PRACTICAL GUIDE TO MODERN LABORATORY INSTRUMENTATION

Experimental Physics: Modern Methods

R. A. Dunlap
Oxford U. P., New York, 1988. 377 pp. $49.00 hc ISBN 0-19-504949-7

Reviewed by Howard H. Sample

R. A. Dunlap has attempted to write a self-contained text suitable for a one- or two-term junior-level laboratory course in physics. He has succeeded admirably; it is an excellent book. Moreover the book will be useful to beginning graduate research students, as a concise and easily understood reference source on instrumentation and measurement techniques in condensed matter physics, nuclear physics and optics.

The book begins with a discussion of the electronic properties of solids, from the one-dimensional Schrödinger equation for electrons to the physics of doped semiconductors—all in 25 pages. While junior physics majors (or graduate students for that matter) cannot gain a full understanding of the material from this whirlwind treatment, they certainly will come away with an appreciation of the important parameters for electrical conduction: electron concentration, bandgaps, Fermi level and scattering time. Dunlap uses hand-waving arguments rather than complex mathematics to get across the important physical ideas. And he lists suitable and readily available references for those students who want a more in-depth treatment.

Today's laboratory instrumentation is almost exclusively solid state and, more often than not, computer controlled. Most physics undergraduates have not had the training in electronics to enable them to understand how these instruments work. For them, Dunlap includes extensive material on the operation of discrete semiconductor devices and integrated electronics, and on interfacing instruments to computers. While the main thrust is toward a basic understanding of the physics of the devices (depletion layers, band bending, biased junctions), a great deal of specific device information is also included. For example, typical circuits utilizing JFETs, MOSFETS and op-amps are explained. CMOS and TTL implementations of common logic gates are discussed. An excellent description of the RS232 and IEEE-488 interfaces is given, including logic levels, baud rates, ASCII code and standard connector pin designations. (Anyone who has tried to obtain this information from computer manuals or instrument instruction manuals will love this section—it alone is worth the price of the book.)

The remainder of the book deals with commonly used measuring instruments and techniques in experimental physics: thermometry, vacuum systems, cryogenic technology, optics (sources, detectors, electronics), x-ray diffraction and magnetic measurements. The book does not attempt to be a laboratory manual of specific experiments, in the spirit of A. C. Melissinos's *Experiments in Modern Physics* (Academic Press, New York, 1966). Nor does it contain the exhaustive tabulations of data for the specialist, found in various topical books, such as G. K. White's *Experimental Techniques in Low Temperature Physics*, (Oxford U. P., Oxford, 1959). Rather, it is a "what it is and how it works" treatise. Physics undergraduates who want to know about a lock-in amplifier or a flux gate magnetometer or a NaI (Tl) scintillation detector, can probably get all they need simply by reading a few relevant pages in Dunlap's book, without having to wade through a lot of theoretical material.

The book does have shortcomings. Most of these are attributable to Dunlap's effort to cover so much material in a reasonable number of pages. Sometimes his discussion of a topic is so brief as to be of little practical value. One example of this is the 14-page chapter on crystal structure and x-ray diffraction. In the thermometry chapter, he unnecessarily confuses the reader by failing to use the integral form for the voltage produced by a thermocouple, instead writing $\Delta V = [S_2(T) - S_1(T)]\,\Delta T$ throughout. The chapter on magnetic phenomena contains confusing statements regarding cgs and SI units. For example, an equation in this chapter gives the magnetic susceptibility of a paramagnet as $\chi = M/H$; immediately below this equation is a graph that says that $(\chi/\mu_0) = \mathrm{M/H}$ (with μ_0 undefined). For me the most jarring omission is Dunlap's failure to allude anywhere to the fact that most common low-temperature thermometers undergo significant changes in even modest magnetic fields.

But these complaints are minor in the context of what Dunlap is trying to do. On the whole, his book is a concise, accurate and very readable description of modern methods in experimental physics. It is at just the right level for physics undergraduates and can be used as at least a "first source" instrumentation reference by graduate students and by professional physicists.

Howard H. Sample is a professor of physics at Tufts University. His research interests include thermal, electrical and optical properties of solids at low temperatures. He has had a long-term interest in the effects of high magnetic fields on common low-temperature thermometers.

Archaeometry: An Introduction to Physical Methods in Archaeology and the History of Art

Ulrich Leute
VCH, New York, 1987. 176 pp. $25.00 hc ISBN 0-89573-612-8

In writing this book, Ulrich Leute explains in his preface, he aimed to reach both students of history and students of science, for he believes there to be a lack of understanding between the two disciplines. This lack, he says, arises from too little knowledge, on the one side, of the possibilities of physics and chemistry and, on the other, of the needs and questions of archaeologists.

However, it is difficult to imagine exactly for whom the book is in fact written. Although the coverage of topics (mainly limited to physics applications) is comprehensive, the book is short and the contents are compressed to the point where most illustrative examples—surely a major attraction in such a topic—have been squeezed out. Yet the basic physics of each technique in turn is painstakingly explained. Perhaps the author aims to provide something for everyone: The professional physicist can enjoy learning how familiar techniques are applied in unfamiliar situations (for example, how nmr is applied to the detection of buried sites); the physicist-to-be can learn basic physics (such as how to combine errors) using intriguing data from the real world. But only a most persevering and brave archaeologist is likely to penetrate far into what is essentially a text in applied physics. Overall, my own impression is of an irritating lack of balance.

This criticism apart, I do think there is much of interest in this book concerning the way physics is brought to bear on investigating human material remains. It covers a wide scientific range, from reversals in the Earth's magnetic field to radiocarbon production from cosmic rays; from the accumulation of radiation damage in crystal inclusions in pottery to Mössbauer spectrometry. Leute's description of the physical basis of each technique is careful and reliable, often invoking much fundamental physics (for example, de Broglie waves are used to explain how electron microscopy functions). The writing, presumably his own translation from the German, is somewhat idiosyncratic, but this more often enlivens than obscures the sense.

The book has three main sections: prospecting, dating and the characterization of inorganic materials. Most of the really useful techniques are covered (for example, 21 dating techniques are considered), and although Leute attempts to explain their successes and pitfalls, there is too little space to give illustrative examples, which might have conveyed the relative importance and reliability of the different methods. Dating methods in particular suffer from the dangers of validation by circular argument, and it is insight at this level that is especially lacking. The description of analytical methods, which includes such recent applications as Auger spectrometry and laser microprobes, again reads like a compendium of potential techniques looking for interesting employment (although the occasional anecdote about how analysis detects forgeries is welcome refreshment).

The study of our past brings with it a simplified perspective, both on a way of living that has now disappeared and on our present existence, with its much more elaborated economic and cultural behavior. It is a pity that in Leute's book you can't see the forest for the trees. But in their own right, the trees are interesting enough, and physicists should enjoy reading about how their subject can be used to enrich—rather than destroy—our present civilization.

R. E. M. Hedges
University of Oxford, UK

The Starflight Handbook

Eugene Mallove and Gregory Matloff
Wiley, New York, 1989. 274 pp. $19.95 hc
ISBN 0-471-61912-4

A century of so will probably have to pass before humanity will be ready to launch small, robotic probes on reconnaissance missions to nearby stars, and then it may be another two centuries (or more) before interstellar colonists will even be able to think about leaving the solar system. As with aviation and interplanetary flight, starflight will not become a reality until the enabling technologies are in place—and for starflight, the list of needs is long. Only when we can routinely build very large structures in space and, off Earth, operate power stations equivalent to a solar collector roughly the size of the Moon will we be able to make more than symbolic excursions into the interstellar deep.

Some people doubt that humanity will ever develop a starflight capability, usually basing their arguments on the fact that, in terms of power-generation capacity, our late-20th-century, global society is still three or four orders of magnitude short of what is required to support starflight. However, as Robert Rood of the University of Virginia is fond of pointing out, judging starflight in 20th-century terms is roughly equivalent to judging the feasibility of the Boeing 747 in terms of the power-generation capac-