

Interior Lighting for Designers

FOURTH EDITION

Gary Gordon FIES, FIALD, LC

Illustrations by Gregory F. Day



John Wiley & Sons, Inc.

Interior Lighting for Designers

About the cover photograph: The developer of this midtown-Manhattan residential tower wanted to lure young, affluent apartment seekers to a less-than-glamorous neighborhood. He relied on architecture to do it. The lighting concept reinforces the architect's asymmetrical, "anti-classical" approach: there is no traditional bottom-middle-top. The white, plaster wall is lighted with floor-mounted 100PAR/HIR lamps 12" on center. A rough, industrial, Italian, factory floor lamp is paired with a soft, Japanese, paper-shade pendant to contribute to the residential scale. The building fully rented six months after the lobby's completion, 18 months ahead of schedule.

Gary Gordon received the 2000 Illuminating Engineering Society Lumen Award and the 2000 International Illuminating Design Award for this project. The New Gotham Lobby, Stephen Alton Architects. Photo by Eduard Hueber.

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*For
my grandfather,
Louis Becker,
who first inspired me to look at buildings*

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Preface to the Fourth Edition

This Fourth Edition expands upon the foundation established in the previous edition, with the added benefit of greater clarity throughout. While it retains the mark of the thorough copy and technical edit provided for the Third Edition by the late luminaire-design genius Edison Price, chapters 9, 10, and 11 have been reorganized to correspond more closely with professional practice. New to this edition is material on the latest advances in lighting technology and practice; state-of-the-art light sources, equipment, and systems; and a comprehensive glossary. For the first time, an Instructor's Manual is available on-line from the publisher to accompany the text.

As with the Third Edition, this book is intended to serve as both a textbook for architecture and interior design students and a manual for practicing professionals. It provides a simple framework for understanding the lighting design process. More than 250 line drawings, photographs, and color plates, many of them new to this edition, illustrate the text. The design of light for inte-

riors is emphasized; tools and techniques are presented as a means by which to achieve the design. This is an architectural approach to lighting design, based on my apprenticeship with the talented architect and lighting designer Carroll Cline, as well as twenty years of professional practice.

The lighting design process outlined in this book parallels the methodology used by lighting professionals to provide solutions for architectural interiors around the world. I developed this system for describing the lighting design process while teaching graduate and undergraduate students at the Parsons School of Design Lighting Institute in New York City. The success of this method is demonstrated by the great number of my former students who professionally practice lighting design today.

ACKNOWLEDGMENTS

This work owes an enormous debt to Caryl Gordon and Mary Hebert for their help with copy-editing and proofreading; to Dr. Kevin Houser for his exceptionally thorough techni-

cal edit; and to David Marini for his assistance with the layout and design.

Valuable research assistance was provided by the able crew of the Gary Gordon LLC office in New York: Kevin Frary, Justin Horvath, Michael Haslam, Christine Kong, Ryan Stromquist, Rob Thomas, and Ryan Wither. Rob Thomas skillfully coordinated all of the drawings, color plates, and photographs.

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Gary Gordon FIES, FIALD, LC

New York, New York

September 2002

Introduction

Lighting design is a process. It is the process of integrating light into the fabric of architecture. Regardless of the space to be lighted—a bank, a church, an office, a gallery, a restaurant, a store, a classroom—and regardless of the light sources available for use, the process is always the same.

Because lighting design is a process, it can be learned. This book traces the steps in the lighting design process much as a professional performs them in practice. Design, of course, is not always a linear process. At times some of these steps are used simultaneously. But, on the whole, the order of the material corresponds to professional practice.

This book does not describe *the* lighting design process; it describes a lighting design process. It is one that has been used successfully by Gary Gordon LLC to provide solutions for more than one thousand architectural projects around the world. It is a process built on the conviction that the lighting condition of a space has enormous emotional impact on people.

A common mistake when providing light for buildings is to select the lighting equipment first. Selecting luminaires is the last step in the process. What is important is not

what makes the light, but which objects and surfaces receive it. The key to successful lighting design is to decide *what* you want to light first, and then work backward to determine the solution.

In chapter 1, we learn by understanding the human visual system that perception of the world around us is based not on the quantity of light entering the eye but on the quantity of contrast. In chapter 2, we learn from psychology that because the sense of sight is contrast-sensitive, the brightness contrast of a space determines its emotional impact. In chapter 3, we learn how the direction and distribution of light determine the brightness contrasts that yield the desired emotional setting.

Once the emotional setting and brightness contrast have been established, we begin our selection of light sources by determining the color of light in chapter 4. The next three chapters provide a thorough knowledge of light sources, from daylight (chapter 5) through incandescent and tungsten-halogen (chapter 6) to discharge sources: fluorescent, mercury, metal halide, and high-pressure sodium (chapter 7). Chapter 8 describes the auxiliary equipment required to operate discharge and low-voltage incandescent lamps.

Chapter 9 explains the external devices employed to modify light sources so that they provide the desired direction and distribution of light and control glare. With the light source modified, Chapter 10 illustrates how we use photometry to predict the quantity of light in completed space. Chapter 11 provides an understanding of the electrical requirements of light sources and methods of lighting system control.

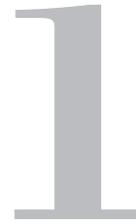
Once the source, with its external devices, methods of modifying distribution and controlling glare, and electrical requirements, is established, we are at last ready to select the luminaire in chapter 12. It is only at this point in the lighting design process that a suitable luminaire can be chosen: after the designer has identified the activity in a space and degree of contrast required, and has determined the color of light, light

sources, modifications to control source distribution and glare, and locations of light sources.

Our final chapter looks at the elements that produce visual clarity; design techniques for lighting architectural surfaces, tasks, and art; the balance of brightness; energy-effective design; and integrating light and architecture.

The architectural lighting design process described in this book produces a space where the casual observer is unaware of the mechanics of light production; he perceives only a comfortable environment that supports his activities and enhances his well-being. With practice, the designer learns to apply this process in ways that go even further, producing environments that stimulate the mind and inspire the spirit.

Perception



Perception of the world around us is based not on the quantity of light entering the eye, but on the quantity of contrast.

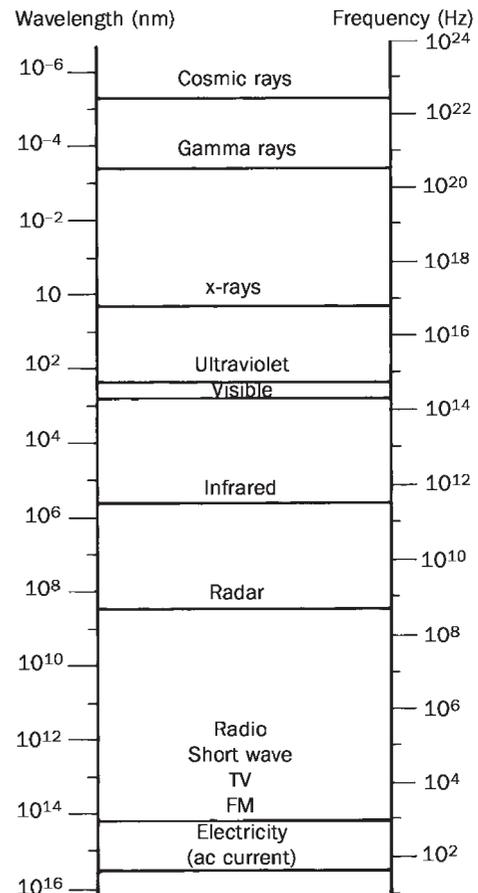
VISIBLE LIGHT

What we perceive as light is a narrow band of electromagnetic energy, ranging from approximately 380 nanometers (nm) to 760 nm. Only wavelengths in this range stimulate receptors in the eye that permit vision (figure 1.1 and color plate 1). These wavelengths are called *visible energy* even though we cannot directly see them.

In a perfect vacuum, light travels at approximately 186,000 miles per second. When light travels through glass or water or another transparent substance, it is slowed down to a velocity that depends on the density of the medium through which it is transmitted (figure 1.2). This slowing down of light is what causes prisms to bend light and lenses to form images.

When light is bent by a prism, each wavelength is refracted at a different angle so the emergent beam emanates from the

Figure 1.1 Visible light is a narrow region of the total electromagnetic spectrum, which includes radio waves, infrared, ultraviolet, and x-rays. The physical difference is purely the wavelength of the radiation, but the effects are very different. Within the narrow band to which the eye is sensitive, different wavelengths give different colors. See also color plate 1.



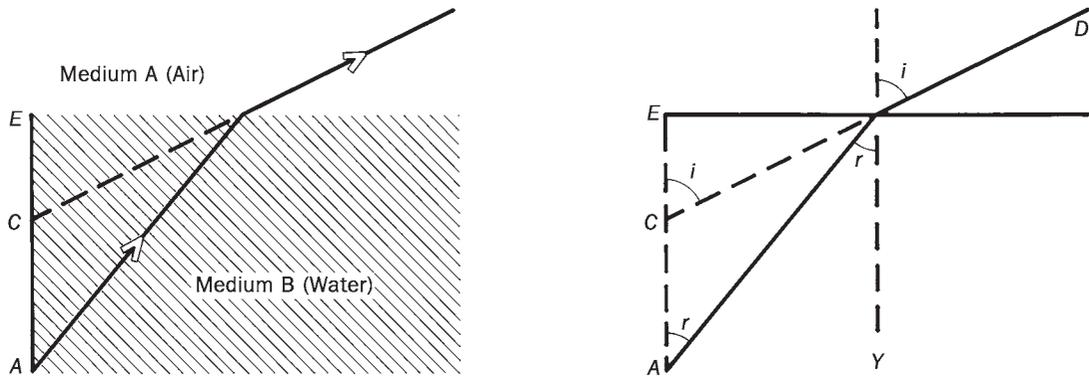


Figure 1.2 The law of refraction (Snell's law) states that when light passes from medium A into medium B the sine of the angle of incidence (i) bears a constant ratio to the sine of the angle of refraction (r).

prism as a fan of light, yielding all of the spectral colors (see color plate 2).

All electromagnetic radiation is similar. The physical difference between radio waves, infrared, visible light, ultraviolet, and x-rays is their wavelength. A *spectral color* is light of a specific wavelength; it exhibits deep chromatic saturation. *Hue* is the attribute of color perception denoted by what we call red, orange, yellow, green, blue, and violet.

THE EYE

A parallel is often drawn between the human eye and a camera. Yet visual perception

involves much more than an optical image projected on the retina of the eye and interpreted "photographically" by the brain.

The human eye is primarily a device that gathers information about the outside world. Its focusing *lens* throws a minute inverted image onto a dense mosaic of light-sensitive receptors, which convert the patterns of light energy into chains of electrical impulses that the brain will interpret (figure 1.3).

The simplest way to form an image is not with a lens, however, but with a pinhole. In figure 1.4, a ray from each point of the object reaches only a single point on the

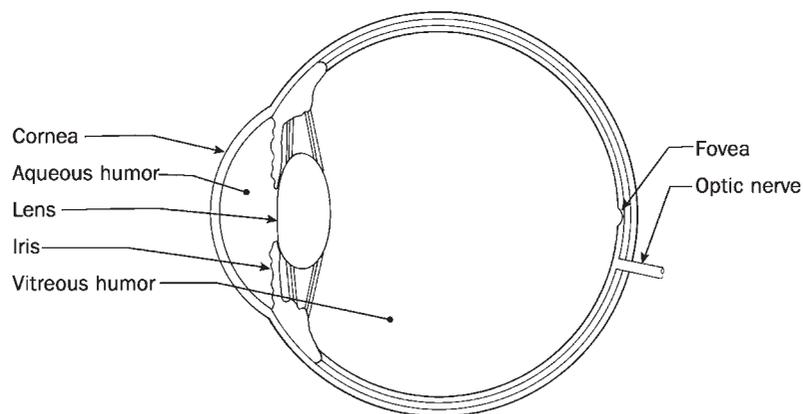


Figure 1.3 Cross section of the human eye.

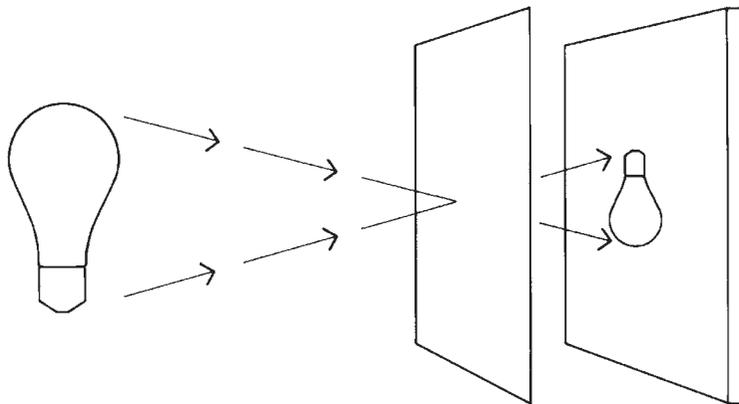


Figure 1.4 Forming an image with a pinhole.

screen, the two parts being connected by a straight line passing through the pinhole. Each part of the object illuminates a corresponding part of the screen, so an upside-down image of the object is formed. The pin-hole image is dim, however, because the hole must be small (allowing little light to pass through) if the image is to be sharp.

A lens is able to form a much brighter image. It collects a bundle of light rays from each point of the object and directs them to corresponding points on the screen, thus giving a bright image (figure 1.5).

The lens of the human eye is built up from its center, with cells being added all through life, although growth gradually slows down. The center is thus the oldest part, and as the cells age they become more compact and harden. As a result, the lens stiffens and is less able to change its shape to accommodate varying distances (*presbyopia*) (figure 1.6).

Lenses work well only when they fit properly and are adjusted correctly. Sometimes the lens is not suited to the eye in which it finds itself: (1) the lens focuses the image in

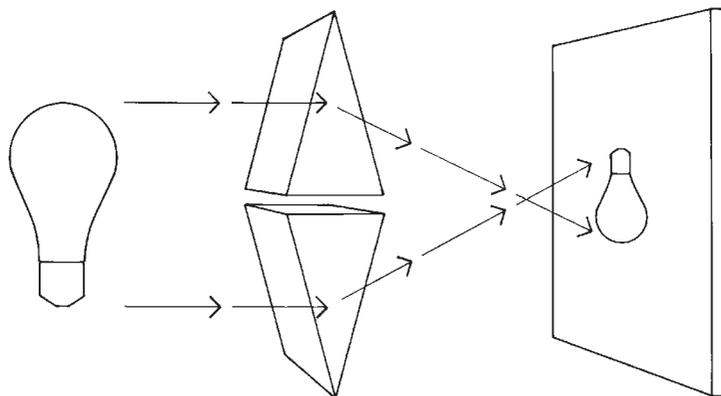


Figure 1.5 Forming an image with a lens. The lens shown is a pair of prisms; image-forming lenses have curved surfaces.

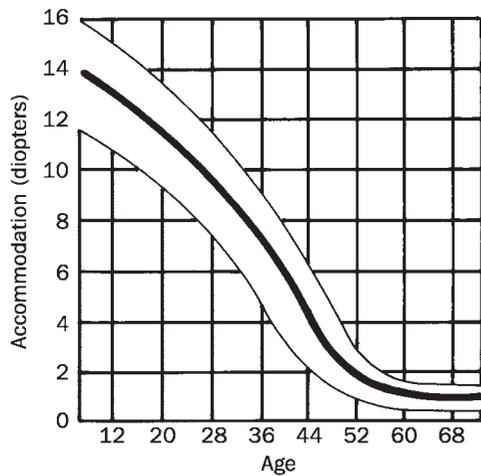


Figure 1.6 Loss of accommodation of the lens of the eye with aging.

front of or behind the retina instead of on it, giving “short” sight (nearsighted or *myopic*) or “long” sight (farsighted or *hyperopic*); (2) the lens is not truly spherical, giving distortion and, in some directions, blurring of the image (*astigmatic*); or (3) the cornea is irregular or pitted.

Fortunately, almost all optical defects can be corrected by adding artificial lenses, which we call *eyeglasses*. Eyeglasses correct for errors of focus (called *accommodation*) by changing the power of the lens of the eye; they correct for distortion (called *astigmatism*) by adding a nonspherical component. Ordinary glasses do not correct damage to the surface of the cornea, but *corneal lenses*, fitted to the eye itself, serve to give a fresh surface to the cornea.

The *iris* is the pigmented part of the eye. It is found in a wide range of colors, but the color has no impact on vision as long as it is opaque. The iris is a muscle that forms the *pupil*. Light passes through the pupil to the lens which lies immediately behind it. This

muscle contracts to reduce the aperture of the lens in bright light and also when the eyes converge to view near objects.

The *retina* is a thin sheet of interconnected nerve cells, which include the light-sensitive cells that convert light into electrical impulses. The two kinds of light-receptor cells—*rods* and *cones*—are named after their appearance as viewed under a microscope (figure 1.7).

Until recently, it was assumed that the cones function in high *illuminance*, providing color vision, and the rods function under low illuminance, yielding only shades of gray. Color vision, using the cones of the retina, is called *photopic*; the gray world given by the rods in dim light is called *scotopic*.

Recent research, however, suggests that both rods and cones are active at high illuminance, with each contributing to different aspects of vision. When both rods and cones are active, vision is called *mesopic*.

THE BRAIN

The eyes supply the brain with information coded into chains of electrical impulses. But the “seeing” of objects is determined only partially by these neural signals. The brain searches for the best interpretation of available data. The perception of an object is a hypothesis, suggested and tested by sensory signals and knowledge derived from previous experience.

Usually the hypothesis is correct, and we perceive a world of separate solid objects in a surrounding space. Sometimes the evaluation is incorrect; we call this an *illusion*. The ambiguous shapes seen in figures 1.8 and 1.9 illustrate how the same pattern of stimulation at the eye gives rise to different perceptions.

BRIGHTNESS PERCEPTION

We speak of light entering the eye, called *luminance*, which gives rise to the sensation