UIUC Department of Mathematics Strategic Plan. February 15, 2006.

Mathematics is the language of science and engineering. The technological developments of the past decades make mathematical research and a mathematically literate workforce more essential than ever before. In recent years, Mathematics has even permeated such diverse areas as the Social Sciences, Business, and Biology. The Mathematics department at UIUC is evolving to reflect these increasingly interdisciplinary trends.

History shows that pure mathematical research anticipates, often by decades, important developments in other subjects. We therefore remain committed to core mathematics. This strategic plan describes how our department will enhance the strength of its core areas, while becoming more interactive with other disciplines, both on and off campus. Our guiding principle is the commitment to excellence in every facet of the mathematical enterprise: research, applications, education, mentoring, and outreach.

This plan will improve our environment for research and teaching. We will recruit higher quality faculty, graduate students, and undergraduate majors. We will adjust to changing trends in the mathematical sciences, and we will develop in interdisciplinary directions. As a consequence, our reputation and our rankings will rise.

Here we state the major goals and initiatives of our plan.

- **Improve our quality and international stature by making six strategic senior faculty appointments.**
- **Provide our faculty with sufficient time and resources for the pursuit of excellence, and remain competitive in hiring, by reducing our teaching load to match the load at peer institutions.**
- **Integrate more fully the educational mission of the department with its research agenda and with the agendas and needs of other disciplines.**
- **Develop and enhance the wide variety of programs which distinguish our department on campus, nationally, and internationally.**

Stature of the Department. Our faculty regularly publish in the best research journals, receive grants for their research and educational activities, receive international recognition for their contributions to all aspects of the mathematical enterprise, receive numerous awards for their research and teaching, and are invited to give plenary talks at major conferences.

The Department is currently ranked 21st by the National Research Council and 16th by U.S. News and World Report. Although we find ourselves at a competitive disadvantage in some areas, we have achieved many successes, and we are poised to compete vigorously with the best public institutions in the US. As mathematics requires less infrastructure than other sciences, we can move into the top tier with only modest budget increases.

Why are we not already there? We have always endeavored to improve by hiring faculty of higher stature than our own. We are able to identify the top candidates, but we often lose them to our peers, who can offer lower teaching loads, higher salaries, and a stronger reputation. We must compete by offering similar resources to our candidates. The university, its faculty, and our students deserve no less.

Assessments. Several internal and external committees have assessed our department over the past few years. Three peer review panels made site visits in association with our $4M NSF VIGRE Grant, and an Alumni Visiting Committee evaluated our graduate program. Our involvement with the Carnegie Initiative on the Doctorate has provided additional useful feedback. An internal Long Range Planning Committee produced a report in 2004, and the search committee for the current chair also produced a useful document. These evaluations have been for us both mirrors and lenses; we have seen ourselves more clearly, and we have focused on the issues most critical to our future. Participation in the current strategic planning exercise has been broad-based. The themes in this plan have surfaced repeatedly in these assessments, and therefore have strong support.

Strategic Hiring. Excellence in hiring at all levels is the most effective way to become a center of mathematical excellence. The primary asset of any department is its faculty, and each new hire affects our quality for decades. Our department has done much excellent junior hiring in recent years. Younger faculty have distinguished themselves nationally and internationally with excellent research, prestigious grants, and prestigious invited lectures. Demographic information suggests that we will be able to continue such hiring in the near future.

Departments (as well as their national rankings) tend to be identified with their top faculty members. Strategic hiring is therefore crucial to our long-term success. The faculty we seek will excel in research, in graduate and postdoctoral advising, and in the ability to bring in grant support. In our recent experience we have seen first-hand how even one such faculty member (our Swanlund Chair) can impact the department; such faculty noticeably affect the intellectual atmosphere, establish new connections both inside and outside the department, and lead to the recruitment of additional excellent faculty, postdocs, and graduate students.

We propose to hire 6 leading senior faculty during the next 5 years. Our Executive Committee has approved the formation of a Strategic Senior Hiring Committee. This committee will identify and recruit leading senior mathematicians who will most benefit our department.

It is important to consider the budget implications of such hiring, since we must be prepared to offer high salaries for true stars. In the last two years, 14 faculty have left our department (due to retirement or resignation) and we have hired only 9 replacements; the difference in salary is approximately $\$530,000$. Furthermore, 10 of our current faculty are at least 65 years old, and their combined salary is approximately $\$960,000$. In view of these facts, the budget increases necessary to accomplish the proposed hiring seem reasonable.

The following objectives will guide the senior hiring committee:

• *Hire senior faculty with outstanding international reputations.* Such faculty improve the research of the existing faculty, raise our collective expectations, improve our visibility and reputation, and improve our ability to recruit at all levels.

• *Hire senior faculty who will interact with several research groups.* The best researchers are typically not bound by traditional barriers between disciplines, and true breakthroughs often occur at the interface of more than one research area. Our department, with its diverse areas of strength, provides an ideal environment for such transformational changes.

• *Hire senior faculty with expertise in applicable mathematics.* The department has hired several excellent applied mathematicians in recent years whose breadth and strength will make it possible to attract exceptionally strong candidates with interdisciplinary interests. Such candidates will be attracted by the chance to collaborate with our world-class engineering and science departments. They will raise our research profile, will promote interaction with other departments, and will allow us access to large sources of funding (e.g., NIH and DARPA). They will also facilitate our participation in such campus-wide programs as the Illinois Informatics Initiative and the Integrated Sciences for Health Initiative.

• *Enhance traditional strengths.* Our department has traditions of excellence in certain areas of specialization, providing us with a competitive advantage in hiring first-rate senior faculty. We will fill gaps between retiring stars and thriving younger faculty.

We have identified several ways to attract star mathematicians to UIUC. The international reputation of the University and the research strength of our faculty are already considerable attractions. An appropriate interdisciplinary candidate would be attracted by the chance to collaborate with our world-class engineering and science departments. Our demographics allow us some flexibility in hiring; for example, they allow for a cluster hire spearheaded by a senior star. We are able to offer a star appointee a significant role in hiring future colleagues. This opportunity can be a decisive inducement (as we have seen, for example, at Michigan).

Time and resources. In order to achieve success in hiring and retention of excellent faculty, it is critical that we reduce the teaching load for research active faculty. We are one of the few Group One research mathematics departments with a $2+2$ teaching load. We cannot successfully compete for the best faculty with our higher teaching load, and we routinely lose top job candidates for this reason. Therefore, reducing the teaching load is an essential component of our strategic plan.

Although the department has recently made progress in this direction, we remain at a competitive disadvantage. We can reduce teaching loads immediately with modest budget increases. In fact, after the proposed senior appointments, our faculty numbers will be sufficiently large to maintain a $2+1$ load without additional budget increases.

We are also critically challenged by our space needs, as discussed in more detail below.

Vertical Integration. Here we describe ongoing and future efforts to integrate our research, education, and mentoring activities. The best mathematicians mentor graduate students and postdocs whose eventual prominence enhances the reputation of the mentor. Although many of our faculty members are first-rate mathematical scientists, and we have a rich research environment, we have seen too little of this phenomenon in mathematics at UIUC. Our assessment mechanisms, and the experience from our VIGRE grant, indicate that we can attack this problem by better vertically-integrating our research enterprise. Such integration will improve the educational experience and the career opportunities for our students and will increase the stature of our department.

The theme of vertical integration runs through this strategic plan (additional examples can be found in the sections on undergraduate and graduate education). By hiring senior stars we will recruit better graduate students and postdocs. If teaching loads are reduced, then faculty will be able to spend more time on research mentoring. By hiring senior stars who fit well with current faculty research interests we will increase coherence in our research agenda, which will enable postdocs and graduate students of different mentors to thrive as part of a broader research group. In fact, many of the hard sciences have such models, whereas mathematics graduate students can easily become isolated when working on their theses.

We propose the following initiatives.

• *Increase the number of postdoctoral fellows.* To enhance our impact and reputation, we should increase our contribution to the national pool of junior faculty. Some of our peers have much larger postdoc programs than do we (in a recent year, for example, Michigan did 20% of the US postdoc hiring in mathematics). Postdocs contribute to all aspects of our mission, and do so at a relatively low cost. They provide teaching strength as well as a fundamentally important circulation of personnel and ideas. Postdoctoral fellows interact with our graduate students, positively impacting both groups.

• *Facilitate transition from course work to thesis research.* We have begun this process with the introduction, over the past several years, of our summer REGS (Research Experience for Graduate Students) program and RAP (Research among Peers) seminars. Several research groups within our department also have successful student seminars. We will continue to expand such initiatives, which integrate the roles of faculty, postdocs, and graduate students.

• *Expand and strengthen curriculum innovations.* We will undertake a thorough curricular review of the graduate program. We will expand the recently introduced "mini-courses;" these are half-semester courses designed to increase student exposure to topics at the frontiers of current research. Postdocs and faculty will often audit these minicourses.

• *Strengthen our REU program.* Through NSF funding, our department has sponsored many REU (Research Experience for Undergraduates) programs for students both from UIUC and from around the country. These focused summer programs bring undergraduates closer to the research frontier, and serve as an excellent recruiting tool.

Graduate Education. The relationship between the graduate program and the research mission of our department is ideally a symbiosis: we train future stewards of the mathematical enterprise, while our students, in turn, enhance the vitality of the research environment.

Our program currently has 183 doctoral and 43 masters students, and we produce approximately 20 new PhDs each year. In recent years we have devoted considerable effort to self-assessment of the program. In addition to ongoing oversight by our Graduate Affairs Committee, this assessment exercise has included a 3-year participation in the Carnegie Initiative on the Doctorate, active participation in the Council of Graduate Schools Completion Project, and creation of an Alumni Visiting Committee that visited in 2003 for the express purpose of evaluating the graduate program. These assessments, together with innovations resulting from the department's VIGRE program (which ended in 2005) form a large part of the foundation upon which this strategic plan stands.

Strategic hiring will lead to the recruitment of top graduate students, which will in turn raise the overall standard of our program. Strong recruitment will lower attrition rates, reduce the time to degree, and, through the future success of our graduates, enhance the stature and impact of our department. Adequate funding, especially in fellowship form, is necessary for such recruitment, and is crucial for the development of future mathematicians. Fellowships provide time for concentrated research effort and active participation in the vertically integrated activities of our department. Currently only one fifth of our students are supported by fellowships or research assistantships.

Graduate school entails more than formal requirements. Preparation for a career in mathematics requires more than course work and thesis research; students must absorb the culture of their field and establish links within it. Our integrated environment will facilitate the requisite acculturation.

We will pursue the following initiatives.

• *Form a Recruitment and Fellowship committee.* The committee will be charged with the active recruitment of talented students and the pursuit of external funding for additional fellowships.

• *Expand multi-disciplinary opportunities.* In the short term, we will develop additional applied mathematics courses and we will promote joint-advisor arrangements with other departments. In the long term we will develop a PhD option in Applied Mathematics, similar to our existing degree option in Computational Science and Engineering.

• *Develop online programs at the Masters level.* Our online objectives include Masters of Science degrees in Applied Mathematics for Engineers, Applied Mathematics for Teachers, and Actuarial Science. These offerings will build on our current online courses.

• *Maintain a comprehensive database of our graduates.* Our alumni represent a resource of immense value. In addition to maintaining our ties to this resource, a database is critical for continuing assessment and development of our program. Conversations with faculty in the Engineering College have revealed to us how effectively such a database might be used in all aspects of our mission.

Undergraduate Education. With approximately 70 regular faculty, 20 instructors, and 100 TAs in the classroom, and with nearly 21,000 undergraduate registrations per academic year, the mathematics department carries one of the largest instructional loads of any unit on campus. We serve a wide spectrum of the undergraduate population, ranging from those fulfilling a Quantitative Reasoning requirement to those enrolled in our honors program. We use diverse modes of instruction, including traditional lecture classes, active learning classes, computer-based courses, and Merit Workshop sections aimed at minorities and other groups underrepresented in mathematics.

Recent reviews of peer institutions and junior colleges showed that our program was not meeting the needs of students as effectively as it could. Two years ago the department began aggressively to make improvements. Collaborations involving the department, the College of Engineering, deans, advisors, staff, and students have resulted in some notable successes. The department has invested its own resources in these efforts (hiring, for example, a half-time academic professional in the undergraduate office). The results so far have been promising, but a great deal more could be accomplished with a modest increase in funding.

We will pursue at least the following initiatives in the coming years:

• *Expand and improve our programs in secondary education.* We recognize that the mathematical education of future generations begins at the public schools. Our current secondary education program should improve, and should double in size (from 30 students per year to 60). With modest

additional resources, juniors in the program could serve as TAs in Math 012 and Math 016, and thus gain teaching experience. We would need an instructor specializing in math education to handle the additional instructional load.

• *Meet staffing needs in Actuarial Science.* By hiring an energetic director in 2003, we have dramatically improved our already strong actuarial science program (the largest in the nation). With 270 students and only two full-time faculty in actuarial science, the current student load is unsustainable. We need to hire additional faculty or instructors. We also require a half-time academic professional for advising students.

• *Create calculus capstone courses.* The advanced placement exams in mathematics pose a recurring problem for all universities. Too often, students with advanced AP credit in calculus do not perform as well as necessary in their math based courses. To address this problem, we intend to create "capstone" courses with other departments and colleges (we ran a successful trial course with Engineering last fall).

• *Expand outreach programs to local schools.* We recently developed a program in which students visit local high schools to teach lessons on key ISAT topics, and we will expand this program. We will continue to work with the MSTE (Math, Science and Technology in Education) lab to expand our outreach efforts in local schools.

• *Improve undergraduate recruiting.* Our math club, MATRIX, with support from the department, sponsors a social evening on campus for high school students on the night before the annual ICTM mathematics competition. Such contact with these highly motivated students should result in additional numbers of them choosing UIUC as their undergraduate institution. We have started a program to set up booths and tables at high school events to advertise our strong honors math sequence and undergraduate program.

• *Develop online outreach programs.* We will expand on our 15 years of experience in interactive computer-based online outreach programs. NetMath offers online courses to high school students who have exhausted the offerings in their schools. Math Teacher Link offers online professional development courses for high school teachers on the effective use of technology in the curriculum. New courses and more aggressive marketing initiatives will be developed as our budget permits.

Other issues. We address three issues which do not fit neatly under the previous headings.

• *Improve the mentoring of junior faculty.* To help our junior colleagues develop to their full potential, we will supplement the existing informal mentoring arrangements with a more formal support structure. This structure will provide regular, detailed feedback on the faculty member's progress towards promotion and tenure, and will also foster his or her broader career development. While our plans for such mentoring are not yet firm, one current proposal is to create an "Associate Chair for Research" whose duties will include providing the feedback described above.

• *Form an external advisory committee.* We will form an advisory committee of alumni and friends of the department in order to continually assess our programs and to enhance our development efforts. The committee will encourage alumni to network with each other and with current students. It will advise the department on such matters as distinguished lecturers, commencement speakers, and potential students, and will develop programs which effectively encourage alumni to make the Department of Mathematics an ongoing part of their lives. This initiative connects closely with the alumni database described above.

• *Meet our space needs.* Like many departments in LAS, we find ourselves with a critical shortage of space. We continue to reutilize space as our needs change, but there is a limit to what we can do without an increase in physical space. We have occupied all available space in Altgeld, Illini, and Coble Halls, yet we lack adequate space for faculty candidates or distinguished visitors. Moreover, some of this space (e.g., Illini Hall) is of poor quality. The report of one of our outside review committees stated that space is the single most pressing issue for the department. We require medium and long term solutions.

Five Year Goals

Research

- Create areas of excellence by targeted senior hiring, while maintaining broad expertise.
- Increase interaction with other disciplines, on and off campus.
- Create a top-tier research environment. As a consequence, our research rankings will rise.

Education

- Better integrate our research program with our educational programs at all levels.
- Expand the scope of programs in interdisciplinary directions.
- Increase use of online and other educational technologies.
- Increase completion rates and reduce time to degree for doctoral students.

Engagement and Service

- Increase involvement in K-12 education and teacher training.
- Build a relationship with the College of Education to expand our outreach to local schools.

Economic Development

- Seek ways to attract new firms to Research Park through interdisciplinary efforts.

Competitive Analysis

Overall

- Berkeley
- Michigan
- Wisconsin
- UCLA
- Texas

Research

- Berkeley
- Michigan
- Wisconsin
- UCLA
- Texas

Education

- Michigan
- Wisconsin
- Texas
- UCLA
- Maryland

Engagement and Service

- NYU
- Michigan State University
- Carnegie-Mellon
- University of Connecticut
- Johns Hopkins

Economic Development

- NYU
- Carnegie-Mellon
- Texas
- Michigan State University
- Johns Hopkins

SWOT Analysis

Research

Strengths

- Large and diverse faculty, with excellence in areas across the mathematical spectrum.
- Demographics of department has allowed much excellent hiring in last several years, with more opportunities to come.
- The quality of academics at UIUC, and the presence of an excellent engineering college.

Weaknesses

- Shortage of high profile senior faculty and chaired positions relative to peer institutions.
- No senior applied mathematicians in math department.
- We have fewer postdoctoral research positions than do many peer institutions.

Opportunities

- Strategic senior hiring and clusters of senior-junior hires.
- Many interdisciplinary opportunities to attract strong applied mathematicians (especially given the strengths of Engineering and Science departments on campus).

Threats

- Many of our peers and competitors (ranked both above and below us) have moved to $2+1$ teaching loads, making it difficult to compete for, and to retain, the best faculty.
- Salary anomalies at all levels make it more difficult to compete for and to retain faculty.
- There are many new directions in research, and especially in applied research. We may be left behind if we do not move in some of these directions.

Education

Strengths

- High quality of faculty and research environment.
- Size and scope of the graduate program; diversity in modes of undergraduate instruction.
- Largest actuarial sciences program in the US.

Weaknesses

- Relative ineffectiveness of recruiting.
- Inadequate graduate student funding.
- Insufficient interdisciplinary programs, especially at graduate level.

Opportunities

- Untapped links with other parts of campus, and interdisciplinary degree initiatives.
- Shared online courses and other innovations exploiting internet technology.

Threats

- Shrinking pool of foreign graduate applicants.
- Decline in faculty size and impact of this decline on number of courses offered.
- Evolving needs of other departments (slowness to adapt is a potential threat, but nimbleness in this regard opens opportunities).

Engagement and Service

Strengths

- Corporate Advisory Council and corporate mentoring for Actuarial Science.
- Track record of providing online educational resources to local teachers and to mathematically advanced high school students.
- Many faculty members have strengths in areas of interest to industrial and financial organizations and professions.

Weaknesses

- An ad hoc, rather than broad institutional, focus on engagement/service.
- Faculty resources limited and stretched by education and research.
- Little historical interaction with industrial and financial organizations.

Opportunities

- Online continuing education and career development opportunities for educators.
- Frequent seminars co-sponsored with regional insurance and financial organizations.
- Creation of a "consulting" facility, staffed voluntarily by faculty and graduate students, to provide needed quantitative services to industrial and financial organizations.

Threats

- Could be shut out of opportunities for interaction with industrial and financial organizations by consulting firms and other universities if quick action is not taken.
- Loss of faculty with consulting experience.
- Possible inability to retain or attract good faculty and graduate students with skills relevant to industrial and financial organizations.

Economic Development

Strengths

- Research Park helped establish State Farm Research Center.
- Access to local companies such as Wolfram Research and those in the U of I Research Park.
- Current online offerings are self-sustaining and easily expandable.

Weaknesses

- Lack of systematic university-wide program for marketing online courses.
- Few resources involving biomedical technology, which is a significant growth area globally.

Opportunities

- Attract an additional insurance or financial organization to develop a research center presence on-campus (in the Research Park).
- Expand online offerings and actuarial science program by developing computer-based continuing education and professional exam preparation courses.

Threats

- Shortage of faculty and graduate student expertise in areas relevant to economic development.
- Could be shut out of opportunities for development of online continuing education opportunities if quick action is not taken— this area is competitive.

Assessment of Distinctive Competencies

Research

- Because of size, we have strengths in a large number of areas.
- Consistent renewal due to faculty retirements.
- Existing collaboration with other departments on campus (Physics, Computer Science, Electrical Engineering, etc.).
- Outstanding traditions in number theory, probability and logic.
- UIUC, Berkeley, and Michigan are the only large math departments in public institutions which have highly-ranked engineering programs.
- One of the best mathematics libraries in the country.

Education

- Size, quality and diversity of our research establishment.
- Large and successful Actuarial Sciences Program.
- Strong undergraduate honors program.
- Mathematics Library is superior to that of our competitors.

Engagement and Service

- Good interdepartmental relations and interdisciplinary environment.
- Geographic proximity to important industrial and financial centers.

Economic Development

- Existence and success of U of I Research Park.
- State of Illinois has a strong industrial and financial base.

Suggestions of Most Promising Interdisciplinary Areas

Research

- Fundamentals of Computer Science (interacting with the Computer Science department using tools from combinatorics, geometry, logic, and topology).
- Mathematical Challenges in Engineering (broad representation of mathematics interacting with engineering; particular foci include dynamics and differential equations intersecting with MIE, and cryptography and coding intersecting with ECE).
- Mathematical Physical Sciences (algebraic geometry, analysis, and differential equations interacting with chemistry, materials science, and physics).

Education

- Spearhead an Applied Mathematics PhD program as a collaborative effort with other colleges on campus, particularly the Engineering College.
- Develop the nation's top Actuarial Sciences graduate program, with an emphasis on the industrial component of research and with strong ties to regional insurance corporations.
- Develop an Interdisciplinary Mathematics advising track for PhD students who wish to gain experience relevant to careers in industry and government laboratories. Create an interdisciplinary seminar with speakers from across campus.

Engagement and Service

- Frequent seminars run jointly with regional insurance and financial organizations.
- Nationally visible math/science partnerships.

Economic Development

- A dramatic expansion of the State Farm Research Center, which has ties to the Research Park, in conjunction with an Actuarial Sciences graduate program having a strong industrial focus and marketed aggressively to employees of insurance corporations across the Midwest.
- By building up Applied and Interdisciplinary Mathematics and increasing the number and depth of collaborative relationships across campus, Mathematics can assist other campus organizations in their pre-existing Economic Development programs. Examples are the Information Trust Institute, the Coordinated Science Laboratory, and the NCSA.

Graduate Program Data

	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995
Total PhDs	19	21	20	19	18	20	18	15	17	14	26
Postdocs/temporary research	11	11	10	8	7	5	5	3	6	2	5
Academic (Research)	3	1	1	2	1	2	7	8	5	3	1
Academic (other)	1	5	6	4	5	8	4	2	1	3	8
Non-academic	3	1	2	2	2	3	0	2	3	3	1
Unknown	1	3	1	3	4	2	2	0	2	3	9