CHAPTER 24

201 YEARS OF MATHEMATICS AT WEST POINT

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Mathematics is the study which forms the foundation of the [United States Military Academy curriculum]. This is necessary, both to impart to the mind that combined strength and versatility, that peculiar vigor and rapidity of comparison necessary for military action, and to pave the way for progress in the higher military sciences. All experience shows that the mind, in order that it may act with efficiency, must be accustomed to exertion. It should be taught gradually to develop its own powers, and as it slowly learns their capacity and the manner of employing them, the increasing lights which are thrown upon its course will enable it to go on for an unlimited extent in the path of improvement.

—Committee on Military Affairs
United States Military Academy, 17 May 1834[1]

The Department of Mathematical Sciences at the U.S. Military Academy celebrated its bicentennial on 21 September 2001, for it was on that date in 1801 that the first mathematics class was taught at West Point. Though the Academy would not be signed into law

and officially founded by Thomas Jefferson until 16 March 1802, his Secretary of War, Henry Dearborn, hired George Baron as Teacher of the Arts and Sciences to the Artillerists and Engineers in July 1801.[2]

Dearborn ordered Baron to purchase 15 to 20 copies of *A Course in Mathematics*, a two-volume text by English mathematician Charles Hutton, so that cadets could study algebra, geometry, plane and spherical trigonometry, conic sections, and surveying.[3] Joseph G. Swift, the first USMA graduate and second individual to serve as Superintendent, described his first lecture as a cadet thus: "Professor Baron furnished me with a copy of Dr. Hutton's Mathematics, and gave me a specimen of his mode of teaching at the blackboard in the academy."[4] Soon afterwards, Swift and Baron got in a shouting match, and Baron was court-martialed and resigned before the Academy was even officially established.[5] Counting Baron as the "zeroeth" head of the Mathematics Department at West Point, in the following two centuries, there have been 20 more department heads, ten in each century. For ease of reference during the course of this chapter, we detail them in Table 24-1.

After Jared Mansfield graduated from Yale, he taught school in New Haven and Philadelphia. In 1802, he published *Essays, Mathematical and Physical*, the first mathematics book published in the United States that contained original work. President Thomas Jefferson was so impressed with the book that he appointed Mansfield captain in the Corps of Engineers so that he could teach mathematics at West Point. He was noted as a kindly teacher and the cadets liked him. Mansfield left the Academy in 1803 when he was appointed Surveyor General of Ohio and the Northwestern Territory, replacing Rufus Putnam, the namesake of Fort Putnam, the best-known of the satellite defense works protecting fortress West Point during the Revolutionary War. He returned to West Point in 1812 as Professor of Natural and Experimental Philosophy and stayed until he retired in 1828.[6]

William A. Barron (the "two r" Barron), who had an impressive flair for teaching, had been a tutor at Harvard before he accepted a captaincy in the Corps of Artillerists and Engineers. After two years, he was assigned to West Point. A year later, in 1803, he purchased 14 copies of *Geometrical and Geographical Essays* by George Adams for

	Professor	Born-Died	Education	Tenure of Mathematics Department Heads
0	George Baron	1769-1812		6 Jan 1801-11 Feb 1802
1	Jared A. Mansfield	1759-1830	Yale 1777	3 May 1802-14 Nov 1803
2	William A. Barron	1769-1825	Harvard 1787	6 Jul 1802-14 Feb 1807
3	Ferdinand R. Hassler	1770-1843		14 Feb 1807-31 Dec 1809
4	Alden Partridge	1785-1845	USMA 1806	13 Apr 1813-1 Sep 1813
5	Andrew Ellicott	1754-1820		1 Sep 1813-29 Aug 1820 †
6	David B. Douglass	1790-1849	Yale 1813	29 Aug 1820-1 May 1823
7	Charles Davies	1798-1876	USMA 1815	1 May 1823-31 May 1837
8	Albert E. Church	1807-1878	USMA 1828	1 Jun 1837-30 Mar 1878 †
9	Edgar W. Bass	1843-1918	USMA 1868	17 Apr 1878-7 Oct 1898
10	Wright P. Edgerton	1852-1904	USMA 1874	7 Oct 1898-25 Jun 1904 †
11	Charles P. Echols	1867-1940	USMA 1891	29 Jun 1904-30 Sep 1931
12	Harris Jones	1892-1977	USMA 1917	1 Oct 1931-1 Sep 1947
13	William W. Bessell, Jr.	1901-1977	USMA 1920	1 Sep 1947-Sep 1959
14	Charles P. Nicholas	1903-1985	USMA 1925	Sep 1959-Sep 1967
15	John S. B. Dick	1913-2004	USMA 1935	Sep 1967-Jan 1974
16	Jack M. Pollin	1922-	USMA 1944	Jan 1974-Jun 1985
17	David H. Cameron	1927-	USMA 1950	Jun 1985-Jun 1988
18	Frank R. Giordano	1942-	USMA 1964	Jun 1988-1995
19	David C. Arney	1949-	USMA 1971	1995-25 Dec 2000
20	Gary W. Krahn	1955-	USMA 1977	25 Dec 2000-

† Died while serving as Department Head

Table 24-1. USMA Mathematics Department Heads.

teaching practical applications of mathematics.[7] During these early days instruction was from 8 a.m. until noon, with Mansfield teaching algebra and Barron doing "geometrical demonstration."[8] Superintendent Jonathan Williams taught surveying in the afternoons.

One of the early students at the Academy was Alden Partridge. Williams and Barron examined the cadets on 17 October 1806 and declared Partridge "the best mathematician in the academy."[9] Unfortunately, this is a hard claim to judge, but there is an undated manuscript at Norwich University, a school that Partridge founded

in 1819, showing that Partridge knew enough about "fluxions" (the Newtonian version of calculus) to calculate the inflection points of a conchoid. Following graduation in 1806, Partridge was promoted to first lieutenant, one of only two graduates to receive this rank upon graduation.[10] He stayed at West Point after graduation to teach mathematics under Barron and later under Ferdinand Hassler, who taught at West Point from 1807 to 1809. On 13 April 1813, Partridge became the first official "Professor of Mathematics" at West Point (the position was not established by Congress until 29 April 1812), but held the office for only a few months. On 1 September 1813, he accepted the position of Professor of Civil and Military Engineering, becoming the first person in the country to hold a professorship in engineering.

Without doubt, Ferdinand Hassler was the most colorful professor the department has ever had. Born in Switzerland, he studied in France and Germany and assisted in a survey of his native canton of Bern. He was an avid collector of books but sold half of his collection before immigrating to the United States. His plan was to set up a utopian farming community in South Carolina. On the voyage across the Atlantic, the captain of the ship had a stroke, and Hassler took over the navigation to Philadelphia.

Upon arrival he learned that one of his business partners in the farming venture no longer had the funds to buy land, so he turned to other pursuits. Hassler quickly impressed the intellectuals of Philadelphia with his versatility and scientific knowledge, his set of surveying instruments (including a copy of the standard meter and kilogram), and his library of 3,000 scientific books. Reports soon reached President Jefferson about Hassler's talents. He was appointed Professor of Mathematics at West Point with a salary of $700 per year in 1807. Reports on his teaching are mixed—he was good for the good students and bad for the bad ones. While teaching at the Academy, Hassler wrote *Elements of Trigonometry*, the first work on analytic trigonometry in English (not published until l826). He thus became the first mathematics professor to write a book while at West Point. Despite these distinctions, his stay at West Point was short-lived because Secretary of War William Eustice, who wanted to abol-

ish the Academy, interpreted the law to mean that civilians could not teach at West Point.

Andrew Ellicott had a considerable reputation as a surveyor when he came to West Point in 1813 to replace Partridge. His most memorable achievement was the surveying of the "ten-mile square" that became the District of Columbia. Interestingly, in that historic task he was aided by the mathematical practitioner Benjamin Banneker, a free Black. Ellicott had a reputation as a good teacher, and it appears that under his leadership the teaching of mathematics was much less tied to the text, although he continued to use the Hutton book noted at the beginning of this chapter. In a letter to Swift dated 10 February 1815, Ellicott writes that the students "have made great progress—these classes are in Conic sections, one of which will be in fluxions before the end of next month."[11] We also know that seven cadets were examined by Ellicott in calculus in 1815. Curiously, one member of that class, future Department Head Charles Davies, was not examined at this time. He must have learned his calculus through private study and under the tutelage of Partridge and Ellicott. While 1815 is the earliest documentation of a class in calculus at West Point, we conjecture Davies was tutored because earlier Partridge tutored the sons of Jonathan Williams in the subject in 1810.

Ellicott was a kindly and friendly man, well liked by the cadets for his interesting stories. They nicknamed him "Old Infinite Series," revealing that the topic was indeed taught to the Corps. He was famous for the perfect geometrical constructions he made at the blackboard with cord and straight-edge. He even had a small slate and sponge attached to his buttonhole so that he could do mathematics on the spur of the moment. He died in 1820 at West Point and is buried there.

One of the most useful advances in military engineering of the late 18th century, the mathematical discipline of descriptive geometry, was the creation of the French mathematician Gaspard Monge. The idea was to produce a two-dimensional representation of a three-dimensional object; today, the subject has evolved into computer-aided design. In Monge's day it allowed moderately quick geometrical solutions of problems that had been done by laborious

arithmetic, such as in calculating specifications for construction of fortifications and optimum emplacement of guns. Descriptive geometry was brought to the Academy by Claudius Crozet, a student of Monge at the École Polytechnique in Paris, who immigrated to the United States in 1816 and immediately took up the position of Assistant Professor of Engineering at USMA.

Crozet undertook to teach descriptive geometry, but the cadets were not prepared to comprehend the material. Since the level of descriptive geometry texts available, all in French, was above the capacity of cadets, Crozet wrote *A Treatise on Descriptive Geometry* in 1821 explicitly for the use of the cadets at the Academy, but it was not published until 1826. Crozet relied heavily on the blackboard for the teaching of descriptive geometry, and since his time the blackboard has been in almost daily use at the Academy.[12] The subject of descriptive geometry was taught in the Mathematics Department from Crozet's arrival in 1816 until 1929 when it was transferred to the Department of Drawing.

To augment the teaching of descriptive geometry, a set of 26 string models was procured from the firm of Pixii in Paris in 1857 for about $500.[13] Designed by another student of Monge, Theodore Olivier, these models depict the intersection of various three-dimensional ruled surfaces, such as cones and hyperboloids. They were used by cadets as models for their two-dimensional drawings. Drawing, both artistic and technical, was an important part of the curriculum (see Chapter 18). As officers in the Corp of Engineers, graduates would be called on to make detailed and accurate drawings of landscapes as well as road and bridge designs as part of the exploration and development of the nation that took place during the 19th century.

The Olivier models are on display today in the Department of Mathematical Sciences. Also, examples of the precise and beautiful drawings done by cadets during this period can be seen both at the USMA museum and in the Special Collections of the USMA Library. Two favorites are signed by Class of 1843 member U.H. Grant, who was later to adopt the name Ulysses S. Grant. After graduation, Grant wrote Professor Church several times requesting to be an instructor in the Mathematics Department.[14] Church turned him down and so

today the wags claim that "it is harder to become an instructor in mathematics at West Point than President of the United States."

After the difficult experience of the War of 1812, national leaders became more concerned with the quality of instruction at West Point. Secretary of State James Madison accepted Swift's recommendation to send Lt. Col. William McRee and Capt. Sylvanus Thayer to Europe "to gain a knowledge of the European military establishment, their fortifications, Military Schools and Military workshops, and also to collect Books, Maps, Plans and Instruments for the Military Academy."[15] They arrived in Europe in May 1815 shortly after the Battle of Waterloo and returned in May 1817. In particular they visited the École Polytechnique in Paris and brought back almost 1,000 French mathematical, scientific, and military texts from the best authors of the period.[16] The École was founded in 1794, and within a few years had become Europe's premier military and scientific institution. Prominent scientists and mathematicians such as Laplace, Lagrange, and Fourier developed a program there that produced some of the best minds of the century. Thayer rebuilt the U.S. Military Academy both militarily and academically using the École as his model. Some of the reforms were already under discussion by the faculty and Superintendent Alden Partridge, but few changes had actually been made. By the end of the second decade of the 19th century, under the superintendency of Sylvanus Thayer, the Academy would take the shape that we are familiar with today.

David Douglass graduated from Yale in 1813, was commissioned a second lieutenant in the Corps of Engineers and ordered to West Point, but was called away by the War of 1812. He was breveted captain for his "distinguished and meritorious service" in the defense of Fort Erie. Returning to West Point, he married Ann Eliza Ellicott, daughter of Prof. Ellicott, in 1815. For the next five years he served as the Principal Assistant Professor of Natural and Experimental Philosophy. Upon his father-in-law's death in 1820, Douglass succeeded him as Professor of Mathematics, serving until 1823 when he became Professor of Engineering, remaining in that position until his resignation in 1831. He later became president of Kenyon College in Ohio.

Charles Davies, under the auspices of the Chief of Engineers, Joseph G. Swift, came to West Point in December 1813 and graduated in December 1815.[17] There were no openings in the Corps of Engineers so he took a less desirable position in artillery, serving a year in garrison duty before being transferred to the Corps of Engineers in August 1816. He resigned from the Army on 1 December 1816 to accept a position at West Point teaching mathematics. He served under Department Heads Andrew Ellicott and David Douglass, and then taught natural and experimental philosophy for two years. He subsequently became Professor of Mathematics in May of 1823 when Douglass became Professor in Philosophy. The use of Hutton's text, which had served yeoman duty since the inception of the Academy, was discontinued at this time.

As professor, Davies began a long and lucrative career as the author of textbooks, initially for use at the Academy but then for use throughout the country. The books he published while at West Point covered the entire Academy mathematics curriculum:

Elements of Descriptive Geometry (1826)
Elements of Geometry and Trigonometry (1828)
Elements of Surveying (1830)
A Treatise on Shades and Shadows, and Linear Perspective (1832)
The Common School Arithmetic (1833)
Elements of Algebra: Translated from the French of M. Bourdon (1835)
Elements of the Differential and Integral Calculus (1836)
Elements of Analytical Geometry (1837)[18]

Not surprisingly, the effort of producing eight books in 11 years left Davies exhausted. He resigned in May of 1837 to tour Europe, restore his health, and then "continue to write and revise wildly successful mathematics textbooks."[19] All of these works except the arithmetic were used as textbooks at West Point, most for long periods of time. Several of them began as translations and then were revised and improved for the Academy and the American market. Owing to the large number of graduates who taught mathematics after leaving

the Army and to the wide recognition of the value of these texts, the books of Davies were extensively used in both colleges and schools.[20] The 1828 text, *Elements of Geometry and Trigonometry,* was his most popular book. During the period from 1828 to 1895, it appeared in 33 editions/printings and some 300,000 copies.[21] In his lifetime Davies published 49 different titles appearing in at least 492 editions/printings. They covered the ground from elementary arithmetic through college mathematics (though none was higher than calculus). By 1875, Davies was selling about 350,000 books every year and reached a total of seven million sold by that year.[22] He completely dominated mathematics textbook writing in the 19th century.

Davies was succeeded by Albert Church, who, as we have seen, would one day refuse a future U.S. president the opportunity to teach mathematics at West Point. When Church arrived at West Point in June of 1824 at age 16, the entrance requirements were simply arithmetic, reading, and writing. During the summer the cadets "received daily and very thorough instruction" in arithmetic by Cadet Dallas Bache, and recited daily to him. Bache had served as Acting Assistant Professor of Mathematics the previous year, and was about to enter his First Class (senior) year. It was then the practice to have a few outstanding cadets serve as instructors, and Bache was outstanding (he eventually became Superintendent of the U.S. Coast Survey).[23] Bache's examination of the "fully qualified" was "hurried and slight," with not more than one or two questions asked, but the proficiency of the weaker cadets was "fully tested." Moreover, every cadet was "required to read and write in the presence of the Academic Board."[24]

During his first year Church and his classmates studied algebra. "The best textbook that could be obtained in the English language was a poor translation of Lacroix," so it had to serve.[25] Also, they used Legendre's *Geometry*,[26] Lacroix's *Trigonometry*,[27] both in translation, and Crozet's book on descriptive geometry.[28] These were all useful books, providing an excellent basis for learning. During the second year, Church and his classmates in the higher sections used the analytic geometry text of Biot and the calculus text of Lacroix, both in

French.[29] Thus the French the cadets studied every afternoon of their plebe (freshman) year was necessary for their study of mathematics during their yearling (sophomore) year. It is noteworthy that in 1825 all cadets were learning some calculus.

Albert Church graduated first in the Class of 1828 and, like Davies, was commissioned in the artillery, there being no vacancies in the Corps of Engineers. Thayer requested that Church stay at West Point to teach mathematics, and there he remained except for two years from 1832 to 1834 when he joined his artillery unit. In 1837 he became Professor of Mathematics when Davies resigned. Church served as professor until his death in 1878, a total of 50 years of service, 48 of them at West Point.

The reports on Church as a teacher are not good. Morris Schaff, who graduated in 1862, called him "an old mathematical cinder, bereft of all natural feeling."[30] Arthur Hardy, an 1869 graduate who taught mathematics at Dartmouth in the 1890s and was also a novelist with a national reputation, observed, "The mathematical recitation was a drill room. In my opinion the result was a soldier who knew the maneuvers, but it did not give an independent, self-reliant grasp of the methods of research."[31]

But Church was influential, both through his guidance of the department and through his own textbook writing. His four texts were used extensively at the Academy and saw moderate success across the country as well.

Elements of Differential and Integral Calculus (1842)
Elements of Analytical Geometry (1851)
Elements of Descriptive Geometry (1865)
Plane and Spherical Trigonometry (1869)

These texts were noteworthy in that they were meant merely as improvements on what was already being taught. There was no broadening or deepening of the curriculum. Church himself admitted that once the mathematics curriculum was set in place, it did not change substantially for the rest of the 19th century, although the annotations in many textbooks in the library show that there was constant tinkering with the presentation of the mathematics.

When Professor Church died in 1878 at the age of 70, Edgar Bass, who had never previously taught mathematics, replaced him. From 1869 to his appointment in mathematics in 1878 he had been Assistant Professor of Natural and Experimental Philosophy, except for 16 months during the period 1874-1875 when he served as assistant astronomer of the U.S. expedition to New Zealand to observe a transit of Venus. Bass was not satisfied with the foundations and clarity of the calculus book of Church, so he worked hard over many years writing his own. As portions were finished, he published them as pamphlets and issued them to the cadets. In 1889 he finally published the completed work under the title *Differential Calculus*. A decade later he retired because of poor eyesight.

If we look at the Academy curriculum from the earliest years, it is clearly "the product of an evolutionary development which, over the years, has reflected the changing requirements of the military profession and advances in the field of higher education."[32] A good example occurred in 1879, when Department Head Bass introduced into the curriculum a course in least squares, a method of statistical analysis for finding the best trend line for a set of empirical observations. This method was invented by Carl Friedrich Gauss and used by him in his spectacular 1801 rediscovery of the first observed asteroid, Ceres. The technique became a standard method for the astronomer and surveyor to correct observational and measurement errors. It was a tool that every military engineer should have in his tool-kit. In 1879 the Board of Visitors recommended the use of *Treatise on the Method of Least Squares*, written by William Chauvenet, one of the founders of the U.S. Naval Academy. The book was used until 1889 when it was replaced by *The Theory of Errors and Least Squares* by W. W. Johnson, which itself was used until 1932.

There is a copy of the latter in the USMA library that reveals a good deal about teaching at West Point. Notes in the book, once in Bass's personal library, indicate which sections of the book were to be covered on which days, and which sections were to be assigned solely to the advanced sections. In 1942, when Col. Harris Jones was Department Head, a portion of the least squares course was replaced by a course in statistics. When William W. Bessell, Jr., was head, all

sections studied the same material, which by this time had developed more broadly into statistics. Electronic computing machines were introduced into the statistics course in 1947 to do the tedious computations that the method of least squares requires. With the development of modern computers the method has been reduced to an exercise in multivariable calculus and a black box on the computer. However, the study of statistics has remained a central part of the curriculum, and the discipline is expected to play an even more important role in the curriculum of the 21st century because familiarity with the applications of statistical analysis has become a vital tool for the educated citizen.

Another noteworthy contribution of Professor Bass was the adoption of special lectures in the history of mathematics in 1896.[33] During the first year, cadets attended a special lecture on the history and early development of geometry and algebra. In the Third Class year, cadets attended one or more lectures on the history of descriptive geometry, which included a comparison of algebraic and geometric methods and a short introduction to projective geometry. Another special lecture during the Third Class year was on the development of calculus, to include the Newton-Leibniz controversy over who first discovered the calculus.

Wright Edgerton was appointed Department Head in 1898. He had much more military experience than his predecessors, having served in the line Army for eight years at ten locations in six states. In 1882 he returned to West Point to be the Principal Assistant Professor of Mathematics, second in the department to Professor Bass. In 1893 he became Associate Professor of Mathematics, the first in the department to hold that title. He made two important changes in the curriculum. Since Thayer's time, algebra and geometry had been taught in that order, but Edgerton decided to teach them simultaneously, with recitations on alternate days. The other change still echoes today. He started giving written tests for the general reviews, thereby allowing students who did well on them to be exempt from the final exams. It had been customary throughout the century to have three kinds of classes, "advance" where new material was covered, "partial reviews" where a portion of the material was revisited,

and then a "general review" before the examination. Beginning with Edgerton, cadets took written partial reviews (or WPRs, to use familiar Academy lingo), which were actually tests. In 1902, to create more time for Spanish instruction, the mathematics curriculum was reduced and surveying was transferred to the Department of Practical Engineering.[34] Professor Edgerton died in 1904, at age 51, from the lingering effects of disease contracted in the summer of 1898 while he was serving as a volunteer aide-de-camp during the U.S. seizure of Puerto Rico from Spain.

Charles P. Echols became head of the Mathematics Department in June of 1904. At the end of the fall term he declared 40 percent of the yearlings deficient in mathematics. This incensed Superintendent Albert Mills, who ordered Echols on a study tour of eastern colleges to observe instruction in mathematics. Then he ordered him to Europe for the following academic year to study military instruction there. In his absence the department experimented with eliminating daily marking in Fourth Class mathematics, and a committee studying the curriculum reduced the mathematics curriculum for the second time in two years.[35]

In 1908, President Roosevelt wrote that it was "a very great misfortune to lay so much stress upon mathematics in the curriculum at West Point and fail to have languages taught in accordance with the best modern conversational standards."[36] The Academic Board dismissed the idea, reiterating the long-held view that a technical curriculum instilled mental discipline. Indeed, it went on to claim, "Mathematical training at the Military Academy has been the main factor in all the accomplishments of graduates."[37]

The workload for the professors was particularly heavy and got even worse during World War I. For example, during Academic Year 1918-1919, there were 18 instructors in mathematics operating under an emergency schedule. Each instructor was in the section room from 8:00 a.m. to 12:35 p.m. daily—three periods of 85 minutes each. According to the Annual Report of the Superintendent, this "is at a rate of twenty-five and a half hours per week of actual section room instruction, which, it is safe to say, is not undertaken ordinarily at any college in the country by an instructor in such subjects."[38]

Brig. Gen. Douglas MacArthur assumed the superintendency at West Point on 12 June 1919, the youngest superintendent since Thayer. When appointing him, Gen. Peyton March, Chief of Staff, told him, "West Point is forty years behind the times."[39] Thus MacArthur's task was to revitalize the Academy. This required reinstatement of the four-year curriculum (although March wanted three) after the abridged terms during World War I. The Academic Board was assigned the task of revising the curriculum, with the work lasting for an entire year. MacArthur approved the Board's report on 20 July 1920, with the result here described by Academy historian Roger Nye:

> The system of recitations was reaffirmed; the practice of assigning review lessons after a few advanced lessons was continued; frequent grading and merit sectioning were retained. Finally, the report reaffirmed the essentiality of a faculty of Academy graduates, suggesting only that a year's assignment to a civilian school would improve their instruction, and that a four-year tour was highly desirable.[40]

Among curricular changes, the mathematics program was cut by a third. Professor Echols, who had 21 years of experience in higher education as opposed to MacArthur's just-completed first year, was incensed, so he issued a minority report. Echols was particularly disturbed by the dropping of descriptive geometry from the curriculum, a subject that had been taught at West Point for a century, and "a subject taught with painstaking elaboration at all the important military schools in the world."[41] Although the new curriculum was approved in Washington, Echols waged a guerrilla campaign. At the end of the fall term, Echols reported that 95 of 572 plebes were deficient in mathematics. The Academic Board saved 11 by reducing the passing mark from 37.5 to 35.3.[42]

MacArthur appointed an ad hoc committee of three lieutenant colonels, each with only their two-year cadet experience in mathematics, to investigate the high failure rate. In historical terms, Echols's 16.6 percent failure rate was not particularly high, for the 1924 *Superintendent's Annual Report* reveals that 24 percent of each plebe class was academically deficient after their first semester at

West Point. This fact notwithstanding, the committee issued, in the words of Roger Nye, "the most careful denunciation of the Professor of Mathematics officially recorded at the Academy."[43] Through actions such as this, MacArthur lost the support of the Academic Board, and soon after he left in 1924 his revisions of the mathematics curriculum were rescinded.

In the penultimate year of Professor Echols's incumbency, the mathematics curriculum was described as follows in the *Howitzer*:

> In the fourth class year algebra is completed in alternation first with plane and solid geometry, then with plane and spherical trigonometry. Plane analytical geometry is begun. The third class year embraces plane and solid analytical geometry and descriptive geometry, both being concluded in alternation. The calculus, differential and integral, and the theory of least squares complete the course.[44]

Harris Jones, who served as Department Head from 1931 to 1947, attended Harvard for two years before entering West Point. As a cadet he earned the nickname "Prof" for his ability in mathematics and willingness to help his fellow cadets. He graduated first in the Class of 1917 and was commissioned as a first lieutenant. A month later he was promoted to captain and led an engineer company into World War I. He earned the Distinguished Service Cross and was back at West Point the next fall. The following year he attended the Massachusetts Institute of Technology for a year of advanced study and then rejoined the field Army for eight years. He returned to West Point in 1931 as a colonel to become the Department Head.

Along with academics, the Academy has always been strong in athletics. The football program, in particular, was a strong competitor in the early decades of the 20th century. The athletic prowess of Army teams and the military nature of the institution, however, led to skepticism among some civilian educators about the quality of West Point's educational methods. In 1932 West Point was called upon to defend its academic honor after Army had won the Army-Harvard football game that year by a score of 46-0. President Abbott Lowell of Harvard commented to Superintendent William Connor at

a post-game gathering at the home of Mrs. William Putnam that even though Army could beat Harvard in football, Harvard would surely win at an academic contest. Superintendent Connor could not ignore the challenge, so they agreed on a mathematical competition to be held at West Point on 19 and 20 May 1933. Ten sophomores from each school would be tested in plane and solid analytic geometry and the differential and integral calculus; the contest was restricted to the first two years of collegiate mathematics because that was all that was taught at West Point. The cadets trained as if for an athletic contest and received all the special treatment normally given to the athletic teams; one of their three coaches was future department head Lt. Charles Nicholas. Newspaper articles anticipating the event appeared in the *Pointer* and even the sports section of the *New York Times*. The cadets' hard work paid off as they beat the Crimson handily. "Army 'Mathletes' Defeat Harvard 98-112," reported a headline in the *New York Times*. Each contestant received a gold medal and a book.[45]

With support from the Putnam family, the contest was expanded in 1938 to a national event, and the Putnam Competition continues to this day as the most prestigious contest in the nation for mathematics undergraduates. Alas, West Point has not won since the zeroeth competition in 1933, primarily because the exam covers the whole range of undergraduate mathematics. Until majors were introduced in 1982, cadets could not have acquired the requisite knowledge. In recent years, cadet teams have participated in the International Mathematical Contest in Modeling and done very well, ranking in the highest category, "Outstanding," in each of the past four years.

A milestone occurred on Prof. Harris Jones's watch in 1943, when the Mathematics Department took over instruction in the slide-rule from the Department of Physics. Glancing ahead, we may note that the Class of 1978 was the last class to be issued this venerable instrument, by means of which thousands of cadets learned to quickly make any mathematical calculation amenable to logarithmic solution—with surprising accuracy.[46]

Also during Professor Jones's period of office was the assignment of the first mathematics instructor at West Point with a Ph.D. (in mathematics). He was Capt. Robert C. Yates, Corps of Engineers,

who arrived for duty on 15 June 1942 as a member of the Army Reserve. In contrast, other engineering colleges and universities had been hiring instructors with Ph.D.s for half a century. Yates received his undergraduate degree at the Virginia Military Institute in 1924 and his doctorate at Johns Hopkins in 1930. One of his duties at West Point was to design and teach a course for new instructors on techniques for teaching mathematics to cadets: "In performing this duty he was considered a superior instructor and also an excellent teacher of teachers."[47] The author of five books and over 60 papers, his text on differential equations was in use at the Academy from 1950 to 1963. The next individual in the department to have a Ph.D. (in systems engineering) was the 16th department head, Col. Jack Pollin. Col. David Arney, who received his Ph.D. in 1985, was the first department head to have a Ph.D. in mathematics.

The 1942 *Howitzer* noted:

> As war becomes more and more mechanized, the study of mathematics assumes a greater importance in the education of a soldier. Without a background in mathematics it is impossible for one to study properly those sciences with whose principles one must be familiar in order to understand the functioning and operation of modern weapons.[48]

Even though the cadets recognized the military applicability of mathematics, and this is doubtless more true today, in the same paragraph as that above they cite the older rationale for studying mathematics—a view championed by the Academic Board throughout the 19th century—as "one of the best methods of training a mind." It was this narrow viewpoint that retarded the development of the mathematics curriculum. The cadets had noted this stagnation two years earlier when they remarked that "in 1835 the course was fundamentally the same as it is today."[49] They were only partially right, for a statistics course had been newly added. This was during World War II, and it is noteworthy that the department once again had to resort to cadets as instructors in some classes, a practice not previously seen since the Civil War.

The *Howitzer* of 1947, the final year of Professor Jones's tenure, gives the cadet view of the department. We quote it in full:

> From the day he first responds to the immortal battlecry of "Take boards!" to the day he graduates, a cadet at West Point makes constant use of the principles he learns at the capable hands of the Mathematics Department. To the cadet, no portion of his academic instruction is more important. During his Fourth Class year he wades through algebra, solid geometry, analytical geometry, and trigonometry. Barely able to distinguish an ellipse from a hyperbola, he is plunged into his Third Class course of differential and integral calculus and statistics. Emerging from this battle with sines, cosines, derivatives, integrals, and their assorted brethren, he possesses a sound mathematical foundation on which to base his scientific education. Although formal instruction in Mathematics finishes with his Third Class year, he continues to use his prowess throughout his courses in physics, chemistry, mechanics, and ordnance; for if he forgets his math in any of them, he's lost![50]

This unmistakable cadet style betrays both the callowness of youth and an emerging maturity. It provides a good basic summary of the curriculum, an acknowledgment that the department is doing a capable job, and an understanding that what they are learning is useful.

Col. William Bessell replaced Jones as Head of the Department in 1947. The Academic Board selected him for Professor from a pool of 31 nominees: 19 Army officers and 12 civilians, several of whom went on to become world-class mathematicians. To join the Corps of Professors, Bessell was required to give up the star that was pinned on him in 1944 during World War II. Bessell's 12-year tenure as Department Head was filled with important accomplishments. One of his first decisions was to offer the probability and statistics course to all cadets, rather than just to the upper sections. Desirous of improving the Academy's teaching facilities, he conceived the idea of converting the 1911 Riding Hall—it served for little more than a parking

lot after equitation was discontinued in the 1940s—into a modern academic building. The renovated structure "of structural steel framing with reinforced concrete, completely air conditioned and practically windowless," became Thayer Hall and the home of the department.[51] To complement the new academic building, Bessell modernized the mathematics classrooms by adding overhead projectors and mechanical computers. Additionally, he was one of the early visionaries in the establishment of a computer center, which found its first home in Thayer Hall (see Chapter 23). Finally, he was instrumental in the Academic Board's decision to require incoming military faculty members to earn advanced degrees prior to their arrival at West Point.

In 1959, Col. Charles Nicholas became the Department Head upon Bessell's elevation to the deanship. During World War II he was a pioneer in the new field of scientific intelligence, serving on the organizing committee for the Central Intelligence Agency of which he was Deputy Assistant Director during the period 1947-1948. Undoubtedly his most important contribution in mathematics was a series of Special Topics Memoranda (STMs). As he revised them, they were repeatedly typed by Ms. Frida Clogston, who served as departmental secretary for over 40 years. The STMs were assembled into a 1,200-page text, *Differential and Integral Calculus*, especially designed for the method of instruction used at the Academy. This was a rigorous book, explaining every detail. The STMs earned their nickname—"The Green Death"—from the color of their covers (and, truth be told, their content).

In 1960, the Academy instituted elective courses to be taken during First Class year. The following year the department offered its first elective courses: abstract algebra with military applications, matrix algebra, and advanced calculus. By 1971 there were tracks of study in the department—one standard and three advanced—each concordant with the particular area of engineering the cadet was interested in, as well as their mathematical ability and interest.[52] The first concentrations or fields of study, the predecessor to majors, became effective with Academic Year 1975-1976. In 1980 the operations research field of study was added to the mathematics offerings,

which would grow into the predominant mathematics degree in the department when majors were finally introduced for the Class of 1985 (cadets no longer had to take an engineering degree, and within a few years more than half the corps would pursue degrees in fields outside of engineering).

John S.B. Dick, after serving seven years as Deputy Department Head, became the 15th head of the department with the retirement of Colonel Nicholas in 1967. Having previously earned a master's degree in civil engineering from the Massachusetts Institute of Technology and a master's in mathematics from the Rensselaer Polytechnic Institute, as deputy head he oversaw a successful advanced placement program that allowed qualified cadets to validate (i.e., receive credit for) some mathematics courses. He was an excellent instructor and faculty mentor who focused on cadet character development. He stressed the importance of assisting cadets in the mastery of logical reasoning and enlightening them concerning the applications of mathematics. He retired in 1974 after serving for a few months as Acting Dean.

Col. Jack M. Pollin graduated from the Academy in 1944 and had a distinguished military career, commanding in Germany, Korea, and Vietnam. He earned a master's degree in electrical engineering from the University of Pennsylvania in 1949, another in mathematics from the Rensselaer Polytechnic Institute in 1957, and a Ph.D. from the University of Arizona in 1969. He became Department Head in 1974. It was under Pollin that a mathematical modeling course was introduced. He was also head of the department during the exciting years when women were first admitted to the Corps of Cadets.

The typical cadet entering in 1976 would take a 12-credit hour calculus course as a plebe; and then multivariable calculus (4.5 hours) plus differential equations, probability theory, and statistical inference (4.5 hours) as a sophomore. The content of these courses was similar to what was being taught across the country at the time. The cadet with advanced preparation would replace the plebe calculus course with multivariable calculus and introduction to linear algebra, the standard probability course, and an elective. The electives available included linear programming, abstract algebra, complex

analysis, numerical analysis, and real variable theory—standard courses that mathematics majors could take at most schools.[53]

The first civilian in the department in the 20th century was Prof. Iso Schoenberg, who joined the faculty as a Visiting Professor in Academic Year 1977-1978. He was a vigorous 72-year-old with a distinguished career in mathematics—he had single-handedly created the field of splines, which are used to approximate a complicated curve by a sequence of shorter, simpler ones. While at West Point, he wrote a popular book, *Mathematical Time Exposures*, which is still in print by the Mathematical Association of America. Moreover, he provided a reminder of the benefits of physical fitness to the junior members of the faculty. One winter night there had been a major snowstorm, bad enough to keep the young officers on the faculty from getting to the office on time the next morning. When they finally arrived they were surprised to find Professor Schoenberg already there, working quietly at his desk. Asked how he got there, he nonchalantly replied that he had skied from his quarters in the Lee housing area. Schoenberg got the visiting professor program off to a good start, and it has continued almost every year since.

In addition to the visiting professor, the Department of Mathematics benefited from the addition of a second visiting civilian faculty position starting in 1994.[54] The Army Research Laboratory, eager to exploit the talents of the mathematics faculty, agreed to provide one of its scientists to the department each year. Dr. Peter Plostins was the first ARL scientist so designated. The Math-ARL relationship led to cooperative and productive research on a variety of important research topics, which are showcased by annual joint conferences.

Col. David Cameron was the Head of the Department from 1985 to 1988. He earned master's and Ph.D. degrees from Princeton in civil engineering as well as a master's in mathematics from Rensselaer Polytechnic Institute. An excellent teacher, Cameron taught the first course in advanced mathematics offered by the department and directed the redesign of the mathematics curriculum to take advantage of computers in the classroom. Under his guidance, a mathematics-consulting element was established that allowed faculty members and students to support the research needs of the Army.

It was under Colonel Cameron's period of office that the first female Academy graduates returned to teach mathematics.

Capt. Kathleen Snook and Capt. Bobbi Fiedler-Prinslow, both from the Class of 1980, joined the mathematics faculty in 1987. They were the first women graduates to teach in mathematics.[55] Snook's career was similar to that of many of the rotating faculty members who have served in the department. After five years as an officer in the line Army, she spent two years in graduate school earning a master's degree in applied mathematics. She then reported to West Point and taught mathematics for four years (one year longer than usual). Upon completion of their teaching duties most officers return to the active Army; many use their mathematical skills to contribute to the Army in operations research and related fields. Capt. Snook followed a different path. Selected to return to graduate school for a Ph.D., she returned a few years later on a permanent basis as an Academy Professor. She retired in 2002.

Col. Frank Giordano was the Head of the Department from 1988 to 1995. After graduating from the Academy in 1964 he served two tours in Vietnam. During the period 1971-1974 he was an Olmstead Scholar at the University of Madrid and the University of Arkansas. Earning a Ph.D. in 1974, he then reported to West Point. He was the first department head since Davies to have a substantial publication record (including both books and journal articles) and a presence in the national mathematical community. Giordano modernized the mathematics classrooms with mobile classroom computers, overhead display devices, and advanced computational software. In recognition of the faculty's expanding interest in applied mathematics, operations research, and computation, he proposed that the department be redesignated the Department of Mathematical Sciences. The suggestion was approved in 1990.

Giordano's most important legacy was the revision of the four mathematics core courses taught to cadets in their first two years. Particularly significant was the introduction of discrete dynamical systems, which blended the old and the new mathematics. The old was the theory of finite differences, a discrete form of the calculus which goes back to Leonhard Euler (1707-1783) and earlier; the new

was the theory of dynamical systems, which analyzes the long-term behavior of mathematical systems. The other three courses were also changed substantially. The combined changes became known by the catch phrase "seven into four," where seven mathematical subjects—differential calculus, integral calculus, multivariable calculus, differential equations, linear algebra, probability and statistics, and discrete mathematics—were condensed into four semesters. This seemingly impossible task was neatly accomplished by omitting material that could be treated more easily using a computer algebra system, a technology introduced into the curriculum at the time, and by carefully coordinating topics. In addition there were five mathematical thread objectives which were revisited in each course: mathematical reasoning, mathematical modeling, scientific computing, communicating mathematics, and history of mathematics.

By this time, teaching in the Mathematics Department had evolved. Cadets no longer had daily recitations in front of the instructor and they were not graded every day, but remnants of these traditions remain. Today cadets work problems at the board on a daily basis and brief their classmates on their solutions. This style of instruction is unique to West Point and places the Academy at the forefront of progressive, interactive learning.

Another significant change during Giordano's tenure was the addition to the faculty of full-time civilian professors (in addition to the visiting professors). In the fall of 1991, Prof. Donald Small, who is still a member of the faculty, joined the faculty in this capacity. He came from the University of Maine, where he had written the calculus textbook, *Calculus: An Integrated Approach* (1990). Today he has a deep interest in helping historically black colleges and universities to improve their teaching of algebra and frequently travels under National Science Foundation support to help them. Over the next decade four others joined the department as senior civilians. All are still on the faculty, with the exception of Prof. Lida Barrett, onetime president of the Mathematical Association of America, who retired in 1998 at the age of 72 after three years at the Academy. Younger civilians joined the faculty in 1992, some as Title X faculty who teach

full time and some as Davies Fellows, a position created in 1996. The Davies Fellows, named in honor of the seventh Department Head Charles Davies, teach one semester and do research in conjunction with a senior researcher at the Army Research Lab during the next semester and summer. The department made the decision to hire these young Ph.D.s on three-year tours to assure a constant pool of vibrant young Ph.D.s in the department.

Giordano passed the baton to Col. David Christopher Arney in 1995. Graduating from the Academy in 1971, Arney earned two master's degrees from the Rensselaer Polytechnic Institute, one in mathematics in 1980, another in computer science in 1982. In 1985, again from RPI, he received his Ph.D. in mathematics. He too has a very substantial publication record. Under his leadership, the department continued to modernize the classrooms. Personal computers found their way into each classroom in addition to use of the internet as a tool for mathematics. His goal was to help the cadets become competent, confident problem-solvers; his motto for the Department, "To Infinity and Beyond," was meant to inspire them in this regard.

The core mathematics program for the bicentennial Class of 2002 started with discrete dynamical systems, turning to differential calculus about two-thirds of the way through. The second semester picked up with integral calculus as supplemented by work on linear algebra and differential equations. The yearling year began with multivariable calculus and concluded with a semester of probability and statistics.

The 20th and current department head is Col. Gary Krahn, whose Ph.D. was awarded by the Naval Postgraduate School in 1994 for work in applied mathematics. Under his leadership the department is focusing the core program on problem-solving through modeling and inquiry, as supported by mathematical concepts and techniques. The purpose of this real-world, problem-based mathematics program is to emphasize the breadth and variety of mathematics; to develop graduates equipped to find answers to vexing practical problems having their roots in the social, information, and physical sciences as well as in operations research, engineering, and technology; and to promote the process of life-long learning.

The U.S. Military Academy has held an honored place in American history. It has been a world leader in the education of scientifically trained military officers. As the oldest and largest department at West Point, the Department of Mathematical Sciences has played a significant role in the shaping of the Academy. Mathematics, which comprises the largest component of the core academic program, provides cadets with a sound foundation for the rest of their quantitative course work. This has been achieved through the unique influence of the departmental staff, through the curriculum and teaching methods, and through departmentally-prepared texts such as *Discrete Dynamical Systems*, by Colonels Arney, Giordano, and John S. Robertson. This influence has spread outward to the rest of the nation for the whole of the Academy's history. Members of the department have influenced education across the nation, both directly by taking the West Point methods to other institutions, and indirectly through textbooks written at West Point. West Point exists to build leaders for the nation, but in accomplishing that goal West Point has also been an institution that built education for the nation.[56]

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[1] U.S. Military Academy, *Annual Report of the Superintendent of the United States Military Academy* (Washington, DC, 1896), 47. Available on the web at http://www.library.usma.edu/search/. Hereafter cited as *Annual Report of the Superintendent*.

[2] Dearborn-Baron correspondence, 11 April, 11 May, 6 June 1801. Available at http://www.dean.usma.edu/math/people/rickey/dms/DeptHeads/Baron-George.htm.

[3] *Annual Report of the Superintendent*, 1896, 42.

[4] *The Memoirs of Gen. Joseph Gardner Swift*, ed. Harrison Ellery (1890), 27. Available on the web at http://www.library.usma.edu/archives/special.asp. The original spelling, both here and in all subsequent 19th-century documents quoted from, will be preserved intact.

[5] Baron moved to New York City where he founded the first mathematical journal in the United States, *The Mathematical Correspondent*. See Edward R. Hogan, "George Baron and the Mathematical Correspondent, the First Mathematical Journal Published in this Country," *Historia Mathematica* 3 (1976): 403-15.

[6] For additional information about Mansfield and his work, see Joe Albree, "Jared Mansfield (1759-1830): Janus Figure in American Mathematics," in *History of Undergraduate Mathematics in America: Proceedings of a Conference Held at the United States Military Academy, West Point, New York, 21-24 June 2001*, ed. Amy Shell-Gellasch (West Point, NY, 2001), 73-94. Copies of this volume are available through the authors. Hereafter cited as *HUMA Proceedings*.

[7] Edgar Denton III, "The Formative Years of the United States Military Academy" (Ph.D. diss., Syracuse University, 1964), 41. University Microform 6501551.

[8] *The Centennial of the United States Military Academy at West Point* (1904), 221, 224.

[9] For a transcription of the report on this examination, see http://www.dean.usma.edu/math/people/rickey/dms/doc/1806-exam.htm.

[10] The other was Oliver G. Burton, Cullum #37, Class of 1808. He served as storekeeper at West Point from 1815 to 1820.

[11] Sylvanus Thayer, *The West Point Thayer Papers, 1808-1872*, ed. Cindy Adams (West Point, NY: Association of Graduates, 1965), USMA Library. Unpaginated. Letters arranged chronologically. Available on the web at http://www.library.usma.edu/search/. Hereafter cited as *Thayer Papers*.

[12] For some history of the blackboard, see Charles Anderson, *Technology in American Education* (Washington: U.S. Dept. of Health, Education and Welfare, 1962), 16-19.

[13] Amy Shell-Gellasch, "The Olivier models at West Point," *Rittenhouse Journal of the American Scientific Instrument Enterprise* 17 (December 2003): 71-84. Photographs of the string models may be viewed on-line at http://www.dean.usma.edu/math/people/rickey/dms/OlivierModels.html .

[14] U.H. Grant stands for Ulysses Hiram Grant. Grant reports in his autobiography, *Personal Memoirs of U.S. Grant* (New York: C.L. Webster & Co., 1885-1886), 40, that the reason he came to West Point was to gain the knowledge to become a professor of mathematics.

[15] Quoted without attribution in Robert F. Hunter and Edwin L. Dooley, Jr., *Claudius Crozet: French Engineer in America, 1790-1864* (Charlottesville: University Press of Virginia, 1989), 19.

[16] There is no catalogue of "Thayer books," but USMA librarian Alan Aimone is preparing one.

[17] Henry Eugene Davies, *Davies Memoir. A Genealogical and Biographical Monograph on the Family and Descendants of John Davies of Litchfield, Connecticut* (privately printed, 1895).

[18] The titles of these works have been shortened (both here and below). For details about the pre-1917 mathematics books in the USMA library, see Joe Albree, David C. Arney, and V. Frederick Rickey, *A Station Favorable to the Pursuits of Science: Primary Materials in the History of Mathematics at the United States Military Academy* (Providence, RI: American Mathematical Society, 2000).

[19] Amy K. Ackerberg-Hastings, "Mathematics Is a Gentleman's Art: Analysis and Synthesis in American College Geometry Teaching" (Ph.D. diss., Iowa State University, 2000). University Microform 9977308.

[20] A list of USMA graduates who taught mathematics at other schools, including which schools, is being compiled. See http://www.dean.usma.edu/math/people/rickey/dms/OldestSchools.html.

[21] Amy K. Ackerberg-Hastings, "Charles Davies, Mathematical Businessman," in *HUMA Proceedings*, 119-132. Almost all of the books of Davies appear in multiple "editions," but many are so alike they should be called "printings."

[22] *First Century of National Existence; the United States as They Were and Are . . . by an Eminent Corps of Scientific and Literary Men. Illustrated with Over Two Hundred and Twenty-Five Engravings* (San Francisco: L. Stebbins, 1875), 268. Available on the web through the Humanities Text Initiative: http://www.hti.umich.edu.

[23] *Annual Report of the Superintendent*, 1821, as quoted in the 1896 *Annual Report*, 44, states, "The superintendent was authorized to detail cadets to act as assistant professors, each to receive $10 per month for extra services." However, Lester A. Webb, *Captain Alden Partridge and the United States Military Academy, 1806-1833* (Northport, AL: American Southern, 1965), 172, indicates that cadets were already being used as instructors in 1816. There is no evidence that either Davies or Church was a cadet instructor.

[24] Albert E. Church, *Personal Reminiscences of the Military Academy, from 1824 to 1879* (West Point, NY, 1879), 39-41. Available on the United States Military Academy Library web: http://usmalibrary.usma.edu/.

[25] Silvestre François Lacroix, *Elements of Algebra* (1st edition 1818). In 1821, neither mathematics Prof. David Douglass nor Superintendent Thayer was aware that John Farrar had published this English translation of Lacroix (Norton to Thayer, 13 August 1821, in *Thayer Papers*). The 1823 Board of Visitors report indicates that an English translation was used, so that this confirms Church's recollection. The 1825 Board of Visitor's report lists Lacroix's *Algebra*, but whether it was in French or English is unclear. The "Tentative List of Text-Books" in the first *Centennial* volume indicates that a French edition of the work was used; moreover, an 1825 French copy in the library bears the stamp "Textbook West Point 1823 to ____ ," but we have come to distrust these stamps, which were probably inserted when Edward Holden was preparing the *Centennial* volumes. Professor Davies must have been very unhappy with the Farrar translation to have the cadets instead use the French original.

[26] Adrien-Marie Legendre, *Elements of Geometry* (first edition 1818) is the edition that Church used. This is a translation of *Éléments de géométrie avec des notes* (first edition 1794). The West Point library has the tenth (1813) edition in French in a Thayer binding, indicating that it was purchased by Thayer while in France. For information on which editions are in the West Point library, see Albree et al., cited in note 18.

[27] Silvestre François Lacroix, *An Elementary Treatise on Plane and Spherical Trigonometry* (first edition 1820) by John Farrar.

[28] Church confirmed his use of these books. See *Personal Reminiscences*, 46-47.

[29] Jean Baptiste Biot, *Essai de géométrie analytique, appliquée aux courbes et aux surfaces du second ordre* (second edition 1805); Silvestre François Lacroix, *Traité élémentaire de calcul différentiel et de calcul integral* (first edition 1802); Jean-Louis Boucharlat, *Elémens de calcul différentiel et de calcul integral* (first edition 1812). Thus use of textbooks in the original French, and especially which editions, is difficult to document due to the paucity of records. There is a copy of Silvestre François Lacroix's *Traité élémentaire de trigonométrie rectiligne et sphérique* (1813 edition) in the West Point library that was owned by Lt. Samuel Stanhope Smith. He graduated in 1818, but the fact that he included his rank may indicate that he procured this book later while teaching mathematics at West Point from 1818 to 1823. After that he taught Natural and Experimental Philosophy until his death in 1828.

[30] Morris Schaff, *The Spirit of Old West Point* (Boston: Houghton, Mifflin, 1907), 68, as quoted by James L. Morrison, Jr., *"The Best School in the World": West Point, the Pre-Civil War Years, 1833-1866* (Kent, OH: Kent State University Press, c1986), 52.

[31] Cited by Florian Cajori, *The Teaching and History of Mathematics in the United States* (Washington, DC: Government Printing Office, 1890), 124.

[32] *Catalogue of the United States Military Academy*, 1970/1971, 17. These are available on the web at http://www.library.usma.edu/archives/archives.asp.

[33] *Annual Report of the Superintendent*, 1896, 74.

[34] Roger H. Nye, "The United States Military Academy in an Era of Educational Reform, 1900-1925" (Ph.D. diss., Columbia University, 1968), 199-200. University Microform 6812943.

[35] Ibid., 205, 211.

[36] Ibid., 231, 253.

[37] Ibid., 233.

[38] *Annual Report of the Superintendent*, 1919, 27.

[39] Douglas MacArthur, *Reminiscences* (New York: McGraw-Hill, 1964), 77, as quoted by Nye, 302.

[40] Nye, 310-11; Nye cites *Annual Report of the Superintendent*, 1920, 37.

[41] Nye, 321, who quotes from Echols's minority endorsement to the Board's curriculum revision report.

[42] Ibid., 321.

[43] Ibid., 322.

[44] U.S. Military Academy, *Howitzer* (1930), 30.

[45] David C. Arney, "Army Beats Harvard in Football and Mathematics!" *Math Horizons*, September 1994, 14-17; Arney and George Rosenstein, "USMA-Harvard Math Competition" at http://www.dean.usma.edu/math/about/history/mathcomp.htm. See also U.S. Military Academy, *Annual Report of the Superintendent*, 1933, 3.

[46] *Annual Report of the Superintendent*, 1933, 3.

[47] Quoted in "Note About the Author" (p. viii) in Robert C. Yates, *Curves and Their Properties* (reprint; National Council of Teachers of Mathematics, 1974). Yates's original appeared in 1952.

[48] U.S. Military Academy, *Howitzer* (1942), 46.

[49] U.S. Military Academy, *Howitzer* (1940), 58.

[50] U.S. Military Academy, *Howitzer* (1947), 44.

[51] *Catalogue of the United States Military Academy*, 1959-1960, 107.

[52] *Catalogue of the United States Military Academy*, 1971-1972, 74.

[53] *Catalogue of the United States Military Academy*, 1975-1976, 75-76.

[54] Earlier there were visitors from the National Security Agency, Nathan Thiesse in 1992-1993 and Roman Tarnawski in 1993-1994.

[55] The first women faculty members in the department (and their years of service in the department) were Captains J. L. Taylor (1980-1983), Karen L. Perkins (1981-1985), and Joan L. Black (1983-1986), who were not Academy graduates. The first civilian woman in the department was the late Edith Luchins, who was the Visiting Professor in 1991-1992.

[56] We would like to thank Joe Albree and Col. Joseph Myers for their helpful comments on an earlier draft of this paper.

The area of study known as the history of mathematics is primarily an investigation into the origin of discoveries in mathematics and, to a lesser extent, an investigation into the mathematical methods and notation of the past. Before the modern age and the worldwide spread of knowledge, written examples of new mathematical developments have come to light only in a few locales. From 3000 BC the Mesopotamian states of Sumer, Akkad and Assyria, together with Ancient Egypt and Ebla began using arithmetic From this point, Babylonian mathematics merged with Greek and Egyptian mathematics to give rise to Hellenistic mathematics . Later under the Arab Empire , Iraq/Mesopotamia, especially Baghdad , once again became an important center of study for Islamic mathematics .Â Written evidence of the use of mathematics dates back to at least 3000 BC with the ivory labels found a Tomb U-j at Abydos . These labels appear to have been used as tags for grave goods and some are inscribed with numbers.Â In the thousand years following the Han dynasty, starting in the Tang Dynasty and ending in the Song Dynasty , Chinese mathematics thrived at a time when European mathematics did not exist. Interestingly, the Mathematical Association of America was organized about 100 years ago around the same time that academic majors came into existence. The undergraduate program in mathematics in America has had a punctu-ated evolution. The Mathematical Association of American was organized 100 years ago at the end of a period of dramatic rethinking of American education at all levels, one product of which was the introduction of academic majors. The mathematics major was static in its rst 40 years, followed by great changes from 1955 to 1975, and then a period of relative stability to the pre Mathematics is everywhere. Mathematics help plan and manage economic and social systems enabling the move towards a sustainable use of resources. We travel the world guided by precise mathematical calculations based on the position of the sun, stars and GPS satellites. We explore the inside of the human body through CT scans and MRI by building images out of numerical data through mathematical algorithms. We discover how human thought works by building AI software that can learn and make decisions through mathematic models. We photographed a black hole and continue exploring the edges of the u