Integrating Catholic and Marianist Historical Perspectives in a Mathematics Course for Elementary Education Majors

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St. Mary's University recently reaffirmed their distinctive nature as a Catholic university promoting the Marianist tradition. This new reaffirmation is in response to the smaller number of Marianists serving in teaching and administrative positions on campus. Faculty have been encouraged to explore new ways to integrate Catholic and Marianist values and historical perspectives in their teaching and research. I will discuss some major Catholic mathematicians and some classroom activities that I developed for the course MT3304 – Mathematics for the Elementary Teacher. These activities were designed to familiarize students with significant contributions made by Catholic mathematicians.

Politically, the European nineteenth century was a time of revolution and turmoil. Materially, it was a time of enhanced living conveniences with improvements in transportation, communication, and production. But, throughout this century, anticlerical laws grew, being the most severe in France. These laws presented challenges for the Catholic Church. During this time, André Ampère, Augustin Cauchy, Karl Weierstrass, Charles Hermite, and Pierre Duhem were champions of mathematics and their Catholic faith. These men were role models for their contributions to mathematics and the Catholic Church (Janson, 1995, p.1).

André-Marie Ampère

André-Marie Ampère was born January 20, 1775, in Lyon, France. His father, Jean-Jacques Ampère, was a wealthy man who owned a house in Lyon and a country home in Poleymieux. Until André-Marie was seven years old the family spent most of their time in Lyon with the exception of the summer months, which were spent at Poleymieux. In 1782, the home at Poleymieux became their main residence since André-Marie's father wanted to spend more time on his son's education. Despite not attending school, André-Marie was given an excellent education. His father had a great interest in Latin and French literature, as well as certain branches of science. He never required Ampère to study, but he knew how to inspire in him the thirst for learning (O'Connor & Robertson, 1998a, p.1).

Ampere's early education was conducted at home in a deeply religious atmosphere. His mother was a devout woman who saw to it that her son was thoroughly instructed in the Catholic faith (Janson, 1995, p.72).

Before he was able to read, Ampère's enjoyed listening to passages from Buffon's natural history. His quest for knowledge demanded the reading of the L'Encyclopédie, which, at times, conflicted with his Catholic tenets. The prevalence in Ampère's time of Kant's philosophy caused another faith struggle. Fortunately, Ampère's formulated his own philosophy ever faithful to his Church (Janson, 1995, p.71).

It has been claimed that Ampère had mastered all known mathematics by the age of twelve years but this seems impossible since Ampère admitted he did not start to read elementary mathematics books until he was 13 years old. Ampère developed his own mathematical ideas very quickly writing a treatise on conic sections. Ampère had little contact with anyone with people who were knowledgeable in mathematics. Hence, he often believed that his ideas were original.

At 13 years of age Ampère submitted his first paper to the Académie de Lyon. In this paper he attempted to solve the problem of constructing a line of the same length as an arc of a circle. His method involved the use of infinitesimals. Unfortunately the paper was not found worthy of publication. Shortly after writing the article Ampère began to read d'Alembert's article on differential calculus in the Encyclopédie and realized that he must learn more mathematics. After taking a few lessons in differential and integral calculus from a monk in Lyon, Ampère began to study works by Euler, Bernoulli, and Lagrange.

Unfortunately, his life was soon to be turned upside down. The French Revolution began with the storming of the Bastille on July 14, 1789. Ampère's father avoided trouble until 1791 when he accepted the position of Justice of the Peace in Lyon. The city of Lyon refused to carry out instructions from Paris and the city was besieged. When the city fell, Ampère's father was arrested for issuing an arrest warrant for the Jacobin Chevalier and was eventually put to death.

His father's death was devastating on Ampère. He gave up his studies of Mécanique analytique and did not study mathematics for 18 months. He only became inspired again when he met a girl, Julie, who he deeply loved. Unfortunately, Julie was less attracted to Ampère.

Despite their differences they were engaged to be married in 1797. Ampère, wanting to show her that he could earn a living, began tutoring mathematics in Lyon. He married Julie in 1799 and they had a son in 1800. Ampère continued tutoring until 1802 when he was appointed professor of physics and chemistry at Bourg École Centrale. Julie became ill and stayed behind in Poleymieux.

In Bourg Ampère spent much time teaching physics and chemistry. He also continued his research in mathematics and composed a treatise on probability, The Mathematical Theory of Games, which he submitted to the Paris Academy in 1803. Ampère was able to correct an error that was noted by Laplace and the treatise was reprinted. This treatise was followed by a work on the calculus of variations in 1803.

After a year in Bourg, Ampère accepted an appointment of a mathematics position at the Lycée in Lyon. Mathematically he produced good work, this time a treatise on analytic geometry. After his wife died in July 1803, Ampère decided to leave Lyon for Paris.

By this time Ampère had a fair reputation as a teacher of mathematics and as a research mathematician. On the strength of this reputation he was appointed a tutor in analysis at the École Polytechnique in 1804. Without formal qualifications his appointment is surprising but shows that his potential was recognized at this stage. His life, already full of many tragedies, did not improve as he embarked on a second marriage on August 1, 1806. Before the birth of their daughter on July 6, 1807, the couple was living apart and not on speaking terms. They were legally separated in 1808 and Ampère was given custody of their daughter.

Appointed professor of mathematics at the École Polytechnique in 1809 he held posts there until 1828. Ampère and Cauchy shared the teaching of analysis and mechanics. Cauchy's rigorous analysis teaching led to great mathematical progress but was found extremely difficult by students who greatly preferred Ampère's more conventional approach to analysis and mechanics. Ampère was appointed to a chair at Université de France in 1826, which he held until his death.

In Paris Ampère worked on a wide variety of topics. In addition to mathematics, he had interest in metaphysics, physics and chemistry. In mathematics he worked on partial differential equations, producing a classification, which he presented to the Institut in 1814.

Ampère was also making important contributions to chemistry. In 1811 he suggested that an anhydrous acid prepared two years earlier was a compound of hydrogen with an unknown element, analogous to chlorine, for which he suggested the name fluorine. Later he produced a classification of elements in 1816.

Ampère also worked on the theory of light, publishing on refraction of light in 1815. By 1816 he was a strong advocate of a wave theory of light, agreeing with Fresnel and opposed to Biot and Laplace who advocated a corpuscular theory.

In the early 1820s, Ampère attempted to give a combined theory of electricity and magnetism after hearing about experimental results by the Danish physicist Hans Christian Orsted. Ampère's most important publication on electricity and magnetism was also published in 1826. It is called Memoir on the Mathematical Theory of Electrodynamic Phenomena, Uniquely Deduced from Experience and contained a mathematical derivation of the electrodynamic force law (O'Connor & Robertson, 1998a, pp.1- 4).

Ampère, in later life, sincerely told others that his mathematical and scientific knowledge was acquired not only through the study of the works of masters before his time but above all because of the talents which God gave him ever so generously (Janson, 1995, p.72).

After 1827, Ampère devoted most of his time to charitable and strictly religious activities. He worked closely with Cauchy and with other conservative members of the Academy to perpetuate sound Catholic thinking among the elite scientists. In 1836, Ampère, as inspector general of the universities of France, was on tour visiting the university at Marseilles. He had not been feeling well and soon found himself at the local hospital. As he lay dying, the religious sister nurse began to recite thoughts on death from the *Imitation of Christ*, an inspirational and devotional spiritual book which Ampère often studied. Shortly, Ampère began to recite the verses along with the sister. He died, June 10, 1836, away from family and friends, as his lips moved in prayer (Janson, 1995, p.89).

Augustin Louis Cauchy

Augustin Louis Cauchy was born August 21, 1789, in Paris, France. Cauchy's father was an accomplished classical and biblical scholar as well as a forthright Catholic. Cauchy's mother was likewise an outspoken Catholic (Janson, 1995, pp.24-25). Paris was a dangerous place to live due to the political events surrounding the French Revolution. When he was four years old his father moved the family to Arcueil for a short time.

They soon returned to Paris and Cauchy's father became active in the education of his son. Laplace and Lagrange were often visitors at the Cauchy home and Lagrange in particular took an interest in Cauchy's mathematical education. Lagrange advised Cauchy's father that his son should obtain a good foundation in languages before starting a serious study of mathematics. As a result, in 1802, Cauchy entered the École Centrale du Panthéon where he spent two years studying classical languages.

Beginning in 1804 Cauchy attended classes in mathematics and he took the entrance examination for the École Polytechnique in 1805, placing second in the overall competition. At the École Polytechnique he attended numerous math courses and was even tutored in analysis by Ampère. In 1807 he graduated from the École Polytechnique and entered the engineering school École des Ponts et Chaussées. He was soon assigned to the Ourcq Canal project. In 1810 he traveled to Cherbourg to work on port facilities for Napoleon's English invasion fleet (O'Connor & Robertson, 1997, p.1).

The vast majority of students at the École Polytechnique were fairly indifferent to religion and faith. The dominant attitude among the students was one of liberalism and anticlericalism. Cauchy was a devout Catholic and his attitude to his religion was already causing problems for him. Many claimed his devotion to religion caused him to become proud, arrogant and self-infatuated (Janson, 1995, p.27).

In addition to his heavy workload Cauchy continued his mathematical research and proved in 1811 that the angles of a convex polyhedron are determined by its faces. He submitted his first paper on this topic and quickly followed it with a second paper on polygons and polyhedra in 1812. Cauchy felt that he must return to Paris if he was to be recognized for his mathematical research. In September of 1812 he returned to Paris after becoming ill with a severe bout of depression.

Back in Paris Cauchy investigated symmetric functions and submitted a memoir on this topic in November 1812. This was published in the Journal of the École Polytechnique in 1815. His request for an associate professorship at the École des Ponts et Chaussées was turned down but he was allowed to continue as an engineer on the Ourcq Canal project.

An academic career was truly what Cauchy wanted and he applied for a post in the Bureau des Longitudes. He failed to obtain this post losing out to Legendre. He also failed to be appointed to the geometry section of the Institute. With political events preventing work on the Ourcq Canal, Cauchy was able to devote himself entirely to research for a couple of years.

In 1815 Cauchy was appointed assistant professor of analysis at the École Polytechnique. He was responsible for the second year course. In 1816 he won the Grand Prix of the French Academy of Sciences for a work on waves. He achieved real fame however when he submitted a paper to the Institute solving one of Fermat's claims on polygonal numbers.

In 1817 when Biot left Paris for an expedition to the Shetland Islands in Scotland Cauchy filled his post at the Collège de France. There he lectured on methods of integration, which he had discovered, but not published, earlier. Cauchy was the first to make a rigorous study of the conditions for convergence of infinite series in addition to his rigorous definition of an integral. His text Cours d'analyse in 1821 was designed for students at École Polytechnique and was concerned with developing the basic theorems of calculus as rigorously as possible.

Cauchy often did not get along with other scientists. His staunch Catholic views had him involved on the side of the Jesuits against the Académie des Sciences. Often he would bring religion into his scientific work. For example he did a report on the theory of light in 1824 where he attacked the author for his view that Newton had not believed that people had souls.

Needing a break he left Paris in September 1830, after the revolution of July, and spent a short time in Switzerland. There he helped in setting up the Académie Helvétique. Unfortunately, this project failed as it was caught up in political events.

The politics of France now meant that Cauchy was required to swear an oath of allegiance to the new regime. When he failed to return to Paris to do so he lost all his positions there. In 1831 Cauchy went to Turin and after some time there he accepted an offer from the King of Piedmont of a chair of theoretical physics. Many described his lectures as confused, skipping suddenly from one idea to another, from one formula to the next, with no attempt to give a connection between them.

After a short stint of tutoring the grandson of Charles X in Prague, Cauchy returned to Paris in 1838 and regained his position at the Academy. In 1839, De Prony died and his position at the Bureau des Longitudes became vacant. Cauchy was strongly supported by Biot and Arago for the position but Poisson strongly opposed him. Cauchy was elected but, after refusing to swear the oath, was not appointed.

In 1843 Lacroix died and Cauchy became a candidate for his mathematics chair at the Collège de France.Again, Cauchy should have easily been appointed on his mathematical abilities but his political and religious activities, such as his support for the Jesuits, became important factors. Instead, Libri was chosen for the position.

During this period Cauchy's mathematical output was minimal. He did do important work on differential equations and applications to mathematical physics. He also wrote on mathematical astronomy, mainly because of his candidacy for positions at the Bureau des Longitudes.

When Louis Philippe was overthrown in 1848 Cauchy regained his university positions. In 1850, when Libri resigned his chair at the Collège de France, Liouville and Cauchy were again candidates for the chair as they had been in 1843. After a close election Liouville was appointed. Additional attempts to reverse this decision led to ill feelings between Liouville and Cauchy.

Many mathematical terms bear Cauchy's name: - the Cauchy integral theorem, in the theory of complex functions, the Cauchy-Kovalevskaya existence theorem for the solution of partial differential equations, the Cauchy-Riemann equations and Cauchy sequences. He produced 789 mathematics papers, an incredible achievement (O'Connor & Robertson, 1997, pp.2 - 6). His publications were so important to him that he could not wait to have his work published. As a result, in 1826 he founded a private journal, *Exercises of Mathematics*, so that he could publish his own works more quickly (Janson, 1995, p.44).

Cauchy was a devout Catholic who took a leading part in numerous charities, such as St. Francis Regis for unwed mothers, aid for starving Ireland, rescue work for criminals, and aid to the street children. Cauchy also worked for the Catholic Society of Good Books, an organization created to finance the publication of religious books, to propagate the Catholic message. Cauchy, Jaques Binet, and Ampère belonged to the Association for the Protection of the Catholic Religion. The aim of the organization was to unite the efforts of all persons of good will in order to defend the Catholic religion. Cauchy also took part in the founding of the Catholic Institute, an organization in which Ampère was very active. The purpose of this institution was to offer philosophical, literary, and scientific conferences and thereby soften the effects of the absence of Catholic influence in university education (Janson, 1995, pp.38-40).

Cauchy died suddenly on May 23, 1857, in Sceaux (near Paris), France when he was sixty-eight years old. He had gone to the country to rest and to cure a bronchial trouble, only to be smitten by a fatal fever. A few hours before his death he had visited with the Archbishop of Paris, describing the numerous charitable works he had planned (Janson, 1995, p.47).

Karl Weierstrass

Karl Weierstrass was born October 31, 1815, in Ostenfelde, Westphalia (now Germany). His father, Wilhelm Weierstrass, was secretary to the mayor of Ostenfelde when Karl was born. Karl's father was a well-educated man who had a great knowledge of the arts and sciences. Karl's mother was Theodora Vonderforst and Karl was the eldest of the four children, none of whom married (O'Connor & Robertson, 1998b, p.1).

Karl received his elementary education at home from his father and also from the local Catholic elementary school. There the Catholic faith was taught through the study of the catechism of St. Peter Canisius, containing simple, correct, and direct explanations of the moral and dogmatic theology of the Church. In his family, meal and nightly prayers were a part of the daily routine. Participation at Sunday mass, special feast day masses, Lenten devotions at the parish church, Corpus Christsi processions, rosary devotions in October, and Marian devotions in May were all a part of the family life (Janson, 1995, pp.50, 54).

Wilhelm Weierstrass became a tax inspector when Karl was eight years old. This job involved him spending short periods of time in any one place so Karl frequently moved from school to school in Prussia. In 1827 Karl's mother died and one year later his father remarried. By 1829 Wilhelm Weierstrass had become an assistant at the main tax office in Paderborn, and Karl entered the Catholic Gymnasium there.

Although Karl was profoundly interested in mathematics, his father wished for him to study finance and so, after graduating from the Gymnasium in 1834, he entered the University of Bonn to study law, finance and economics. Karl's father hoped he would pursue a career in the Prussian administration. However, Karl suffered from the conflict of either obeying his father's wishes or studying the subject he loved, namely mathematics. He reacted to this conflict badly by pretending that he did not care about his studies, spending four years fencing and drinking.

He did study mathematics on his own, however, reading Laplace's Mécanique céleste and then a work by Jacobi on elliptic functions. He also came to understand the necessary methods in elliptic function theory by studying transcripts of lectures by Gudermann.

After deciding to study mathematics, he stayed one more semester at the University of Bonn, his eighth semester ending in 1838. Having failed to study the subjects he was enrolled for he left the University without taking the examinations. Weierstrass's father was very upset that his son gave up his studies. His father was persuaded by a family friend to allow Karl to study at the Theological and Philosophical Academy of Münster so that he could take the necessary examinations to become a secondary school teacher.

On May 22, 1839, Weierstrass enrolled at the Academy in Münster. Karl attended Gudermann's lectures on elliptic functions. Gudermann strongly encouraged Weierstrass in his mathematical studies. Leaving Münster in the autumn of 1839, Weierstrass studied for the teacher's examination, which he registered for in March of 1840. By this time Weierstrass's father had moved jobs yet again and the family was now living in Westernkotten.

By April 1841 Weierstrass had taken the necessary oral examinations and he began a one-year probation as a teacher at the Gymnasium in Münster. Weierstrass began his official career as a qualified teacher of mathematics at the Pro-Gymnasium in Deutsch Krone in West Prussia (now Poland) in 1842 where he remained until he moved to the Collegium Hoseanum in Braunsberg in 1848. As a teacher of mathematics he was also required to teach other topics too, so Karl taught physics, botany, geography, history, German, calligraphy and even gymnastics.

Beginning in1850 Weierstrass began to suffer from attacks of dizziness. Frequent attacks over a period of about 12 years made it difficult for him to work. Many believe these problems may have been caused by mental conflicts he had suffered as a student, together with the stress of applying himself to mathematics in every free minute of his time while undertaking a demanding teaching job.

When Karl published papers on abelian functions in the Braunsberg school prospectus they went unnoticed by mathematicians. However, in 1854 he published Zur Theorie der Abelschen Functionen in Crelle's Journal and this was certainly noticed. This paper gave a preliminary description of his methods involving representing abelian functions as constantly converging power series.

With this paper Weierstrass burst from obscurity. The University of Königsberg conferred an honorary doctor's degree on him March 31, 1854. In 1855 Weierstrass applied for the chair at the University of Breslau left vacant when Kummer moved to Berlin. Kummer, however, tried to influence things so that Weierstrass would go to Berlin. Weierstrass was not appointed. After being promoted to senior lecturer at Braunsberg, Weierstrass obtained a year's leave of absence to devote himself to the study of advanced mathematics.

There was a move from a number of universities to offer him a chair. While universities in Austria were discussing the prospect, an offer of a chair came from the Industry Institute in Berlin. Although he would have preferred to go to the University of Berlin, Weierstrass certainly did not want to return to the Collegium Hoseanum in Braunsberg so he accepted the offer from the Institute on June 14, 1856.

While attending a conference in Vienna in September 1856 he was offered a chair at any Austrian university of his choice. Before he had decided what to do about this offer, the University of Berlin offered him a professorship in October. This was the job he had long wanted and he accepted quickly.

Weierstrass's lectures in mathematics attracted students from all over the world. His lectures included the application of Fourier series and integrals to mathematical physics, an introduction to the theory of analytic functions, the theory of elliptic functions (his main research topic), and applications to problems in geometry and mechanics.

Despite achieving the positions that he had dreamed of, his health gave out in December 1861 when he collapsed completely. It took him about a year to recover sufficiently to lecture again. From this time on he lectured sitting down while a student wrote on the blackboard for him.

In his 1863/64 course on the general theory of analytic functions Weierstrass began to formulate his theory of the real numbers. In his 1863 lectures he proved that the complex numbers are the only commutative algebraic extension of the real numbers. In 1872 his emphasis on rigor led him to discover a function that, although continuous, had no derivative at any point.

A large number of students benefited from Weierstrass's teaching, such as, Cantor, Frobenius, Klein, Lie, and Schwarz. One student in particular, however, deserves special mention. In 1870 Sofia Kovalevskaya came to Berlin and Weierstrass taught her privately since she was not allowed admission to the university. It was through Weierstrass's efforts that Kovalevskaya received an honorary doctorate from Göttingen, and he also used his influence to help her obtain the post in Stockholm in 1883.

The standards of rigor that Weierstrass set, defining, for example, irrational numbers as limits of convergent series, strongly affected the future of mathematics. He also studied entire functions, the notion of uniform convergence and functions defined by infinite products. For his efforts he's become known as the father of modern analysis (O'Connor & Robertson, 1998b, pp.1 - 5).

During the last three years of his life he was confined to a wheelchair, immobile and dependent. He finally died of pneumonia at the age of eighty-two on February 19, 1897, at his home in Berlin, Germany. His last wish was that the priest say nothing in his praise at the funeral but restrict the services to the customary prayers (Janson, 1995, p.70).

Charles Hermite

Charles Hermite was born December 24, 1822 in Dieuze, Lorraine, France. Charles Hermite's father was Ferdinand Hermite and his mother was Madeleine Lallemand. His father was a trained engineer working in a salt mine near Dieuse. After he married Madeleine he joined the draper's trade in which her family worked. However Ferdinand had always wished to pursue art as a career. Charles was the sixth of his parents' seven children and when he was about seven years old his family left Dieuse and went to live in Nancy where the business had moved.

Education was not a high priority for Charles's parents. Despite not taking an interest in their children's education, they did provide them with good schooling. Charles was a worry to his parents for he had a defect in his right foot, which meant he moved around with great difficulty. This handicap would present him with problems in finding a career.

Charles attended the Collège de Nancy, and then went to Paris where he attended the Collège Henri. In 1840-41 he studied at the Collège Louis-le-Grand where some fifteen years earlier Galois had studied. In some respect Hermite was similar to Galois for he preferred to read papers by Euler, Gauss, and Lagrange rather than work toward his formal examinations.

Even if Hermite neglected his studies, he showed remarkable research ability publishing two papers while at Louis-le-Grand. Also like Galois he was attracted by the problem of solving algebraic equations and one of the two papers attempted to show that the quintic cannot be solved in radicals.

Again like Galois, Hermite wanted to study at the École Polytechnique and he took a year preparing for the examinations. He was tutored by Catalan in 1841-42 and certainly fared better than Galois had done for he passed. However it was not an impressive pass for he only placed sixty-eighth in the ordered list. After one year at the École Polytechnique Hermite was refused the right to continue his studies because of his disability. The decision was reversed so that he could continue his studies but strict conditions were imposed. Hermite did not find these conditions acceptable and decided that he would not graduate from the École Polytechnique.

Hermite made friends with important mathematicians often visiting Joseph Bertrand. This would later prove significant, as he would marry Joseph Bertrand's sister. More significantly from a mathematical point of view he began corresponding with Jacobi. The letters he exchanged with Jacobi show that Hermite had discovered some differential equations satisfied by theta-functions and he was using Fourier series to study them. He had also found general solutions to the equations in terms of theta-functions.

After spending five years working towards his degree he took and passed the examinations for the baccalaureate and license, which he was awarded in 1847. The next year he was appointed to the École Polytechnique, the institution that had tried to prevent him from continuing his studies some four years earlier; he was appointed admissions examiner.

Hermite made substantial contributions to number theory and algebra, orthogonal polynomials, and elliptic functions. He discovered his most significant mathematical results over the ten years following his appointment to the École Polytechnique. In 1848 he proved that doubly periodic functions could be represented as quotients of periodic entire functions.

Another topic Hermite worked on and made significant contributions was the theory of quadratic forms. This led him to study invariant theory and he found a reciprocity law relating to binary forms. With his understanding of quadratic forms and invariant theory he created a theory of transformations in 1855. His results on this topic provided connections between number theory, theta functions, and the transformations of abelian functions.

On July 14, 1856 Hermite was elected to the Académie des Sciences. However, despite this achievement, 1856 was a bad year for Hermite for he contracted smallpox. It was Cauchy who, with his strong religious conviction, helped Hermite through the crisis. This had a profound effect on Hermite who, under Cauchy's influence, abandoned his agnostic beliefs and turned to the Roman Catholic religion (O'Connor & Robertson, 2001a, pp.1- 2).

Hermite was simple in his manifestations of his religious sentiments. He was seen in the poorest and lowliest churches. At other times he attended the most solemn ceremonies of the cathedrals, always devout and dignified, with no longing to be noticed.

Through his teaching Hermite came in contact with the Marianists in the person of Brother Charles Biehler, director of the preparatory school at Stanislas College. The Marianists believed that through normal schools and teaching in general, the Marianist influence and the influence of the Catholic Church could spread. Hermite saw the same in the Superior State Normal School where he taught and worked diligently against the anticlerical atmosphere that was becoming more prevalent.

Hermite believed firmly in the power of prayer. It was noted that he would unabashedly pray the rosary in the front row while one of his students would be defending his doctorate thesis (Janson, 1995, pp.5, 9).

The next major mathematical result by Hermite is one for which he is rightly famous. Although an algebraic equation of the fifth degree cannot be solved in radicals, a result that was proved by Ruffini and Abel, Hermite showed in 1858 that an algebraic equation of the fifth degree could be solved using elliptic functions. He applied these results to number theory, in particular to class number relations of quadratic forms.

In 1862 Hermite was appointed maître de conférence at the École Polytechnique, a position that had been specially created for him. In the following year he became an examiner there. The year 1869 saw him become a professor when he succeeded Duhamel as professor of analysis both at the École Polytechnique and at the Sorbonne. Hermite resigned his chair at the École Polytechnique in 1876 but continued to hold the chair at the Sorbonne until he retired in 1897.

The 1870s saw Hermite return to problems that had interested him earlier in his career such as problems concerning approximation and interpolation. In 1873 Hermite published the first proof that e is a transcendental number. This is another result for which he is rightly famous. Hermite is now best known for a number of mathematical terms that bear his name, such as, Hermite polynomials, Hermite's differential equation, Hermite's formula of interpolation and Hermitian matrices. Hermite's great love was for analysis and, not surprisingly, he had a great respect for Weierstrass (O'Connor & Robertson, 2001a, p.3).

Hermite died on January 14, 1901, at his home in Paris, France. As a Christian he was ready to depart from his life. He was perfectly serene and, the night before he died, he spoke to his family and the religious Sisters around him of the progress of the church in the United States in contrast to the violent political restlessness in France (Janson, 1995, p.19).

Pierre Duhem

Pierre Duhem was born June 10, 1861, in Paris, France. Pierre Duhem's father was Pierre-Joseph Duhem, a commercial traveler, and his mother was Alexandrine Fabre. Duhem's earliest education was at the Eglise St. Roch where he attended catechism classes. He quickly made an impression as one who never failed to come up with the correct answer. He credits his great interest in mathematics to the Arnoul sisters, his elementary teachers at the Eglise St. Roch (Janson, 1995, p.92).

When he was eleven years old he entered the Marianist Collège Stanislas where he remained for ten years and proved to be a brilliant student. Pierre would read from the Prospectus of Stanislas College. Discipline as an objective of the rules of conduct was based on St. Paul's words that all authority comes from God. The spirit of the rules was described as order, work, docility, decency, and piety. Pierre believed, by example, one lives his reasoned convictions and the fullness of his faith. He was certainly devout and respectful of matters of religion but he did not espouse his religious ideas loudly. In fact, he later voiced that bright Catholic youth must not be discouraged from entering state universities nor from seeking teaching posts there subsequently (Janson, 1995, pp.94 - 96).

Duhem saw himself formed as a mathematical physicist and a professor through the courses of mathematics and physics given at Stanislas by such Marianists as Maleyx, Vazeille, Moutier, and Biehler. From what he witnessed at Stanislas he grew to believe that innovations of teaching had better chances in private schools than in the vast system of state education. In private schools, learning could be pursued for its pure beauty, not for the sake of passing an entrance or exit exam, as it was in the state schools (Janson, 1995, pp. 98 - 99).

Leaving the Collège Stanislas with an outstanding background in Latin, Greek, science, mathematics and other subjects, he had to choose between studying at the École Polytechnique which prepared one to be an engineer, and the École Normale, the more academic of the two. Duhem's father wanted him to study science at the École Polytechnique since he wanted his son to follow a technical career. Duhem's mother, on the other hand, wanted him to study Latin and Greek at the École Normale, principally because she feared that a study of science would turn him away from the Roman Catholic beliefs that she had instilled in her children. Duhem chose to please neither of his parents by studying pure scientific at the École Normale. He began his studies on August 2, 1882.

In 1884, while still at the École Normale, Duhem published his first paper that was on electrochemical cells. Even before receiving his license in mathematics, Duhem submitted his doctoral thesis in 1884. The thesis was on thermodynamic potential in physics and chemistry and in it he defined the criterion for chemical reactions in terms of free energy. By doing this he was challenging the incorrect criterion, which Marcellin Berthelot had formulated twenty years earlier. Unfortunately being right is not always sufficient and the influential Berthelot was able to arrange for Duhem's thesis to be rejected.

Duhem knew he was correct and boldly published the rejected thesis in 1886. This move did not help his relations with Berthelot, as one can imagine. Further bad news for Duhem came when Berthelot became French Minister of Education in 1886. Duhem meanwhile worked on a second thesis, this time wisely choosing a mathematical topic. His mathematical work on magnetism was accepted in 1888.

Before his second thesis was submitted Duhem was already teaching at Lille. In Lille he lectured on hydrodynamics, elasticity, and acoustics, publishing these lectures in 1891. While in Lille he married Adèle Chayet in October 1890. She died two years later during the birth of their second daughter, who also died. This personal tragedy may have made it difficult for him to get along with his superiors in Lille.

It was after a dispute with the Dean, M. Demartres that Duhem requested a move from Lille and was appointed maître de conférence at Rennes in October 1893. Arriving in Rennes he found that it was not well equipped for his work and he at once requested another position. He became professor of theoretical physics at the University of Bordeaux on October 13, 1894.

Although he requested a move to Paris, which a scientist of his outstanding ability would naturally expect, it was blocked.

One should note that Duhem's thesis was not the only reason that he did not achieve the appointment in Paris. As well as the scientific dispute, Duhem was at odds with Berthelot on religious issues as well.

After becoming a corresponding member of the Académie des Sciences on July 30, 1900, in the following year he again requested a move from Bordeaux. Once again it was refused.

Few scientists have contributed in works of leading importance as Duhem. He made contributions to the philosophy of science, the historiography of science, and science itself. It might be said that his writings, strongly influenced by his ultra-Catholic views, prevented him from approaching subjects with an open mind.

His interests in science itself were mainly in the area of mathematical physics, and in particular thermodynamics, hydrodynamics, elasticity, mathematical chemistry, and mechanics. He viewed mechanics as a special case of a more general theory of space and he considered that a generalized version of thermodynamics would provide a theory to explain all of physics and chemistry.

In many ways Duhem can be seen as very modern in his approach. He would begin by setting up axioms, which the physical system that he was studying satisfied. He then studied in depth the consequences of the initial axioms deducing properties of the physical system from mathematical theorems developed from the axioms alone. He was opposed, however, to studying mathematical problems that did not arise from physical situations.

As well as his major contributions to science he also wrote articles of major importance on the philosophy of science. Duhem believed that a physical theory was a system of mathematical propositions, deduced from a small number of principles, which had the object of representing a certain number of experimental laws as simply, as completely, and as exactly as possible.

If scientific work itself led Duhem towards the philosophy of science, then in turn the philosophy of science led him towards the history of science. His paper L'évolution de la mécanique in 1902 is really an article on the philosophy of science but it is based heavily on using historical examples. Earlier important work on the history of science was Les théories de la chaleur published in 1895. His most important work on the history of science was, however, research that showed that the period from 1200 onwards was not a period when science had been ignored. Of course he was very keen to show that this was the case since the Catholic Church had been blamed by many for preventing scientific work during this period.

Duhem saw different national characteristics lead to different approaches to science. He disliked British science describing it as broad and shallow while he said that French science was narrow and deep. German sciences he claimed were highly geometrical, which for Duhem was a criticism for he considered an approach using an analytical style of mathematics to be far superior to a geometrical one.

Late in his career Duhem was offered a professorship in Paris as a historian of science and not as a mathematical physicist. Duhem refused the chance to work in Paris, the position he had always longed for, saying that he was a mathematical physicist and did not want to get to Paris through the back door (O'Connor & Robertson, 2001b, pp.1-4).

Pierre Duhem, as he did many summers, spent the summer of 1916, at his ancestral mountain summer home in Cabrespine. After a walk on September 2, 1916, Duhem suffered a cardiac seizure during the night. Two weeks later he had a second seizure and succumbed (Janson, 1995, p.117).

Sample Activities

Activity 1 – Famous Mathematicians Word Search

Find and circle the names below. The names may read forward, backward, up, down, or diagonally up or down.

Ampere, Euler, Bernoulli, Lagrange, Laplace, Cauchy, Legendre, Newton, Poisson, Weierstrass, Gudermann, Kovalevskaya, Hermite, Galois, Duhem

G	P	B	K	M	F	B	H	C	H
R	L	E	R	E	P	M	A	J	E
A	W	R	D	O	U	U	E	L	R
Y	E	N	A	T	C	L	C	W	M
A	I	O	G	H	U	I	E	F	I
K	E	U	Y	D	V	B	W	R	T
S	R	L	A	G	R	A	N	G	E
V	S	L	E	N	H	E	O	A	C
E	T	I	K	J	W	Y	S	L	A
L	R	S	M	T	I	C	S	O	L
A	A	O	O	E	N	M	I	I	P
V	S	N	A	Z	H	U	O	S	A
O	S	R	T	P	S	U	P	V	L
K	N	N	A	M	R	E	D	U	G
Z	A	L	E	G	E	N	D	R	E

Activity 2 – Story About Cauchy

Find the missing words by using the code below:

A2 B4 C6 D8 E10 F12 G14 H16 I18 J20 K22 L24 M26 N1 O3 P5 Q7 R9
S11 T13 U15 V17 W19 X21 Y23 Z25

Augustin Louis Cauchy was born August 21, 1789, in Paris, France. Cauchy's father was an accomplished classical and biblical scholar as well as a forthright Catholic. Cauchy's mother was likewise an outspoken Catholic. Paris was a difficult place to live in when he was a young child due to the political events surrounding the 12-9-10-1-6-16 9-10-17-3-24-15-13-18-3-1. When he was four years old his father, fearing for his life in 5-2-9-18-11, moved his family to Arcueil for a short time.

They soon returned to Paris and Cauchy's father became active in the education of his son. 24-2-5-24-2-6-10 and 24-2-14-9-2-1-14-10 were often visitors at the Cauchy home and Lagrange in particular took an interest in Cauchy's mathematical education. Lagrange advised Cauchy's father that his son should obtain a good foundation in 24-2-1-14-15-2-14-10-11 before starting a serious study of mathematics. As a result, in 1802, Cauchy entered the École Centrale du Panthéon where he spent two years studying classical languages.

Beginning in 1804 Cauchy attended classes in mathematics and he took the entrance examination for the École Polytechnique in 1805, placing second in the overall competition. At the École Polytechnique he attended numerous math courses and was even tutored in analysis by 2-26-5-10-9-10. In 1807 he graduated from the École Polytechnique and entered the engineering school École des Ponts et Chaussées. He was an outstanding student and for his practical work he was assigned to the Ourcq Canal project. In 1810 he was assigned to Cherbourg to work on port facilities for Napoleon's English invasion fleet.

The vast majority of students at the École Polytechnique were fairly indifferent to religion and faith. The dominant attitude among the students was one of liberalism and anticlericalism. Cauchy was a devout 6-2-13-16-3-24-18-6 and his attitude to his 9-10-24-18-14-18-3-1 was already causing problems for him. Many claimed his devotion to religion caused him to become proud, arrogant and self-infatuated.

In addition to his heavy workload Cauchy continued his mathematical research and proved in 1811 that the angles of a 6-3-1-17-10-21 polyhedron are determined by its faces. He submitted his first paper on this topic and quickly followed it with a second paper on 5-3-24-23-14-3-1-11 and polyhedra in 1812. Cauchy felt that he must return to Paris if he was to be recognized for his mathematical research. In September of 1812 he returned to Paris after becoming ill with a severe bout of depression.

Activity 3 – Word Scramble on Weierstrass

Rearrange the letters to spell out words related to Weierstrass's life. The words can be determined by the given clue.

1. Birthplace	MANREGY
2. Subject his father wanted him to study	NECIANF
3. Sport he played	NGICENF
4. Function theory studied	LLTIIPCE
5. Took exams to become this	AEERHCT
6. Had attacks of this	ZZSSIINED
7. Represented these functions as converging power series	LIBENAA
8. Wanted a professorship at the University of	INEBLI
9. Discovered one that was continuous but had no derivative at any point	IONTCNUF
10. Famous female student	EVALAYAKSKVO
11. Was the father of	LYSSIAAN
12. Were part of his daily routine	YRPARSE
13. Confined to during later years	CHEEHWLRAI
14. Died from this	UNOMAIENP

References

Janson, Herbert (1995). *High five – Catholic mathematicians*. San Antonio, Texas: St. Mary's University.

O'Connor, J.J. & Robertson, E.F. (1997). *Augustin Louis Cauchy*. Retrieved May 19, 2005, from www-groups.dcs.st-and.ac.uk/~history/Mathematicians/Cauchy.html.

O'Connor, J.J. & Robertson, E.F. (1998a) *André Marie Ampère*. Retrieved May 19, 2005, from www-groups.dcs.st-and.ac.uk/~history/Mathematicians/Ampère.html.

O'Connor, J.J. & Robertson, E.F. (1998b). *Karl Theodor Wilhelm Weierstrass*. Retrieved May 19, 2005, from www-groups.dcs.st-and.ac.uk/~history/Mathematicians/Weierstrass.html.

O'Connor, J.J. & Robertson, E.F. (2001a). *Charles Hermite*. Retrieved May 19, 2005, from www-groups.dcs.st-and.ac.uk/~history/Mathematicians/Hermite.html.

O'Connor, J.J. & Robertson, E.F. (2001b). *Pierre Maurice Marie Duhem*. Retrieved May 19, 2005, from www-groups.dcs.st-and.ac.uk/~history/Mathematicians/Duhem.html.