DEPARTMENTS

BOOK REVIEWS

Optical Engineering Fundamentals

Bruce H. Walker, xv + 341 pages, illustrations, appendices, and index. Optical Engineering and Electro-Optical Engineering Series. ISBN: 0-07-067930-4. McGraw-Hill, 11 West 19th Street, New York, NY 10011 (1994) $40 hardbound.

Reviewed by John S. Loomis, University of Dayton, OH 45469-0151.

Until now, many readers may have found the average book on optical engineering filled with formidable algebra and geometry. In *Optical Engineering Fundamentals,* Bruce H. Walker has created a personal, lively, and easy-to-read introduction to modern optical engineering. True to its promise, there are almost no mathematics. Many quantitative ideas are expressed through examples or very simple formulas, but the overall impression is descriptive and tutorial rather than rigorous and mathematical. The field of view of a telescope, for example, is illustrated by a drawing of the moon as seen through the telescope, while the text compares the angular subtense of the moon seen by the naked eye with that seen through the telescope. Optical designs are presented through examples and case studies using figures and tables generated by a commonly available optical design program.

After a brief preface and introduction, the book begins with a historical review of optics from ancient times to the recent unfortunate circumstances of the Hubble telescope. This is followed, in Chap. 3, by a discussion of the basic concepts of light: its wave nature, wavefronts and rays, reflection and refraction, and diffraction. The author's expressed intent is for the reader to develop a *feeling* for what light is, so the reader must look elsewhere for such abstract concepts as Fermat's principle.

The reader will find in Chap. 4, "Thin lens theory," such topics as optical power, pupils and stops, and formulas relating object/image distance and magnification. Then in Chap. 5 the reader is introduced to optical design with the OSLO Melles Griot (MG) software package. The examples of a Petzval lens and a laser transmitting system are used to illustrate the way such software is used by the optical engineer.

In Chap. 6, "Primary lens aberrations," spherical aberration, coma, field curvature, and astigmatism are introduced via spot diagrams and radial energy distributions. Chromatic aberrations and ray aberrations (fans) are also discussed. Chapter 7, "Optical components," covers the operation of lenses, mirrors, and prisms.

Chapter 8, "Basic optical instruments," discusses the magnifier, eyepiece, microscope, telescope, binoculars, riflescope, surveying and optical tooling instruments, periscope, borescope, and endoscope. Some of the discussions are very short. The topics of binoculars and the riflescope are confined to one or two paragraphs (less than a page), plus an accompanying figure.

Chapter 9, "Optical materials and coatings," presents a variety of common optical materials, including optical glass, low-expansion materials, infrared materials, and optical plastics. Chapter 10, "The visual optical system," introduces the structure and characteristics of eye, resolution, and visual instrument design considerations.

Chapter 11, "Lens design and image evaluation," identifies the major steps in the optical design process as: defining the problem, selecting a starting point, optimizing the design, evaluating performance, and documenting the final design. These steps serve as subheadings for a series of short case studies, including a 10X telescope, a collimator lens for a spectrometer, an imager lens for a detector, and a null lens for aspheric testing. The software package used to illustrate these design studies is the OSLO Series 2, although the author emphasizes that there are a number of other very fine optical design software packages to choose from.

The last chapter, "Optics in our world," presents a variety of visual experiences, such as optical illusions, stereo displays, photography, and rainbows. It also discusses some recent applications of optics in compact disk readers and projection TV.

There are also several short appendices: "Basic optical engineering library" (the author's top ten books and references), "Optical design software" (seven sources), "Optical glass sources" (four primary, five secondary), "Conversion factors and constants," "Measures and equivalents," "Photometric considerations" (exposure values), and "Surface sag and conic sections."

Each chapter ends with a review and summary. There are four references on history, and Appendix A contains an annotated bibliography of 17 books and publications. There are no other references or specific bibliography material for the other chapters. The appendices on units, conversions weights, and measures offer little of optical interest but are otherwise harmless. I thought the title of the appendix on photometric considerations meant a discussion of photometry and/or radiometry, but it is really a discussion of exposure values (especially for film). There are no problems or projects, so the book is incomplete as a textbook.

The book is well illustrated, both with figures taken directly from the output of the OSLO and with figures prepared by the author. The style of the illustrations is reasonably consistent throughout the book and seems to use typefaces of laser printer quality. Some of the author's plots, however, do show some aliasing (raggedness) in the lines and curves.

I plan to try this book as a supplemental textbook for an introductory course on geometrical optics. The book should give my students a good second opinion on the gen-

eral nature of optical engineering without imposing a mathematical notation that I would not want to use. The author's basic coordinate system, for example, is left-handed, where I prefer a right-handed system. Luckily, there is nothing that really depends on that fact, and we agree on the importance of the concepts of optic axis (*Z*-axis), tangential plane (*YZ*) plane, and sagittal plane (*XZ*) plane.

In all, Bruce H. Walker's *Optical Engineering Fundamentals* is an excellent first book to read about optical engineering.

Electro-Optical Imaging System Performance

Gerald C. Holst, 481 pages, illustrations, index, references, and one appendix. ISBN 0-9640000-1-6. JDC Publishing, 2932 Cove Trail, Winter Park, FL 32789 (1995) $80 hardbound.

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The analysis of electro-optical imaging systems is a broad subject that involves topics ranging from the generation of optical radiation to digital postdetection processing. Gerald C. Holst's book attempts to be, according to the back cover of the book, "the complete end-to-end system analysis book." This book is a step in that direction, covering many of the topics that are common to all electronic imaging systems, including some that are not usually found in current textbooks. However, since many of the topics are not covered in depth, this book will not supplant standard texts on the basics in areas such as radiometry, geometrical optics, physical optics, or image processing. There are problems at the end of each chapter, but the book will probably be of more use to the practicing engineer than to the student because most of the formulas and rules of thumb for "back of the envelope calculations" are presented with little derivation and often without reference.

Each chapter in the book begins with an overview of the material in the chapter and ends with a summary that repeats some of the more pertinent tables and formulas that are presented in the chapter. The first half of the book is loosely organized according to the historical development of infrared imaging systems. Embedded within the chapters are the theoretical tools necessary to conduct systems analyses. The book, therefore, is somewhat disjointed in that one topic may be discussed in several chapters, making it necessary to consult the index and to flip to different parts of the book to gather all of the information.

The first five chapters of the book provide an introduction to infrared imaging systems, including definitions of most of the system components. The chapters introduce the theoretical tools needed by the systems analyst in the areas of radiometry, linear systems theory, and sampling theory. Much of the information in these chapters is presented quickly and repeated in more detail in the later chapters. In addition, some concepts such as a Lambertian radiator and noise equivalent differential temperature are discussed without prior definition, which is found in later chapters.

Chapters 6 through 10 consider different types of infrared systems that vary primarily in terms of how the image is sampled and displayed. Chapter 6, titled "Common module systems," is almost exclusively a discussion of the various modulation transfer functions (MTFs) associated with optics, detectors, motion, and the eye. The chapter contains several useful formulas and approximations for the various MTF values. However, it would have been better presented in Chap. 4, titled "MTF theory," since the discussion pertains to all imaging systems. Chapter 8, titled "EMUX systems," discusses various aspects of image reconstruction, but also contains detours into theoretical aspects such as image phasing with respect to the sampling lattice, which again has general application to all sampled imaging systems. Chapter 9 on staring systems is quite brief given the vast amount of research underway in this area, though it does highlight one relatively recent development, microscanning.

Chapters 11 through 14 discuss some of the metrics by which imaging systems can be evaluated. Chapter 11 is a good summary of most of the MTF discussions distributed in the preceding chapters. Chapter 12 is a good presentation of the concept of resolution and its different definitions. Particularly noteworthy is the distinction the author makes between resolution and sampling rate. Chapter 13 contains a quick summary of a few quantitative measures of image quality. Chapter 14 discusses sampling from the point of view of image quality and is a good review of current work in the area with several references to recent publications.

Chapters 15 and 16 discuss the effects of the atmosphere on imaging systems, both in terms of transmission (Chap. 15) and the effect on MTF (Chap. 16). The chapters are reasonable overviews of these very complex subjects, and include references to relatively recent work, such as the effect of atmospheric aerosols on MTF. There are a couple of instances, however, where better proofreading would have been beneficial. In one instance, a table is mislabeled and in another instance the same symbol is alternately referred to as radiance and intensity.

Chapters 17 and 18 discuss signal and noise. Included in the discussions are brief descriptions and references to several computer models for calculating signals. The sections on noise contain a large number of formulas for responsivity, detectivity, and noise from different sources. However, the formulas are presented with little context on how they are derived or how they should be used, which limits the utility of the material except for those engineers that are already familiar with the subject. In particular, the discussion on shot noise is presented in the section titled "Large array systems," which would seem to imply that only systems with a large array of detectors experience shot noise. The problem is further compounded by the statement that visible sensors do not experience shot noise, implying that only radiation from the background produces shot noise and completely ignoring the effect of signal shot noise.

Chapter 19 contains an overview of the FLIR92 Thermal Imaging Systems Performance Model and does help to explain some of the assumptions that underlie the calculations in the model. A caution is included to read the documentation for the model to understand the regions of validity.

The book concludes with a chapter on the various categories of target discrimination based on Johnson criteria and a chapter on range performance predictions. These chapters provide application-oriented metrics to assess system performance. The effect of resolution and sensitivity on system performance is discussed.

Electro-Optical Imaging System Performance is a reasonable overview of the many topics that one needs to consider in the analysis of an electronic imaging system. It contains many current, useful references and highlights existing computer models that perform the modeling tasks. As such, the book may be useful to practicing engineers as a summary of pertinent formulas and an up-to-date index of work in the area.

BOOKS RECEIVED

Scanning Probe Microscopy and Spectroscopy: Methods and Applications, by Roland Wiesendanger. xxii + 637 pp., illus., subject index, references, list of acronyms. The book consists of two parts. The first deals with the theoretical background of scanning tunneling microscopy, and discusses in detail the design and instrumentation of practical STM systems. Part one concludes with a discussion of the experimental methods employed in scanning force microscopy, and other related scanning probe techniques. In part two,

the importance and widespread use of local probe techniques are highlighted by a thorough description of their applications in fields such as condensed matter physics, chemistry, biology, and nanotechnology.

Nonlinear Systems, by P. G. Drazin. xiii + 317 pp.; illus.; subject, author, and motion picture and video index; problems and further reading following each chapter; bibliographical references; answers to problems at end of book. Volume 10 from the Cambridge Texts in Applied Mathematics. ISBN 0 521 40668 4. Cambridge University Press, 40 West 20th Street, New York, NY 10011-4211 (1992) $29.95 softbound. The text evolves from courses given by the author in England and the United States. It introduces the mathematical properties of nonlinear systems, mostly difference and differential equations, as an integrated theory, rather than presenting isolated fashionable topics. Discusses classification of bifurcations of equilibrium points, difference equations, ordinary differential equations, second-order autonomous differential systems, forced oscillations, and chaos.

Diagrammatica: The Path to Feynman Rules, by Martinus Veltman. xii + 284 pp., illus., subject index, six appendixes. Volume 4 from the Cambridge Lecture Notes in Physics. ISBN 0 521 45692 4. Cambridge University Press, 40 West 20th Street, New York, NY 10011-4211 (1994) $29.95 softbound. The book begins with a brief review of some aspects of Einstein's theory of relativity that are of particular importance for field theory before going on to consider the relativistic quantum mechanics of free particles, interacting fields, and particles with spin. The techniques learned in these chapters are then demonstrated in examples that might be encountered in real accelerator physics. Further chapters contain discussions on renormalization, massive and massless vector fields, and unitarity. A final chapter presents concluding arguments concerning quantum electrodynamics.

Optical Solitons — Theory and Experiment, edited by J. R. Taylor. xv + 4564 pp., illus., subject index, references following each chapter, list of contributors. Volume 10 from the Cambridge Studies in Modern Optics. ISBN 0 521 40548 3. Cambridge University Press, 40 West 20th Street, New York, NY 10011-4211 (1992) $95 hardbound. This book describes both the theoretical and experimental aspects of optical soliton generation, soliton properties, and soliton applications. The intention of the book is to provide an overview of our current understanding of optical soliton properties, introducing the subject for the student and reviewing the most recent research. Only temporal optical solitons in fibers are considered.

Unusual Telescopes, by Peter L. Manly. xvii + 221 pp., illus., subject index, references, list of illustrations. Paperback version; hardback published in 1991. ISBN 0 521 48393 X. Cambridge University Press, 40 West 20th Street, New York, NY 10011-4211 (1995) $19.95 softbound. In this book, Peter Manly describes more than 150 of the less common telescope designs, from the inflatable telescope to liquid optics. The telescopes were built by both amateurs and professionals. The reasons for each telescope's uniqueness are given along with an engineering approach to the rationale of the design. Background information such as unusual observing requirements or environmental constraints are stated to explain why the designer chose a particular approach.

Ultrafast Diode Lasers: Fundamentals and Applications, by Peter Vasil'ev. xi + 271 pp., illus., subject index, references following each chapter, list of major symbols. From the Artech House Optoelectronics Library. ISBN 0 89006 736 8. Artech House, 685 Canton Street, Norwood, MA 02062 (1995) $88 hardbound. The purpose of this book is to present a comprehensive treatment of ultrafast diode lasers and describe the present state-of-the-art parameters that are of great importance for major applications. Chapters cover basics of semiconductor lasers; ultrashort pulse measurement techniques; gain and q-switching in diode lasers; mode-locked diode lasers; optical pulse compression and ultrafast nonlinear phenomena; ultrafast diode lasers in fiber optics communications; diode lasers in ultrafast optoelectronics and instrumentation; and trends and conclusions.

Coherent Optics: Fundamentals and Applications, by Werner Lauterborn, Thomas Kurz, and Martin Wiesenfeldt. x + 294 pp., illus., subject index, two appendixes, problems following each chapter, solutions at end of book. ISBN 3-540-58372-6. Springer Verlag, 175 Fifth Avenue, New York, NY 10011 (1995) 49 hardbound. Topics discussed include: history of optics; main areas of optics; fundamentals of wave optics; coherence; multiple-beam interference; speckles; holography; interferometry; Fourier optics; nonlinear dynamics of the laser; nonlinear optics; and fiber optics. Special attention is paid to a thorough presentation of the fundamentals.

Laser Communications in Space, by Stephen G. Lambert and William L. Casey. xix + 390 pp., illus., subject index, references following each chapter, list of acronyms, seven appendixes. From the Artech House Optoelectronics Library. ISBN 0 89006 722 8. Artech House, 685 Canton Street, Norwood, MA 02062 (1995) $99 hardbound. Chapter 1 provides the history and background of laser communications. Chapters 2 through 7 identify architectures, design methodologies for systems, optical design guides, and a detailed description of the acquisition, tracking, and communication processes. Chapter 8 deals with the state-of-the-art technology and Chap. 9 is a primer on how to design a system. Chapter 10 identifies weight and power trends and Chap. 11 provides a comparison to RF systems and identifies key parametrics for decision making. Finally, Chap. 12 overviews potential applications for laser communication systems.

Optical Methods of Engineering Analysis, by Gary L. Cloud. xii + 503 pp., illus., subject and author index, references following each chapter. ISBN 0-521-45087-X. Cambridge University Press, 40 West 20th Street, New York, NY 10011-4211 (1995) $79.95 hardbound. Beginning from a base in modern optics, the book proceeds through relevant theory of interference and diffraction, and integrates this theory with descriptions of laboratory techniques and apparatus. Among the techniques discussed are classical interferometry, photoelasticity, geometric moiré, moiré interferometry, holography, holographic interferometry, laser speckle interferometry, and video-based speckle methods.

Optical Engineering *is currently seeking reveiwers for the books listed in the "Books Received" section. In exchange for a publication-worthy critique, reveiwers will receive a complimentary copy of the book they review. Interested individuals should contact Dr. Bradley D. Duncan, Book Reviews Editor, The University of Dayton, Center for Electro-Optics, 300 College Park, Dayton, OH 45469-0245. E-mail: bduncan@engr.udayton.edu. Phone: 513/229-2796.*