James Joseph Sylvester

One of the most colorful mathematicians and prolific letter writers of all time was Victorian algebraist **James Joseph Sylvester** (September 3, 1814 – March 15, 1897). He has been described as an absent-minded, brilliant, volatile and impetuous, temperamental and erratic, warm and irascible, benevolent and egocentric bachelor, who unexpectedly would burst into orations or recite poetry, often his own. Sylvester did seminal work in number theory, the theory of equations, matrix and determinant theory, and in collaboration with his close friend Arthur Cayley invented the theory of invariants. The difference between the two men was striking. Sylvester seldom remembered theorems so he had to deduce them anew when he needed them.

Cayley, on the other hand, was thoroughly familiar with everything that had been done in almost every branch of mathematics. Sylvester made up for this peculiarity by his enthusiasm. Max Noether wrote: "Sylvester was so fully possessed by the matter which for the time being engaged his attention, that it appeared to him and was designated by him as the summit of all that is important, remarkable and full of future promise."

Sylvester was born in London into a Jewish family with nine children. The surname of the family was originally "Joseph," but the eldest son moved to America, where, for a reason, long forgotten, he assumed the new surname "Sylvester," with the rest of the family following suit. Sylvester first went to school at Highgate and then to the Royal Institution School in Liverpool. In 1828 he entered the University of London, a new institution operated by and for Dissenters (i.e. non-members of the Church of England), where he studied with Augustus De Morgan and won several prizes for his mathematics. Sylvester didn't last long at the school, being sent down for fighting against the anti-Semitism he found there by threatening a classmate with a table knife. Although Sylvester earned the coveted Second Wrangler in the mathematical Tripos at St. John's College, Cambridge (1837), he was denied a degree, as well as being barred from competing for one of the Smith's prizes, a fellowship or a professorship at Cambridge. At the time students had to swear to the Thirty-nine articles of the Anglican Church before graduating. Being Jewish, he refused to take the oath necessary so that he might graduate. The constraints were even worse at Oxford, which required a student to subscribe to the articles before matriculation. In

1841Sylvester succeeded in earning his bachelor's and master's degrees from Trinity College, Dublin, where religious requirements were no longer in force. When the "articles" requirement was lifted thirty-five years later, Cambridge finally awarded him an M.A.

During the period 1837 to 1841, Sylvester taught physics at the non-sectarian University of London. Dissatisfied with his teaching duties, he left England for Charlottesville in the United States where he was appointed to the professorship of mathematics at the University of Virginia. Even before he arrived, anti-Semitic articles against him appeared in the Richmond newspapers. At Virginia he found the students were not as respectful of their professors as they were in England, and were known for their "drunkenness and lawlessness." One student had murdered a faculty member just before Sylvester's arrival. His strongly expressed views on slavery did not sit well with Southerners. He spent only a brief period in the post. He criticized one student whose pride was offended. The latter armed himself with a heavy walking stick and together with his older brother confronted Sylvester. The young man demanded an apology and when it was not forthcoming knocked Sylvester's hat off with the stick and struck him a blow on his head. Sylvester was armed with a sword cane with which he pierced the young man just above his heart. The wounded man fell back into the arms of his brother crying, "I am killed." Fortunately, a rib had deflected the sword away from the heart and he survived. Sylvester didn't bother to pack his books in beating a hasty retreat from Virginia to New York.

Unable to secure a position with Columbia, Harvard or anywhere else, Sylvester returned to London where he worked as an actuary with the Legal and Equitable Life Assurance Company. In 1846 he became a student in the Inner Temple and four years later was called to the bar. He also tutored students in mathematics; one was Florence Nightingale. By 1850 Sylvester had published twenty papers in which he outlined his ideas on what would become invariant theory. During this period he met Cayley. The two discussed mathematics, in particular matrix theory, and became great friends. It was Sylvester who gave an abstract definition to the term "matrix," in an 1858 article, "Memoir on the theory of matrices." He defined a matrix to be "an oblong arrangement of terms," viewing it as an array of numbers derived from systems of equations out of which determinants can be formed. "Matrix" is Latin for "womb," but can also mean any place in which something is formed or produced. Matrix methods to solve systems of linear equations have been found in the ancient (c. 300 BCE to 200 BCE) Chinese text *Chiu Chang Suan Shu* (*Nine Chapters of the Mathematical Art*).

Sylvester returned to academia in 1855 with a position as professor of mathematics at the Royal Military Academy,

Woolrich. The fifteen years he spent there were not ideal for research. His students cared little for mathematics and he continuously fought with the military authorities over his teaching loads. Although he didn't do as much mathematical research, he exercised his creative powers in poetry. In 1870 he published his *The Laws of Verse*, which pleased him so that he sometimes signed himself as "J.J. Sylvester, author of *The Laws of Verse*." During this period, he became the president of the London Mathematical Society and of the Mathematical and Physical Section of the British Association. In 1870 he was forced into retirement from the Academy and spent the next six years doing little mathematics but continued writing verse.

At age 61 Sylvester was recruited by Daniel Coit Gilman, the president of the newly established Johns Hopkins University in Baltimore, Maryland, where Sylvester was expected to develop a research community – a concept totally new in the United States. He accepted the appointment but insisted that his yearly salary of $5,000 be paid in gold. His first class in higher mathematics at Johns Hopkins consisted of only one student, G.B. Halsted, who urged Sylvester to lecture on modern algebra. Halsted recalled his professor: "To know him was to know one of the historic figures of all time, one of the immortals; and when he was really moved to speak, his eloquence equaled his genius." A short, broad man, with a white beard and a few locks of grey hair, Sylvester's teaching was not carefully planned, nor did it always turn out to be what was advertised. He was forever guessing until he made a discovery in the classroom, with everything he came across suggesting to him something new. His students often heard him announce, "I haven't proved this, but I am as sure as I can be of anything that it must be so. From this it will follow …" Many times at the next lecture he had to announce that what he had been so sure of was wrong. He contributed thirty papers to the first U.S. mathematical journal, the *American Journal of Mathematics*, of which he was the first editor. In his seven years at Hopkins he did more than any other individual to establish graduate studies in pure mathematics in the United States. He also fought for and won the admission of a brilliant graduate student, Christine Ladd.

While at Johns Hopkins, Sylvester arranged to give a reading at the Peabody Institute of a poem that ran to four hundred lines, all rhyming with the name Rosalind. He announced that his unique experiment in verse required a large number of explanatory footnotes and so not to interrupt the reading of the poem itself he would read them first. Every footnote suggested some extra explanation to the poet. He became so enamored of his remarks that he took no note of the time. By the time he had finished reading all the footnotes and making his extempore remarks a period of an hour and a half had passed. He begged the indulgence of his audience who good-naturedly sat back to listen to him finally read the Rosalind poem. The following are some of the closing lines of the poem.

"With each mortal thing unkinned

Heaven's light comforting the blind

To those tones of Orpheus twinned

That could death's decrees rescind,

Soft as notes of Jenny Lind

Ere by Time's harsh sickle thinned,

Thy sweet name, dear Rosalind!

In 1884 Sylvester returned to England where at the age of seventy he became Savilian Professor of Geometry at Oxford. He preferred to lecture on his own research while his students wished to be prepared to take examinations. He was known for stopping in mid-lecture whenever a new idea, relevant or not, occurred to him. He would then pursue the thought to the bewilderment of his students. In 1892 Oxford appointed a deputy professor in Sylvester's place. By this time he was partially blind and suffered from melancholy and lapses of memory. He returned to London where he spent the last years of his life at the Athenaeum Club. While working on a mathematical paper in February 1897 Sylvester suffered a massive stroke, which resulted in his death early the next month.

Sylvester may be considered a founding father of Graph Theory, having coined the terms "graph" and "tree." His tremendous collection of mathematical papers fills four large quarto volumes. He used glowing prose in his papers, no doubt the poet in him. P.A. MacMahon wrote: "Sylvester's writings are flowery and eloquent. He was able to make the dullest subject bright, fresh and interesting. His enthusiasm is evident in every line. He would get quite close up to his subject, so that everything else looked small in comparison, and for the time would think and make others think that the world contained no finer matter for contemplation." His work in theory of invariants became of major importance when used in quantum mechanics and relativity theory. He introduced so much terminology into mathematics that he likened himself to Adam who had named the beasts and plants.

Quotation of the Day: "The mathematician lives long and lives young; the wings of his soul do not early drop off, nor do his pores become clogged with the earthy particles blown from the dusty highways of vulgar life." – James Joseph Sylvester