BAYLOR {mathematics}

FALL 2011 NEWSLETTER

A Message from the Chair

Another exciting academic year at Baylor University is now underway! And we are planning lots of exciting events all year round in our department.


Lance Littlejohn

The department is flourishing in both its teaching and research duties. As a result, the Baylor administration continues to be very supportive of our drive to become a nationally ranked mathematics department in the country.

On the departmental level, we have added a new post doctoral fellow in Oleksandra Beznosova. Oleksandra, who works in harmonic and Fourier analysis, finished her Ph.D. degree at the University of New Mexico in 2008 and spent the last two years at the University of Missouri - Columbia. We also are excited to add Gary Taylor to our faculty. For the past 25 years, Gary has taught high school mathematics at Garland High School and Allen High School. We also welcome six new graduate students to our program: Nathan Averbeck, Nathaniel Hiers, Reeve Hunter, Michal Kokta, Josh Sutherland, and Tim Tennant.

HOMECOMING 2011

Homecoming this year is Saturday November 5. Last year, we had a terrific turnout for Homecoming and this year, we would like to see more and more math alumni! We will plan to host a brunch on Saturday morning from 10am – 1pm on the first floor lobby of the Sid Richardson building. Please join us after the parade!

Ed Oxford announced his retirement this spring after 29 years of dedicated service to Baylor University. Ed served a seven-year term as Chair of the Department of Mathematics during the years 1997-2004; prior to this position, Ed was the Associate Chair (1996-1997) and the Director of Graduate Studies (1992-1996) in the mathematics department. It was during Ed's years as chair when several key hires were made that set the tone for today's department. Ed deserves enormous credit for putting the department in the excellent shape that it currently is in. One particular 'sacrifice' that Ed, and others, did for the department that has not gone unnoticed by many of us was his unselfish decision to double his teaching load to help the department's graduate program grow. I view this move by Ed and others to be a major step in turning the department into a well-regarded research department.

In our Winter 2011 newsletter, I mentioned an important report released in late 2010 by the National Research Council and it bears repeating to our alumni to indicate how well the department compares to other mathematics departments in the nation. Baylor has one of the youngest doctoral programs in mathematics in the country (having started in 2002) and it is remarkable how well the department has done in this short time. The NRC has us ranked sixth in the Big 12 and close to several mathematics programs in the country that have had successful Ph.D. programs for several decades.

Throughout the academic year, we will bring in several distinguished visitors and lecturers to the department in our three premier department lecture series. From October 5-8, Professor David Bressoud, Past President of the Mathematical Association of America and the DeWitt Wallace Professor of Mathematics at Macalester College in St. Paul (Minnesota), will visit our campus and deliver the fourth annual Baylor Undergraduate Series in Mathematics lectures. Baylor's 'own' Dr. M. Ray Perryman (BS Math, Baylor, 1974) will give the third annual lecture in the Life Experiences in Mathematics series on March 21, 2012. On April 11-13, Professor Ron Graham will visit Baylor next April 11-13 and deliver two lectures in the fifth annual Baylor Lecture Series in Mathematics. Ron is the Irwin and Joan Jacobs Professor in Computer Science and Engineering at the University of California, San Diego and holds numerous national honors, including membership in the National Academy of Sciences. Ron has also served as President of both the American Mathematical Society and the Mathematical Association of America.

The $100 Million President's Scholarship Initiative, started last year by Judge Starr, continues to move towards its goal. Baylor alumni have stepped forward to help in this unprecedented drive and we would appreciate any help that you can give. Of course, we would be grateful if you would also consider adding to existing mathematics scholarships that we have, or, starting new endowed mathematics scholarships. We are grateful to several mathematics alumni who have recently made significant donations to scholarships, including Bill and Carol Brian, of Amarillo, who recently established the Brian Family Endowed Scholarship in Mathematics.

We have set several major fund-raising goals in our department. Specifically, we want to:

(1) increase the number of mathematics scholarships in the department; the number of deserving undergraduate students always outnumbers the scholarships that our department has to offer. Information on current mathematics scholarships can be found at our Mathematics Scholarships page.
(2) endow several graduate assistantships in the department; this would give us the opportunity to be more competitive with other universities and allow us to nationalize and internationalize our applicant pool.
(3) obtain three fully endowed chairs in the department within the next 10 years. Every top department in the country has endowed chairs; these chairs would help us significantly increase our profile and recognition in the United States. The department has hired very well over the years but we could make a significant leap forward if we had endowed chairs available to attract established, world-renowned teachers and researchers.

If you would like to help in any of these areas, please contact me at Lance_Littlejohn@baylor.edu. Alternatively, you can contact Frank Shannon (Frank_Shannon@baylor.edu) or Rose Youngblood (Rose_Youngblood@baylor.edu) in university development.

For our next newsletter, I would like to start an "Alumni News" section with its sole purpose to provide you with information on your classmates and fellow mathematics alumni. If you have some alumni 'newsworthy' information, please pass it on to me and I will get it into our next newsletter. And please keep in touch with us – better still, come and visit us!

Best wishes,

Lance

Department News

Math Department Welcomes New Faculty

On September 15, the annual fall faculty banquet will be held at the Clifton House in Waco. Among the guests are the department's new faculty members, Oleksandra Beznosova and Gary Taylor.


Oleksandra Beznosova **Gary Taylor**

Oleksandra Beznosova joins our faculty as a new post doctoral visiting professor in the department. She comes to us from the University of Missouri, where she spent the past three years in a visiting role. She earned her Ph.D. degree from the University of New Mexico in 2008 under the supervision of Cristina Pereyra. A native of the Ukraine, Oleksandra works in harmonic analysis and, in particular, she is an expert in the theory of Bellman functions and weighted inequalities. She is a welcome addition to our analysis group.

Gary Taylor joins the math department after a 25 year career teaching high school mathematics at Garland High School and Allen High School. He earned his BS and MS at Texas A&M Commerce. Gary has taught a wide range of high school mathematics classes, including AP Calculus for the past 16 years. In his spare time, Gary writes, orchestrates, performs, and records music. Among several professional accomplishments, he wrote the music for the play “A Lone Star Christmas”.

Ron Morgan named Director of Undergraduate Research

Dr. Ron Morgan has been named Director of Undergraduate Research in the department. His main duties in this capacity will be to oversee all facets of undergraduate research, including notifying Baylor students of research and fellowship opportunities and placing them with appropriate faculty. Ron will also be in charge of seeking funding from various state and federal sources for undergraduate research.

Ron Morgan

Ron obtained his Ph.D. degree from the University of Texas at Austin in 1986. He has been on the faculty in the mathematics department at Baylor since 1992.

A Huge Thank You to Ed Oxford

Robert Piziak

Ed Oxford

Ed Oxford has retired. However, he will not be disappearing from the halls of Sid Richardson any time soon as he will be teaching two sections of calculus in the fall. Ed, a native of Arkansas, did his undergraduate work at Southern Arkansas University graduating in 1961. He received his master’s degree from Louisiana Tech University in 1963 and his Ph. D. at New Mexico State University in 1971. After spending some years at the University of Southern Mississippi, he joined the Baylor faculty in 1982.

Ed did his Ph.D. research in the area of Abelian groups under Ray Mines. He continued with research on preradicals. However, his love of combinatorics soon became evident. He directed a number of undergraduate and master's theses centered on counting problems. When the course MTH 3312 Foundations of Combinatorics and Algebra was established as a required course for mathematics majors, the "combinatorics" part can be directly attributed to Ed. More recently, Ed has become interested in the problem of "bias with regard to larger and smaller states" when apportioning the United States of Representatives.

In his early years at Baylor, Ed established himself as an excellent classroom instructor. He had high expectations of his students that they work hard (as he always did) and learn. He became noted for some of the comments he used to write on homework papers, such as "lacks clarity and detail" and "the hard way!" At the end of one semester, a student with a delightful sense of humor presented him with two red-ink rubber stamps containing these phrases. However, it wasn't long before Baylor administrators and the department took notice of his administrative skills. In 1984, he was part of the Academic Support Planning Group of the Self Study. He was elected to the Faculty Senate in 1987-1989. From 1986-1991, he served on the Curriculum Committee of the College of Arts and Sciences. He was selected as Director of Graduate Studies in Mathematics and served in this role from 1992-1996. He chaired the search committee for the Dean of the College of Arts and Sciences in 2005.

Probably the greatest service Ed performed was his seven year term as department Chair. He served a year as Associate Chair under Howard Rolf 1996-1997 to learn the "nitty-gritty" of all the things the Chair has to do. Then he served as Chair from 1997-2004. During this time, the administration made the decision to increase research at Baylor while maintaining Baylor's Christian environment and commitment to excellence in undergraduate education. Under Ed's steady and thoughtful leadership, the department developed and implemented a Ph. D. program, hired the kind of people who could help build our research program yet support the goals stated above and graduated our first Ph.D. students. This department and this university owe a great deal to Ed Oxford.

Recent Ph.D. Graduates

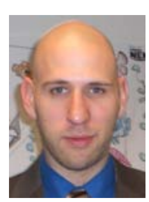
Three graduate students, Jeff Lyons, Jeff Neugebauer and Brent Hamilton, graduated with their Ph.D. degrees during 2011. Lyons and Neugebauer were both students of Dr. Johnny Henderson while Hamilton was a student of Brian Raines. The department has now had 23 students obtain their Ph.D. degrees since the Ph.D. program began in 2002.

Dr. Lyons is on the mathematics faculty at Texas A&M Corpus Christi, Dr. Neugebauer has accepted a tenure track position in the Department of Mathematics at Eastern Kentucky University, and Dr. Hamilton has accepted a position at the University of Tennessee Chattanooga.

Congratulations to all three of you – we are all very proud of your hard work and accomplishments!

Jeff Lyons

Jeff Neugebauer



Brent Hamilton

The titles of their Ph.D. dissertations are:

Brent Hamilton "Asymptotic Arc-Components in Inverse Limits of Dendrites"

Jeff Lyons "Boundary Data Smoothness for Solutions of Nonlocal Boundary Value Problems"

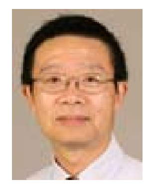
Jeff Neugebauer "Comparison of Smallest Eigenvalues and Extremal Points for Third and Fourth Order Three Point Boundary *Value Problems".*

Ed Burger Returns!


Ed Burger

Edward B. Burger, Baylor's most recent recipient of the Robert Foster Cherry Award for Great Teaching, joins Baylor for the 2011-2012 academic year as Vice Provost for Strategic Educational Initiatives. Ed is a Professor of Mathematics at Williams College (MA) where he is also the Lissack Professor for Social Responsibility and Personal Ethics. Ed earned his Ph.D. degree in mathematics from the University of Texas at Austin in 1990. He is well recognized and highly respected throughout the world as both a first-rate research mathematician and a superb teacher and lecturer. He is also one of the most sought-after speakers for national and regional mathematics meetings. Dr. Burger has won a number of national awards for his research and teaching. Among these honors are the National Distinguished Teaching Award (2000), the Pólya Lectureship (2001-2003), the Chauvenet Prize (2004), and the Lester R. Ford Award (2006), all from the Mathematical Association of America. Welcome back, Ed!

Tim Sheng Organizes September PDE Workshop


Tim Sheng

Professor Qin (Tim) Sheng has organized a conference at Baylor on September 16-17 on the topic of *Splitting and Multiscale Methods for Computational PDE's*. This research workshop is aimed to bring together researchers having overlapping interests in solving partial differential equations by using cutting-edge splitting and/or multiscale methods. The list of plenary speakers for this workshop include Yalchin Efendiev (Texas A&M University), Bjorn Engquist (University of Texas at Austin), Roland Glowinski (University of Houston), Jan S. Hesthaven (Brown University), Arieh Iserles (University of Cambridge), and William Symes (Rice University).

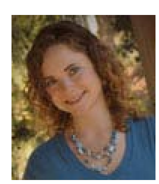
Mary Margaret Shoaf Leads NSF-Baylor Teaching Workshop


MM Shoaf

Baylor mathematics professor Mary Margaret Shoaf led a group of Baylor educators in June to help prepare elementary and middle school teachers to transition to teach mathematics.

Because of a critical shortage of qualified mathematics teachers in our nation's schools, the National Science Foundation is providing support money to help retrain in-service teachers to teach mathematics. Under the supervision of Dr. Shoaf, more than 30 teachers from Region 12 participated in the two-week program.

Chelsea Mitcham Receives Fulbright Grant


Chelsea Mitcham

Chelsea Mitcham, a senior secondary mathematics education major from Houston who graduated in May 2011, was awarded a Fulbright Fellowship in the spring of 2011. Chelsea, who is fluent in Spanish, will participate in the English Teaching Assistantships (ETA) Program, an element of the Fulbright U.S. Student Program, as a teacher in various schools in Mexico for 2011-2012.

Elizabeth Vardaman, Associate Dean for Special Academic Projects in the College of Arts and Sciences, who helped facilitate and oversee Chelsea's Fulbright application says "Chelsea is an amazing student who has earned English as a Second Language certification, has majored in math for secondary education and is completing the Honors Program. She is also a caring, compassionate individual who lights up a room when she speaks about her students and her love of teaching."

Under the mentorship of Dr. Trena Wilkerson, Associate Professor of Curriculum and Instruction in the School of Education, Chelsea wrote her Honor's Program thesis on "*Effects of Relevant Verbalizations on Symbolic Understanding*". "Chelsea has an exceptional gift for teaching, one that reflects an in-depth understanding of not only content such as mathematics and English but the ability to relate that content to students," Wilkerson said. "She is creative, innovative and committed to providing quality education to all students. It was a privilege to mentor her in her studies at Baylor, and I know that we will continue to see and hear about the amazing things that she does in her commitment to teaching and learning."

Profiles of Current Mathematics Graduate Students


Quinn Wicks

Quinn Wicks: Whenever I wonder how I ended up choosing a career in math, I always think back to a photograph my mother has of me from preschool. It shows me sitting alone at a table, looking down at a pattern I had made with some triangles. I was so mesmerized that I hadn't noticed that everyone else had left to go join in some other activity. When I was in second grade however, I wanted to be an artist; in high school, I wanted to study psychology. At Boston College I double-majored in philosophy (along with math), then wanted to be a development economist; I even wrote my senior thesis on the effect of globalization on poor countries. The summer after I graduated, I was hired as an analyst at a firm in the energy industry. It was a good job, but something was missing: it was the first time in my life I wasn't in a math class. I left that job to go to graduate school in math and haven't looked back since.

I earned my MS degree in mathematics at Syracuse University while my husband (whom I met in college and married while in graduate school) finished his law degree. After he joined the JAG Corps, we had a baby boy and awaited orders from the army. We could have been sent anywhere in the world, and now that I was a new mother as well, I doubted I would ever finish my Ph.D. As soon as we found out that Bill would be at Fort Hood, I applied to Baylor. Even after I was accepted, I dreaded what would certainly be a constant struggle to balance my studies with my family life. Visiting Baylor laid all my fears to rest. Everyone in the math department was friendly, welcoming, and supportive. (Rita, one of the math staff, even babysat my son Tommy while I sat in on a few classes.) I was put in contact with a recent math graduate (Dr. Leslie Jones) whose husband had also been stationed at Fort Hood; she had managed to finish her Ph.D. in four years with two kids! If she could do it living twice as far from campus, with twice the number of kids, in only four-fifths of the amount of time, surely I could manage it too!

This past year was my first at Baylor. I enjoyed the constant support of my fellow classmates and my professors and passed my qualifying exams this past May. I am now working with Dr. Lance Littlejohn on a thesis in differential operator theory, involving the study of Glazman-Krein-Naimark theory and left-definite theory. After I graduate with my Ph.D., I hope to be a professor at a liberal arts college.

Jose Franco: When you are a child, the most common question you get from adults, after the classic "How old are you?" is "What is your favorite subject in school?" Without hesitation I would always answer

“Math.” When I started college, in my home country of Guatemala, I thought the only career that would use my love for mathematics was some branch of engineering. Therefore, I chose chemical engineering as my major.

Jose Franco

However, when I finished the math courses in my degree, I found myself stressed about the fact that I would not learn more mathematics anymore. I asked one of my good friends, who is very talented in mathematics, what should we do. We both agreed that we should sign up for a double major in math. As we looked at the first courses we could take, we decided to take topology and geometry. Some faculty members giggled a little when we said that we wanted to take topology. After all, we did not had a formal course in set theory. Nonetheless, after a few jokes, they let us take those courses, probably more out of curiosity than anything else. When, the course started, I remember reading Kuratowski's “Introduction to Set Theory and Topology” for hours and hours, until my head would hurt but I was hooked. Thinking about sets of sets was a new and awesome thing for me. “Not open” does not mean “closed? How so? It was wonderful.

When I graduated, I started working as a chemical engineer. It was definitively not something I enjoyed. I found myself longing for the quiet hours in the library, reading a good book with good coffee; in summary, I was really missing the academic life. So, it hit me: I had to pursue my doctorate degree in math. Every single step of the process is worth a story of its own, but let's just say that it was an adventure in and of itself to move to the US with nothing else but a box full of clothes and books.

Once at Baylor, I met the math professors and got really excited. They all were very amiable and clearly loved math as much as I do. So, I immediately felt at home. The first year in the program was quite demanding, but I enjoyed every second of it. Not only because I was learning such interesting topics, but because I was experiencing a different country and culture.

When I was researching schools back in my application process, I came across the subject of “Lie groups”. “What deceptive little creatures,” I thought. When I heard these words for the first times, it sounded more like “Lee groups”. So, I knew that they were named after somebody, but “what were they?” I read the definition and it involved manifolds. Then I disregarded my curiosity until a course on Lie algebras was offered. I think I was the first person to sign up. I wanted to know more about that topic.

After taking a few courses in representation theory of Lie algebras and Lie groups, I knew I wanted representation theory to be my research area. I am going to begin my last year at Baylor this year. It is a bittersweet feeling. I am excited about the new challenges in the future, but I know I will miss Baylor and Waco.

Xueyan (Sherry) Liu: I come from the small village of Taian in the Shandong Province of China. My interest in mathematics traces back to my father who used the simple Pythagorean principle that he learned in school and helped his family set up an accurate right rectangular foundation for a house. At that time, due to lack of techniques and training, no people around my village had any idea on how to do that. I was so touched when I learned this story. Imagine that a very simple mathematical result can solve a possibly difficult practical problem in our real world! For me, mathematics became not completely abstract anymore but visible and significant.

My four year undergraduate study at Jilin University concentrated on mathematics and applied software. In 2001, I was admitted to Ocean University in Qingdao for my Master’s degree in applied mathematics under the instruction of Professor Binggen Zhang, a very well known mathematician. I studied nonlinear analysis and differential equations, read some new research papers in differential equations, and learned how to do research with critical thinking. When I graduated in 2004, I had two papers published and one talk presented at a conference on differential equations in Shanghai, China. This encouraged me to do future research. Then, with my husband, I moved to Beijing and worked as the duty editor of an English mathematical journal – the Journal of Systems Science and Complexity, sponsored by Academy of Mathematics and Systems Science of the Chinese Academy of Sciences. In 2008, encouraged by Professor Zhang and my family, I came abroad to the U.S. to broaden my study and research. Baylor was the most attractive college for me because of its strong Ph.D. program in nonlinear analysis.


Sherry Liu

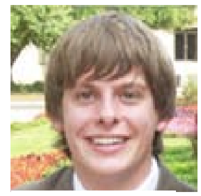
I was nervous and concerned about the challenge of studying abroad, especially since I had been out of the academic life for four years. However, this concern changed after my visit to the Baylor math department and conversations with Dr. Johnny Henderson and Dr. Lance Littlejohn. These professors were so generous, welcoming, and nice, and made me feel that Baylor is my second home. The following first year of study was challenging but not as painful as I thought. I could feel that I was improving a lot and getting back into research. Baylor has supportive, nice, understanding, and accessible faculty who encourage students to think independently; furthermore, friendly, active, and open-minded graduate students in the department made me love the atmosphere of studying and living here in Waco. In my second year, I began to participate in seminars given by Dr. Henderson and I passed my preliminary exams. In our seminars, with the help of such a wonderful and helpful instructor, we studied the latest results in differential equations and all of the graduate students were encouraged to come up with our own thoughts and publish our ideas. For me, doing research in differential equations, or more generally in analysis, is like having thoughts dancing in your head and you can create your own dancing styles. It makes you fall in love with it. Another exciting thing is that I started to teach some undergraduate courses. The teaching experience is amazing for graduate students. I enjoy teaching, caring about students, encouraging them to think just like my professors do in my classes.

In January 2011 and April 2011 of my third year, generously supported by the math department and the graduate school of Baylor, I attended the 2011 Joint Math Meeting in New Orleans and the Spring 2011 meeting of the Texas Section in Tyler, Texas and presented papers in both conferences. Attending these meetings helped familiarize me with the latest progress of research in differential equations and gave me opportunities to communicate with researchers and students from other institutions and colleges. Also, the math department often provides colloquia with presenters from our own faculty or invited speakers outside of the department throughout the whole academic year. In addition, each month we have a pizza seminar for all graduate students and faculty with usually two faculty speakers. These informal lunches easily let colleagues gather together and talk about what they are doing on their research and discuss interesting ideas in their areas. The 'tons' of seminars give me and other graduate students great opportunities to discuss with each other and learn new ideas and knowledge from other people's research.

This current year will be my fourth year here at Baylor. I am planning to finish my dissertation and continue doing my research. After graduation, I hope to look for a research position in nonlinear analysis and to teach at the college or university level.

Profiles of Some Top Undergraduate Mathematics Students

Evan Bauer: My mathematical background is quite different from most. Before my first college calculus class, I had only ever had one math teacher—my mother, and I happen to think she was an exceptional teacher. Sure, she was just teaching stuff like long division and basic algebra, but I think those subjects offer their own set of specific teaching challenges. Let's face it; long division is kind of boring compared to calculus or number theory. Then again, maybe number theory is actually boring and Dr. Burger just cleverly deceived all twenty some students in his class! I just know that if I were given the choice, I would rather teach a self-motivated college math major than a six year old who would prefer cutting holes in his own shirt to learning basic addition. And yes, both characters in that last sentence were named Evan.


Evan Bauer

My mother devoted a decade to developing my interest and ability in mathematics, among other disciplines. I was homeschooled all the way through high school, and while dad helped out a lot along the way, mom was in charge of math until I took a college calculus class my senior year of high school. She managed to take that distracted six year old and eventually develop a student who was both interested in mathematics and sufficiently prepared to pursue those interests. I first began to begrudgingly admit that math wasn't all that bad in junior high when I was studying geometry. As I began to apply myself, I learned that math was something that was worth putting time into, and as my mother describes it, it was an "upward spiral" from there.

Perhaps Baylor is where my story becomes rather more conventional, though none the worse for it in my opinion. I was drawn to Baylor by great scholarship opportunities, the variety of honors program opportunities, and the Christian atmosphere. At Baylor I found great professors and a welcoming environment. I am not technically a math major; I am a University Scholar with concentrations in math and physics, and I have found both departments to be very encouraging and supportive of my double major. Having just completed my sophomore year, I have already had the opportunity to take a lot of exciting math classes at Baylor. I particularly enjoyed the concepts and challenges I encountered in Number Theory with Dr. Burger and Introduction to Analysis with Dr. Raines. It's not just the professors that make the Baylor math department a great place to learn though. I also really benefit from the infectious enthusiasm of my fellow undergrads like Adam Telatovich (featured in last semester's newsletter).
As I write this, I am currently living just outside Chicago at Fermilab, where I am involved in high-energy physics research for the summer with Dr. Hatakeyama from the physics department. I am looking forward to the next two years I have at Baylor, where I plan to continue to take advantage of the opportunities to immerse myself in mathematics and related disciplines. I plan to work toward a graduate degree in some combination of physics and mathematics after I am done at Baylor, though I am still unsure as to what specific area of research interests me most. Ultimately, I hope that my commitment to my Christian faith and my desire to continue my academic pursuits will lead to more opportunities like those I have found at Baylor.

Kim Woodsum: My entire life I have ridden horses and competed across the nation in show jumping. I was recruited by various colleges to ride on their equestrian teams, including Baylor. Upon visiting Baylor I fell in love with the campus and the team. My decision to attend Baylor was based mainly on the fact that I would be challenged in the classroom and in the riding arena.


Kim Woodsum

My major changed multiple times before even entering college. When I applied, I was a math education major. Soon after, I changed my major to computer science on the advice of my dad. He was convinced I would enjoy this area of study. Upon visiting Baylor for orientation, I changed my major once again. I sat through the lecture on computer science and realized it wasn't for me. But my parents were hesitant with my desire to major in mathematics. At orientation, I found a flyer listing all of the possible jobs one could hold with a degree in math. After presenting this flyer to my parents, they both agreed with my decision.

When I was younger, I used to struggle with math. I never understood why I didn't know the answer right away. My dad was the one to sit down and help me out. And as soon as I stopped being the problem, as he put it, I understood exactly what was being asked. In middle school I remember questioning why each equation worked. That was my first introduction into proofs. My teacher would go through a proof, step by step, to help me grasp the equation. All of the other students accepted that the equation was true, but I was never satisfied with that answer alone. Finally in high school I started loving math. Everything seemed to click into place. I would help all of my friends understand the material, which in turn added to my understanding.

My freshman year I was "red-shirted" for the equestrian team. This means that I was on the team, but never competed. In exchange, I get another year of eligibility after my senior year. The last two years I have been a part of the show team. I received the sportsmanship award for the equestrian team in the spring of 2009 and 2010. In 2010, I was named "Most Improved" on the flat team and in 2011 I earned MVP on the flat team. I have made the Dean's List five semesters and each semester have made Big 12 Academic Honor Roll.

In the past few years, I have been challenged more academically than ever before. Even though everyday is a lot of work, I love when I understand something very complex. It feels like all of my hard work has paid off. A huge reason for my success is my professors in the math department. With practice, competitions, 6am workouts, and barn days I really appreciate all of the help I have gotten from my professors. Traveling with the team does not make it easy to rise to the challenges of being a math major. But with the help of my professors and fellow classmates, I am always able to learn the material I have missed and handle my time constraints. Juggling my studies and my commitment to the team has taught me a lot about time management and what I am capable of achieving. Even though everyday is a challenge, I wouldn't change anything about my college experience.

Mathematics Scholarship Recipients

The Mathematics Department awarded $119,980 in scholarships to mathematics students for the current academic year. The following Baylor students received this scholarship support. We are very grateful to the families that endowed these scholarships and we wish each of the chosen students continued success in the coming year!

The John C. Lattimore Mathematics Scholarship Fund: Ryan Warnick

The Earl, Maxine, Max, and Anita Bodine Mathematics Scholarship Fund: Evan Bauer, Taylor Braly

The K. L. and Vivian Carter Mathematics Scholarship Fund: Mikayla Chien, Chrystal Rogers, Emily Peirce

The Jerry Johnson Mathematics Scholarship Fund: Mare Belvin, Whitney Banik, Ashleyanne Thornhill, Emily Peirce

The Howard L. Rolf Mathematics Scholarship Fund: Emily Peirce

The Hickey Mathematics Scholarship: Kaylan Hearne

The Piziak Mathematics Scholarship Fund: Kim Woodsum

The Roy Donald Perry Memorial Endowed Scholarship Fund: Tyler Underwood, Emily Peirce

The Professor Albert Boggess Mathematics Scholarship Fund: Kim Woodsum, Sara Menix, Ashleyanne Thornhill

The Ruth and Gene Royer Mathematics Scholarship Fund: Kelsey Carpenter, Ryan Cowan, Erwin Gostomski, Caitlyn Thelen, Janie Hoorman, Adam Telatovich, Christina Tripp, Caroline Clark

The Schultz-Werba Mathematics Scholarship Fund: Tyler Underwood

The department usually solicits applications each March for the following year's scholarships. Students may pick up an application form in the Mathematics office (SR 317). For more information concerning scholarships, students may contact Brian Raines at Brian_Raines@baylor.edu or at 710-4382.

Department Welcomes Distinguished Visitors to Speak in Departmental Lecture Series

Besides running a regular colloquium series throughout the year involving visiting mathematicians from around the world, the Department of Mathematics runs three prestigious lecture series that are funded through the Office of the Dean in the College of Arts and Sciences. These lecture series are *The Baylor Lecture Series in Mathematics*, *The Baylor Undergraduate Lecture Series in Mathematics*, and the *Life Experiences in Mathematics Series*. The 2011-2012 academic year features several outstanding mathematicians lecturing in these series. All lectures are open to the public; we would especially love to see our alumni at these lectures!

David Bressoud headlines 2011- 2012 Baylor Undergraduate Lecture Series

Professor David Bressoud will be the fourth speaker in the Baylor Undergraduate Lecture Series in Mathematics when he visits Baylor from October 5-8, 2011. The titles of his two lectures are *Calculus in High School: Too much of a good thing?* and *Proofs and Confirmations: The Story of the Alternating Sign Matrix Conjecture*. Further information on these lectures can be found by visiting the Baylor Undergraduate Lecture Series web page.


David Bressoud

Dr. Bressoud is the DeWitt Wallace Professor of Mathematics at Macalester College in St. Paul, MN and the 53rd President of the Mathematical Association of America, serving in this role for the two-year period 2009-2010. The MAA is the world's largest professional society devoted to collegiate mathematics with more than 23,000 members. David is a highly respected figure in the country on the state of mathematics in our nation's schools.

David obtained his Bachelor of Arts degree from Swarthmore College and earned both his M.A. and Ph.D. degrees from Temple University, where his Ph.D. advisor was Emil Grosswald. He joined the Macalester faculty in 1994 after 17 years at Penn State. He has served as Chair of Macalester's Department of Mathematics and Computer Science, Chair of the Mathematical Association of America's Committee on the Undergraduate Program in Mathematics (CUPM), and Chair of the College Board AP Calculus Development Committee, the committee that sets the AP Calculus syllabus and writes the exams. He is also one of the authors of the CUPM Curriculum Guide 2004. He has held several visiting academic positions, including the Institute for Advanced Study, the University of Wisconsin-Madison, the University of Minnesota, and the Université Louis Pasteur.

David has received the MAA Distinguished Teaching Award, the MAA Beckenbach Book Award for his text *Proofs and Confirmations*, and has been a Pólya Lecturer for the MAA. He is a recipient of Macalester's Jefferson Award which honors faculty members who exemplify the principles and ideals of Thomas Jefferson. David has won both a Fulbright Fellowship and Sloan Foundation Fellowship. He has published over fifty research articles in number theory, combinatorics, and special functions. His other books include *Factorization and Primality Testing*, *Second Year Calculus from Celestial Mechanics to Special Relativity*, *A Radical Approach to Real Analysis*, *Proofs and Confirmations: The Story of the Alternating Sign Matrix Conjecture*, *A Radical Approach to Lebesgue's Theory of Integration*, and, with Stan Wagon, *A Course in Computational Number Theory*.

Ray Perryman to speak in 2011- 2012 Life Experiences in Mathematics Series

Dr. Ray Perryman (Baylor '74, Mathematics) will be the third speaker in the Life Experiences in Mathematics lecture series when he visits Baylor University on March 21, 2012. The title of his lecture, to be delivered in the Hankamer School of Business is "*Madmen and the Village Watchman - Mathematics in the Trenches of Economics and Public Policy*". For further information, please visit the Life Experiences in Mathematics web page.

Besides holding a BS degree in Mathematics from Baylor, Dr. Perryman earned a Ph.D. in Economics from Rice University. Dr. Perryman has held numerous academic positions in his career including ten years as Herman Brown Professor of Economics and five years as University Professor and Economist-in-Residence at Baylor University, as well as five years as Business Economist-in-Residence at Southern Methodist University.

Dr. Perryman is Founder and President of The Perryman Group (TPG), an economic and financial analysis firm headquartered in Waco, Texas. He is widely regarded as one of the world's most influential and innovative economists. His complex modeling systems form a basis for corporate and governmental planning around the globe. His thousands of academic and trade articles and presentations span a wide variety of topics, gaining him international respect and acclaim. He has also authored several books, including *Survive & Conquer*, an account of the Texas economy during the turbulent 1980's, and *The Measurement of Monetary Policy*, a treatise on Federal Reserve activity. A popular speaker, he addresses hundreds of audiences throughout the world every year.

Among Dr. Perryman's numerous awards are (1) the Nation's Outstanding Young Economist and Social Scientist, (2) the Outstanding Young Person in the World in the Field of Economics and Business, (3) one of the Ten Outstanding Young Persons in the World, and (4) the Outstanding Texas Leader of 1990. During his nearly 30 years of experience, he has been presented citations for his efforts from both the Congress of the United States and the Texas Legislature. He has been honored by (1) The Democracy Foundation for his role in promoting capitalism in mainland China, (2) the Asia and World Institute for his efforts to encourage international academic exchange, and (3) the Systems Research Foundation for his contributions to the field of economic modeling. He is a Fellow of the International Institute for Advanced Studies and has received the Institute's prestigious Lifetime Achievement Award.


Ray Perryman

Dr. Perryman authors *The Perryman Economic Forecast*, a subscription service detailing projections of state and metro area business activity, and *The Perryman Report & Texas Letter*, a succinct newsletter providing vital information about various aspects of the Texas economy. Dr. Perryman also writes a weekly syndicated column, *The Economist*, and hosts a daily syndicated radio commentary on economic affairs, "The Perryman Report." In former positions as a research chair-holder, University Professor, and Economist-in-Residence at Baylor University and Business Economist-in-Residence at Southern Methodist University, Dr. Perryman pioneered the use of timely and reliable economic information for a spectrum of strategic purposes. His studies have played a role in the creation and retention of hundreds of thousands of jobs.

Cited by major media as "a world-class scholar" and "the most quoted man in Texas," Ray Perryman is an active participant in state, national, and world economic scenes. He has been a member of dozens of state, federal, and international task forces, served as editor of both academic and trade journals, and led conferences within the fields of economics, statistics, forecasting, modeling, and simulation. A member of several corporate boards and advisor to numerous governmental leaders, Dr. Perryman has been honored by the Texas Legislature for his "tireless efforts in helping to build a better Texas."

Ronald Graham to speak in 2011- 2012 Baylor Lecture Series in Mathematics

Professor Ronald Graham will be the fifth speaker in the Baylor Lecture Series in Mathematics when he visits Baylor from April 11-13, 2012. His public lecture "*Computers and Mathematics: Problems and Prospects"*" will take place on April 12 and his departmental lecture "*The Combinatorics of Solving Linear Equations*" will be given on April 13. More information on these lectures can be found by visiting the Baylor Lecture Series in Mathematics web page.

Professor Graham is the Irwin and Joan Jacobs Professor in Computer Science and Engineering at the University of California, San Diego and the Chief Scientist at the California Institute for Telecommunications and Information Technology. He is a mathematician credited by the American Mathematical Society as being *"one of the principal architects of the rapid development worldwide of discrete mathematics in recent years"*. For his important and fundamental contributions to mathematics and computer science, in particular to graph theory, combinatorial number theory, scheduling theory, Ramsey theory, and approximation algorithms, Ron was elected a member of the National Academy of Sciences in 1985.


Ron Graham

At the age of 15, Ron started his university studies at the University of Chicago. He received his Ph.D. in mathematics from the University of California, Berkeley in 1962. For the next 37 years, Dr. Graham worked at AT&T Bell Laboratories in New Jersey working on several problems in pure and applied mathematics. His work at Bell Labs gave rise to worst-case analysis theory in scheduling, and helped lay the groundwork for the now-popular field of computational geometry. It also ignited interest in an obscure branch of discrete mathematics called Ramsey theory, which deals with the underlying order in apparently disordered situations. For his contributions to these fields, the American Mathematical Society awarded Graham the Steele Prize for Lifetime Achievement in 2003. In 1999, Ron returned home to California when he accepted a position at UC-San Diego.

An important 1977 paper by Dr. Graham considered a problem in Ramsey theory, and gave a "large number" as an upper bound for its solution. This number has since become well known as the largest number ever used in a mathematical proof (and is listed as such in the Guinness Book of Records), and is now known as Graham's number.

Graham popularized the concept of the Erdõs number, named after the highly prolific Hungarian mathematician Paul Erdõs (1913–1996). He co-authored almost 30 papers with Erdõs, and was also a good friend.

Between 1993 and 1994 Graham served as President of the American Mathematical Society. He also served as President of the Mathematical Association of America in 2003-2004. Graham was featured in Ripley's Believe It or Not for being not only "one of the world's foremost mathematicians", but also "a highly skilled trampolinist and juggler", and past president of the International Jugglers' Association.

In 2003, Graham won the American Mathematical Society's annual Steele Prize for Lifetime Achievement. In 1999 he was inducted as a Fellow of the Association for Computing Machinery. Graham was also one of the laureates of the prestigious Pólya Prize the first year it was awarded, and among the first to win the

Euler Medal. The Mathematical Association of America has also awarded him both the Lester R. Ford prize and the Carl Allendoerfer prize in 1976.

Professor Graham has published more than 320 papers and five books, including *Concrete Mathematics* with Donald Knuth and Oren Patashnik.

A Student Essay on Steganography

Joel Weinert

(*Joel Weinert graduated in May 2011 with his BSECE degree in Electrical and Computer Engineering. In the Spring 2011 semester, Joel took Professor David Arnold's course in Cryptology (Math 4312). This essay was part of the course requirements. Joel will begin graduate school at Duke University this semester. Joel: from all of us in the math department, good luck and best wishes!*)

Steganography is the general term applied to the science of hiding information in plain sight. Steganography is closely related to the field of cryptography in that both fields attempt to transfer information without possible interceptors being able to read the information. Cryptography, however, relies upon codes and encryption to accomplish this task. After the information to be transferred has been encrypted, it is typically transmitted in the clear, without attempting to conceal the fact that encrypted information is being transmitted. Steganography, on the other hand, is the science of attempting to hide information. Steganography attempts to transfer information without a third-party (and sometimes even the messenger itself) knowing that the message is being transferred. Pure steganography does not encrypt transmitted information, although transmitted information can be combined with cryptological methods and encrypted accordingly before being covertly transferred. Steganography has a long and useful history. It was utilized in ancient times and has been in continuous use, in varying forms, up to the present day. While modern techniques only slightly resemble those used thousands of years ago, the goal of steganography has remained constant.

The field of steganography has its origins in ancient Greece. The great historian Herodotus records the first example of steganography as being used to transfer military information in 499 BC. According to Herodotus, the sender of the message was Histiaeus, a tyrant who ruled Miletus, which had been conquered by Persia. Histiaeus had gained the trust of Darius I, king of Persia, but still wished to see his Persian masters overthrown. To this end, he supported open rebellion by the cities of Ionia against Darius. As he could not send a message explicitly inciting rebellion against the king, he shaved the head of a trusted slave and tattooed his message onto the slave's scalp. Histiaeus then waited a sufficient amount of time for the slave's hair to regrow. After the slave's hair had grown enough to conceal the message, Histiaeus sent his slave to Aristagoras, ruler of one of the Ionian cities. Aristagoras had instructions to shave the slave's head, which he did, revealing the message. Although the rebellion failed (and Histiaeus was later executed), the field of steganography had been established and would not soon fade into obscurity. Only a few years after Histiaeus's ill-advised attempts to cause rebellion, Demaratus, a Greek exile in Persia, wished to warn Sparta of a forthcoming invasion by Xerxes, king of Persia. To accomplish this goal, Demaratus took a wax writing tablet and scraped off the wax. After writing his message on the underlying wood, Demaratus once again covered the tablet in wax, making it appear unused. Because sentries had no reason to stop a man carrying a blank tablet, the messenger was able to carry Demaratus's warning to Sparta.

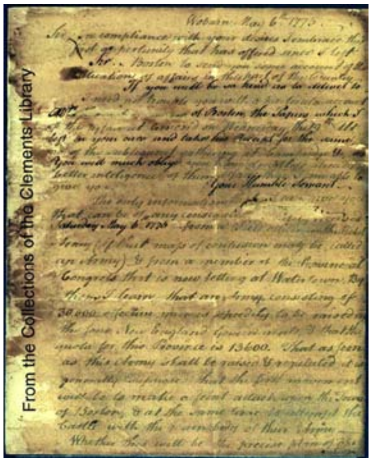


Figure 1: A message from Benjamin Franklin written in invisible ink

The next major advance in the field of steganography was the discovery of invisible ink, the use of which is detailed as far back as the first century A.D. Records indicate that Roman officer Pliny the Elder was the first to write about the invisible ink properties of milk of the thithymallus plant. These invisible inks would dry to be transparent, but would become opaque when the correct conditions were applied to reveal them. Organic compounds, such as lemon juice, milk, and urine, are all invisible when dry, but darken when exposed to an open flame. Academic John Wilkins wrote in 1641 of many compounds that were easily usable as invisible inks. Among these were onion juice, alum, ammonia salts and distilled “juice of glowworms,” which could be used for glow-in-the-dark writing. Invisible inks were used extensively during the American Revolution by both American and British agents. Agents would mix ferrous sulfate and water, creating an ink that was extremely easy to work with. The agent would then write the secret message in spaces between the lines of an ordinary letter. The secret message could be revealed using heat or certain chemicals, such as sodium bicarbonate. The American rebel army used invisible inks frequently in their reports to General Washington.

Invisible inks would continue to advance and be used in a variety of applications. They played a significant role in the Indian Mutiny of 1857, using rice starch and iodine to write and develop, respectively. However, what is often seen as an archaic form of steganography continued to play a major role in both World Wars, the Cold War, and even in modern times. During the World Wars, both American and foreign spies were well-documented as using carbon transfer papers when sending messages. These papers were coated with a special chemical which was transferred to a normal sheet of paper in the same manner as modern-day contact paper. These chemicals could only be developed using very specific specialized chemicals. Because the exact chemical was necessary to develop the hidden message, keeping the specific chemical compound secret was as vital a task as keeping traditional codes secret from the enemy. Recently released documents show that the French did indeed manage to crack the German invisible ink recipe, yielding them a significant tactical advantage during World War II. The full extent of American covert operatives’ knowledge regarding invisible inks is still not known to the general public, as the CIA typically files for (and receives) exemptions for documents regarding invisible ink from standard declassification timelines, citing that they are still relevant and in use today. Beginning in April 2011, the CIA stated that they would begin releasing additional documents regarding invisible ink from the early 20th century, as the technology described in these documents has only become outdated in the recent past. Even in the 21st century, invisible ink is still being used to transfer secret information. A prison gang in 2002 was discovered to be using invisible ink to spread their control to additional facilities, while a British Muslim in 2008 was found to possess a book containing Al-Qaeda telephone numbers in invisible ink.

Not all invisible inks are used to send illicit information, however. Many commercial invisible inks fluoresce only when exposed to ultraviolet (UV) light. One modern application of these inks builds upon the work done by the CIA. Modern personal checks and many official documents typically have the word “VOID” printed on them in invisible ink. This ink is only visible when exposed to ultraviolet light, such as that used by copiers and scanners. This makes it difficult to create forgeries of these vital documents. Many consumers have also taken to marking their possessions with UV-sensitive invisible ink. The consumers mark non-porous surfaces of expensive devices (such as televisions and computers), which can then be readily identified if stolen. Invisible ink has also made its way into commercial entertainment products. Many children’s markers now mark in invisible ink which can only be revealed when used on chemically treated papers or after being colored over with another special marker.

There also exist many other written forms of steganography. One common method is to use only certain words or letters to form new sentences. For instance, by using only the third letter of every word, the sentence “Fishing freshwater bends and saltwater coasts rewards anyone feeling stressed. Resourceful anglers usually find masterful leapers fun and admit swordfish rank overwhelming anyday.” becomes

“Send lawyers, guns, and money.” Other forms of textual steganography can be as simple (the first word of each sentence) or as complicated (each letter that is in a position that is the lower of a pair of twin primes) as the author desires. Textual steganography such as this has been used for millennia and has been documented as also being used extensively in World War II to transfer enemy troop movement to the German military and in modern times by terrorists to pass target information to agent cells. Combatting textual steganography has traditionally been a difficult task, owing to the wide variety of possible decoding techniques. In order to prevent any possible information passing during World War II, the American Office of Censorship, banned deliveries of flowers that contained dates and all crossword puzzles and report cords, and even went so far as to reword letters to counter any possible steganography present. With the invention of modern computers, detection of textual steganography has become an easier, if not trivial, task.


Figure 2: A microdot camera used in World War II

The invention of the photograph allowed for the development of the microdot. Microdots are images that have been significantly reduced from their original size. Modern-style microdots, which were used extensively during the World Wars, are typically circular dots of film approximately a millimeter in diameter. The film was exposed using specialized cameras. Because these spots of film were roughly the same size as typographical dots, such as periods and tittles, they would be attached to a letter in place of a standard typographical punctuation mark. Microdots were also small enough that they could be inserted between the layers of a normal postcard without any noticeable changes to the card’s appearance. Any security personnel attempting to decipher a hidden meaning in the text of the letter or postcard would not find any incriminating evidence, not knowing that the secret information was in plain sight the entire time. The recipient of a microdot message, who typically is informed of the presence of a microdot in advance or by the specific wording of the message of the letter, would then use a normal microscope to view the message printed on the microdot. These techniques of passing information via microdots was used frequently by German intelligence operatives and proved difficult for American counter-surveillance groups to combat. American operatives only discovered the German use of microdots when a German double agent revealed their existence. J. Edgar Hoover was reported as saying that German microdots were “the enemy’s masterpiece of espionage.”


Figure 3: Image containing a secret text message

Much like invisible ink, however, not all applications of microdots are related to espionage or military uses. Several companies now exist that attach microdots to personal belongings, typically cars and motorcycles. These microdots are small enough that they can be easily concealed from potential thieves and will therefore remain attached even after the vehicle is stolen. However, it is easy for investigators with the right equipment (and who know where to look) to detect and read any microdots hidden in vehicles. One effective aspect of microdots is their relatively cheap cost. Companies that specialize in tagging vehicles with microdots routinely apply upwards of 10,000 microdots to a single vehicle. While it may be possible for thieves to remove multiple thousands of the microdots, thousands more still remain and a single dot is sufficient for identification. These dots are hidden throughout the car in overt and covert locations and even in engine parts, so that even if the car is stripped, its constituent components can still be tracked.

Many forms of steganography can only be utilized using modern computers. Many of these techniques revolve around the digital representation of pictures. Each pixel in a typical modern picture contains three eight-bit values, one each for the red, greed, and blue value of the pixel. These eight-bit values have a range of 0-255 and can be manipulated quite easily. It is almost impossible for the human eye to detect the difference between a certain color intensity of, say, 171 (10101011) versus 170 (101011). Because each eight-bit value is stored in standard binary form, the first several bits carry much more weight than the last ones. Each bit from left to right in an eight-bit number has a decimal value of 128, 64, 32, 16, 8, 4, 2, and

1, respectively. Because of the nature of binary numbers, a specific bit has a greater weight than the combination of all bits to the right. For instance, the fourth bit, which has decimal a value of 16, is weighted more heavily than the last four bits combined, which have a decimal value of 15. Therefore, it is possible to actually change the last several bits in the color values of each pixel without significantly affecting the overall image, as long as the more significant bits remain intact. Only a close inspection of the two images will reveal that the data has been tampered with.

One of the simplest methods of encoding messages within pictures involves zeroing out the last several bits of one or more color values for the image. For example, a user could choose to zero the last four bits of the red value for all pixels. This would mean that the red value of each pixel was of the form $b_1b_2b_3b_4 0000$, where b_i is either a 0 or a 1. The user could then take a message and reduce each character to its 8-bit ASCII binary form. That is, the letter 'a' becomes 01100001, 'b' becomes 01100010, and so on for the entire alphabet. The user could then take the first four bits of the first character and attach them to the first pixel using the bitwise OR operation. If the first letter was an 'a,' the red value of the first pixel would now be $b_1b_2b_3b_4 0110$. The next four bits would be attached to the second pixel's red value (which would become $c_1c_2c_3c_4 0001$) and so on for the entire message. As most users would not be zeroing the last four bits of all colors, doing this to one color is imperceptible by almost all but users who are specifically looking for this change. Using this method, half of a character can be encrypted per color per pixel, resulting in a character and a half per pixel for all colors. Therefore, a standard image from an eight megapixel consumer camera could contain 12,083,328 characters of hidden text. This is more than enough to contain ten full-length novels, all without most users noticing a single change, although the difference would be fairly obvious to trained investigators. Figure 3 shows a photo of a bear that has been encrypted by this author using only a few lines of MATLAB code to contain the phrase "A long time ago, in a galaxy far, far away... It is a period of civil war. Rebel spaceships, striking from a hidden base, have won their first victory against the evil Galactic Empire." This phrase was encrypted only in the red color value of the first few pixels and would fit easily in only the top two rows of pixels.

Figure 4: Host image without hidden image

Figure 5: Composite image with secret picture embedded

This method of steganography is particularly popular among terrorists. Terrorist leaders post pictures to certain Internet message boards that have had textual messages regarding targets, dates, etc., embedded into them. These messages are then retrieved by the individual agents, who act on the messages. Even legitimate governments have begun using this method of contacting agents. A 2010 report by the Federal Bureau of Investigation revealed that Russian intelligence agencies routinely embedded text messages into images that were transmitted to illegal spies in foreign countries. Because of the extreme size of the Internet, as well as its open-access nature, filtering and catching images of this type can be extremely difficult. The posted images can be anything from a tranquil waterfall scene to a movie poster for an upcoming Hollywood blockbuster. Furthermore, it can be difficult to detect altered images if special care is taken when embedding the secret message into the host image.

Figure 6: Secret picture extracted from composite image

However, it is possible to not only encrypt other images as well as text onto image files. Taking two images, both images have all color values for all pixels reduced to only their four most significant bits. The color values for one image (which will become the secret image), are all shifted to the right by four bits, becoming $0000b_1b_2b_3b_4$. This essentially creates a very dark version of the original secret image. The original host image does not have its color values shifted and each value remains of the form $c_1c_2c_3c_4 0000$. The two color values are now added, creating a single color value of the form $c_1c_2c_3c_4b_1b_2b_3b_4$. Because the last four bits of the combined image (which are the most significant bits of the hidden image) are dominated by the more significant bits, only the host image is seen. The hidden image is concealed within the dominating visible picture. This composite image can then be distributed using normal means. Only a user with prior knowledge of the existence of the hidden image would know to extract this second image. Extraction is trivial, with the bits of each color value for the composite image being shifted to the left by four positions. This can be done using a variety of math or image manipulation software packages, including MATLAB. Figure 4 shows an unmodified image of the space shuttle orbiting the Earth. Figure 5 shows the composite image of the shuttle, along with a secret, hidden image. Figure 6 then shows this secret image after it has been extracted from the composite image, using the method described above. Picture quality for all extracted pictures remains fairly high with very little picture quality being lost at each step during the process. Once again, all encoding examples shown were done by this author using less than 100 lines of MATLAB code.

This method of transmitting hidden images has been used mostly for nefarious purposes. One of the most prevalent uses in the modern age for this method of transmitting information has been to transfer child pornography between computers. As child pornography is illegal throughout the world, people wishing to send this information to someone else must embed it within another image. This method is difficult to detect by all but the most specialized, well-equipped law enforcement agencies. This is unfortunate, as the pornographers can hide images easily and quickly using a normal math package or one of many freeware software tools available on the Internet. There is a growing fear that more and more child pornography rings will go even further underground and begin using more advanced ste ganography techniques to conceal their contraband. Much like other steganography methods, legitimate uses for this technique exist, though. By embedding hidden images within other pictures, digital authors and photographers are now able to digitally “watermark” their work, marking it as their own. These watermarks, which are practically imperceptible, mark only specific parts of certain pixels and are therefore only revealed only when the examiner is looking at the correct pixels. By concealing how and which pixels have been modified, the author is able to maintain a measure of control over his or her own work.

Recent advances have been made in the detection of hidden information in images, though. Most images contain a certain amount of white noise, especially in lower-valued bits. This white noise is present in all photographs, regardless of the quality of the equipment used to generate the photographs. Embedding extraneous images, or even extra text, alters the pattern of this white noise, making each value much more regular than it would otherwise be. By detecting these patterns, it is sometimes possible to determine when an image has been modified to carry extra information. It is also possible to examine a pixel with its two adjacent pixels. In most circumstances, the color difference between these pixels will be minimal. If the difference is more than expected, though, it can indicate that the pixel has been modified to carry information. Both of these methods of steganalysis can be combatted in two main ways. First, by only using a single bit or two from the pixels that are modified, the person doing the embedding can minimize the change that his or her actions have on the overall picture. This will decrease the quality of any embedded images, however, as instead of having four bits of the concealed image, only one or two bits are retained. While this decrease in quality is noticeable, messages embedded in this manner are still recognizable. Another method of concealing steganography is to use only certain pixels. If only every thousandth pixel is used, it is still sufficient to transmit a text message, but is exponentially more difficult to detect and combat. Also, by switching the color used to embed the message, it can be ensured that the message will have a minimal impact on the overall host image. By using only a few bits, for a rotating set of colors, for a minimal amount of pixels, one can pass messages (and reduced quality images) that are nearly impossible to detect. Current steganography techniques vastly outpace detection algorithms.

Although only image steganography applications have been discussed in this essay, nearly any file type can be used to secretly transmit data. Video files are easily encoded to transmit images when they are played a different speed or with a different software program. Audio files can easily be modified slightly to carry extra data to the recipient. Even the method in which the data is transferred (the ordering of packets, the timestamp on certain packets, etc.) can be utilized to carry extra information. These methods, though, are outside the scope of this essay.

Steganography has a history of more than 2500 years. In that time, the techniques have grown more and more complicated, although the goal has remained the same – to transmit extra information without interceptors of a message (or even the messenger) knowing the secret information is present. The field of steganography has played a vital role in several international situations, including both World Wars, but also has a variety of legitimate and illegitimate purposes and applications. Steganography is a relevant area of mathematics and information theory that will continue to play an important part in information transfer in the coming years and decades.

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Math News Briefs

- William (BA & JD, 1974) and Carol (BA, Math, 1973) Brian, of Amarillo, recently established the Brian Family Endowed Scholarship in Mathematics.

- Faculty member Dr. Ray Cannon finished up his one year term as Chair of Baylor’s Faculty Senate. He will now serve as Past Chair during the 2011-2012 academic year.

- Dr. Paul Hagelstein received a 5 year $35,000 collaboration grant from the Simons Foundation.

- Dr. Curtis Kunkel, who graduated with his Ph.D. degree in Mathematics from Baylor in 2007 under the supervision of Dr. Johnny Henderson, was promoted to Associate Professor of Mathematics at the University of Tennessee at Martin.

- Math majors Jaclyn Hazelwood, Brittney Turner, and Michael Kokta were honored in April at the annual Honors Convocation ceremony at the Bill Daniels Student Center.

- Seniors Jaclyn Hazelwood, Brittney Turner, and Samantha Sirignano were honored by the Department during our Spring Student-Faculty Luncheon as the ‘Outstanding Mathematics Majors’ for 2010-2011.

- Senior math education student Chelsea Mitcham was honored by the Department during our Spring Student-Faculty Luncheon as the ‘Outstanding Mathematics Education Major’ for 2010-2011.

- Dr. Brian Raines has been named a Baylor Faculty Fellow for the 2011-2012 academic year. Brian is one of nine Baylor faculty chosen by the Provost in consultation with the Deans. Selection to this program is based on excellence and creativity in teaching.

- Matt Hrna, who graduated in May 2011 with both a double major in Mathematics and Economics and who just recently started his Ph.D. degree in Economics at the University of North Carolina, has taken leave from UNC for medical reasons. Please keep Matt in your thoughts and prayers as he recovers from his recent illness.

Keep in Touch!

We want to hear what you are up to and the role that your experience with the Department of Mathematics has played in your ongoing journey. We invite you to remain active in the life of the department. There are a variety of ways for alumni and friends to be involved.

- Please stay in touch. Our current students welcome information about internships and other opportunities, and students greatly appreciate presentations by alumni and others who talk about their careers and share their insights into the employment landscape. If you are interested in giving a talk to our majors, please contact Lance_Littlejohn@baylor.edu.

- Each of the 27 chairs within the College of Arts and Sciences administers a discretionary fund that directly supports his or her department. If you are interested in contributing to these funds, please contact Lance Littlejohn at Lance_Littlejohn@baylor.edu. Alternatively, you can contact Frank Shannon at Frank_Shannon@baylor.edu or Rose Youngblood at Rose_Youngblood@baylor.edu in university development.

- As we pursue our goal of becoming one of the nation's top mathematics programs, endowed chairs, lectureships, and scholarships can play a very important role. If you are interested in supporting the department through an endowed fund or scholarship, please contact Frank Shannon at Frank_Shannon@baylor.edu or Rose_Youngblood@baylor.edu in university development.

Let us know what you are doing, and share your stories with us. Beginning with our next newsletter, we will have an 'Alumni News' section – so please send me (Lance_Littlejohn@baylor.edu) some 'alumni newsworthy' snippets! We look forward to hearing about your successes!