Who Was Earnshaw?

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The originator of the theorem that stable equilibrium is impossible for a particle under inverse-square forces alone is identified as the Rev. Samuel Earnshaw (1805–1888), and the original reference is located [Trans. Cambridge Phil. Soc. **7**, 97–114 (1842)].

MANY textbooks on electricity and magnetism refer to Earnshaw's theorem,[1] namely that a charged particle in empty space cannot remain in stable equilibrium under electrostatic forces alone, or alternatively that there can be no maximum or minimum of the potential at points free of charge density. None of these texts, however, give a reference or identify Earnshaw. When the writer started to work on his own text,[2] one of his students asked "Who was Earnshaw?" Failure to find an immediate answer led to a considerable search, whose successful outcome is reported below.

Maxwell, in his *Treatise*,[3] refers to the theorem under the name given in the foregoing, but gives no clue to the originator other than the fact, noted in the index, that his first initial was S. Nearly all more recent authors have contributed as little enlightenment as Maxwell. Examination of the indexes of roughly fifty texts, histories, etc., of both the nineteenth and twentieth centuries revealed no clue. On the other hand, the list[4] of all the students who ever attended Cambridge University revealed the name of the Reverend Samuel Earnshaw (1805–1888), M.A. St. Johns College 1831, author of a treatise on statics and one on dynamics. Neither of these texts on examination contained any statements on equilibrium under inverse-square forces.

Examination of the index of *The Philosophical Magazine* for the years 1850–1875 revealed Earnshaw as a mathematical physicist of considerable skill who was primarily concerned with the velocity of sound, especially of large-amplitude sounds as in certain loud thunder-claps. Lord Rayleigh, in his *Collected Works*,[5] gives a dozen references to the man in question. The voluminous Royal Society catalog of all scientific works published in the nineteenth century[6] gives 25 references to Earnshaw up to the year 1883.

Examination of those references readily available was fruitless. The final act, like that of many good detective stories, occurred recently in the author's own office. During a search for information on another subject in the table of contents of one of the fifty-odd books mentioned above, namely, Vol. I, Part II of Thomson and Tait's *Treatise*,[7] a section on Earnshaw's theorem was noted. On page 50, the long-sought reference was found, although given by year of reading of the paper, not by volume and year of publication.[8]

This paper is in fact of considerable interest. It is entitled "On the Nature of the Molecular Forces which Regulate the Constitution of the Luminiferous Ether," but actually deals with the question of what type of central forces would allow any collection of particles to remain in equilibrium and be capable of transmitting vibrations

[1] L. Page and I. I. Adams, Jr., *Principles of Electricity* (D. Van Nostrand Company, Inc., Princeton, New Jersey, 1949 or 1958), second or third edition, Sec. 10; G. P. Harnwell, *Principles of Electricity and Electromagnetism* (McGraw-Hill Book Comgany, Inc., New York, 1949), second edition, p. 63; J. A. Stratton, *Electromagnetic Theory* (McGraw-Hill Book Company, Inc., New York, 1941), p. 16; Sir J. H. Jeans, *The Mathematical Theory of Electricity and Magnetism* (Cambridge University Press, New York, 1908), p. 165; W. R. Smythe, *Static and Dynamic Electricity* (McGraw-Hill Book Company, Inc., New York, 1950), second edition, p. 13.

[2] W. T. Scott, *The Physics of Electricity and Magnetism* (John Wiley & Sons, Inc., New York, 1959).

[3] J. C. Maxwell, *Treatise on Electricity and Magnetism* (Clarendon Press, Oxford, England, 1881 and 1904), article 116.

[4] J. A. Venn, *Alumni Cantabrigienses* (Cambridge University Press, New York, 1944), Part II, Vol. II, p. 374.

[5] John William Strutt, Baron Rayleigh, *Scientific Papers* (Cambridge University Press, New York, 1899 and 1920), Vols. I–VI.

[6] Royal Society of London, *Catalogue of Scientific Papers*, Vol. II, p. 434; Vol. VII, p. 588; Vol. IX, pp. 768–9 (London, 1868–1891).

[7] Sir W. Thomson and P. G. Tait, *Treatise on Natural Philosophy* (Cambridge University Press, 1879). Vol. I, Part II, Art. 495b, p. 50.

[8] S. Earnshaw, Trans. Cambridge Phil Soc. **7**, 97–114 (1842), read March 18, 1839.

in any direction. The conclusion is that there must exist a repulsive force whose inverse power is greater than two, along with an attractive force of the inverse-square type. The derivation, using old-fashioned but perfectly clear notation, involves the Laplace equation.

One quotation is worthy of perpetuation (page 106):

"It is therefore certain, that the medium in which luminiferous waves are transmitted to our eyes is not constituted of such particles [acted on by purely inverse-square forces]. The coincidence of numerical results, derived from the hypothesis of a medium of such particles, with experiment, only shows that numerical results are no certain test of a theory, when limited to a few cases only."

Physical Sciences in Our Secondary Schools

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This paper covers early recognition of physical sciences; two guiding objectives; development of uniform college entrance courses; trends in enrollments; textbook and laboratory manuals; methods in teaching; supporting claims for present courses; the teacher's education; suggested new developments in physical science courses and in the preparation of teachers with proper education and specialization for success in their work.

THE physical sciences were given prominent recognition in our early secondary schools. Printed records indicate that five courses—namely, physical geography, astronomy, geology, chemistry, and physics—were offered in more than half the schools during the interval of 1870–1900. At the end of this interval enrollment in astronomy and geology had declined. Physical geography, offered in 1900 as a required course in the ninth grade, has since that time been replaced, for the most part, by general science. There have been sporadic efforts to introduce advanced general science and applied science, but these efforts have not gained much recognition except in industrial or technical schools. Physical science in grades above the ninth is now taught in our comprehensive high schools as chemistry and physics.

GUIDING OBJECTIVES

Trends in science teaching have been guided through the past half-century by two main objectives. One may be stated briefly as for the common purposes of life—which has been interpreted in practice as science education for all. The other is for preparation for college—which has been interpreted in practice as science education for a restricted group. It has been contended that education for the second of these purposes is at the same time education for the first, but this contention has not been well supported in practice. The support in the beginning, when courses in science were first introduced, was generally in terms of the common purpose objective.

Near the end of the nineteenth century it was observed that the sciences as they were taught in the best schools "add to the wealth of mind as well as the stock of facts, and the college must recognize them as full equivalents for other work which they have hitherto demanded to the exclusion of science." This opinion, shared by college officials generally and supported by officials in the schools, placed the preparatory function in the ascendency where it has continued for many years.

NINETEENTH CENTURY OFFERINGS

Courses in science although recognized as "equivalents for other work" were by no means uniform. An examination of a sampling of descriptive matter dated 1891 to 1895 gathered from public schools revealed some similarities and many differences in courses in the same subject. Physics, for example, was commonly offered as a required course during the third year, but frequently it was given during the second year. In