MATH 181 NOTES: JANUARY 17, 2022

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Today I will present a biography of the mathematician Thomas Edwards Hart with the goal of illustrating what we can learn about a historical figure from records. Hart is a convenient figure to study because (a) he's certainly historically significant because he was one of the first American to earn a PhD in mathematics and (b) he's not discussed in any textbook.

What I won't be able to do is provide any intimate details about Hart's life. None of Hart's personal writing has been preserved, and in fact, the only extent records that Hart himself produced are his dissertation and a few exams that he wrote.

A BIOGRAPHY OF T. E. HART

T. E. Hart was born on Kalmia Plantation in Darlington County, South Carolina on June 26, 1833 to Thomas E. and Hannah Lide Hart. The plantation was located along the bluffs of Black Creek between the towns of Society Hill and Camden, where the modern city of Hartsville (named for the family) lies. The location is shown in Figure 1. The plantation was a large agricultural operation, but it was not as opulent as the plantation homes depicted in films like *Gone with the Wind* and *Django Unchained*. The Hart family lived in a two-story farmhouse that is still standing.

The Hart family farmed on approximately 1,000 acres of land and owned 7,000 acres more. By comparison, the USCS campus is roughly 2,000 acres. They raised food provisions (hogs, corn,...) and raised cotton, the main way to earn money in South Carolina. Most of the manual labor was done by workers that the Hart family enslaved. The enslaved workforce grew from thirty people to one-hundred while Hart was growing up. A photograph of the home appears as Figure 2.

The area around Kalmia Plantation was rural. Most people lived along the Black Creek on plantations or large family farms. The only business was a store that Hart's father ran. The father also served as postmaster and justice of the peace. A solid majority (60% in 1840) of residents were enslaved African-Americans.

The abundance of enslaved labor allowed people like Hart to lead a life of leisure. A contemporary of Hart's, Joseph LeConte (an early Berkeley professor and the former namesake of the physics building), wrote in his autobiography that life as a planter's son was "a very paradise for boys." He had "unlimited freedom" to explore his interests as was far away from the city and spared the task of manual labor.

FIGURE 1. The location of Kalmia Plantation.

FIGURE 2. The Kalmia plantation home.

Hart's early education was rudimentary. In the antebellum, South Carolina did not have anything like a public K-12 educational system. Hart attended a simple one-room log school house. No information about the teacher or the curriculum is available, but the education offered was certainly rudimentary. Hart's formal education began when was eighteen years old (in 1851). That year he left home to enroll as a cadet at the Citadel Academy, in Charleston.

Hart's decision to attend the Citadel likely reflects a decline in his family's fortunes. The family lost much of their wealth in the Panic of 1836, and two years later, his father died. Attending the Citadel was a good option for a recently orphaned plater's son. The academy received generous financial support from the state government, and Hart's education was fully funded by a scholarship. Moreover, after graduating, he could expect to make a living by joining the military or working as a teacher.

FIGURE 3. Not the Kalmia plantation (still from *Gone with the Wind*).

A military academy may seem like an unusual place for a future mathematician, but it was a good option during the 1850s. Most American colleges focused on learning classical literature (Virgil, Cicero, Tacitus,....) in Latin and ancient Greek. In contrast, military academies emphasized mathematics more heavily because it was necessary for the engineering needs of army. During this period, the Military Academy at West Point was national leader in math education with its faculty writing many of the most widely used textbooks.

The Citadel only offered a four-year undergraduate degree, and all students took the same sequence of courses. The classes are listed in Figures 4 and 5. We will take a closer look at the course textbooks later, but you'll see that the math education is pretty basic. Students learn algebra, geometry, and calculus. This is more math than the typical UCSC student takes, although slightly less advanced than what an modern engineering major takes.

After graduating from the Citadel, Hart moved to Greenville, South Carolina to teach at Furman University. At the time, Greenville was small resort town of perhaps one-thousand people, and Furman was a recently establish private university affiliated with a Baptist church. In addition to a four-year college degree, it also offered a program of religious study and a college preparatory program (essentially a private high school within the university). The university was a relatively small operation: approximately two-hundred students were taught by ten professors. Hart was hired as the math tutor, responsible for teach the college preparatory math classes. Two years later he was promoted to adjunct professor of chemistry and natural philosophy (an old timey term for physics). After a year, he left Furman to pursue more advanced studies in Europe.

Hart never wrote about his reasons for going abroad, but it likely was for professional advancement. Many of the Furman professors had more impressive educational credentials than Hart's Citadel degree, and this was a barrier to his advancement at the university. Europe offered the best opportunities for an advanced education. No American university offered any advanced earned degree like a doctorate.

SYNOPSIS OF COURSE OF STUDIES AT SOUTH CAROLINA MILITARY ACADEMIES.

	STUDIES.	TEXT BOOKS.
Fourth Year. First Class.	Engineering and Science of War,	Mahan and Lectures.
	Intellectual and Moral Philosophy,	Abercrombie.
	Political Economy,	Wayland's Elements.
	National and Constitutional Law,	{ Constitutions of U. S. and So. Ca. Calhoun's Disquisition on Gov't.
	Chemistry,	Fowne,
	Mineralogy,	Dana, } and Lectures.
	Geology,	Lyell,
	Artillery and Infantry Tactics,	U. S. Art. Tactics and Scott.
	Topographical and Arch. Drawing,	Eastman.
Third Year. Second Class.	Calculus,	Church.
	Natural and Experimental Phil.,	{ Bartlett's Mechanics, Gummere's Astron, and Muller's Principles of Physics and Meteorology.
	Rhetoric,	Blair,
	Chemistry,	Fowne, } and Lectures.
	Mineralogy,	Dana,
	Drawing, Crayon and Linear,	

FIGURE 4. The last two years of courses at the Citadel

		STUDIES.	TEXT BOOKS.
Second Year. Third Class.		Geometry and Trigonometry,	Davies' Legendre.
		Descriptive Geometry,	Davies.
		Surveying,	Davies.
		Analytical Geometry,	Davies.
		Universal History,	Tytler.
		French,	Historie de Charles XII.
		Drawing, Landscape,	
First Year. Fourth Class.		Arithmetic,	Davies.
		Algebra,	Young.
		English Grammar,	Smith.
		History,	Frost, U. S.
		French,	Collot's Reader and Grammar.
		Mythology,	Elements of.

FIGURE 5. The first two years of courses at the Citadel

Hart decided to go to Germany. Most of his time was spent at Heidelberg University, but he first spent a year a Göttingen University and then to Heidelberg. Germany universities were the leading research universities of the age, and they were accessible to foreigners. Students were required to pay a small enrollment fee and then were free to attend whatever lectures they wished. Unlike American universities were students completed a sequence of required courses, students in Germany had a great deal of flexibility
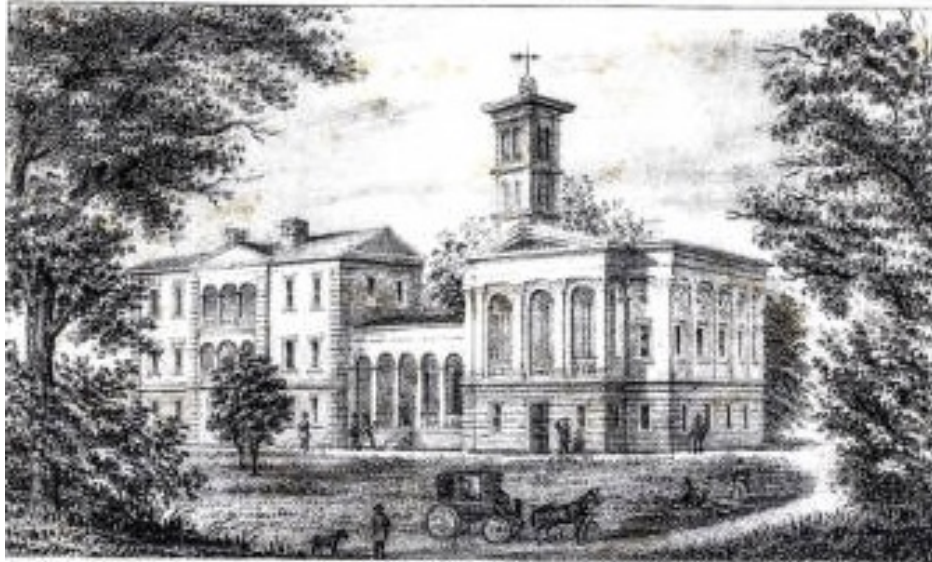
FIGURE 6. The Furman University campus

in shaping their education. The degrees were awarded for passing a comprehensive oral examination.

The professors Hart studied under in Germany were a totally different species than the professors he had met in America. A typical American professors had more in common with a modern teaching at a boarding school than a professor at UCSC. They often had no advanced training in the subjects they taught, and their main duty was to teach introductory classes like calculus. In contrast, the typical German professor was a world-expert in his subject, and much of his time was spent producing original research.

At Heidelberg, Hart studied under the chemist Robert Bunsen (of Bunsen burner fame), the physicist Gustav Kirchhoff, and the mathematician Otto Hesse (the namesake of the Hessian in multivariable calculus). His classmates included several people who went on to become accomplished mathematicians themselves: Paul De Bois-Reymond, Heinrich Weber, Jakob Löroth, and Max Noether. (Max Noether was the father of Emmy Noether whose work appears in abstract algebra).

No detailed account of Hart's course of studies exists, but one of his classmates wrote about attended lectures by Otto Hesse:

> Hesse lectured freely and without written notes, but he was exceptionally clear and easy to understand. He taught two semesters of differential calculus and integral calculus during which he also covered the foundations of the theory of differential equations and the analytic geometry of the plane and space. He conveyed to everyone the spirit of symmetry and elegance which he so loved. He also taught Mechanics, Calculus of Variations, and a course titled "Encyclopedia of Mathematics" in which we learned the foundations of the so-called "algebraic analysis," combinatorics, series, higher

IV. MATHEMATICS.

First Class.—Practical Arithmetic and Book-Keeping: This Course comprises a thorough training in Mental and Practical Arithmetic, and in Book-Keeping; which Studies are prosecuted until the Student is familiar with business forms and the calculus of integers and fractions, whether abstract or concrete, through Proportion and Percentage.

TEXT BOOKS.—Dodd's Practical Arithmetic; Greenleaf's Common School Arithmetic; Colburn's Mental Arithmetic; Palmer's Book-Keeping.

Second Class.—Higher Arithmetic and Elements of Algebra: Properties and Relations of Numbers; Units of Measure; Fractions, Decimals and Duodecimals; Analysis, Proportion, Percentage; Square Root, Cube Root; Abbreviated Methods of Operation; Difficult Problems in Analysis; Mensuration, Probabilities and Insurance.

A Practical Course of Arithmetical Algebra, through Equations of the Second Degree, is also included in this course.

TEXT BOOKS.—Dodd's High School Arithmetic; Chase's Arithmetic; Loomis' Elements of Algebra; Palmer's Book-Keeping.

Third Class.—Higher Algebra and Elements of Geometry: A more complete Exposition of the Principles of Algebra than is contained in the "Elements;" The Theory of Radicals; Discussion of Equations of the Second Degree; Series; Bynomial Theorem and Logarithms; Elements of Geometry, including three books of Legendre.

TEXT BOOKS.—Loomis' Algebra; Crosby's First Lessons in Geometry; Loomis' Geometry.

FIGURE 7. A description of the classes Hart taught at Furman

equations. Of particular interest were the weekly exercise sections where Hesse primarily dealt with geometric questions.

In March 1866, after passing oral examinations and submitted his dissertation *Elemente Der Geometry und der Gerade Linie,* he was awarded the degree of Doctorate of Philosophy. This was a high honor. The mathematics in Hart's dissertation is too advanced for me to

cover in class, but it might be accessible to students who have taken a class in abstract algebra.

A few months after completing his dissertation, Hart returned to America. He was returning as one of the greatest mathematical minds in the country. His dissertation compared favorable with the best mathematical research being done in America, and he now had a deep knowledge of his subjects as well as a broad social network of accomplished academics. One would have expected that he had a brilliant career ahead of him. Tragically, this was not the case.

While Hart had been in Germany, the Civil War broke out. The war hit the families of South Carolina planters, families like Hart's, especially bad. Virtually all of Hart's former Citadel classmates and many of his relatives enlisted in the Confederate army. Two of Hart's brothers killed in battle. The Confederacy's loss in the Civil War devastated the Hart family finances. Their greatest source of wealth had been the workers they enslaved, but now the workers were free, and slavery was banned. Left without a workforce, the Hart family plantation was forced to severely curtail its operations. While T. E. Hart had been planning on leaving the plantation to be a college professors, the higher educational system was also a mess. Most colleges had closed during the war, and most college-aged men had been forced to abandon their studies and serve in the army for several years.

Hart's difficulties were compounded by personal tragedies. His wife died a few months after he completed his dissertation, and he began experienced health problems that caused him to walk with a limp. He was able to continue to work in higher education for a few years. Furman University reopened the year he returned, and he served as the university's professor of chemistry and natural philosophy for a year before going to Kentucky to teach at another college. He returned to South Carolina to teach for a year at the University of South Carolina.

Unfortunately, Hart's health problems worsened during this period. His slight limp worsened until he was partially paralyzed. At the University of South Carolina, students would sometimes have to attend lectures at Hart's home as he was bedridden. In 1872, he finally resigned his position and left public life. He spent the next twenty years as a bedridden invalid living with his sister's family. He died 1891. Despite his professional accomplishments, he never received any measure of recognition. Shortly after he was hired at the University of South Carolina, *The Charleston daily news* published an article about the latest developments at the university. Four full paragraphs were devoted to the professor who Hart was replacing, but of Hart, the author just wrote, "we hope to say more anon." When he resigned his position, the newspaper simply reported that he was leaving, and they even got his name wrong, calling him "John Heart."

WHAT QUESTIONS CAN WE ANSWER?

What do we learn about the history of mathematics by learning about the biography of T. E. Hart? The most basic thing we get is a human interest story. We learn the life story of someone who studied mathematics, and we similarities and differences with our own lives as mathematicians. (Like us, he took math classes at university; unlike us, he

grew up on a plantation that ran on slave labor....). Although it is usually deemphasized in university history classes, biography is popular form of history that readers turn to for lessons about how to be successful or avoid failure or to simply learn about an interesting and adventuresome life.

We also learn about what was happening in mathematics in America during Hart's lifetime. For example, one question I posed in the previous day's lecture notes was, "How was Hart educated? How was he able to study at Heidelberg University?" As far as I can tell, he was really smart and worked hard. While the education he received in America fully prepared him to teach at a US college, it was wholly inadequate to the expectations of German research university.

What impact did Hart's research have? We can't answer this yet, but we at least know how to approach this question. In principle, we could read his dissertation and compare it with research published by his PhD supervisor and his classmates during this time. In order to do this, we would need to learn German as well as some advanced mathematics. This is the type of thing that you need to go to graduate school for.

A similar question is whether Hart brought new educational ideas back to America from Germany. Unlike the previous question, we more-or-less have all the tools we need to answer this, although we would need to look more closely at his teaching. For example, we could look at the classes he taught and the textbooks he used before and after he went to Germany. We haven't done this yet, but we could make good progress if we spent a class or two on it. I quickly looked into this, and it doesn't look he really changed his approach to teaching. This isn't surprising. Between the Civil War, the death of his wife, and his failing health, Hart had a LOT going on.

We should also question the questions. Now that we have more information, can we formulate new questions?

WHERE'S THE MATH?

So far we have focused on the *history* of mathematics and said little about mathematics itself. The biography of Hart provides a few natural entry points for looking more closely at math. Reading Hart's dissertation give us an opportunity to learn some advanced mathematics, but unfortunately, mathematics that is too advanced to reasonably cover in this class. More accessible is the mathematics that Hart taught. A few students studied an exam Hart wrote for Homework Set 1. Next class, we will took a close look at one of the mathematics textbooks that Hart used.

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