

of them are rather rococo too. See here—do you know what a “potatory measure” is? I had to guess it from the context. But the style is not too clear for the geometrical and theoretical descriptive parts. Could you tell from this description, for example, how a polar dial works?

ME: (*Takes book*) Hmm. Well, I can see easily enough from the drawing, anyway. (*Browises*) These drawings are all good, aren't they? And I see there are tables of trigonometrical data you would need if you were designing a dial. And what's this fold-out chart... (*reads*) “Analemma for a horizontal dial...” I see, it's a detailed drawing of the layout of a dial that incorporates corrections for the time of year. You know, I could put a sundial like that in my backyard... (*exits, still reading*). —JTS

Universe, Earth, and Atom: The Story of Physics

By Alan E. Nourse

688 pp. Harper and Row, New York 1969. \$10.00

Alan Nourse's stated aim in this book is to provide a comprehensible frame of reference for the nonscientist interested in the mysteries being probed today by physicists. In doing this he traces the line of thought that scientific thinking has followed and is still following. Therefore the frame of reference he chooses is historical, although the book never purports to be an historical treatise.

A curious but definitely nonmathematically minded person wanting to become acquainted with the things that get physicists excited can find here a book that is well written, contains almost no formulas, has several pictures and diagrams and does not condescend to the reader. Nourse has succeeded everywhere with the possible exception of conciseness. The nearly 700 pages almost overwhelm the reader who would like just to know something about why quasars quare, for example.

Even a dedicated reader will have difficulty jumping in at a given point of interest. Nourse has not been able to eliminate completely all the technical terms of physics, so his words need no further definition. What comes next definitely depends on what has preceded, so the discussion on the heart of physical matter is obtuse to the reader who has not gone through the previous 562 pages.

But these objections are minor in the light of the book's goals. Laymen of physics, if there still are any, can find the book informative and interesting.

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General Properties of Matter

By B. Brown

292 pp. Plenum, New York, 1969. \$12.50

Despite some similarity in the end result, the educational process is strongly culturally dependent. B. Brown is a senior lecturer in physics at the University of Salford, Manchester, England, and his *General Properties of Matter* is intended as a concise introductory text for first-year university physics students. Even allowing for the difference in level (an entering student in Britain corresponds roughly to a midterm sophomore on a US campus), it is difficult to find any possible points of contact with an American college curriculum.

Title notwithstanding, the first half of the book constitutes a short, self-contained course on Newtonian mechanics (calculus through differential equations is assumed, but no mention is made of vectors until later). There follow chapters on surface tension (the next to longest chapter in the book), viscosity, hydrodynamics, osmosis and related phenomena, and finally the production and measurement of low pressures. Thermodynamics is not covered. The point of view is classical, mechanical and rigidly macroscopic with virtually no attempt to make contact with underlying molecular mechanisms nor to put the discussion in the larger context of “modern” physics.

Brown's clearly written exposition is enhanced by well illustrated discussion of a wide variety of classic experiments (for example, measurements of G by Boys, Heyl, von Jolly and Poynting, in addition to Cavendish) and techniques (no less than six distinct types of liquid viscometers are described). However, the physics program for which it was written is clearly quite different from the US norm, and, as a consequence, the book will appear rather stodgy and old-fashioned.

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Axiomatization of the Theory of Relativity

By Hans Reichenbach

208 pp. University of California Press, Berkeley, Calif., 1969. \$7.95

This is the English translation of a curious museum piece, whose place in the history of thought may well deserve a detailed study. The foreword by Wesley C. Salmon is, alas, too apologetic. Salmon endorses Hans Reichenbach's positivism in general—philosophy can learn from physics but never teach it. And he defends Reichenbach's axiomatization: Weyl and Suppes have criticized it from the viewpoint of math-

ematical method, but it was written, he protests, from the viewpoint of physical method. This will not do. If positivism is correct then the present volume, as well as all that follows its wake, must be viewed as useless for physics.

In this volume Reichenbach tried to present, first, the topology of Minkowski's space occupied by light rays but no matter; second, the metrics of that space; third, the same metric when rods and clocks are introduced, and finally, general relativity. The mathematics is shoddy, and has been since somewhat improved upon. The physics is governed by various tendencies that need not always harmonize.

First, his extreme empiricism is expressed in the introduction: “The particular factual statements of the theory of relativity can be grasped by means of prerelativistic concepts; only their combinations within the conceptual system is new.” This view is no longer held even by Reichenbach's colleagues and disciples. When he comes to assess the empirical basis (in the beginning of chapter 2), Reichenbach speaks of crucial experiments between the old view and the new, not of facts in isolation: These do not exist. Second, he formulates the axioms so that the intuitively acceptable and the intuitively unacceptable parts of special relativity stand out clearly: He wishes to shake those who object to relativity on intuitive grounds, especially when these are elevated to the status of philosophy—Reichenbach's pet aversion. Here he acts as a museum piece at his best.

Third, he smuggles in much general relativity to special relativity, presenting the ray of light's world line as a geodesic from the start. Although he has no refraction coefficient other than 1 in special relativity, he still calls the principle “Fermat's Axiom.” This is rather laudable, because it forces a contrast between general and special relativity and shows the existence of divergence between the two. Here the accent, however, is on the claim of nondivergence in the small: The empirical basis of general relativity is not discussed at all, and, for instance, the fact that in general relativity but not in special relativity the speed of light *in vacuo* is variable is not mentioned. Fourth, Reichenbach stresses (in his final section) that a metaphysics of causality, including chiefly proper time sequence, is essential to the philosophy of space-time (hence the prominence of topology). So even the separateness of space from time in the four-manifold is stressed quite heroically and in the teeth of the whole literature on the subject. Again, one would like a contrast between this view and later works, such as Goedel's circular time cosmologies, not to mention the more recent theories

permitting superluminal velocity at the cost of reversing the sequence of time.

It is intriguing that the program of starting from topology is amenable in some degree to divergent tendencies, from extreme empiricism to metaphysics, from subservience to the physics textbook to intellectual independence. No doubt, all this still awaits a critical assessment. It took over a century before we could evaluate the significance for physics of the modern axiomatics of geometry: Russell's summary of it in his *Foundations of Geometry*, of 1897, prior to Einstein, is correct but not appreciative of its significance for physics. It is too early to say what is the value of the investigations to which this volume belongs as an integral part. It is also curious that Reichenbach's falling on the bare bones of modern geometry, namely topology, is much reminiscent of Russell's falling back on that period's bare bones, that is, affine geometry. But then Russell declared himself at the time a Kantian metaphysician of sorts, whereas Reichenbach would have been insulted deeply if a reviewer were to say the same about him.

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Conceptual Physics: Matter in Motion

By Jae R. Ballif, William E. Dibble
631 pp. Wiley, New York, 1969. \$9.95

Jae R. Ballif and William E. Dibble of Brigham Young University, have written a physics text for nonscience majors that can be covered in one semester or, with certain specified omissions, in one quarter. Using an approach that is conceptual rather than mathematical, they give an excellent presentation of modern physics and classical physics from a modern viewpoint.

The book opens with a chapter on the first law of motion, which treats the special principle of relativity as an example of a symmetry principle, introduces the basic kinematic quantities and discusses the methods of science with emphasis on Galileo's contributions. Systematic development of the concepts of acceleration, mass and force leads to the second law of motion. Emphasis is placed upon the vector nature of force and of the kinematical quantities. This is followed by a brief chapter on the third law of motion and the conservation of momentum. Next, the concepts of gravitational attraction and rotary motion are developed, and these, along with the above dynamical constructs, are used to describe the solar system. This section ends with a discussion of experimental philosophy and the impact of the grand "Newtonian

synthesis" upon the philosophical and religious thinking of the Age of Reason. A further discussion of dynamics includes equilibrium, fluids at rest and in motion, falling bodies and kinematics in a plane; the mechanics part of the book ends with a treatment of work, machines, and energy with emphasis upon energy conservation and transformation.

Heat is discussed in a single chapter that opens with a kinetic-theory description of pressure, temperature and internal energy. Great emphasis is placed on the entropy concept as it is understood in terms of heat and temperature, disorder, probability and lack of information. Another single chapter is devoted to electric charge and fields. Following the development of the ideas of charge and charges in motion and the respective electric and magnetic fields, applications are made to motors, generators, electron tubes, and to the cyclotron.

The treatment of waves describes fundamental properties of progressive waves in terms of transverse and longitudinal mechanical waves and then discusses other wave characteristics such as standing waves, beats, doppler effect, interference effects and polarization in terms of either sound waves or light waves, whichever is applicable or more convenient.

A lucid qualitative description of Einstein's special theory opens the chapter on relativity. Sufficient formulae are given to treat quantitatively time, space and mass dilation, and there are discussions of the fourth dimension and simultaneity. General relativity is treated in terms of the general principle of relativity, the principle of equivalence and Mach's principle. Experimental evidence is discussed.

An introduction to the experimental bases for quantum physics is followed by a presentation of the meaning of quantum physics, the Copenhagen interpretation, the uncertainty principle and operationalism. The chapter ends with a description of the laser principle.

Emphasizing nuclear forces, the chapter on the nucleus deals with strong and weak interactions, symmetry principles, fundamental particles, radioactivity and nuclear structure. Also treated are applications of radioactive-dating techniques and fission and fusion reactions.

The climax of the book is a chapter titled "Systems of the World, Modern View," in which there appear very pithy discussions of symmetry principles, conservation principles, particle identity, fundamental particles, basic interaction forces and applications to biophysics and to outer space.

The several appendices contain useful basic mathematical tools, an elementary description of the calculus and

derivations of some formulae used in special relativity. At the end of most chapters are extensive examples, a well organized summary, questions, problems, and a starred section on "more difficult questions and problems." MKS units are used.

The text is outstanding in that its clear up-to-date conceptual presentations employ a modicum of mathematics but yet leave the door open for a mathematically inclined student to exercise his talents.

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Models of Elementary Particles

By B. T. Feld
546 pp. Blaisdell, Waltham, Mass.,
1969. \$19.50

Strong interactions of elementary particles is a field where data continue to be collected at a great rate (and, incidentally, great cost) while their interpretation is as yet inadequate despite a multitude of dynamical theories. This makes an up-to-date presentation of the subject a formidable if not impossible task. Bernard Feld has wisely chosen here to stress those models that rely more on symmetries than on specific dynamical solutions.

The book is intended as a graduate-level text to provide the student with the critical tools necessary to approach experimental high-energy physics. It can be read with comprehension by the usual second-year graduate student after a year of quantum mechanics, and thus is an excellent first text on elementary particles not only for the experimentalist, but for the theorist as well.

Feld's approach is refreshing and unusual in that he relies heavily on experimental data, against which he compares the relative merits of various models by making extensive numerical calculations. The tone of the book is set immediately after the introduction where a copy of Rosenfeld's ubiquitous particle-property tables appears. The book contains an extensive number of helpful tables and figures that compare theory with experiment as well as summarize the forms and ratios of decay and scattering amplitudes. The treatment of subjects is broad as opposed to deep, but appropriate references direct the inclined reader to the original and more comprehensive treatment of the various subjects.

Part I deals with the classification of the baryons, mesons and weakly interacting particles; kinematics, phase space, angular-momentum and isotopic-spin conservation and S-matrix theory, dispersion relations, optical approxima-