APPENDIX A GOOD BOOKS

A.1 Why Books?

If you're going to build electro-optical systems for a living, you're going to have to change fields a lot. If you're still in school, use the opportunity to broaden your expertise—an optics or experimental physics student should learn signal processing and circuit design, and an electrical engineering student, classical and quantum mechanics. It's well worth devoting an extra semester to, if you can afford it (graduate students usually can). The rest of us need good readable books that don't demand total devotion. As a bonus, a lot of these books can be read for pleasure as well as instruction—many of these folks are very engaging writers.

The present author's usual way to start learning a new field is to get a good undergraduatelevel textbook and read it like a novel. Pay special attention to getting the very basic concepts down perfectly; as we've seen in earlier chapters, our confidence in working in a new area depends entirely on how sure we are of our tools. For example, Fourier optics is an approximation, but the Fourier decomposition of an optical field is exact; in electronics, metal resistors are linear and have only Johnson noise, and capacitors subtract DC noiselessly. In this class also are the classical techniques of other fields. For instance, the use of UHF modulation to suppress mode hopping in diode lasers is an idea first used around 1930, in the quench circuits of superregenerative receivers. (Superregeneration is an amazingly cute idea—you can amplify the Johnson noise enough to drive headphones with a single low-gain stage; see Section 2.14.3 and Terman, *Radio Engineering*.)

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There's another very important advantage to books: they're written by experts in the field, who not only know what topics are important, but *know what things are called*. Without that crucial information, you can spend an appalling amount of time trawling through blogs and forums and videos and still not find what you need because you don't know how to search for it.[†]

A.2 Good Books For Instrument Builders

Legend:

X	Introductory level: Accessible to technical people from outside the field
XX	Intermediate: Advanced undergraduate level, some background required
XXX	Advanced: university-level preparation required.
8	Available free online

MATHEMATICS

The present author cannot emphasize too strongly the need for good mathematical preparation for electro-optical instrument building. To do this stuff at a high level, you really need differential and integral calculus, vector calculus, ordinary- and partial-differential equations, calculus of complex variables, and Fourier analysis of both analog and digital signals and systems. Calculus of variations and asymptotic analysis are also very useful. (Note to students: concentrate your course work on stuff that's harder to pick up on your own.)

George B. Arfken and Hans-Jurgen Weber, *Mathematical Methods for Physicists*, Fourth edition, Academic, 1995. Good standard undergraduate text on classical analysis, with the physicist's mathematical permissiveness; especially good on complex variables.

Carl M. Bender and Steven A. Orszag, *Advanced Mathematical Methods for Scientists and Engineers: Asymptotic Methods and Perturbation Theory*, Springer, 1999, (Reprint of the 1978 edition). The best applied math book of all time: light on the rigor, but powerful and full of physical insight (and good graphs). Excellent problems.

Ronald N. Bracewell, *The Fourier Transform and Its Applications*, Third edition, McGraw-Hill, 1999. Bracewell teaches you how to think in Fourier space, which is hugely valuable for optics and electronics folk.

I. M. Gelfand and S. V. Fomin, *Calculus of Variations*, Richard A. Silverman, translator, Dover, 2000 (Reprint of the 1963 Prentice-Hall edition). Variational methods are a uniquely powerful way to get solutions to a lot of problems in electromagnetics and me-

[†]Thanks are due to the assembled expertise of the Usenet groups sci.optics and sci.electronics.design for suggestions and criticism of the following list. Those groups are also excellent places to find electro-optical design help. One thing to remember about Usenet technical groups: the crisper and more detailed the question, the more helpful the answer, in general. Oh, and ignore the trolls.

chanics, which lead straight to useful algorithms. Short, accessible and has all the variational horsepower you're likely to need. XX

Roger A. Horn and Charles R. Johnson, *Matrix Analysis*, Cambridge University Press, 1987. Covers advanced linear algebra topics, such as singular value decomposition, condition numbers, and so on. It's a math book, all right, but it's nice and clear, and states results in algorithmically useful forms. \Re

George Polya, *How To Solve It*, Princeton, 1945 (continually reprinted). Ever wonder how people actually discover those mathematical techniques they teach students? Polya gives many useful exploration approaches that you can use quickly. Elementary but not simple. \Re

Athanasius Papoulis, *Probability, Statistics, and Stochastic Processes*, Third edition, McGraw-Hill, 1991. Readable and full of useful examples in statistical signal processing, *e.g.* Wiener and Kalman filters, maximum entropy estimation, maximum likelihood tests, Monte Carlo methods, and detection of signals in noise.

MATHEMATICAL TABLES

Milton Abramowitz and Irene A. Stegun, *Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables*, US National Bureau of Standards, 1964. All about practical uses of special functions. Contains low and high accuracy tables, integral representations, asymptotic forms, and polynomial approximations.

Izrail S. Gradshteyn and Iosif M. Ryzhik, *Tables of Integrals, Series, and Products*, Fourth edition, Academic Press, 1994, Corrected reprint of the 1980 edition. A gigantic, well organized, and highly accurate set of integral tables.

Daniel Zwillinger, *CRC Standard Mathematical Tables and Formulae*, 30th edition, Chemical Rubber Company, 1996. Smaller and more accessible than G&R, this one has trigonometric and combinatoric identities and a much smaller table of integrals.

ELECTROMAGNETICS

Roger F. Harrington, *Time Harmonic Electromagnetic Fields*, Second edition, IEEE, 1996 (Reprint of the 1961 edition). Especially good on variational principles and the radiation reaction concept—powerful but less widely known tools for EM problems.

Roger F. Harrington, *Field Computation by Moment Methods*, Second edition, IEEE, 1993 (Reprint of the 1968 MacMillan edition). The method of moments is the standard way to solve complicated antenna and metal waveguide problems. This book gives a unified and easy-to-follow development. **XXII**

John D. Jackson, *Classical Electrodynamics*, Third Edition, Wiley, 1998 An excellent upper-level electromagnetics text, with particularly good chapter problems. \mathcal{RR}

Lev D. Landau, Evgeny M. Lifshitz, and Lev P. Pitaevskii, *Electrodynamics of Continuous Media*, Pergamon, 1984. Gives another angle on electromagnetics. L&L is especially good

on crystal optics. XX

Simon Ramo, John R. Whinnery, and Theodore Van Duzer, *Fields and Waves in Communication Electronics*, Third edition, Wiley, 1994. An advanced E&M text with unusual coverage that's often very helpful; things like conservation of complex power, calculating inductance and capacitance, antennas, transmission lines and resonators.

Albert Shadowitz, *The Electromagnetic Field*, Dover, 1988. A 'div, grad, curl' E&M textbook with an engineering angle and lots of very clear explanations, at an introductory level (Maxwell's equations don't show up till Chapter 11). Inexpensive.

Allen Taflove and Susan C. Hagness, *Computational Electrodynamics: The Finite Difference Time Domain Method*, Third edition, Artech House, 2005. A big book on the state of the FDTD art, with lots of details; explicit equations and algorithms you can code.

OPTICS

Nicolaas Bloembergen, *Nonlinear Optics*, Fourth edition, World Scientific, 1996, (Reprint of 1965 edition with updated references.) The best books are usually written by the pioneers, and Bloembergen is an excellent example: clearly written and physically lucid.

Max Born and Emil Wolf, *Principles of Optics*, Sixth edition, Cambridge University Press, reissued 1998. The standard work on optical theory: propagation, diffraction, coherence, aberrations, you name it.

V. A. Borovikov and B. Ye. Kinber, *Geometrical Theory of Diffraction*, IEEE, 1994. If you have to do GTD for real, this is the book. Not elementary, but clear and complete.

Robert F. Fischer, *Optical Systems Design*, Second edition, McGraw-Hill, 2007. More centered on lenses than Smith. Has a lot of hands-on stuff, from design to glass selection to tolerancing, and a great list of bloopers at the end. \propto

Grant R. Fowles, *Introduction to Modern Optics*, Second Edition, Dover, 1989. Fowles provides a lot of good physical insight into optical phenomena. Inexpensive.

Jack D. Gaskill, *Linear Systems, Fourier Transforms, and Optics*, Publisher: Wiley-Interscience, 1978. Develops the whole theory of 1- and 2D linear systems from scratch, then derives Fourier optics and CTF/OTF as consequences. More mathematical than some.

A. Gerrard and J. M. Burch, *Introduction To Matrix Methods In Optics*, Dover, 1994. Presents the mathematics of ABCD, Gaussian beam, and polarization matrix calculations in a clear and comprehensive way; Inexpensive. \Re

Joseph W. Goodman, *Introduction to Fourier Optics*, Second edition, McGraw-Hill, 1986. A well-written brief introduction, whose elementary level limits it to the paraxial case.

Joseph W. Goodman, *Statistical Optics*, Second Edition, Wiley-Interscience, 2015. Very readable and complete: covers speckle, classical and quantum fluctuations, and the complete theory of imaging with partially coherent light, using fairly advanced statistical reasoning.

Eugene Hecht, *Optics*, Addison-Wesley, Fourth edition, 2002. An introductory optics text, with lots of physical insight. Especially good on Fourier and physical optics.

Kenji Kawano and Tsutomu Kitoh, *Introduction to Optical Waveguide Analysis*, Wiley, 2001. All about numerically calculating modes and propagation in optical waveguides and fibers. Lots of details.

Rudolf Kingslake, *Lens Design Fundamentals*, Academic Press, 1978, and *Optical Systems Design*, Academic Press, 1983. These books are classics, reflecting the Conrady tradition of hand calculation in optical design. You can't run a numerical optimizer with a desk calculator, so Kingslake talks a lot about heuristics and intuitive methods, and this alone is worth the price of the books even in our computer-heavy era.

Miles V. Klein and Thomas E. Furtak, *Optics*, Second edition, Wiley, 1986, Compared with Hecht, K&F has much more on geometric optics and aberration and less on physical optics. Some mathematical errors.

Virendra N. Mahajan, *Aberration Theory Made Simple*, SPIE, 1991. An accessible but oddly split treatment of wave and ray aberrations. A bit weaker on the connections and disconnects between them, *e.g.* the subtle changes in terminology. \mathbf{x}

Bahaa E. A. Saleh and Melvin C. Teich, *Fundamentals of Photonics*, Second Edition, Wiley, 2007. Starts from the basics and covers most devices of interest.

Warren Smith, *Modern Optical Engineering*, McGraw-Hill, Fourth edition, 2007. Good self-teaching book on all aspects of classical optics—rays, aberrations, diffraction, lens design, combining stock lenses. Accessible but not at all simplistic.

J. J. Stammes, *Waves in Focal Regions*, Adam Hilger, 1986. A very clear and complete treatment of wave propagation in all cases where diffraction is important: especially good on the fine points of the plane wave spectrum. XX

Pyotr Ya. Ufimtsev, *Elements of the Physical Theory of Diffraction*, Wiley, 2007, and *Theory Of Edge Diffraction In Electromagnetics*, SciTech, 2009. Ufimtsev's theory is the foundation of stealth technology—PTD is GTD taken one perturbation order further. (An old version is available at http://www.dtic.mil.)

US Department of Defense, *Optical Design: Military Standardization Handbook 141* (*MIL-HDBK-141*), US Defense Supply Agency, 1962, Everything from optical glass to atmospheric optics and lens testing. Still remarkably current.

<https://www.optics.arizona.edu/optomech/references/Mil-hdbk-141.mht>. X (***)

OTHER PHYSICS

Lev D. Landau, Evgeny M. Lifshitz, and Lev P. Pitaevskii, *Statistical Physics* Third edition, (2 vols), Pergamon, 1980. Especially good on black body radiation and the fluctuation-dissipation theorem, from a theoretical physics point of view.

Simon M. Sze, *Physics of Semiconductor Devices*, Second Edition, Wiley, 1981 (The third edition (2006) isn't as good on the basics.) Gives detailed explanations of how semiconductor devices work; enough equations but few derivations. XX

CIRCUITS

If you're going to be building electro-optical gizmos for a living, you need a couple of circuits classes and one each on signals-and-systems and control theory. If you have the math, you can pick these up on your own, but you have to actually build stuff and get it to work.

American Radio Relay League, *The Radio Amateur's Handbook*, ARRL, Annual. Covers modulation, signal processing, and wave propagation with lots of lore and heuristic arguments: accessible, not rigorous. Pre-1990 editions had lots of RF prototyping lore.

Harold S. Black, *Modulation Theory*, Van Nostrand, 1953. Lots of detail on AM, FM, time and frequency division multiplexing, Shannon's theorem and entropy in modulation schemes, in a clear style, by the inventor of the feedback amplifier.

Hendrik W. Bode, *Network Analysis and Feedback Amplifier Design*, Van Nostrand, 1945. Bode more or less invented network analysis, and the combination of clear explanation and conceptual rigor is unbeatable. Especially good on matching network design. (PS: It's pronounced *boh-dah*, not *boh-dee*.)[†]

Allen L. Hollister, *Wideband Amplifier Design*, SciTech Publishing, 2007. Hollister, along with Carl Battjes, Ian Getreu, Barrie Gilbert, Thor Hallen, Pat Quinn, Bob Ross, and Einar Traa, is one of the great names of the old Tektronix, where they figured out how to build amazingly fast test gear using no better components than their customers had—in Carl Battjes' phrase, 'Who wakes the bugler?'. This book teaches you how to do that.

Hans Camenzind, *Designing Analog Chips*, http://www.designinganalogchips.com. By the designer of the 555 timer chip; an interesting read with a lot of good background on devices and simulation.

Ralph S. Carson, *High Frequency Amplifiers*, Wiley, 1982. A lucid explanation of Sparameter design of RF amplifiers, based on Smith charts. Getting good with those will let you impress all your friends. \Re

Jiri Dostal, *Operational Amplifiers*, Second edition, Butterworth-Heinemann, 1997. Combines arm waving and rigorous mathematical treatment of high performance op amp cir-

[†]M. E. Van Valkenburg, IEEE Trans. Automat. Control AC-29, 3, pp. 193–194 (1984).

cuits. Very readable and full of insight, and covers every op amp problem imaginable. Out of print; bootleg soft copies are available at various places on the web. $X \times S$

Floyd M Gardner, *Phaselock Techniques*, Third edition, Wiley, 2005. All about highperformance phase-locked loops, including frequency synthesis, PLL signal detection, telemetry, and Doppler tracking. Just the right amount of math so you can do it yourself.

Paul A. Gray and Robert G. Meyer, *Analysis and Design of Analog Integrated Circuits*, Second edition, Wiley, 1984. Lots of insight into BJT, FET, and IC performance and behavior. If you don't know how a transistor works, this is your book. (They and others have been updating the book steadily—it's up to the fifth edition, but the newer ones are very CMOS-heavy.)

Paul Horowitz and Winfield Hill, *The Art of Electronics*, Third edition, Cambridge University Press, 2015, and *The Art of Electronics: The X Chapters*, 2019. Full of lore, and indispensable if you design circuits, even if it's just the occasional op amp. All the good things everybody says about this book are true.

Arthur Williams and Fred J. Taylor, *Electronic Filter Handbook*, Fourth Edition, McGraw-Hill, 2016. Perfect for people who occasionally need to design a custom active or *LC* filter but don't care about the math. Previous editions were better printed. X

Donald E. Lancaster, *Active Filter Cookbook*, Second Edition, Newnes, 1996. Only slightly changed from the 1975 edition, but still very useful when you need to hack together a low-frequency filter.

Robert A. Pease, *Troubleshooting Analog Circuits*, Butterworth-Heinemann, 1991. An entertaining and readable look at troubleshooting. Full of war stories, and applicable to a lot of other types of systems besides analog circuits.

Frederick E. Terman, *Radio Engineering*, Third edition, McGraw-Hill, 1947. A big, very good book on all aspects of analog signal processing and network design. Also has good stuff that's directly transferable to electro-optics.

Frederick E. Terman, *Radio Engineer's Handbook*, McGraw-Hill, 1943. Full of old-butuseful tables, curves, and classical techniques for when the derivative modern treatments don't have enough detail.

Mac E. Van Valkenburg, *Reference Data For Engineers*, Eighth edition, Howard W. Sams, 1995. Lots of practical stuff about design of RF, communications, analog and digital circuits. This edition branches out from the previous radio-only focus, but still has a lot of great RF lore.

Jim Williams, ed. *Analog Circuit Design: Art, Science, and Personalities*, Butterworth-Heinemann, 1991, and *The Art and Science of Analog Circuit Design*, Butterworth-Heinemann, 1995. The lore of analog design, told in a playful and sometimes whimsical style by masters of the art. The second book is especially good on high-impedance, high frequency

circuits—very useful in front end design. X

Anatol Zverev, *Handbook of Filter Synthesis*, Wiley, 1967. A big book of passive *LC* filter design tables and plots. Has unique designs, *e.g.* the equiripple group delay filter. XX

Clyde Coombs and Happy Holden, *Printed Circuits Handbook*, *7th Ed.*, McGraw-Hill, 2016. The standard reference handbook on PCB technology. It isn't a tutorial, but if you have a question, the answer is in there someplace.

NOISE AND INTERFERENCE

Aldert van der Ziel, *Noise in Solid State Devices and Circuits*, Wiley, 1986. A brief, accessible, but complete introduction to noise in semiconductors and circuits, which is a surprisingly pretty subject. XX

Ralph Morrison, *Grounding and Shielding Techniques*, Fourth edition, Wiley, 1998. Morrison gives the physical causes of interference and spurious radiation, then shows how to get rid of it.

Henry W. Ott, *Noise Reduction Techniques In Electronic Systems*, Second edition, Wiley, 1988. Solid on grounding, shielding, decoupling, filtering, and how to calculate noise and interference. Essential for low noise circuit designers.

T. H. Wilmshurst, *Signal Recovery From Noise In Electronic Instrumentation*, Second edition, Adam Hilger, 1991. The gory details of lock-in detection, signal averaging, and so forth. \Re

OPTOMECHANICS

Eugene A. Avallone and Theodore Baumeister III, *Marks' Standard Handbook for Mechanical Engineers*, 10th edition, McGraw-Hill, 1996. Covers a wide field, even incineration and power generation, but the depth of detail and choice of material is excellent.

Erik V. Oberg and Christopher J. McCauley, *Machinery's Handbook*, 31st edition, Industrial Press, 2020. Full of good stuff about machine shop practice and building things.

Stephen P. Timoshenko, *Theory of Plates and Shells*, Second edition, McGraw-Hill, 1959, (Recently reprinted). A wonderful mixture of explanation and cookbook formulas on deflection, resonance, buckling, and deformation of structures, especially those that have to be stiff and light.

Paul R. Yoder, *Opto-mechanical Systems Design*, Third edition, CRC Press, 2005. Covers the mechanical design of optical instruments, test jigs, and so on. Yoder has immense design experience, and the book repays close attention.

S. T. Smith and D. G. Chetwynd, *Foundations of Ultra-Precision Mechanism Design*, CRC Press, 1994. All about motion control and mechanical stability at the nanometer level.

Good in combination with R. V. Jones.

Eric Oberg (and a cast of thousands), *Machinery's Handbook, 31st Ed.*, Industrial Press, 2020. The standard machine shop manual since 1914; the headline author died in 1951, but the tradition remains strong.

DETECTION AND FRONT ENDS

Stephen B. Alexander, *Optical Communications Receiver Design*, Institution of Electrical Engineers, 1997. A good book on how to detect optical signals in the presence of noise, with attention to various modulation schemes. XX

Eustace L. Dereniak and Glenn D. Boreman, *Infrared Detectors and Systems*, Wiley, 1996. Has a good discussion of most modern IR detectors, plus sections on noise, MTF, statistics, and general photodetector operation.

Silvano Donati, *Photodetectors: Devices, Circuits, and Applications*, Prentice-Hall, 1999. A clear presentation of the physics and circuit characteristics of photodetectors.

Hamamatsu Photonics, *Photomultiplier Tubes: Basics and Applications*, Third Edition. Not just product information, but how PMTs work and lots of good lore on the ins and outs of making good PMT measurements.

Mark Johnson, *Photodetection and Measurement: Maximizing Performance in Optical Systems*, McGraw-Hill, 2003. How to make optical measurements, starting from simple concepts and progressing to the whole system. Especially good hands-on sections.

MEASUREMENTS AND SYSTEMS

Brian Culshaw and John Dakin, eds. *Optical Fiber Sensors Volume 3: Components and Subsystems*, Artech, 1996. A survey of fiber sensors and some of the underlying technology. Uneven in quality but good on fiber gratings and spectral measurements.

Robert Hanbury Brown, *The Intensity Interferometer: Its Application to Astronomy*, Halsted Press (Wiley), 1974. An epic technical war story of getting a completely novel type of telescope built, and its unique contributions. \Re

Richard D. Hudson, *Infrared Systems Engineering*, Wiley, 2006, (Reprint of the 1969 edition). The essential problems of infrared systems don't change much with time, and Hudson remains the best guide to IR system design. XX

Albert V. Jelalian, *Laser Radar Systems*, Artech House, 1992. Everything about detecting objects by bouncing laser beams off them. Jelalian is readable and clear.

R. V. Jones, *Instruments and Experiences: Papers on Measurement and Instrument Design*, Wiley, 1988. Jones was an amazing man—founder and head of British scientific intelligence during World War II, radar pioneer, and one of the best instrument builders of the 20th century. This book contains many of his pioneering papers on optical measurements

and optomechanical instrument design, each with about an equal length of discussion of the motivation, difficulties, and subsequent history—in other words, lore. Clear, compelling, and very illuminating.

David S. Kliger, *Ultrasensitive Laser Spectroscopy*, Academic Press, 1983. Now somewhat dated, but still very good on the techniques and difficulties of ultrasensitive optical measurements. Engaging and full of lore. \Re

Merrill I. Skolnik, *Radar Handbook*, Second edition, McGraw-Hill, 1990. More advanced signal processing and the problems and tradeoffs of instrument design. Applicable far beyond radar—one of the present author's maxims is that you can learn a lot about tomorrow's optics by looking at yesterday's radio.

Eric Udd, Fiber Optic Sensors: An introduction for Engineers and Scientists, Wiley-Interscience, 1991. A bit long in the tooth now, but contains a fair amount of lore from experts. Non-fiber alternatives are not really given their due. XX

CONSTRUCTION

Daniel Malacara, ed. *Optical Shop Testing*, Third Edition, Wiley, 2007. Covers all kinds of interferometric testing, as well as screen (Ronchi and Hartmann), star, profilometer, and other tests for optical surfaces. If it isn't here, you probably can't test it.

John H. Moore, Christopher C. Davis, and Michael A. Coplan, *Building Scientific Apparatus*, Fourth Edition, Addison-Wesley, 2009. A very readable beginner's guide to building apparatus, with lots of stuff about basic optics, mechanics, vacuum, and electronics.

John Strong, *Procedures in Experimental Physics*, Lindsay Publications, 1986 (Reprint of 1938 edition.) A great hands-on book on glasswork, molding, vacuum, and so on.

LASERS

Samuel M. Goldwasser, *Sam's Laser FAQ*, http://www.repairfaq.org/sam/lasersam.htm. Everything about lasers, from basic physics to connector pinouts. A labor of love drawing on decades of nitty-gritty experience. \Re

Walter Koechner, *Solid State Laser Engineering*, Sixth edition, Springer, 2006. The standard work on building solid state lasers—theory, materials, pumping and thermal strategy, Q-switching, mode locking, and nonlinear elements.

Motoichi Ohtsu, *Highly Coherent Semiconductor Lasers*, Artech House, 1991, and *Frequency Control of Semiconductor Lasers*, Wiley, 1996. Design and experimental data on how to stabilize diode lasers, for spectroscopy, frequency standards, and other uses.

Anthony E. Siegman, *Lasers*, University Science Books, 1986. Covers all aspects of lasers at a first year graduate level; accessible and full of good intuitive examples. Due to its age,

better on gas and solid state lasers than diodes. XX

DIGITAL SIGNAL PROCESSING AND NUMERICAL ANALYSIS

Forman Acton, *Numerical Methods That Work*, Mathematical Association of America, 1990, (Reprint of 1970 Harper & Row edition) Salty, opinionated, and very lucid; full of lore, including a lovely section on what *not* to compute.

Philip J. Davis and Philip Rabinowitz, *Methods of Numerical Integration*, Academic Press, 1975. Covers all sorts of numerical integration, by way of hundreds of short discussions of the algorithmic ingenuity of each approach, which sheds a lot of light on numerical mathematics generally.

Dennis C. Ghiglia and Mark D. Pritt, *Two Dimensional Phase Unwrapping*, Wiley, 1998. 2D unwrapping is a ubiquitous and very thorny problem; G&P gives the gory details for times when the seat-of-the-pants approach fails. XX

Richard W. Hamming, *Digital Filters*, Third edition, Dover, 1997, (Reprint of Prentice Hall 1989 edition). Covers nonrecursive digital filters from an intuitive point of view; good for coming up to speed rapidly. Inexpensive.

J. F. Hart *et al.*, *Computer Approximations*, R. E. Krieger, 1978, (Reprint of 1968 Wiley edition). Computer-generated rational function approximations to special functions.

Alan V. Oppenheim and Ronald W. Schafer, *Digital Signal Processing*, Prentice-Hall, 1975. Old but good; fairly heavily theoretical.

William H. Press, Brian P. Flannery, Saul A. Teukolsky, and Steven Vetterling, *Numerical Recipes in C*, Second Edition, Cambridge University Press, 1992. A pretty good numerical analysis book that comes with a lot of working code you can use right away. There's a third (C++) edition, but the second (C) edition is available free, and the C routines may be easier to integrate with your code. \mathcal{X}

L. R. Rabiner and B. Gold, *Theory and Application of Digital Signal Processing*, Prentice-Hall, 1974. The applied follow-on to Oppenheim and Schafer. Not so mathematical, and with a fair amount of lore and good insights on when to use the different algorithms.

Anthony Ralston and Philip Rabinowitz, A First Course in Numerical Analysis, Second edition, Dover, 2001 (Reprint of the 1978 McGraw-Hill edition). An undergraduate text with lots of examples, good for self-teaching. R&R have no patience with 'neat but use-less' techniques.

Steven W. Smith, *The Scientist and Engineer's Guide to Digital Signal Processing*. An elementary DSP book with a wide coverage, lots of pictures and discussion, cookbook tables, and very little math. Excellent for getting your feet wet, and free. See http://www.dspguide.com. 🛠 🌑

HANDBOOKS WORTH HAVING

J. S. Accetta and David L. Shumaker, *The Infrared and Electro-Optical Systems Handbook* (8 volumes), Infrared Information, 1993, also available for download from http://www.dtic.mil. All kinds of tables and discussion—not as handbooky as most others. Includes chapters written by other widely cited authors, *e.g.* Smith, Yoder, Vukobratovich, and Breault.

C. W. Allen, *Astrophysical Quantities*, Third edition, Athlone, 1985. Where else can you find out that the night sky has ~ 0.1 naked-eye visible stars per square degree?

Michael Bass *et al.*, editors, *Handbook of Optics*, *3rd Ed.* (4 volumes), Optical Society of America and McGraw-Hill, 2009. Volume I: Fundamentals, Techniques, and Design; Volume II: Devices, Measurements, and Properties; Volume III: Classical, Vision, and X-Ray Optics; and Volume IV: Fiber Optics and Nonlinear Optics. Truly gigantic—not the last word on any optical subject, but a good place to start for most.

Radio Corporation of America, *Electro-Optics Handbook*, 2nd Ed., 1974. The 'RCA handbook' that started it all, and still very very useful. You can get it various places on the Web, and from the Internet Archive: https://web.archive.org/web/20060312184011/http://www.burle.com/cgibin/byteserver.pl/pdf/Electro_Optics.pdf

Chemical Rubber Company, *CRC Handbook of Chemistry and Physics*, CRC Press, Annual. A huge book full of tables, indispensable for mixed-technology systems like EO systems: the 'rubber bible' has lots about materials, including enough optical properties that you may not need Palik & Ghosh. Twenty-first century editions are *much* better than the old ones.

G. W. C. Kaye and T. H. Laby, *Handbook of Physical and Chemical Constants and Some Mathematical Functions*, 16th edition, Longman, 1995. A real instrument-builder's handbook, very useful when you have to choose materials, or calculate heat transfer—it has obscure things like the specific heat and thermal conductivity of tantalum wire. Now available online at <htps://web.archive.org/web/20190506031327/http://www.kayelaby.npl.co.uk/>

Lakeshore Cryotronics, Inc., *Lakeshore Cryotronics Catalog*, published in various configurations. Besides their products, it contains a great deal of useful info on cryogenic systems and temperature control in general.

Edward D. Palik and Gorachand Ghosh, *Handbook of Optical Constants of Solids*, Second edition (4 volumes) Academic, 1997. Very expensive but sometimes invaluable. Lots of detailed critiques of how the constants were measured.

William L. Wolfe and George J. Zissis, *The Infrared Handbook*, Revised edition, ERIM, 1985. Lots of good tables and curves make this a useful handbook for designers.