PREFACE TO THE FIFTH EDITION

The first laser was fabricated in 1960 - and since then there has been a renaissance in the field of optics. From optical amplifiers to laser physics, fiber optics to optical communications, optical data processing to holography, optical sensors to DVD technology, ultra-short pulse generation to super continuum generation, optics now finds important applications in many branches of science and engineering. In addition to numerous practical applications of optics, it is said that it was the quest to understand the "nature of light" that had brought about the two revolutions in science: the development of quantum mechanics started with an attempt to understand the "light quanta" and the starting point of the special theory of relativity was Maxwell's equations which synthesized the laws of electricity and magnetism with that of light. Because of all this, an undergraduate course in optics has become a "must" not only for students of physics but of engineering as well. Although it is impossible to cover all areas in one single book, this book attempts to give a comprehensive account of a large number of important topics in this exciting field and should meet the requirements of a course on optics meant for undergraduate students of science and engineering.

New to the Edition

- Addition of a new section (Part 8): Three chapters on Special Theory of Relativity.
- Sections on Interference pattern, Directionality of laser beam, Malus' law, Interference of polarized light, Maxwell's equations, Jones calculus, Optical fiber sensors and waveguide theory have been rewritten in Chapters 2, 10, 14, 18, 22, 23, 26, 27 and 28.
- Many figures have been redrawn for better understanding and visuals for students

Organization of the Book

The book attempts to give a balanced account of traditional optics as well as some of the recent developments in this field. The plan of the book is as follows:

- **Chapter 1** gives a brief history of the development of optics. I have always felt that one must have a perspective of the evolution of the subject that he wants to learn. Optics is such a vast area field that it is extremely difficult to give a historical perspective of all the areas. My own interests are in fiber optics and hence, there is a bias towards the evolution of fiber optics and related areas. In the process, I must have missed names of many individuals who have made important contributions to the growth of optics. Fortunately, there is now a wealth of information available through the Internet. I have also tried to include a number of references to various books and websites.

- **Chapter 2** gives a brief historical evolution of different models describing the nature of light. It starts with the corpuscular model of light and then discusses the evolution of the wave model and the electromagnetic character of light waves. Then there is a discussion of the early twentieth-century experiments, which could only be explained by assuming a particle nature of light, and end with a discussion of how we reconcile to "wave-particle duality".

- **Chapters 3 to 6** are on geometrical optics. **Chapter 3** starts with Fermat's principle and discusses ray tracing through graded-index media explaining in detail the phenomena of mirage and looming, ray propagation through graded index optical waveguides and also reflection from the ionosphere. **Chapter 4** is on ray tracing in lens systems and **Chapter 5** is on the matrix method in paraxial optics, which is used in the industry. **Chapter 6** gives a brief account of aberrations.

- **Chapters 7 to 12** discuss the origin of refractive index and the basic physics of wave propagation including Huygens' Principle. Many interesting experiments are discussed. The concept of group velocity and the dispersion of an optical pulse as it propagates through a dispersive medium have been discussed in detail. Self-phase modulation, which is one of the phenomena leading to the super continuum generation has also been explained.
- **Chapters 13 to 16** cover the very important and fascinating area of interference and many beautiful experiments associated with it - the underlying principle is the superposition principle, which is discussed in **Chapter 13**. **Chapter 14** discusses interference by division of wave front including the famous Young's double hole interference experiment. In **Chapter 15**, interference by division of amplitude is discussed which allows us to understand colors of thin films and applications like anti-reflection films, etc. The basic principle of the working of the Fiber Bragg Gratings (usually abbreviated as FBG) is discussed along with some of their important applications in the industry. In the same chapter, the Michelson interferometer is also discussed for which Michelson received the Nobel Prize in Physics in 1907. To quote Sir James Jeans, "(the interferometer is) perhaps one of the most ingenious and sensational optical instruments…". **Chapter 16** discusses the Fabry-Perot interferometer that is based on multiple beam interference and is characterized by a high resolving power and hence finds applications in high-resolution spectroscopy.
- **Chapter 17** discusses the basic concept of temporal and spatial coherence. The ingenious experiment of Michelson, which used the concept of spatial coherence to determine the angular diameter of stars, has been discussed in detail. Topics like optical beats and Fourier transform spectroscopy have also been discussed.
- **Chapters 18, 19, and 20** cover the very important area of diffraction and discuss the principle behind topics like diffraction divergence of laser beams, resolving power of telescopes, laser focusing, X-ray diffraction, optical media technology, Fourier optics and spatial frequency filtering.
- **Chapter 21** discusses the underlying principle of holography and some of its applications. Dennis Gabor received the 1971 Nobel Prize in Physics for discovering the principle of holography.
- **Chapters 22, 23, and 24** are on the electromagnetic character of light waves. **Chapter 22** discusses the polarization phenomenon and propagation of electromagnetic waves in anisotropic media including first principle derivations of wave and ray velocities. Phenomena like optical activity and Faraday rotation (and its applications to measuring large currents) have been explained from first principles. In **Chapter 23**, starting with Maxwell's equations, the wave equation has been derived which led Maxwell to predict the existence of electromagnetic waves and also to propound that light is an electromagnetic wave. Reflection and refraction of electromagnetic waves by a dielectric interface have been discussed in **Chapter 24**. Results derived in this chapter directly explain phenomena like Brewster's law, total internal reflection, evanescent waves, Fabry-Perot transmission resonances, etc.
- **Chapter 25** is on the particle nature of radiation - which was first put forward by Einstein in 1905. The chapter also discusses the Compton Effect (for which Compton received the 1927 Nobel Prize in Physics), which established that the photon has a momentum equal to $h\nu/c$.
- **Chapter 26** is on lasers - a subject of tremendous technological importance. The basic physics of optical amplifiers and of lasers along with their special characteristics are also discussed.
- **Chapters 27, 28, and 29** are on waveguide theory and fiber optics - an area that has revolutionized communications and has found important applications in sensor technology. **Chapter 27** discusses the light guidance property of the optical fiber (using ray optics) with applications in fiber optic communication systems; the chapter also gives a very brief account of fiber-optic sensors. **Chapter 28** discusses basic waveguide theory with Maxwell's equations as the starting point. **Chapter 29** discusses the propagation characteristics of single mode optical fibers, which are now extensively used in optical communication systems.
- In 1905, Einstein put forward the special theory of relativity which is considered as one of the revolutions in the last century. **Chapters 30, 31, and 32** describe briefly the important consequences of the special theory of relativity viz., time dilation, length contraction, the "mass energy relation" and Lorentz transformations.

- Very often, a good photograph clarifies an important concept and also makes the student interested in the subject. It is with this intention that I have given a few colored photographs (in the prelim pages of the book) that describe important concepts in optics.

In summary, the book discusses some of the important topics that have made tremendous impact in the growth of science and technology.

Salient Features of the Book

- A large number of figures correspond to actual numerical calculations which were generated using software like GNUPLOT and Mathematica. There are also some diagrams which give a three dimensional perspective of the phenomenon
- Every chapter starts with important milestones in the area. This gives a historical perspective of the topic
- All important formulas have been derived from first principles so that the book can also be used for self study
- Numerous worked out examples are scattered throughout the book to help clarify difficult concepts
- Each chapter ends with a summary of important results derived in the chapter

Explore the Web

Additional material is available at *http://www.mhhe.com/ghatak/optics5*

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New Delhi **Ajoy Ghatak**
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Feedback

I will be very grateful for suggestions for further improvement of the book, my email addresses are ajoykghatak@gmail.com and ajoykghatak@yahoo.com

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