Concepts of Mass in Classical and Modern Physics

Max JammerM. W. Friedlander,

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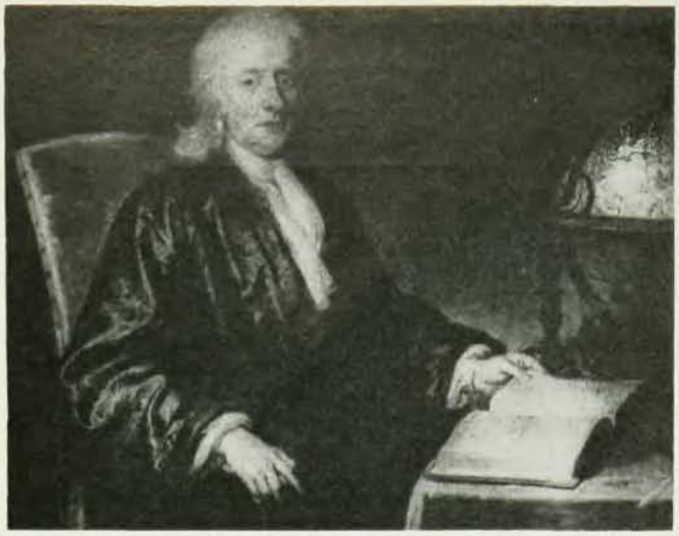


Isaac Newton (*The Bettmann Archive*)

lected and edited by Samuel Horsley, was published between 1779 and 1785. Perhaps modern scholars have been deterred by the enormous mass of manuscript material which Newton left behind and the uncertainty regarding what he intended to be taken seriously. Fortunately, a move in the right direction is being taken by the Royal Society of London which has a program now under way to publish Newton's correspondence. The present volume, edited by two distinguished historians of science, is the first addition, in nearly 125 years, to the published collection of Newton's scientific writings. Hopefully, it will stimulate further efforts along the same line.

From the famous Portsmouth collection of Newton's papers in the Cambridge University Library, the authors have selected some twenty-two items covering his work in mathematics, mechanics, theory of matter, manuscripts relating to the *Principia*, and popular science and education. A few of these are rather substantial tracts consisting of thirty to fifty pages of text, but most are short pieces or even fragments. Some are in Latin and the rest are in English. The authors have included both the original Latin text (without correcting Newton's errors) and a translation in English of their own. In the English pieces they have retained the quaint and uncertain spelling of Newton's time. Evidently he worried no more about this than his contemporaries!

The modern reader will find the reading of many of the selections rather difficult, largely because of the unfamiliar notation of the mathematical analysis. For example, in the long piece "To resolve problems by motion", in which Newton applied his calculus method to draw tangents to curves, to find the lengths of curves and the areas under them, and to calculate centers of gravity, he is still apparently uncertain as to the best notation in which to express his results, and consequently, the analysis appears clumsy and laborious. Nevertheless, the germ of the fluxion notation is there for anyone interested to see. The authors have conferred a great boon on the reader by prefacing each selection with an extensive introduction, explaining not only the historical status and significance of the piece but also its mathematical and physical meaning.

The physicist will probably find greatest interest in the papers on mechanics, to which about 100 pages are devoted. Here the longest piece is "De Gravitatione et Aequipondio Fluidorum" (on gravity and the equilibrium of fluids), which contains principally a vigorous criticism of Descartes' physics and vortex theory of cosmology, with a heavy leaning on theological arguments. In spite of the title, there is little hydrostatics in it. The physicist will also examine with interest the pieces containing Newton's notions on the constitution of matter. Here, he left no doubt about his belief in some kind of corpuscular theory, but his writing indicates considerable indecision with respect to the kinds of forces needed to explain the observed properties of materials, presumably rooted in his unhappiness over the "action at a distance" idea, in spite of its formal success in his gravitational theory of the solar system.

Present-day university educators and administrators will read with wry satisfaction the fragment "Of Educating Youth in the Universities", probably dating from 1690. In his suggestions for university reform, Newton showed scant sympathy for students who were indolent, drank too freely, and would not pay their bills!

The authors are to be congratulated on this splendid addition to the body of Newton's published works.

Concepts of Mass in Classical and Modern Physics. By Max Jammer. 230 pp. Harvard Univ. Press, Cambridge, Mass., 1961. $6.00. *Reviewed by M. W. Friedlander, Washington University.*

IN much of our teaching, "mass" is skimmed over—some sort of patched-up definition in the freshman year and all too rarely a deeper look in the junior year. A quick check through the definitions of mass given in a few of the standard, freshman-level best sellers will bring home this point. How often do we indicate in our teaching the conceptual difficulties? How often do we examine really critically the foundations of our subject or even take advantage of the efforts of one who has?

Mass is one of the most important physical concepts. We use it constantly and with great precision in our physical computations. Yet—its definition still eludes us. Over the centuries, mass has been viewed in many ways, but it was not until the mechanistic revolution of the 16th and 17th centuries that the modern aspects of mass could be discerned emerging from the philosophical and mystical-scientific undergrowth. Jammer traces the evolution of the concept, from Biblical times to the present, in a fascinating account bristling with scholarship.

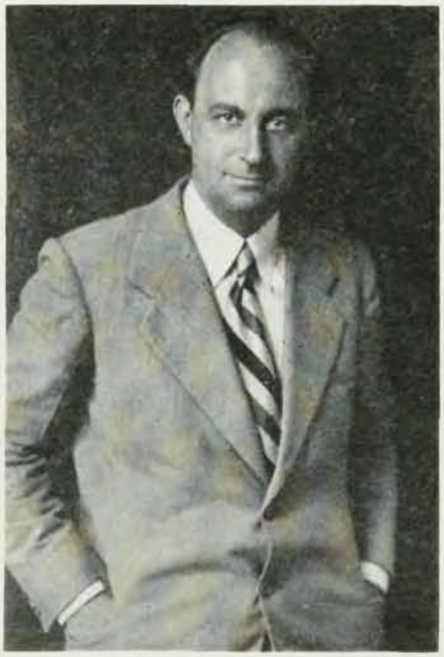
After a discussion of the etymology of the word itself, the early approaches to recognition of the concept are traced. Then, from the important stage of "quantitas materiae", the thread is followed via Galileo, Kepler, and Newton to Mach, to the modern aspects and diffi-

culties as they appear in the gravitational, electromagnetic, relativistic, and field theories of today. With his earlier books, this forms a trilogy of most stimulating reading.

Collected Papers. Vol. 1, Italy 1921–1938. By Enrico Fermi. 1043 pp. (Accademia Nazionale Dei Lincei, Rome.) Univ. of Chicago Press, Chicago, 1962. $15.00. *Reviewed by Nandor L. Balazs, State University of New York at Stony Brook.*

IN earlier times it was part of the intellectual activity of a scientist to study the works of his predecessors. Einstein mentions in his autobiography his interest in Kirchhoff, Helmholtz, and others. In what manner did one benefit from these excursions? I believe there are three major points to consider: (1) the best way to learn physics is to learn from the best physicists; (2) by reading many papers of the same scientist one slowly perceives a connected, persistent pattern in his approach toward physics instead of isolated "tricks"; (3) finally, the sweep of a whole lifetime's work reveals much about the personality of the investigator. (Just as in a good novel, the author does not simply describe the character of the protagonists but allows it to be revealed by their actions, so in a way one can find out much about the deepest personality traits by reading the collected works of a brilliant physicist.)

And yet, in spite of all this, the habit well nigh has disappeared. Why? Of course there is always the increased pressure caused by the acceleration of physics, the greater competition in one's own field, which leaves less time for curiosity in other branches. However, a historical accident has also occurred. The rapid developments in physics of the last forty years resulted in two qualitatively new features. First, the pursuit of contemplative, solitary physics diminished, and a new, more competitive spirit became manifest. Second, most of the great figures who were instrumental in this surge are still alive or at least were so until quite recently. The first cause made the writings of the great ancestors less tempting, the second explains the lack of replacement.



An early portrait of Enrico Fermi
(*courtesy of Mrs. Laura Fermi*)

The appearance of the collected works of Fermi wonderfully fills this gap. Until his early death, he was among the guiding spirits of the most active fields of physics: neutron physics, nuclear physics, and elementary-particle physics. Moreover, he both generated and found to his liking the new research temperament.

The first volume of his collected works comprises his published papers from 1921 to 1938, his years in Italy from the age of 21 to 37. Very broadly, the articles fall into six groups: (1) general relativity; (2) statistical mechanics; (3) quantum mechanics; (4) quantum electrodynamics; (5) neutron physics; (6) expository articles. The arrangement of the articles are for the most part in chronological order; introductions are provided for each which summarize the essential features of the research, give historical information, and list other articles by Fermi which deal with the same problem. They are written with great care and are very helpful. (Occasionally one finds delightfully unexpected information; on p. 641 there is a letter from Rutherford to Fermi containing the following lines: "You may be interested to hear that Professor Dirac also is doing some experiments. This seems to be a good augury for the future of theoretical physics!" Optimism or malice?) The short prefaces coupled with the excellent biographical introduction by E. Segrè enable one to reconstruct to a surprising degree Fermi's scientific portrait as it emerges from his writings.

In each of the five different fields mentioned, one finds both contributions to the foundations and applications. Let us sample them! In general relativity his basic contribution is the invention of the so-called "Fermi coordinates", [29]. (The number in brackets stands for the number of the article in the collected works.) The applications deal with a possible resolution of the factor 4/3 in the electromagnetic mass and the behavior of electric and elastic fields in the presence of a gravitational field. Statistical mechanics was always of great interest to Fermi. The main topics which engaged his attention were: ergodic properties of mechanical systems, adiabatic invariance, the invention of Fermi-Dirac statistics [30, 31], and the statistical theory of the atom [43, 44]; there is an interesting paper with Rasetti [40a, b] on the experimental verification of the Boltzmann distribution for the thermal equilibrium of atoms among different energy levels. His paper for the "Diploma" of the Scuola Normale [38b] deals with an amusing derivation of the central limit theorem and its application to the perturbation caused by Jupiter on solar comets. Among his popular writings there is an article [83] on statistical mechanics