorption in quantum dots and quantum wires and their applications in semiconductor lasers; and novel microcavity and photonic crystal lasers, quantum-cascade lasers, and GaN blue-green lasers within the context of advanced semiconductor lasers. Physics of Photonic Devices, Second Edition presents novel information that is not yet available in book form elsewhere. Many problem sets have been updated, the answers to which are available in an all-new Solutions Manual for instructors. Comprehensive, timely, and practical, Physics of Photonic Devices is an invaluable textbook for advanced undergraduate and graduate courses in photonics and an indispensable tool for researchers working in this rapidly growing field.

Guided-Wave Acousto-Optics-Chen S. Tsai 2013-12-01 The field of integrated- or guided-wave optics has experienced significant and continuous growth since its inception in the late 1960s. There has been a considerable increase in research and development activity in this field worldwide and some significant advances in the realization of working in tegrated optic devices and modules have been made in recent years. In fact, there have already been some commercial manufacturing and technical applications of such devices and modules. The guided-wave-acoustooptics involving Bragg interactions between guided optical waves and surface acoustic waves is one of the areas of in tegrated-optics that has reached some degree of scientific and technological maturity. This topical volume is devoted to an in-depth treatment of this emerging branch of science and technology. Presented in this volume are concise treatments on bulk-wave acoustooptics, guided-wave optics, and surface acoustic waves, and detailed studies of guided-wave acoustooptic Bragg diffraction in
three promising material substrates, namely, LiNbO₃, ZnO/SiO₂, and GaAs, the resulting wide band modulators and deflectors, and applications. The chapters cover not only the basic principles and the theoretical analysis, but also the design, fabrication, and measurement of the resulting devices and modules, and their applications.

Handbook of Optofluidics-Aaron R. Hawkins 2010-03-19 Optofluidics is an emerging field that involves the use of fluids to modify optical properties and the use of optical devices to detect flowing media. Ultimately, its value is highly dependent on the successful integration of photonic integrated circuits with microfluidic or nanofluidic systems. Handbook of Optofluidics provides a snapshot of the s

Introduction to Semiconductor Integrated Optics-Hans P. Zappe 1995 This comprehensive book introduces semiconductors and integrated optics and provides in-depth derivations and analysis of key integrated optical components for more advanced study. The author emphasizes practical application -- developing and explaining the concepts and techniques needed to understand the engineering issues and solve real-world problems. With its clear explanations and design examples, the book provides experienced and budding engineers with the information necessary to design the structure and fabrication process of a semiconductor integrated optical device. Invaluable for engineers and applied scientists in optics/semiconductors, R&D engineers in communications, sensors, and medicine, and graduate students. Complete with 280 equations and 95 illustrations.

Photonic Devices and Systems-Hunsperger 2017-10-19 This work describes all the major devices used in photonic systems. It provides a thorough overview of the field of photonics, detailing practical examples of photonic technology in a wide range of applications. Photonic systems and devices are discussed with a mathematical rigor that is precise enough for design purposes yet highly readable.

Optoelectronic Integrated Circuits and Packaging III-Michael R. Feldman 1999

Telecommunication Networks-Eugenio Iannone 2011-12-14 Many argue that telecommunications network infrastructure is the most impressive and important technology ever developed. Analyzing the telecom market’s constantly evolving trends, research directions, infrastructure, and vital needs, Telecommunication Networks responds with revolutionized engineering strategies to optimize network construction. Omnipresent in society, telecom networks integrate a wide range of technologies. These include quantum field theory for the study of optical amplifiers, software architectures for network control, abstract algebra required to design error correction codes, and network, thermal, and mechanical modeling for equipment platform design. Illustrating how and why network developers make technical decisions, this book takes a practical engineering approach to systematically assess the network as a whole—from transmission to switching. Emphasizing a uniform bibliography and description of standards, it explores existing technical developments and the potential for projected alternative architectural paths, based on current market indicators. The author characterizes new device and equipment advances not just as quality improvements, but as specific responses to particular technical market necessities. Analyzing design problems to identify potential links and commonalities between different parts of the system, the book addresses interdependence of these elements and their individual influence on network evolution. It also considers power consumption and real estate, which sometimes outweigh engineering performance data in determining a product’s success. To clarify the potential and limitations of each presented technology and system analysis, the book includes quantitative data inspired by real products and prototypes. Whenever possible, it applies mathematical modeling to present measured data, enabling the reader to apply demonstrated concepts in real-world situations. Covering everything from high-level architectural elements to more basic component physics, its focus is to solve a problem from different perspectives, and bridge descriptions of well-consolidated solutions with newer research trends.

Multi-Photon Quantum Information Science and Technology in Integrated Optics-Jonathan C.F. Matthews 2012-10-05 Photons are an attractive option for testing fundamental quantum physics and developing new quantum-enhanced technology, including highly advanced computers and simulators, as well as precision sensing beyond shot-noise. Traditionally, bulk optical components have been bolted onto optical benches to realize metre-scale quantum circuits. However this approach is ultimately proving unwieldy for increasing the complexity and for scaling up to practical quantum technologies based on photons. The work presented here demonstrates a series of quantum photonic devices based on waveguide circuits embedded in miniature monolithic chips. This represents a paradigm shift in the underlying architecture of quantum optics and provides key building blocks for all-optical and hybrid quantum technologies.

Optoelectronic Interconnects, Integrated Circuits, and Packaging-Louay A. Eldada 2002

Fundamentals of Optical Waveguides-Katsunari Okamoto 2010-08-04 Fundamentals of Optical Waveguides is an essential resource for any researcher, professional or student involved in optics and communications.
Integrated Optics Theory And Technology Solution

engineering. Any reader interested in designing or actively working with optical devices must have a firm grasp of the principles of lightwave propagation. Katsunari Okamoto has presented this difficult technology clearly and concisely with several illustrations and equations. Optical technology encompassed in this reference includes coupled mode theory, nonlinear optical effects, finite element method, beam propagation method, staircase concatenation method, along with several central theorems and formulas. Since the publication of the well-received first edition of this book, planar lightwave circuits and photonic crystal fibers have fully matured. With this second edition the advances of these fibers along with other improvements on existing optical technologies are completely detailed. This comprehensive volume enables readers to fully analyze, design and simulate optical atmospheres. Exceptional new chapter on Arrayed-Waveguide Grating (AWG) In-depth discussion of Photonic Crystal Fibers (PCFs) Thorough explanation of Multimode Interference Devices (MMI) Full coverage of polarization Mode Dispersion (PMD)

Programmable Integrated Photonics-José Capmany 2020-02-21 This book provides the first comprehensive, up-to-date and self-contained introduction to the emergent field of Programmable Integrated Photonics (PIP). It covers both theoretical and practical aspects, ranging from basic technologies and the building of photonic component blocks, to design alternatives and principles of complex programmable photonic circuits, their limiting factors, techniques for characterization and performance monitoring/control, and their salient applications both in the classical as well as in the quantum information fields. The book concentrates and focuses mainly on the distinctive features of programmable photonics, as compared to more traditional ASPIC approaches. After some years during which the Application Specific Photonic Integrated Circuit (ASPIC) paradigm completely dominated the field of integrated optics, there has been an increasing interest in PIP. The rising interest in PIP is justified by the surge in a number of emerging applications that call for true flexibility and reconfigurability, as well as low-cost, compact, and low-power consuming devices. Programmable Integrated Photonics is a new paradigm that aims at designing common integrated optical hardware configurations, which by suitable programming, can implement a variety of functionalities. These in turn can be exploited as basic operations in many application fields. Programmability enables, by means of external control signals, both chip reconfiguration for multifunction operation, as well as chip stabilization against non-ideal operations due to fluctuations in environmental conditions and fabrication errors. Programming also allows for the activation of parts of the chip, which are not essential for the implementation of a given functionality, but can be of help in reducing noise levels through the diversion of undesired reflections.

Harnessing Light-National Research Council 1998-09-25 Optical science and engineering affect almost every aspect of our lives. Millions of miles of optical fiber carry voice and data signals around the world. Lasers are used in surgery of the retina, kidneys, and heart. New high-efficiency light sources promise dramatic reductions in electricity consumption. Night-vision equipment and satellite surveillance are changing how wars are fought. Industry uses optical methods in everything from the production of computer chips to the construction of tunnels. Harnessing Light surveys this multitude of applications, as well as the status of the optics industry and of research and education in optics, and identifies actions that could enhance the field’s contributions to society and facilitate its continued technical development.

Guided-Wave Optoelectronics-Theodor Tamir 2013-03-08 The first guided-wave components that employed signals in the form of light beams traveling along thin films were fabricated a little more than two decades ago. The parallel development of semiconductor lasers and the subsequent availability of low-loss optical fibers made possible the implementation of completely optical systems for communications, signal processing and other applications that had used only electronic circuitry in the past. Referred to as integrated optics, this technology has been reinforced by utilizing electronic components that act as controlling elements or perform other functions for which the optical counterparts are not as effective. The broader area thus generated was aptly named optoelectronics and it currently represents a fascinating, rapidly evolving and most promising technology. Specifically, the amalgamation of electronic and optics components into an integrated optoelectronics format is expected to provide a wide range of systems having miniaturized, high speed, broad band and reliable components for telecommunications, data processing, optical computing and other applications in the near and far future. This book is intended to cover primarily the optical portion of the optoelectronics area by focusing on the theory and applications of components that use guided optical waves. Hence all aspects of integrated optics are discussed, but optoelectronic components having primarily electronic rather than optical functions have not been included. Each chapter has been written by experts who have actively participated in developing the specific areas addressed by them.


Encyclopedic Handbook of Integrated Optics-Kenichi Iga 2018-10-03 As optical technologies move closer to the core of modern computer architecture, there arise many challenges in building optical capabilities from
the network to the motherboard. Rapid advances in integrated optics technologies are making this a reality. However, no comprehensive, up-to-date reference is available to the technologies and principles underlying the field. The Encyclopedic Handbook of Integrated Optics fills this void, collecting the work of 53 leading experts into a compilation of the most important concepts, phenomena, technologies, and terms covering all related fields. This unique book consists of two types of entries: the first is a detailed, full-length description; the other, a concise overview of the topic. Additionally, the coverage can be divided into four broad areas: A survey of the basics of integrated optics, exploring theory, practical concerns, and the fundamentals behind optical devices Focused discussion on devices and components such as arrayed waveguide grating, various types of lasers, optical amplifiers, and optoelectronic devices In-depth examination of subsystems including MEMS, optical pickup, and planar lightwave circuits Finally, systems considerations such as multiplexing, demultiplexing, 3R circuits, transmission, and reception Offering a broad and complete treatment of the field, the Encyclopedic Handbook of Integrated Optics is the complete guide to the fundamentals, principles, and applications of integrated optics technology.

Silicon Photonics-W Westerveld 2017-12-27

Integrated Optics and Photonic Integrated Circuits-Giancarlo C. Righini 2004 Proceedings of SPIE present the original research papers presented at SPIE conferences and other high-quality conferences in the broad-ranging fields of optics and photonics. These books provide prompt access to the latest innovations in research and technology in their respective fields. Proceedings of SPIE are among the most cited references in patent literature.

Integrated Optics-J. T. Boyd 1991

Televised Higher Education-Western Interstate Commission for Higher Education 1984 THE Catalog is a comprehensive listing of videocourses appropriate for postsecondary-level study on a wide range of academic fields.

Handbook of Fiber Optics-Chai Yeh 2013-10-22 Dr. Yeh supplies a firm theoretical foundation in such topics as propagation of light through fibers, fiber fabrication, loss mechanisms, and dispersion properties. He then expands from this into such practical areas as fiber splicing, measuring loss in fibers, fiber-based communications networks, remote fiber sensors, and integrated optics. Whether involved in fiber optics research, design, or practical implementation of systems, this handbook will be extremely useful. Here is a comprehensive, "one-stop" reference with state-of-the-art information on fiber optics. Included is data on: Optical fibers and fiber materials Light sources and detectors Coupler, LEDs, and other individual components Coherent optics Lasers The development of fiber optics-based telecommunications systems Optoelectronics and Fiber Optic Technology-Ray Tricker 2002-05-29 *Covers selection and application of the key technologies *A down-to-earth introduction to a cutting-edge technology *Covers all the main engineering applications with a minimum of maths A unique practical guide for professionals and students Optoelectronics and Fiber Optic Technology provides user-friendly information on the technology and applications of fiber optics and the wider technologies of optoelectronics. Ray Tricker has demystified this core area of communications technology with a minimum of maths, in a language that is accessible to a wide range of managers, technician engineers, students and professionals needing to gain an understanding of the available technologies. This is also the ideal introductory text for installation engineers and field service engineers seeking to gain a broad understanding of the field they are working in. All the key technologies are described: types of cable, transmitters, receivers, couplers, connectors, etc. with the emphasis firmly on their selection and application. Key aspects of installation, test techniques, safety and security are also covered in depth, making this book a genuinely useful guide for engineers and managers alike. Topical areas such as optoelectronics in LANs and WANs, cable TV systems, and the global fiber-optic highway make this book essential reading for anyone who needs to keep up with the technology of modern data communications.

Engineering Optics-Keigo Iizuka 2019-04-30 Engineering Optics is a book for students who want to apply their knowledge of optics to engineering problems, as well as for engineering students who want to acquire the basic principles of optics. It covers such important topics as optical signal processing, holography, tomography, holographic radars, fiber optical communication, electro- and acousto-optic devices, and integrated optics (including optical bistability). Practical examples, such as the video disk, the Fresnel zone plate, and many more, appear throughout the text, together with numerous solved exercises. There is an entirely new section in this updated edition on 3-D imaging.

Optical Waveguides-Maria L. Calvo 2018-10-03 Although the theory and principles of optical waveguides have been established for more than a century, the technologies have only been realized in recent decades. Optical Waveguides: From Theory to Applied Technologies combines the most relevant aspects of waveguide theory with the study of current detailed waveguiding technologies, in particular, photonic devices,
telecommunication applications, and biomedical optics. With self-contained chapters written by well-known specialists, the book features both fundamentals and applications. The first three chapters examine the theoretical foundations and bases of planar optical waveguides as well as critical optical properties such as birefringence and nonlinear optical phenomena. The next several chapters focus on contemporary waveguiding technologies that include photonic devices and telecommunications. The book concludes with discussions on additional technological applications, including biomedical optical waveguides and the potential of neutron waveguides. As optical waveguides play an increasing part in modern technology, photonics will become to the 21st century what electronics were to the 20th century. Offering both novel insights for experienced professionals and introductory material for novices, this book facilitates a better understanding of the new information era—the photonics century.

Journal of the Optical Society of America- 1990

Optics and Lasers-Matt Young 2013-06-29 Optics and Lasers is an introduction to engineering and applied optics, including not only elementary ray and wave optics, but also lasers, holography, coherence, fibers, and optical waveguides. It stresses physical principles, applications, and instrumentation. The textbook will be most useful to the practicing engineer or experimental scientist, graduate student, or advanced undergraduate. It contains more than enough material from which to select the core of an introductory optics course and sufficient to form the bulk of a more advanced course.
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