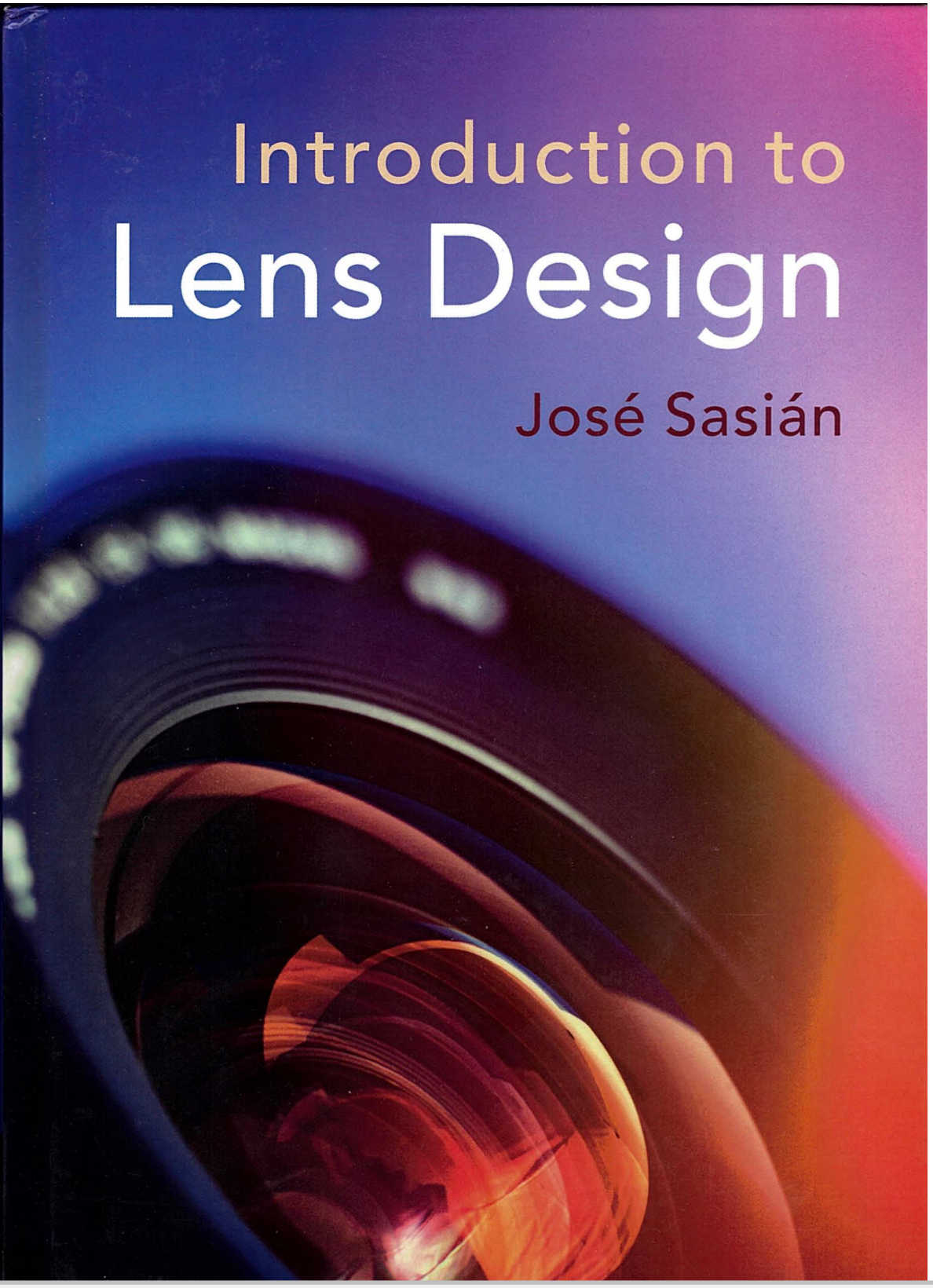

Introduction to Lens Design

Optical lenses have many important applications, from telescopes and spectacles, to microscopes and lasers. This concise, introductory book provides an overview of the subtle art of lens design. It covers the fundamental optical theory, and the practical methods and tools employed in lens design, in a succinct and accessible manner. Topics covered include first-order optics, optical aberrations, achromatic doublets, optical relays, lens tolerances, designing with off-the-shelf lenses, miniature lenses, and zoom lenses. Covering all the key concepts of lens design, and providing suggestions for further reading at the end of each chapter, this book is an essential resource for graduate students working in optics and photonics, as well as for engineers and technicians working in the optics and imaging industries.

JOSÉ SASIÁN is Professor of Optical Design at the James C. Wyant College of Optical Sciences at the University of Arizona in Tucson, AZ. He has taught a course on lens design for more than 20 years and has published extensively in the field. He has worked as a consultant in lens design for the optics industry, and has been responsible for the design of a variety of successful and novel lens systems.

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10

Lens Tolerancing

A lens manufacturer requires tolerances in the dimensions of a lens to be able to provide a cost estimate and be able to manufacture the lens. Further, for the lens to meet the lens specifications after it is built, it is necessary that the actual lens dimensions do not depart from the nominal design ones by some amounts known as fabrication and assembly tolerances. Thus, the task of the lens designer is not only to provide a lens design that meets image quality requirements, but to also provide tolerances, so that the as-built lens actually meets the specifications and satisfies the needs of the application. Critical goals of the lens tolerancing process are to provide tolerances to each of the constructional parameters of the lens, and to find out the statistics of the as-built lens so that the fabrication yield, and final cost, can be estimated. This chapter provides a primer into the lens tolerancing process. Commercial lens design software allows for the lens tolerancing analyses discussed below.

10.1 Lens Dimensions and Tolerances

A lens designer needs to develop an understanding of physical dimensions and their measurement so that realistic tolerances can be assigned. He or she needs to have insight into linear and angular dimensions, such as how big a micrometer is, or one-arc second is. In lens fabrication, both of these magnitudes often separate what is very difficult to make from what is reasonable to make. One must find out how a given lens dimension will be achieved and measured in the optics shop. If it cannot be measured, it probably cannot be made to specification.

Twenty-five micrometers (25 μm) is a useful reference. The minimum measurement division of many instruments and machining tools is 0.001″, or about 25 μm. Asking for an optical element to be made with a tolerance of

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