Sinclair Mathnet

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FROM THE CHAIR

Any doubts I have had about whether it is time for me to retire were quickly dispelled several weeks ago when I sat down to write this article and soon realized that everything I ever had to say that was remotely worth saying had already been more than used up in the first 68 *Mathnet* articles. Yes, the well was dry and nothing more has seeped into it in the three weeks I have been trying to meet this deadline. Then tonight I realized I don't really have to say something worth saying at all. It can be anything whatsoever as long as it uses the appropriate number of kilobytes. I could even repeat the word word word as many times as I want to fill the necessary space and it wouldn't matter. After all, the payroll office doesn't even read *Mathnet.* In fact, you may be the only person that does, and how do I know you're even reading it? And I will be gone in a few weeks, so if you aren't impressed I probably won't even know about it. Realizing this gave me an overwhelming sense of freedom and I now feel completely comfortable telling you the remarkably boring story of why I studied mathematics. (Actually I've told you this story before, but I don't care because I like telling it. And besides most of you weren't here then, and this is a different version anyway.)

I remember in college hearing a fellow student ask our physics professor why he studied physics. He said, "Because I wasn't any good at biology." Young idealist that I was, I was devastated to hear such a shallow answer. I was expecting a deep, insightful and elegant explanation about the wonders of physics and how it fulfilled some deep longing within him and how the study of physics had enabled him to experience an enriching and satisfying intellectual and spiritual growth. Well, I wasn't any good at biology either, but that's not what drew me to mathematics. Here is how it happened.

My Chaminade High School chemistry teacher, Brother Robert Geary (six feet-six inches tall, meaner than a junkyard dog, and infamous for the "100 formula test" on which you had to correctly write down the chemical formulas for 100 compounds without missing a single one to get a grade higher than F) taught us a lot about molecular and atomic structure. This fascinated me because I really wanted to understand how the physical universe works and why it behaves the way it does, and it seemed that understanding matter at its most elementary level was the way to do this.

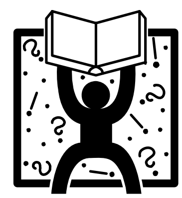
So I went off to major in chemistry at college in the hope of better understanding these mysteries. However, in my first semester I soon realized that chemistry is as much a lab science as a theoretical one and I was about as bad in the lab as I am in the kitchen. I also noticed in my physics class that the physicists seemed more interested in understanding what was really going on inside atoms than the chemists who only seemed interested in what kinds of substances were produced when certain atoms linked up with other atoms. So off I went to the counselor's office to declare myself a physics major. Well this worked out okay for awhile. And I decided that mathematics was pretty interesting too, so I decided to take math courses for my electives so I could end up with a *(Continued on Page 2)*

(Continued from page 1) double major. But by the time I finished my degree I was disillusioned again, this time with the physicists. I found out that for several centuries after Isaac Newton had come up with calculus and the theory of gravitation and Newtonian mechanics, the physicists thought they had the physical universe pretty well figured out. These theories, they thought, were adequate to explain completely how things worked in the universe, which was assumed to be Euclidean, and all that was left to do was to figure out the gravitational constant to a few more decimal places, calculate the orbits of the planets a little more accurately and maybe understand light, electricity and magnetism a little better.

Then at the turn of the last century everything changed. The Michelson-Morley experiment, the photoelectric effect, the theory of relativity, quantum mechanics and other events and ideas ushered in a new age. Newtonian mechanics, which seemed such a perfect and reliable explanation and predictor of motion in the universe, suddenly became just an approximation instead of an explanation. It didn't really work if the speeds were too high or the distances too small. And there were surprises about light. It doesn't really travel in a straight line. And it travels at the same speed regardless of the motion of the observer. And what is light anyway - a particle, or a wave? Doesn't it have to be one or the other or else neither? How can we pretend it's both? What disillusioned me was that the physicists didn't really seem to care about questions like these any more. Since early in the last century they seem to have lost hope of understanding the fundamental *truths* about what the universe is made of and how and why it works the way it does. They were satisfied with finding models that gave good *predictions* about how the universe would behave and were not concerned with whether the models were true or not. The search was not for truth but for more accurate models. Well I don't really blame the physicists for this because it is a complicated universe and hard to figure out. (Or maybe it is just too simple to figure out and we are missing the whole point and will never figure it out.)

Anyway, I noticed that the mission mathematicians have staked out for themselves really is a search for truth. But it is also a much more doable mission *(Continued on Page 5)*

DEPARTMENT COLLOQUIUM



We will have a Department Colloquium on Friday, February 9, at 2:30 p.m. in Room 1001. This quarter's speakers will give real-world examples of the use of mathematics in different fields.

Robert Bennington
Anti-Tamper/Software Protection Research Team Leader
Air Force Research Lab

Kurt Hanaway
Manager, Equipment Product Support
Pitney Bowes

Martin Alice
Mechanical Engineer
Sheffield Measurement Division of Giddings and Lewis

David Fridenmaker
Quality Assurance Manager
Fisher Data Products

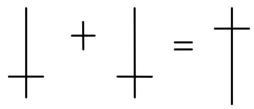
Refreshments will be served.

Fast Cars and Card's Tricks Part III

by Karl Hess

[In the last *Mathnet*, we saw that Cardano's method for solving cubics led to expressions that involved square roots of negatives.]

The engineer Raphael Bombelli had no qualms about studying the square roots of negative numbers. He was the first to publish an account of their basic arithmetic properties—the ones we teach in intermediate algebra today. It does not appear that he had any special symbol for them. He simply wrote things such as (I'm using modern notation) $\sqrt{-1}+\sqrt{-1}=2\sqrt{-1}$. He may as well have been writing



It would have gone over about as well. Bombelli's ideas were largely ignored at first, especially by the French, who didn't get along with the Italians much better in the sixteenth century than they did in the 18th and 19th centuries. France wasn't the center of the mathematical world yet. Fermat, Descartes, and Pascal were still a generation away. Gallileo had not yet been imprisoned in Italy for refuting the Aristolean model of the universe. (Gallileo was a professor of mathematics, and Italian mathematicians got the message. It's no accident that calculus was not developed in Italy. At that time, some leaders in the church were touchy about anything that involved infinity or zero. Even in the late 19th century, Georg Cantor, who was a devout Catholic, had to write a letter of explanation for his work to church leaders to avoid excommunication.)

But in the late sixteenth century, France did have one of the world's most talented mathematicians, Francois Viete. Viete is remembered for a number of things, although perhaps most notably for introducing much of modern mathematical symbolism. At that time, most countries and even individual regions had their own mathematical notation. The fact that Viete's was so widely adopted speaks not only to the usefulness of the symbols, but also to how many people read his work.

In the 1590s, Viete was still concerned with the problem of solving cubics. He didn't feel the issue would be truly resolved until someone found a way to do it without deviating from the straight and narrow path that is the real number line. Viete didn't know what the complex plane was. Heck, he didn't even know what a coordinate plane was (this was a decade before Descartes was even born). But he knew he didn't want to wander around in it.

Perhaps taking a cue from the Islamic scholars who had worked on the problem of cubics centuries before, Viete turned to the "go-to" tool of mathematics: trigonometry. And indeed, he was successful in devising a clever technique for solving cubics. A simple example involves the equation $\frac{1}{2}=4x^3-3x$. To solve it with Cardano's formula, you would have to do some arithmetic with complex numbers. Using Viete's method, we would use the trig identity $\cos(3\theta)=4\cos^3(\theta)-3\cos(\theta)$. (Hint: Let $\theta=20^\circ$)

Viete's method was unsatisfactory in Europe, however, for the same reason the Islamic scholars were never satisfied with it—it was not an *algebraic* method. To add irony to injury, many modern textbooks derive the trigonometric sum identities, which lead to the one above, using complex numbers.

However, Viete's investigations into solving cubics appear to have had an interesting side effect. The solution to the equation $\frac{1}{2}=4x^3-3x$ is $\cos(20^\circ)$. You can check for yourself using the rational root theorem that this equation has no rational solutions. Because it is of degree three, that implies that it does not factor in the field of rational numbers. This in turn

François Viète 1540-1603

implies that $\cos\left(20^{\circ}\right)$ has degree three over the field of rationals. Because three is not a power of two, this implies that $\cos\left(20^{\circ}\right)$ is not constructible. Finally this implies that a 60 degree angle cannot be trisected, thereby settling another, much older mathematical question. I'm honestly not sure if Viete understood the implications of his method, but I suspect he did. It is known that one of his hobbies was exposing the flaws in proposed positive solutions to the Greek construction problems. Coincidence?

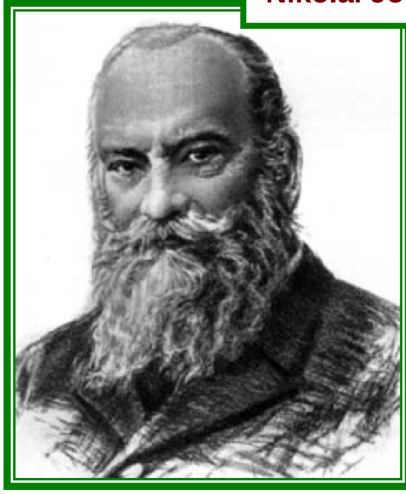
Over time (okay, centuries) mathematicians began to accept (imaginary) complex numbers as an unavoidable part of the number system. In modern lingo, Cardano had demonstrated that the real number system is not "algebraically closed." Euler believed that the field of complex numbers was. Characteristically, he didn't rigorously prove that. Also characteristically, he was right.

Gauss proved that the field of complex numbers is algebraically closed in his doctoral thesis. He did not view any complex numbers as imaginary, and he advocated the use of the term "lateral number" for complex numbers that did not fit the traditional definition of a real number. While his terminology didn't take off, his ideas did. Gauss (and also several others around the same time) thought of complex numbers as vectors in a coordinate plane. He used them to model several quantities in physics, most notably magnetism and electricity. Electrical engineers still utilize this model today.

It was in the realm of physics that imaginary numbers came into their own. The complex plane provided a playground in which physicists dared to (big surprise here) imagine. They apparently had none of the qualms that were still troubling many mathematicians. (As late as the 1840s, the famous mathematician and logician August De Morgan was still insisting that negative numbers are not real numbers. I don't think he even wanted to talk about imaginary numbers.)

Here's my favorite example of imaginary numbers at work in physics. In the late 19th century, a Russian professor of fluid dynamics named Nikolai Joukowski proposed a simple complex-valued function for designing airfoils. It only involved adding complex numbers to their reciprocals. Despite the fact that Joukowski is now known as the father of Russian aviation, his model had little value in the early days of flight. The model was computationally intensive, and only two or three working airfoils were ever created from it in Joukowski's lifetime. It became very usable and useful, however, in the computer age. From my research online, it seems that NASA's Glenn Research Institute is still using it to study airfoil designs.

Nikolai Joukowski 1847 - 1921



Here's an exercise you can try with your inter-mediate algebra students. Ask them to simplify an expression such as $\left(1+i\right)+\dfrac{1}{\left(1+i\right)}$. You can then tell them simplifications like this one (thousands of them done on a computer) are at the heart of airplane wing design. If you teach multivariable calculus, you might be able to get even more mileage out of this example. I'm still a little hazy on the details, but apparently the lift and drag coefficients for an airfoil can be calculated by summing the pressure vectors acting on it. The pressure at each point on the surface of the foil can be computed using information from the Joukowski model. Since the magnitude and direction of the pressure change continuously as we move around the airfoil, a contour integral is required. This allows aeronautical engineers to study the flight characteristics of an airfoil before they ever build a prototype! □

If you'd like a copy of the PowerPoint presentation I used at the colloquium or the handout that went with it, please e-mail me at karl.hess@sinclair.edu.

(Continued from page 2) than understanding the universe. It is a mission that seeks to find out what we can conclude when we think logically. It is a mission that simply asks the question: given a set of assumed statements and given a set of rules of inference by which we deduce further statements from the assumed ones, what are the further statements we can deduce? So, whereas it is not a search for truths about the physical universe, it is a search, and it seems to me it has been a rather successful one, for the truths of the universe in which our minds operate. Of course this understanding of mathematics doesn't become clear from a study of mathematics at the elementary level, but what is equally intriguing to me about mathematics is that what does become clear even at elementary levels is that when the assumptions agree with what we observe in the universe and when the rules of inference agree with those patterns of thought in our minds that we call logical or critical thinking, then the inferred statements also seem to have great agreement with what we observe in the physical universe. In other words, it appears possible that there are mathematical models that are consistent with the universe. Maybe the physicists just haven't found all of them yet. This apparent consistency between the laws by which the universe operates and the rules by which our minds operate suggests to me a common source for both. I find that very fascinating and have greatly enjoyed basking in the warm light of that reality for over forty years.

Egad! I still have one more article to write.

Al Giambrone ■

REMINDERS

- Full timers, please remember to schedule a sub or reschedule yourself for another time if you can't make your scheduled time in the Math Help Room.
- Please remember to turn in a copy of your tests as well as the grade distributions to your course coordinator.
- Be sure that unregistered students are not permitted to attend your class.
- When giving outside of class graded assignments, be sure students understand what resources they are allowed to use and what they aren't, and take steps to ensure that the credit you give is for work that *they* have done. When working in the Math Help Room please be sure you are not helping students with graded assignments.
- All tests should be approximately one hour in length, even in classes meeting for more than an hour.
- Please remember that classes should not be cancelled and they should meet for the entire scheduled time. There are always students who can benefit from more time on task. If you need to miss class please get a substitute from the sublist and let the Office know.
- Please be sure you are aware of departmental policies in matters such as extra credit, testing, grading, attendance policies and so forth. Review our departmental Faculty Handbook. If you need a copy, please contact Emmilla.

Faculty Feature – Michelle Harris

The Math Lab and Help Room is trying to cope with the sudden departure of Michelle Harris, longtime Math Lab coordinator. Michelle made the difficult choice to take a disability retirement at the end of last year.

Michelle received her Bachelor's Degree from Wright State University in March of 1986, and was hired by Sinclair in October of the same year to run the newly developed Math Lab. She explains, "Several department faculty members had received some grant money to put together the lab, and that is when I was hired." They began with some old computers and some videotapes. Of course much has changed since then with the addition of software and an online presence. By the end of Michelle's tenure, the Lab was staffed by two full-time coordinators, one part-time coordinator and many student workers. The Math Help Room, which was started as a separate entity staffed primarily by faculty, eventually came to be staffed by Michelle most of the time. In the winter of 2006 the Help Room moved to the former computer classroom space, which is adjacent to the Math Lab and allows for a more efficient staffing of both rooms.

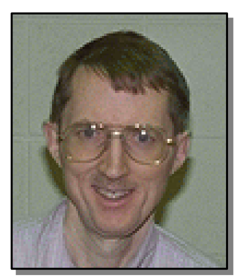
I asked Michelle what she would miss most, and she said, "The great people I work with, the students, and the social interaction with people that I meet every day. I'll miss Sinclair; it's a great place to work." Michelle also talked about how she runs into former students in Dayton, and how they give her hugs and thank her for getting them through their math class. She said that after helping about 1000 students a year, she does not always recognize the students who greet her, but many people know her. Michelle says she nurtured an atmosphere of "Cheers" in the Math Lab and Help Room, where "everyone knows your name."

Michelle has no definite plans for the near future, but is looking into providing online tutoring with the help of her tech-savvy brother in law. She said that she is learning to live life at a much slower pace, and taking care of her body. Michelle has either muscular dystrophy, or spinal muscular atrophy (the symptoms are the same). Not having a full time job is much easier on her physically. Although she knew that a disability retirement was inevitable, Michelle had hoped to work longer. Due to changes in insurance coverage as of January 1 of this year, she decided that she had better retire by the end of December.

Michelle will be deeply missed by Math Department staff and faculty, but she will be missed the most by students whom she has helped. We wish you a happy, healthy retirement, Michelle!

Susan Harris ■

Harvey's Joke Corner



Middle School Math Teacher: "I have a student who knows the table of fives like the back of his hand."

[From Gwen English]
There are only 10 kinds of people in the world… those who understand the binary system, and those who don't.

Zero Tolerance

You make me feel like a million!

1,000,000