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Review

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existing chaos regarding units, Messrs. Jackson and Milne have been wise in confining their attention to statics, and not extending the sphere of their operations to dynamics. G. H. B.

**Lehrbuch der Mechanik.** 1 Teil. **Kinematik.** By DR. KARL HEUN, Professor an der Technische Hochschule in Karlsruhe. (Leipzig: G. J. Goschen.) 1906. pp. xvi, 339. Price 8 marks.

The complete work, of which this is the first part, is intended as a presentation of higher dynamics, and as a book of reference for technical students.

A quotation indicates the spirit in which Prof. Heun has approached his task: "As mathematical aids to the investigation of a problem in mechanics, the methods of geometry and analysis in all their vast extent are at our service. But which tools from the immense storehouse shall we grasp as being the most useful? A man whose mathematical knowledge is so limited that the choice of means presents no difficulty, is not in reality in an unfavourable position, but he is most to be envied who has always considered the value of the simplest mathematical tools, and has trained himself by the continual use of these few tools" (p. 4).

The elements of the calculus and vector algebra are the tools used here. The treatment is vectorial throughout, not merely in the sense of M. Appell's great treatise, that is, physically, but mathematically. As to notation, a vector is distinguished by a bar,  $\bar{a}$ ; the scalar product, termed work product (*arbeits produkt*) is written  $\bar{a} \bar{\beta}$ ; and the vector product (moment produkt) as  $\bar{a} \bar{\beta}$ . Dr. Heun agrees with Professor Tait in thinking that in many cases a vectorial formula suggests its own physical significance almost as clearly as a model could do. The technical student, however, beyond all others, always ends with arithmetic. That is, whatever analytical processes he may employ on the way, his goal is always some number. Dr. Heun has fully appreciated this fact, and realises that, however concise a vector formula may be, it can never furnish the final answer to a problem, and that when numerical results are wanted the services of Messieurs *X*, *Y*, and *Z* are indispensable.

In the first 112 pages, after some preliminary work in geometry, the kinematics of a particle are dealt with. Next the motion of two connected particles is considered, and the question is put: Are these particles geometrical points distinguished only by difference of position? No, we must distinguish a *material* from a geometrical point, attributing to the former mass a numerical coefficient of the velocity or of the acceleration vector. This mode of treatment avoids several metaphysical topics with which the discussion of mass is usually associated.

In the third section, Euler's equations and moving axes, with special reference to the motion of the earth, and, in general, the kinematics of a rigid body, are considered. The least satisfactory part of this section appears to be that dealing with moments of inertia, where the suffix notation employed gives a needlessly complicated appearance to some of the formulae. To adjust the conflicting claims of the most elementary method, the most obvious method, the most elegant method, and the most universal method of dealing with a problem is a difficult task for an author. Professor Heun has preferred the claims of uniformity of method, and it is not to be doubted that many students will be grateful to him for shewing how much can be done with limited mathematical resources. C. S. JACKSON.

**The Scientific Papers of J. Willard Gibbs.** Two Vols. £2 2s. net. (Longmans.)

Josiah Willard Gibbs was born in New Haven, Connecticut, on February 11, 1839, of a family sprung from the early Puritan colonists of Massachusetts. His father, likewise Josiah Willard Gibbs, was a professor in the Divinity School at Yale, and his ancestry on both sides had for many generations been connected with the two most ancient and most celebrated of American Universities.

After a course of general distinction at Yale, followed by three years of somewhat miscellaneous teaching in the College, Gibbs, in his twenty-seventh year, set out for Europe and spent some time at Heidelberg, then in the zenith

of its fame. Kirchhoff and Helmholtz were professors together; ten years previously, Kirchhoff had discovered the elements in the solar atmosphere by spectrum analysis, and the intervening decade had seen the publication of Helmholtz's *Physiological Optics* and his *Theory of Tone-sensations*. The discoveries of Thomson, Stokes, and Clerk-Maxwell in England were eagerly studied and discussed in Germany; and the young American readily allowed himself to be carried away by the prevailing enthusiasm, and resolved to devote his life to the advancement of Mathematical Physics.

Shortly after his return from Europe, Gibbs was appointed to a full professorship in his old university; and two years later, at the age of thirty-four, he published his first paper, "On Graphical Methods in the Thermodynamics of Fluids." This was followed shortly by a second memoir, "A Method of Geometrical Representation of the Thermodynamic Properties of Substances by Means of Surfaces," and in 1876-8 by his greatest work, "On the Equilibrium of Heterogeneous Substances."

It is scarcely too much to say that these investigations created a new department of science. But recognition came slowly. The *Transactions of the Connecticut Academy* was a somewhat obscure periodical, and no previous researches had given Gibbs a claim on the attention of the world. Moreover, the papers are very long—the third paper occupies over three hundred pages of the reprint—and are difficult reading even to modern students trained in the ideas of physical chemistry. In 1878 the average chemist had little acquaintance with mathematics, and the average mathematician had little interest in chemistry. Thus it was not until the group of memoirs was translated into German in 1891 by Ostwald that scientific men fully realised the epoch-making character of the work.

While the contributions to thermodynamical chemistry must be regarded as the greatest achievement of Gibbs's career, the volumes before us bear ample testimony to his interest in other branches of mathematical physics. The second volume is occupied chiefly with Vector Analysis—including his Theory of Dyadics—and the Electromagnetic Theory of Light. The professorial lectures on the former subject have already been published under the editorship of Dr. E. B. Wilson, and are not here reproduced. The work on *Statistical Mechanics*, which appeared towards the end of Gibbs's life, is also not reprinted.

At the end of the second volume is a biographical sketch of Gibbs's colleague, H. A. Newton, which deserves to be studied as a model of what such a sketch should be. At the beginning of the first volume is another excellent biography, that of Gibbs himself, written by Professor H. A. Bumstead. It gives a pleasant picture of the quiet unassuming scholar, his simple life at New Haven, and the affection with which he was regarded by those who had the privilege of his guidance at the outset of their own work.

E. T. W.

**Introduction to Infinitesimal Analysis: Functions of one Real Variable.** By OSWALD VEULEN and N. J. LENNES. New York: John Wiley & Sons; London: Chapman & Hall, Ltd. 1907. vii + 227 pages.

"A course dealing with the fundamental theorems of infinitesimal calculus in a rigorous manner . . . appears in the curriculum of nearly every [American] university. . . . This little volume is designed as a convenient reference book for such courses" (p. iii). And the first chapter (on the system of real numbers\*) shows the influence on a text-book of those logical considerations on the principles of mathematics which are, of course, essential to mathematics. Thus, on p. 3, we read that "the essential step in passing from ordinary rational numbers to the number corresponding to the symbol  $\sqrt{2}$  is thus made to depend upon an assumption of the existence of a number  $\alpha$  bearing the unique relation just described to the sequence  $a_1, a_2, a_n, \dots$ "; and this statement is to be welcomed as almost the first explicit acknowledgment in a text-book that a real number is to be defined at all, though it seems that the authors carefully avoid

\* This chapter is not intended to be a full treatment of the theory of real numbers, but chiefly a classification (p. 1) of them into rational, algebraic, and transcendental. Proofs are given (pp. 19-20) of the transcendency of  $e$  and  $\pi$ .