

BOOK REVIEW

A review of *Modern Ophthalmic Optics*

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Outside of the laboratory, it is my visit to the optician that affords me the best opportunity to view a large collection of exciting physics kit. Sitting on that black chair, surrounded by boxes of lenses and all manner of interesting high-tech contraptions, I get the sense that there must be a lot of physics at the root of what opticians do. Of course, in school we all learned about simple geometrical optics and how the eye is supposed to work, including that spectacles with concave lenses are prescribed to correct short-sightedness (the disorder in which a sharp image is cast in front of the retina, rather than on it, resulting in blurry vision), while convex lenses are used for the opposite case of long-sightedness (when the image would be brought into focus behind the retina). You might think that this is all there is to the subject of ophthalmic optics, at least as far as physics is concerned. It's just a matter of adjusting the focal length of the defective eye so as to form a sharp image, and hence there really cannot be anything new to learn. If that is your limited view, this comprehensive account of the field will really open your eyes.

For a start, there are the materials out of which the spectacle lenses are made. We want something with a high transmissivity, and a large refractive index, but real materials have a refractive index which depends on wavelength, meaning that there will be chromatic aberration (the effects of which can be more significant when viewing things off-axis, as those of us who wear corrective lenses know well). The lenses should be tough but light and should not degrade over time, and one of the reasons our spectacle lenses have become thinner over the last few decades has been because of remarkable advances in material science, developing new polymeric materials with suitable properties.

Designing the curved surfaces of lenses is highly complex, requiring a surprising amount of geometry and matrix algebra, particularly because astigmatism is often also present (so the curvature of the spectacle lens will have an azimuthal dependence). Then there are the effects of parts of the lens acting as prisms, shifting the image, and the spectacle lens (unlike a contact lens) does not sit on the eye, so the image size is changed, and these effects can vary across the lens, creating distortion. It turns out that a 5x5 matrix technique is used for modelling the effects of decentred or tilted optical surfaces. These mathematical approaches are treated exceptionally well.

Things become even more complicated when the lens is progressive, as used in varifocals. In these lenses the focal length changes as you look down the lens, so that both distance and near can be pin sharp, even for the ageing eye. This requirement is impossible to satisfy everywhere across the lens, so the off-axis distortions can be even greater. It turns out that a complete theory for some of the new multifocal lenses does not exist, but the authors provide a model that captures the essential features and demonstrates how the design of progressive lenses is essentially a matter of balancing pros and cons.

All these effects and more are described, calculated and modelled in this remarkable book. Contact lenses, machines for measuring lenses, manufacturing techniques, antireflection coatings, lens aberrations, all are all treated with clarity and erudition. It is a book packed with mathematics and physics, proof that this field is extraordinarily rich, surprisingly beautiful and still remarkably active with new discoveries and rapid advances, driving what is of course an enormous, worldwide industry. The book is really designed for researchers, manufacturers and practitioners in ophthalmic optics, but for the more general reader (who will need a good grounding in physics) it will make us see our next trip to the optician in a new light and realise just how much physical science goes into bringing our world into focus.