Duke University Math News

May 3, 2000

The Duke Math News

This 2000 graduation issue reviews some of the transitions and developments in the mathematics department. Very soon, 36 undergraduates will receive their AB or BS with a major in mathematics and 20 with a minor in mathematics. Several will continue their education in math, computer science, physics, economics and other graduate programs around the country. Others are looking forward to rewarding careers in mathematically related areas. Congratulations to all on a job well done!

Among those graduating this spring is the editor of this newsletter, Carleton Kingsford. Carl has continued the fine editing of his predecessor, W. Garrett Mitchener, and, further following Garrett's example, will enter graduate school at Princeton University this fall. Juliet Pulliam, former editor of Vertices, will take over this task with the assistance of Carl Miller in the Problem Corner and Matt Atwood as Features writer. These three have helped a lot with the current issue and we look forward to their distinguished contributions next year.

—David Kraines, faculty advisor

Graduation luncheon

Graduating students who major in mathematics are cordially invited to attend a luncheon in the Levine Science Research Center Dining Room after Graduation Exercises on Sunday, May 14. In a brief ceremony at the end of the luncheon, Professor J. Thomas Beale will present the diplomas to those with math as their first major.

Black holes are where God divided by zero.

—Steven Wright

Math Department Celebration

A large group of students and faculty attended the annual department party in the mathematics lounge on Tuesday, April 25. Dean Kay Singer welcomed the students and professors. Tom Beale and David Kraines recognized the graduating seniors, announced various scholarships and gave out cash prizes totaling $6500 to the students for their various successes, honors and awards. This was an enjoyable opportunity for all in the Duke mathematical community to get better acquainted with fellow students and teachers while enjoying the food and festivities.

Contests

Modelers Threepeat!!!

For the third year in a row, a team of three Duke students has achieved Outstanding status for one of the best papers in the grueling weekend math modeling competition held last February. Nearly 500 teams from all around the world competed in this 16th annual event administered by the Consortium for Mathematics and its Applications and the National Security Agency. After nearly 90 straight hours with very little sleep, the team of Sam Malone '02, Jeff Mermin '00, and Daniel Neill '01 produced a 35 page paper and a computer program that could help air traffic controllers better assess the risks of air collisions. They devised and assessed five different models that ranked the potential danger in an air sector and provided guidelines to air traffic controllers for reacting to this danger. See `http://www.dukenews.duke.edu/dial00/models421.htm`.

Malone was a member of the '99 MCM team and Mermin was a member of the '98 MCM

team. The team has been invited to present their results at the summer Mathematical Association of America meetings in Los Angeles this August. Because the team members will be out of the country or attending other events in August, they hope to reschedule their presentation for a later MAA meeting.

Putnam Competition

In one of the most difficult Putnam competitions in decades, Duke students placed third among teams from 431 colleges and universities in the United States and Canada. For 6 hours on December 4, 1999, 2900 of the most mathematically talented undergraduates in North America worked on 12 challenging problems. The highest score among all participants was only 74 out of 120, the lowest top score since at least 1982. Any student answering even two of the 12 problems correctly would have ranked among the top 10% and just 10 points out of 120 would place the participant in the top quarter. This year, the University of Waterloo came in first and Harvard placed second. Two Duke teams finished first and two placed second during the 1990's.

Three Duke math majors, John Clyde '01, Michael Colsher '01, and Kevin Lacker '02, ranked among the top 10 of the 2900 participants. Each received an award of $1000 from the Putnam Foundation for their exceptional work and an additional $250 award as winners of the department's Karl Menger prize. Clyde and Lacker received the Menger Prize in 1999 as well. Other cash awards will go to first year student and Putnam team member Melanie Wood who received Honorable Mention and to junior team member Carl Miller. The department is awarded $15000 to be used to enhance the undergraduate program. Eight other Duke students, Matt Atwood '03. Sooraj Bhat '03, Ning Lin '01, Jeff Mermin '00, Daniel Neill '01, Taren Stinebrickner-Kauffman '03, Tristan Tager '02, and John Thacker '01, distinguished themselves with rankings among the top 500.

For more information, see `http://math.scu.edu/putnam/`.

Awards and Scholarships

Julia Dale Prize Winners

The 2000 Julia Dale Prize for excellence in undergraduate mathematics has been awarded to Sarah E. Dean with second prizes to Jeffrey A. Mermin and Luis A. Von Ahn. For more information about Julia Dale and previous winners of this award, see `http://www.math.duke.edu/news/awards/dale/index.html`.

Dean has been working in superstring theory with assistant professor of mathematics and physics Paul Aspinwall. Her undergraduate thesis studies certain questions that arise in "Mirror Symmetry," which refers to a physical duality between string theories that can be interpreted geometrically as an equivalence relating the complex structure moduli spaces and complexified Kähler form moduli spaces of two Calabi-Yau 3-folds.

Dean has been involved with mathematical research throughout her four years at Duke. "I think with any research problem the part that I've enjoyed the most was the excuse to learn a lot of different things along the way," she said. Both math and physics appeal to Dean because they allow her "to think instead of memorize," she said. Dean said she liked the Duke math department for its atmosphere. "There are many professors here whom I consider good friends," she said. "A lot of the things I've learned have been from conversations I've had with people at [the daily math department] tea."

Dean is a National Science Foundation Scholar, Duke Faculty Scholar, B. M. Goldwater Scholar, and a National Defense and Engineering Fellow. She plans to study mathematical physics in the Harvard mathematics graduate program or the Stanford physics graduate program next year. After that, she said, "I imagine I'm doomed to academia, though in my book that is not too horrible a fate."

Mermin received the Julia Dale Award for his advanced graduate level work, his excellence in mathematical competitions, and his various research projects at Duke. At an NSF supported

REU (math research) program at the University of Washington in summer 1998, Mermin wrote a paper on a mathematical method to identify broken resistors within a planar network from "boundary" data. Mermin was a member of two Math Contest in Modeling teams that received Outstanding awards and has ranked among the top five percent of Putnam contestants twice. He will enter the Ph. D. program at Cornell University in the fall.

Von Ahn received the Julia Dale Award for his outstanding scholarship and his senior research project in logic under the direction of Richard Hodel. On Monday, April 24, immediately preceding the mathematics department celebrations, Von Ahn discussed his senior thesis "Models of LST and ZF." He reviewed model theory and the axiom of choice and explained why the Axiom of Choice and the Generalized Continuum Hypothesis are consistent in the Zermelo-Frankel (ZF) axiom system. Von Ahn plans to study artificial intelligence in the computer science graduate program at Carnegie Mellon University next fall.

Goldwater Scholarships

Mathematics major Kevin D. Lacker '02 was named a B. M. Goldwater Scholar this year. Duke engineering majors Pavan K. Cheruvu '02, Daniel B. Neill '01 and Scott W. Smith '02 also were among the 309 winners of this award for outstanding ability in mathematics, natural science and engineering. These students will receive a scholarship worth up to $7500 per year toward their college expenses. Since its establishment in 1989, a total of 17 mathematics majors and 24 others at Duke have been among the winners. See `http://www.act.org/goldwater/index.html` for more information.

Summer Plans

Each summer, many mathematics majors participate in research programs or internships at which they can improve their mathematical skills while receiving a good stipend. Research Experiences for Undergraduate (REU) programs sponsored by the National Science Foundation provide an opportunity for a small group of students to participate in mathematical research. For more information, see `http://www.nsf.gov/mps/dms/reulist.htm`. At least five Duke students will attend REU programs in mathematically related areas this summer. Pending approval by the NSF, four to six Duke students will participate in a more extensive research program at Duke. This program combines course work, summer research with a mentor, and a senior thesis in a vertically integrated environment leading toward a research paper published in a scientific journal. In addition, two students have been invited to join the Director's Summer Program at the National Security Agency and others will be summer interns or trainees with actuarial or financial concerns.

Graduate Student News

Aaron C. Ashih receives his doctorate for his thesis *Spatial and Stochastic Models of Population Growth Sexual and Asexual Reproduction* under the direction of Professors David Schaeffer and William Wilson in Zoology. He plans to enter medical school.

R. Paul Horja received his doctorate last December for his thesis *Hypergeometric functions and mirror symmetry in toric varieties* under the direction of Professor David Morrison. He will spend this summer at Max-Planck-Institut für Mathematik in Bonn, and the 2000–2001 academic year at the Institute for Advanced Study in Princeton.

Alexander Solodovnikov received his doctorate this spring for his thesis *Absolute Intensity Independence in a Directional Hearing Model* under the direction of Professor Michael Reed.

Laura A. Taalman received her doctorate this spring for her thesis *Monomial generators for the Nash sheaf of a complete resolution* under the direction of Professor William Pardon. Next fall she will start a tenure-track assistant professor position at James Madison University in Harrisonburg, Virginia.

Lectures

Nobel Laureate Speaks on Atomic Bomb

On Wednesday, March 22, Physics Nobel Prize winner Professor Val Fitch spoke about his first-hand experience at Los Alamos and the first atomic bomb test. He also spoke of the history of advances in physics that led to the creation of the bomb. Fitch's talk was cautionary: "We have to get the number [of nuclear weapons] down to zero."

In other talks of interest to the general math and science community, Nobel Laureate Russell Hulse reviewed his discovery of the binary pulsar, David Berlinski discussed his recent book, *The Advent of the Algorithm*, and Brian Greene gave an encore performance of his popular presentation of superstring theory.

Mathematical Immunology Conference

The Center for Mathematics and Computation in the Life Sciences and Medicine co-sponsored an international conference on Mathematical Immunology on April 24, 25 and 26th. The conference brought to Duke some of the leading scientists from Theoretical Biology, Immunology, Medicine and Mathematics and provided a forum for discussing and expanding the current research in areas of mathematical modeling in HIV, Immunology, Infectious diseases and Genetics. It also provided an opportunity for young researchers to present their work which in turn fostered the development of a few new collaborations. More information about the conference and the talks can be found at `http://www.math.duke.edu/conferences/duicmi00`.

A mathematician is a blind man in a dark room looking for a black cat which isn't there.

—Charles Darwin

Duke math shirts

The attractive 1999–2000 Duke Math T shirts are available in Math-Physics 121 for $8.50 in L or XL and $9.50 for XXL. These Duke blue shirts feature a challenging geometry problem, the statement and proof of which is included with the purchase price. Impress your friends!

Math Degree Candidates, Academic Year 1999–2000

First Majors

Angela Christine Bohn
Sarah Elizabeth Dean
Jeremy Daniel Ellis
Kari Margaret Forde-Anderson
Eric Jason Forman
Jennifer Leanne Forte
Benjamin Michael Goetz
Ida Janina Grochowska
Micole Kathryn Hamburger
Benjamin Alan Hutz
Achyut Shankar Joshi
Ethan Yu Lee
Joseph O'Lear McCaskill
Jeffrey Abraham Mermin
Harold Reed Ogrosky
Sara Rebekah Osterling
Jennifer Wickliffe Robb
Kamran Patrick Sajadi
Azeem Mahmud Shaikh
Spencer Howell Shepard, IV
Matthew Allen Todd
James Stanley Vasak
Luis Alfonso Von Ahn
Virginia Elizabeth Wise

Second Majors

Michael Lee Cooney
Jennifer Sarah Edwards
Eric Seth Gordon
Krishna Venkata Gumidyala
Jonathan Andrew Huntley
Carleton Lee Kingsford
Bryan Richardson Looper

Benjamin Morcos
Jonathan Carl Myers
Anil Sathia Nathan
Garrick Alcarez Sevilla
Michael Clifford Strauss

Minors

Anthony Bova
Katherine Jane Brennan
Edward Wells Caughey
John David Fries
Ayisha Nimat Karim
Robert Wesley McWaters
Corey Michael Miller
Alexander George Okleshen
Victor Jan Orlikowski
Amrith Venkat Ram
Scott Benjamin Roh
Emma Louise Russell
Mark J. Sayers
Casey Marie Schmierer
Christopher Warren Seymour
Peter Douglas Smith
Nancy Tao
Paul Heschel Tzur
Thomas Bradley Worsham
Can Yazicioglu

Master of Arts

Christian G. Benes
Timothy R. Deering
Michael J. Kozdron
Michael Silverstein

Ph.D.

Aaron C. Ashih
R. Paul Horja
Alexander Solodovnikov
Laura A. Taalman

Mathematical discoveries, small or great, are never born of spontaneous generation They always presuppose a soil seeded with preliminary knowledge and well prepared by labour, both conscious and subconscious.

—Henri Poincaré

Problem Corner

Solutions from Last Issue

Problem 1: *Partition Puzzle*

A *partition* of a positive integer n is a non-increasing sequence of positive integers which sums to n. (For example, the partitions of 4 are (4), $(3,1)$, $(2,2)$, $(2,1,1)$, and $(1,1,1,1)$.) Let $A(n)$ be the total number of partitions of n, and let $B(n)$ be the number of partitions of n in which the first and second terms are equal. Prove that $A(n) = 1 + \sum_{k=1}^{n} B(k)$.

Solution to Problem 1:

Let A be the set of all partitions of n excluding (n), and let B be the set of all non-decreasing sequences whose first two terms are equal and whose sum is between 1 and n inclusive. Define $f : A \mapsto B$ by $f((a_1, a_2, a_3, \ldots, a_k)) = (a_2, a_2, a_3, \ldots, a_k)$ and define $g : B \mapsto A$ by $g((b_1, b_2, b_3, \ldots, b_k)) = (n - \sum_{i=2}^{k} b_i, b_2, b_3, ..., b_k)$. These functions are clearly inverse to one another, thus we have a one-to-one matching between A and B. Therefore $A(n) - 1 = |A| = |B| = \sum_{k=1}^{n} B(k)$.

Problem 2: *Bijection Brainteaser*

Prove or disprove: For any bijection $f : \mathcal{Z} \mapsto \mathcal{Z}$, there exists a bijection $g : \mathcal{Z} \mapsto \mathcal{Z}$ and a constant c such that $|g(f(n)) - g(n)| \leq c$ for all n.

Solution to Problem 2:

The statement is false. Take f to be any bijection with an infinite number of infinite cycles; for example, $f(n) = n + 2^{i+1}$ where 2^i is the largest power of 2 which divides n. This function has cycles $\{\ldots, -3, -1, 1, 3, 5, \ldots\}$, $\{\ldots, -6, -2, 2, 6, 10, \ldots\}$, $\{\ldots, -12, -4, 4, 12, 20, \ldots\}$, and so forth. Label these cycles $C_1, C_2, C_3, \ldots$.

Suppose, for the sake of contradiction, that a function $g(n)$ and a constant c exist satisying the given condition. The infinite sets $g(C_i)$ are each either unbounded above, unbounded below, or both. We may assume without loss of generality that an infinite number of the $g(C_i)$'s are unbounded above (if not, replace g with $-g$). Choose $c + 2$ of these: C_1, C_2, ..., C_{c+2}, relabelling if necessary. Chose m large enough that

each set $g(C_i)$ contains an element less than m. Let c_i be an element of C_i. For each i, the sequence

$$(\ldots, g(f^{-1}(c_i)), g(c_i), g(f(c_i)), g(f^2(c_i)), \ldots)$$

contains elements both above and below m, while adjacent terms differ by at most c, so each cycle $g(C_i)$ contains an element in $[m, m+c]$. Yet there are only $c+1$ elements in $[m, m+c]$ and the $c+2$ cycles $g(C_1), \ldots, g(C_{c+2})$ are disjoint — this is a contradiction.

New Problems

Problem 1: *Integral Inquiry*

Let $f : R \mapsto R$ be a continuous function such that $\int_{t=0}^{1} f(t)dt = 1$ and $f(x+1) = f(x)$ for all x. Show that for some real value x_0, $\int_{t=x_0}^{x_1} f(t)dt \geq x_1 - x_0$ for all $x_1 > x_0$.

Problem 2: *Are you dense?*

Define sequences (a_n) and (b_n) by $a_0 = 0$, $b_0 = 1$, $a_n = a_{n-1} + 3b_{n-1}$, $b_n = b_{n-1} - 3a_{n-1}$. Show that the set $\{a_n/b_n : b_n \neq 0\}$ is dense on the real line.

Problem Editor
Carl Miller . . . . . carl@math.duke.edu
Student Editor
Carl Kingsford . . . . . clk@math.duke.edu
Student Editor
Julie Pulliam . . . . . jrp10@acpub.duke.edu
Faculty Sponsor
David Kraines . . . . . dkrain@math.duke.edu

Department of Mathematics
Box 90320
Durham, NC 27708-0320
http://www.math.duke.edu/math_news/