Department of Mathematics Strategic Plan
Executive Summary

This Strategic Plan presents a bold vision which will make the department dramatically better in all aspects of its mission.

A vibrant department of mathematics plays a critical role in a major research university. Mathematics is the language of interdisciplinary collaboration in the sciences, engineering, and beyond. The activities of our Department are interwoven with disciplines across the scientific, engineering, and business communities. While many of these interactions are with partners whose primary concern is not mathematics, the mathematical sciences are the indispensable framework for their inquiry.

The Department of Mathematics runs a truly massive educational operation, serving mathematics and actuarial science majors, and also large student populations in other departments and colleges. We must continue to excel in education, particularly undergraduate education.

Research in core areas of mathematics has historically anticipated important developments in other areas, often by decades. We are now seeing a more rapid interaction between research at the core of mathematics and applications in many fields. It is therefore critical that we remain committed to basic research in mathematics, while aggressively pursuing collaboration with other disciplines.

Our plan involves five key, largely inter-related objectives, each defined by several supporting deliverables. The objectives will be achieved by accomplishing the deliverables, and we will track progress on the plan by measuring progress on the deliverables. Annual reviews will track progress and allow for appropriate adjustments and mid-course corrections.

1. Be one of the top research departments in the world, and be widely recognized as such

2. Maintain an exciting, dynamic, collaborative environment supporting activities at the frontiers of the mathematical sciences

3. Develop world-class facilities for collaborative research and learning in mathematics

4. Provide excellent and innovative undergraduate math education for all audiences: math, engineering, sciences, and non-STEM majors

5. Prepare graduate students for leadership in both academic and nonacademic career paths in an increasingly interdisciplinary world

Overview

Mathematics is essential and pervasive in an ever increasing array of research areas including engineering, communications, cryptology, advanced materials, finance, business, climate, biology, medicine, and social sciences. These areas draw on the interplay of a wide range of techniques from mathematics, and they make significant contributions to the advancement of science, economic growth, and national competitiveness. The discipline of mathematics expands both through its internal progress and its essential role in developing the conceptual and computational tools for many of the aforementioned research areas.

This is an exciting time in the history of the interaction of science, engineering, and even the humanities with mathematics. Mathematics is interacting with other disciplines, new and old, on an unprecedented scale and at an increasingly rapid rate. For example, massive data sets require new mathematical tools for understanding their structure ("Big Data"). Biology, which traditionally has had limited interaction with mathematics, is using increasingly sophisticated mathematical tools with tremendous impact. The rapid application of new results in core areas of mathematics led in part to an influential National Academy report, "The Mathematical Sciences in 2025," which surveys the landscape for mathematics and sets an agenda for the coming years. Its fundamental findings include the following.

> Mathematical sciences work is becoming an increasingly integral and essential component of a growing array of areas of investigation... This work involves the integration of mathematics, statistics, and computation in the broadest sense and the interplay of these areas with areas of potential application... The mathematical sciences have an exciting opportunity to solidify their role as a linchpin of twenty-first century research and technology while maintaining the strength of the core, which is a vital element of the mathematical sciences ecosystem and essential to its future. The enterprise is qualitatively different from the one that prevailed during the latter half of the twentieth century, and a different model is emerging—one of a discipline with a much broader reach and greater potential impact...

The University of Illinois is extremely well positioned to prepare itself for these opportunities, and indeed to arrive in 2025 ahead of the pack. Our campus is home to one of the strongest engineering colleges in the world, has many superb science departments, is rapidly developing in biology, and has an excellent Department of Mathematics—among the best and getting even better. We are committed to core mathematics as the engine that drives innovation and also to participating directly in interdisciplinary innovation.

The number of classes we teach and the number of students enrolled in our courses have continually increased for the last several years. These trends are expected to continue into

the foreseeable future. Our facilities are inadequate for collaborative activity of all types, including faculty-student interactions, the experience of researchers visiting our campus, informal gatherings, and colloquia.

The challenges that we face include: attracting and retaining the strongest faculty; fostering and sustaining a diverse and inclusive academic environment; improving teaching efficiency while maintaining excellence in education, particularly undergraduate education; and renovating our facilities to improve our classrooms and to support and encourage team efforts.

Background and Plan Details

We identified areas in which we can become excellent through strategic investment, or become truly exceptional where we are already excellent, while better serving the needs of faculty, staff, graduate students, undergraduate students, the university, the community, and the profession. The five objectives listed in the Executive Summary collectively lay out our path to excellence.

We are already among the leading public mathematics departments in the U.S. and, through our planning process, we are setting our sights on becoming a truly exceptional department. We will become a top research department, known nationally and internationally as a place where exciting new ideas are developed, which will help to set the international mathematics agenda.

Our Department will foster and thrive upon the generation of exciting and cutting-edge ideas and activities, which will take place in the classrooms and lecture rooms, in faculty offices, and in the hallways. Our objectives encompass both activities at the core of mathematics as well as outward-looking activities in collaboration with students and faculty from other departments.

The renovation of Altgeld and Illini Halls will profoundly transform what we are able to do, providing the department and the university with an exciting world-class environment for collaborative learning and research, while at the same time restoring a campus icon to its historic splendor. The multitudes of students taking mathematics classes on our campus will receive an enriched education, including undergraduate research and innovative modes of instruction. Our educational efforts will be inclusive, addressing all majors and benefiting a diverse student body. Outstanding scholars and innovators will prepare students for leadership in an increasingly complex and interdisciplinary world. The achievement of these goals will dramatically improve our department and have a tremendous impact on our campus and far beyond.

In the following pages we discuss each objective in turn, along with supporting deliverables. The objectives will be achieved by accomplishing the deliverables, and we will track progress on the plan by measuring progress on the deliverables.

1 Be one of the top research departments in the world, and be widely recognized as such

Analysis of leading departments indicates that the reputation of a department is often measured by its most prominent and prolific members. Adding outstanding faculty to this group is the most reliable and the most effective way to improve our department's status. Highly regarded departments are able to attract top-notch faculty, postdocs, and students.

The mathematics department has hired world-class faculty over the last several years, filling two endowed professorships just recently. These professors not only add tremendous strength in core disciplines, but they interact well with scientists outside of the Department of Mathematics. The National Research Council's 2025 report concludes that innovation and discovery will come from first-class mathematicians collaborating with experts from physics, engineering and the life and social sciences, a conclusion with which we fully agree. This interaction is best taught by example and by role models along with maintaining ambitious research in the core mathematical disciplines. An outstanding example of such collaboration is the effort which produced the mathematical methods to effectively analyze Big Data. Research on Energy and Environment, as well as Health and Wellness, both proposed by Chancellor Wise's *Visioning Future Excellence* initiative, rely on effective evaluation of large data sets and hence on mathematical modeling and computational resources. Furthermore, the Health and Wellness theme relies on investment in the new quantitative biology, while associated financial and risk management aspects are extensively studied by actuarial scientists in our department.

One of the main strengths of our mathematics department is a collegial environment that allows individual faculty to emphasize their greatest strengths while still operating as a team. This quality is crucial in accommodating and identifying superstars who are willing and able to go the extra mile towards collaborative applications without compromising research quality in their focused core areas.

Deliverables for this objective

A. Ten new world-class senior hires in the math department. At least four of these positions will be endowed.

Announcing that ten first-rate positions will be filled in the next five to eight years will create the necessary momentum to attract not only senior superstars, but the very best assistant professors available. It is important to be clear that the hiring of these senior faculty will not come at the expense of the ongoing hiring of assistant professors. Assistant professors constitute the lifeblood of the profession and serve to attract higher quality postdocs and graduate students, and even the senior hires themselves, all of whom contribute to improving the ranking of our department. Several of these new positions will be in areas of mathematics

which are relevant to the campus strategic plan. A commitment of this order of magnitude will require and inspire fundraising for the endowed positions.

B. Partner with the college to conduct a review of the mathematics department by world known experts by 2014, and use the results to establish specific deliverables for improvement over the next few years.

An outside review based on a joint initiative by the College of LAS and the Department of Mathematics will provide an unbiased and thorough analysis of our strengths and weaknesses; highly-respected reviewers will see what we're currently doing and where we're headed. The results of the review will identify specific areas for improvement, provide guidelines for hiring, and identify new innovative trends leading to collaboration between mathematics and other disciplines.

An outcome of this strategic planning discussion is the need for a more proactive, year-long pursuit of new hires. From an outside review, the department expects insights and suggestions on current hiring strategies and policies.

C. Create a competitive, permanent Named Scholar Program for newly hired assistant professors within the next three years.

The Named Scholar Program would provide additional funds and prestige to attract some of the top candidates on the market. In order to maintain the prestige of the Program, no more than three such positions will be filled over the next five years.

D. Develop a five-year plan for addressing faculty salary problems.

Our salaries are noticeably below average compared to peer institutions and significantly below top public universities. It will be difficult, at best, to hire at the level of excellence we require at our existing salary structure, and our department is vulnerable to attempts to recruit our best researchers at a 30%–40% salary increase. Without a proactive retention strategy, hiring ten new stars could be accompanied by loss of existing strength. Unless we address salary problems systemically, attracting new outstanding assistant professors at market value will require salaries which are higher than those of long-term contributors in the department and rising stars among the associate professors.

We will present clear and unequivocal data as to the extent of the salary problem and what it will take to correct it. If the increase needs to be phased in, our immediate priority would be to offer competitive salaries for new faculty hires and for retentions. The next phase would be a prioritization process for addressing the salaries of existing faculty in order to minimize attrition due to salary during the next five years.

E. Analyze citation patterns and use the results to improve the impact of the research performed in the math department.

The Department has many indicators of excellence. Most of the Academic Analytics metrics are high (for example, we are 3rd in total articles published) and our faculty have collectively achieved high honors such as a large number of Fellows of the American Mathematical Society, Sloan Fellows, an exceptionally high number of prestigious invitations to speak at the International Congress of Mathematicians, and much more. Nevertheless, Academic Analytics data has us ranked 47th in total citations and 173rd in citations per publication. We performed an independent analysis with the help of MathSciNet, and our preliminary analysis is that the number of citations per paper or per faculty is comparable with those of mathematics departments with similar rankings, but lower than for top public departments. This analysis will be the starting point of a broader review with the goal of improving the impact of the research performed in the math department.

2 Maintain an exciting dynamic collaborative environment supporting activities at the frontiers of the mathematical sciences

We will become a much better department by taking full advantage of the collaborative opportunities presented by the world-class faculty both in the department and the university as a whole and by bringing in visitors and sponsoring conferences to make sure that we are fully up-to-date, and so that others are aware of the cutting-edge research taking place within our walls.

Deliverables for this objective

A. Establish a regular internal faculty colloquium by 2014 to be held weekly.

The University of Illinois has assembled an extraordinary group of people. By establishing a regular internal faculty colloquium we will encourage collaboration both within the department and with other departments on campus. A seminar will be established to let each other know what we are or would like to be thinking about and to facilitate the formation of working groups. All faculty members will be strongly encouraged to speak periodically, and newly tenured faculty will be encouraged to explore new and more ambitious avenues of research.

B. Hold regular conference series "X at Illinois" supported by the department, at least one per semester, beginning no later than 2014. Also, maximize the impact of our guest lecture series by branding them as the "Illinois Distinguished Lecture Series."

The frequent conferences that some areas in the department hold have already raised their profile and contributed to attracting strong faculty and students. These conferences will be institutionalized and organized to maximize their effectiveness as vehicles for exposure and recruitment. The department will streamline and encourage the organization of the conferences and exploit them for recruitment.

The department currently has several prestigious lecture series. We can raise their profile by organizing them together as part of the "Illinois Distinguished Lecture Series," without changing their individual names or character. They will be advertised collectively at mathematics departments nationwide, a year in advance. We will produce an "Illinois Distinguished Lecture Series" video and/or a set of lecture notes from the lectures themselves.

C. Establish a visitors program and have the first visiting professor here by 2015.

A visitor's program consisting of month- or semester-long visits by prominent faculty from around the world will supplement our prestigious lecture series. This visitors program would inform the department of cutting-edge research, create opportunities for collaboration and networking with faculty and graduate students, and raise our profile. Challenges include identifying a funding source and allocating space commensurate with a prestigious visiting professor.

D. Address campus and national research priorities, such as environment and Big Data, through our Distinguished Lecture Series and by incorporating mathematical modeling into our department culture.

Most research priorities at both the campus and national levels have strong links to mathematics, and we will persuasively encourage our faculty to engage with them while making strategic collaborative hires. More generally, we will add mathematical modeling to the department culture by establishing courses that teach modeling, hosting conferences where real-world problems are presented to our faculty and students, and finding internship opportunities for our students.

E. Establish and maintain a postdoctoral program which supports a postdoctoral fellow in every research group in the department.

Increasing our postdoctoral program to a size commensurate with our standing will greatly enrich the life of the department. Postdoctoral fellows bring new techniques and perspectives

from their PhD institutions to our research. They are natural collaborators for our faculty and graduate students, and they are a great asset to our formal and informal teaching.

We estimate that a ratio of 2 postdocs to every 3 faculty will be needed to achieve this objective. This ratio may seem large, but it is consistent with practice at the best public and private institutions. Thoughtful balancing of the number of tenure-stream faculty, postdocs, and PhD students will play an important role in the implementation of this strategic plan.

F. Significantly increase involvement of the faculty with the online presence of the department.

For the purposes of promoting the department, each month our webpage will highlight a "featured research area." Previous featured research areas will remain easily accessible so that interested parties can learn about the exciting research represented at Illinois. The individual research areas, or subsets thereof, will provide our webmaster with content and work with them to organize and exhibit it.

We will develop a central announcement scheme that replaces the current ad hoc email system with prominent announcements of upcoming events and visitors.

3 Develop world-class facilities for collaborative research and learning in mathematics

In order to attain and sustain excellence, our facilities must be excellent, but they are in fact far from excellent. There is an inadequate amount of space for faculty and students and the space that we do have, including our classrooms, is of poor quality. Furthermore, the members of the department are divided between four buildings.

To take advantage of the opportunities on our campus and in keeping with the recommendations of the *Mathematics in 2025* report, the department must become even more collaborative and outward-looking than it currently is, but our physical space limits our ability to do so. While collaboration can and does take place in virtual environments, the most effective collaborations take place in spaces where people can come together easily and spontaneously. Our facilities plans are designed to accomplish just that.

Our improved facilities will transform our classrooms and our research environment, making the University of Illinois Department of Mathematics a coveted destination for researchers and students worldwide. Our research faculty will be housed in one building in support of our research objectives. We will begin to improve our facilities immediately while creating world class facilities for the longer term.

Deliverables for this objective

A. Raise funds and begin renovation by 2017.

A major renovation is necessary to transform our facilities from their current aging state to a world class collaborative learning environment. We have already completed a feasibility study for the project and have begun to secure funds. It is imperative that we aggressively pursue multiple funding sources immediately so that construction is ready to commence by 2017. We need to move as quickly as possible, as the feasibility study has a limited shelf life. The target of 2017 is an aggressive but achievable goal.

B. Create new spaces for collaboration in the next two years. These spaces can be in our current facilities or those nearby, and will include an improved common room or its functional equivalent.

Enhancing our collaborative environment in advance of the renovation supports another objective of this plan and will have immediate effects on our programs and on the experiences of our students. Our experiences with these new collaborative spaces will be of critical importance as we further develop our plans for the renovation and will help us use our improved space even more effectively after the renovation. Most leading mathematics departments have a common room where innovative ideas are generated as members of the department come together throughout the day for informal interaction. Our current common room is too small relative to the size of the department to serve this purpose.

C. Add new and improved spaces for graduate students near our current facilities over the next five years.

Since graduate students participate fully in both collaborative research and undergraduate teaching, facilities must be provided for them in order to achieve this objective. Due to their large numbers, graduate students could not be fully accommodated in our renovation plans, and so must be accommodated independently. The last external visiting committee which evaluated our doctoral program identified space as the most pressing need of our program.

D. Between now and the renovation, maintain the department's current space allocation policies, so that new faculty, postdocs, and research visitors will continue to receive quality space.

To support our objective between now and the renovation, it is imperative that our space quality not be allowed to degrade as we attract new faculty to our department. Our space constraints are becoming increasingly felt as the Department of Mathematics grows to meet student demand. Our faculty space is already woefully below our peers and was a data point that adversely affected our ranking by the National Research Council.

4 Provide excellent and innovative undergraduate math education for all audiences: mathematics, engineering, sciences, and non-STEM majors

Innovative and effective mathematics instruction is a valuable component of undergraduate education at any university. In light of our strength in engineering and the sciences, mathematics instruction is simply indispensable at the University of Illinois. Mathematics makes science and engineering possible.

The mathematics department, as part of its mission at the University of Illinois, runs a massive educational operation, serving not only mathematics and actuarial science majors, but large student populations in other departments as well. It is important that our department continue to excel in undergraduate education, not only as delivered in traditional modes of instruction, but also in new modes being rapidly created by online technologies.

Deliverables for this objective

A. Increase the scope of undergraduate research programs in the Department of Mathematics, measured both by the number of participating students and by faculty involvement, with the first new programs in place by the end of the 2013–2014 academic year. Every undergraduate major will have a research experience.

Increasing the scope of undergraduate research is a priority for the department, consistent with the campus's priority. The ability to involve students in research is one of the characteristic strengths of a residential university. Participation in research has been shown to increase undergraduate students' understanding and confidence, while clarifying their career interests. It has been shown to be strongly correlated with the decision to continue on to graduate work, particularly for female students and underrepresented minorities.

B. Increase active-learning components in a significant proportion of undergraduate courses, with the first additions in place by the 2014–2015 academic year.

The inclusion of active learning in classes has a significant positive influence on undergraduate instruction in all of the STEM fields, and particularly in mathematics. Students learn to collaborate with each other in active learning classes, better preparing them for success in both graduate school and the corporate world. Students in active learning classes typically perform better than their counterparts in traditional classes.

C. Identify and attract excellent undergraduate majors to our program while at least tripling the number of scholarships available over the next five years.

It is particularly important for the department to raise scholarship funds in order to attract

strong students to our department, due to the high level of unmet student financial need on our campus as compared to peer institutions.

D. Perform a large-scale and global analysis of our curriculum and use the results to improve the quality of our course offerings.

We will collect data about the different populations of students in our classes and about the performance of each of these populations, and we will use the results to improve our course offerings by adjusting the course content and more appropriately identifying the target audience.

E. Add new and innovative modes of instruction in the Department of Mathematics such as LAS Blockbuster courses, Discovery Courses, additional online courses, or MOOCs, the first such course(s) being offered by the 2014–2015 academic year.

New innovative Discovery Courses would provide excellent General Education experiences to first-year students and would also help attract students to Mathematics and other STEM disciplines. Furthermore, Discovery Courses often have an active learning component, in support of deliverable B.

The LAS Blockbuster Courses serve an interdisciplinary audience and complement other interdisciplinary initiatives in this plan, particularly objective 5 below. Enrollments in mathematics courses have grown significantly over the past decade and demand is expected to increase, but we need to be innovative to maintain our edge in the rapidly changing environment created by new online teaching and learning technologies.

5 Prepare graduate students for leadership in both academic and nonacademic career paths in an increasingly interdisciplinary world

A strong graduate program is one of the most important features of any research department. Graduate students help advance faculty research and spread new ideas that originate at Illinois. Successfully employed graduate students improve the reputation of our department, which in turn causes more and stronger students to apply to Illinois. Some of the more successful alumni will likely become donors to the department.

The Department of Mathematics has a traditionally strong graduate program with many graduates accepting postdoctoral positions in top mathematics departments. There is, however, room for improvement. First, students must be well prepared for the increasingly

interdisciplinary world by having broader expertise, which can be acquired through summer research and internships. Second, with the shortage of academic jobs, many students need to be prepared for jobs in industry. This preparation would be acquired through internships and appropriate training. Third, all students need to have excellent writing and presentation skills and to be able to form professional networks.

Deliverables for this objective

A. Support summer research activities for all interested first and second year graduate students, as well as entering students, and secure grants from NSF or other funding agencies to help fund the program.

These research activities would distinguish the Illinois mathematics department from other schools and would help attract top students. Compared to graduate studies in engineering, graduate studies in mathematics inherently require a longer time for a student to start doing research. To become competitive in today's interdisciplinary scientific environment, graduate students must get involved in research earlier. Summer research ensures that students get the most out of this critical time of their careers.

The department must continue its highly successful Research Experiences for Graduate Students (REGS) program by securing new funding. Having both academic and non-academic internships (deliverables B and C below) would make a strong case for NSF funding. The REGS program attracted attention to Illinois through visiting faculty and students (especially in the combinatorics group REGS).

B. Facilitate internships for graduate students in industry and government labs, ramping up to at least 20 concurrent internships over the next 5 years.

With fewer jobs in academia and more demand for advanced mathematics in industry and industrial research, our graduate students, particularly those in the applied math PhD program, will greatly benefit from industrial research internships.

C. Initiate an academic internship program, a new initiative, and have the first interns placed by the 2014–2015 academic year.

The students would spend 4–6 weeks at the mathematics department of a partner university to participate in research activities. These opportunities will create a broader spectrum of research areas for graduate students and will also help them to form professional networks.

D. Add at least six new graduate fellowships within the next four years.

An increase in the number of graduate fellowships would allow our graduate students to devote more time towards their career preparation, either academic or non-academic as appropriate to the student and the nature of the fellowship. These fellowships will also have the desirable effect of shifting the culture of the department's graduate program from a teaching culture towards a research culture. A peer analysis indicates that our graduate student TA teaching loads are competitive, but we fall behind in the overall teaching load because we are relatively low in the number of RAs.

E. Develop a course and seminar on professional development for both academic and non-academic careers; conduct the first session by the 2014–2015 academic year.

Some work in this area is already underway. Graduate students will acquire new skills for writing articles, oral communication, applying for jobs, etc. Such skills are important for landing a job. The seminar will also host departmental alumni to discuss their real-world experiences.

F. Create a database for job placement. Use this to analyze and report on the shifting pattern of employment and quality of jobs over 5 years.

It is important to track the career paths of mathematics graduates. Currently, only the first job after graduation is tracked. Our alumni network will help current graduate students find jobs both inside and outside of academia.