will find some very interesting examples of wave acoustics, which should relate to various nonmilitary problems. A careful study of the numerous graphs and clear explanations, which Eckart and his associates have provided, will impress the reader with the excellence of the book and will also suggest many areas where additional precise and detailed data should be found. Research in these areas has continued actively since the end of World War II, and I hope that other similar books will be forthcoming. Nevertheless, this book is most welcome and may be the only authoritative one available for many years. It can be highly recommended to all those interested in underwater sound or wave acoustics in general.

ROBERT S. SHANKLAND
Ambrose Swasey Professor of Physics
Case Western Reserve University

Basic Equations and Special Functions of Mathematical Physics

By V. Ya. Arsenin
361 pp. American Elsevier, New York, 1969. $13.50

Although he wrote for physicists, V. Ya. Arsenin maintains a reasonably high level of mathematical precision in this book based on his lectures at Moscow University. It is a concise and up-to-date introduction to the mathematical methods and the special functions that a physicist will encounter in partial-differential equations.

After displaying a few examples of second-order partial-differential equations in physics, Arsenin devotes the first part of the book to the basic methods for solving the typical equations. The criterion for primary classification is the method (characteristics, separation of variables, Green's functions, potentials, integral equations) rather than the type of equation (elliptical, parabolic, hyperbolic) that is more usual in textbooks. (Of course, the classification according to the type of equation is maintained in the second order.) This approach appears to render good results from the pedagogical point of view, but the success is largely due to the remarkable clarity of the exposition and the excellent quality of the translation.

The second part deals with the properties of special functions involved in solving partial-differential equations in physics: gamma function, cylindrical functions, spherical harmonics and Chebyshev–Hermite and Chebyshev–Laguerre polynomials. An appendix discusses the definition of generalized functions and the delta function, which is freely used in the book. Although it is also clearly and neatly written, the second part does not appear to provide as remarkable an account of its subject as the first. However, this impression may be a matter of personal taste regarding the selection of topics. A noteworthy feature of the book is the large number of problems (150), all of which have full answers.

JACQUES E. ROMAIN
La Thébaïde, Faux,
Court-St-Etienne
Brabant, Belgium

Principles of Quantum Electronics

By William S. C. Chang
540 pp. Addison-Wesley, Reading, Mass., 1969. $17.50

Even more than the invention of the transistor, the advent of masers and lasers has helped establish quantum mechanics in the electrical-engineering curriculum. The term "quantum electronics" has become popular to describe the applications of masers and lasers, nonlinear optics and the resulting new electroöptical devices. It is good to keep in mind that the so called "classical" electronics curriculum included such topics as the photoelectric effect, luminescence and contact rectifiers. The distinction between the new "quantum" and the old "classical" electronics is based more on the greater, current emphasis on discrete energy levels rather than on the properties of quasicontinuous-energy bands.

The title of this book conforms to present fashion and market trends, but a more informative title would have been *Intermediate Quantum Mechanics, Group Theory and Statistical Mechanics with an Application to Lasers.* The book is based on a graduate course for electrical engineers that William Chang developed at Ohio State University. He is now professor and chairman of the electrical-engineering department at Washington University, St. Louis.

His first six chapters are on quantum mechanics, energy levels of atoms and molecules, crystal symmetry and group theory, energy levels of transition-metal ion in crystals, interaction of radiation and matter and quantum-statistical density matrix. These are followed by two chapters on lasers and then twelve appendixes, including one that contains 60 pages of laser bibliography updated to about the beginning of 1967.

The strong point of the book is the condensed, and yet fairly rigorous, exposition of the quantum-mechanical calculation of energy levels of free atoms and ions in crystals, which is accompanied by numerous tables and diagrams. The tables include Clebsch–Gordan coefficients, characters of irreducible representations of point groups, laser wave lengths and operating characteristics of solid-state, semiconductor, atomic, molecular and ionic lasers.

The question is whether a beginning student can really learn quantum theory, group theory and statistical mechanics from such a condensed exposé. If he has taken separate courses in these subjects, the first six chapters may be useful as a refresher and as a reference for standard theorems and equations. He can then turn directly to the last two chapters on lasers. These chapters could, of course, be understood without the preceding detailed knowledge of wave functions, energy levels and crystal-field splittings.

The organization of these two chapters is somewhat rambling. Eigenmodes of the electromagnetic field are discussed at the end of the chapter on basic laser theory instead of before it. Although the amplification of a pulsed signal is treated in the general laser chapter, the pulsed operation of a Q-switched oscillator is postponed to the special section on solid-state lasers. Although the spontaneous-emission probability into a single mode, and into a frequency band df and solid angle $d\Omega$, is carefully distinguished in the chapter on interaction of radiation and matter, this question is confused in discussion of the noise power of a diffraction-limited amplifier. At the end of this section the reader is led to believe that this noise is proportional to f^3. The concept of coherence remains vague in contrast to the mathematical development of other concepts.

The compilation of the large amount of laser material would have been more valuable if it had been better integrated with previously developed theories. Nonlinear coupling of

modes, modulation, raman lasers, parametric and other nonlinear effects are not mentioned, but the survey of various types of lasers with the exception of chemical and dye lasers, is rather detailed.

The book will be mainly valuable as a convenient reference to a large amount of laser data and pertinent equations from quantum and electromagnetic theory. The typography of the text, equations, tables and figures is very clear, for which the publishers are to be commended.

NICOLAAS BLOEMBERGEN
Gordon McKay Professor of Applied Physics
Harvard University

Experiments in Physics

L. A. Sander, *ed.*
(4th edition) 169 pp. Pacific Books, Palo Alto, Calif., 1968. $3.95

This book is a manual of elementary-physics experiments, presumably written by university teachers conducting a course in practical physics and intended for first-year students. I say "presumably" because no information is given about the authors or the potential reader.

The manual describes 40 experiments in mechanics, sound, heat, electricity, light and atomic physics. The experimental apparatus appears to have been especially constructed for the course, but an instructor trying to set up a similar course would have some difficulty. In many cases the apparatus is fairly obvious but in others it is not, and a small photograph is the only information given.

The major criticism is that the book contains a large number of careless mistakes. For instance, the answer to the question "What is the power in watts consumed by the iron?" is given as 516 ± 3 volts; the formula for finding the sine of an angle greater than 90 deg is stated as $\sin\theta = -\sin(180 - \theta)$. Also in introducing an experiment on simple harmonic motion, there is a confusion of sign in the basic equation, from which it is deduced that the period of the motion is

$$T = 2\pi\sqrt{-\frac{m}{k}}$$

(I am giving the authors the best of it—the π is omitted in the original.) The minus sign under the square root discreetly disappears in a subsequent equation.

Carelessness on this scale is not to be condoned, but a greater objection can be made to the general spirit of the book. The introduction reads more like a military manual than one intended for physics students, for example: "The data, computations, and notes for all experiments must be kept in the special laboratory notebook. Rules for keeping the notebook are as follows: (a) Make all entries for the experiment on the right-hand pages. Use the left-hand pages for scratch work. Do not use loose sheets of paper. . . ."

This rigidity may well turn many students away from physics, especially the more intelligent ones. Experimenting in physics is not a matter of blindly following a set of rules. Certainly there are good habits that one wishes to inculcate in students, but it is vital for the teacher to get his priorities right. For example, I would say that it is more important that students get into the habit of checking their calculations—a point nowhere mentioned in the manual—rather than writing on a special kind of paper, whether on the left- or right-hand side.

Having made these points, I must add that the experiments are reasonably varied, and that some of the questions are penetrating and thought provoking. Many of the instructions and pieces of advice are sensible. It is a pity that the book should be marred by so much carelessness, itself a prime enemy in practical work, and by the apparent rigid outlook.

GORDON L. SQUIRES
Professor of Physics
Trinity College
Cambridge, England

The Physical Foundations of General Relativity

By D. W. Sciama
104 pp. Doubleday, New York, 1969. Cloth $4.50, paper $1.25

Karl Marx said that he turned Hegel's philosophy the right side up (or upside down, depending on your viewpoint). Dennis Sciama proposes to do a similar tour de force with the general theory of relativity.

The usual introductions to general relativity follow a standard path. After a brief discussion of the equivalence principle, one starts to emphasize the geometrical content of the theory. This is because general transformations and invariance are of paramount importance and whatever is not invariant can not be thought of geometrically. In this way one reaches the notion of curved space–time and the field equations. Next there is usually a discussion of geodesics to describe the worldlines of moving bodies. The equivalence of inertial mass and gravitational mass briefly reappears to show that they are automatically the same, because there is no provision in the theory to insert two different mass parameters. Why there is an inertial mass and what determines its value is mentioned briefly under the ambiguous heading of Mach's Principle.

In Sciama's book the process is completely reversed. In the beginning, the notion of inertia and inertial frames appears. (Why is the second derivative of the displacement influenced by external agencies, and not say, the first or the fourth?) Then Mach's Principle is introduced: "Inertial frames are those which are unaccelerated relative to some suitably defined average of all matter in the universe; matter has inertia only because there is other matter in the universe."

How does this matter determine inertial mass? The author suggests that there is a long-range inertial interaction. Its acceleration-dependent part determines the inertial force, its static part the gravitational force; the same parameters appear in both so we get to the equivalence principle. This is all heuristic and attractively done.

Chapter three is an excellent sample of exploratory guessing, strengthened by order-of-magnitude arguments. The big leap is from the heuristic argument to the field equations. The author suggests that the inertial interaction is represented by a nonlinear field derived from ten potentials. The motivation arises from the fact that the source of the field is also characterized by ten functions, and that the nonlinearity is needed to create a gravitational field by its own energy content. (It is not surprising that the discovery of the tensor nature of the gravitational field and the nonlinearity of the field equations can not be told in a few lines. It took Einstein nine years to get from the equivalence principle to the correct field equations, after trying in vain a scalar-field theory first.)

This is followed by an excellent and