

Department of Mathematics
Academic Plan
October 13, 2008

1. Mission and aspirations

The next five years promise tremendous opportunities, as well as challenges, for the Mathematics Department as it pursues the following goals:

- excellence in interdisciplinary education and research
- development of a top-flight PhD program with internationally recognized expertise in focused areas
- design and implementation of curricula to equip UW graduates with the quantitative and reasoning skills necessary to become productive citizens and compete in today's high-tech job market.

Three critical action items lie at the heart of the department's efforts to align its research and teaching goals with Areas of Distinction in MFII. These are:

Math-1: To pursue excellence and establish depth in the following targeted research areas: Algebra, Combinatorics & Number Theory; Analysis; Applied Mathematics; and Computational Mathematics.

Math-2: To play a central role in strengthening UW's scholarly communities. In particular, to continue developing our research and teaching collaborations with the School of Energy Resources, the Interdisciplinary Computational Science Program, and the Program in Ecology.

Math-3: To enhance interdisciplinary learning by creating undergraduate and graduate curricula that give students the quantitative expertise they need to be important players in emerging areas of science and engineering.

Each of these action items builds upon existing strengths within the Mathematics Department and its successful collaborations with UW faculty in other disciplines. Departmental hiring decisions will promote teaching excellence, research strength and institutional priorities, while paying attention to these targeted areas of mathematics. Through the implementation of new courses and the assessment and redesign of existing courses, the department will aggressively develop curricula with enhanced interdisciplinarity and vertical and horizontal integration.

2. Relevant institutional issues

Challenges include:

- Prioritizing our limited human and capital resources to fulfill all of our service and outreach demands while aggressively pursuing excellence in undergraduate and graduate education and in mathematical research.
- Enhancing the recruitment and mentorship of faculty to foster an intellectually stimulating environment that develops leading mathematics researchers and teachers.
- Pursuing and acquiring the human and capital resources necessary to allow the Department of Mathematics to contribute to key UW initiatives.
- Finding the necessary resources to increase the quality and size of our graduate program.
- Improving our facilities by securing the necessary space for faculty and graduate student offices.
- Procuring high-performance computing equipment, communication infrastructure, and systems administration necessary for interdisciplinary computational science research.
- Creating the classroom infrastructure (e.g. computer-equipped classrooms and labs) that enables effective integration of technology into our undergraduate and graduate curriculums.

3. Action items and implementation plans

Below is a discussion of the rationales for our actions items and implementation plans leading to their resolution.

Math-1: To pursue excellence and establish depth in the following targeted research areas of Algebra, Combinatorics & Number Theory; Analysis; Applied Mathematics; and Computational Mathematics.

The utility and ubiquity of mathematics places our department in a key role in UW's quest for excellence as identified in *Creating the Future*. Of primary importance is the vital contribution of Action item Math-1. If pursued vigorously, development of the targeted areas of mathematics identified in Math-1 will enhance UW's interdisciplinary research efforts in the following three areas of distinction: 1) Critical Areas of Science and Technology, 2) the Environment and Natural Resources, and 3) the Life Sciences. The following is a discussion of how the targeted areas of mathematics identified in Math-1 positively influence other disciplines at the university.

Progress on important problems (e.g. reliable and secure communication, effective data mining, and the structure and functionality of networks) in science and technology will involve the design and study of discrete structures using algebraic, geometric, number theoretic, and combinatorial methods and tools. Our goal is to hire faculty who broaden our existing strengths in Algebra, Combinatorics & Number Theory, cultivate research bridges with other groups in our department, and effectively collaborate with the various research groups across campus with interests in these important problems.

Analysis provides the theoretical underpinning for the majority of applications in other scientific disciplines, such as engineering, life sciences, and physical sciences. Most recently analytic techniques have been used to better understand the behavior of complex systems, such as financial markets. Currently we have a small group of strong faculty working in analysis. Our task is to hire faculty who strengthen our existing group so that we may more effectively interact with research groups in other disciplines and pioneer new projects with input from scientists and engineers.

Applied Mathematics is catalyzed by and in turn solves problems that arise in science and engineering. For example, our department's applied mathematics group is studying the control of airflow past the blades of wind turbines, the design of an optimal robotic manipulator capable of performing specific tasks, the geophysical fluid dynamics arising in CO₂ sequestration, and the bio-fluid dynamics of blood flow around stents. Our plan is to hire applied mathematicians who, along with existing faculty, contribute significantly to multidisciplinary research at UW. Two areas of applied research that are of particular importance to the university are our projects within the School of Energy Resources, and our role in the developing of the UW-NCAR collaboration.

Computational Science, along with theory and experiment, form the three modes of modern-day scientific investigation. As pointed out by President Buchanan, the NCAR supercomputer will place UW among the finest centers for computational science in the world. Mathematicians play a key role in computational science by designing theoretical models for simulations, creating and analyzing algorithms, improving optimization and design in the presence of uncertainty, and developing techniques to glean information from very large data sets. Our goal is to build upon our existing faculty strength in scientific computing by hiring additional faculty who can work within a computational-science framework to solve problems in engineering, life sciences, energy sciences, and physical sciences. By doing so, UW would move into the highest tier of universities with computational science programs.

Math-2: To play a central role in strengthening UW's scholarly communities, SER, and the UW-NCAR collaboration.

The Mathematics Department has a long history of interdisciplinary research contributions and collaborations, and we plan to expand and accelerate the scope and intensity of this involvement through the following:

- The establishment of a UW-SER Center for Porous Media Studies. Initial discussions regarding this have already taken place with SER Director Mark Northam.
- The development of an Interdisciplinary Computational Science Program (ICS) that offers minors for undergraduate and graduate students and supports computationally oriented research programs. Within ICS, a new program called Mathematical and Statistical Modeling and Scientific Computation would be jointly administered by the Mathematics Department and the Statistics Department. This program would be closely tied with NCAR's Institute for Mathematical and Geosciences (IMAGE) and the School of Energy Resources. See Appendix C for more details.
- Increased research and curricular collaborations with Life Sciences (catalyzed by the upcoming EPSCoR hire in Theoretical Biology, a joint position between Mathematics and Zoology, with shared interests in computational science).
- A leadership role regarding improvements in science, technology, engineering and mathematics (STEM) education, and in particular, in the integration of computational science in the K-12 curriculum.

Math-3: To implement aggressive graduate student recruitment strategies and strengthen our graduate curriculum.

Catalyzed by an influx of ten highly qualified faculty over the last six years, our graduate program is poised for a renaissance. This is evidenced by a recently re-designed graduate curriculum, placement of recent Ph.D.s in prestigious post-doctoral positions, a significant increase in journal publications, a many-fold increase in external funding, and an increased number of GAs supported on grants.

Keys to upscaling our graduate program include:

- More aggressive advertising and recruiting efforts. A newly designed graduate program, the developing Interdisciplinary Computational Science Program, faculty involvement in exciting research projects, the department's recently funded Research Experiences for Undergraduates site, and planned joint recruiting efforts with Statistics are examples of such efforts.
- Seeking additional sources to support graduate students (e.g. donations, GA-ships funded by grants, infrastructure-development grants such as NSF's VIGRE and MTCTP, National Lab internships graduate fellowships).
- Enhanced UW support of our graduate program through some additional state-funded GA-ships.
- Continued increases in the instructional excellence and support budgets.
- Creating an environment where minority and women mathematics students thrive.
- Recognizing and rewarding faculty who successfully work with graduate students (perhaps by making their teaching load reflect their contributions to the graduate program).

Math-4: To create undergraduate and graduate curricula that enhance interdisciplinarity, provide students access to merging areas of science and engineering, and strengthen UW Areas of Distinction.

The developing Interdisciplinary Energy Science Program, graduate Interdisciplinary Energy Resources Program, Interdisciplinary Computational Science Program, and the proposed interdisciplinary program in Mathematical and Statistical Modeling & Scientific Computation demand the expertise of mathematicians and dictate the development of interdisciplinary courses dealing with complex issues at the interface of science and mathematics.

In several meaningful ways, the curricular changes represented by **Math-4** are already underway. One example is the recent revision of our entire graduate curriculum featuring a core of regularly offered courses designed to

benefit both our students and students in other areas of science and engineering. Other examples include an updated project-driven undergraduate modeling course, an advanced probability course, an undergraduate cryptography course, and a more accessible undergraduate analysis course. Judicious use of our topics graduate courses (whose titles specify the area of the course but not its specific content) will be one way to avoid course proliferation while adapting to rapid changes in the mathematical sciences. However, additional faculty and computing classrooms will be needed to fully support this initiative.

Math-5: To enhance the research environment and increase external funding in the Department.

Relevant plans include:

- Stimulating new research collaborations through our colloquium series that brings to UW speakers of international fame who present research on cutting-edge interdisciplinary themes.
- Leveraging our membership with the Institute for Mathematics and its Applications at the University of Minnesota by proposing and leading Hot Topics Workshops, New Directions Tutorials, and Thematic Years.
- Fostering increased ties to national laboratories and research agencies.
- Pursuing infrastructure and workforce development grants.
- Playing a key role in energy-related research and development, including such areas as CO₂ sequestration, wind-energy, and enhanced oil recovery.
- Encouraging interdisciplinary research through co-supervision of students in the Interdisciplinary Computational Science Program, and the Mathematics and Statistical Modeling & Computational Science Program.
- Securing the necessary space for faculty and graduate student office.
- Promoting UW acquisition of high-performance computing equipment and systems administration for interdisciplinary computational science research.
- Strengthening existing research collaborations with ME, EE, ECE and Geology & Geophysics.
- Developing a departmental culture that better encourages and rewards proposal writing.
- Creating an atmosphere wherein successful hires develop into top-flight mathematicians and stay permanently in the department. This will entail establishing favorable teaching loads for exceptional research faculty.

Math-6: To provide an excellent curriculum for undergraduate mathematics majors and minors.

Keys to success are:

- Active recruitment of mathematics majors from all of our courses, especially those at the freshman level.
- A redesigned curriculum that encourages students to experience real mathematics sooner.
- Active involvement in advising students and aggressive placement of students in internships and research experiences.
- Continued development of the Student Math Association of Wyoming.
- Attracting additional students to mathematics through the Interdisciplinary Computational Science Program.

Math-7: To provide sufficient high quality courses for USP and to support the science and professional majors.

Possible activities related to this action item include:

- Supplemental Instruction (SI) in our QA and QB courses. SI will help students better master course content, improve students' critical and quantitative reasoning skills, and (as studies show) significantly improve student performance. In addition, research shows that the opportunity for students to be SI instructors greatly adds value to their educational experience. See Appendix D for more details.

- Ongoing development of our curriculum to include technologies (such as WebWork) that improve student performance and learning.
- Possible introduction of QA and QB courses designed to better meet needs of certain majors (e.g. a Math Ecology QB course for Life Science Majors, or a QA Data Analysis course for some Health Science majors)

Math-8: To take on a leadership role in teacher training and mathematics education.

The Mathematics Department involvement in K-12 teaching and mathematics education is deep, broad, and enduring. Yet national reports on elementary and secondary education, as well as Wyoming-wide discussions catalyzed by the Hathaway Scholarship program, demand that both pre- and in-service K-12 Mathematics and Science teachers be better prepared to teach mathematics. We will help UW meet this mandate through:

- Better articulation with Wyoming schools regarding the development of quantitative reasoning skills and lasting mathematical knowledge.
- Redesigning our mathematics curriculum for elementary teachers to a 3-course sequence, as recently urged by a National Center for Teacher Quality report, giving students a deep conceptual knowledge of the math they will teach and that their students will learn in middle school.
- Working to find permanent funding for the Summer High School Math Institute.
- Encouraging and recognizing faculty who become involved in teaching content courses for teachers.
- Maintaining close relationships with the Science Math Teaching Center and the College of Education.

Math-9: To use established assessment plans to improve teaching and student learning.

Assessment and improvement of curriculum and of our teaching effectiveness is truly a continuous task. The department has picked up the pace in its assessment of its USP courses, its undergraduate major degree, and its graduate degrees. Common syllabi for our USP courses were written and approved; a curriculum mapping from our undergraduate courses to our goals and objectives was established; a mechanism for faculty assessment of each course they taught was developed and implemented; math majors' work in key senior-level courses was studied to evaluate the department's effectiveness in producing majors capable of reading and writing advanced mathematical proofs; and a detailed assessment of our curriculum for concurrent Secondary Math Education majors was undertaken.

Our goal is to identify and implement meaningful improvements to various departmental programs while keeping the administrative impact of the assessment process at a reasonable level. Our curriculum sequencing, our allocation of fiscal and human resources, our commitment to teacher training instructional staff, and other aspects of departmental operations may need to change in response to the results of our assessment of student learning.

Math-10: To promote mathematics throughout Wyoming and the Rocky Mountain region.

This will be accomplished through our involvement in math contests, articulation with community colleges, the establishment of and participation in Math Teachers' Circles throughout the state, articulation with K-12 teachers regarding the transition to university-level mathematics, and the pursuit of infrastructure grants for liaisons between UW and Wyoming's middle and high schools.

Math-11: To cultivate stewardship activities to continue developing a strong community of alumni, organizations and businesses who support UW Math.

Steps towards attaining this goal include:

- Improved mailings, a newsletter, and development of a UW Math Alumni News webpage.
- Targeted events for Math alumni and friends (e.g. a regular alumni meeting).

- Improved PR regarding our special events and faculty and student accomplishments.
- Enhanced activities for our students and their families at graduation and at the honors convocation.

Appendix A: Math Academic Plan (2009-2014) Timeline

Action Item	Projected time-frame
Math-1: To pursue excellence and establish depth in the following targeted research areas of Algebra, Combinatorics & Number Theory; Analysis; Applied Mathematics; and Computational Mathematics.	This action item requires a sustained effort throughout the planning period.
Math-2: To play a central role in strengthening UW's scholarly communities, SER, and the UW-NCAR collaboration.	Establish the Center for Flow through Porous Media by 2009; develop and obtain approval for the Interdisciplinary Computational Science graduate minor for the 2009-2010 AY.
Math-3: To implement aggressive graduate student recruitment strategies and strengthen our graduate curriculum	Begin aggressive advertising and recruiting efforts immediately. Seeking additional sources to support graduate students and creating an environment where minority and women mathematics students thrive will require a sustained effort throughout the planning period.
Math-4: To create undergraduate and graduate curricula that enhance interdisciplinarity, provide students access to merging areas of science and engineering, and strengthen UW Areas of Distinction.	On-going throughout the planning period.
Math-5: To enhance the research environment and increase external funding in the Department.	Initial focus will be on <ul style="list-style-type: none"> • leveraging our membership with the Institute for Mathematics and its Applications at the University of Minnesota by proposing and leading Hot Topics Workshops, New Directions Tutorials, and Thematic Years. • Fostering increased ties to national laboratories and research agencies. • Pursuing infrastructure and workforce development grants. • Promoting UW acquisition of high-performance computing equipment and systems administration for interdisciplinary computational science research.

Math-6: To provide an excellent curriculum for undergraduate mathematics majors and minors.	Evaluate in 2008 -2009; design new curriculum in 2009-2010; implement in 2010-2011; evaluate and modify in 2011-2012.
Math-7: To provide sufficient high quality courses for USP and to support the science and professional majors.	On-going commitment.
Math-8: To take on a leadership role in teacher training and mathematics education.	Establish statewide Math Teacher Circles by 2011.
Math-9: To use established assessment plans to improve teaching and student learning.	This will be an ongoing task throughout the planning period.
Math-10: To promote mathematics throughout Wyoming and the Rocky Mountain region	On-going commitment.
Math-11: To cultivate stewardship activities to continue developing a strong community of alumni, organizations and businesses who support UW Math.	Establish a stewardship plan and committee by 2010.

Appendix B: Math Academic Plan (2004-2009) Report Card

Action Item	Progress
Math-1: Expand expertise in the Mathematics of Complex Systems and Engineering	Hired 9 faculty, including 2 SER faculty, with expertise in Stochastic Processes and Modeling; High Performance Computing; Flow through Porous Media; Conservation Laws; Multiphase flow and nonlinear waves.
Math-2: Expand expertise in Mathematics of Information Theory	Hired one faculty member with expertise in Cryptography, and in process of hiring second in Algebra, Combinatorics or Number Theory.
Math-3: In consultation with appropriate units, continue to restructure undergraduate and graduate curricula to enhance interdisciplinarity, strengthen MFII Areas of Distinction, and support imperatives Math-1 and Math-2.	Designed first year graduate courses to be attractive and useful to Engineering and Computer Science majors; re-designed computational science sequence, math modeling courses; introduced new cryptography courses. Introduce WeBWork into Calculus sequence.
Math-4: Implement aggressive graduate student recruitment strategies, revamp the graduate curriculum.	Actively and successfully pursued minority and women fellowships; increased number of GAs funded from grants; re-designed the graduate program from top to bottom.
Math-5: Enhance the research environment, and increase external funding in the Department.	Increased number level of faculty participation in grants to nearly 2 out of 3; increased external funding-levels to about \$300K per year; successfully pursuing infrastructure grants such as SCREMS and REUs. Ran a high profile, active colloquium and seminar series.
Math-6: Maintain an appropriate level of faculty/APL support for teacher training and mathematics education.	Hired a Math Educator with expertise in the Professional Development of Middle School Math teachers.
Math-7: Implement assessment plans according to assessment time-line.	Established student-learning outcomes and objectives. Developed curricular map for our undergraduate major.
Math-8: Provide sufficient high quality courses for USP and to support the science and professional majors.	Continually on-going.

Math-9: Conduct timely reviews of our basic lower division course sequences.

On-going reviews of USP courses, and Calculus sequence

Appendix C: Proposal for new interdisciplinary program in Mathematical and Statistical Modeling and Scientific Computation ((MS)²C)

Synopsis

The Departments of Mathematics and Statistics propose a new interdisciplinary program in Mathematical and Statistical Modeling and Scientific Computation ((MS)²C) that will help UW in its pursuit of excellence in Computation Science, will be closely tied with NCAR's Institute for Mathematical and Geosciences (IMAGE), will play a role in School of Energy Resources, and will be part of UW's Interdisciplinary Computational Science program.

The proposed ICS and (MS)²C programs will bring us new challenges and new opportunities. In our opinion the University of Wyoming and our Departments Mathematics and Statistics are on the leading edge of an exciting time of program revitalization and expansion.

Justification

Statistics and Mathematics are natural players in Computational Science. Their contributions are symbiotic in that the creation and implementation of sophisticated mathematical models require substantial computing power; almost all such models that are realistic also require statistical and stochastic components that go beyond classical mathematical model. The Departments of Mathematics and Statistics believe that it is in the interests of UW, as well as in their interests as departments, to work cooperatively rather than competitively to advance these goals.

Costs

We propose to pursue creation of this program through concurrent development of faculty resources and recruitment of graduate students who will participate in this program. Mathematics and Statistics will aggressively and cooperatively pursue additional GAs for the (MS)²C program through the Reallocation Pool, the SER pool, and through external funding sources.

Math has 21 Tenure-track faculty, with 11 hired in the past 6 years. These resources could easily support a graduate program of 35-40 students (double the current size) without significantly increasing faculty resources or number of classes offered. Statistics has 7¼ tenure track faculty and has the carrying capacity in its current doctoral degree program and course offerings to double the number of graduate students. The department's two most recent hires have been in statistical modeling with spatial applications.

The skills necessary to develop a cutting edge computational science and (MS)²C programs will require resources, both faculty and students, beyond those in existence at UW. Thus we will need to utilize and combine institutional commitment (UPIII), State commitment (NCAR computer), and departmental commitments to successfully attract competitive faculty and students. This could prove particularly problematic in the area of recruiting students. Past experience in recruitment suggests that a concerted and dynamic

recruitment strategy, different in nature not just intensity, will be essential for attracting qualified applicants, especially at the start of the program.

Benefits

Together, Mathematics and Statistics can develop materials and resources such as brochures and web pages and we can cooperatively recruit students in both Math and Statistics. By cooperatively working to design and offer cross-listed courses, we can provide both Math and Statistics students with enhanced educational and career opportunities, at no additional cost to UW.

Appendix D: Proposal for Supplemental Instruction in core undergraduate Mathematics courses

Synopsis

The Department of Mathematics proposes to enhance student learning in UW's entry-level Mathematics courses (College Algebra; Trigonometry; Calculus I and II) through the introduction of supplemental instruction. Undergraduate mathematics, engineering and science majors will be trained and supported to offer supplement instruction session outside of class. These sessions will incorporate peer-learning techniques, problem-solving practice, fun activities such as Math-Jeopardy, and discussions on study-skill strategies such as textbook reading, note-taking, time-management, test-taking strategies.

Benefits

Supplemental instruction in the targeted courses will help students better master course content, improve students' critical and quantitative reasoning skills, and (as studies show) significantly improve student performance. In addition to the benefit to students in these courses, research shows that the opportunity for students to be SI instructors greatly adds value to their educational experience. It should be noted that each semester roughly 1500 UW students are enrolled in these courses. Thus, successful SI in these courses would greatly impact UW.

Costs

Each semester the Mathematics Department teaches at total of approximately 36 sections of Math 1400, Math 1405, Math 1450, Math 2200 and Math 2205. We propose that each undergraduate supplemental instructor will cover two sections, and that the costs will be:

\$900/semester per supplemental instructor for salary and training

\$3000/semester for an SI supervisor (most likely, an experience graduate student).

This results in an estimated budget of \$33,000/year.