1 Introduction: Program Review 2003–2004

The Mathematics Department’s last program review was conducted seven years ago, in the fall of 2003 and the spring of 2004. The visiting committee had many complimentary things to say about the Department, especially in light of our limited resources. They suggested a few opportunities to explore, while acknowledging that we were facing challenges that stood in the way of future development and potential improvements. They concluded by offering several recommendations to both the Department and the Administration.

1.1 The Mathematics Department, 2004

The previous reviewers first commended the Department on our contribution to the Mission of the University. Next they assessed the quality of the Department in terms of the faculty, curriculum, department administration, and students.

- Faculty: The scholarship of several of our faculty members was recognized, as was our dedication to our students and the “warm and welcoming environment” we have created within the department.

- Curriculum: We were commended for our service to the university, since 85% of our teaching is devoted to service courses. At the same time, the visiting committee believed that we were serving our majors well by offering a broad range of both pure and applied courses.

- Department Administration: It was noted that, supplemental to the efforts of our enthusiastic chair (Paul Zeitz), other members of the Department had made use of their talents and interests to concentrate on specific programs. One concern was a threat to our collegiality caused by differing faculty opinions concerning the University’s conversion from a three-credit to a four-credit system in 2002.¹

¹It should be noted these disagreements are now a fairly distant memory.
• Students: While the reviewers did not comment directly on the quality of our students, they noted “a remarkable level of enthusiasm for mathematics,” which they attributed to our committed faculty.

1.2 Opportunities
The visiting committee of 2004 suggested that we pursue the following opportunities.

1. Develop new interdisciplinary programs.
2. Increase the diversity of the faculty.
3. Create a colloquium program.

1.3 Challenges
It was acknowledged by the 2004 visiting committee that our Department faced several challenges that stood in the way of pursuing the suggested opportunities. As previously mentioned, many of these challenges still exist today.

1. Space. The insufficient size of many of the faculty offices and the lack of overflow space other than the department office were singled out as major hindrances to being able to properly accommodate the needs of both the faculty and our students.

2. Technology. It is extremely challenging to incorporate technology into the curriculum when so few of the classes are able to meet in a room equipped with even a single computer for projection.

3. Number of Regular Faculty. The Department must rely heavily on part-time faculty to deliver many of the service courses. Also, an increase in the number of tenure track faculty is needed in order to achieve goals such as new programs.

4. Decision-making. The reviewers felt that the Department needed a better forum for discussing issues and resolving any grievances.

1.4 Recommendations
The report of the visiting committee concluded with the following recommendations.

1. That the University solve the Department’s space problems.
2. That the University provide two new faculty positions.
3. That the Department pursue the opportunities previously outlined.
4. That the Department review its decision-making procedures.

For the Department, they also suggested that we discuss the use of technology in Calculus, set basic standards for each of the courses in our major so as to smooth transitions from one course to the next, continue our efforts to recruit more majors, do a better job at educating our majors about summer research opportunities, and have more faculty involvement in the allocation of teaching assignments each semester.

For the Administration, in addition to solving our space problems and hiring more tenure track faculty, they also suggested that our major program receive extra support in some way that would serve as a reward for our tremendous service to the University. Ideas included allowing courses with low enrollment to remain in the schedule, supporting an Honors Calculus course or first-year seminar for potential majors, providing greater access to technology, funding a colloquium series, and allowing for ample faculty input for ameliorating our space shortage.

While there have been some changes in the Department in the past seven years, mostly for the better, many of the challenges faced by the Department in 2004 still remain. For that reason, our current Self-Study and Preliminary Development Plan will re-visit many of the issues that were addressed in 2004.

# 2 The Math Department, 2004–2010

## 2.1 The State of the Department

The past seven years have transformed our department, much of it in positive directions. There are a number of continuing issues, but we hope that the department and the University can address them and continue its journey forward. Much of this material will be discussed in more detail later in this report.

### 2.1.1 Progress

We’ll begin with a brief enumeration of the progress the department has made since the last program review.

- **New Faculty.** The Department has been very fortunate to hire three new faculty: Stephen Yeung, Cornelia Van Cott, and Jennifer Chubb. They are all excellent mathematicians and superb teachers. Their energy and enthusiasm have already contributed to improved morale among students and faculty.

- **Changes to the Curriculum.** There have been some changes to the curriculum since the last program review. Among these are the introduction of a new core course, Great Ideas in Mathematics. This course was designed by Steve Devlin for students with weak backgrounds in mathematics. We routinely fill two thirty-five student sections, and next fall we’re planning to offer three sections. One of our adjunct faculty, Dayna Soares, has introduced a
new core course, Real World Mathematics. In addition to fulfilling the core mathematics requirement, it also fulfills the Service Learning requirement by involving students in the community through activities such as tutoring. Paul Zeitz’ course, Mathematical Circles, also fulfills the Service Learning requirement by having our students work with local high school students. It exposes students to Eastern European problem-solving methods.

One of the biggest changes to the curriculum was the elimination of mandatory Mathematica labs in Calculus I and II. This change was made at the request of some of the other science departments who felt that the technology was distracting the students from learning basic methods of differentiation and integration.

The major has been made more demanding: students are now required to take either Real Analysis or Modern Algebra. They must also take a total of six instead of five upper division courses. Students are now required to take a course with a significant computational component: currently either Introduction to Computer Science I or Computational Physics.

• **Recognition.** During the past seven years, several members of the Department have received recognition both within and outside the University.

  – Paul Zeitz was invited to give the keynote address at the First World Mathematics Team Championship in Beijing in 2010.
  – Jennifer Chubb received a grant from the Association for Women in Mathematics so that she could travel to Ponta Delgada for the Computability in Europe meeting and the Workshop in Computability Theory in the summer of 2010. She gave a one-hour invited talk at the Workshop.
  – In 2009 the Association of Jesuit Colleges and Universities and the Alpha Sigma Nu, the honor society of Jesuit Colleges and Universities gave John Stillwell its National Book Award for mathematics and computer science.
  – Benjamin Wells won the University’s Distinguished Research Award for 2008-2009.
  – In 2005 the MAA awarded John Stillwell the Chauvenet Prize for an outstanding expository article.

• **Colloquium.** Steve Devlin took it upon himself to start a department colloquium in the spring of 2009. He and Cornelia Van Cott continued the colloquium last year, and Cornelia has been organizing it this year. Just this semester we’ve had the following speakers and talks:

  – Alon Amit, “Quaternion numbers: history and applications.”
  – Federico Ardila, “Matroids as a theory of independence.”
  – Ben Alamar, “Making sports as fun doing your taxes: How statistical analysis is used to build teams, plan for opponents and give fans more to argue about.”
• **Pi Mu Epsilon.** Steve Devlin also took it upon himself to found a chapter of the math honor society at USF. Each spring there’s a meeting for the induction of new members followed by a department party.

• **Math Tea.** The Department has been having a weekly “tea” for quite some time now. There can be little doubt that this contributes greatly to the esprit de corps among the majors.

• **Mathematics and the University Mission** Our program continues to be consistent with the University’s Mission. Mathematics attempts “to pursue truth and follow evidence to its conclusion” (Core Value #2), and our Department in particular believes in “learning as a humanizing, social activity rather than a competitive exercise” (Core Value #3). And like other departments at USF, we strive to become truly outstanding, to move our University toward its goal of being “internationally recognized as a premier Jesuit Catholic, urban University” (Vision Statement).

2.1.2 **Issues**

In spite of all the good news, there *are* some problems, some of them of long standing:

• **Space.** In spite of some modest improvements in Department offices, some of us continue to work in offices that the previous team of outside reviewers characterized as “grossly inadequate.” In addition to inadequate faculty offices the department office is far too small for our weekly math teas: frequently participants are forced to stand. Furthermore, there is no space dedicated to math student use. Thus, there is no convenient space for such fundamental morale-builders as group study, group discussion, and informal socializing.

The administration has taken some steps to address these issues. The new “Center for Science and Innovation” should provide two rooms dedicated to Math Department use, and these rooms should provide better accommodation for both the math tea and student gatherings. Ground-breaking is scheduled for December, 2010, but it will be several years before the building is completed. In addition, there are no immediate plans to improve faculty offices.

The previous associate dean for sciences, Brandon Brown, devised a plan to remodel the two groups of mathematics offices on the second floor of Harney. At the cost of fewer offices, the remodeled space would provide two additional offices with windows. Unfortunately, the price tag for this remodel is currently $250,000, and the University can’t afford this. Furthermore, even if this plan were implemented, two of our current full-time faculty and any future hires would still have inadequate offices.

• **Faculty.** The Department places far too much reliance on part-time faculty. As an extreme example, in the spring of 2011, we anticipate offering fourteen classes taught by full-time
faculty, and nineteen classes taught by part-time faculty. Indeed the figures would be worse if we compared SCH instead of classes, since the part-time faculty almost invariably teach crowded service courses, while full-time faculty often teach relatively small upper-division classes for majors.

While some of our part-time faculty are excellent teachers, the Department and the University don’t have the resources to routinely monitor their performance. Also since the part-time faculty are paid so little, they must work elsewhere, and consequently cannot participate in department activities.

In 2004 the outside reviewers recommended that the University hire two new regular faculty. Unfortunately, in spite of the fact that we have hired three new regular faculty, we have lost four, and what should have been a net gain of two regular faculty is, in fact, a net loss of one.

- **Service Courses.** The Department teaches far more service courses than any other department in the sciences. Inter alia, this means that our faculty must teach large numbers of students with no interest or aptitude for mathematics.

- **Majors.** There has been little change in the number of majors. Our faculty are quite popular, and after taking calculus or precalculus a few students from other disciplines decide to change their majors to mathematics. But this isn’t nearly enough. Every semester we struggle to fill our upper division courses. Indeed, many students manage to fulfill the requirements for the major only by taking directed studies in upper division courses.

- **Technology.** It has become much easier to use computers in the classroom, since more classrooms are equipped with projectors. However, hands-on work by the students remains a challenge. In the service courses such as Elementary Statistics and Quantitative Methods in Business, class sizes are too large to permit faculty to give computer examinations, and in the classes for majors, the lab with mathematical software installed on the computers is too small for individual student access to the systems. Perhaps most disturbing, the University is trying to make WiFi access ubiquitous. Yet the Mathematics department remains a dead zone.

## 2.2 The Faculty

During the past seven years (2004-2010), the Department of Mathematics has been highly productive, despite continuing pressure from short staffing. Here are summaries of of faculty achievements and productivity, followed by biographical sketches. Curricula Vitae may be found in an addendum to this Review. The section concludes with an analysis of some staffing difficulties that we have had, and may continue to have.

### 2.2.1 Faculty Awards

As we observed earlier, the faculty have been recognized both within and outside the University:
• Paul Zeitz was invited to give the keynote address at the First World Mathematics Team Championship in Beijing in 2010.

• Jennifer Chubb received a grant from the Association for Women in Mathematics so that she could travel to Ponta Delgada for the Computability in Europe meeting and the Workshop in Computability Theory in the summer of 2010. She gave a one-hour invited talk at the Workshop.

• In 2009 the Association of Jesuit Colleges and Universities and the Alpha Sigma Nu, the honor society of Jesuit Colleges and Universities gave John Stillwell its National Book Award for mathematics and computer science.

• Benjamin Wells won the University’s Distinguished Research Award for 2008-2009.

• In 2005 the MAA awarded John Stillwell the Chauvenet Prize for an outstanding expository article.

Note that this is the second national book prize and second national distinguished writing award for our department since 1996, and the third DRA since 1986.

2.2.2 Faculty Productivity

Of eleven fulltime faculty members, nine were very active in pedagogical development, scientific research, and professional service. Together we published 16 articles in peer-reviewed journals, half as single authors. Nine additional refereed articles were published in books and conference proceedings, and there were 25 reviews, abstracts, and other published articles. The faculty wrote or edited 7 books, translated (or had translated) another 3 books, and created one DVD lecture series for national commercial distribution. We contributed 9 book chapters. We have admitted to 7 papers and 4 books in progress, many with scheduled publication dates.

Fourteen patents issued with our faculty as inventors. We have been awarded 9 external research grants and have conducted 8 funded research programs. Steve Devlin guided 8 undergraduates in five original research projects. Besides the awards listed above, younger faculty members won 8 grad school prizes in the last few years for research, writing, and teaching.

Invitations led to 67 local/national and 7 international lectures, and we gave 9 more domestic and 6 more international talks.

We organized conferences, served on program committees, or gave workshops at 21 events, and served as referees or wrote reviews for publishers 22 times. The total number of society memberships reported is 29.

The faculty created 10 new math courses and reoriented many others. Their current and recent research interests include:

• Complex networks
• Computability
• Computable structure theory
• Dynamical systems theory
• Josephson junction arrays
• Sigma-delta data converters
• Equational logic
• Game theory
• Geometry
• History of mathematics
• Hypercomputation
• Knot theory
• Logic
• Low-dimensional topology
• Parallel programming
• Problem solving
• Quantum computing
• Recursion theory
• Tongue twisters
• Universal classical computers
• Visual differential geometry
2.2.3 Biographical Sketches of Faculty

Jennifer Chubb (Assistant Professor) is the newest member of the Mathematics faculty. Her general research area is logic and recursion (or computability) theory, and she has a particular interest in computable structure theory.

She holds a B.S. in Physics and Applied Mathematics, and an M.S. in Applied Mathematics from George Mason University. While pursuing those degrees, she worked in experimental physics and studied chaos and nonlinear dynamics. She received her Ph.D. from George Washington University, where she studied logic and computability theory in the Department of Mathematics.

Renée Brunelle Hubert (Instructor) received a BS in mathematics from the University of San Francisco in 1994 and an MA in pure mathematics with emphases in algebra and complex analysis from the University of California, San Diego in 1997 where she was a recipient of the Cota Robles Fellowship. During her thirteen years of term faculty appointments at USF, she has specialized in teaching the Department’s service courses. As one of the few full-time faculty members who regularly teaches these courses, she has been involved in curricular planning, integrating the use of technology, and mentoring adjunct faculty.

Stephen Devlin (Associate Professor) grew up in New York and graduated from Manhattan College. He went on to earn a Ph.D. in representation theory at the University of Maryland, and was a C.L.E. Moore Instructor at M.I.T. before joining the faculty at USF in 2004. His recent interests include complex networks and game theory.

Tristan Needham (Professor), son of the distinguished social anthropologist Rodney Needham, grew up in Oxford, England, where he attended the Dragon School (with Stephen Wolfram and Hugh Laurie). He studied physics at Merton College, Oxford, before moving to the Mathematical Institute, where he enjoyed the great privilege of studying black holes under the supervision of Sir Roger Penrose. Tristan received his D. Phil. in 1987, and joined the faculty of the University of San Francisco in 1989. His current focus is Differential Geometry, but Complex Analysis, General Relativity, and the history of science are abiding loves. His continuing mission is to seek out new intuitive forms of understanding, and new visualizations.

His book Visual Complex Analysis won first prize in the National Jesuit Book Award Competition. An earlier paper received the Mathematical Association of America’s Carl B. Allendoerfer Award.

Stanley D. Nel (Professor) grew up in South Africa, and studied Cosmology under George Ellis at the University of Cape Town, where he earned a Ph.D. in Applied Mathematics. As a Rhodes Scholar at Balliol College, Oxford, he performed research as a member of Roger Penroses Relativity Group at the Mathematical Institute. His papers have focused on the
observational foundations of cosmology, and on techniques for obtaining solutions of Einsteins field equations in General Relativity. He joined the Mathematics Department at USF in 1983, and served as Dean of the College of Arts and Sciences 1990-2003. He is currently the Vice President for International Relations at the University of San Francisco, working from Bangkok and now Beijing.

**Peter Pacheco** (Professor) received a Ph.D. in mathematics from Florida State University. His main research interest is parallel computing. He’s been involved in the development of the MPI Standard for message-passing. His book *Parallel Programming with MPI* is an elementary introduction to programming parallel systems that use the MPI 1 library of extensions to C and Fortran. His book *An Introduction to Parallel Programming* is designed to teach inexperienced programmers how to program both shared- and distributed-memory parallel systems.

**John Stillwell** (Professor) was born in Melbourne, Australia, and taught at Monash University from 1970 until 2001, before moving to USF in 2002. He was an invited speaker at the International Congress of Mathematicians in 1994, and his mathematical writing has been honored with the Chauvenet Prize of the Mathematical Association of America in 2005 and the book award of the Association of Jesuit Colleges and Universities in 2009. Among his best-known books are *Mathematics and Its History* (3rd edition, 2010) and *Yearning for the Impossible* (winner of the AJCU book award in 2009).

**Cornelia Van Cott** (Assistant Professor) received her undergraduate degree from Wheaton College (Wheaton, Illinois), where she majored in mathematics and minored in music. She did her graduate studies in math at Indiana University, getting a Ph.D. in 2008. She joined USF in the fall of 2008. Her research is in geometric topology with a focus on knot theory. She organizes the Math Department Colloquium Series together with Steve Devlin and enjoys giving talks to undergraduate math clubs at colleges in the area.

**Benjamin Wells** (Professor) teaches both mathematics and computer science courses as a member of both departments. He regularly teaches freshman seminars that combine science and art. He holds mathematics degrees from MIT and UC Berkeley and has studied in four countries. He won the 2008-2009 Distinguished Research Award jointly sponsored by USF and USFFA, becoming the third Mathematics and first Computer Science faculty member to do that. He won a John Templeton Foundation science and religion course prize (1998) and held the USF Davies Professorship (1989). The last student of noted logician Alfred Tarski, Wells works on the boundary of logic, algebra, and computing; he also contributes to computer graphics, visual communication, hypercomputation, math and art, and classic computers.

His current research is centered on the USF Fusion Project, a distinct program of the College of Arts and Sciences with the collaboration of the School of Education. The goal is to
improve middle school math education by connecting classrooms with art museums and other agencies, especially the de Young Museum.

He enjoys mysticism, cooking, hiking, languages, travel, tales, and a rich life with dancers.

**Robert Alan Wolf** (Assistant Professor) graduated from the Massachusetts Institute of Technology in 1962 with an SB degree in mathematics. From the University of California at Berkeley, he received a master’s degree in 1964 and a doctorate in 1968, both in mathematics. He received an MS degree in physics in 1990 from San Francisco State University in 1990. He is interested in the mathematical and physical sciences.

**Stephen Yeung** (Associate Professor) received his B.Sc. from the Chinese University of Hong Kong and his Ph.D. from Cornell University. He has diverse research interests, having worked on dynamical systems theory including coupled oscillators, Josephson junction arrays, injection lasers, and sigma-delta data converters, on which he is a co-inventor on two patents. He has also developed algorithms to analyze microarray data to reconstruct gene regulatory networks efficiently.

**Paul Zeitz** (Professor) majored in History at Harvard and received a Ph.D. in Mathematics from the University of California, Berkeley, in 1992, specializing in ergodic theory. Between college and graduate school, he taught high school mathematics in San Francisco and Colorado Springs.

One of his greatest interests is mathematical problem solving. He won the USA Mathematical Olympiad (USAMO) and was a member of the first American team to participate in the International Mathematical Olympiad (IMO) in 1974. Since 1985, he has composed and edited problems for several national math contests, including the USAMO. He has helped train several American IMO teams, most notably the 1994 "Dream Team" which, for the first-and only-time in in history, achieved a perfect score. This work, and his experiences teaching at USF led him to write *The Art and Craft of Problem Solving* (Wiley, 1999). He has also been very active in local events for high school students. He founded the Bay Area Math Meet in 1994 and co-founded the Bay Area Mathematical Olympiad in 1999.

Recently, he has focused on two different projects: expanding mathematical enrichment to underrepresented populations, and promulgating Eastern European "math circles" culture. With regards to the former, he founded the San Francisco Math Circle in 2005, under the auspices of the Mathematical Sciences Research Institute and with generous funding from the Moody’s Foundation and Bechtel Foundation. This project serves over a hundred students and a dozen teachers in several locations around the city. Also, he created a service-learning class, Mathematical Circles, which helps to train students to teach in this program. With regards to the latter, he has worked extensively in teacher-training programs around the country, and serves on several editorial boards, and most recently edited and helped to translate the American edition of a celebrated Russian work, *Malyshi i Matematika* ("Kids and Math"), by Alexander Zvonkin.
When not doing mathematics, he enjoys outdoor adventures with his wife (a former park ranger) and his two children.

2.2.4 Problems Faced by Faculty

Our department has been blessed with a friendly, collegial, and talented faculty. A healthy faculty culture is crucial for the life and growth of the department. Although we have hired excellent young teachers and researchers in Chubb, Van Cott, and Yeung since the previous program review, there are challenges. Pacheco and Wells are effectively half in Math and half in CS, and both have their offices on the fifth floor of Harney Science Center, geographically and socially somewhat distant from the Math department, anchored on the second floor.

Wells is planning on retiring at the end of 2010–11. Hubert will be on a leave-of-absence in spring 2011, and Chubb during 2011–12. Hubert continues on term appointments, which does not diminish the valuable role she plays in teaching lower division courses excellently. Others are planning sabbatical leaves. Although still listed as a member of our department, Nel will continue as Vice President for International Relations, living abroad.

2.3 The Curriculum

2.3.1 Service curriculum

All USF students are required to take four units in math or a quantitative science as part of the Core Curriculum. Courses satisfying this requirement comprise the majority of courses taught by the math department, and we list them below. Highlights in the service curriculum include the two first-year seminars and Math 190, Real-World Mathematics, which are described in more detail.

- Math 100 Great Ideas in Mathematics
  This course was added to the curriculum in 2007 by Steve Devlin. The course overviews some of the seminal achievements in mathematics from ancient to modern times. Topics include number theory, geometry, fractals, topology, probability, and statistics.

- Math 101 Elementary Statistics
  This course is required for nursing and sociology majors.

- Math 102 Biostatistics
  This course is required for biology majors.

- Math 104 Algebra for Business & Science
  This course is a prerequisite for students whose test scores upon entering USF are not high enough to take other required math courses.
• Math 105 Mathematics for Educators
  All students in the Dual Degree in Teaching Preparation Program at USF are encouraged to take this course to fulfill their Core Curriculum math requirement.

• Math 106 Quantitative Methods in Business
  This course is required for all students in the USF Business School.

• Math 107 Calculus for Liberal Arts
  This one-semester introduction to calculus is designed for non-science majors. Students majoring in architecture and community design and students minoring in architectural engineering are required to take either this course or Math 109 Calculus and Analytic Geometry I.

• Math 108 Precalculus

• Math 190 Real-World Mathematics
  This course covers topics in quantitative literacy, financial mathematics, and statistics. Students also study how these topics relate to social justice issues (for example, predatory lending and income inequality). Readings include *What the Numbers Say* (Niederman and Boyum) and *Radical Equations: Math Literacy and Civil Rights* (Moses and Cobb). In addition to classwork, each student volunteers in the community on a related project. Typical projects include volunteering at Seven Teepees Youth Program or the Network for Teaching Entrepreneurship. Students help these organizations develop curriculum on financial literacy. This course meets the Service Learning Requirement from the Core Curriculum. (All USF students are required to take one course with a service learning component.)

• Math 195 First-Year Seminar
  Two of our faculty members, John Stillwell and Benjamin (Pete) Wells, have consistently taught seminar courses in the fall semesters for incoming freshmen.

  Stillwell’s seminar is titled *Mathematics & the Impossible*. This course is a novel introduction to mathematics and its history. It tackles some of the most difficult ideas in math head on: the seemingly impossible concepts of irrational and imaginary numbers, the fourth dimension, curved space, and infinity. By focusing reason and imagination on several apparent impossibilities, the course aims to show interesting math to students whose major may be in another field, and to widen horizons of math students whose other courses are necessarily rather narrowly focused.

  Wells’s seminar is titled *Mathematics & Esthetics*. The course examines art and mathematics along three orthogonal axes of space (geometry and cosmology), time (dynamics, chaos, and fractals), and light (reason, order, symmetry, illusion, and paradox). There are numerous field trips to museums and other activities (fractal field hunts, concerts, movies) and class
visits by Bay Area practitioners of art and science. An additional lab period allows software and web exploration of topics under the guidance of a previous student as TA and extra time for field trips.

- Math 202 Linear Algebra & Probability
  
  This course is required for computer science majors. It is a combination of matrix algebra, geometric applications of linear algebra, and topics in probability.

2.3.2 Curriculum for Math Majors

Courses  The complete list of courses taught for math majors is as follows:

- Lower division courses
  - Math 109 Calculus & Analytic Geometry I
  - Math 110 Calculus & Analytic Geometry II
  - Math 130 Elementary Linear Algebra
  - Math 201 Discrete Mathematics
  - Math 211 Calculus & Analytic Geometry III
  - Math 235 Introduction to Formal Methods

- Applied mathematics courses
  - Math 340 Differential Equations
  - Math 345 Mathematical Modeling
  - Math 370 Probability and Statistics
  - Math 422 Combinatorics

- Classical mathematics courses
  - Math 310 History of Mathematics
  - Math 314 Mathematical Circles (Problem Solving)
  - Math 355 Complex Analysis
  - Math 367 Number Theory
  - Math 380 Foundations of Geometry
  - Math 435 Modern Algebra
  - Math 453 Real Analysis
  - Math 482 Differential Geometry
As we noted earlier one of the biggest changes to the curriculum was the elimination of mandatory Mathematica labs in Calculus I and II. This change was made at the request of some of the science departments. They felt that learning to use the software was distracting students from learning basic techniques of differentiation and integration.

One course on the above list which is unique to USF is Math 314 Mathematical Circles. This course is taught by Paul Zeitz using his book *The Art and Craft of Problem Solving*. Students in the course spend the semester exploring problem solving methods. In addition, they volunteer outside of class time with junior high and high school students in the San Francisco Math Circles program. This course meets the Service Learning Requirement from the Core Curriculum.

The courses in the department’s curriculum are offered at differing intervals. Calculus I and Calculus II are offered every semester. Calculus III, Linear Algebra, and Formal Methods are offered once a year. All upper division courses are offered *every two years* to keep enrollments up. The infrequency of class offerings (and the occasional canceling of a course due to low enrollment) can be problematic for students who need particular classes for graduation or as prerequisites. As a result, students often ask faculty members to teach independent studies on the needed topics. Steve Devlin, John Stillwell, and Paul Zeitz have taught several such independent studies over the years.

**Requirements**  
Math majors are required to take three semesters of calculus, linear algebra, and a proof writing course. Beyond this, students must take six upper division math courses. One of these six courses must be either modern algebra or real analysis. A second course must be in applied mathematics, and a third must be in classical mathematics. In addition to these math courses, majors are required to take one computational course (for example, CS 110 Introduction to Computer Science), and students must participate in one semester of an approved activity related to mathematics (for example, tutoring or grading for the department). Altogether, the major requires 48 units of coursework.

These requirements for the math major have changed somewhat since the last report in 2003. The main changes are the requirement that one of the students’ upper division courses must be either modern algebra or real analysis, the requirement that a student take six instead of five upper division courses, and the requirement that all majors take a course with computational component.

The department offers an honors major, as well. To complete the honors major, students must satisfy all the requirements for a math major and additionally take two semesters of calculus-based physics and three more upper division math courses, including at least one 400-level course.

### 2.3.3 Beyond the Requirements

At times, students request independent studies that cover deeper mathematical topics not in the standard curriculum. Recent topics include:

- Advanced linear algebra (taught by Steve Devlin)
• Complex networks (taught by Steve Devlin)
• A survey of knot theory (taught by Cornelia Van Cott)
• The prime number theorem (taught by Paul Zeitz)

Occasionally, the interest level in special topics is high enough to create a special topics course. Recent examples include a course on nonlinear dynamics and chaos, taught by Stephen Yeung in Spring 2009, and a course on quantum computing, which will be taught by Jennifer Chubb in Spring 2011.

Another area of activity for the department has been undergraduate research. Steve Devlin has been actively involved in several research projects with undergraduates. The following is a list of recent projects he has done with students:

• Alex Wong (Spring/Fall 2005)
  Project: Evolutionary game theory.
  Result: Alex gave a talk on his results at the Northern California Undergraduate Mathematics Conference.

• Marisa Keller (Spring/Fall 2005-2006)
  Project: Voting theory and representation theory.
  Result: Marisa gave a talk on her results at the Northern California Undergraduate Mathematics Conference.

• Dustin Kerksieck (Spring/Fall 2006)
  Project: Evolutionary game theory on networks.
  Result: Dustin gave a talk on his results at the Northern California Undergraduate Mathematics Conference.

• Brendan Foley (Spring 2007 - 2008)
  Project: Evolutionary games on big graphs.
  Result: Brendan gave a talk on his results at the Northern California Undergraduate Mathematics Conference, and at the Pacific Coast Undergraduate Mathematics Conference.

2.4 The Math Majors

Between 2003 and now, the number of and composition of our math majors did not change much in any significant way, although our yield (graduates) did increase. Details below.

2.4.1 Profile of Math Majors, 1994–2003 and 2003–2010

In the last self-study, we reported that 75 math majors graduated from USF in the 10-year period from 1994 to 2003. The numbers improved rather dramatically during the most recent 7-year
period (2003-2010), with 95 majors graduating. So the average number of graduates per year increased by more than 60 percent! However, this must be tempered with the extreme variability; the number of math-major graduates has fluctuated from 3 to 16 in a single year. Also, the actual number of reported majors and minors has not changed in any statistically significant sense: the total number of minors — with the exception of 2002, evidently a fluke — has remained below 40, but rarely below 30. See Figure 1. The average has not changed when compared with our last self-study, although the fluctuations are smaller. Perhaps our greater average number of graduates therefore is evidence of greater morale and retention of majors.

Between 1994 and 2003, we depicted the “average” math major as a female with a math SAT score in the mid-660s. This is still the case. The SAT scores have not changed, and we still have somewhat more female than male students. The quality of the majors at the top end has continued to be good, with our top students getting into good graduate schools (e.g., UC San Diego, Boston University), and continuing to score well on the Putnam, although we have not had any teams matching the performance of 2000.
2.5 Attracting Majors

In the last two self-studies (1993 and 2003) we articulated the need to get more math majors. Objectively, we have not succeeded, although we are not moving backwards, and can be proud of modest increases in the number of graduates. However, we don’t deserve to be very proud, because we neither understand nor have control over these trends (if indeed they are trends). Since 2003, we have changed our faculty, adding four dynamic, younger people. Our faculty are active on- and off-campus, our majors appear to have good morale and our classes appear to have good reputations. But clearly, this is not sufficient. In order to truly change the number of majors, we need a much more aggressive and focused recruitment effort, with assistance from the Admissions office.

2.6 The Role of Technology

2.6.1 Introduction

The use of technology as an instructional tool, as part of the curriculum, and in research and scholarship is now the industry standard in academics. In many of our courses, trips to the computer lab to learn software constitute a substantial portion of the course; interactions with our students are often via electronic channels (e.g. Blackboard, Banner, email, etc.), and often the subject of discussion is software. In this section, we identify, explain, and discuss several technology-related issues that affect the USF Mathematics Department and its students.

2.6.2 Smart classrooms

USF provides outstanding classroom technology in the form of Smart classrooms, nearly all of which are equipped with an online computer, LCD projector, and other audio/visual equipment. These devices are utilized by math department faculty during lectures to demonstrate software (like Mathematica and Excel) and explain how to use it, and to aid students in visualization and understanding concepts by using web-based tutorials or other content, as well as electronic content and visualization aids generated by USF faculty in specialized mathematics software applications.

2.6.3 Basic computer labs/classrooms

Part of the curriculum for many of our core courses (101 and 106, especially) includes instruction in Microsoft Excel 2007 and Smart classrooms are invaluable for these courses. Classes also meet regularly in computer labs for instructional and assessment purposes. One issue instructors for these courses have struggled with is that the size of the computer labs for these courses (each contains 20 computers for student use) is not usually adequate as enrollment for these courses always exceeds this number. This semester, for example, enrollments in Math 101 are 40, 33, 27, 26, 25, 24, 24, and 22. Enrollments for Math 106 are 28, 27, 26, 25, 25, 24, 23, 23, and 22. Classrooms with 30 computers equipped with Excel would accommodate nearly all sections.
and make it possible for students to work without sharing computers, which some faculty feel too frequently leads to an imbalance in learning and contribution to the work at hand. Computer classrooms of this size would, in addition, make more feasible Excel-based exams and quizzes under standardized conditions.

2.6.4 Computer classroom/lab for majors and mathematics software

USF supports faculty by providing licenses for specialized mathematics software that we use both in our research and in the classroom. The University similarly supports students by providing access to such software on a limited number of computers in a lab in the Computer Science Department (Harney 530). We are thus able to create visualization aids for demonstration purposes and acquaint USF students with sophisticated tools used in mathematics. Many of our students have never seen specialized mathematical software (e.g. Mathematica, Maple, MATLAB), nor used the command-line style interface employed by most of them. Courses for mathematics majors often introduce students to, and some require them to use, software that is available in Harney 530. Though the ubiquitous Smart classrooms are wonderful for demonstrating the software, these students benefit tremendously from one or more meetings in a computer lab where supervised and guided exercises can be carried out while they try to navigate the interface for themselves. Harney 530 contains 12 computers that run Mathematica, and provides access to other specialized software for both computer science and mathematics students. It is not, however, large enough for many of our classes to meet in. For example, enrollments in Calculus I & II this semester are 37, 26, and 24; Linear Algebra has 23 students.

2.6.5 Wireless access in the Math Department

USF provides wireless access to students and faculty on campus. In most locations signal strength is outstanding and this is an extremely valuable and useable tool for all of us. Unfortunately, wireless access in the Math Department in Harney is just not up to par. It is often difficult or impossible for students at office hours to access USFConnect on their own computers, get help with Blackboard, find things (like the Excel or Mathematica homework they worked on in the computer lab) in their email, etc. Our weekly Math Tea (attended by students, faculty, alumni, and guest speakers) is currently held in a room with no computers and no access to the USF wireless network at all, which, frankly, can be rather frustrating for a roomful of nerds.

2.6.6 Lynda.com access

The USF Center for Instruction & Technology is currently reviewing a web-based instructional resource called Lynda.com, which would provide an outstanding resource for students in our courses with Excel-based curricula, as well as faculty and students in general. Lynda.com is an online collection of training videos and tutorials providing introduction and instruction in a huge variety of applications, software, and programming. Of particular interest for our department would be the extensive repository of instructional videos for basic and moderately sophisticated Excel tasks.
Faculty teaching Math 101, 106, and similar courses routinely develop elaborate lab exercises that include detailed guided instructions for users new to Excel, which is extremely time consuming. Often it is necessary to explain these basic tasks a multitude of times to individuals who fail to attend the instructional lab meetings, were sharing a computer and did not internalize what was happening, or simply forgot how to do something. Some faculty have recorded and made available to students via Blackboard demonstration videos for some of the most frequently and repeatedly asked questions. All of this is time consuming though, and the high-quality training videos available on Lynda.com could prove a valuable resource. We hope the University will elect to subscribe to Lynda.com so that our students (and selves) will have access to this invaluable tool.

2.6.7 Math space in CSI

In the new Center for Science & Innovation space, two rooms have been allocated to the Mathematics Department, and one is intended to provide a work area for mathematics students and a possible new location for the (perhaps overly cozy) weekly Math Tea. In this new facility, and in particular in the room where our students are likely to be working and meeting with faculty to talk about mathematics, we hope to have available a small number of computer stations with specialized mathematics software in addition to Mathematica, MATLAB, and Maple-type general purpose math software. A room like this with space for students to work (tables, chairs, boards), a couple of computers with sophisticated math visualization software, and an LCD projector and screen would provide a much-needed environment for group and individual work, one-on-one teaching, special seminars, and perhaps the weekly Tea.

2.6.8 Technology use by faculty

USF’s generous faculty computer replacement policies have provided the members of our department with modern equipment greatly facilitating all aspects of our work.

Both Wells and Pacheco use computing in their research that goes well beyond word processing and typesetting (which we all do, of course): Pacheco’s research is in parallel scientific computing. He has made extensive use of parallel computers at remote sites as well as local use of a 32-processor nCube, the 128-processor Keck Cluster, and, most recently, the 96-core Penguin Cluster. In most of his research he has involved mathematics and computer science majors as developers of parallel software. Wells uses Maya (and similar software) for his work in mathematical art and fractal research.

Many faculty implement technology in the design of their lectures, either in giving demonstrations of software (e.g., Excel and Mathematica), or by using slides to present material. Chubb projects as she writes on a tablet PC so that the written lecture notes may be posted on Blackboard for later review and study by students.

All faculty make use of technology in routine University-related matters, and are occasionally hindered by problems encountered within the USF system. Advisortrac is a particularly clunky and time-consuming application to use, as are Banner and the current version of Blackboard (though
next Fall will see the release of the new and much improved *Blackboard Learn*, Release 9.1, at USF. *Advisortrac* is a mechanism for tracking at-risk students’ performance and reporting on their performance to the administration midway through the semester, inarguably an extremely worthwhile endeavor. Unfortunately, it is not optimized for usability and makes this a much more tedious and time-consuming process than it should be, discouraging many from completing an important task. *Banner* (which manages enrollment and a host of other faculty, student, and employee data and services) is similarly cumbersome, and together these applications use up seconds and minutes from the already very full schedules of all USF faculty.

3 Summary

For the sake of clarity and brevity, this summary will take the form of bullet points, broken down according to the topics contained in the preceding sections.

3.1 Progress

- Three new faculty.
- Three new courses for the “Core” and “Service Learning”.
- Several faculty recognized with honors and awards.
- Mathematics Colloquium series successfully launched.
- USF chapter of Pi Mu Epsilon founded.
- Weekly Math Tea successfully continued into its 20th year.

3.2 Issues

- There has been no improvement in what previous reviewers called “grossly inadequate” space: this applies to both faculty offices and meeting space for students. Former Associate Dean Brown proposed a concrete (partial) solution to the windowless faculty offices, but what appears to be a gross overestimate of the cost (the Administration claims it is $250,000) has mired this plan for several years now.

- The Department’s dependence on part-time faculty (already the most extreme of all the sciences at USF) has only worsened, because, despite the new hires, retirements have led to a net loss of one full-time faculty member.

- While the quality and the morale of the majors remains high, their number remains far too small for the good health of the program: several courses have to be offered less frequently
than students need, and upper division courses often have such low enrollments that they risk (and sometimes suffer) cancellation by the Dean’s Office.

- Inadequately sized and equipped computer labs block better integration of technology into the mathematics curriculum. Also, the Mathematics Department Office (where students meet, work, and socialize) continues to be a WiFi deadzone.

3.3 The Faculty

- Three faculty members have received national awards from the MAA; two have received national book prizes; and others have received significant honors of other kinds.

- Almost all of the eleven members of the full-time faculty have been very actively engaged in successful scholarly work, yielding the long catalog of books, papers, grants, patents, talks, etc., detailed in Section 2.2.2.

- The atmosphere in the Department continues to be remarkably friendly and collegial: faculty assist each other with ideas for their scholarly work and their teaching, and socialize with each other off campus. The students clearly sense this camaraderie, and this helps to create a feeling of family within the major.

- Challenges include the fact that two full-time professors only teach half-time in Mathematics, and their offices are not located within the Mathematics Department; Nel is a Vice President of the University, and a professor in name only; and while we are immensely proud to have Stillwell on our faculty, he nevertheless teaches at USF for only half the year. The greatest challenge remains the high ratio of part-time to full-time faculty.

3.4 The Curriculum

- The majority of course sections offered by the Department each semester are service courses taken by non-majors, most of whom are not even science majors, in order to fulfill the 4-unit mathematics requirement in the “Core Curriculum.”

- Highlights within the service courses are two first-year seminars, “Great Ideas in Mathematics,” and “Real-World Mathematics.”

- Mathematica labs have been removed from Calculus I and II, at the request of other science departments, who felt it distracted from the mastery of basic techniques of differentiation and integration.

- Zeitz’s “Mathematical Circles” course is a unique blend of problem solving and mathematical outreach to local school children.
Math majors are required to take three semesters of calculus, linear algebra, and a proof-writing course, followed by six upper division courses. Of these six, one must be either Modern Algebra or Real Analysis, a second must be in applied mathematics, and a third must be in classical mathematics. In addition, students are required to take a computational course. While they are encouraged to take some physics, this is only a requirement for Honors students, who must also take three additional upper division mathematics courses.

Upper division classes are only offered every two years, and even then enrollments are often dangerously low.

According to the interests of faculty and students, no red tape stands in the way of occasionally offering a “Special Topics” course. The latest example is Chubb’s “Quantum Computing.”

There are occasional undergraduate research opportunities: Devlin and Van Cott have both been particularly active in this area.

3.5 The Mathematics Majors

The profile of the mathematics majors has changed little in the last 15 years. Their number is typically between 30 and 40, while the number of minors has fluctuated significantly (between 5 and 20). We have slightly more women than men.

Our top students do well on the Putnam, and are accepted at good graduate schools.

While morale and retention prospects are excellent once a math major arrives at USF, and internal recruiting has also had some success, we desperately need a dedicated external recruitment drive. We very much hope that Dean Camperi can serve as our advocate to enlist the help of the Admissions Office in creating such a dedicated recruitment drive for mathematics.

3.6 Technology

Several faculty members make extensive use of computers in the classroom. This has been greatly simplified (since the previous Self-Study) by much wider availability of “smart classrooms,” with built-in, bright projectors with easy computer connectors, and motorized screens.

Lack of adequate computer labs blocks more extensive integration of technology with the mathematics curriculum: the few labs that are available seat 20, while many of the classes that could most benefit from technology have enrollments closer to 30.

The Mathematics Department continues to be a WiFi deadzone.
• The only specialized computer lab (with Mathematica, MATLAB, etc.) that is available to math majors only seats 12.

• It would be very helpful if the Administration would agree to subscribe to Lynda.com, so that our students would have access to high-quality software training videos.

• The Advisortrac software that the Administration has chosen for tracking at-risk students is so clunky and time-consuming to use that many math faculty have simply given up trying to use it.

4 Preliminary Development Plan

Since the previous Program Review in 2003–04, our department has undergone a lot of changes, in terms of student population, personnel, and physical space. While we believe that many of the changes are positive, and that we have good prospects for the future, there are issues that need to be addressed.

4.1 Increase the Number of Majors and Minors

As reported in the section on the math majors, in the past few years we have had moderate success in attracting new students to major or to minor in mathematics. We still need more vigorous efforts to recruit students. In particular, we need to reach out to a larger pool of students who may be undecided regarding their majors. As of now, many students take classes such as

• MATH 101: Elementary Statistics,

• MATH 106: Quantitative Methods in Business

and work with the administration to encourage more students to take these classes to fulfill core curriculum requirements. But it is difficult to recruit majors and minors from these classes as these courses do not count towards a math major or a math minor. If we can offer more sections of courses such as

• MATH 109: Calculus and Analytic Geometry I,

• MATH 130: Elementary Linear Algebra

and work with the administration to encourage more students to take these classes to fulfill core curriculum requirements, it may be easier to attract students from these classes to minor or even major in mathematics, as these classes count towards a math major and a math minor so that the students will already have a headstart.

A related issue, as noted in the section on the curriculum, is the frequency at which courses are offered. Infrequency of upper-division courses can make it difficult for students to fulfill graduation requirements, while infrequency of lower-division courses can make it difficult to fulfill prerequisite requirements.
While the department lists many upper-division courses, they are typically offered only once every two years. As a result, if a student spends four years at USF, and takes upper-division mathematics courses only in his or her junior and senior years, he or she may have only one chance for any given course. Offering upper-division courses more frequently will allow the students more flexibility in deciding what classes to take.

Currently there are five lower-division courses that are required for all mathematics majors. Among these,

- MATH 109: Calculus and Analytic Geometry I,
- MATH 110: Calculus and Analytic Geometry II

are offered every semester, but

- MATH 130: Elementary Linear Algebra
- MATH 211: Calculus and Analytic Geometry III
- MATH 235: Introduction to Formal Methods

are offered only once every two semesters. Many of the upper-level mathematics courses require some combination of these foundational courses as prerequisites. Any student who happens to decide to become a Math Major during the “wrong” semester may have to sit out a full year before being able to take certain of the foundational courses, thereby pushing back his schedule for upper-level courses and hence graduation date. It would be most helpful to the students, and to the department’s effort in recruiting students, if we could offer Math 130, Math 211 and Math 235 every semester.

### 4.2 Increase Faculty Size

In the Report of the Visiting Committee for the previous Program Review in 2003–04, the reviewers recommended that the University provide two new faculty positions for the department. Since then, we have hired three new faculty members. But as reported in the section on the state of the department, we also have seen the departure of four faculty members. So, the net change in the number of faculty members is $-1$. Such a small faculty size causes severe problems for staffing courses, especially those for majors. The department would greatly benefit from an increase in faculty size.

As reported in the section on the state of the department, currently the department hires a large number of part-time faculty members. While many of them are good teachers, they may have teaching duties in several universities, and we cannot reasonably expect them to be fully dedicated to our department. An increase in the number of full-time, term positions would help the department a lot. Whether we convert some of the current part-timers to full-timers, or whether we hire new people for new full-time positions, these new full-timers can be more dedicated to the department.
4.3 Improve Departmental Space

Since the previous Program Review in 2003–04, the department has acquired some new and better office spaces. In particular, more faculty members have nicer offices, ones with windows; and the department office is now housed in a larger room. The university as a whole has also seen an improvement in the classrooms. Most of the classrooms are now equipped with computer projectors, and some of the classrooms allow students wireless Internet access, although the connection can sometimes be unstable (see the section on technology issues). When the Center for Science and Innovation is completed in a few years’ time, we expect that the learning environment for the students will improve further. But in the meantime, we can improve the offices and the classrooms in several ways.

While some of the faculty members are now in better offices than before, some of them are still in small, window-less offices. It would help morale if we could provide nice offices not just to the senior faculty members, but also to junior ones, including those with term positions. The classrooms also need some improvements. Some of the chalkboards are rather old and the writing surfaces are worn out at a few spots. Ventilation in some of the classrooms and some of the library areas can be quite poor occasionally, and on a hot day, it can be very hard for the students to focus. It would also help student morale if we could be more timely when replacing broken chairs and projectors, repairing non-working water fountains, repainting walls with peeling paint, etc. In some of the bathrooms, there is not enough shelf space for students to put their books and bags. A simple and inexpensive fix of putting some bathroom shelves there will go a long way for making life easier for many students. As noted in the section on technology issues, the department can also benefit from a computer lab with 30 or more computers, with software such as Excel, Mathematica, Matlab and Maple installed, so that students can work in groups during and after class. Another area where we need improvement is stable wireless Internet access, in the classrooms and in the faculty offices where faculty members hold office hours. Such improvements will benefit not just the Department of Mathematics and the students majoring in mathematics, but will help all students and all departments.

4.4 Summary

The three issues outlined above are deeply interconnected. Improving the physical resources of our department will increase faculty morale and will make our department more attractive to students considering majoring in mathematics, and will also make us more attractive to job applicants when we hire new faculty members. With more full-time faculty members, who can be more dedicated to students here at USF, students will get a better education and may be more inclined to take more mathematics classes or even to major in mathematics. With more students taking classes in mathematics, the department can plan more easily, in terms of class offerings, staffing, etc. The department will then also be under less stress in terms of low enrollment and class cancellations, and may be able to offer a more diverse slate of classes, which may in turn attract more students who may not be considering majoring in mathematics originally, and may also attract students who
are majoring in other disciplines to double-major. We will then have a healthier environment for the students and the teachers alike.