

Duke University Math News

May 10, 2002

◇GraduationEdition◇

Events

Math Department Gala

Members of the Duke math community enjoyed plentiful food and conversation in the informal atmosphere of the math lounge on Thursday afternoon, April 18. In addition to a large group of math students and faculty, the party was attended by President Nan Keohane, Provost Peter Lang, Deans Berndt Mueller, Robert Thompson, Mary Nijhout and Kay Singer. The faculty and administrators recognized the many accomplishments of math majors this year.

Graduation Luncheon

Graduating students who major in mathematics and their families are cordially invited to a luncheon in the Levine Science Research Center dining room after the Graduation Exercises on Sunday May 12. In a brief ceremony at the end of the luncheon, Director of Undergraduate Studies, Stephanos Venakides, will present the diplomas to those with math as their first major.

Differential Equations Conference

A conference in honor of James B. Duke Professor David G. Schaeffer will be held at Duke from May 20 through May 22, 2002. The conference will bring together a large body of distinguished speakers in a meeting spanning pure and applied mathematics, the physical sciences, and engineering disciplines.

During his career, Schaeffer has made fundamental contributions to bifurcation theory and the study of systems of hyperbolic conservation laws. More recently, he has also turned his focus to mathematical problems in biology and the nonlinear dynamics of granular materials.

In 1968, David Schaeffer received his PhD in mathematics at MIT under the direction of Takeshi Kotake. He came to Duke after two years at Brandeis University and eight years at MIT. His two volume work *Singularities and Groups in Bifurcation Theory* (with Golubitsky and Stewart) is considered a classic reference in bifurcation theory. He has written more than 80 other publications and received numerous honors, including an Alfred P. Sloan fellowship and the Max Planck Research Award. For more information, see <http://www.math.duke.edu/applied/NDEMB/index.html>

Undergraduate News

Putnam Team

Duke collected \$15000 for its third place finish in the 62nd William Lowell Putnam Mathematical Competition taken on December 1, 2001, by nearly 3000 students at more than 400 colleges and universities throughout the United States and Canada. The team members, sophomore David Arthur and seniors Nathan Curtis and Kevin Lacker, each received a cash award. For the second time, Lacker was named Putnam Fellow for placing among the top 5 in the competition. He received an award of \$2500. For her top ten individual ranking, junior Melanie Wood won the \$1000 Elizabeth Lowell Putnam Award for the highest score among the participating females. Arthur also received a cash award for his ranking among the top 25. Curtis and Oaz Nir '05 were named Honorable Mention and Matt Atwood '03 was in the top 5%. All of the 13 Duke students who participated ranked among the top third of these most talented of math undergraduates in North America.

Since 1990, Duke teams have won the competition three times, placed second twice and

third twice. They have ranked in the top 10 for all but one of the past 10 years. For more information, see <http://www.math.duke.edu/news/awards/competitions.html#putnam>.

Math Modeling

A Duke team has been named Outstanding for the FIFTH year in a row in the math contest in modeling. The team has been invited to present their results at the 50th annual meeting of the Society for Industrial and Applied Mathematics in July. Each team member will receive a \$300 award from SIAM.

In a four day and four night stretch last February, the team of David Arthur, Sam Malone and Oaz Nir wrote a 42 page paper to estimate the optimal level of "overbooking" for airlines. They incorporated sophisticated probability theory and an "auction" system and supported their algorithm with nine pages of computer code. Using an average value for the price of tickets, number of seats, and "no-show" rate, their algorithm suggests that by selling 177 seats for a 150 seat aircraft, airlines would maximize revenues.

The Outstanding papers will be published in the journal *Undergraduate Mathematics and its Applications*. Malone has been on an Outstanding MCM team each of his four years at Duke. See <http://www.comap.com/undergraduate/contests/mcm/2002Results.html> and <http://www.math.duke.edu/news/awards/competitions.html#modeling> for more information.

Undergraduate Math Lecture

Walter Mientka, the former director of the USA Mathematics Olympiad program and professor at the University of Nebraska, presented a lecture entitled *Approximations of Arithmetic Sums and their Applications to Number Theoretic Functions* on January 29, 2002, to a large group of math majors.

Mientka addressed the following question. How does one find a useful approximation for the sum of an infinite series whose arguments are the natural and real numbers? The results have implications for the Prime Number Theorem and other questions in number theory.

This was one of the series of Undergraduate Mathematics Lectures sponsored and arranged by members of DUMU.

Julia Dale Prize

The 2002 Julia Dale Prize for excellence in undergraduate mathematics has been awarded to seniors Kevin D. Lacker and Samuel W. Malone.

Lacker shared this award for his excellence in many advanced mathematics courses and his success in mathematical contests. In the national Putnam competition, Lacker ranked among the top ten of 3,000 competitors for all four of his years at Duke, twice being named a Putnam Fellow for finishing among the top five individual participants. He will attend graduate school at the University of California, Berkeley, on an NSF Graduate Fellowship and plans to work in the area of Artificial Intelligence. Lacker is a Presidential Research Fellow and Goldwater Scholar.

Malone has been honored for his many research projects, his unprecedented four wins in the Mathematics Contest in Modeling and his many special scholarship awards including A. B. Duke Scholar, Goldwater Scholar, Faculty Scholar and Rhodes Scholar. Malone has published six research papers during his four years at Duke and was one of the first PRUV Fellows at Duke. As a Rhodes Scholar, he will study economics at Oxford University next year with a focus on finance and development. For his senior thesis, *Black-Scholes Revised: Alternative Price Processes and Stochastic Volatility*, Malone will Graduate with Highest Distinction.

Julia Dale joined the Duke mathematics department in 1930 as an Assistant Professor and died of renal failure just six years later at the age of 43. Friends and relatives established the Julia Dale Memorial Fund to honor Duke undergraduates for their mathematical achievements. For more information about Dale and for a list of previous winners, see <http://www.math.duke.edu/news/awards/dale/index.html>.

Alice T. Schafer Prize

At the meetings of the mathematical societies in San Diego in January, the Association for Women in Mathematics (AWM) presented the Twelfth Annual Alice T. Schafer Prize to Melanie

Wood '03. The AWM cited her for several research projects, including a paper accepted for publication in a major mathematics journal, her outstanding success in graduate level mathematics courses starting in her first year at Duke and her excellence in mathematical competitions. Wood is an A. B. Duke Scholar and a B. M. Goldwater Scholar. She expects to pursue a doctorate in mathematics.

This prize for excellence in mathematics by an undergraduate woman was established in honor of Alice T. Schafer, Professor Emerita from Wellesley College, who contributed significantly to women in mathematics throughout her career. The first Schafer prize was won by Duke graduate Jeanne Nielson Clelland in 1991. Other Duke winners include Jennifer Slimowitz, Honorable Mention, and Sarah Dean '00, Runner Up. For more information, see <http://www.awm-math.org/schaferprize.html>.

Virginia Tech Math Contest

Duke students continued their domination of the Virginia Tech Regional Math Contest. On Saturday November 3, 2001, 269 students from 35 schools throughout the southeast, including 16 from Duke, competed in this two and a half hour contest of mathematical ingenuity and problem solving ability. For placing second, David Arthur '04 won \$150. He was followed by third and fourth place contestants Kevin Lacker '02 and Oaz Nir '05 who each received \$50. Other Duke students finishing among the top 15% were Matt Atwood '03, Albert Chu '05, Noah Dean '02, David Mermin '04, Mike Miller '03, Lori Peacock '04, Adam Siegel '04, Mayank Varia '05, and Charles Wang '05.

ACM International

The Duke team of David Arthur '04, Andrew Chatham '03 and Kevin Lacker '02 tied for 8th among the 64 teams competing at the World Finals of the 26th annual ACM International Collegiate Programming Contest held in Honolulu on March 23, 2002. These teams were selected from regional competitions involving over 3,000 teams representing 1,300 universities in 70 countries on six continents. See <http://cpc.baylor.edu/cpc/> for more details.

Duke Math Meet

Over 100 high school students from Georgia to Virginia participated in the annual Duke Math Meet on Saturday, November 17, 2001. Members of the Duke University Math Union sent out invitations, wrote and graded the problems and presented the awards to the winners of this ARML style team/individual competition. The winner was the A team from Thomas Jefferson High School of Science and Technology. NC School of Science and Math and the B team from TJHSST tied for second place and the Charlotte Math Club and Chapel Hill HS finished fourth and fifth among the 18 teams of six. Congratulations to DUMU president Mike Miller and to David Arthur, Nathan Curtis, Melanie Wood and the other DUMU members for a job well done!

Karl Menger award

The Menger award is given in recognition of superior performance on the William Lowell Putnam Mathematical Competition. The winners of the \$250 prize are David Arthur '04, Kevin Lacker '02 and Melanie Wood '03. These students each ranked among the top 25 among the 3000 participants. This is the fourth Menger award for Lacker.

Born in Vienna 100 years ago this year, Karl Menger exerted a strong influence on many fields of mathematics in Europe and America throughout his long life. He was a member of the Vienna Circle, a group of philosophers and mathematicians that also included Carnap, Gödel, Hahn and Reidemeister. His daughter contributed his papers to the Duke library and established the Menger Award in 1990. For more information, see <http://www.math.duke.edu/news/awards/menger/index.html>

PRUV Research Fellows

The third class of PRUV fellows will begin their research in mathematics this summer. Those selected for this program sponsored by the National Science Foundation are rising seniors Thomas Bringley, Ben Cook, Marie Gueraty, Meredith Houlton, Steve Nicklas and Dane Voris and rising juniors Eric Fountain and David Marks. Each student will study under the direction of a Duke professor for six weeks in May and

June in areas related to mathematical biology, financial mathematics, network theory, game theory and theoretical physics. The following year, they will continue their research with the aim of graduation with distinction.

The members of the first PRUV class, Michael Colsher, Sam Malone, Carl Miller and Daniel Neill, have each won major scholarships to continue their studies. Members of the second class, Matt Atwood, Tom Finley, Carl Pearson, Tristan Tager and Melanie Wood, have each carried out significant research projects.

Goldwater Scholars

Math/CS major, David Arthur '04 was one of four Duke students and the only sophomore to be named B. M. Goldwater Scholar for 2002. This prestigious honor and its \$7500 scholarship is given to over 300 students annually for outstanding achievement in mathematics, science and engineering. The total number of Goldwater Scholars from Duke since 1989 is now 49 of whom 20 have been math majors. Nationally about 10% of the Goldwater Scholars and math majors. See <http://www.act.org/goldwater/2002pressr.html> for more information.

Graduate Student News

Receiving Ph.D.

David Ambrose, student of J. Thomas Beale, will be taking a postdoctoral position at the Courant Institute. His thesis is titled *Well-posedness of vortex sheets with surface tension*.

Anne Collins, student of John Harer and Pankaj Agarwal, will be taking a postdoctoral position at Stanford University. Her thesis is titled *Configuration Spaces in Robotic Manipulation and Motion Planning*.

Marianty Ionel, student of Robert Bryant, accepted a postdoctoral position at McMaster University in Canada. Her thesis is titled *Second order families of Special Lagrangian 4-folds in C^4* .

New Courses

Math 236/Physics 292 General Relativity

Introduction to the basic concepts and techniques of General Relativity. The course will cover tensor calculus, Lorentzian geometry, Einstein's equations, weak field limits, cosmology, black holes, and gravitational lensing. Each student will write a paper selected from a list of topics tailored to the student's mathematics and/or physics background (e.g., Morse inequalities and its applications, Lagrangian and Hamiltonian methods, cosmic censorship, large-scale structure of the universe, detection of extra-solar planets, dark matter reconstruction, gravitational waves, etc.).

—Instructor Arlie Petters

Problem Corner

Solutions From Last Issue

- Problem.** Find all solutions, if any, in positive integers to

$$a + b = c$$

where c is the least common multiple of a and b .

Solution. Consider any solution to the given equation. Since $a = c - b$, where b and c are both multiples of a , it follows that a is also a multiple of b . Similarly, b is a multiple of a , and hence $a = b$. Thus, the least common multiple of a and b is a , so the equation reduces to $a + a = a$, which has no solutions in positive integers.

- Problem.** Let i be the square root of -1 and let n be a positive integer. Prove that the polynomial

$$f(x) = (x + i)^n - (x - i)^n$$

has only real roots. Must they all be distinct?

Solution. Suppose r is a repeated root of the given equation. Then, $f(r) = f'(r) = 0$. Thus $|r + i|^n = |r - i|^n$ so $|r + i| = |r - i|$. Letting $r = a + bi$ and simplifying, we find $b = 0$. Therefore f must be real.

Also $n(r + i)^{n-1} = n(r - i)^{n-1}$.

Since f must be real, $r + i$ and $r - i$ cannot be 0. Divide the above equations to get $\frac{1}{n}(r + i) = \frac{1}{n}(r - i)$, which is impossible. It follows that $(r + i)^n - (r - i)^n = 0$ has no repeated roots.

3. **Problem.** Let n be a positive integer. Define the ordered set of positive integers, S , to be quaint if the sum of the elements in S plus the number of elements in S is n . For example, if $n = 6$, then the quaint sets are $\langle 5 \rangle$, $\langle 3, 1 \rangle$, $\langle 2, 2 \rangle$, $\langle 1, 3 \rangle$, and $\langle 1, 1, 1 \rangle$. Let $f(S)$ denote the product of the elements in S . Compute the sum of $f(S)$ as S ranges over all quaint sets.

Solution. Let $S = (a_1, a_2, \dots, a_m)$ be any ordered set of positive integers. Then, $f(S)$ counts the number of (unordered) sets T of distinct positive integers satisfying:

T has precisely $2m$ elements.

For each positive integer k , the $2k^{\text{th}}$ smallest element in T is $a_1 + a_2 + \dots + a_k + k$.

Thus, if we sum $f(S)$ over all quaint sets S , we are counting the number of unordered sets T of distinct positive integers satisfying:

T has an even number of elements.
The largest element in T is n .

It follows that the sum of $f(S)$ as S ranges over all quaint sets is given by

$$\begin{aligned} & \binom{n-1}{1} + \binom{n-1}{3} + \binom{n-1}{5} + \dots \\ &= \frac{1}{2}((1+1)^{n-1} - (1-1)^{n-1}) \\ &= 2^{n-2} \end{aligned}$$

New Problems

1. If the sum of the coefficients of polynomials $p(x)$ and $q(x)$ are both 1, prove that the sum of the coefficients of $p(q(x))$ is also 1.
2. Find all real numbers, x and y , satisfying

$$\begin{aligned} x &= 11 - \frac{50y}{x^2 + y^2} \\ y &= 10 - \frac{50x}{x^2 + y^2} \end{aligned}$$

3. **Putnam 2001.** In a triangle of area 1, each of three lines from the vertices to the opposite sides are bisected by another of these lines forming an interior triangle. Find the area of this smaller triangle.

Math Degree Candidates, Academic Year 2001-2002

First Majors

Wendell Bernard Barnwell III
 Alison Rochlin Benton
 Arman Bhalla
 John Gwyn Campbell
 Francesco Nicholas Caruso
 Noah Barker Dean
 Faith Anne Drickamer
 Jennifer Rose Fiorita
 Sreelata Kintala
 Katharine Nicholette Knight
 Kevin David Lacker
 Olga Natalia Lipinska
 Samuel Westmoreland Malone
 William Blair Searle
 Matthew George Semrad
 Quinn Matthew Snyder
 Taowei David Wang
 Frederick Craig Zahrn

Second Majors

Justin Bledin
Andrew Scott Brohl
Patricia I-Pearn Chen
Benjamin Rudolf Crawford
Bristol James Crawford
Benjamin Lovegren De Bivort
Sitaramesh Emani
Marco Antonio Garcia
Richard Albert Huang
Jared Ian Strauss Klyman
Jason Adam Koslofsky
Edward James Moulton
Neil Kamal Puri
Bradley Williams Renuart
Kimberly Fayme Roitman
Patrick Jay Rosenthal
Timothy Douglas Roy
Paola Sardi
Michael Joseph Smolow
Andrew David Tuttle
Joel Jonathan Winegarden
Edith Yunching Yang

Minors

Eric Mark Aldrich
Nicholas David Atchison
Kyle Thomas Beauchamp
Christina Lynn Belmore
Julie Paige Brown
Hao Chen
Kevin Brian Chen
David Cheonho Chung
Jonathan Greely Curtis
Parima Damrithamanij
Joshua Rothschild Danziger
John Ballard Davenport
Peter Matthew Fishman
Christopher Brian Fleizach
David Scott Frist
Charles Jeremy Kelley
James Connor Kelly
Francis Xavier Lane
Ryan Maged Mostafa
Michael Victor Nehme
Kathryn Rita Nowicki

Mark Andrew Ozaki
Juliet Rachel Crowder Pulliam
Stacie Harper Rabinowitz
Dennis William Simon
Michael Joseph Smolow
David Allen Stuebe
Sherwin Leu Su
Dana Catherine Upton
David Patrick Williams
Enrico Arturo Zappi
John Christopher Zeok

Master of Arts

David Fredrick Anderson
Robert John Buckingham
John Wesley Cain
Benjamin Perry Cooke
Carina Pamela Curto
Daniel Fox
Daniel Abraham Goldstein
Ryan Patrick Haskett
Robert Laszlo Karp
Timothy Allen Lucas
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