studies he will find this book a most useful volume to have at his elbow.

The few errors noted by the reviewer were of no great importance. Perhaps some mathematicians will be disturbed by an occasional lack of completeness or of precision, but such defects seem trivial by comparison with the high merits of the book as a whole.

The reviewer considers the book to be a very valuable addition to mathematical literature, bridging the gap as it does between the mechanics of the nineteenth century and more recent developments.

E. J. MOULTON

*Mechanics*. By S. Banach. Trans. by E. J. Scott. (Monografie Matematyczne, vol. 24.) Warszawa-Wrocław, 1951. 4+546 pp. $6.00.

This work was first published in Polish in 1938.

The book is notable for its clarity, and for the completeness of its exposition of the range of material covered. Assuming that the mathematical preparation of the student includes nothing beyond the elements of the calculus, the author undertakes to give as easy a presentation of classical mechanics as possible. To him this means the giving of a logically arranged set of definitions, assumptions, and theorems, with detailed proofs and with numerous illustrative examples. He has carried out his task exceptionally well—at least from the viewpoint of a mathematician.

As a text book the volume would be improved by the inclusion of problems to be solved by the student (none are given), but a teacher may select such exercises from the many which are available in standard works.

The illustrative examples are interesting, and cover a wide range. Thus we find (a) the reactions when a three-legged stool rests on a floor, (b) the fuel load required for an interplanetary rocket, (c) the determination of the mass of a planet, and so on. Chapter VI, on statics of a rigid body, is particularly designed for students of technology, and is so written as to be independent of much of the material in the preceding chapters.

The first chapter is devoted to that portion of the algebra of vectors which is most important in the study of mechanics. This tool is then freely and effectively used throughout the remainder of the book.

The mathematical quality of the exposition may be suggested by the following introductory paragraph: "Time. In kinematics, in addition to known geometric concepts, there arises the concept of time.

For purposes of theoretical kinematics it is sufficient to assume that to each moment there is assigned a certain number $t$, and that there are assigned smaller numbers before $t$ than for moments after $t$. Conversely, to each ordering of numbers $t$ there should correspond a certain moment: to a larger number a later moment."

The order of presentation and the extent of the theory covered is indicated by the titles of the successive chapters: I. *Theory of vectors*. II. *Kinematics of a point*. Subheadings are: motion relative to a frame of reference; change of frame of reference. III. *Dynamics of a material point*. Subheadings: dynamics of an unconstrained point; dynamics of a constrained point; dynamics of relative motion. IV. *Geometry of masses*. Subheadings: systems of points; solids, surfaces and material lines. V. *Systems of material points*. VI. *Statics of a rigid body*. Subheadings: unconstrained body; constrained body; systems of bodies. VII. *Kinematics of a rigid body*. VIII. *Dynamics of a rigid body*. IX. *Principle of virtual work*. X. *Dynamics of holonomic systems*. XI. *Variational principles of mechanics*.

The commendable detail with which the author discusses his material expands the text to some 546 pages; but by a judicious use of boldfaced titles, italicized statements, and displayed equations he has made it easy to pick out essential results. The careful insertion of references to previous formulas or theorems by page and number will save the reader's time and energy, and add materially to the value of the volume as a reference book.

While the discussion is detailed it is not carried to the point of pedantry. For example, the author devotes nearly three pages to the definitions of density of a body, surface, or line in terms of its mass (as a limit of a ratio), and to the formulas for the mass when the density is given (as integrals). He notes that the integral formulas check when the density is constant, and may be used to find the mass of an arbitrary part of the whole body, surface, or line. He does not, however, invoke the aid of some variant of Duhamel's theorem in arriving at the integral formulas, nor does he elaborate on the character of the curves and surfaces involved; in fact, the definition of density at a point of a body does not give a density for points on the surface of the body which would yield a continuous density function. To look after all such matters adequately is clearly impossible in an elementary course in mechanics.

The book is characterized by a high standard of precision, but is marred by occasional slips, some of which should, perhaps, be charged against the translator. Besides such editorial items as the omission of commas, the division of the word "makes" into two syllables, the occasional dropping of the dot in the scalar product of two vectors, and so on, there may be found logical errors which may be corrected by changing a "the" to an "a" or to "certain," or "both" to "the two" (pp. 53, 55), and errors such as "a virtual displacement is said to be every displacement of the point $A$ . . . " (pp. 470, 471). Such slips are, however, not numerous enough to be very serious. An error of another kind arises from the inclusion of a factor 1/6 in a formula for the volume of a parallelepiped (p. 13).

The most serious blunder which the reviewer noted is the statement (p. 144) that if the density of the earth is distributed symmetrically with respect to the center of mass then it can be proved that the force of attraction is directed constantly toward the earth's center of mass. It is a vitally important fact in celestial mechanics that this is not so; the conclusion is incorrect even for a homogeneous oblate spheroid. It is an interesting problem to determine for what surfaces and what laws of density the attraction of a body for a particle exterior to it is constantly directed toward the center of mass of the body. The appropriate vector equation, equivalent to three scalar equations, is an integral equation for the density function, has an unknown function in an equation of the surface of the body, and a third unknown proportionality function. Solutions to this problem are known, but they do not agree with the one in the book.

We must express our appreciation to the author, to the translator, and to the publisher for adding this fine book to the collection of works on classical mechanics.

E. J. MOULTON

*The theory of the Riemann zeta-function.* By E. C. Titchmarsh. Oxford University Press, 1951. 6+346 pp. $8.00.

The zeta-function was introduced almost 100 years ago by Riemann in his famous memoir on the number of primes less than a given number. While since then enough has been discovered about the zeta-function to justify its use in analytic number theory, the question raised by Riemann about the location of its zeros remains unanswered. The milder hypothesis of Lindelöf that $\zeta(1/2+it)=O(t^{\epsilon})$ for every $\epsilon>0$ also remains unsettled. The zeta-function continues to be a major challenge to mathematicians.

The author in his well known Cambridge Tract of 1930 gave a remarkably comprehensive and concise account of the zeta-function. Now he has given an expanded account in order to include recent results of which the most notable are due to A. Selberg. The sole prerequisite for reading this treatise is a knowledge of the funda-