# Self Study

Department of Mathematics
Iowa State University
September 13, 2007

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# 1. Background

## Progress since the 1999 External Review

In April, 1999 the Mathematics Department completed a comprehensive self-study in preparation for an external review. The review team consisted of Thomas Manteuffel, University of Colorado (Chair); Patricia Bauman, Purdue University; Joseph Flaherty, Rensselaer Polytechnic Institute; C. Ward Henson, University of Illinois; Hector Sussman, Rutgers University; and Srinivasa Varadhan of the Courant Institute of New York University. They visited the campus during September, 1999, and issued their report in November of that year. A departmental response to the report was made in January, 2001.

The main findings and issues identified by the report were

- High quality and intensity of research activities
- Praise from other departments on campus for the outreach efforts of the Mathematics Department
- The Department was well positioned with respect to new funding opportunities
- The Department was understaffed
- Strengthen the graduate program
- Surprising lack of a postdoctoral program
- Number of temporary instructors was high in relation to total faculty

**Research activities, funding, and interdisciplinary activities**.

Since fall, 1999, the Department has hired eleven new tenure-track faculty; however, the number of tenure-track faculty lost to resignations and retirements in this period has been even greater. The quality and intensity of the research activities remains strong, due in significant part to strong hires that have been made. We continue to have a healthy group involved in interdisciplinary activities, and the number of faculty receiving external funding, both through interdisciplinary activities and from individual investigator grants is higher now than at any time in the past. The review team mentioned the NSF-REU grant, and the current Chair obtained another such grant in 2003.

The report cautioned that the Department should not just hire "applied mathematicians" to the exclusion of traditional "core" areas of mathematics. In the hiring that has taken place since the report, this advice has been followed, with about half the new hires falling in each category, though as the report indicated, the boundary between what is core and what is applied is not a settled matter, and in fact is changing.

**Math education**

The report referred to the responsibilities of the Department in the areas of elementary and secondary teacher education. It recommended that some of those should be transferred to the College of Education (now Human Sciences), which has happened. The issue as to what extent the Department should be involved in K-12 education is still up in the air. One thing is clear, though: without additional resources, the Department cannot take on any additional major responsibilities.

There is a major initiative underway which involves the five mathematical sciences departments at the three Regents' universities. Some funding was provided by the LAS Dean in summer 2007. The initiative is comprehensive in that it involves improving teacher education in the state of Iowa, as well as addressing the transition of high school students/community college students to the Regents' universities. A proposal was submitted to the Board of Regents in August 2007.

**The graduate program**

About 25% of the nine page report was devoted to the graduate program. The Department offers both M.S. and Ph.D. degrees in both mathematics and applied mathematics. The MSM (Master of School Mathematics) is offered to in-service secondary school mathematics teachers. Graduate students also have options of pursuing a co-major Ph.D. degree, a concurrent M.S., or an interdisciplinary degree such as in the BCB (bioinformatics and computational biology) program.

At the time the report was done, graduate programs in the Department enrolled 33 students, and it was observed that the number was too low for the size of the Department, and it was recommended that it be increased to 60 – 70. We have had good success: at present we have over 60 graduate students, of whom 55 are supported by the Department, nearly all as TA's; furthermore, we believe we have increased quality as well as quantity. Almost all the students being admitted with support are being admitted to the Ph.D. program. One obstacle we face in raising the numbers further is lack of funding.

Another issue raised was that of graduate tuition, which had been a deterrent to recruiting some of the best applicants. Here credit must be given to the Graduate College, as now all Ph.D. students receive full tuition scholarship, in addition to the TA stipend, which averages about $15,000 per year.

The review team noted that there is a lack of fellowship support for graduate students. Since the report, funding has been obtained for students in the BCB program through IGERT fellowships and for students in Information Assurance through another federal grant (NSA). However, they recommended that we raise funds through other sources (such as alumni) so we can award fellowships to outstanding applicants. Presently we are working with the ISU Foundation on this goal. One fellowship has already been established.

**Postdoctoral program**

The report stated: *It is very important for the Department of Mathematics at Iowa State to have a strong post-doctoral program. The current program is virtually nonexistent. … Almost all major departments have such a program. … Year after year they bring new talent to the department, and the mathematicians who have held the position leave with a good experience…*

This is an area in which little real progress has been made. This year we have four post-docs, three of whom we were able to hire due to the number of faculty on sabbatical leave, and one of whom was hired by a faculty member using his NSF-CAREER grant. However, this is exceptional, and unless a new source of funds becomes available, the Department will probably not be hiring any additional post-docs.

The report called on the university to supply additional funds for a post-doctoral program. That has not happened.

**Staff**

The report claimed that the office was understaffed. For a department of this size, this level of office staff seems dangerously inadequate. It mentioned that comparable departments have an office staff approximately twice as large. Since that report, the faculty size has decreased by about 20%, and we now have a ½ time position, in addition to the four office staff positions at the time of the report.

Given that faculty now type their own exams and research papers, we have little need for technical typing support in the main office, so that we are able to get by with the size of the current staff. Fortunately we have been able to hire some excellent work-study students, who assist the office staff.

Another matter is computer support. We have now, as before, just one full time systems support person; the recommendation called for a second such person. In lieu of a second full time P&S position we have used TA's or lecturers with computer expertise to assist Jon Roden.

**Space**

In December 2005 the Department was given 15 renovated offices on the 3rd floor of Carver Hall, following the move of the Business College to their new building. The Math office moved into new quarters on the 3rd floor. This did much to alleviate the crowded quarters that we had on the 4th floor. The Department still occupies the entire 4th floor, about 1/3 of the 3rd floor, and has a computer lab and graduate office space on the second floor of Carver Hall.

**Temporary instructors/lecturers**

The final issue was that of temporary instructors. It noted the problems associated with the hiring of staff at the start of the semester. It also commented that the number of such instructors seemed to be unusually high. Of course, the situation has improved with the institution of the lecturer position, for which multi-year contracts are possible. Still, the report concluded instruction could be improved if the Department replaced temporary instructors with graduate assistants and post-docs. We have now a lower number of lecturers (FTE's) than we had temporary instructors, and to some extent teaching assistants have replaced lecturers. But we do not have a post-doc program, which would allow us to further cut back on the lecturers.

# 2. Faculty

## Faculty Funding

**Research grants**
Currently fourteen faculty have external research funding:

- Domenico D'Alessandro NSF (CAREER GRANT)
- James Evans NSF, DOE
- Howard Levine NIH
- Hailiang Liu NSF
- Ling Long NSA
- Glenn Luecke DOD, industry
- Ryan Martin NSA
- Richard Ng NSA
- Sunder Sethuraman NSF, NSA
- Michael Smiley NIH
- Bo Su NSF
- Moulay Tidriri NSF
- Ananda Weerasinghe DOD
- Zhijun Wu NIH

**Research related/infrastructure proposals and funding**

Justin Peters is PI on the current NSF-REU grant and on the renewal proposal, and Leslie Hogben is co-PI. Leslie is PI on the NSF-MCTP proposal, along with four co-PI's (Justin Peters, Paul Sacks, Stephen Willson, Zhijun Wu).

Leslie Hogben, Wolfgang Kliemann and Y. T. Poon are PI's on the IMA (i.e., the Institute for Mathematics and its Applications, housed at the University of Minnesota) grant which will host the IMA summer graduate student program in 2008. They are also PI's on the NSF conference proposal to accommodate additional graduate students at the summer program.

Clifford Bergman is co-PI on an NSA grant providing fellowships in Information Assurance.

**Other faculty funding**

Zhijun Wu has been named an *IMA New Directions Professor* for the academic year 2007 – 2008, which he will spend at the IMA.

Leslie Hogben has just been named *Associate Director for Diversity* at AIM (i.e., the American Institute for Mathematics).

# 3. Salary

## 3.1 Salary Data

Faculty salaries were below peer averages at the time of the 1999 external review, and since that time raises in the Department have lagged those of peer institutions and failed to keep up with inflation, so now the situation is indeed critical. We have lost faculty to other institutions due primarily to salary issues, most recently Oleg Emanouvilov to Colorado State University and Dan Ashlock to Guelph University.

*Table 1. 2006-2007 Professor Salary Survey*

| | | | | | | # Years in rank | |
|---|---|---|---|---|---|---|---|
| UNIVERSITY | Number | 75%tile | median | 25%tile | average | average | maximum |
| BRANDEIS | 9 | 112,366 | 106,000 | 79,600 | 102,000 | 17.0 | 34 |
| CALIF-RIVERSIDE | 17 | 110,900 | 96,400 | 96,400 | 101,089 | 16.4 | 35 |
| CALIF-SAN DIEGO | 38 | 165,100 | 113,500 | 93,200 | 127,600 | | |
| CARNEGIE MELLON | 18 | 147,463 | 121,020 | 104,519 | 127,131 | 17.7 | 38 |
| CORNELL | 27 | 144,103 | 133,783 | 122,655 | 137,061 | 23.9 | 41 |
| ILLINOIS | 37 | 104,152 | 99,002 | 88,511 | 101,224 | 16.0 | 34 |
| INDIANA | 29 | 103,277 | 89,090 | 78,706 | 95,873 | 11.0 | 27 |
| IOWA | 28 | 103,000 | 90,850 | 75,900 | 95,552 | 18.0 | 35 |
| IOWA STATE | 18 | 91,828 | 81,882 | 76,090 | 87,369 | 18.0 | 29 |
| JOHNS HOPKINS | 14 | 123,750 | 115,470 | 99,750 | 118,095 | 21.6 | 37 |
| MARYLAND | 43 | 130,200 | 106,300 | 93,739 | 111,754 | | |
| MICHIGAN | 51 | 127,260 | 110,777 | 103,386 | | | |
| MICHIGAN STATE | 32 | 125,375 | 105,025 | 91,500 | 110,106 | 24.0 | 42 |
| NORTH CAROLINA | 23 | 100,331 | 87,992 | 80,378 | 92,211 | 11.0 | 26 |
| NORTHWESTERN | 21 | 136,600 | 118,500 | 94,200 | 120,506 | 21.0 | 39 |
| OHIO STATE | 44 | 112,755 | 99,462 | 87,099 | 104,089 | 13.0 | 29 |
| PENN STATE | 39 | 128,628 | 111,960 | 91,044 | | 12.2 | 36 |
| PURDUE | 44 | 125,700 | 107,000 | 97,300 | 109,464 | 17.1 | 43 |
| RICE | 10 | 158,100 | 102,800 | 87,000 | 118,706 | 25.0 | 42 |
| RUTGERS | 54 | 144,750 | 133,450 | 113,100 | 132,500 | 19.6 | 40 |
| SUNY STONY BROOK | 14 | 138,913 | 122,060 | 115,373 | 127,000 | 25.0 | 30 |
| TEXAS | 35 | 108,600 | 123,760 | 101,440 | 129,347 | 15.1 | 32 |
| UTAH | 32 | 104,501 | 100,052 | 84,059 | 98,872 | 16.2 | 39 |
| VIRGINIA | 19 | 115,800 | 96,300 | 92,600 | 102,532 | | |

NOTE: Blanks indicate data that is not available.
U. Illinois is at Champaign-Urbana
U. Indiana is at Bloomington
U. Iowa is at Iowa City
U. Maryland is at College Park
U. Michigan is at Ann Arbor
U. North Carolina is at Charlotte
U. Texas is at Austin

*Table 2. 2006-2007 Associate Professor Salary Survey*

| UNIVERSITY | Number | 75%tile | median | 25%tile | average | #Years in rank average | maximum |
|---|---|---|---|---|---|---|---|
| CALIF-RIVERSIDE | 3 | 66,650 | 64,700 | 63,150 | 64,967 | 15.7 | 37 |
| CALIF-SAN DIEGO | 8 | 79,200 | 73,200 | 66,200 | 73,100 | | |
| CARNEGIE MELLON | 6 | 94,575 | 81,690 | 76,065 | 85,255 | 4.2 | 13 |
| CORNELL | 3 | 91,944 | 91,678 | 91,424 | 91,686 | 4.3 | 6 |
| ILLINOIS | 16 | 81,614 | 75,602 | 70,431 | 76,891 | 4.0 | 22 |
| INDIANA | 12 | 71,000 | 70,000 | 67,175 | 71,035 | 9.0 | 28 |
| IOWA | 6 | 75,000 | 66,350 | 63,000 | 75,600 | 10.0 | 17 |
| IOWA STATE | 13 | 74,814 | 66,349 | 63,717 | 67,974 | 10.0 | 24 |
| MARYLAND | 10 | 87,985 | 80,000 | 76,588 | 79,794 | | |
| MICHIGAN STATE | 9 | 96,000 | 80,000 | 73,000 | 81,862 | 7.8 | 16 |
| NORTH CAROLINA | 10 | 71,731 | 68,392 | 62,214 | 67,867 | 10.0 | 26 |
| NORTHWESTERN | 4 | 85,400 | 85,400 | 82,200 | 86,250 | 4.0 | 8 |
| OHIO STATE | 10 | 77,817 | 74,574 | 66,384 | 73,176 | 10.0 | 29 |
| PENN STATE | 6 | 94,572 | 72,576 | 71,748 | | 6.1 | 33 |
| PURDUE | 8 | 83,500 | 76,312 | 76,000 | 79,304 | 2.8 | 4 |
| RUTGERS | 8 | 87,750 | 82,050 | 79,200 | 82,850 | 6.0 | 22 |
| SUNY STONY BROOK | 5 | 84,207 | 81,992 | 80,000 | 83,000 | 2.6 | 6 |
| TEXAS | 5 | 81,000 | 80,000 | 79,000 | 78,700 | 11.0 | 27 |
| UTAH | 7 | 73,373 | 72,900 | 71,732 | 73,092 | 2.6 | 8 |
| VIRGINIA | 3 | 78,100 | 77,300 | 76,900 | 77,433 | 6.2 | 7 |

*Table 3. 2006-2007 Assistant Professor Salary Survey*

| UNIVERSITY | Number | 75%tile | median | 25%tile | average | #Years in rank average | maximum |
|---|---|---|---|---|---|---|---|
| CALIF-RIVERSIDE | 4 | 67,225 | 65,500 | 63,125 | 64,850 | 2.0 | 3 |
| CALIF-SAN DIEGO | 7 | 71,800 | 67,200 | 65,200 | 68,200 | | 6 |
| CORNELL | 6 | 71,896 | 68,276 | 64,617 | 69,592 | 3.0 | 7 |
| ILLINOIS | 17 | 71,439 | 66,644 | 65,311 | 70,068 | 2.0 | 5 |
| INDIANA | 3 | 69,965 | 69,326 | 68,742 | 69,363 | 2.0 | 3 |
| IOWA | 4 | 69,500 | 68,750 | 68,000 | 68,845 | 1.0 | 3 |
| IOWA STATE | 9 | 59,795 | 58,794 | 58,269 | 58,547 | 4.0 | 7 |
| JOHNS HOPKINS | 6 | 58,710 | 56,460 | 55,000 | 57,025 | 2.5 | 4 |
| MARYLAND | 6 | 72,160 | 72,000 | 71,387 | 71,387 | | |
| MICHIGAN STATE | 11 | 71,000 | 69,500 | 66,450 | 68,421 | 2.4 | 5 |
| NORTH CAROLINA | 12 | 59,789 | 58,378 | 57,212 | 58,201 | 2.0 | 6 |
| NORTHWESTERN | 4 | 72,000 | 71,750 | 69,300 | 71,950 | 2.0 | 4 |
| OHIO STATE | 5 | 69,000 | 68,640 | 68,424 | 68,681 | 1.3 | 2 |
| PENN STATE | 11 | 67,968 | 65,016 | 62,460 | | 2.6 | 5 |
| PURDUE | 6 | 69,713 | 68,850 | 68,813 | 69,050 | 1.2 | 3 |
| RUTGERS | 8 | 63,200 | 51,300 | 50,650 | 56,800 | 4.5 | 29 |
| SUNY STONY BROOK | 5 | 72,100 | 65,920 | 60,000 | 66,000 | 1.4 | 2 |
| TEXAS | 8 | 76,000 | 73,250 | 72,000 | 73,813 | 3.3 | 7 |
| UTAH | 4 | 66,560 | 66,560 | 66,560 | 66,560 | 1.0 | 1 |
| VIRGINIA | 6 | 70,600 | 70,000 | 68,250 | 69,617 | 2.5 | 6 |

*Table 4. Answers to questions on teaching loads*

| UNIVERSITY \ QUESTION | 1 | 2 | 3 | 4 | 5 | 6A | 6B | 7 |
|---|---|---|---|---|---|---|---|---|
| BRANDEIS | 177 | 848 | 728 | 240 | 0 | 13.0 | 13.0 | 13.0 |
| CALIF-RIVERSIDE | 9,906 | 7,854 | 2,018 | 339 | 524 | 40.0 | 35.0 | 56.0 |
| CALIF-SAN DIEGO | 1,632 | 17,300 | 4,696 | 1,070 | 77 | 83.0 | 83.0 | 106.0 |
| CORNELL | 28 | 12,166 | 1,011 | 600 | 0 | 60.0 | 60.0 | 62.0 |
| ILLINOIS | 2,869 | 21,992 | 6,969 | 1,149 | 230 | 93.0 | 86.0 | 104.0 |
| INDIANA | 5,072 | 23,250 | 1,580 | 834 | 0 | 60.0 | 53.0 | 102.0 |
| IOWA | 1,908 | 10,845 | 1,979 | 1,082 | 88 | 46.0 | 46.0 | 75.0 |
| IOWA STATE | 2,234 | 16,759 | 2,753 | 528 | 8 | 51.0 | 41.0 | 45.0 |
| JOHNS HOPKINS | 204 | 3,552 | 1,616 | 252 | 312 | 27.0 | 27.0 | 31.0 |
| MARYLAND | 8,394 | 11,333 | 3,231 | 1,107 | 557 | 93.0 | 83.0 | 79.0 |
| MICHIGAN | 2,376 | 14,880 | 7,428 | 1,746 | 643 | 98.0 | 98.0 | 86.0 |
| MICHIGAN STATE | 19,336 | 14,092 | 1,725 | 935 | 0 | 80.0 | 62.0 | 184.0 |
| NORTH CAROLINA | 9,483 | 9,570 | 1,800 | 1,710 | 372 | 54.0 | 48.0 | 28.0 |
| NORTHWESTERN | 0 | 3,852 | 1,050 | 273 | 290 | 40.0 | 40.0 | 33.0 |
| OHIO STATE | 2,346 | 42,209 | 4,101 | 2,225 | 0 | 104.0 | 104.0 | 116.0 |
| PENN STATE | 9,900 | 19,200 | 10,000 | 650 | 5,350 | 87.0 | 48.0 | 42.0 |
| PURDUE | 15,931 | 25,390 | 5,739 | 2,649 | 359 | 94.0 | 76.0 | 144.0 |
| RICE | 0 | 2,535 | 246 | 273 | 0 | 23.0 | 23.0 | 15.0 |
| RUTGERS | 15,185 | 14,582 | 3,096 | 921 | 6 | 91.0 | 59.0 | 47.0 |
| SUNY STONY BROOK | 1,719 | 15,668 | 1,485 | 681 | 554 | 45.0 | 43 | 74 |
| TEXAS | 3,526 | 26,489 | 8,921 | 1,293 | 833 | 84.0 | 79 | 65 |
| UTAH | 8,433 | 6,348 | 3,886 | 974 | 0 | 65.0 | 57 | 36 |
| VIRGINIA | 0 | 4,146 | 1,852 | 810 | 0 | 30.0 | 30 | 37 |

## 3.2 Salary Questionnaire

SURVEY OF MATHEMATICS SALARIES AND TEACHING LOADS
Department of Mathematics
University of Illinois at Urbana-Champaign
AY2006-2007

University: _____

Name of Person Completing Form: _____

E-Mail: _____

Phone: _____

**These data are for the academic year 2006-07 only**. (As a check, the 75th percentile should be a larger number than the 25th percentile.)

| | | ACADEMIC YEAR SALARY# | | | YEARS IN RANK | |
|---|---|---|---|---|---|---|
| Full Time Faculty | Number* | 75th percentile | median | 25th percentile | average | maximum |
| Professor | | | | | | |
| Associate Professor | | | | | | |
| Assistant Professor | | | | | | |

* If fewer than three, salary data may be omitted to protect anonymity.
# Gross salary, exclusive of contracts, fringe benefits, summer school, etc.

**Please return form by November 1, 2006**
to: Sandee G. Moore, Assistant to the Chair
Department of Mathematics
University of Illinois at Urbana-Champaign
1409 W. Green St.
Urbana IL 61801

**TEACHING LOADS**

In this survey we are interested in the courses below, at and above the calculus level, your department teaches during the **Fall 2006** semester. Please base your estimates of total student hours taught on enrollment figures gathered near the beginning of the course.

Here we make the following definitions.

The number of **student hours** for a course is the number of students enrolled in the course at the beginning of the term multiplied by the number of hours that the course meets each week. For example, for a course that meets three hours a week, report the head count times three.

A **post-calculus course** is a course for undergraduate students normally taken only after the student has passed a course or courses in which infinite series, partial differentiation, and multiple integrals have been taught.

A **0-level course** is a course taken before the calculus sequence in which arithmetic, high school algebra, trigonometry or high school geometry are taught.

**At the beginning of the Fall Semester of 2006:**

1) How many student-hours were taught in 0-level courses?_____

2) How many student-hours were taught in calculus courses and other undergraduate courses that are not 0-level and not post calculus courses?_____

3) How many student-hours were taught in post-calculus undergraduate courses?_____

4) How many student-hours were taught in graduate courses?_____

5) How many student-hours were taught at the post-calculus level by teaching assistants? (Here, a student in a course meeting four hours a week, three with a professor and one with a TA, would add only one to the count.)_____

6) Excluding TAs, how many are teaching in the Fall semester? (Include faculty at all ranks and visitors, adjuncts, etc. For those with a split appointment, include only the fraction in mathematics.)_____
Excluding TAs, how many of those teaching are qualified to teach most post-calculus courses?_____

7) How many Teaching Assistants (head count, not FTE's) do you have this Fall who meet with students in all or part of a course?_____

# 4. Department Organization

The Department of Mathematics administration consists of a Chair, Associate Chair, Graduate Coordinator, Undergraduate Coordinator, and Coordinator of the Master of School Mathematics Program. The Chair position is a 12-month position, and each of the others entails one month of summer salary, except for the MSM Coordinator.

The Department has an office staff consisting of an administrative assistant, three secretaries, and a half-time program assistant.

# 5. Computer Labs

**Carver 400** (Faculty & Graduate Student Lab)

**Project Vincent workstations**

- PV Alpha workstation *duluth*(*duluth.math.iastate.edu*)- Limited use must get permission from Howard Levine.

**Linux Workstations**

- PC Linux workstation *proton (proton.math.iastate.edu )*Software: Mathematica v.5.0, and Matlab v.7.0.1
- PC Linux workstation *pollux (pollux.math.iastate.edu)* Software: Matlab v.7.0.1

**Linux Workstations** (Visually Impaired)

- PC Linux workstation *mapleta (mapleta.math.iastate.edu)* Software: *GCC*.

**Windows**

- 4 Pentium PC's
- DVD/CD Burner
- Software: Mathematica, Matlab, McAfee Anti-Virus, & Microsoft Windows

**Apple**

- 1 Mac Pro
- Software: Mathematica, Matlab, & Microsoft Office

**Scanner**

- Epson Scanner with Document Feeder

**Printers**

- Color LaserJet printer (ca400hp5m)
  (model HP 2605dn 1200 x 1200 dpi, 64Mb, PCL 6, color)
- Hewlett Packard LaserJet printer (ca400hpp3005n)
  (model HP P3005n, 1200 x 1200 dpi, 80 Mb, PCL6)

**Carver 250** (Mathematics Computer Lab)

50 Pentium PC's
LaserJet printer in 250 Carver
(model HP4300N,1200 dpi 80MB, PostScript Level 3)

Software: Microsoft Office, Winedit, Matlab, McAfee Anti-Virus, Geometer Sketchpad, MyMathLab, NVU, and Graphic Calculator.
Six TV's for viewing.

**Carver 449** (Mathematics Computer Lab)

49 Dell Pentium PC's
LaserJet printer in 449 Carver
(model HP4100N, 1200 dpi, 80MB, PostScript Level 3)
Software: Microsoft Office, Winedit, Matlab, McAfee Anti-Virus, Mathematica, MyMathLab, NVU, and Graphic Calculator.
One Mitsubishi projector.

**Carver 379** (Math 10 Lab)

3 Dell Pentium PC's
LaserJet printer (model HP4300N, 1200 dpi, 80MB, PostScript Level 3)
Software: Microsoft Office, Geometer Sketchpad, McAfee Anti-Virus, and MyMathLab

## Web and networking

**Adding Personal Computer to ISU Network**

*http://www.ait.iastate.edu/dns/netreg.html*

**Creating and Maintaining Web Pages**
*http://www.ait.iastate.edu/pubs/bag299/bag_299.html*

# 6. Undergraduate Mathematics Major

The last departmental Self-Study was performed in Fall 1998. Since that time, there have been many changes in our undergraduate offerings and operations. These include:

- The abandonment of the applied mathematics option for the B.S. in Mathematics.

- The research requirement for the B.S. has been changed. All mathematics majors who are seeking certification to teach high school are required to take CI/LAS 480C, a seminar course in Mathematics Education. All other mathematics majors must take Math 492, an undergraduate seminar course on a topic of the instructor's choosing.

- We have worked to make available research experiences for undergraduates. We have an active and vibrant summer REU in which some of our majors participate. During the year students occasionally work with a faculty mentor on a research project.

- We have changed the format of the life sciences calculus courses (Math 181, 182.) These courses were created with an accompanying wet lab. Students did experiments in a biology lab, then brought the data to the mathematics class for analysis, modeling, etc. A few years ago the life sciences units withdrew support for the lab, so the course is now taught in a traditional manner in a small to medium sized lecture format.

- Our one credit calculus "theory" courses (Math 165T etc.) have been replaced with an Introduction to Proofs course (Math 201). Originally this course was a two credit course (meeting two hours per week) but in Fall 2007 the course will become a three credit course. The course is required by all mathematics majors and minors and is a prerequisite for many our three- and four hundred level courses.

- We started offering some of our courses as web based courses. These include Math 150 (discrete mathematics for business students) Math 140 (college algebra) and Math 141/2 (trigonometry and analytic geometry.) The web based Math 150 has proved very successful. However, we have had a number of complaints about the web based Math 140/1/2 offerings. As of Fall 2006 we have reverted to small lecture format for Math 140. As will be mentioned later, our web based offerings of Math 140/1/2 have suffered because of the under-funding of the mathematics department.

- Two years ago the Business College moved from Carver Hall to its own new building. With that move the mathematics department gained a half floor of office space. This has allowed us to open an undergraduate lounge (important to

providing a sense of community for our majors) and to improve the mathematics help room. In addition, the move by Business has freed up classroom space in Carver. As a result, all but a handful of our courses meet in Carver Hall.

## 6.1 Enrollment

The University calculates and publicizes the teaching done, measured in student credit hours (SCH), for each department for the Fall semester. For each year since 1999 the Mathematics Department has delivered more SCH than any other department on campus. Over this period the Mathematics Department SCH total has exceeded that of second-place English by anywhere from 1300 to 4000 SCH for each Fall semester. (The University does not publish SCH data for Spring semesters). On the other hand, the Mathematics Department budget is over one million dollars less than that of the English Department.

The Mathematics Department has a very large service teaching load and offers a wide variety of introductory courses for students in different majors. The department also teaches a full slate of graduate and upper level undergraduate courses for its undergraduate and graduate majors, including many PhD candidates. In addition, in recent years, we have seen an increase in the number of non-mathematics students taking our upper level courses. In fact, for each Fall 2004-Fall 2006 we have had to offer extra sections of our Real Analysis and Measure Theory courses.

The bulk of the teaching, however, is in the form of service courses to students who are not mathematics majors. Low-level courses with high enrollments include college algebra, trigonometry, mathematics for liberal arts students, discrete mathematics for pre-business students, calculus, differential equations, and matrix theory. There are several courses in mathematics for elementary education majors. There are also several varieties of calculus courses, targeted directly for different clienteles in pre-business, economics, engineering, or biology. Each such group of courses presents its own difficulties. Further discussion of these courses will appear in later sections. We are also seeing significant enrollment by non-majors in some of our upper level courses, including Graph Theory, Combinatorics, Complex Analysis, and Advanced Calculus.

In the table on the following page we summarize the distribution of our teaching efforts by course type for Spring 2006 and Fall 2006.

*Table 5. Distribution of teaching efforts by course type during Spring 2006 and Fall 2006*

| Course | Spring 2006 | Fall 2006 | #Sections |
|---|---|---|---|
| 10 (R,S) | 72 | 216 | 8 |
| 104 (S) | 95 | 187 | 2 |
| 105 (S) | 164 | 197 | 2 |
| 140 (R,S) | 197(W) | 302(SL) | 14 |
| 141/2 (ES,S) | 213(W) | 377(LL)+397(W) | 33 |
| 150 (B,S) | 562(W) | 964(W) | 39 |
| 151 (B,S,C) | 415(LL) | 247(LL) | 27 |
| 160 (S,C) | 55 | 98 | 4 |
| 165 (ES,C,S) | 414(SL) | 373(LL)+549(SL) | 40 |
| 166 (ES,C,S) | 662(LL) | 375(LL)+274(SL) | 37 |
| 181 (LS,C) | 41 | 89 | 2 |
| 182 (LS,C) | 43 | not offered | 1 |
| 195 (EE,S) | 118 | 140 | 7 |
| 196 (EE,S) | 88 | 66 | 5 |
| 201 (M) | 25 | 53 | 3 |
| 265 (ES,C,S) | 378(LL) | 299(LL)+222(SL) | 30 |
| 266 (ES,S) | 113 | 123 | 10 |
| 267 (ES,S) | 402 | 299 | 20 |
| 297 (EE,M,S) | 15 | 24 | 2 |
| 301 (M) | 50 | 59 | 5 |
| 302 (M) | 20 | not offered | 1 |
| 307 (ES,S) | 169 | 114 | 10 |
| 314 (M) | 12 | not offered | 1 |
| 317 (M) | 38 | 40 | 4 |
| 350 (M) | 23 | not offered | 1 |
| 365 (ES,M) | 11 | 19 | 2 |
| 385 (ES,S) | 25 | 28 | 3 |
| 414 (M) | 23 | 26 | 3 |
| 415 (M) | 10 | not offered | 1 |
| 426 (ES,S) | not offered | 25 | 1 |
| 435 (M) | not offered | 18 | 1 |
| 436 (M) | 21 | not offered | 1 |
| 471 (ES,S) | not offered | 8 | 1 |
| 481 (ES,S) | 12 | not offered | 1 |
| 489 (M) | 24 | not offered | 1 |
| 492 (M) | 20 | not offered | 1 |
| Graduate | 239 | 157 | 36 |
| TOTAL | 4,769 | 6,365 | 360 |

B: Business
C: Calculus
EE: Elementary Education
ES: Engineering and Sciences
LS: Life Sciences
LL: Large Lecture
M: Math Majors
S: Service
SL: Small Lecture
W: Web-based
R: Remedial

In Summer 2006 we taught 623 students in 41 sections. Summer school is one of the main ways that we support graduate students during the Summer. Thus the bulk of our calculus and pre-calculus teaching and grading is done by graduate assistants during the Summer. Unfortunately we find it difficult to offer many upper level courses in the

Summer because very few faculty want to teach then. Thus we have had to cancel some upper level offerings (for example, numerical analysis) even though the courses had enrollments high enough to run.

## 6.2 Staffing

In the table below we have listed several course groups and for each group the number of sections taught by teaching assistants, lecturers, and tenured/tenure track faculty. The data are for Spring 2006 and Fall 2006 but are typical of the teaching assignments for a year. In Fall we have a heavier service load so offer slightly fewer graduate level and upper level undergraduate courses. In the Spring the service teaching load is lighter so we offer a wider variety of graduate courses and upper level undergraduate courses. In addition, Spring is typically the semester for those that have 2/1 teaching responsibilities to teach one course. Finally, we also have a few faculty members on phased retirement; these faculty typically teach in the Fall but not in the Spring. As a result most of our available tenured/tenure track faculty teach upper level or graduate courses in the Spring, so a larger percentage of teaching assistants teach introductory level courses during this semester. Generally, graduate assistants can have full responsibility for small lecture classes in remedial mathematics, college algebra, and various calculus courses. Teaching assistants also teach recitation sections that accompany large lecture sections of pre-calculus or calculus and also act as aides for web-based courses.

*Table 6. Teaching by assistants, lecturers, faculty, for Spring 2006 and Fall 2006.*

| Courses | Spring 2006 | | | Fall 2006 | | |
|---|---|---|---|---|---|---|
| | TA | Lect | Fac | TA | Lect | FAC |
| M 10 | 0 | 2 | 0 | 4 | 2 | 0 |
| M 140/1/2 | 3 | 3 | 0 | 13 | 3 | 0 |
| M 150/1 | 9 | 3 | 2 | 7 | 2 | 2 |
| M 165/6 | 26 | 0 | 4 | 13 | 2 | 14 |
| M 196/6/297 | 0 | 6 | 0 | 0 | 7 | 0 |
| M 265/6/7 | 8 | 7 | 14 | 7 | 0 | 17 |
| M 300-400 | 2 | 1 | 18 | 0 | 0 | 17 |
| Grad | 0 | 0 | 17 | 0 | 0 | 16 |
| TOTALS | 48 | 22 | 55 | 40 | 16 | 66 |

In this table each section taught counts as 1. Assistants doing 3-4 recitations are counted as teaching one section.

## 6.3 Facilities and support

### Small sections

Classrooms in Carver Hall are generally adequate for small and medium size classes. In particular, there is sufficient blackboard space. However, many of the classrooms have either fixed desks or tables, which make cooperative learning exercises difficult. The availability of classroom space in Carver Hall has markedly improved after the Business

College moved to a new building in 2004, and we are no longer forced to teach many mathematics classes in other buildings.

**Large lectures**

The department continues to offer many low-level courses in large lecture format. There are only two large lecture classrooms in Carver Hall, and all of the others are far away. Most of the large lecture classrooms on campus are inadequate for mathematics courses. In particular, the blackboards are much too small and there are no sliding blackboards. This is a big problem in large rooms because the instructor's writing must be very large. Also, some of the blackboards are so old that chalk does not show up well. Finally, some of these rooms actually have no desks; students must try to balance textbook and notes on a lap board.

**Distance education classrooms**

These rooms are fairly new and for the most part work well. The main problem is that most of them are across campus. More details about distance education can be found Section 9.5.2.b.

**Supplies and Services**

The department provides little support for instructors in terms of copying and typing of exams and syllabi. All instructors are required to do all of their own typing. Copying is done by the department only for larger jobs, but instructors can do their own copying for instructional purposes for free on departmental machines. However, every year the department provides this support by tapping into salary money because the university's allocation to the department for supplies and services is woefully inadequate. There have been problems with quality of chalk provided in the classrooms. In spite of complaints by the department and suggestions for better brands of chalk, the university insists on buying the cheapest brand available.

**Computer labs**

The department maintains two computer labs in Carver Hall, in rooms 449 and 250.

The lab in Carver 449 accommodates 46 students on Windows XP machines, plus a lab monitor and an instructor. The room is equipped with two display projectors that can project the instructor’s screen onto two large screens. The projectors are getting old but are still serviceable. It is not clear whether the department actually owns the projectors and is responsible for maintaining and replacing them, or whether they are owned by Instructional Technologies or some other unit. The lab has a printer which the students can use. Printing costs are charged to the students’ university print quota. These charges pay for supplies and maintenance.

The lab in Carver 250 accommodates 49 students on Windows XP machines. We inherited this lab (without computers) from the Business College when they moved out. Each computer is mounted inside a desk with a glass surface; the keyboard and mouse are in a tray that can be pulled out. The keyboard/mouse trays are quite flimsy, and there is little room to move the mouse. Instead of a projector screen the room has several TV monitors on each side which can display the instructor's screen. The room is equipped with a security system consisting of several cameras. Each camera can be watched and controlled through a web interface. The presence of the security system has reduced the amount of cheating in web-based tests, and is also a deterrent to theft. The lab has a printer which the students can use. Printing costs are charged to the students' university print quota. These charges pay for supplies and maintenance.

Regular funding from the Computer Advisory Committee (CAC) and/or the Liberal Arts and Sciences Computer Advisory Committee (LASCAC) has enabled us to replace one fourth of the machines in the two labs every year. Thus, none of the machines in either lab is more than four years old. We anticipate that we will continue to receive regular funding to keep the machines up to date. CAC and/or LASCAC funding has also paid for the initial purchase of the printers and security system. (Note: The CAC distributes student fees collected for computer support. LASCAC is the same, but only within the College of Liberal Arts and Sciences.)

The labs are open days and evenings during the week, afternoons and evenings during the weekend. Most of the cost of paying the lab monitors is also provided by CAC and/or LASCAC funding.

Software available in the labs includes web browsers, the Microsoft Office Suite, Matlab, FTP, and Telnet. Mathematica is available on a few machines.

**Other computer facilities**

Every office is equipped with at least one computer. For faculty members, instructors and staff this means at least one computer per person. Graduate students may need to share one machine with two or three office mates.

There are several public machines in room 400 for use by faculty and graduate students. One of the machines has a scanner and image processing software. Room 400 also contains several printers.

The Richard Sprague Undergraduate Lounge contains two computers for use by undergraduate math majors.

The department has four laptops available for check-out by faculty and graduate students, for use in teaching, colloquium talks, or to take to a conference. There are also four portable projectors that can be checked out for teaching or other presentations on campus.

Most of the computers in private offices are Windows XP machines. However, there is also a wide variety of other machines: some Macintoshes, some PCs running Linux, and a number of workstations. Every machine has TeX and Matlab available, as well as the standard software (web browsers, FTP, Telnet, Microsoft Office Suite or Open Office, etc.). Mathematica is only available on a few machines.

The department tries to accommodate requests for hardware and software, within budgetary constraints, for use in teaching and/or research. We are able to satisfy most of the requests, except that the demand for laptops (in addition to desktop machines provided by the department) exceeds available resources.

**Overall**

In general, computer facilities are good, but the university's allocation for supplies and services is inadequate, and the classrooms are poor. One faculty member commented that he has visited most of the colleges in the state of Iowa, and the classroom facilities here are the worst in the state except for one other college. The problems are fixed chairs, small blackboards, unreadable blackboards, bad chalk, no desks in some cases, and not enough large classrooms nearby. The large lecture classroom situation is particularly bad.

## 6.4 Evaluation of teaching

The department uses the 12 item course evaluation form included in Appendix 2. The questionnaire consists of 8 items related to an instructor's teaching method: preparation, presentation, speaking and writing, interest, questions, use of class time, availability, and overall rating and 4 items on the instructor's classroom administration: homework, testing, grading, and announcement of policies. Each item is rated on a five point Likert scale (1-5) with five being the highest (best). With this particular instrument the overall rating, the average rating of the 8 instructional attributes, and the average of the 4 administrative attributes are nearly identical. Hence we present only the average of the overall rating. These data are displayed in the two charts below. The first figure provides information on courses taken by students in their first two years and includes most of our service courses. The second chart focuses on courses generally taken during their last two years and includes most of our “major specific” courses.

Generally, the instruction in the department is rated at an "above average" level. Because different instruments are used by different departments across campus, comparison to other departments is difficult.. Comparison across types of sections and within types should also be done cautiously. In particular we have found that a given instructor’s evaluation may suffer in a large lecture. In addition to course evaluations, the teaching of assistant and associate faculty is evaluated annually by a classroom visit by a senior faculty member.

*Figure 1.*

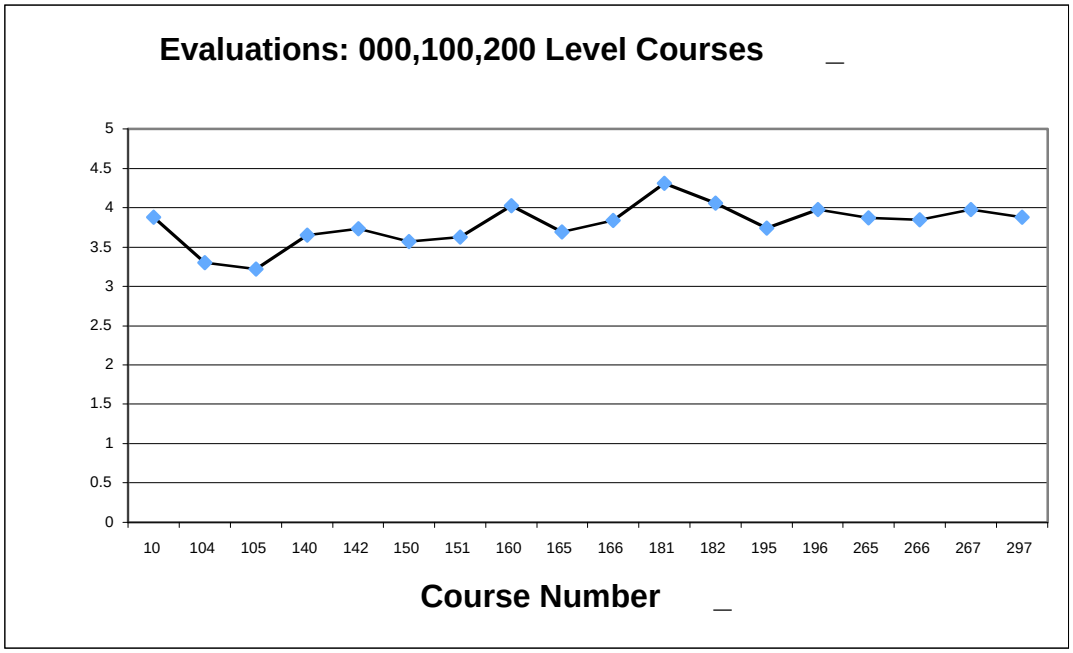
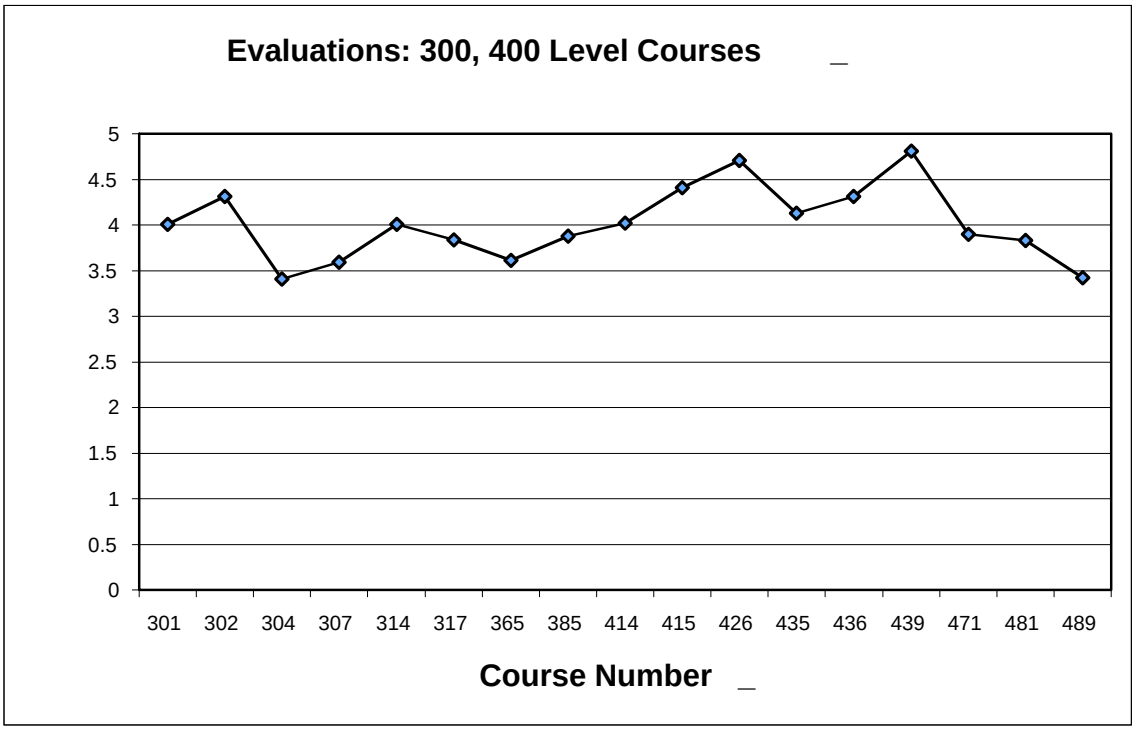



*Figure 2.*



## 6.5 Service instruction

### 6.5.1 Placement

To place students without college-level mathematics experience in entry-level mathematics courses, the department relies upon ACT and SAT mathematics scores and placement exams designed by the department. The departmental exams are thirty-minute exams in Algebra, Trigonometry, and Calculus. Incoming student take two of the three exams, depending upon their mathematics backgrounds. The various indicators qualify students to take our courses according to standards listed at http://orion.math.iastate.edu/placement/. For example, to take Calculus I, a student must score at least 26 out of 30 on ACT Math, 600 out of 800 on SAT Math, or 16 out of 20 on the Algebra placement exam, and at least 9 out of 20 on the Trigonometry placement exam. We make satisfactory placement an enforced prerequisite for some courses where we have seen many unprepared students.

We administer the placement exams via the World Wide Web only, an improvement instituted this year. Students can try sample questions and then take the exams before coming to campus for orientation. In the past, they took the exams at orientation, when many were distracted or unprepared.

We normally place transfer students according to their college mathematics experience and performance, without requiring placement exams. We know that some of these students are not well served because of the variability in standards. As extreme cases, we have seen community college transfer students with A/B+ in three semesters of calculus whose placement exam results suggest that they should be placed in beginning high school algebra.

We are considering revising these exams for ISU students, something we have not done for many years, but we are first looking into other options. All three regents universities in Iowa are currently cooperating to write and use common placement exams. This option has the potential to influence the content and emphasis of mathematics courses at high schools and community colleges throughout the state. Another option is to use the placement exams offered by the Mathematical Association of America.

### 6.5.2 Remedial and pre-calculus

#### 6.5.2a Math 10

Math 10, 25, and 30 are designators for remedial courses in high school algebra. The courses carry no college credit. The content of much of the traditional introductory and intermediate algebra courses has been combined and reapportioned into this sequence. This reorganization eliminates overlap of topics and allows us to tailor the two parts to meet specific needs. The first semester (Math 25) emphasizes linear equations and

inequalities and systems of linear equations in order to provide preparation for finite mathematics courses. The second semester (Math 30) deals with factoring, quadratic, polynomials, and rational and radical expressions. The designator Math 10 is a formal designator since students typically do not know which course they actually need when they register for high school algebra.

On the first day of class, students who have registered for Math 10 take a diagnostic exam. This exam determines whether they need to start with the first semester (Math 25) or with the second semester (Math 30) of the sequence. In the fall the students are divided accordingly into sections of Math 25 and Math 30. These sections may vary in size from 15 to 50. In the fall, these sections, with individual instructors, meet 4 days per week. Three days each week are spent in the classroom in a lecture-recitation format. The fourth day is spent in the computer lab, where students work drill problems. The students take common exams every three to four weeks and have regularly scheduled quizzes. The classes are graded on a Satisfactory-Fail basis with 72% of the possible points required for passing. Students who do not pass an individual exam are given a second chance on a similar exam

In the spring all four class days are spent in the computer lab.

Because the course is remedial, a special fee is charged. The fee covers the added cost of the instructors needed for this course. Administrative details of the course are handled by one experienced lecturer. The other instructors deal almost exclusively with instruction and tutoring.

Statistics show that students coming out of this program are competitive with other students in terms of the grades that they receive in subsequent courses. Students with the maturity to realize their need for the subject matter appreciate the relatively small classes with the higher amount of attention they receive.
A continuing concern about the program is morale. Many incoming students do not understand why they need to take Math 10, especially since an extra fee beyond normal tuition is assessed. Because students receive no credit for the course, they are often poorly motivated.

Another concern is the lack of qualified instructors. The students in Math 10 need teachers who care about them. While there have been some excellent teaching assistants in Math 10, most graduate students are mainly concerned with getting their degree, not teaching and seeing that their students learn. This has caused some problems.

In either format (lecture-recitation plus computer lab or all computer lab), students who do the work and take the course seriously succeed. It is likely that different students succeed in the different formats. In the spring, some students find the computer aspect of the course daunting. It is believed that some students take the relevant coursework at DMACC (Des Moines Area Community College) or other community colleges to avoid this format.

### 6.5.2b Online and distance instruction

By "online instruction" we mean courses that are taught entirely in a self-study format, except perhaps for a weekly meeting in a computer lab. The students access a web site to find their study assignments, and they complete their assignments in a computerized testing system. By "distance instruction" we mean courses that are offered to students in remote locations. Distance instruction can be online instruction, but it can also be televised lectures, for example.

Some remedial and pre-calculus courses have been offered in web-based format for a number of years. Reasons for offering web-based courses include

- Cost savings
- Increased student study hours through computer-graded homework assignments and quizzes
- Distance education
- Experimentation with new forms of instruction

Some courses have also been offered in televised form via the ICN (Iowa Cable Network). A faculty member lectures in a multimedia classroom to some students, while other students are watching the lecture via the ICN from a local community college or high school. Students in remote locations can ask questions and interact with the instructor. The lectures are also recorded and can be watched again later. Typically, the remote students are either employed full-time in other towns and take classes after work, or they are high school students in smaller communities where advanced math classes are not available.

### 6.5.2c Math 140 (College Algebra) and Math 141/142 (Trigonometry)

**Note:** Math 141 is Trigonometry (2 credit hours), Math 142 is Trigonometry and Analytic Geometry (3 credit hours). Both courses are identical for two thirds of the term, then Math 141 ends and Math 142 continues.

These were the first courses converted to online form through the initiative of a former faculty member (Bruce Wagner), with the encouragement and support of the chairman at the time. Each course is structured as a sequence of units (approximately one unit per week),each unit followed by an exam. Students can take exams repeatedly, at their own convenience, until they master the material or the exam deadline has passed. There are no graded homework assignments.

A succession of faculty members and graduate students has taught these courses over the years, but the basic format and the assignments have remained virtually unchanged. In some semesters, both classroom sections and online sections are offered. The department has received increasing complaints about both of these courses, and is experimenting with ways to improve them.

The course creator (Bruce Wagner) is still running small sections of these courses through ISU as distance-learning courses from his new job in California. These sections are running better than the on-campus sections, presumably because distance-learning students deliberately choose the online format. Most on-campus students prefer the classroom sections, and some of the students in online sections only end up there because space in classroom sections is unavailable. The distance-learning sections are self-financing. Over the six years that the distance-learning sections have been offered, they have averaged 170 students per year (Fall, Spring and Summer combined, for Math 140/141/142 combined).

**Math 150 (Finite Mathematics)**

Math 150 is a required course for all students in the Business College. It is also taken by a number of students in other non-technical majors. It is the largest single course in mathematics (about 1800 students annually when the online course was created, about 1600 students annually now).

In 2001, Iowa State University received a grant of $200,000 for converting Math 150 to online form. This was one of 30 such grants financed by the Pew Charitable Trust and administered by the Center for Academic Transformation. The goal of the program was to demonstrate that online instruction could save money for the university and simultaneously improve student learning. One of the requirements of the grant was that the entire course had to be converted to online form.

The redesign involved a group of people from mathematics, statistics, instructional technology, and the Business College. The main coordinator from mathematics was Fritz Keinert, who continues to supervise this course. The course is divided into four large topic areas, with an exam after each topic, plus a comprehensive final exam. In addition, there are many homework assignments (3 per week on the average), and four Excel spreadsheet assignments. The course encourages cooperation among students by letting self-selected study groups turn in joint assignments.

There are occasional complaints about the course, but they are usually directed against the concept of online teaching in general. In general, this course is running very well, and has lower failure rates than most classroom courses at this level.

There are a few students who take Math 150 as a distance education course by individual arrangement with the instructors, but it is not directly offered as a distance education course. Usually the distance education students are young mothers who have trouble arranging for childcare.

**Math 165/166 (Calculus I/II)**

One section of the Calculus I/II sequence is taught each semester as a distance education course over the Iowa Cable Network.

**Other Courses**

There are no sections of undergraduate courses other than Math 140, 141/142, 150, 165 that are offered completely in online form or as distance education courses, and there are no plans to create any. Graduate courses for the Masters in School Mathematics are also offered as distance education courses in the summer.

Math 10 (Remedial Math) uses the ALEKS computer tutorials as part of the course. This has been very successful and well-received by the students.

Several calculus instructors have used computer-graded assignments to supplement their courses. These efforts are also working well.

**Overall Evaluation of Online Instruction**

Our experiences with online instruction have been generally successful. They required a lot of work on the part of a few interested instructors, but the department has been able to save money because of these efforts, and we have remained knowledgeable about the state of the art in online teaching.

The main reason that many students don't succeed in mathematics is that they don't study enough. The standard recommendation is two hours of studying for every hour in the classroom, but in practice it is more like two hours per week in the form of one six-hour cram session every three weeks. Computer-graded homework assignments and quizzes force the students to actually do the work, and the students get immediate feedback. Letting the students do assignments multiple times (with minor modifications each time) keeps the students happy because they can repeat an assignment until they get an acceptable score. It also keeps the instructors happy because the students spend more time doing mathematics, and they [the instructors] don't have to do a lot of grading. Computer tutorials can also explain the material.

What the students don't like is when they have to read the material themselves. They prefer to have an instructor in the classroom explain it to them. Ideally, computer-graded assignments would be used to supplement classroom instruction, not replace it.

For some lower-level courses we have instituted completely web-based sections. This was done mainly for cost savings. It has worked well for Math 150 and for the distance-ed versions of Math 140 and 141/142. It used to work well for the campus web-based sections of Math 140 and 141/142 also, but those classes have received a number of complaints lately. We are looking into ways to improve the situation. For Spring 2007,

we will offer only classroom sections of Math 140, and add two weekly lectures to web-based Math 141/142.

All our web-based courses need to be updated. Math 140 and 141/142 are much older and much more in need of updating, but Math 150 could also profit from incorporating new publisher-provided tools that were not available five years ago when the course was created. The problem is that modifying a web-based course is a major effort, much more so than modifying a classroom-based course, and requires considerable experience.

Online teaching is a skill that is not acquired in a semester, or even two. What the department really needs are at least two instructors or tenured faculty members who are familiar with the online tools we have available, who can supervise and upgrade the web-based courses, and help other faculty members who simply want to supplement their course with online exercises or a grade book and bulletin board.

One of our long-time instructors (Cheryl Doolittle) was beginning to acquire this expertise, but then the department was forced to lay her off because of budget problems. This has had a very detrimental effect on our long-term plans with online teaching. We should actively recruit some online teaching specialists, and take steps to insure that their jobs are safe from budget-related layoffs.

*Figure 3.*


**Overall evaluation of distance education courses**

Our distance education services are restricted to small sections of three courses. We don't anticipate that we will expand this in the near future. These courses are self-supporting in the sense that the additional income generated pays for the additional teaching load, These courses provide an important service to the students who sign up for them.

### 6.5.3 Calculus

#### 6.5.3a Calculus for science and engineering: Math 165, 166, 265

**Curriculum**

The science and engineering calculus courses are Math 165, 166 and 265 (Calculus I, II and III, respectively).

In 2003 we revised the syllabus in each of these courses because the sole textbook supporting the order of topics we were then using (including e.g. vectors in the first semester) went out of print.

The present configuration of these courses is fairly traditional: limit, derivative and introduction to the integral in Calculus I; integration and series in Calculus II; multivariable topics in Calculus III.

Documents setting out learning objectives in the three courses are available on the department's web site. These documents provide guidance to instructors as they prepare to teach and in designing the common departmental midterm and final exams; they also inform students what will be expected of them on the common exams.

The calculus courses are in no sense courses in analysis. Students learn the rules for calculating with limit, derivative and integral. They apply what they know to solve elementary problems, principally in mechanics, by formulating them in mathematical terms and using calculus to solve the mathematical problem. We include units on topics such as exponential growth and decay, work and moments and center of mass to develop students' ability to formulate problems mathematically.

We adopted the eighth edition of Varberg's *Calculus* as the textbook in 2003; in the Fall Semester, 2006, we began phasing in the ninth edition.

**Teaching**

Faculty in this department would prefer to teach calculus in single sections of fewer than 40 students. However, for the last several years this has not been feasible, and most students take calculus in a large lecture format with three lectures and one recitation per week. Recitation sections have about 30 students, led by a graduate teaching assistant.

In the fall semester of 2006 the configuration was as follows.

- Calculus I: Two large lectures, each with 200 students, fifteen single sections with 38 students in each.
- Calculus II: Two large lectures, each with 180 students, six single sections with 38 students in each.
- Calculus III: Two large lectures, each with 180 students, five single sections with 38 students in each.

**Current concerns and initiatives**

Faculty have a number of concerns about these courses. Some feel that the pace is too fast with too many topics for students to master them all. We observe too that many students, even those who took a calculus course in high school, lack elementary knowledge and skill in algebra.

Faculty also express disapproval of textbook publisher's rapid production of new editions. We adopted the eighth edition of the Varberg textbook in 2003; three years later that has gone out of print and we had to choose between the new ninth edition and selecting a different textbook. (Our reviewers did agree that the ninth edition is better organized for our courses than is the eighth edition; it is also better edited: in the eighth edition we found so many typographical errors we were obliged to publish a dense two-page errata sheet on the department's web site.)

In recent years many publishers have brought to market ``course management'' software. Among other things, this software is said to make it feasible to assign homework that students can do over an internet connection and have it graded on the spot by the software. We have seen numerous promotional presentations of different products over the past three years. The systems as they currently exist are quite primitive as to the kind of problems that can be assigned; many, too, demand that the user have a very specific operating system and internet browser configuration. A few of our instructors have used the system that is coordinated with the Varberg text.

Students find the course difficult. They complain that they are taught by TAs who can't speak English. Officials in the Dean's office report that of all courses in the LAS college, calculus generates the largest number of complaints from students.

Several projects are under way that will affect how calculus is taught in the future. One committee in the department is studying the placement exam given to incoming students, with a view toward having a common exam among the three Regents' Universities (University of Iowa, University of Northern Iowa and ISU). A committee appointed by the LAS dean is looking into ways to improve the teaching of calculus.

### 6.5.3b Business Calculus: Math 151

Math 151 is a single 3-credit semester course called Calculus for Business and Social Sciences. It is offered in large lectures of up to 180 students twice a week with a recitation one hour per week. Most students in Business take this course, which is a standard course which business accreditation agencies expect Business students to have. Approximately 650 students per year take the course.

### 6.5.3c Survey of Calculus: Math 160

Math 160 is a single 4-credit semester course called Survey of Calculus. It gives an overview of analytic geometry, derivatives and integrals of elementary functions, as well as partial derivatives and applications. Most economics majors take this course instead of engineering calculus. A substantial number of biology majors seeking a one-semester overview of calculus also take this course. Approximately 150 students take Math 160 each year.

### 6.5.3d Calculus for the Life Sciences: Math 181/182

The sequence of courses Math 181 and 182 offer topics in calculus and mathematical modeling for the life sciences. Math 181 is offered both Fall and Spring semesters, while Math 182 is offered only Spring. Approximately 130 students take 181 during the year, while approximately 45 students take 182 during the year.

The courses Math 181 and 182 were originally developed for small classes of 35 and with a wet lab in which students took biological measurements for use in modelling. Because of lack of funding, the lab has been eliminated and the courses have become lecture-style courses with no small recitations. Calculators and occasionally computers (for applications using Excel) are used in the courses.

Currently students with a major in Biology have the option of taking the 2-semester sequence Math 181/182; or Math 165/166; or Stat 101 (or 104) and 401. Students with other majors in biological sciences often need only one semester of mathematics. Some opt just for Math 181. Many opt for Math 160 despite the fact that the course is designed for economics majors. One reason for taking Math 160 is that an introduction to both differentiation and integration is in the single one-semester course Math 160, while Math 181 does not contain integration but instead contains topics in mathematical modeling. It might be possible to reorganize Math 181/182 to have both differentiation and integration in 181 at the cost of moving the mathematical modeling into 182. Discussions on the subject with members of the Biology Curriculum Committee have been inconclusive so far.

### 6.5.4 Other service courses

In addition to remedial, pre-calculus, calculus, and introductory differential equation courses, the Department offers 11 undergraduate service courses. This category includes some courses important to majors as well but whose clientele is primarily found outside the Department. The Department is responsive to requests from other departments to revise course content and to introduce new courses to meet the needs of other majors. The courses are listed below. Full catalog descriptions and some pertinent data for these courses are given in Appendix 1. The courses are taught by regular faculty and lecturers, some with discussion sections taught by TAs.

- MATH 104. Introduction to Probability and Matrices.
- MATH 105. Introduction to Mathematical Ideas.

- MATH 150. Discrete Mathematics for Business and Social Sciences.
- MATH 195. Mathematics for Elementary Education I.
- MATH 196. Mathematics for Elementary Education II.
- MATH 297. Intermediate Topics for School Mathematics.
- MATH 307. Matrices and Linear Algebra.
- MATH 373. Introduction to Scientific Computation.
- MATH 385. Introduction to Partial Differential Equations.
- MATH 426. Mathematical Methods for the Physical Sciences.
- MATH 465. Advanced Calculus for Applied Mathematics.

### 6.5.5 Service to mathematics education students

The Department plays a central role in the mathematical training for K-12 teachers with three courses for elementary education majors, the option for mathematics majors to become certified to teach grades 7-12, and a live two-way audio and video distance learning program for in-service secondary mathematics teachers. Though each of the three components displays strength, faculty resources in the area of mathematics education are severely stretched. Since the previous review period, the Department has lost three tenured faculty members in mathematics education, two due to retirement, and one due to a move to another institution. As a result, the responsibilities for mathematics education rest on lecturers. While the lecturers are highly qualified in the area of Mathematics Education, the stability of the program should be strengthened and deepened by hiring tenured or tenure-track faculty whose area of expertise is mathematics education. Additional faculty are needed to advance mathematics education in the Department and to ensure that the Department's endeavors are met including the continual training of secondary mathematics teachers (an area of teacher shortage in Iowa), the development of in-service secondary mathematics teachers through the Master of School Mathematics program, and the covering of existing and new courses.

At Iowa State University, pre-service teachers who plan to teach mathematics in grades 7-12 are required to satisfy most of the requirements of the mathematics major. Thus, discussion of the Department's role in training mathematics secondary education teachers will occur within the discussion of the undergraduate mathematics major. (See Section 6.6.6)

#### Elementary school teacher training

In *The Mathematical Education of Teachers*, the Conference Board of the Mathematical Sciences (CBMS) recommends that prospective teachers take mathematics courses that develop a deep understanding of the mathematics they will teach. In addition, they recommend that prospective elementary grade teachers should be required to take at least 9 semester-hours on fundamental ideas of elementary school mathematics. During the previous review period, the Department developed a tailored, three-semester sequence for prospective elementary school teachers and early childhood educators, Math 195, 196, and 297. As recommended by the CBMS, all prospective elementary school teachers are

required to take nine credit hours in mathematics in addition to three credit hours in instruction of the current methods of teaching mathematics. Six of the nine required mathematics credits are earned by passing Math 195 and 196. The third course, Math 297, is available to all prospective elementary teachers and required of those who will be mathematics specialists at the elementary school level. The Department has continued to commit to teaching future teachers in small-sized sections as the training of these teachers is so important to the advancement of mathematical reasoning of children, though the maximum class sizes have increased from 28 to 40 over the past ten years. The increased class sizes limit the instructors' ability to provide the necessary assistance the pre-service teachers need.

The courses are designed specifically for their client population and use textbooks and materials that focus on that clientele. The instruction in Math 195, 196, and 297 models and applies the kinds of instruction required by the Iowa Administrative Code for elementary teachers of mathematics. Specifically, elementary mathematics should "be taught through an emphasis on problem solving, reasoning and applications; language and symbolism to communicate mathematical ideas; and connections among mathematical topics and between mathematics and other disciplines." The nine credits of mathematics required by the College of Human Sciences exceeds the requirements by the state that the professional education core of pre-service elementary teachers contain methods and materials of teaching elementary mathematics. Once meeting the required core, some elementary education majors decide to take additional coursework in mathematics to gain an area of concentration in mathematics. These students take a total of 24 credit hours. With this additional mathematics course work, they take a leadership position in their elementary schools and often find themselves in departmental situations, teaching mostly mathematics.

The concerns of the instructors of Math 195, 196, and 297 include the need for ongoing support for the courses. In particular, with class sizes of 40, the ability to ensure the advancement of understanding in mathematics for the pre-service teachers becomes limited. Assistance with grading papers in order to provide feedback makes the larger classes more feasible. In addition, supporting materials for hands-on use in the classroom are needed. Items such as base 5 or 10 blocks, fraction circles, geoboards, and Multi-link cubes help to foster the deep understanding of the mathematics they will teach, provide meaning to the algorithms, and assist in modeling how to teach the underlying concepts. Items that are missing or broken need to be replaced, and new items need to be purchased to provide enough materials for the larger classes.

**The mathematics education group**

The Department has a handful of faculty interested in the field of mathematics education, fewer than we had at the time of the previous study. No one in the Department is currently conducting research in mathematics education. On the teaching side, the tenured faculty members interested in issues surrounding mathematics education include Wolfgang Kliemann, Leslie Hogben, Irvin Hentzel, and Elgin Johnston. The lecturers

interested in mathematics education include Heather Thompson, Gail Johnston, and Christian Roettger. A close association exists with the Mathematics Education faculty in the Department of Curriculum and Instruction which includes Beth Herbel-Eisenmann, Jenna Seymour, Corey Drake, and Alejandro Andreotti, a mathematician turned mathematics educator.

The instructors of the mathematics courses for pre-service elementary teachers continue to pursue scholarly activities in the advancement of mathematics education. Weekly meetings are conducted to ensure that quality of instruction occurs for each section of Math 195 and 196. Joint talks are given at state, regional, and national meetings of teachers of mathematics. One publication has resulted from such collaborations.

Those teaching the mathematics courses for pre-service elementary teachers interact regularly and have a strong rapport with colleagues in the Curriculum and Instruction Department at Iowa State University. Beth Herbel-Eisenmann, Jenna Seymour, Corey Drake, and Alejandro Andreotti in mathematics education have given written support of the work and teaching conducted in Math 195, 196, and 297. They have stated that the depth of mathematics discussed in these courses frees them to discuss the methods of teaching mathematics rather than having to spend additional time explaining the mathematics to the pre-service teachers. Colleagues at other institutions have shared their envy of the mathematics preparation of future elementary teachers established at Iowa State University. The strength of the association has resulted in two Miller Faculty Fellowships, one in 2004-2005 for advancing statistics education for future teachers and a second to the mathematics education faculty in 2006-2007. The second builds on the work completed in the previous fellowship and further connects the mathematics, mathematics teaching, and science teaching future teachers receive.

Collaboration has also occurred with faculty and advisors of pre-service early childhood educators. In particular, communication among H. Thompson, G. Johnston, and C. Roettger with Sue Hegland, Karen Colbert, and Kate Shafer in the Department of Human Development and Family Studies has emphasized the need to increase the study support available for the early childhood education majors including mentoring possibilities for undergraduates. Plans are in place to implement instructor support to advance effective teaching strategies. A learning community for early childhood education majors has been realized, and strategies for learning and understanding mathematics will be a part of the activities for the learning community.

Those teaching the mathematics courses for pre-service elementary teachers also interact with colleagues at other institutions to promote the mathematical education of pre-service elementary teachers. With support from the Iowa Department of Education and the Iowa Mathematics and Science Coalition, members of the mathematics and mathematics education faculty at community colleges, 4-year institutions, and universities have met on several occasions to promote additional mathematics requirements for all pre-service elementary teachers in the state of Iowa and to exchange ideas for the best methods in teaching the future teachers.

Since 1999, the Mathematics Education group has pursued various projects, some of which have been funded. Collaboration with persons from other departments or other institutions is at the core of each project as the advancement of mathematics instruction is pursued at all levels, K-12, Community Colleges, and Universities.

- Best Practices in Mathematics Content and Pedagogy in Preparing Elementary Teachers. Iowa Department of Education and Iowa Mathematics and Science Coalition, (Collaboration among persons at ISU, Iowa, UNI, and Community Colleges), 2004, $1500.

- Advancing statistics education for future school teachers. Miller Faculty Fellowship, Iowa State University, (H. Thompson, G. Johnston, T. Pfantz, R. Stephenson, L. Hogben, B. Herbel-Eisenmann, A. Andreotti), 2004-2005, $20,416.

- Best Practices in Mathematics Content and Pedagogy in Preparing Elementary Teachers II. Iowa Department of Education, (Collaboration among persons at ISU, Iowa, UNI, and Community Colleges), 2005, $750.

- Connecting Mathematics, Mathematics Teaching, and Science Teaching. Miller Faculty Fellowship, Iowa State University (J. Seymour, C. Drake, B, Herbel-Eisenmann, A. Andreotti, H. Thompson, G. Johnston, J. Olson, M. Clough), 2006-2007, $21,976.

- Iowa Initiative of Colleges of Mathematics and Statistics Education, (Collaboration among the Departments of Mathematics and Statistics at ISU, Iowa, UNI), 2006-.

## 6.6 The Mathematics Major

### 6.6.1 Overview of the mathematics major

The undergraduate mathematics major offered by the Department has as its goal the training of students either for further study in mathematics or in allied disciplines or else for jobs in industry, commerce, or education.

The total number of mathematics majors (at all levels) has remained steady at around 135 per year. Not all register each semester, however. The official ISU statistics count only students whose first major is mathematics and hence ignores those students with a double major in which Mathematics is the second major.

Table 1 gives a break-down of the number of enrolled students (men, women, and total) whose first major was mathematics.

*Table 7. Undergraduate enrollment with first major in mathematics*

| Semester | Men | Women | Total |
|---|---|---|---|
| F00 | 65 | 46 | 111 |
| F01 | 66 | 51 | 117 |
| F02 | 71 | 52 | 123 |
| F03 | 65 | 52 | 117 |
| F04 | 70 | 47 | 117 |
| F05 | 69 | 48 | 117 |
| F06 | 83 | 37 | 120 |

Table 1 indicates a fairly steady level of numbers of mathematics majors over the reporting period. The numbers are not high. For example, in Fall 2005 the entire College of Liberal Arts and Sciences (LAS) had a total of 5853 undergraduate students enrolled, of which 117 or 2% had mathematics as a first major. When all math majors are included (not just those with first major in mathematics), the percentage would be closer to 2.3%. Note that enrollments in other colleges, such as Engineering, are not included in the figure 5853.

The peak in the numbers of mathematics majors occurred in Fall 992 with 171 majors, while the low was 96 in Fall 1996. Hence we have experienced a substantial improvement since 1996.

Substantial numbers of women are math majors, but the fraction of majors who are women has recently declined.

The count of mathematics majors is problematic since it changes so frequently during the year. A number of students transfer into the mathematics program from other majors each year, but a number also leave mathematics for other majors.

Hence perhaps a more accurate picture of the numbers of mathematics majors is given by the numbers of students who actually graduate with a mathematics major. Table 8 gives the counts of students who graduated with a mathematics major (whether first or second major) during recent calendar years (spring, summer, and fall). Numbers for 2006 do not include graduates during Fall 2006.

*Table 8. Number of graduates with a mathematics major, by calendar year*

| | # Math Majors | | | # Receiving teaching certificate | | |
|---|---|---|---|---|---|---|
| Year | Male | Female | Total | Male | Female | Total |
| 2000 | 10 | 7 | 17 | 2 | 6 | 8 |
| 2001 | 11 | 4 | 15 | 6 | 2 | 8 |
| 2002 | 13 | 8 | 21 | 3 | 3 | 6 |
| 2003 | 17 | 13 | 30 | 4 | 5 | 9 |
| 2004 | 20 | 8 | 28 | 4 | 3 | 7 |
| 2005 | 10 | 11 | 21 | 6 | 8 | 14 |
| 2006 | 13 | 11 | 24 | 5 | 8 | 13 |
| 2000-06 | 94 | 62 | 156 | 30 | 35 | 65 |

Table 8 indicates that large numbers (42%) of the mathematics major graduates received teaching certificates. The fraction of women graduates is 40%. There was a slight bulge in the number of graduates during 2003 and 2004.

The Career Services Office collects information on the employment of graduates six months after graduation. The data indicate that roughly 25% are in graduate school (not all in mathematics), 20% are teaching, 30% are professionally employed, 15% have temporary employment, and 10% are seeking employment. Although these averages add up to 100%, there are also a few who are in the military, are not seeking employment, or have not given employment information.

At the time of the previous self-study, the department had just provisionally adopted an applied mathematics option within its B.S. major. The option, however, was never fully implemented. Brochures were mailed to all high schools in Iowa, but there was minimal response. Because of lack of student interest and also because some of the faculty especially interested in the option left the department, there was no further development of the option.

### 6.6.2 Courses for majors

Following are the courses intended for mathematics majors. Full catalog descriptions as well as the five-year averages for student teaching evaluations are given in Appendix 1.

- MATH 165. Calculus I.
- MATH 166. Calculus II.
- MATH 201. Introduction to Proofs.
- MATH 265. Calculus III.
- MATH 266. Elementary Differential Equations.
- MATH 267. Elementary Differential Equations and Laplace Transforms.
- MATH 268. Laplace Transforms.
- MATH 301. Abstract Algebra I.
- MATH 302. Abstract Algebra II.
- MATH 304. Introductory Combinatorics.
- MATH 314. Graphs and Networks.
- MATH 317. Theory of Linear Algebra.
- MATH 331. Topology.
- MATH 341. Introduction to the Theory of Probability and Statistics I. (Cross-listed with STAT.)
- MATH 342. Introduction to the Theory of Probability and Statistics II. (Cross-listed with STAT.)
- MATH 350. Number Theory. (Cross-listed with COM S.)
- MATH 365. Complex Variables with Applications.
- MATH 385. Introduction to Partial Differential Equations.
- MATH 414. Analysis I.

- MATH 415. Analysis II.
- MATH 421. Logic for Mathematics and Computer Science. (Cross-listed with COM S.)
- MATH 435. Geometry I.
- MATH 436. Geometry II.
- MATH 439. Mathematics of Fractals and Chaos.
- MATH 471. Computational Linear Algebra and Fixed Point Iteration. (Cross-listed with COM S.)
- MATH 481. Numerical Solution of Differential Equations and Interpolation. (Cross-listed with COM S.)
- MATH 489. History of Mathematics.
- MATH 490. Independent Study.
- MATH 491. Undergraduate Thesis.
- MATH 492. Undergraduate Seminar.

### 6.6.3 Requirements and curricula

Requirements for a Bachelors of Science degree in Mathematics are specified in the University General Catalog, which is published in a two-year cycle. Below we state the requirements for a major for each of the last few catalogs, and then we discuss the rationale for the changes that were made.

**Requirements in the 1997-99 catalog**

- 165, 166, 265, 301, 317, 414, and either 266 or 267.
- Two of 165T, 166T, 265T.
- Two of 341, 365, 471, 481.
- Nine or more additional credits in mathematics courses at the 300 level or above.
- One of the sequences 301-302, 414-415, 435-436 must be included in the above.

**Requirements in the 1999-2001 catalog**

- 165, 166, 265, 301, 317, 414, and either 266 or 267.
- Two of 165T, 166T, 265T.
- Two of 341, 365, 471, 481.
- Nine or more additional credits in mathematics courses at the 300 level or above.
- One of the sequences 301-302, 414-415, 435-436 must be included in the above.
- At least one of 490, 491, 492, or 542.

**Requirements in the 2001-2003 catalog**

- (175 and 175), or (165, 166, and 201). Also 265, 301, 317, 414, and either 266 or 267.
- Two of 341, 365, 471, 481.
- Nine or more additional credits in mathematics courses at the 300 level or above.
- One of the sequences 301-302, 414-415, 435-436 must be included in the above.
- At least one of 490, 491, 492, or 542.

**Requirements in the 2003-2005 catalog**

- (175 and 175), or (165, 166, and 201). Also 265, 301, 317, 414, and either 266 or 267.
- Two of 341, 365, 471, 481.
- Nine or more additional credits in mathematics courses at the 300 level or above.
- One of the sequences 301-302, 414-415, 435-436 must be included in the above.
- Either 492 or C I/LAS 480C (for students seeking secondary school certification).

**Requirements in the 2005-2007 catalog and the 2007-2009 catalog**

- 165, 166, 201, 265, 301, 317, 414, and either 266 or 267.
- Fifteen or more additional credits in mathematics courses at the 300 level or above.
- One of the sequences 301-302, 414-415, 435-436 must be included in the above.
- Either 492 or C I/LAS 480C (for students seeking secondary school certification).

There is also an English proficiency requirement which can be met in various ways.

Here is a summary of the reasons for the changes in the requirements for the mathematics major:

- In the 1999-2001 catalog, the courses 165T, 166T and 265T were all one-credit classes in the theory (epsilons and deltas etc.) for beginning calculus, which was eliminated from the mainstream calculus course 165-166. It was felt that these subjects were needed early for mathematics majors. The one-credit format, however, was not found pedagogically suitable, so a 2 credit class 201 was designed to replace 165T and 166T. At the same time, 165T and 166T were deleted from the catalog. Alternatively, a 5 credit sequence 175-176 could be taken in which the material could be integrated into the courses. Ultimately, however, the enrollments in 175 and 176 dwindled to the point that it was no longer economical to retain them. Hence 175 and 176 were eliminated for the 2005-07 catalog because of low enrollments in the courses.

- The undergraduate "research" requirement of 490, 491, 492, or 542 first appeared in the 1999-2001 catalog. From the start, however, the requirement did not fit the needs of students seeking secondary certification. Hence for the 2005-07 catalog the option of C I/LAS 480C was made available for such students. The MSM course 542 was eliminated as an option. Moreover, the individual attention provided by 490 and 491 were becoming a burden to faculty, especially when they involved the weaker majors who merely took the courses to satisfy a requirement. As a result, the 490 and 491 options were removed.

- In the 1999-2001 catalog (and before) there was a requirement of two courses from 341, 365, 471, 481. By the time of the 2005-07 catalog, however, it was becoming clear that the requirement shortchanged many students, for example students interested in the discrete mathematics courses. For example, the fifteen

additional credits at the 300 level or above typically included 302, 415, 341, and 365, making only one additional course in effect available. It was felt that a more flexible requirement was now appropriate to suit the wider interests of the students.

- For the 2007-09 catalog it was decided to raise Math 201 (Introduction to Proofs) from 2 credits to 3 credits and to make it a prerequisite for Math 301 and a co-requisite for Math 317. Students taking Math 301 without having taken 201 often had great difficulty with the proofs, and time needed to be taken from the content of 301 in order to develop proof methods. In addition, students were often postponing Math 201 until late in their career because it was not seen as a prerequisite to other courses. This meant that they learned only late in their careers about any difficulties they encountered with proofs.

### 6.6.4 Advising

Our undergraduate mathematics majors, who currently (December 2006) number 151, including double majors, are advised by self-selected faculty members. Students are assigned to advisors based upon special interests of the students and advisors and upon the workloads of the advisors. Five faculty members each with about twenty-five advisees do most of the advising. Five other faculty members advise smaller numbers. J. Wilson, the Undergraduate Coordinator, assigns advisors, communicates with the college and university offices regarding advising, sees prospective students, and teaches the fall orientation course for mathematics majors. Wilson and department associate chair E. Johnston advise incoming students at orientation and advise non-math majors regarding mathematics courses and minors in mathematics. H. Thompson advises most of the students planning to earn secondary certification.

An organizational question we consider is whether the department should employ professional advisors, as do many other departments. Faculty members do not verse themselves as well as professional advisors in the many technicalities of academic requirements, special course offerings, legal rights and protections, and forms and procedures. However, we believe that advising is a worthwhile investment of faculty time, as mathematicians' advice on careers and programs of study is invaluable to the students.

### 6.6.5 Secondary school teacher training

For convenience, Table 8 is repeated in this section, showing the numbers of mathematics majors and the numbers receiving teaching certificates.

*Table 8. Number of graduates with a mathematics major, by calendar year*

| | # Math Majors | | | # Receiving teaching certificate | | |
|---|---|---|---|---|---|---|
| Year | Male | Female | Total | Male | Female | Total |
| 2000 | 10 | 7 | 17 | 2 | 6 | 8 |
| 2001 | 11 | 4 | 15 | 6 | 2 | 8 |
| 2002 | 13 | 8 | 21 | 3 | 3 | 6 |
| 2003 | 17 | 13 | 30 | 4 | 5 | 9 |
| 2004 | 20 | 8 | 28 | 4 | 3 | 7 |
| 2005 | 10 | 11 | 21 | 6 | 8 | 14 |
| 2006 | 13 | 11 | 24 | 5 | 8 | 13 |
| 2000-06 | 94 | 62 | 156 | 30 | 35 | 65 |

Increased emphasis has been placed on mathematics education in grades K-12 as comparisons are made between US and international students' mathematics test scores. As a result, requirements for the mathematics education of students have changed at federal and state levels. The No Child Left Behind legislation requires that every teacher be highly qualified. In addition, the federal government has sought to strengthen innovation and competitiveness at the international level by improving mathematics and science education. At the state level, Iowa recently adopted the Model Core Curriculum which requires that all high school students, beginning with the graduating class of 2011, complete a core academic program which includes 3 years of mathematics. All indicators point to the need for a strong program to prepare mathematics teachers at all levels, particularly at the secondary level.

At Iowa State University, secondary education teachers who specialize in mathematics education are required to satisfy most of the requirements of the mathematics major. To be certified to teach mathematics in grades 7-12, the State of Iowa mandates that each secondary teacher have a bachelor's degree with completion of 24 semester hours in mathematics including a linear algebra or an abstract (modern) algebra course, a post-calculus geometry course, a two course sequence in calculus, a computer programming course, a probability and statistics course, and coursework in discrete mathematics. The Department of Mathematics and the University Teacher Education Program have set the requirements for certification to be above that which is required by the State. Students who wish to obtain certification to teach mathematics at the secondary school level must successfully complete course work in mathematics, mathematics related courses (computer science, statistics), and professional courses including student teaching and pre-service teaching experiences in the schools. The focus of the program is to provide a strong background in mathematics in addition to a firm foundation in teaching and learning mathematics. The students must also take courses to meet general education, basic education, foreign language, and major requirements which all students in the College of Liberal Arts and Sciences must complete. A total of 120 semester hours is required to graduate and 48 of these hours are at the 300 level or above.

The Department of Mathematics and the University Teacher Education Program (UTEP) housed in the Department of Curriculum and Instruction share responsibility for the preparation of secondary mathematics teachers. Due to a loss of faculty in the area of mathematics education, the Department no longer oversees the supervision of student teachers nor does it manage Math 497, the methods course for prospective secondary mathematics teachers. In spite of the transfer of ownership of these responsibilities, we feel the prospective teachers receive high quality supervision and instruction from Alejandro Andreotti, a mathematician turned mathematics educator and coordinator for mathematics licensure. A significant number of our undergraduate students are assigned mentors who are graduates of the Iowa State University Master of School Mathematics program. As can be seen in Table 8, the number of persons receiving certification to teach secondary mathematics has remained steady since 1999 with an increase in 2005 and 2006. In addition, the undergraduate enrollment in Math 497 in Fall 2006 was 18. The projected number of student teachers for Spring 2007 is 11.

Many mathematics majors who plan to teach protest the amount of undergraduate mathematics courses required to obtain certification. They question why they must take Abstract Algebra I, two semesters of post-calculus Geometry, and Analysis I when they plan to teach secondary mathematics. The Conference Board of the Mathematical Sciences states in the *Mathematical Education of Teachers*, "Prospective high school teachers of mathematics should be required to complete the equivalent of an undergraduate major in mathematics that includes a 6-hour capstone course connecting their college mathematics courses with high school mathematics." Taking into account both students' needs and the CBMS recommendation, in Spring 2007 the Department will launch a three hour course, Math 397X Teaching Secondary Mathematics Using University Mathematics. In the course students will relate topics from calculus, abstract algebra, geometry, and discrete mathematics to secondary mathematics.

Another change for mathematics majors obtaining certification is also under consideration. In the American Competitiveness Initiative, a call was made for more students to complete Advanced Placement Mathematics and Statistics in high schools. With more high school students taking these courses, more teachers need to be adequately prepared to teach these courses. The current mathematics and statistics courses required for those pursuing certification do not adequately prepare the pre-service secondary teachers to teach AP Statistics. The required Math/Stat 341, the Introduction to the Theory of Probability and Statistics, primarily emphasizes the theory of probability and does not provide instruction on inferential statistics, a critical component of the AP Statistics course. As a result, we are collaborating with the Department of Statistics to explore the best courses to help prepare the pre-service teachers without significantly increasing their course load. Both the evaluation of statistics course requirement and launching of the course Math 397X are components of the Iowa Initiative in College Mathematics and Science Education.

One incentive for Iowa residents to consider teaching secondary mathematics is the availability of forgivable loans. Since 1999, the state of Iowa has recognized a shortage of

mathematics teachers for grades 7-12. Iowa residents who obtain certification to teach secondary mathematics and teach for five years in Iowa are eligible to have their loans forgiven. The number of teachers who have taken advantage of this program or have pursued certification to teach mathematics in grades 7-12 is unknown.

To address the teacher shortage area of secondary mathematics, Iowa State University also offers a Masters in Education leading to licensure to teach 7-12 mathematics. Housed in the Department of Curriculum and Instruction, the program provides those with a bachelor's degree in mathematics or a closely related field the opportunity to complete the requirements needed for certification in as little as 15 months. These students may take some of the required courses in the Department if their mathematics backgrounds are incomplete, but the majority of their courses are taken in the Department of Curriculum and Instruction.

Few mathematics faculty members advise mathematics education students. Consequently, those who do such advising have a large number of students. In addition, all students who are interested in certification, whether advisees or not, regularly see the liaison for the Department and the University Teacher Education Program, H. Thompson, to discuss certification requirements and their progress in the program. The liaison also maintains the website for undergraduates interested in obtaining certification to teach mathematics in grades 7-12. Advising these students, updating information for the Department's advisors and undergraduates, and facilitating correspondence between the Department and UTEP are time consuming activities which are essential to the Department and the certification program.

### 6.6.6 Outcomes assessment

In order to assess student satisfaction with the mathematics major, graduating seniors are given anonymous questionnaires about their experiences. These questionnaires are utilized by the Undergraduate Committee to assess the effectiveness of the program. It is sometimes hard to guarantee the return of the questionnaires, so the amount of feedback obtained in this way is limited. The questionnaire is included in Appendix 3. Instructors in advanced courses typically taken by graduating seniors are also given a questionnaire, included in Appendix 4.

Under consideration are ways to increase the amount of feedback from students about the mathematics major. One possibility is to have exit interviews of graduating seniors. It is, however, unclear how these should be conducted. Especially problematic are interviews for graduating majors obtaining secondary certification, since these students typically are student-teaching at middle or high schools their last semester and are therefore not on campus. Another possibility is to try to contact alumni.

Information about the goals of assessment are posted online at
*http://www.las.iastate.edu/academics/assessment/math.shtml*

These formal methods for assessing student outcomes have only recently been implemented. Following, however, are some recent programmatic changes and the basis for each in terms of student assessment.

- In recent catalogs, the requirements for the mathematics major have included 15 additional credits from mathematics courses at the 300 level or above, including 6 credits from the courses Math 341, Math 365, Math 471, and Math 481. This requirement has been simplified for the 2005-07 catalog to require merely 15 additional credits from mathematics courses at the 300 level or above. Student feedback to advisors had indicated that the special list of four courses was burdensome to some majors whose interests and needs did not overlap with those four courses. The students most strongly affected were those interested in discrete mathematics and those seeking certification to teach at the secondary level.

- The order of topics in the basic calculus sequence (Calculus I, Calculus II, and Calculus III) has been changed to be more in line with the order of topics in those courses at other colleges and universities and in most textbooks. The change in order was in part a response to difficulties faced by transfer students, whose calculus classes taken elsewhere did not match those available here.

- Feedback from instructors and students indicates that, currently, students taking Math 301 often have considerable difficulty with proofs. Typically such students have not taken an earlier course in which proofs have been stressed and they are inadequately prepared for Math 301. Consequently, starting Fall 2007 a course involving proofs (Math 201) will be a prerequisite for Math 301. This requirement will impact students with majors in mathematics (who often in the past have postponed Math 201 until after Math 301), as well as students with minors in mathematics.

- The 2003-05 catalog recommended two years of French, German, or Russian for students contemplating graduate study in mathematics. In accordance with current practices and because of difficulties faced by majors (for whom only one year of a foreign language is required), we have changed the recommendation in the 2005-07 catalog to only a reading knowledge of French, German, or Russian.

- Students seeking secondary certification in mathematics are now required to take Math 297 or 397X. The new requirement is the result of feedback from instructors in Curriculum and Instruction and from students reacting to their student-teaching experiences. The feedback suggested that prospective elementary school teachers taking Math 195, 196, and/or 297 were much more comfortable and skilled when they performed student-teaching (LAS 417) than were the students seeking secondary certification.

## 6.7 Interdisciplinary majors

The Mathematics is currently proposing participation in two interdisciplinary majors.

### 6.7.1 Proposed BS/MS program in financial statistics and mathematics

The Departments of Statistics and Mathematics at Iowa State University are seeking to create a professional BS/MS program in "Financial Statistics and Mathematics" to serve the needs of industry, nongovernmental organizations and the public sector. The program is has been proposed to the college, but it has not yet been approved.

The program is envisioned as a 5-year BS/MS program with (currently) two areas of specialization--Investment Statistics and Risk Statistics. Students in both areas would study a joint core program with the option of specializing at the upper undergraduate and the graduate level in either Investment Statistics (financial markets and instruments) or Risk Statistics (insurance and consumer debt). Both areas represent a regional (Des Moines and Midwest) as well as a national professional profile that is currently underserved by academic institutions.

The program is a joint endeavor of the Departments of Statistics and Mathematics. It is designed to provide students with:

- the basic mathematical, statistical, economics and modeling skills to collect and analyze financial data,
- a clear comprehension of the theoretical basis for statistical, mathematical and business reasoning and model building,
- a strong background in finance,
- a solid foundation in statistical, mathematical and computational methods,
- the ability to apply and convey quantitative, model and data-driven concepts in oral and written form,
- the skills to immediately contribute to the hiring entity in business, industry or commerce, nonprofit institutions or government, and to be able to incorporate new developments into his/her work for many years to come.

Accomplishing this goal requires cooperation between ISU and businesses that might hire students, e.g., through internships at the end of years 3 and 4, and through the introduction of actual data problems into the newly designed application courses.

### 6.7.2 Proposed undergraduate major in bioinformatics and computational biology

The Mathematics Department has joined the Department of Computer Science and the Department of Genetics, Development, and Computational Biology to propose a new undergraduate interdisciplinary major in Bioinformatics and Computational Biology (BCB). The proposal has been approved by the College of LAS and is currently being prepared for review by the Regents. The Mathematics Department will be one of the three

administering departments for the major, implemented in a BCB Curriculum Committee with representatives of each of the three departments.

Objectives: This curriculum is designed
(1) to provide foundations in computer science, biology, statistics, and mathematics; and
(2) to provide orientation, principles and experiential courses that enable students to solve basic and applied problems in biological informatics.

ISU currently has an interdisciplinary graduate major in BCB. Experience with BCB graduate programs at ISU and elsewhere has shown that students "who lack adequate early exposure to mathematics, computer science and statistics cannot really successfully make the transition to a graduate program in bioinformatics and computational biology, regardless of the breadth and depth of their training in biology, whereas students who have some undergraduate training in biological sciences but have had significant exposure to mathematics, statistics and computer science are able to make such a transition rather effortlessly" (Vasant Honavar, Professor and Director, Center for Computational Intelligence, Learning and Discovery; and Professor of Bioinformatics and Computational Biology; Iowa State University).

It is anticipated that graduates of this proposed curriculum should be better prepared, and more attractive for employment in biological industries, than those with undergraduate degrees in computer science, in biology, or in mathematics alone. This is the case even for joint majors because the double majors do not require a synthesis of what students learn in each major individually. To offer such synthesis in the proposed BCB major, new upper-level BCB courses will be designed.

NOTE: This was approved by the Board of Regents in the summer of 2007.

## 6.8 The mathematical minor

Table 9 shows the numbers of undergraduates in each calendar year who have graduated with a mathematics minor. (The 2006 figure does not include Fall 2006.) While the figures vary substantially from year to year, the table shows a general increase in the numbers of minors since the late 1990's.

*Table 9. Numbers of graduates with a mathematics minor, by calendar year*

| Year | Number of minors |
|---|---|
| 1998 | 16 |
| 1999 | 11 |
| 2000 | 22 |
| 2001 | 16 |
| 2002 | 26 |
| 2003 | 22 |
| 2004 | 38 |
| 2005 | 30 |
| 2006 | 25 |

During the period 1999-2007, the requirements for a mathematics minor have been 165, 166, 265, (266 or 267), (307 or 317), and 301. These requirements matched the core requirements in the mathematics major and included an introduction to abstract mathematics in 301. It is believed that many students decided to take a mathematics minor because so much of the mathematics required for the minor was already required for their major.

Starting in Fall 2007, the requirements for a mathematics minor will instead be 201, 265, (266 or 267), (307 or 317), and 301. Since 301 will have a prerequisite of 201, we needed to add 201 to the list of courses for the minor. The addition also gives more emphasis on proofs. The requirement of 165, 166 was regarded as moot since these courses were prerequisites for 265 and 266 anyway and were already taken by the students.

It is possible that the new requirements for the mathematics minor may reduce the numbers of students seeking a minor. Future trends will show whether this is true. Nevertheless, it is believed that under the new requirements the minor will be more meaningful and will indicate a higher level of accomplishment.

## 6.9 Concerns about undergraduate instruction

- Online course instruction. Currently, the department offers Math 141, 142, and 150 online. Until recently Math 140 was also offered online, but the format was changed after a number of complaints. The online instructional material was designed by several people over the last 8 years. As such, the material presentation is somewhat discontinuous, and some material was designed using old technology. Since there is newer, more sophisticated technology available for delivering content online, a redesign of all of the courses is overdue. However, the department is constrained by not having a full time, permanent instructor to oversee the updating of the online course delivery. Moreover, the department has also been reluctant to utilize any commercially available development and delivery tools out of concern that future changes both of software and textbook may become exceedingly difficult.

- Related to online courses, the department also lacks unified online assistance for other courses such as calculus. Calculus students can seek information or help from individual instructors' web pages, WebCT (from instructors who use it) and the department's basic course web pages. In addition, in Fall 2006 one professor is experimenting with on-line grading of homework via an option provided by the textbook publisher. Unified and detailed course web pages, with online help available, is not an option given current department resources.

- Accommodations for student with disabilities. The University Disability Resource office assists students with disabilities in requesting accommodations designed "to

level the playing field". Frequently, these requests involve extended examination periods as well as examination venues which are "low distraction". The number of students with such requests is steadily increasing, placing burdens upon the department's abilities to meet all the requests. The department does not have physical space to provide the low distraction venues needed and is also short of people to proctor such exams. Moreover, any differing accommodation request places further burdens on the department's abilities to fulfill those requests.

- Number of majors. The low number of mathematics majors is a concern. The department typically graduates about 20 majors per year. Given the size of the University, this is a very small number. The department has several small initiatives to increase the population of majors, but a large scale, unified plan for doing so is needed.

- Alumni relations. The department needs more data about our own alumni. The department, as part of ongoing assessment of our programs, distributes an alumni survey to recent graduates. Responses by the alumni have been infrequent. Much of the current information the department has accumulated has been through unsolicited alumni contact with faculty.

- Exit interviews. In an effort to obtain better information regarding future plans of graduating majors, program assessment, and student performance, the department has considered implementation of exit interviews for seniors. However, it is unclear whether sufficient resources for carrying out such a plan are available.

- Increasing failure rate in service courses. The department has taken notice of a recent increase in the failure rate in the Math 142 and Math 165 courses. With regard to Math 142, the department has recently used the lecture/recitation format and also a web-based format. Since we are not happy with either result, the department is studying the possible options. The concerns in item 1. are relevant here.

- With regard to Math 165, in response to concerns of the previous department review, there has been a concerted effort to increase the quality of the instruction in those courses. In particular, we have made an effort to staff Math 165 with experienced instructors and teaching assistants with good language skills. Recent student evaluations indicate that this effort has been successful. Moreover, the department uses a common textbook for every section, and has a midterm and final exam that is common to all sections.

- Course supervisors. The department desires that each lower division course have a “course supervisor”--someone to oversee the course’s many sections and instructors, to maintain uniformity across sections, and to maintain uniformity from one year to the next. We have a tremendous need for supervisors for a number of our course sequences. This need was an issue at the time of the

previous self study. Many of our pre-calculus courses are without course supervisors. Two of the primary reasons are lack of personnel and continued cuts to our budget. We are desperately in need of people to supervise Math 140/1/2 (algebra and trigonometry), Math 160 (calculus for economics majors), and Math 150/1 (pre-business mathematics.) We do not have enough faculty to staff all of our courses above the first year level. Thus faculty rarely if ever teach at the pre-calculus level. This makes it inappropriate for faculty to act as supervisors for these courses. In addition, there is no mechanism for rewarding faculty who might take on these jobs. In 2002 the university introduced the rank of lecturer. This new rank was supposed to allow us to hire good instructors with a Masters degree and was supposed to give some guarantee of job security for the person hired. It also would simplify long-term planning for the department. However (seemingly) never-ending budget cuts have prevented the department from hiring and retaining good lecturers who could take on these supervisory duties while providing quality instruction at this level. Just last year our budget was cut by about $80,000, forcing us to terminate two lecturers. One of these lecturers had served as course supervisor for the algebra and trig courses and was working hard to reform our web based offerings of these courses. This lack of the course supervisors has led to a lack of leadership in the courses affected and to greater variation among the different sections of the courses.

- Student Placement. In view of the increasing failure rates in first year courses, the department has identified the current method of student placement as potentially flawed. The current method involves using high school transcripts, math scores on entrance exams, as well as placement exams for a small percentage of students. As mentioned in the discussion of placement, several options are being considered for revising our mathematics placement procedures.

- Classrooms. There is a shortage of good classrooms, especially large lecture rooms. Blackboards are often old and hard to erase. The whiteboards that have replaced some of them rapidly become hard to clean, and markers dry up rapidly. Best might be the replacement of some old blackboards with new ones. In addition, we need more high tech classrooms with built-in computer-compatible audio-visual equipment.

- Supplies and services. The supplies and services budget for the department is woefully inadequate.

- Large lectures. Several years ago we started teaching calculus on large lecture sections. As a result we have, for years, been teaching some calculus in large lectures and some in sections of size 38. At the time that the department agreed to large lectures, we were told that (i) only superior instructors would be put into calculus large lectures and (ii) that there would be release time for faculty who teach large lectures. Although (i) has happened, (ii) has not. Furthermore, some instructors refuse to teach large lectures while many others are unsuited to that

format. As a result, the large lecture burden has fallen onto those better teachers who are willing to take on these tougher teaching assignments.

In addition, some faculty members feel that teaching in large lectures is less effective. We have limited teaching assistant resources to staff recitation sections (1.5 assistants per large lecture class) and do a meaningful amount of grading. As a result many instructors give multiple choice exams in such classes. Students in these sections are often dissatisfied with the all-or-nothing nature of such exams and many faculty feel that such exams are not an optimal way to assess students in a course like calculus. Some instructors do give more standard graded-for-partial credit exams in large lectures, but often require extra grading help so that the assistants assigned to the course are not overwhelmed.

In Spring 2005 and Spring 2006 the Associate Chair has managed to eliminate large lectures in the Spring. However, have been some questions about the way the department wants to teach calculus: are large lectures the format we should use and if so how can we find resources to reward faculty for teaching such classes and how do we obtain enough TA support to effectively teach such classes? Or should we continue to work to return to teaching calculus in small classes.?

- Uniformity of grading. Uniform grading is easy to achieve for web based courses. However for courses for which several sections are taught in large and small lecture format uniform grading continues to be a problem. While we do offer departmental midterms or finals in many of these courses, individual instructors of different sections usually give different hour exams, have different grading criteria, and different grading scales. Moreover, some faculty members refuse to use the departmental exams.

- Calculus. There has been a good deal of concern campus-wide about our calculus offerings. These concerns include a high failure rate in some of the calculus classes, appropriateness of topics covered, and poor performance of students in courses that require calculus. There is now a cross college committee to study calculus offerings at ISU with the hope of coming up with innovative ideas to improve calculus teaching. The committee has representatives from the colleges of Liberal Arts and Sciences, Engineering, and Business and includes four mathematics faculty members.

- Advanced courses taught to non-majors. Certain upper-division courses are attracting increasing numbers of students who are not majoring in mathematics. For example, in Fall 2003 only one section of Math 414 was needed, while in Fall 2006 two sections were required. These courses are especially sensitive since they must be taught in small sections by regular faculty.

# 7. The Graduate Mathematics Major

## 7.1 Graduate Program Overview

The Department of Mathematics offers five graduate degrees:

- MS in Mathematics
- PhD in Mathematics
- MS in Applied Mathematics
- PhD in Applied Mathematics
- Master of School Mathematics

In addition the department participates in the following interdepartmental graduate programs:

- Bioinformatics and Computational Biology
- Information Assurance
- Human Computer Interaction
- Ecology and Evolutionary Biology
- Complex and Adaptive Systems

## 7.2 Mathematics and Applied Mathematics Programs

The core instructional activities of the Mathematics department at the graduate level are its MS and PhD programs. Since the middle of the 1980s we have offered both a Mathematics and Applied Mathematics degree with parallel degree requirements.

### Student demographics

At the present time (Fall 2006) there are a total of 70 graduate students enrolled as MS or PhD students in Mathematics or Applied Mathematics, distributed as shown in Table 10.

*Table 10. Fall 2006 Enrollments*

| Mathematics MS | Applied Mathematics MS | Mathematics PhD | Applied Mathematics PhD |
|---|---|---|---|
| 11 | 4 | 35 | 20 |

Five of the above students are enrolled in co- or concurrent degree programs with another program outside of Mathematics. Many of the MS students hope to continue in the PhD program after completing the MS.

Some of the imbalance of numbers between the Mathematics and Applied Mathematics programs is due to the fact that students who express no preference on admission will typically be assigned to the Mathematics program – the numbers of students graduating from each program are closer, with in fact slightly more graduating with Applied Mathematics degrees.

The number of female students is 20 (28%) and the number of international students is 34 (49%) from 15 different countries. There are no US minority students currently enrolled. Further information about current students (aggregating Mathematics and Applied Mathematics) is shown in Table 11. Historical statistics about the numbers of female and international students can be found in Table 12.

*Table 11. Currently enrolled students Fall 2006*

| | PhD | MS | Total |
|---|---|---|---|
| US Male | 21 | 7 | 28 |
| US Female | 5 | 3 | 8 |
| International Male | 20 | 2 | 22 |
| International Female | 9 | 3 | 12 |

*Table 12. Historical trends in enrollments (Fall semester)*

| | US Male | US Female | Non US Male | Non US Female | Total |
|---|---|---|---|---|---|
| 2006 | 28 | 8 | 22 | 12 | 70 |
| 2005 | 22 | 13 | 25 | 8 | 68 |
| 2004 | 22 | 7 | 24 | 8 | 61 |
| 2003 | 16 | 8 | 21 | 6 | 51 |
| 2002 | 19 | 10 | 20 | 4 | 53 |
| 2001 | 11 | 8 | 23 | 5 | 47 |
| 2000 | Na | na | na | na | na |
| 1999 | 7 | 10 | 15 | 8 | 40 |

### 7.2.1 Administration of the programs

The DEO of the Mathematics department appoints a Graduate Coordinator, who serves as the Director of Graduate Education for the Mathematics and Applied Mathematics programs, and administers the programs on a day-to-day basis. This individual typically serves a 3-5 year term, by mutual agreement with the DEO. The Graduate Committee, consisting of the Graduate Coordinator, 3 elected faculty members and one faculty member appointed by the DEO, determines general policy for the graduate programs, oversees the admissions process, recommends instructors for all graduate level courses, appoints qualifying examination committees, selects students for awards, and performs other duties spelled out in the Department Governance Document. Some decisions, such as changes in the graduate part of the catalog must be approved by a vote of all graduate faculty.

While admission to degree programs is handled by the Graduate Coordinator and Graduate Committee, the awarding of financial support is in the hands of the DEO, who

must balance departmental teaching needs and financial resources along with recommendations of student abilities from the Graduate Committee.

Specific degree requirements originate from three sources:

- The Graduate College which imposes certain degree requirements for all graduate programs at ISU. These may be found in the Graduate College Handbook (GCH).
- The Mathematics Department, whose rules are given in the Mathematics Graduate Student Handbook (MGSH), see Appendix A-6.
- The Program of Study (POS) Committee, a committee of 3-5 faculty members formed for each individual student, chaired by the student's advisor.

### 7.2.2 Principal degree requirements, PhD

Iowa State University requires 72 semester credit hours for the PhD. The Mathematics department requires that 54 of these be in formal course work, i.e., exclusive of research credits, and 42 of these must be in graduate level Mathematics courses. PhD students must also satisfy a cognate course requirement, which is 12 semester credit hours of courses acceptable for graduate credit, listed in another department and relevant to the major. The principal difference between Mathematics and Applied Mathematics requirements comes in the so-called 'core requirements', a set of six required courses, which must be passed with a grade of B or higher, see Table 13. The rules of both programs allow, when appropriate and within certain limits, for replacement of core courses by those of the other program.

PhD students must pass written qualifying examinations in two of the four areas: Algebra, Analysis, Applied Mathematics and Numerical Analysis. Syllabi for the four exams may be seen in Appendix A.5 – each is based roughly on two of the core courses.

All PhD students must pass an oral preliminary examination administered by the student's Program of Study (POS) committee, focusing more narrowly on topics related to the proposed research area; this examination is administered after both qualifying examinations have been passed. Finally, of course, a doctoral dissertation and oral dissertation defense are required. Details may be found in the Mathematics Graduate Student Handbook, Appendix A.6.

*Table 13. Core courses*

| Mathematics core courses | Applied mathematics core courses |
|---|---|
| 504 Abstract Algebra I | 502 Numerical Analysis I |
| 505 Abstract Algebra II | 503 Numerical Analysis II |
| 510 Linear Algebra | 519 Methods of Applied Mathematics I |
| 515 Real Analysis I | 520 Methods of Applied Mathematics II |
| 516 Real Analysis II | 515 Real Analysis I |
| 511 Complex Analysis | 511 Complex Analysis or 557 Ordinary Differential Equations |

### 7.2.3 Principal degree requirements, MS

Iowa State University requires 30 semester credit hours for the MS degree, and the Mathematics Department requires that 21 of these be in graduate level Mathematics courses. Students in the Mathematics program must pass two of the three Analysis core courses and two of the three Algebra core courses, while Applied Mathematics students must pass four of the courses from the Applied Mathematics core, including either the 502-503 sequence or the 519-520 sequence, with a grade of B or better. There is no written exam requirement. An MS student may elect either the Thesis or Nonthesis option. In the latter case the student writes a Creative Component, a mathematics paper which need not contain original research. Historically, most MS students in Mathematics or Applied Mathematics have elected the Nonthesis option.

### 7.2.4 Financial Support

Most students enrolled in the Mathematics or Applied Mathematics degree programs receive financial support in the form of a Teaching Assistantship. Exceptions to this are most commonly due to (i) international students receiving support from their governments, (ii) students who are supported by RAs and fellowships, (iii) students who have 'timed out', i.e. failed to complete degree requirements in a timely way, but still seek to finish the degree, (iv) local students whose previous record is not quite competitive enough for funding, but who wish to attend ISU while supporting themselves in some other way, (v) students primarily supported by another program, and (vi) eligible students who have declined financial support for personal reasons.

In the current semester, for example, 57 of the 70 enrolled students have some kind of financial support, 55 as TAs, 1 as an RA and 1 by a departmental fellowship. Stipends for teaching assistants for 2006-07 range from $1580-$1700 per month for 9 months ($14,220-15,330 per academic year). In addition, we have been able to provide 1 to 1.5 months of summer salary for many students in the form of teaching or research support in recent years. This money is very unreliable, and cannot be predicted from year to year.

Starting with the Fall 2006 semester, any PhD student with an assistantship receives a complete tuition scholarship. MS students on an assistantship get 50% tuition scholarship, with the remainder charged at the in-state rate (i.e. 50% of $2968 per semester). Stipends in this range seem to be reasonably competitive with those offered by other comparable departments, see Table 14 for comparison in 2005-06.

*Table 14. Comparisons of TA Stipends*

| School | Typical TA salary |
|---|---|
| Louisiana State | 21,200 |
| Arizona State | 16,751 |
| University of Kansas | 16,353 |
| University of Nebraska | 14,950 |
| Michigan State | 14,550 |
| Purdue | 14,425 |
| **Iowa State** | **14,231** |
| Florida State | 12,150 |
| University of Iowa | 11,734 |

(Source: These figures come from *Assistantships and Fellowships in the Mathematical Sciences 2005-2006*, published by the American Mathematical Society. When a range of salaries is given we have averaged the high and low figures, and subtracted required fees.)

### 7.2.5 Recruitment patterns and activities

Over the past twenty years, students enrolling in ISU Mathematics programs tend to come from (i) small colleges and small campuses of state university systems in the upper Midwest, and (ii) foreign countries. In recent years we are starting to see a third stream of applicants, those who have made some kind of connection to ISU through the summer REU program. Table 15 shows the undergraduate institution for each of the 20 new students enrolling in Fall 2006.

*Table 15. Undergraduate Institutions for students entering the program in Fall 2006*

| US | Foreign |
|---|---|
| Maharishi University (Fairfield, IA) | Seoul National University, Korea |
| Minnesota State Univ, Mankato | Ewha University, Korea |
| University of Wisconsin, Lacrosse | National Sun Yat Sen University, Taiwan |
| Luther College (Decorah, IA) | Hong Kong Baptist University, China |
| University of Wisconsin, Stout | Southeast University, China |
| Mount Holyoke (South Hadley, MA) | University of Science and Technology, China |
| Illinois State University (Normal, IL) | Chulalongkom University, Thailand |
| Bowdoin College (Brunswick, ME) | Istanbul Technical University, Turkey |
| Midwestern State University (Wichita Falls, TX) | University of Augsburg, Germany |
| Carleton College (Northfield, MN) | |
| Winona State University (Winona, MN) | |

Foreign applicants represented about 2/3 of the total applicant pool last year, and well over half of these came from China. Informally we seek to maintain the proportion of US students at around 50% of the total. While the foreign applicants, especially the Chinese and Koreans, come with higher qualifications on the average than the US applicants, we still feel that in recent years we have been able to recruit a satisfactory number of well qualified US applicants.

Among the foreign students who have enrolled in Mathematics graduate programs here, a significant number are due to institutional ties that the Mathematics department has developed with departments in other countries. Purposes served by these connections include (i) increasing enrollment in our programs, (ii) increasing diversity of students in our programs, (iii) assisting in the promotion of mathematical talent in developing countries, and (iv) fostering research connections. In recent years our most significant connections of this type have been with the following:

- University of Augsburg, Germany: in most years one student from Augsburg spends a year at ISU enrolled as an MS student. In many cases the student is able to complete the MS degree by the end of the following summer. Somewhat less frequently an ISU PhD student will spend a year in Augsburg. This does not lead to a German degree for the student, but is regarded as an interesting and valuable experience for the students involved. Since 1999 10 Augsburg students have studied here, of whom 5 completed an MS here. One ISU student spent the year in Augsburg during 2001-02.

- Kenyatta University, Kenya: Mathematics faculty in this university, who are not already trained at the doctoral level, come to ISU to complete the PhD. Since 1999 three of these students have completed the PhD, 1 more is expected in Fall 2006 and one other completed a second MS degree.

There was a similar agreement for several years with the Armenian Academy of Sciences, through which one student completed the PhD and one completed an MS. A new agreement is now in the works with the University of Antofagasta, Chile, focusing more on the research connection aspect.

### 7.2.6 Applications, admission and enrollment

There were 121 completed applications received for Fall 2006 admission, a significant increase from previous years, for which we see no clear explanation. Some factors which we believe to have contributed are:

- An overall improving US applicant pool
- A successful REU program, which has run at ISU in the summers of 1998,1999, 2001 and 2003-2006, leading to increased visibility of our programs
- Improvements in the graduate program web site and more transparent application procedures
- Continual improvement of faculty research quality, also leading to increased visibility of our programs

US applicants represented about 1/3 of the total and female applicants also represented about 1/3 of the total. Admission was offered to 37 of these and 20 actually enrolled, see Table 16 for a more detailed breakdown. See Table 17 for corresponding figures for earlier years. We were able to offer financial support in the form of a teaching assistantship to 15 of the 20 students who enrolled.

*Table 16. Details for Fall 2006 applicants*

| | US | International | Male | Female | Total |
|---|---|---|---|---|---|
| Applied | 40 | 81 | 80 | 41 | 121 |
| Admitted | 22 | 15 | 22 | 15 | 37 |
| Enrolled | 11 | 9 | 13 | 7 | 20 |

*Table 17. Applicants to Mathematics/Applied Mathematics programs*

| | US | International | Male | Female | Total |
|---|---|---|---|---|---|
| 2006 | 40 | 81 | 80 | 41 | 121 |
| 2005 | 26 | 60 | 58 | 28 | 86 |
| 2004 | 33 | 52 | 61 | 24 | 85 |
| 2003 * | 9 | 44 | 38 | 15 | 53 |

* based on incomplete information, so these numbers may be somewhat lower than they actually are.

Women represent about 1/3 of the individuals involved at each stage of the process, application, admission, and enrollment. The department now has six female tenured/track faculty members, several of whom are actively involved in recruiting graduate students, and many of the graduate student leadership roles are filled by women, who also help recruit new female graduate students. The presence of a solid core of female graduate students and active involvement of women in the recruiting process is effective.

There are currently no US underrepresented minorities enrolled in the graduate program, despite some fairly serious efforts at recruitment. One such student from Puerto Rico was enrolled in 2004-05, but then transferred to Computer Science.

It is generally agreed that enrolling the first few minority students is the most challenging, and it gets much easier after a small 'critical mass' is achieved. One path which we hope eventually will lead to some successes in this regard is that of recruiting minority REU students. In addition to the students supported by the NSF REU site grant, for the past four summers 1-4 African-American students have been supported by grants targeted specifically at under-represented minority students, primarily AGEP/Alliance. These students have generally reported a positive experience and have developed strong connections with individual faculty members. Two such students enrolled in graduate programs at ISU this semester, but in other departments (one in Statistics one in Electrical Engineering). The AGEP/Alliance programs, which ISU participates in, provide substantial funding opportunities for qualified minority students. Nevertheless success has been lacking up to this point. Another complication for us is that the University of Iowa Mathematics Department has been extremely successful at minority recruitment, and is indeed a national leader now in this effort, so will naturally be particularly attractive for any students considering graduate school in Iowa, and in fact some of the AGEP/Alliance students we have hosted have enrolled there.

### 7.2.7 Course Offerings

The current (2005-2007) catalog lists 42 distinct courses in graduate level Mathematics, which are regularly taught by Mathematics department faculty members, 20 at the 500 level and 22 at the 600 level. In addition there are 7 courses listed primarily for students in the School Mathematics program and 7 more courses cross-listed in Mathematics which almost always are taught by faculty members in other departments. Advanced topics courses (690) are run as interest and enrollments permit. The general guidelines for numbers of students needed to run a course are 8 for 500 level courses and 5 for 600 level courses but exceptions to these rules are not uncommon.

The 500 level courses are offered every year and rarely fail to meet minimum enrollment requirements. Courses at the 600 level are in many cases only offered in alternate years, for example the two semester sequences in logic, topology and functional analysis. Before this year, the Partial Differential Equations sequence also was taught only in alternate years, but we hope now that there is sufficient enrollment for it to be taught each year. A four semester sequence in Discrete Mathematics (605-606-607 -690I) has been designed, so that each course is taught in alternate years, but so that the sequence can be begun in the Fall semester of any year.

In the current (Fall 2006) semester 15 graduate level courses are being taught by Mathematics department faculty, two of which are Advanced Topics (690) courses and there are 4 more graduate level courses which are cross listed with Mathematics currently being taught by faculty in other departments. Five of the six core courses being offered this semester are well above minimum enrollment requirements, and in fact for at least the past three years the first semester Real Analysis class has had to be split into two sections. For the coming Spring semester there are 23 Mathematics Graduate courses open for enrollment, including 5 Advanced Topics. Table 18 shows enrollment figures near midterm of Fall 2006

*Table18. Graduate course enrollments for Fall 2006*

| Number | Name | Math Grad | Other Grad | Under grad |
|---|---|---|---|---|
| 501 | Intro Real Analysis | 2 | 4 | 1 |
| 502 | Numerical Analysis | 8 | 7 | 0 |
| 504 | Abstract Algebra | 15 | 1 | 2 |
| 510 | Linear Algebra | 11 | 1 | 0 |
| 515 | Real Analysis | 22 | 3 | 0 |
| 517 | Finite Element Methods | 8 | 2 | 0 |
| 519 | Applied Mathematics | 4 | 3 | 0 |
| 557 | ODEs | 6 | 5 | 0 |
| 601 | Logic | 4 | 0 | 1 |
| 605 | Design Theory and Association Schemes | 5 | 0 | 0 |
| 617 | Category Theory | 6 | 0 | 0 |
| 645 | Stochastic Processes | 4 | 4 | 0 |
| 655 | PDEs | 3 | 0 | 0 |
| 690Q | Representation Theory of Finite Groups | 6 | 0 | 0 |
| 690P | Mathematical Biology | 4 | 1 | 0 |

We mention also that several graduate level classes not being taught this semester have tended to attract many students from outside of the Mathematics department:

- MATH 533 (Cryptography) enrolled about 50 students in Spring 2005, 40 of whom were graduate students in other departments, and about 20 of these took the course in an off campus video-streaming format. The class has had as many as 70 students registered in some previous years.
- MATH 607 (Modern Structural Graph Theory) enrolled about 25 students in Spring 2006 and would have had a few more if enrollment had not been capped. About half of these were graduate students from other departments.

### 7.2.8 Degree counts and placement of recent graduates

There have been 54 MS degrees and 38 PhD degrees awarded from 1999-2006. Year by year degree counts are shown in Table 19. Individual degree recipient, advisor, and first employment after graduation, if known can be found in Appendix A.8.

*Table 19. Degree counts by year*

| Year | Math MS | Applied Math MS | Math PhD | Applied Math PhD | Female PhD | US PhD |
|---|---|---|---|---|---|---|
| 1999 | 5 | 5 | 1 | 2 | 1 | 2 |
| 2000 | 0 | 3 | 1 | 2 | 1 | 1 |
| 2001 | 2 | 3 | 2 | 2 | 2 | 0 |
| 2002 | 3 | 4 | 2 | 3 | 2 | 1 |
| 2003 | 3 | 4 | 1 | 4 | 0 | 2 |
| 2004 | 6 | 4 | 3 | 2 | 0 | 0 |
| 2005 | 2 | 3 | 5 | 2 | 4 | 3 |
| 2006 | 2 | 5 | 1 | 3 | 1 | 3 |

These figures show in particular a modest increase in PhDs awarded, and it is our opinion that this trend will continue.

### 7.2.9 Enrichment activities

In order to improve the quality of the graduate school experience, to increase the likelihood of successful completion of the degree program, and to better prepare graduate students for the Mathematics profession, we are working to provide relevant opportunities beyond the normal classroom environment and take maximum advantage of already existing ones. These include:

#### 7.2.9a Graduate Student Seminar

This is a weekly meeting oriented towards first year graduate students but often of interest to more advanced students, covering a variety of topics such as TeX, web pages, Matlab, Mathematics organizations and how to search the Mathematics literature. There are also presentations about research areas by faculty members

and about institutional procedures by faculty, staff and administrators. The weekly schedule for Fall 2005, Spring 2006 and Fall 2006 can be seen in Appendix A8.

### 7.2.9b Graduate student mentors

All incoming students are paired with a current mathematics graduate student from May through their arrival at ISU. The student is there to help them with questions about their arrival, where to live, what it costs to live in Ames, and what courses they might be interested in. Many pick them up at the airport and help them find housing as well as get them checked in at ISU.

### 7.2.9c Summer REU program

The Mathematics department has run an REU program for four years, usually consisting of 7-8 small groups led by a faculty member. Each faculty member is assisted by one graduate student who is a full participant in the research group activities.

### 7.2.9d Preparing Future Faculty Program

The Center for Excellence in Learning and Teaching at Iowa State University offers graduate students the opportunity to participate in the Preparing Future Faculty program (PFF), to ease the transition from graduate student to post doctoral fellow to faculty member. PFF is a national movement sponsored by the Association of American Colleges and Universities and the Council of Graduate Schools.

### 7.2.9e Organization of qualifier study groups

We are experimenting with assigning advanced graduate students the task of organizing and leading groups of beginning students in preparing for written qualifying examinations. Besides being of value to the students studying for the qualifier, this provides a good opportunity for the group leaders to develop communication, organization and leadership skills.

### 7.2.9f Graduate student teaching supervisor (GSTS)

An advanced graduate student chosen for his/her teaching abilities, the GSTS assists the Associate Chairman in making teaching assignments for Teaching Assistants, conducts an orientation program for new Teaching Assistants and provides ongoing advice about teaching.

### 7.2.9g Institute memberships

The Mathematics Department maintains memberships in the Institute for Mathematics and its Applications (IMA) at the University of Minnesota and the

Mathematical Biosciences Institute (MBI) at Ohio State University, partly with a view towards the opportunities for graduate students that both of these provide.

#### 7.2.9h Mathematics Graduate Student Council

The MGSC is an organization run by and for mathematics graduate students sponsoring graduate student activities and through which general concerns of the graduate students may be communicated to the department administration. A member of the MGSC is generally invited to attend all open meetings of the Graduate Committee.

### 7.2.10 Future activities and concerns

Our main goals for the future are to continue to improve the quality of the program, to maintain or slightly increase the number of students enrolled in the program each year, and increase the number of PhDs awarded each year. This last goal would necessarily result in an increase in the size of the program, as PhD students take longer to complete the degree. To achieve any or all of these, it seems essential to obtain more diverse sources of funding for the graduate students. Nearly 100% of the financial support we are able to offer to students is in the form of Teaching Assistantships, and fewer of these are available than in earlier years. Occasionally a student may be supported by a faculty member's research grant, and we have a scholarship fund (Wolfe fund) by means of which we award a one semester fellowship each year to an advanced student. However it is clear that much more is needed to grow the programs. Steps being undertaken currently or in the recent past include:

- Submission of departmental VIGRE proposal, (July1999)
- Submission of an MCTP proposal in 2006. This was declined but was rewritten and submitted again in 2007
- Attempts to obtain support for graduate students from NSA [about 12 proposals by 8 algebra, discrete math, and number theory faculty sent to NSA or NSF last fall and at least 8 request grad student funding]
- Encouragement of faculty with grants to include funding for students
- We seek to increase contributions to fellowship funds

## 7.3 School Mathematics Program

Since the mid-1980's the Mathematics department has offered a program in School Mathematics for persons who teach mathematics at the secondary level (grades 7-12) or developmental mathematics courses at community colleges. Completion of the program fulfills the requirement of a "master's degree in a teaching endorsement area" for a master educator's certificate. Applicants to the program must have at least two years of teaching experience. The program is designed so that teachers who are teaching full-time in a secondary school may complete the program. Coursework for this program is offered

primarily during the summer while the secondary schools are not in session. In addition, the courses are offered on a three-summer cycle through the Iowa Communications Network (ICN), a fiber-optics system owned and operated by the state of Iowa. The network connects schools, libraries, hospitals, and government facilities in the state of Iowa in order to facilitate communication via high quality, full-motion video. The ICN is interactive television.

**Student demographics**

At the present time (Fall 2006), there are a total of 25 students in the program including 16 active enrollments, meaning they took courses Summer 2006, and 2 enrolled in courses Fall 2006. The remaining nine are considered inactive in that they have been admitted to the program and have yet to take coursework, have not taken courses in more than a year, or have completed all coursework but have not yet completed a creative component. Of the 25 students in the program, 13 are male and 12 are female. Of the 16 who are active, 9 are male, and 7 are female. There are no US minority students currently enrolled in the School Mathematics program. One international student has been accepted into the program and has not yet taken graduate coursework in the program.

### 7.3.1 Administration of the program

The DEO of the Mathematics Department appoints the Director of Graduate Education for the School Mathematics program who administers the program, henceforth called the MSM-DOGE. The individual serves a term of unspecified length and by mutual agreement with the DEO. Six members of the faculty of the Department of Mathematics serve as faculty for the program. These faculty members have demonstrated interest in improving mathematics teacher education in the state. The MSM faculty determines general policy of the program. The Director of Graduate Education and another MSM faculty member review all applications for admission to the MSM program. In addition, the MSM-DOGE corresponds with the Department of Continuing Education and Communication Services to ensure smooth operation and transmission of the courses via distance education. The DEO makes decisions regarding any financial support for MSM students based on the recommendation of the MSM-DOGE.

### 7.3.2 Principal degree requirements, MSM

The degree requirements for the MSM degree are set at 33 semester credit hours, above the 30 required by Iowa State University. Students in the program must complete six core courses for a total of 20-21 credits with a grade of B or better in each and earn an additional three credits by writing a Creative Component. Table 20 shows course requirements for the School Mathematics Program. The remaining 9-10 credits are electives taken most frequently through the Departments of Curriculum and Instruction or Mathematics or at another university near their home. After fulfilling the coursework requirements and the written Creative Component, students complete a final oral

examination. The final oral examination is the only component that must be completed in Ames. All other components may be completed through distance learning.

Current MSM faculty members have pushed for Creative Components that place greater emphasis on mathematics topics rather than on education topics. The reasons for doing so are twofold. One, the current faculty are less familiar with conducting studies in mathematics education. Of the six MSM faculty, one has a background in mathematics education. Thus, the strength of the MSM faculty lies in mathematics. Secondly, the teachers enrolled in the program seek the strength of the mathematics offered in the program. In order for these teachers to teach calculus at the high school level and their students to obtain college credit at the local community colleges, they must obtain a minimum of 12 graduate credits in mathematics and/or a master's degree in mathematics. Thus, requiring more mathematics in a Creative Component seems reasonable as the teachers are expected to function on a higher level mathematically. In the Creative Component, the teachers generally do not discover new mathematics, but explore a topic of mathematics beyond the undergraduate level that is new to them as well as meets the standards established by their Program of Study Committee. As the authors are practicing teachers, most Creative Components also include discussion of how high school students could be exposed to related topics.

*Table 20. Core Course Requirements for MSM degree*

| | School Mathematics Core Courses | Credits |
|---|---|---|
| 540 | Seminar in Mathematics Education | 3 |
| 545 | Intermediate Calculus | 4 |
| 546 | Algorithms in Analysis and Their Computer Implementation | 3 |
| 547 | Discrete Mathematics and Applications | 4 |
| 549 | Intermediate Geometry | 3 |
| One of: | | |
| Stat 401 | Statistical Methods for Research Workers | 4 |
| ResEv 552 | Basic Educational Statistics | 3 |

### 7.3.3 Financial support

A few students enrolled in the School Mathematics degree program receive financial support in the form of a Teaching Assistantship during summer enrollment. Since most students are actively employed throughout the school year and few take courses during the school year, the primary need for support occurs during the summer. In addition, during the summers, most students take the core courses at off-campus locations and are not physically present to teach a course in the department. The few remaining students who are taking courses on campus may teach a summer course, though the times of the MSM course offerings often conflict with the times of courses they would be asked to teach. Therefore, most of the teaching assistantships occur in the form of grading responsibilities or tutoring students for specific courses or summer programs. In Summer 2006, four School Mathematics students each had a half-time teaching assistantship in the amount of $1,275 for each of two months of the summer or a total of $2,550 for the

summer. In addition, these teaching assistants received a 50% tuition scholarship of $825 with the remainder charged at the in-state rate (i.e. 50% of $1650 for the summer term).

### 7.3.4 Recruitment patterns and activities

The teachers enrolled in the School Mathematics program primarily teach mathematics at high schools or community colleges in Iowa. Some teachers from Rock Island and Moline Illinois, just on the other side of the Iowa-Illinois border, take courses in Davenport, IA. In addition, one teacher from Minnesota recently spent two summers and one school year in Ames to complete the program. Use of the Iowa Communication Network currently limits the Department's ability to reach teachers outside Iowa.

Many new applicants have a colleague who completed a degree in School Mathematics. Word-of-mouth seems to be our strongest recruitment tool. The website for the program also seems to be a strong point of contact for teachers wanting to pursue a master's degree. Those who are interested in the program frequently state their desire to remain at a site near their home as they do not want to travel to Ames to take courses. Thus the distance education component is one of the strongest characteristics of the program. Additional advertisement of the program occurred through brochures directly mailed to each of the Iowa high schools and Area Education Agencies in Spring 2005 and distributed when the MSM-DOGE presented at state and regional meetings of teachers of mathematics.

### 7.3.5 Applications, admission and enrollment

There were 11 completed applications received for Summer 2006 admission. This is the same as the number of applications received for Summer 2005 and up from the number (7) of applications received for Summer 2004. The increase in applications from Summer 2004 to Summer 2005 can be attributed to the direct mailing of brochures to Iowa high schools. The number of applications continues to remain steady or increase as the teachers desire graduate work in mathematics, as opposed to administration or education, prefer the distance education component, and want their students to be able to obtain dual-credit for college level courses offered at the high school where they teach.

Requests for information about the School Mathematics distance education program continue to come from teachers of mathematics. Typically 20 requests are made each year, with at least 4-5 from teachers outside Iowa looking for a distance education program. The limitations of the Iowa Communication Network prevent the program from being offered to them in the current form. However, alternate methods of transmission are under consideration.

### 7.3.6 Course offerings

The core courses of the School Mathematics program are taught during the summers on a three year cycle. Thus, a student in the program can finish the core coursework in three

consecutive summers. Most students complete the coursework in three summers and complete their electives and creative component by the fourth summer, though the possibility and goal exist for the students to complete all the requirements of the program by the completion of the third summer. Typical enrollment in the core courses is approximately 13-14 students including 3-4 at an Ames location and the others at 4-5 different ICN sites throughout the state. Table 21 shows enrollment figures for the most recent MSM core courses.

*Table 21. MSM course enrollments for summers 2004-2006*

| Course | Term | Name | MSM Student in Ames | MSM Student Off-Campus | Total MSM Student | Other Graduate | Under-graduate |
|---|---|---|---|---|---|---|---|
| 540 | SS 05 | Seminar in Mathematics Education | 3 | 12 | 15 | | |
| 545 | SS 04 | Intermediate Calculus | 4 | 9 | 13 | | |
| 546 | SS 04 | Algorithms in Analysis and Their Computer Implementation | 4 | 9 | 13 | | |
| 547 | SS 06 | Discrete Mathematics and Applications | 3 | 10 | 13 | | 1 |
| 549 | SS 06 | Intermediate Geometry | 3 | 11 | 14 | | |
| Stat 401 | SS 05 | Statistical Methods for Research Workers | 3 | 10 | 13 | 4 | 5 |

### 7.3.7 Degree counts

There have been 39 MSM degrees awarded from 1999 – 2006. Year by year counts are shown in the Table 22. See Appendix A.9b for a list of School Mathematics degree recipients with advisor(s), topic studied, and first employment after graduation, if known.

*Table 22. MSM degrees counts*

| Year | Total | Male | Female |
|---|---|---|---|
| 2006 | 5 | 1 | 4 |
| 2005 | 3 | 0 | 3 |
| 2004 | 5 | 2 | 3 |
| 2003 | 4 | 0 | 4 |
| 2002 | 9 | 5 | 4 |
| 2001 | 4 | 0 | 4 |
| 2000 | 6 | 2 | 4 |
| 1999 | 3 | 2 | 1 |
| Total | 39 | 12 | 27 |

### 7.3.8 Costs of the program

The costs of operating the School Mathematics program include the payment of summer salaries to the instructors and expenses related to distance learning. Payment of each instructor originates from the Department's Summer School Budget. Each course costs one-ninth of the instructor's academic year salary. The other expenses of the program are related to the operation of a distance education course. Students' tuition is used to offset the cost of ICN room rentals, the use of telephone lines, postage, and administration fees charged by the Department of Continuing Education and Communication Studies and the College of Liberal Arts and Sciences. Students' tuition is sufficient to cover the costs of the distance learning components of the course, but is not adequate to cover payment to the instructors. The Department associates the additional expense to providing a service to the State of Iowa as mathematics education is advanced.

### 7.3.9 Future activities and concerns

The main goals for the MSM program for the future are to continue to improve the teaching of mathematics at the secondary level by increasing enrollment in the program, increasing completion rates of the program, and improving the experiences teachers have in the program. One way to increase the enrollment in the program is to make the program available to a wider audience through online classes with video-streaming. The MSM faculty members are not willing to sacrifice the live two-way audio and video interactions currently available through the ICN. The need to communicate mathematics through both written and spoken means is crucial for practicing high school teachers of mathematics, particularly as many are in rural schools and serve as the only mathematics teacher in the school. In addition, the MSM faculty members desire to expose the teachers to mathematics that is new to them and model appropriate methods of instruction. Promoting change in mathematical understanding and mathematics instruction is difficult without live audio and visual interaction. As a result, communication between the Continuing Education and Communication Services Department and the MSM-DOGE has focused on various methods that can be implemented to maintain the integrity of the courses with live two-way audio and video communication. Advances in technology are being made in which teachers could take the courses from virtually anywhere, and the MSM faculty will soon make use of such technology in the MSM courses.

Another component of offering online courses is the possibility for students to complete the program at a faster rate. If the courses are offered through video-streaming, students would not necessarily have to wait for the next summer offering of the course. A minimum number of students would need to enroll to warrant running the course and to ensure some interaction among students and between students and faculty. If transmission of the courses is pursued through video-streaming as described here, live two-way audio and video components would likely be lost.

With the changing technology and the potential for more teachers to take the courses remotely, the need for a sense of community increases. One concern of the MSM faculty is that teachers complete the coursework and then fail to complete the Creative Component due to a sense of isolation and uncertainty as to what topics to explore. Plans are in place for teachers to connect with a major professor by the end of the second summer of coursework. Thus, the teacher can explore mathematics topics and begin work on the creative component before the completion of the coursework. This will advance completion rates.

To further build a sense of community, day-long or weeklong on-site components, as part of the Iowa Initiative for Collegiate Mathematics and Statistics Education ($I^2$CMASE), are planned at the start of the summer courses. All teachers in the MSM program will come to campus for a designated period to complete problem-solving sessions, interact with faculty, and build community with other teachers in the program. During such sessions, the teachers will gain exposure to a variety of topics that may be further researched and explored in their Creative Components, better know the MSM faculty with whom they may work when completing their Creative Components, better understand the nature of mathematics, and connect with other teachers so that when they return to their more remote sites to complete the courses, bonds have been established through which they can communicate and exchange mathematical ideas. Thus, they will feel less isolated in the courses, have greater success in the program, and improve completion rates.

Advancing statistics education is a component of $I^2$CMASE as it relates to improving the teaching of mathematics at the secondary level. The state of Iowa has recently put into place the Mathematics Model Core Curriculum. The curriculum promotes mathematical discussion of probability and statistics at a level for which most teachers of mathematics are unprepared. Most teachers of mathematics in Iowa have had one course in the theory of probability and statistics. At Iowa State University, this course does little to prepare them to understand or teach the main ideas of inference or data analysis, topics emphasized in the Model Core Curriculum and in Advanced Placement Statistics. Teachers in the MSM program are required to take a statistics course. Most take Stat 401. Plans are in place to offer laboratory experiences in Stat 401 in Summer 2008 which would be designed specifically to help teachers better understand the key concepts of statistics and data analysis and how the concepts can be taught in the secondary classroom.

Concerns related to the program primarily center on resources. The teaching and advising responsibilities of the MSM program primarily lie with two of the six MSM faculty members. More incentive needs to be given to teach during the summer and/or work with practicing teachers of mathematics. In addition, more release time is needed for the MSM-DOGE to seek and secure funding for the program. Additional funding is needed to bring the teachers to campus for problem-solving sessions in order to facilitate interactions with faculty and other teachers in the program. Funding is also needed in order to explore alternative means of transmission of the courses to offer the program to a wider audience. In addition, no funding exists to support any teachers wanting to come

to Iowa State University for a year to work on their degree. Funding is also needed to further promote the program. Interest in the program increased following the printing and mailing of brochures to Iowa high schools and Area Education Agencies. Financial support to continue to inform practicing teachers of the opportunity for advancement in their mathematics education is needed.

## 7.4 Interdisciplinary Programs

Many degree programs at ISU are not under exclusive control of a single academic department and so are controlled by the faculty appointed to the program. Such programs often do not have independent budgets, and so rely on cooperating departments for support of graduate students enrolled in the program, and in any case all graduate students must have a home department, that is, a normal academic department to which the student is assigned for administrative purposes. Thus the participation of the Mathematics department in the interdisciplinary programs mentioned in section I has at least these aspects: (i) Mathematics faculty participation as advisors and members of POS committees, (ii) Mathematics faculty teaching graduate level courses in the program, (iii) financial support of some students in the program, (iv) administrative responsibility for some students in the program. Here is a bit more detail concerning each of the four programs.

### 7.4.1 Bioinformatics and computational biology

There are currently seven faculty members in the Mathematics department who are also members of the BCB program and have actively participated in the BCB activities including teaching and advising graduate students as major or co-major professors or POS committee members, supervising student 'laboratory rotations', and serving on various administrative committees such as the supervising, curriculum, and admissions committees. In particular, former faculty member Dan Ashlock has developed and taught a BCB course on Computational Mathematics for Biologists, and Zhijun Wu has developed and taught a course on Introduction to Computational Structural Biology.

So far, there have been at least eight BCB associated students who have chosen the math department as their home department and worked with math faculty members as their major professors. Four of them have graduated with a Ph.D. in BCB, and some of them also co-majored in applied math. These students have been supported for one or two years by the BCB program and later supported by the math department.

(Faculty participants: Levine, Boushaba, Smiley, Su, Wilson, Smith, Wu)
(Four graduates: Feng Cui, Di Wu, Peter Vedell, Justin Schonfeld)
(Eight BCB associated students: 5 with Wu, 2 with Ashlock, 1 with Levine)

### 7.4.2 Information assurance

The Information Assurance program has received national recognition. Iowa State has been designated a "Center of Excellence in Information Assurance Education" by the National Security Agency. Three members of the department faculty participate in the program. Between them they have supervised 8 students and served on 16 program of study committees in InfAs. All of the mathematics students that have graduated from the program have found excellent jobs directly related to their fields of study, several with the NSA.

As of 2006, mathematics faculty members have developed and teach two courses taken by many of the students in information assurance. Math 533 (Cryptography) has been taught every spring since 1997, and typically has 50–70 students enrolled. Math 535 (Steganography and Watermarking) has been offered every spring since 2003, with an enrollment averaging 12 students/year. The cryptography course is also one of the four courses that comprise the Information Assurance Certificate, offered through Engineering Distance Education. In addition, one of our faculty moderates the Information Assurance Colloquium (*http://www.math.iastate.edu/IA*), a general interest forum open to all members of the University and surrounding community.

Several InfAs students have received support from the Mathematics Department in the form of teaching and research assistantships. Four students have received full support (tuition, room board, books and living expenses) through Iowa State's CyberCorps grant. This grant is part of the NSF's Scholarship for Service program. In exchange for two years of support, each participating student serves for two years as a security specialist at a Federal Agency. This program has been extremely successful with both students and the agencies. Informal feedback we have received indicates that the agencies are particularly happy with the work our students have performed.

### 7.4.3 Ecology and evolutionary biology

There is very little involvement on the part of the Mathematics program. Only one faculty member participates in the program, and no students have been financially or administratively associated with the Mathematics department.

### 7.4.5 Human computer interaction

There is very little involvement on the part of the Mathematics program. Only one faculty member, whose main appointment is in Economics, participates in the program, and no students have been financially or administratively associated with the Mathematics department. Dr. Dan Ashlock was expected to be an active participant, but he unfortunately has left ISU.

### 7.4.6 Complex and adaptive systems

This is an interdepartmental Graduate Minor oriented around the concepts and methodologies of Artificial Life. The most active participant from the Mathematic Department has been Dr Dan Ashlock, now gone from ISU. Two other Mathematics faculty maintain formal affiliation with this program.

# 8. Research Groups

## 8.1 Algebra, Geometry and Logic

Since 1999, Peake and Pigozzi have retired, Long and Ng were hired, Bergman and Hogben were promoted to Professor from Associate Professor. The group contains five Professors, one Associate Professor, and two Assistant Professors.

*Table 23. Composition of the Algebra, Geometry, and Logic group*

| Name | Rank | At ISU since |
|---|---|---|
| Clifford Bergman | Professor | 1982 |
| Robert Gregorac | Associate Professor | 1964 |
| Irvin Hentzel | Professor | 1968 |
| Leslie Hogben | Professor | 1978 |
| Ling Long | Assistant Professor | 2003 |
| Roger Maddux | Professor | 1977 |
| Siu-Hung Ng | Assistant Professor | 2003 |
| Jonathan Smith | Professor | 1984 |

*Table 24. Publication statistics for the Algebra, Geometry and Logic*

| | **Mathematics** | | | | **Outside Mathematics** | | | | Other |
|---|---|---|---|---|---|---|---|---|---|
| Year | Books | Journal Articles | Other Refereed | Reports | Books | Journal Articles | Other Refereed | Reports | |
| 1999 | 1 | 8 | 2 | | | | 1 | | |
| 2000 | | 12 | 2 | 1 | | | | | |
| 2001 | | 10 | 1 | 1 | | | | | |
| 2002 | 1 | 13 | 1 | 2 | | | | | |
| 2003 | | 15 | 3 | 2 | | | | | |
| 2004 | | 16 | 3 | 1 | | 1 | | | |
| 2005 | | 17 | 1 | | | | 2 | 2 | |
| 2006 | 1 | 23 | 1 | 4 | | 1 | | 1 | |

*Table 25. External funding statistics for the Algebra, Geometry, and Logic group*

| Year | Funding Agency | Duration | PI/co-PI | Total Amount |
|---|---|---|---|---|
| 1999 | NSF | 3 yrs | Bergman (co-PI) | 387,136 |
| 2000 | P+G Corp | 3 yrs | Maddux (co-PI) | 220,000 |
| 2001 | NSF | 2 yrs | Bergman (co-PI) | 199,998 |
| 2001 | NSF | 4 yrs | Bergman (co-PI) | 2,626,026 |
| 2002 | NSF | 1 yr | Bergman (co-PI) | 10,000 |
| 2002 | IMA | 1 wk | Hogben (PI) | 3,000 |
| 2002 | ILAS | 1 wk | Hogben (PI) | 300 |
| 2004 | MFRC | 1 yr | Bergman (co-PI) | 79,000 |
| 2004 | NSF | 3 yrs | Hogben (co-PI) | 217,112 |
| 2005 | NSF | 4 yrs | Bergman (co-PI) | 888,008 |
| 2005 | AWM-NSF | 2 yrs | Long (PI) | 4,000 |
| 2005 | Number Theory Foundation | 1 yr | Long (PI) | 1,000 |
| 2005 | NSA | 2 yrs | Ng (PI) | 38,516 |
| 2006 | AIM (NSF) | 1 wk | Hogben (PI) | 33,000 |
| 2006 | Number Theory Foundation | 1 yr | Long (PI) | 1,000 |

Total funding for the period 1999–2006 is $4,708,096.

Table 26. Presentation statistics for the Algebra, Geometry, and Logic group

| | National or International Meetings | | | | Regional | Local |
|---|---|---|---|---|---|---|
| Year | Plenary | Invited | Contributed | Posters | Meetings | Colloquia/ Seminars |
| 1999 | 1 | 2 | 3 | 1 | | 7 |
| 2000 | | 1 | 3 | | 3 | 6 |
| 2001 | 1 | 8 | 3 | | 2 | 4 |
| 2002 | 1 | 8 | 5 | | 4 | 10 |
| 2003 | 1 | 5 | | | 2 | 12 |
| 2004 | | 1 | 4 | | 3 | 7 |
| 2005 | | 5 | 1 | 1 | 7 | 6 |
| 2006 | 2 | 9 | 4 | | 1 | 8 |

*Table 27. Refereeing and reviewing statistics for the Algebra, Geometry, and Logic group*

| | Refereeing | | | Reviewing | | |
|---|---|---|---|---|---|---|
| | Books | Papers | Proposals | Books | Papers | Problems |
| 1999 | | 13 | 1 | | 9 | |
| 2000 | | 11 | 1 | | 5 | 4 |
| 2001 | | 7 | | | 9 | 29 |
| 2002 | | 29 | 2 | | 8 | 22 |
| 2003 | 1 | 25 | | 4 | 11 | 21 |
| 2004 | 3 | 20 | 2 | | 6 | 9 |
| 2005 | | 23 | 1 | 1 | 8 | 14 |
| 2006 | | 28 | | 2 | 8 | 10 |

*Table 28. M.S., M.S.M., and Ph.D. students of the Algebra, Geometry, and Logic group*

| | M.S. Students | | M.S.M. Students | | Ph.D. Students | |
|---|---|---|---|---|---|---|
| | Completed | Current | Completed | Current | Completed | Current |
| 1999–2006 | 14 | 2 | 15 | 1 | 12 | 8 |

**Summary of research areas**

**Bergman:** From 1999-2001, Bergman continued his collaboration with Giora Slutzki (ISU Computer Science) on the computational complexity of problems in algebra. Since 1999, Bergman has taught a graduate course in cryptography and has actively been doing research in that area. He has collaborated with Kristi Meyer (ISU Math graduate student) on new work on message authentication codes, and has run seminars on stream ciphers and on electronic voting.

In collaboration with Jennifer Davidson (ISU Math), he has been working in steganography and steganalysis. Their recent work on this subject was funded by the Midwest Forensics Resource Center and resulted in a software package that is being distributed to local law-enforcement agencies. This work has received local and national attention from the popular press.

**Gregorac:** Gregorac has recently completed a cycle of papers dealing with extending in various ways certain results of classical geometry in $R^n$. This generally requires completely different proofs as well as some ingenuity in determining what form the extension should take. He has also had some success in extending various results in $R^2$ to higher dimensions. He has had papers published in *International Journal of Math and Science, Geometry Dedicata, Journal Geometry,* and *The European Journal of Combinatorics*, all of which are respected journals containing mostly paper in modern geometry and combinatorial geometries.

**Hentzel:** After doing some research papers the traditional way, Hentzel turned to writing computer programs to do research in algebra. His most productive venture was using the representations of the symmetric groups to study identities in non-associative algebras. But he has also written programs to do Peirce Decompositions, Finite Division Ring searches, Super Identities, and Representations. He has had a series of Post Doctorates and Visiting Faculty who have come to Ames to learn his techniques and collaborate on problems. He has also visited colleagues in Italy, Germany, England, Brazil, and Chile to work with them with his programs and techniques. He was a collaborator in the program ALBERT which has become a widely used program for studying non-associative algebras. He has published 99 papers over a broad spectrum of associative and non-associative algebra

**Hogben**: Hogben used her Faculty Professional Development Assignment in fall 2003 to broaden her research program beyond matrix completions to include minimum rank/maximum eigenvalue of a graph or sign pattern, spectral graph theory, spectrally arbitrary patterns, etc. and to increase her research productivity (from 1–2 papers per year

in 1999–2002 to 4 or more papers per year from 2005 on).

She regularly organizes conferences, workshops, and special sessions nationally and internationally, including the recent workshop "Spectra of families of matrices described by graphs, digraphs, and sign patterns" at the American Institute of Mathematics, where substantial research was done that will likely change the direction of research in several areas, including minimum rank problems.

In 2000 Hogben founded the ISU Combinatorial Matrix Theory Research Group. This group, whose primary purpose is to teach graduate students to do research in combinatorial matrix theory, has also involved faculty members at non-doctoral institutions and summer REU students. Through 2006, this group has involved seven ISU mathematics graduate students. Four of the students have received their Ph. D. s; two are current Ph. D. students. Only three of the students were/are Hogben's students; for all but one of the students involved, participation in this group was her/his first experience doing research. The group has been productive, publishing six papers and having submitted an additional two.

Hogben edited the Handbook of Linear Algebra, published by CRC Press.

Hogben has served as an editor of a special issue of Linear Algebra and Its Applications and will be joining the editorial board as an associate editor on January 1.

Hogben co-directs the REU program, including running the day-to-day operations, serves as a mentor to several undergraduates each summer, and regularly does publishable research with them.

**Long:** Algebraic Number Theory Long is working on arithmetic geometry, modular forms, and related problems. She had worked on the Shioda-Inose structure on extremal K3 surfaces and its applications. In the past 3 years, she has been mainly working on the arithmetic properties of modular forms for noncongruence subgroups and the modularity of noncongruence cuspforms similar to the work of Andrew Wiles via which he proved the Fermat's Last Theorem. She and her collaborators have identified interesting new relations between noncongruence modular forms and classical congruence modular forms. She has several collaborators including A. O. L. Atkin who is famous for his pioneering work on the theory of newforms as well as the theory of noncongruence modular forms; Wenching Winnie Li who is famous for her continuing work on the theory of newforms and her recent work on Ramanujan graphs; Yifan Yang at Taiwan and Zifeng Yang at Beijing China. Long (with her colleagues) has also written one paper on discrete mathematics and another interdisciplinary paper on sensor network distribution. Her work has been published some well-regarded journals such as J. Number Theory, Canad. Math. Bull., and J. Combin. Theory Ser. A.

**Maddux:** Maddux's main research area is algebraic logic (primarily relation algebras but also cylindric algebras) and its applications in logic (to •nite-variable logic, equational formalization of set theory, relevance logic, etc.) and in computer science (constraint

satisfaction problems, computational complexity, and the semantics of programming languages). In the summer of 2006 he published the monograph Relation Algebras, Studies in Logic and the Foundations of Mathematics Volume 150, Elsevier, 2006, 758 pp. This comprehensive treatment of the theory of relation algebras and the calculus of relations is the first devoted to a systematic development of the subject, and also contains many new research contributions. Maddux has also worked in mathematical biology (biogeography) and combinatorics. His recent collaborators are R. Hirsch (University College, London), I. Hodkinson (Imperial College, London), M. Frias (Univ. Buenos Aires), P. Jipsen (Chapman Univ., CA). Most of his published papers are in Alg. Univ. (10), Ann. Pure Appl. Logic (2), Proc. Amer. Math. Soc. (3), J. Symbolic Logic (5), Theoret. Comput. Sci. (2), and Trans. Amer. Math. Soc. (2).

**Ng**: Hopf algebras, quasi-Hopf algebras and tensor categories. Ng has been working on finite-dimensional Hopf algebras. He had completed the classification of Hopf algebras of dimension $p^2$ which was a well-known open problem in the area. He had also proved that Hopf algebras of dimension 2p or a product of twin primes are semisimple. His joint worked with Geoffrey Mason (UCSC) discovered the 2nd Frobenius-Schur indicators for quasi-Hopf algebras, and proved they are gauge invariants. In his recent collaborations with Peter Schauenburg (Universit¨at M¨unchen), he discovered the higher Frobenius-Schur indicators for pivotal tensor categories and proved a higher indicator formula for conformal field theory. This work is currently supported by an NSA grant and some of the results have been published in some well-regarded journals such as Adv. Math., Trans. Amer. Math. Soc. and J. Algebra.

**Smith:** Smith's work in algebra is primarily focused on the representation theory of quasigroups and related nonassociative algebras. He also works on abstract convexity, coding and information theory, and enumerative combinatorics. Over the last few years, the major development in representation theory has involved the concept of permutation representations for quasigroups, giving exact models of approximate symmetry. His main collaborators have been B. Im (Chonnam National University) and A. Romanowska (Warsaw University of Technology).

## 8.2 Analysis

*Table 29. Biographical Data for Analysis Group*

| Name | Current Rank | Start date |
|---|---|---|
| Rajbir Dahiya | Full Professor | 1968 |
| Elgin Johnston | Full Professor | 1977 |
| Gary M. Lieberman | Full Professor | 1979 |
| Justin Peters | Full Professor | 1976 |
| Yiu Poon | Associate Professor | |
| Moulay Tidriri | Associate Professor | |
| Eric Weber | Assistant Professor | 2003 |

**Field of study**

Dahiya: Delay, Neutral and Advanced Differential Equations, Transform Theory
Johnston: Complex analysis, especially univalent function theory
Lieberman: regularity theory for elliptic and parabolic equations
Peters: Functional Analysis, Operator Algebras
Poon: Matrix Analysis, Operator Theory, Operator Algebras, Mathematics Education
Tidriri: Applied Math, Mathematical Modeling
Weber: frames, both the theory and applications, with a special emphasis on wavelet frames

## 8.3 Applied Mathematics (CAM/Control)

Given the large size of this research group, as well as the extensive number of publications, invited talks, and grants, it is divided into two intersecting subgroups for a more coherent presentation. The first of these which might be described loosely as **Computational Applied Mathematics (CAM)**, currently includes *D. D'Alessandro, J. Evans, A. Gautesen, S. Hou, F. Keinert, H. Liu, G. Luecke, and J. Yan*. More explicitly, this subgroup covers a spectrum of efforts including high-performance computing, classic numerical analysis, computational PDE's, and modeling of a variety of complex physical systems. This subgroup suffered a significant reduction in numbers with the departure of M. Gunzburger and J. Peterson (to Florida State), and Q. Du (to Penn State) midway through the review period. The second of these subgroups, **Control Theory**, is more focused, and includes *D. D'Alessandro, S. Hansen, S. Hou, W. Kliemann* and formerly *O. Emanouilov* (who left for Colorado State only at the end of 2005, and thus was on the ISU math faculty for essentially the entire review period) and *M. Gunzburger* (who left for Florida State in 2002). It should be noted that D'Alessandro and Hou are included in both subgroups, so their publications, etc., are double-counted in the tabular summaries provided below. A number of faculty listed in the Applied Math Research Group are also listed in other Departmental Research Groups.

**Computational Applied Mathematics (CAM) Subgroup**

Below we provide a comprehensive assessment of the activities and accomplishments of this research subgroup. Some discussion of future directions is also included.

*Table 30. Composition of the Computational Applied Mathematics Subgroup.*

| Name | Rank | Joined ISU Math |
|---|---|---|
| Domenico D'Alessandro | Associate Professor | 1999 |
| Jim Evans | Full Professor | 1991 |
| Art Gautesen | Full Professor (phased retirement) | 1980 |
| Lisheng Steven Hou | Full Professor | 1997 |
| Fritz Keinert | Associate Professor | 1988 |
| Hailiang Liu | Professor | 2002 |
| Glenn Luecke | Full Professor | 1969 |
| Jue Yan | Assistant Professor | 2006 |

Statistics for the CAM subgroup are presented below in Tabular form. Data are provided for: publication output; external and internal grants and contracts; plenary, invited, and contributed talks; refereeing and reviewing activity; supervision of graduate students and postdocs; and teaching duties. Almost all statistics presented are for activities which took place in the review period 1999-present while individuals were on the ISU faculty. All grants and contracts which are listed overlap with this review period.

**Publications:** As can be seen from Table 31, over the review period 1999-present, the CAM subgroup has generated a very substantial output of 139 journal publications, 39 conference proceedings articles, 9 book chapters, and 3 books or major review articles. Of these 53% are mathematics publications, and 47% are interdisciplinary (the majority of publications by Evans, Gautesen, and Luecke and being in the latter category).

***Table 31.*** *Publication record for the Computational Applied Mathematics subgroup.*

| | **Mathematics Publications** | | | | **Interdisciplinary Publications** | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Journal | conf proc | book chapter | book/ review | Journal | Conf proc | Book chapter | Book / review |
| 1999 | 3 | 1 | 0 | 0 | 7 | 0 | 1 | 0 |
| 2000 | 5 | 4 | 3 | 0 | 9 | 3 | 0 | 0 |
| 2001 | 15 | 5 | 0 | 0 | 7 | 0 | 0 | 0 |
| 2002 | 9 | 3 | 0 | 1 | 12 | 2 | 0 | 0 |
| 2003 | 12 | 3 | 2 | 1 | 8 | 3 | 0 | 0 |
| 2004 | 5 | 1 | 1 | 0 | 6 | 0 | 1 | 0 |
| 2005 | 10 | 1 | 0 | 0 | 10 | 3 | 1 | 0 |
| 2006- | 10 | 3 | 0 | 0 | 11 | 0 | 0 | 1 |
| **Total** | **69** | **18** | **6** | **2** | **70** | **11** | **3** | **1** |

**External Basic Research Grants from Federal Agencies**: Table AM3 details the funding obtained for basic research from premier federal funding agencies (NSF, DOE, DOD). Two key factors should be emphasized. *First*, the majority of these grants with a total funding of $ 7.2 million have a math faculty member as **sole- or lead-PI** (i.e., the research effort is directed by a math PI). *Second*, partly reflecting the first point, a substantial fraction of the total funding is directed to the research efforts of the math PI's. This large amount for math PI research, i.e., $ 2.2 million, provides the most appropriate measure of success in obtaining funding as it impacts the Mathematics Department.

*Table 32. Summary of external funding for basic research from NSF, DOE and DOD.*

| Years | Agency (NSF etc) | Sole-, lead-, or co-PI | TOT grant amount | math PI amount |
|---|---|---|---|---|
| 1997-2001 | NSF-CHE | Evans (lead-PI) | 550,000 | 260,000 |
| 1999-2004 | DOE-ChemPhys | Evans (sole-PI) | 480,000 | 480,000 |
| 2000-2005 | NSF-CHE | Evans (lead-PI) | 556,000 | 260,000 |
| 2000-2004 | NSF-EE(SGI) | Evans (co-PI) | 1,070,000 | 228,000 |
| 2001-2004 | NSF-DMS | Liu (co-PI) | 134,000 | 77,000 |
| 2001-2003 | DOE-SciDAC | Evans (co-PI) | 500,000 | 120,000 |
| 2003-2006 | NSF-CAREER | D'Alessandro (sole-PI) | 600,000 | 600,000 |
| 2003-2006 | DOE-Catalysis | Evans (co-PI) | 1,800,000 | 45,000 |
| 2004-2007 | DOE-ChemPhys | Evans (lead-PI) | 990,000 | 420,000 |
| 2004-2007 | DOE-MatSci | Evans (co-PI) | 840,000 | 90,000 |
| 2004-2007 | NSF-CHE | Evans (lead-PI) | 540,000 | 270,000 |
| 2005-2008 | NSF-DMS | Liu (sole-PI) | 67,000 | 67,000 |
| 2005-2006 | DOE-AmesLab | Liu (sole-PI) | 12,000 | 12,000 |
| 2006-2009 | DOE-SciDAC | Evans (co-PI) | 720,000 | 135,000 |
| **Grand Tot** | | | **$ 7.21 million** | **$ 2.22 million** |

**Internal (ISU) Grants for Research and Education**

Table 33 details funding from internal ISU institutes and programs for research and education.

*Table 33. Summary of internal funding for research and education.*

| Years | ISU Institute | Sole-, lead-, or co-PI | Tot grant amount | math PI amount |
|---|---|---|---|---|
| 2000 | LAS Research Init. | D'Alessandro (solePI) | | |
| 2001 | ISU Nanotech | D'Alessandro (co-PI) | | |
| 2001-03 | Cr. Acad. Transf | Keinert (co-PI) | 200,000 | ~80,000 |
| 2003-05 | Plant Sci. Inst. | Liu (co-PI) | 52,000 | 26,000 |

**External Contracts from Government and Industry:** The CAM subgroup has major support from industry, primarily due to G. Luecke's research in performance evaluation of high performance computers and related studies. See Table 34.

*Table 34: Summary of external contract funding from government and industry.*

| Years | Funding source | Sole-, lead-, or co-PI | Tot grant amount | math PI amount |
|---|---|---|---|---|
| 1999-2006 | Cray Inc. | Luecke (co-PI) | 1,900,000 | 1,900,000 |
| 1999 | NIST/IMTC | Hou (sole-PI) | 15,000 | 15,000 |
| 1999 | USDA Y2K | Hou (co-PI) | 60,000 | 20,000 |
| 2000-2001 | USDA Y2K | Hou (co-PI) | 30,000 | 30,000 |
| 2000-2002 | NIST/IMEP | Hou (sole-PI) | 20,000 | 20,000 |
| 2001-2004 | Sun Microsystem | Luecke (sole-PI) | 135,000 | 135,000 |
| 2004-2007 | DOD | Luecke (sole-PI) | 720,000 | 720,000 |
| **Grand tot.** | | | **$ 2.88 million** | **$ 2.84 million** |

**Presentations**: In the listing in Table 35 below, we separate plenary and invited talks from contributed talks due to the much greater significance of the former. We use the operating definition that a plenary talk is an invited talk at a meeting which is not given in parallel with other talks or sessions. We also distinguish presentations at other universities from those at ISU, given the greater significance of the former.

*Table 35. Summary of research presentations.*

| | National/International Meetings | | | Other Universities | Regional Meetings | ISU |
|---|---|---|---|---|---|---|
| Year | Plenary | Invited | Contributed | Invited | Talks | Colloquia |
| 1999 | 1 | 5 | 2 | 3 | 0 | 2 |
| 2000 | 4 | 7 | 5 | 7 | 2 | 0 |
| 2001 | 5 | 5 | 3 | 6 | 1 | 2 |
| 2002 | 3 | 8 | 3 | 16 | 0 | 1 |
| 2003 | 2 | 7 | 3 | 9 | 0 | 1 |
| 2004 | 1 | 12 | 5 | 16 | 0 | 2 |
| 2005 | 7 | 6 | 4 | 17 | 0 | 4 |
| 2006 | 1 | 9 | 4 | 13 | 0 | 4 |
| **Totals** | **24** | **59** | **29** | **87** | **3** | **16** |

**Professional activities**. The following summarizes professional activities and honors.

**Awards, Honors, Offices held 1999-**

D. D'Alessandro, ISU Foundation Award for Early Research Achievement 2004
Axelby Outstanding Paper Award IEEE Control 1998-99

J.W. Evans, Fellow of the American Physical Society 2002-
ISU Liberal Arts & Sciences Mid-Career Research Award 2005

H. Liu, Dio Lewis Doll Chair in Applied Math at ISU 2002
Sorgenfrey Distinguished Teaching Award UCLA 2002

G. Luecke, Treasurer of Parallel Tools Consortium 2000-2004

**Editorships of journals, book series, conference proceedings**

J.W. Evans, Co-editor of MRS Symp. Proceedings in 2000-1, 2001-2, 2004-5

S. Hou, Assoc Editor SIAM J. Numerical Analysis 2002-

**Conference and workshop organization, special panel participation 1999-**

D. D'Alessandro, Organizer/Chair United Session Decision & Control Conf. 2001
Chair or Co-Chair of several other sessions

J.W. Evans, Co-organizer Spring Materials Research Soc (MRS) Symp. 2000

Co-organizer Fall MRS Symp. (Stat Mech in Materials) 2001
Co-organizer March Amer. Phys. Soc. Focus Session 2003
Lead Organizer Fall MRS Symp. (Morphological Evolution) 2004
Co-organizer ISU Workshop on Comp. PDE's 2005
Member DOE H-Initiative Panel Review (on Nano-catalysis) 2006
Co-Chair ISU-IMA Workshop: Math of Materials & Fluids 2007

H. Liu, Chair/Org. Int. Conf. on Evolution Equations Kaifeng China 2002
Organizer Iowa PDE/Applied Math Seminar 2002
Organizer U. Maryland CSCAMM Analysis/Modeling Mtg 2003
Organizer 2nd MIT Conf. Comp. Fluids & Solids session 2003
Organizer Mini-Symp. SIAM Conf. PDE 2004
Co-Chair/Main organizer ISU Workshop on Comp. PDE 2005
Co-Chair ISU-IMA Workshop on Math of Materials/Fluids 2007

G. Luecke, Member SUN Microsystems Tech Advisory Committee 2000
Program Chair: Parallel Tools Conference in San Diego 2001
Tech program for IEEE Int. Conf. Cluster Comp. Brisbane 2001
Member tutorials committee for Supercomputing 2001
Program Committee EuroPar 2001, Manchester
Tech Prog for IEEE Int. Conf. Cluster Comp. Newport Beach 2001
Member tutorials committee for Supercomputing 2002
Chair local arrangements Parallel Tools Conf Knoxville 2002
Member Technical Program Supercomputing 2006

**Number by year (1999-) for papers refereed, proposals refereed, reviews written.**

***Table 26.*** *Service in refereeing papers and proposals, and in writing reviews.*

| Year | Papers refereed | Proposals refereed | Reviews written |
|---|---|---|---|
| 1999 | 39 | 3 | 11 |
| 2000 | 32 | 2 | 13 |
| 2001 | 48 | 3 | 14 |
| 2002 | 55 | 5 | 10 |
| 2003 | 59 | 3 | 7 |
| 2004 | 65 | 1 | 7 |
| 2005 | 93 | 12 | 8 |
| 2006 | 90 | 4 | 7 |
| **Total** | **481** | **33** | 77 |

**Individual descriptions of research area and accomplishments**.

**Domenico D'Alessandro**. Nonlinear and geometric control. Application to control of quantum systems overlapping quantum information theory and quantum mechanics. Key results in controllability and observability, and methods to obtain decompositions of quantum dynamics. Contract for book on Quantum Control. 42 publications and 10 invited talks since 1999.

**Jim Evans**. Non-equilibrium statistical mechanics. Especially atomistic, continuum, and multi-scale modeling of far-from-equilibrium surface processes. Developed predictive atomistic and multi-scale modeling for thin film growth and relaxation [Surf. Sci. Rep. 61 (2006) 1]. Developed realistic atomistic models for surface reactions including heterogeneous multi-scale techniques for spatiotemporal behavior. 68 publications, 24 plenary and 27 invited talks since 1999. Web of Science lists >560 citations to papers since 1999, and >3500 citations since 1990.

**Art Gautesen**. Scattering of waves in elastic media. Solved class problem of scattering of Rayleigh wave from wedge. Working on scattering by small angle wedges, cracks at the interface of two anistropic media, detection of poorly mixed nanotubes in smart materials. 10 publications and 2 invited talks since 1999.

**Steven Hou**. Numerical analysis for PDE's. Optimal control for nonlinear PDE's. Control of fluids and CFD. Numerical methods in finance. 16 publications and 4 invited talks since 1999.

**Fritz Keinert**. Numerical analysis; Wavelets. 6 publications and 7 invited talks since 1999.

**Hailiang Liu**. Computational methods and analysis for applied partial differential equations. Level-set methods for high frequency waves; kinetic theory of polymers; critical thresholds in non-linear balance laws; multiscale wave dynamics; hyperbolic balance laws; genetic networks and their evolution. 22 publications and 25 invited talks since 1999. MatSciNet lists 103 citations by 83 authors for publications in years from 1997.

**Glenn Luecke**. Performance evaluation of high performance computers; parallel computing; mathematics and high performance computing; parallel linear algebra, parallel algorithms, tools for high performance computing. 12 publications and 16 invited talks since 1999.

**Jue Yan**. Computational Applied Mathematics. Computational Methods for PDE's. Level set methods. 4 papers and 6 invited talks since 1999.

**Interdisciplinary collaborations, leadership roles, support of research personnel**

Some members of this group play a leadership role in major interdisciplinary research programs. These address fundamental problems at the forefront of quantum information theory and control, engineering science, fluid mechanics, polymer science and materials science, thin film growth, surface-based nanoscience, surface chemistry and catalysis, and statistical mechanics. This is evidenced by substantial funding often as sole- or lead-PI on interdisciplinary efforts.

D. D'Alessandro obtained an ISU Nanotechnology grant to work with faculty members in the Physics and ECPRE on magnetic spin systems. He was a Visiting Professor at the Institute of Quantum Electronics and Quantum Photonics Group at ETH-Zurich. His NSF CAREER grant has supported 2 postdocs to work on his research.

J.W. Evans is lead-PI of an internationally-recognized thin film research project (NSF-funded) collaborating with surface chemistry/materials science faculty at ISU and guiding experimental grad students on the project from these departments. He is lead-PI in the Ames Lab USDOE Chemical Physics program, and co-PI on an Ames Lab USDOE Scientific Computing for Advanced Discovery (SCIDAC) grant collaborating with quantum chemistry faculty at ISU and their students. He is co-PI on an Ames Lab USDOE Catalysis grant collaborating with inorganic chemistry faculty at ISU. He is co-PI on a DOE Comp. Materials Science Network (CMSN) grant collaborating with Physics faculty at ISU and Materials Science faculty elsewhere. He leads a research group with one ISU/Ames Lab Staff Scientist, one or two postdocs, and one or two Ph.D. students from various departments fully supporting these personnel (cost 205-280 K/yr).

H. Liu has obtained an ISU Plant Sciences Institute Grant to support collaboration with ISU genetics faculty and also to support a postdoc on this project. He has a close connection with faculty in the ISU Computational Fluid Dynamics (CFD) center, and is expanding connections with faculty in various other ISU departments.

**International activities and collaborations**.

Several members of this group are active internationally at the highest level of scientific activities (i.e., leading internationally recognized research efforts, giving plenary and invited talks at international conferences outside of the US; giving invited talks and undertaking scientific visits at premier institutes around the world, collaborating on research publications with leading groups around the world). For example, during the review period 1999-present, the number of invited talks given outside the US by D'Alessandro is 4, by Evans is 27, by Liu is 9, and by Luecke is 4. D'Alessandro, Evans, and Liu have had extended scientific stays at foreign institutions.

**Educational responsibilities.**

Members of this research subgroup teach the usual variety of undergraduate courses. In addition, they are largely responsible for a number of graduate courses related to Numerical Methods. This includes the core courses on numerical analysis (Math 502-503); numerical solution of differential equations (Math 507), finite difference methods (Math 517), finite element methods (Math 666). They may be involved in teaching more analytic courses on Methods or Applied Math or Partial Differential Equations. They also offer other specialized courses such as Numerical Analysis of High Performance Computing (Math 525), Mathematical Modeling of Complex Physical Systems (Math 646). Liu also developed a course on Advanced Numerical Methods (Math 690N) and runs a "Focused Research Interaction" graduate student seminar in computational applied math (Math 610). Offerings related to computational applied math or numerical analysis and related PDE courses have were developed at different times over many years. It may be appropriate to give some consideration to whether these offerings provide the optimum coherent collection of courses to train graduate students to tackle the numerous emerging problems in computational applied mathematics.

Numbers of graduate students (M.Sc., Ph.D) and postdocs supervised during 1999-present (both completed and current) are listed in Table 37. Given the size and level of output of the computational applied math group, this is a fairly small number of grad students (noting some are from other departments). Research programs in this research subgroup would be enhanced by access to more high quality graduate students, and this would also facilitate the retention of high-caliber faculty in this area. Members of this research group also serve on numerous POS committees for students inside and especially outside the math department in a range of other departments including physics, chemistry, and various engineering departments (~40 for Evans, ~15 for Keinert, ~10 for Luecke, ~5 for Liu, etc.) Some of these Ph.D students and postdocs have gone on to successful careers in high-level research.

***Table 37**. Graduate student and postdoc supervision.*

| | MSc students | | PhD students | | Postdocs | |
|---|---|---|---|---|---|---|
| | completed | current | completed | current | completed | current |
| 1999-2006 | 16 | 1 | 5 | 8 | 7 | 3 |

*Includes students with majors in other departments.

**Future plans**.

There continues to be tremendous impetus in development and funding of computational applied math which is oriented towards solution on problems of real interdisciplinary interest in physical and engineering sciences (a recent example being the DOE Applied Mathematical Sciences Initiative on Multiscale Modeling). The current CAM group has a core of very high profile research with extensive funding. Expansion in this area might be

considered given the recent loss of faculty (Gunzburger, Petersen, Du), and given the compatibility of this direction with the goals and mission of ISU. Another avenue towards enhancing the program by attracting more high-caliber graduate students could be the formation of a separate research-oriented graduate program in Computational Applied Mathematics, plausibly with involvement of selected premier faculty in computational sciences from outside the mathematics department.

## 8.4 Control Theory Subgroup

During the time period 1999-2006, the Department had six faculty members working in the area of control theory. Two of these (Max Gunzburger and Oleg Emanouilov) are no longer with ISU, having accepted other academic positions. A short description of each follows:

**Domenico D'Alessandro:** Assistant Prof. 1999-2004, Associate Prof. 2004-present. Areas of research: Control of Quantum Dynamical Systems, Mathematical Modeling of Quantum Systems

**Oleg Emanouilov:** Assistant Prof. 1999-2004, Associate Prof. 2004-2006. Areas of research: Optimal Control Theory, Inverse Problems, Partial Differential Equations. Prof. Emanouilov resigned from ISU in 2006 to accept a position with Colorado State University

**Max Gunzburger:** Full Professor and Department Chair: 1999-2002. Areas of research: Optimal Control of PDE's, Scientific Computing, Computational Fluid Dynamics, Numerical Analysis of PDE's. Prof. Gunzburger resigned in 2002 to accept a position with Florida State University

**Scott Hansen:** Assistant Prof: 1992-1997, Associate Prof. 1997- present. Areas of Research: Distributed Parameter Control Theory, Mathematical Modeling of Elastic Systems

**L. Steven Hou:** Associate Prof 1997-2000, Full Prof. 2000- present. Areas of Research: Optimal Control of PDE, Numerical Analysis of PDE, Computational Fluid Dynamics

**Wolfgang Kliemann:** Full Professor 1992-present, Associate Department Chair 1999, Associate Dean, College of Liberal Arts and Science 2000-2001, Associate Vice Provost for Research 2001-2005; Areas of research: Deterministic and stochastic nonlinear systems theory, in particular dynamical systems, skew product flows, stochastic systems, control systems and their interconnections, with applications in engineering and the natural sciences.

*Table 38.*

| Name | Rank | Period with ISU |
|---|---|---|
| D. D'Alessandro | Associate | 1999-present |
| O. Emanouilov | Associate | 1999-2006 |
| M. Gunzburger | Full | 1995-2002 |
| S. Hansen | Associate | 1993-present |
| L. S. Hou | Full | 1997-present |
| W. Kliemann | Full | 1983-present |

The following paragraphs summarize some of the research activities of the Control Theory subgroup, including publication record, external funding, presentations, refereeing and reviewing, supervision of graduate students, and teaching duties. All Control Theory subgroup table data refers to faculty in the Control Theory subgroup who were with Iowa State University essentially over the entire review period 1999-2006, i.e., excluding Max Gunzburger. The contributions of Max Gunzburger are outlined separately as only the years 1999- 2002 are relevant in his case.

**Publications**

The Control Theory subgroup produced 76 journal papers and 126 total publications over the review period, or a bit more than 3 publications per person each year.
In addition, Max Gunzburger produced 30 journal papers and 11 conference proceeding papers from 1999 to 2000. A statistical summary of the publications activities of the Control Theory Subgroup (excluding Gunzburger) are described in Table xxx.

*Table 39.*

| Year | Journal | conf proc | book chapter | book/ review | Annual Totals |
|---|---|---|---|---|---|
| 1999 | 5 | 3 | 2 | | 10 |
| 2000 | 8 | 8 | 3 | | 19 |
| 2001 | 8 | 6 | 1 | | 15 |
| 2002 | 13 | 4 | 0 | | 17 |
| 2003 | 13 | 3 | 5 | | 21 |
| 2004 | 6 | 2 | 1 | 1 | 10 |
| 2005 | 12 | 4 | 2 | | 18 |
| 2006 | 11 | 5 | 0 | | 16 |
| **Totals** | **76** | **35** | **14** | **1** | **126** |

**External Funding**

During the period 1999-2006 the control subgroup (excluding Gunzburger) received nine grants or government contracts worth $2,809,000 with Control Subgroup members listed as PI's or co-PI's. W. Kliemann's $1,481,000 DOD grant involved collaboration with ISU engineering faculty. Otherwise, all grants listed went primarily to for support of Control Subgroup members, postdocs and graduate students in the ISU math department. The total estimated amount going to math group members or the math department of this

total amount is $1,299,000. (Some of this total involves grant periods outside of the review period 1999-2006.)

S. Hansen and O. Emanouilov were collaborators on their NSF grant at the total counts that contribution once.

*Table 40. External funding overlapping review period 1999-present*

| Years | Agency (NSF etc) | Sole-,lead-, co-PI | Tot grant amount | Amount to PI/department |
|---|---|---|---|---|
| 1996-2000 | NSF (DMS) | sole-PI (Hansen) | 48,000 | 48,000 |
| 1998-1999 | ONR | lead-PI (Klieman) | 654,000 | 500,000 (est) |
| 1999-2003 | EPRI, DOD | co-PI (Kliemann) | 1,481,000 | 185,000 |
| 1999 | NIST/IMTC | sole-PI (Hou) | 15,000 | 15,000 |
| 1999-2001 | USDA (Y2K) | sole-PI (Hou) | 90,000 | 30,000 (est) |
| 2000-2002 | NIST/IMEP | sole-PI (Hou) | 20,000 | 20,000 |
| 2002-2006 | NSF (DMS) | lead-PI (Hansen) | 101,000 | 101,000 |
| 2002-2006 | NSF (DMS) | co-PI (Emanouilov) | 101,000* | 101,000* |
| 2003-present | NSF (Career) | sole-PI (D'Alessandro) | 400,000 | 400,000 |
| **Totals** | | | **2,809,000** | **1,299,000** |

Not included in the above are several smaller travel grants, conference support grants of several subgroup members totaling about 30K, and Gunzburger's grants and contracts outlined below.

*Table 41. Gunzburger's external funding overlapping review period 1999-2002*

| Years | Agency (NSF etc) | Sole-,lead-, co-PI | Amount to PI/Dept. |
|---|---|---|---|
| 1995-2000 | AFOSR, DOD | co-PI | 460,000 (est) |
| 2001 | Sandia Contract | sole-PI | 30,000 |
| 1999-2002 | NSF | sole-PI | 19,000 |
| 1998-2002 | NSF | sole-PI | 83,000 |
| 2000-2003 | NSF | co-PI | 200,000 (est) |
| 2001 | NIST (MEP) | co-PI | 35,000 |
| 1999-2000 | NIST (Y2K) | lead-PI | 153,000 |
| 2000 | USDA (Y2K) | co-PI | 50,000 |
| **Totals** | | | **1,030,000** |

**Presentations**

Members of the Control Subgroup give about 15 talks each year at national, international, regional meetings, outside colloquia and seminars. Table 42 contains summary statistics of these lectures. The category “Colloquia/Seminars” refers to presentations outside of ISU. In addition to the below data, Gunzburger's CV lists 9 plenary talks from 1999 to 2002, and over 20 other invited talks at other universities and conferences.

*Table 42.*

| Year | National/International Meetings | | | Other Universities Colloquia/ Seminar | Regional Meetings |
|---|---|---|---|---|---|
| | Plenary | Invited | Contributed | | Talks |
| 1999 | 1 | 5 | 1 | 7 | |
| 2000 | 1 | 7 | 2 | 3 | 1 |
| 2001 | | 6 | 6 | 9 | 1 |
| 2002 | | 4 | 5 | 8 | |
| 2003 | 1 | 8 | 1 | 3 | |
| 2004 | | 3 | | 9 | 2 |
| 2005 | | 7 | 1 | 1 | 2 |
| 2006 | | 6 | 2 | 5 | 1 |
| **TOTALS** | **3** | **46** | **18** | **45** | **7** |

**Refereeing and reviewing**

All group members regularly referee journal submissions and grant proposals. The numbers in the table below contains total papers and proposals refereed/ reviewed, as best estimated by Control Subgroup members. Data for Gunzburger is unavailable and not included. The data show that over the review period, Control Theory subgroup members averaged 6 reviews per year, with a closer to 8 per year in recent years.

*Table 43. Refereeing of papers and proposals*

| Year | Papers refereed | Proposals refereed |
|---|---|---|
| 1999 | 20 | 2 |
| 2000 | 21 | 0 |
| 2001 | 24 | 2 |
| 2002 | 22 | 0 |
| 2003 | 28 | 1 |
| 2004 | 44 | 0 |
| 2005 | 42 | 1 |
| 2006 | 37 | 2 |
| **TOTALS** | **238** | **8** |

**Professional Activities**

**Awards, Honors, Offices held**

- W. Kliemann received recognition for excellence in teaching by being awarded the Iowa State University College of Liberal Arts and Sciences Master Teacher Award, 1999.
- D'Alessandro received a prestigious NSF career award in 2003.
- D. D'Alessandro received an ISU Foundation Award for Early Achievement in Research in 2004
- M. Gunzburger was awarded University Distinguished Professor status in 2001.

- O. Emanouilov gave an invited lecture at the ICM (Madrid, July 2006) on his recent research, 2006.

**Editorships of journals, book series, conference proceedings**

- Emanouilov, O – Associate editor SIAM J. Control 2004 –
- Emanouilov, O – Associate editor ESAIM (COCV) 2004 –
- Gunzburger, M – Editor in Chief, SIAM J. Numerical Analysis
- Gunzburger, M – Editorial board, SIAM J Control
- Gunzburger, M – Editorial board, Int. J. Comp Fluid Dynam.
- Gunzburger, M – Editorial board, SIAM book series: Advances in Design & Control
- Hansen, S – Associate editor, Systems and Control Letters, 1999-2004
- Hou, L. S. – Associate editor, SIAM J. Numerical Analysis, 2002 –
- Kliemann, W – Advisory editor of Birkhauser book series 'Modeling and Simulation in Science, Engineering and Technology', 1996 – 2000, 2002 -
- Kliemann, W – Comite Editorial 'Proyecciones, Revista de Matematica', 1997 -- Comite Editorial 'Ars Dilemmae Mathematicae', 1997 – 2002
- Kliemann, W – Associate Editor 'Revista Boliviana de Matematica', 2002 –
- Kliemann, W – Editorial Board of 'Boletim da Sociedade Paranaense de Matematica', 2003 -

**Conference and workshop organization**

- Gunzburger, M. - Co-Organizer of 4 conferences, 3 minisymposiums,
- Hansen, S. - Co-Organizer for 1 Minisymposium, 1 Scientific Committee, 1 organizational committee for series of conferences
- Hou, L.S. - Co-Organizer of 2 minisymposiums
- Kliemann, W. - Co-organizer of 3 conferences, one series of conferences, Scientific Committee for 5 conferences from 1999 to 2006 and Member of NSF Review Panel Probability 2000 (December 1999).

**Individual Statement on research and accomplishments:**

Domenico D'Alessandro: (See summary in Group Report)

Max Gunzburger: 41 publications, 9 plenary talks, over 20 invited talks from 1999 to 2002.

Gunzburger's research over the review period touched on a number of topics: Flow Control, Least-Squares Finite Element methods, Superconductivity, and Domain Decomposition methods.

Scott Hansen: 13 publications, 2 NSF grants, 21 invited talks, 1 plenary talk since 1999.

Much of Hansen's research over this period has involved modeling and analysis of layered elastic systems, particularly with shear or interlayer damping. More recent publications consider controllability issues for such systems. This work provides a more rigorous mathematical framework from which composite structures that occur frequently in engineering can be studied.

L. Steven Hou: ( See summary in Group Report)

Wolfgang Kliemann. 25 publications and 28 invited talks since 1999 in mathematics, not including administrative publications and presentations.

Although W. Kliemann had full time administrative duties from 2000-2005, nevertheless has had very successful interdisciplinary collaborations. Together with A. Fouad (Electrical Engineering, Member NAE, now retired) and V. Vittal (Electrical Engineering, Member NAE, now at Arizona State University) W. Kliemann developed the normal form approach to analysis and design of power systems with support from NSF, EPRI and DoD. This approach, which was termed 'one of the two or three most important developments in electric power systems of the 20$^{th}$ century' by EPRI, is now making its way into the power industry in the US. W. Kliemann, who is a member of the Graduate Faculty in the Department of Statistics at ISU, collaborates with colleagues from statistics on analysis of nonlinear models, including optimization of recursive systems, statistics on compact manifolds, and memory structures in financial time series.

**Grad students and postdocs supervised 1999-present**

The table below describes the number or graduate students and postdocs supervised by Control Subgroup members. (Here we include Gunzburger's 2 Ph.D students and 2 M.S. students supervised at ISU.)

Table 44. Graduate Students Supervised by Control Theory Subgroup Members

| | M.Sc. students | | Ph.D. students | | Postdocs | |
|---|---|---|---|---|---|---|
| | completed | current | completed | current | completed | current |
| 1999-2006 | 10 | 1 | 11 | 4 | 4 | |

In addition to supervision of graduate students, most committee members serve on numerous
POS Committees for graduate students both in and outside of mathematics.

**Educational responsibilities**

Generally, Control Theory subgroup members teach both between 3 or 4 courses each year. This excludes M. Gunzburger (1999-2002) and W. Kliemann (2000-2005) who had full time administrative duties. Control Theory subgroup members taught a variety of classes at both the graduate level. Some of the particular graduate courses taught by

subgroup members are Numerical Analysis core classes (Math 502-503); Complex Analysis (Math 511); Finite Differences (Math 517); Applied Mathematical Methods (Math 519-520); Optimal Control (Math 574); Partial Differential Equations (Math 655-656); Finite Element Methods (Math 666); Dynamical Systems (Math 658).

**Looking Forward**

The loss of Gunzburger and, more recently, Emanouilov were substantial setbacks to the department and more directly to the Control Theory group, particularly in connection to distributed control (control theory of PDE). We hope that every effort will be made to rebuild in this area. Nevertheless, the remaining Control Theory subgroup members maintain strong research programs and all indications are that this will remain to be the case.

## 8.5 Differential Equations

Research group for differential equations: Boushaba, Dahiya, Lieberman, Levine, Liu, Sacks, Smiley, Su

The differential Equations group consists of 8 individuals indicated in the following table.

*Table 45. Composition of the Differential Equations group*

| Name | Rank | At ISU since |
|---|---|---|
| Khalid Boushaba | Assistant | 2003 |
| Rajbir Dahiya | Full | 1968 |
| Gary Lieberman | Full | 1979 |
| Howard Levine | Full | 1978 |
| Hailiang Liu | Associate | 2002 |
| Paul Sacks | Full | 1981 |
| Michael Smiley | Full | 1980 |
| Bo Su | Assistant | 2004 |

**Summary statistics**

We now provide below a summary of the basic statistics for the group, including publication record, contracts and grants, invited talks, refereeing and reviewing, supervision of graduate students, and teaching duties.

*Table 46. Publication statistics for the Differential Equations group*

| | Mathematics Publications | | | | Interdisciplinary Publications | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Journal | conf proc | book chapter | book/ review | Journal | Conf proc | Book chapter | Book / review |
| 1999 | 5 | | | | | 1 | | 1 |
| 2000 | 18 | 1 | | | 1 | 1 | | |
| 2001 | 23 | 3 | | | | | | |
| 2002 | 5 | 2 | 1 | 1 | 1 | | | |
| 2003 | 15 | 3 | 1 | | | | | 1 |
| 2004 | 12 | 2 | | | 2 | | | 1 |
| 2005 | 3 | 2 | 1 | | 2 | | | |
| 2006 | 10 | 1 | 1 | | 3 | | | |

*Table 47. External funding statistics for the Differential Equations group.*

| Group Member | Years | Agency (NSF etc) | Sole-,lead-, co-PI | Tot grant amount | Amount to you |
|---|---|---|---|---|---|
| Howard Levine | 2004-2005<br>2004-2008<br>1998-2001 | NIH<br>NIH-NIGMS<br>NSF | Co-PI<br>Co-PI<br>PI | $100, 000<br>$1.6M<br>$140,000 | |
| Hailiang Liu | 2001-2004 | NSF | Co-PI | $134,464.00 | 50% |
| | 2002 | NSF | PI | $2,000.00 | Travel funds |
| | 2003<br>2003-2005 | NSF<br>Plant Science Institute | Sole-PI<br>Co-PI | $2,500.00<br>$52,000.00 | Travel funds<br>50% |
| | 2004 | ISU | Sole-PI | | Travel award |
| | 2005-2006<br>2005-2008<br>2006 | Ames Lab(DOE)<br>NSF<br>IMA | Sole-PI<br>Sole-PI<br>PI | $12,000.00<br>$66,576.00<br>$5000.00 | Collaborative 100%<br>Conference funds |
| Paul Sacks | 2001 | MSRI | | $7196 | Living Expenses |
| | 2002-2003 | NSF | Co-PI | $8000 | Conference funds |
| | 2002-2003 | IMA | Co-PI | $3000 | Conference Funds |
| Michael Smiley | 2004-2008 | NIH | Co-PI | $1,175,009 | 4 months + equipment (ask Jan) |
| Bo Su | 2004-2007 | NSF | PI(Sole) | $103,129 | |

*Table 48. Presentation statistics for the Differential Equations group.*

| | National/International Meetings | | | Other Universities | Regional Meetings | At ISU |
|---|---|---|---|---|---|---|
| Year | Plenary | Invited | Contributed | Invited | talks | colloquia |
| 1999 | | 1 | 3 | 2 | | |
| 2000 | | 5 | 2 | 2 | 1 | |
| 2001 | | 4 | 3 | 4 | 1 | |
| 2002 | 2 | 12 | 2 | 11 | | 1 |
| 2003 | 3 | 7 | 2 | 11 | | |
| 2004 | 4 | 10 | | 18 | 1 | 1 |
| 2005 | 5 | 7 | | 14 | 6 | |
| 2006 | 1 | 5 | 1 | 11 | 1 | 1 |

*Table 49. Refereeing and reviewing statistics for the Differential Equations group.*

| Year | Papers refereed | Proposals refereed | Reviews written |
|---|---|---|---|
| 1999 | 21 | 3 | 16 |
| 2000 | 20 | 3 | 24 |
| 2001 | 15 | 2 | 21 |
| 2002 | 21 | 2 | 30 |
| 2003 | 37 | 3 | 21 |
| 2004 | 36 | 12 | 20 |
| 2005 | 50 | 0 | 14 |
| 2006 | 40 | 0 | 11 |

*Table 50. M.S. and Ph.D. students in Differential Equations group.*

| | **M.Sc. students** | | **Ph.D. students** | | **post-docs** | |
|---|---|---|---|---|---|---|
| | completed | current | completed | current | completed | current |
| 1999-2006 | 9 | 1 | 2 | 11 | 3 | |

**Research Accomplishments**

The research interests of members of the Differential Equations group span many of the important areas of nonlinear differential equations. Here is a brief description for each group member.

K. Boushaba: Professor Boushaba's research area is mathematical modeling of biological systems (such as tumor growth, metastasis…), with special emphasis on biological pathways, kinetics and spatial variability.

R. S. Dahiya: Professor Dahiya's research interests include Delay, Neutral and Advanced Differential Equations, Transform Theory.

G. Lieberman: Professor Liebermann's area of interest is regularity of solutions of elliptic and parabolic equations. Such equations model various physical and biological phenomena, and I study how smooth such solutions are. Since 1999, I have published 24 papers, given 20 invited talks, and (according to MathSciNet) been cited 574 times by 461 different authors since 1999.

Howard Levine: Professor Levine's major work in the last several years has been in mathematical biology. He is one of the 300 most highly cited mathematicians in the world according to the ISI web of Science. He works with Marit Nilsen Hamilton (biochemistry), Surrya Mallapragada, (ChE) and Don Sakaguchi (GDCB). He has a joint collaboration with Jeff Essner (GDCB) and Boushaba.

Hailiang Liu: Professor Liu's major work in last several years has been in computational methods and Analysis for applied partial differential equations. Since 1999 he has 33

publications and 25 invited talks. MathSciNet lists 103 Citations by 83 authors (for years from 1997)

Paul Sacks: Professor Sacks' research lies in Analysis and computational methods for inverse spectral and inverse scattering problems, and other inverse problems for ordinary and partial differential equations. Since 1999 he has 7 publications and 15 invited talks. MathSciNet lists 227 Citations by 193 authors (for all years -- those for 1999 onward cannot be isolated), Science Citation Index lists about 700 citations (again for all years)

Michael Smiley: For the past four years the main focus of Professor Smiley's research has been mathematical modeling and numerical simulation of cellular processes, including tumor angiogenesis and neuronal stem cell growth and differentiation. Collaborators in the research includes the following colleagues at ISU: Howard Levine (Mathematics), Marit Nilsen-Hamilton (Biophysics, Biochemistry, and Molecular Biology), Surya Mallapragada (Chemical and Biological Engineering), and Don Sakaguchi (Genetics, Development, and Cell Biology).

Joint work in progress strives to further the scientific understanding of how environmental cues promote cell differentiation, in which cells adopt specific cell fates. Mathematical models and experimental paradigms are being developed in parallel to achieve this goal.

In addition to regular undergraduate teaching duties, he is the coordinator of the differential equations courses, Math 266 and 267, and he serves as an advisor to approximately 25 of our mathematics majors.

B. Su: Professor Su's research interest is nonlinear PDEs and its application in mathematical biology, calculus of variations, free boundary problems, homogenizations, and fluid mechanics.

With collaborators, he has established the theory of discontinuous solutions of Hamilton-Jacobi equations-existence, uniqueness, and regularity, Rigorous analytical result in large global solutions in compressible Navier-Stokes equations, free boundary problems in conduction-convection problem. Major breakthrough in time-dependent Stefan-type problem by originally establishing co-dimension one Hausdorff measure estimate of interface and Holder continuity estimate of temperature. He is now working with Immunologist, statistician on campus on mathematical modeling of immune response to infectious disease in tissue; working with pharmacologist, mathematicians at Vanderbilt on signal transduction generated by Thrombin.

**Other professional activities**

Members of the group contribute to the larger mathematics community in a variety of ways. All the group members do a significant amount of refereeing of papers and proposals.

Levine serves on the editorial board of 6 journal, Lieberman serves on the editorial board of 2 journals and Sacks serves on the editorial board of two journals and was a co-editor of a special issue of Mathematical Methods in the Applied Sciences in 2004. Liu served as a co-chair of the ISU workshop held in November 2005, and a co-chair of the IMA participating workshop to be held at ISU in Spring 2007, as well as a chairman of the international conference on evolution equation held in China, 2002. Liu also has organized special sessions at three national or international meetings. Sacks was chair of organizing committee for a conference held at ISU in 2002, and organizers or co-organizers of four workshops since 1999. Lieberman organized a special session at an international conference in Italy in 2002. Levine co-organized a workshop at the NSF funded institute: IPAM in 2001, and a chief local organizer of a workshop in 2006 at IPAM.

Sacks has been the Director of Mathematics and Applied Mathematics Graduate Program since 2005.

## 8.6 Discrete Mathematics

Discrete mathematics was not considered an independent research group at the time of the last self-study (1999). At that time, members of the group were considered to be part of the group in Algebra, Combinatorics and Logic. The development of the Discrete Math group is a result of fortuitous hiring as well as a redefinition of the research specialty of several members. There is still a good deal of overlap between the interests of this group and the group in Algebra and Logic.

*Table 51.*

| Name | Rank | At ISU since |
|---|---|---|
| Maria Axenovich | Associate | 1999 |
| Clifford Bergman | Full | 1982 |
| Alexander Burstein | Assistant | 2000 |
| Jennifer Davidson | Associate | 1989 |
| Leslie Hogben | Full | 1978 |
| Ling Long | Assistant | 2003 |
| Ryan Martin | Assistant | 2003 |
| Sung Yell Song | Associate | 1988 |

**Summary Statistics**
The discrete mathematics group has a very active research program and performs a moderate amount of professional service in the form of editing, refereeing and reviewing. This imbalance is to be expected since the group consists primarily of junior members (and one, Prof. Davidson, is half-time).

**Publications**
The following table provides raw numbers on the year-by-year activities of the group.

*Table 52.*

| | Mathematics | | | | Outside Mathematics | | | |
|---|---|---|---|---|---|---|---|---|
| | Books | Journals | Other | Reports | Books | Journals | Other | Reports |
| 1999 | 0 | 3 | 1 | 2 | 0 | 1 | 0 | 0 |
| 2000 | 0 | 6 | 1 | 0 | 0 | 0 | 2 | 0 |
| 2001 | 0 | 3 | 0 | 3 | 0 | 3 | 1 | 0 |
| 2002 | 0 | 9 | 1 | 3 | 0 | 0 | 0 | 0 |
| 2003 | 0 | 14 | 1 | 3 | 0 | 0 | 0 | 0 |
| 2004 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2005 | 0 | 12 | 2 | 0 | 0 | 0 | 4 | 2 |
| 2006 | 1 | 19 | 2 | 6 | 0 | 0 | 0 | 0 |

**External Funding**
The following table describes those funded research activities in which a group member was a principal or co-principal investigator. For multiyear grants, the amount is apportioned to each year.

*Table 53.*

| Year | Total Amount |
|---|---|
| 1999 | $229,707 |
| 2000 | $264,577 |
| 2001 | $983,213 |
| 2002 | $774,806 |
| 2003 | $656,507 |
| 2004 | $1,049,879 |
| 2005 | $309,373 |
| 2006 | $353,373 |

**Presentations**
The following table indicates the invited and contributed talks given by members of the discrete mathematics group.

*Table 54.*

| | National or International Meetings | | | | Talks at Regional Meetings | Colloquia and Seminars |
|---|---|---|---|---|---|---|
| | Plenary | Invited | Contributed | Posters | | |
| 1999 | 1 | 0 | 1 | 1 | 1 | 7 |
| 2000 | 0 | 7 | 4 | 0 | 2 | 10 |
| 2001 | 0 | 3 | 1 | 0 | 1 | 8 |
| 2002 | 0 | 4 | 4 | 1 | 2 | 11 |
| 2003 | 0 | 5 | 4 | 0 | 3 | 14 |
| 2004 | 0 | 2 | 6 | 0 | 4 | 18 |
| 2005 | 1 | 3 | 7 | 1 | 5 | 18 |
| 2006 | 1 | 7 | 7 | 3 | 3 | 19 |

*Refereeing and Reviewing*
The following table provides statistics on professional activities performed by the members of the group.

*Table 55.*

| | Refereeing | | | Reviewing | |
|---|---|---|---|---|---|
| | Books | Papers | Proposals | Books | Papers |
| 1999 | 0 | 15 | 0 | 0 | 5 |
| 2000 | 1 | 10 | 1 | 0 | 2 |
| 2001 | 0 | 16 | 0 | 0 | 5 |
| 2002 | 0 | 15 | 2 | 0 | 5 |
| 2003 | 0 | 15 | 0 | 0 | 8 |
| 2004 | 0 | 20 | 17 | 0 | 14 |
| 2005 | 0 | 25 | 0 | 0 | 23 |
| 2006 | 1 | 24 | 0 | 0 | 14 |

**Other Professional Activities**

Members of the group are active professionally in other ways. Some highlights:

- Alexander Burstein
  Conference organizer 2005
- Leslie Hogben
  Associate editor, Linear Algebra and its Applications
  Organizer of six conferences between 2002 and 2007
- Ryan Martin
  Moderator and webmaster for DM-Net (SIAM activity group on Discrete Math)
- Sung Y. Song
  Associate editor, Journal of Applied Mathematics and Computing
  Member of Mathematical Science Review Board for Korea Research Foundation
  Organizer of six conferences between 1999 and 2006

**Graduate Education**

Members of the group in Discrete Mathematics supervise numerous students working towards both M.S. and PhD. degrees. The following table summarizes this activity.

*Table 56.*

| M.S. Students | | M.S.M. Students | | Ph.D. Students | |
|---|---|---|---|---|---|
| Completed | Current | Completed | Current | Completed | Current |
| 14 | 4 | 5 | 1 | 7 | 7 |

The majority of our students have obtained the kind of job they sought after receiving their advanced degrees. The following table lists some of that data.

*Table 57.*

| Year of Degree | Name | Employment |
|---|---|---|
| 2006 | Kristin Meyer | Wisconsin Lutheran College (tenure-track) |
| 2005 | Mandi Maxwell | Trinity Christian College (tenure-track) |
| | Joohyung Kim | Univ. Wisconsin, Madison (postdoc) |
| | Amy Wangsness | Fitchburg State College (tenure-track) |
| 2002 | Joy Becker | Univ. Wisconsin, Stout (tenure-track) |

In addition to the students listed above, several students with degrees in Information Assurance are now employed at the National Security Agency (exact position unknown).

**Educational Responsibilities**

Members of the Discrete Math group contribute to the educational mission of the department in a variety of ways. In addition to the usual service courses, they have primary responsibility for the undergraduate courses in introductory combinatorics, graph theory and number theory and share responsibility for the linear and abstract algebra courses. For graduate students, the members offer courses in abstract and linear algebra, design theory, combinatorics, graph theory, universal algebra, cryptography and steganography. These latter two courses are cross-listed in the Department of Electrical and Computer Engineering, where they form part of the core curriculum in computer security. One member of the group (Hogben) also contributes to the department effort in school mathematics through her supervision of students in the MSM program.

**Summary of Research Interests**

**Maria Axenovich**. My main research areas are extremal and structural graph theory as well as extremal combinatorics in general. Specifically, I investigate the unavoidable structures in partitions of combinatorial objects, such as graphs, matrices, numbers, and others. In addition, I work on editing problems in graphs and other structures answering questions of how to modify a given structure to obtain a structure from a desired set. This has many applications in bioinformatics, especially in studying genetic networks. There is a number of other combinatorial problems I work on, for example, a problem of partitioning and packing graphs. This problem finds its applications in scheduling theory. My work also involved interdisciplinary research in physics investigating properties of molecular magnets.

**Clifford Bergman**. From 1999-2001, Bergman continued his collaboration with Giora Slutzki (ISU Computer Science) on the computational complexity of problems in algebra. Since 1999, Bergman has taught a graduate course in cryptography and has actively been doing research in that area. He has collaborated with Kristi Meyer (ISU Math grad student) on new work on message authentication codes, and has run seminars on stream ciphers and on electronic voting.
In collaboration with Jennifer Davidson (ISU Math), he has been working in steganography and steganalysis. Their recent work on this subject was funded by the

Midwest Forensics Resource Center and resulted in a software package that is being distributed to local law-enforcement agencies. This work has received local and national attention from the popular press.

**Jennifer Davidson**. My research is the application of mathematics and statistics to solving problems in image processing. Currently I am focusing on steganography, or data hiding in images, and the analysis of image data for stego content, steganalysis. Combining statistical properties of linear transformations with pattern recognition techniques (the artificial neural network), I have worked with designing a system that will distinguish between stego and nonstego images. I have also coded up such a system. (This is joint work with colleagues Cliff Bergman and Eric Bartlett). This involves understanding and manipulating the transform coefficients of linear transforms (discrete Cosine transform, discrete Fourier transform, the wavelet transform, and the singular value decomposition); understanding and manipulating statistical properties of transform coefficients for pattern classification; and the application of nonlinear pattern recognition techniques to solving these types of problems.

**Leslie Hogben**. Hogben used her Faculty Professional development assignment in fall 2003 to broaden her research program beyond matrix completions to include minimum rank/maximum eigenvalue of a graph or sign pattern, spectral graph theory, spectrally arbitrary patterns, etc. and to increase her research productivity (from 1-2 papers per year in 1999-2002 to 4 or more papers per year from 2005 on).

She regularly organizes conferences, workshops, and special sessions nationally and internationally, including a recent workshop at American Institute of Mathematics. Hogben edited Handbook of Linear Algebra, published by CRC Press. She has have served as an editor of a special issue of Linear Algebra and Its Applications and will be joining the editorial board of LAA as an associate editor on January 1.

In 2000 she founded the ISU Combinatorial Matrix Theory Research Group. This group, whose primary purpose is to teach graduate students to do research in combinatorial matrix theory, has also involved faculty members at non-doctoral institutions and summer REU students. Through 2006, this group has involved seven ISU mathematics graduate students, publishing six papers with an additional two submitted. She co-directs the REU program, including running the day-to-day operations, serves as a mentor to several undergraduates each summer.

**Ling Long**. Long is working on arithmetic geometry, modular forms, and related problems. She had worked on the Shioda-Inose structure on extremal K3 surfaces and its applications. In the past 3 years, She has been mainly working on the arithmetic properties of modular forms for noncongruence subgroups and the modularity of noncongruence cuspforms similar to the work of Andrew Wiles via which he proved the Fermat's last theorem. She and her collaborators have identified interesting new relations between noncongruence modular forms and classical congruence modular forms. She has several collaborators including A.O.L. Atkin who is famous for his pioneering work on

the theory of newforms as well as the theory of noncongruence modular forms; Wenching Winnie Li who is famous for her continuing work on the theory of newforms and her recent work on Ramanujan graphs; Yifan Yang at Taiwan and Zifeng Yang at Beijing China.

Long (with her colleagues) has also written one paper on discrete math and another interdisciplinary paper on sensor network distribution. Her work has been published some well-regarded journals such as J. Number Theory, Canad. Math. Bull., and J. Combin. Theory Ser. A.

**Ryan Martin.** My research spans a wide area of extremal combinatorics. The main part of which is in the field of extremal graph theory. My research features both random models of graphs and probabilistic techniques and often has direct applications, particularly to computer science. In particular, the determination of a sharp threshold for both the existence and size of an identifying code in a graph that is determined by random processes. I have co-founded of a number of areas of research. One is the so-called smoothed analysis of graphs, a powerful generalization of the classical model of the Erd's-Rényi random graph. In an early paper that I co-authored, there was a surprising result that has applications to sociology. With respect to the so-called small world problem, in a large population where no particular member is very unpopular and a there is a very small amount of randomness, the graph has diameter at most five. I have also begun the study, along with Prof. Axenovich, of the editing distance in graphs. We have two seminal papers on the subject which have already been cited by others, who have investigated the same question.

The techniques that I use to solve problems in extremal graph theory also include the so-called probabilistic method, a means by which probability theory can be used to answer questions about systems and structures that have no randomness. I also use techniques from optimization and operations research in order to solve extremal graph problems. Foremost, my expertise lies in applying Szemerédi's regularity lemma, a complex but powerful tool that has produced a number of striking results in graph theory.

**Sung Yell Song**. I study algebraic combinatorics, in particular, association schemes and their related topics, including combinatorial designs, distance-regular graphs, classical groups and geometries, permutation groups, and cryptology. My research is often focused on the characterization and classification problems of commutative association schemes and various combinatorial structures. I calculate the character tables of several classes of group-case primitive commutative association schemes. I investigate various products and compositions of association schemes and distance regular graphs, and fusion and fission of association schemes, posets attached to the classes of small association schemes. I am also interested in the existence and construction of various combinatorial structures including certain block designs in connection with survey sampling plans, a class of distance-regular graphs, and some topics related to cryptology. I try to develop algebraic techniques and use them to resolve certain characterization problems in the theory of association schemes.

## 8.7 Math Biology

The mathematical biology group is composed of 8 faculty members:

*Table 58.*

| Name | | Academic | Rank | At ISU since |
|---|---|---|---|---|
| Khalid | Boushaba | Assistant | Professor | 2003 |
| Howard | Levine | Distinguished | Professor | 1978 |
| Roger | Maddux | Full | Professor | 1977 |
| Michael | Smiley | Full | Professor | 1980 |
| Jonathan | Smith | Full | Professor | 1984 |
| Bo | Su | Assistant | Professor | 2004 |
| Stephen | Willson | Full | Professor | 1973 |
| Zhijun | Wu | Associate | Professor | 2000 |

A short description of individual research areas is given below.

**Khalid Boushaba.** Mathematical modeling of biological systems, such as tumor growth and metastasis, with special emphasis on biological pathways, kinetics and spatial variability. His collaborators include Howard Levine (ISU Mathematics), Marit Nilsen-Hamilton (ISU Biochemistry, Biophysics and Molecular Biology), and Jeff Essner (ISU Genetics, Development & Cell Biology). He has mentored 3 REU students on projects related to his research during the last 2 summers.

**Howard Levine.** Mathematical modeling of a variety of biological systems including tumor induced angiogenesis, tumor dormancy and growth, and systematic evolution of ligands by exponential enrichment (SELEX). He has played a leading role in the development of mathematical biology at ISU. His collaborators include Marit Nilsen-Hamilton (ISU Biochemistry, Biophysics and Molecular Biology), Surya Mallapragada (ISU Chemical and Biological Engineering), Don Sakaguchi (ISU Genetics, Development & Cell Biology), Michael Smiley and Khalid Boushaba (ISU Mathematics). He has mentored several REU students over the last several years.

**Roger Maddux**. The theory of relation algebras is his primary research area, with applications in logic and computer science. Maddux's research in mathematica biology lies in biogeography. He has refereed papers on this topic for Science, Ecology Lettres, Oikos, and Ecological monographs. Maddux found errors in models of species-area and species-abundance distributions proposed by J. Harte (U.C.B.) and his colleagues. This led to publications in Science and the American Naturalist.

**Michael Smiley**. Mathematical modeling and numerical simulation of cellular processes, including tumor angiogenesis and neuronal stem cell growth and differentiation. Collaborators in this research includes the following colleagues at ISU: Howard Levine

(Mathematics), Marit Nilsen-Hamilton (Biophysics, Biochemistry, and Molecular Biology), Surya Mallapragada (Chemical and Biological Engineering), and Don Sakaguchi (Genetics, Development, and Cell Biology). Joint work in progress strives to further the scientific understanding of how environmental cues promote cell differentiation, in which cells adopt specific cell fates.

**Jonathan Smith.** Primarily works on representation theory of quasigroups and related nonassociative algebras. Uses coding and information theory in modeling complex systems. He has proposed a new model for human demography, which is simpler and more accurate that Leslie matrices or equivalent differential equation models. Collaborators in these studies include J. Dekker (ISU) and D. Brooks (University of Toronto).

**Bo Su**. Professor Su's research interest is nonlinear PDEs and its application in mathematical biology, calculus of variations, free boundary problems, homogenizations, and fluid mechanics.

With collaborators, he has established the theory of discontinuous solutions of Hamilton-Jacobi equations-existence, uniqueness, and regularity, Rigorous analytical result in large global solutions in compressible Navier-Stokes equations, free boundary problems in conduction-convection problem. Major breakthrough in time-dependent Stefan-type problem by originally establishing co-dimension one Hausdorff measure estimate of interface and Holder continuity estimate of temperature. He is now working with Immunologist, statistician on campus on mathematical modeling of immune response to infectious disease in tissue; working with pharmacologist, mathematicians at Vanderbilt on signal transduction generated by Thrombin.

**Stephen Willson**. Studies of algorithms for building phylogenetic trees and networks, which start with DNA data and infer evolutionary history. Some of his results concern: i) ways to improve the construction of phylogenetic trees using quartets, ii) way to improve signal and reduce noise for maximal parsimony methods, iii) theoretical limitations of minimum evolution methods, iv) ways to generate more efficient formulas for use in minimum evolution methods, v) ways to infer phylogenetic networks from distance data, including recognition of hybridizations and homoplasies. He has been invited to participate (expenses paid) in a semester on phylogenetics at the Isaac Newton Institute in Cambridge, England during the fall of 2007. He is the course supervisor for the undergraduate sequence Math 181-182, a course in calculus and mathematical modeling for students in biology.

**Zhijun Wu**. Protein x-ray crystallography computing, NMR distance geometry modeling, potential energy minimization, protein dynamic simulation, flux equation and metabolic network optimization. He has developed a fast Newton method for x-ray crystallographic entropy maximization, a linear-time algorithm for the molecular distance geometry problem with dense distances, a smooth transformation method for energy minimization, a database statistical approach for protein structure refinement, and a multiple shooting

method for the simulation of the transition of protein conformation. He collaborates with Robert Jernigan, ISU Biochemistry, Biophysics and Molecular Biology and Director of the Baker Center for Bioinformatics and Biological Statistics. He mentored 2 REU students during the summer 2006 on projects related to his research.

*Table 59.*

| | **Publications in Mathematics** | | | **Publications outside Mathematics** | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Books | Journal Articles | Other Refereed | Reports | Books | Journal Articles | Other refereed | reports |
| 1999 | 1 | 6 | 2 | 1 | | 2 | 2 | |
| 2000 | | 13 | 1 | 2 | | 1 | 2 | |
| 2001 | | 9 | 1 | 1 | | 5 | | 1 |
| 2002 | 1 | 9 | 3 | 2 | | 2 | | 1 |
| 2003 | | 12 | 4 | 1 | | | 1 | |
| 2004 | | 10 | 3 | 1 | | 2 | | |
| 2005 | | 9 | | 1 | | 1 | 1 | 1 |
| 2006 | 2 | 16 | 2 | | | 6 | | |

*Table 60.*

| | Talks at national or international meetings | | | regional | Colloquia & |
|---|---|---|---|---|---|
| Year | Plenary | Invited | contributed | meetings | seminars |
| 1999 | 1 | 4 | 5 | 1 | 8 |
| 2000 | | 5 | 6 | 3 | 7 |
| 2001 | 2 | 18 | 6 | 2 | 12 |
| 2002 | 1 | 12 | 5 | 3 | 10 |
| 2003 | 1 | 5 | 3 | 3 | 12 |
| 2004 | 1 | 3 | 6 | 2 | 7 |
| 2005 | 1 | 11 | 3 | 4 | 9 |
| 2006 | 3 | 15 | 5 | 2 | 5 |

*Table 61.*

| | Refereeing | | Reviewing |
|---|---|---|---|
| Year | books/papers | proposals | books/papers |
| 1999 | 10 | 1 | 7 |
| 2000 | 9 | 2 | 4 |
| 2001 | 6 | 1 | 13 |
| 2002 | 25 | 1 | 4 |
| 2003 | 28 | 2 | 4 |
| 2004 | 21 | 1 | 5 |
| 2005 | 22 | 1 | 9 |
| 2006 | 24 | 1 | 6 |

*Table 62.*

| | MS | | PhD | |
|---|---|---|---|---|
| | completed | current | completed | current |
| 1999-2006 | 11 | 2 | 13 | 9 |

## 8.8 Probability Theory and Dynamical Systems

**Research Group on Probability Theory and Dynamical Systems**

The research group on Probability Theory and Stochastic Processes (Athreya, Kliemann, Sethuraman, Suh, and Weerasinghe) represents an area of traditional strength at Iowa State University. This group has strong ties to the Department of Statistics on campus (Athreya has a joint appointment in Mathematics and Statistics, Kliemann is a member of the graduate faculty in Statistics), including joint publications, joint supervision of Ph.D. students, organization of joint seminars, participation in the NSF VIGRE program and the NSF RTG in the Department of Statistics, and joint teaching of some of the theoretically oriented courses in probability and statistics.

Dynamical systems and qualitative theory of differential equations has traditionally been an area of very active research at ISU. Currently, this area of mathematics is represented by J. Murdock, and partially by W. Kliemann, whose research includes connections between dynamical systems, stochastic systems, and control systems. With J. Murdock planning to enter 'phased retirement' during the next year, the department faces the threat that the area may actually disappear from the list of active research fields at ISU at a time when it enjoys strong international growth.

*Table 63. Members of the Probability Theory / Dynamical Systems group*

| Name | Current Rank | Joined ISU Mathematics |
|---|---|---|
| Krishna B. Athreya | Distinguished Professor | 1980 |
| Wolfgang Kliemann | Professor | 1983 |
| James Murdock | Professor | 1976 |
| Sunder Sethuraman | Associate Professor | 1998 |
| Jiyeon Suh | Assistant Professor | 2005 |
| Ananda Weerasinghe | Associate Professor | 1986 |

Statistics for the Probability / Dynamical Systems research group are presented below in tabular form, including publications, external funding, and presentations since the last departmental self-study in 1999. The two sections that follow list on an individual basis the professional activities of the members of the group, as well as descriptions of their individual research interests.

**Publications:** Over the last eight years, the group has produced a total of 81 publications, most of them in top tier journals in mathematics and interdisciplinary areas, such as IEEE. To put the number of publications in context, one should notice that J. Suh joined the department only in 2005, and W. Kliemann served in administrative positions from 2000 to 2005, which much diminished research output.

***Table 64.*** *Publication overview of the Probability Theory / Dynamical Systems group*

| | Mathematics Publications | | | | Interdisciplinary Publications | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Journal | Conf. Proc. | Book Chapter | Book | Journal | Conf. Proc. | Book Chapter | Book |
| 1999 | 3 | 1 | 1 | 1 | | 1 | | |
| 2000 | 3 | 1 | 1 | 1 | 1 | 4 | | |
| 2001 | 1 | 1 | 1 | | 4 | 2 | 1 | |
| 2002 | 4 | 1 | | | 3 | | | |
| 2003 | 8 | | | 1 | 1 | | | |
| 2004 | 2 | 3 | 1 | | 4 | 1 | 2 | |
| 2005 | 4 | | 1 | | 3 | | | |
| 2006 | 9 | 1 | 1 | 1 | 2 | | | |
| Total | 34 | 8 | 6 | 4 | 18 | 8 | 3 | |

**External Research Awards:** The following table shows external research funding for the probability / dynamical systems group. The number of total research $$ is somewhat inflated, since both of W. Kliemann's grants were multi-investigator projects. Of the ONR award, about $500,000 were actually housed in Mathematics, and of the DOD/EPRI grant about $185,000, which would bring the group total over the last eight years to about $1,070,000.

***Table 65.*** *External funding obtained by members of the Probability Theory / Dynamical Systems group*

| Years | Agency | PI / Co-PI | Award Amount |
|---|---|---|---|
| 1996 - 1999 | ONR | Kliemann (PI) | 654,340 |
| 1997 - 2001 | NSF | Sethuraman (PI) | 59,079 |
| 1998 - 2003 | DOD / EPRI | Kliemann (Co-PI) | 1,481,234 |
| 2000 - 2004 | NSF | Sethuraman (PI) | 66,212 |
| 2001 | NSF | Sethuraman (PI) | 3,080 |
| 2003-2005 | NSF | Athreya (Co-PI) | 70,501 |
| 2005 - 2007 | DOD | Weerasinghe (PI) | 57,772 |
| 2005 - 2007 | NSA | Sethuraman (PI) | 35,959 |
| 2005 - 2008 | NSF | Sethuraman (PI) | 92,966 |
| Total | | | 2,521,143 |

**Presentations:** The following table lists the presentations given by group members since the last departmental self-study in 1999. 'Plenary talks' are defined as presented that were listed as plenary in conference programs and were not given in parallel with other talks.

We are not listing the seminars presented at ISU since they do not contribute to the outside reputation of the group.

*Table 66. Presentation overview of the Probability Theory / Dynamical Systems group*

| Year | International/National Meetings Plenary | Invited | Contributed | Regional Meetings | Seminars/ Colloquia outside ISU |
|---|---|---|---|---|---|
| 1999 | 1 | 6 | | 2 | 12 |
| 2000 | | 7 | 1 | 2 | 13 |
| 2001 | | 6 | 1 | | 12 |
| 2002 | | 2 | 1 | | 6 |
| 2003 | 1 | 8 | 1 | 3 | 6 |
| 2004 | | 2 | 1 | 1 | 13 |
| 2005 | | 7 | 1 | | 9 |
| 2006 | | 3 | | 1 | 7 |
| Total | 2 | 41 | 6 | 9 | 78 |

**Conference and workshop organization, special panel participation 1999 –**

**Professional Activities:** The following summaries list the individual activities of group members. Substantial activities not related to research or graduate education are listed in other parts of this self-study.

**Awards, honors, offices held 1999 –**

K.B. Athreya Fellow, Institute of Mathematical Statistics, U.S. A.
Fellow, Indian Academy of Sciences
Elected Member, International Statistical Institute

W. Kliemann ISU College of Liberal Arts and Sciences Master Teacher (1999)
State of Iowa Board of Regents Award for Faculty Excellence (2000)

**Editorships of journals, book series, conference proceedings**

K. B. Athreya Associate Editor of J. Th. Probability 1998 - 2004
Associate Editor of J. Ind. Academy of Sciences (Mathematics) 2000 -
Associate Editor of Sankhya, Indian Journal of Statistics, 1999 -
Associate Editor of Resonance J. Science Education, 1996 -
Associate Editor of Statistics & Prob. Letters, 1980 – 2000

W. Kliemann Advisory editor of Birkhäuser book series 'Modeling and Simulation in Science, Engineering and Technology', 1996 – 2000, 2002 -
Comite Editorial 'Proyecciones, Revista de Matematica', 1997 -
Comite Editorial 'Ars Dilemmae Mathematicae', 1997 – 2002
Associate Editor 'Revista Boliviana de Matematica', 2002 –

Editorial Board of 'Boletim da Sociedade Paranaense de Matematica', 2003 -

S. Sethuraman Associate Editor of Statistics and Probability Letters, 11/02 –

W. Kliemann Co-organizer of the Oberwolfach conference series on 'Nonlinear and Stochastic Systems' 1998 –

Member of NSF Review Panel Probability 2000 (December 1999).

Scientific Committee of the 8th ASCE Joint Specialty Conference on Probabilistic Mechanics and Structural Reliability, University of Notre Dame, July 2000.

Co-organizer of the International Conference on Monte Carlo Simulation (MCS 2000),
Monte Carlo, June 2000.

Co-organizer of the Oberwolfach Conference on Nonlinear and Stochastic Systems and Their Numerics, 2002.

Scientific Committee of MTNS 2002, Notre Dame University, 2002.

Scientific Committee of IUTAM Conference on Nonlinear Random Vibrations, Urbana,
Illinois, 2002.

Scientific Committee of COMCA 2003, Antofagasta, Chile, 2003.

International Scientific Committee for Advances in Engineering Structures, Mechanics & Construction, Waterloo, Canada, 2006.

Scientific Committee of COMCA 2006, La Serena, Chile, 2006.

Co-organizer of 1st Latin American Conference on Systems Theory, San Pedro de Atacama, Chile, Sept. 2007.

J. Murdock Organizer of mini symposium "Normal forms and averaging in ODEs and PDEs", SIAM Conference on Applications of Dynamical Systems, Snowbird, Utah, May 22-26, 2005.

S. Sethuraman Co-organizer of Ames Weekend Workshop on Particle Systems, 2001. Scientific Committee Midwestern Probability Colloquium, Northwestern University, Evanston, 2002.

Member of NSF-DMS panel Probability, 2007.

**Refereeing and reviewing**

All members of the Probability / Dynamical Systems group regularly act as referee for journals (reporting on one to six papers per year) and review proposals for federal agencies, such as NSF and DoD, and international organizations (reporting on one to six proposals per year).

**Individual descriptions of research areas**

**Krishna B. Athreya.** Probability Theory and branching processes, stochastic processes in particular, Markov chains, random iteration, super processes, random graph models, mathematical statistics, MCMC, bootstrap theory. Athreya's 1972 book "Branching

Processes" with Peter Ney, published as Band 196 of the Springer Yellow Series has been republished as a Dover Classic. 16 papers and 46 invited talks since 1999.

**Wolfgang Kliemann.** Deterministic and stochastic nonlinear systems theory, in particular dynamical systems, skew product flows, stochastic systems, control systems and their interconnections, with applications in engineering and the natural sciences. Served full-time as Associate Dean for Research in the College of Liberal Arts and Sciences (Jan. 2000 – June 2001) and as Associate Vice Provost for Research of Iowa State University (July 2001 – Sept. 2005). 25 publications and 28 invited talks since 1999 in mathematics, nor including administrative publications and presentations.

**James Murdock.** Dynamical systems, perturbation theory, normal forms for systems of differential equations, and their relationship to classical invariant theory and group representation theory. 8 publications, including two books, and 9 invited presentations since 1999.

**Sunder Sethuraman.** Probability, stochastic analysis of interacting particles systems and other statistical physics models, Brownian trapping problems, order statistics, random graphs. 17 publications and 33 invited presentations since 1999.
**Jiyeon Suh.** Probability theory, martingale inequalities, stochastic analysis, probabilistic methods in complex analysis. 2 publications.

**Ananda Weerasinghe.** Stochastic optimal control problems arising in queuing networks (currently funded through ARO), problems in mathematical finance related to pricing and hedging financial derivatives, and term structure models for interest rates. 8 publications and 6 invited presentations since 1999.

**Interdisciplinary collaborations**

All members of the probability group have extensive interdisciplinary collaborations, mostly with statisticians. (K.B. Athreya has a joint appointment with the Department of Statistics, and W. Kliemann is member of the graduate faculty in Statistics.) These collaborations include joint publications, joint supervision of Ph.D. students, joint seminars and working groups. At this moment, main interdisciplinary topics include random networks, financial mathematics and statistics, statistics and dynamics, statistics and compact manifolds, and characterization of posterior distributions of mixed linear models.

J. Murdock collaborates with engineers on issues of normal forms and multiple scales analysis in engineering systems.

Together with A. Fouad (Electrical Engineering, Member NAE, now retired) and V. Vittal (Electrical Engineering, Member NAE, now at Arizona State University) W. Kliemann developed the normal form approach to analysis and design of power systems with support from NSF, EPRI and DoD. This approach, which was termed 'one of the two or

three most important developments in electric power systems of the 20th century' by EPRI, is now making its way into the power industry in the US.

**International activities and collaborations**

All senior members of this research group have extensive international experience, including long term visiting positions, joint publications, and grants from international organizations. J. Murdock collaborates with colleagues in Holland, and S. Sethuraman visited France and Brazil for extended periods of time.

K.B. Athreya collaborates with colleagues in the mathematics department of the Indian Institute of Science in Bangalore, India. He holds an honorary visiting professorship at this institute. He is also active in the Indian Academy of Sciences. He visits various universities and colleges in India and gives short courses on analysis probability and stochastic processes, MCMC methods.

W. Kliemann regularly collaborates with colleagues in Germany, Brazil, and Chile. He gave more than 20 invited mathematics presentations at international venues since 1999. He served as departmental coordinator for graduate student and faculty exchange programs with Augsburg (Germany), Antofagasta (Chile) and the National Academy of Sciences of the Republic of Armenia. He is co-initiator and the international coordinator of the Ph.D. program in Mathematics at the Universidad Catolica del Norte (Antofagasta, Chile, in collaboration with Augsburg (Germany), Campinas (Brazil) and Iowa State University). He has received several international research grants in Germany (DFG) and Chile (CONICYT, Fundacion Andes) and holds the title of Investigador Grado 5 at PEDECIBA (Programa de Desarollo de Ciencias Basicas), Universidad de la Republica, Montevideo, Uruguay. He also serves as member of the 'Rector's Circle' at the University of Bremen (Germany).

**Educational responsibilities**

Members of the research group teach the usual variety of undergraduate courses. On the graduate level they are responsible for courses in probability theory (Math 642), stochastic processes (Math 554, Math 645), differential geometry (Math 624) and dynamical systems (Math 658) in the Department of Mathematics. They also participate in teaching graduate level courses in the Department of Statistics and the real analysis sequence (Math 501, Math 514, Math 515) in the Department of Mathematics. K.B. Athreya just published a graduate text entitled "Measure Theory and Probability Theory" jointly with S. Lahiri in the series Springer Graduate Texts in Statistics.

An overview of the graduate students and postdoctoral associates that have been supervised by members of the group, is given in Table PD5 below. The number of Ph.D. students is relatively small given the stature and size of the group, specifically when taking into account that three of Kliemann's Ph.D. students are from the Department of

Statistics. We expect that these numbers will increase with the changing structure of the graduate program in the Department and the recruiting of highly motivated Ph.D. level students. Members of the research group serve on numerous POS committees of graduate students outside of the department, including statistics, economics, and all engineering departments.

***Table 67.*** *Graduate students and postdocs supervised by the research group 1999-2006*

| | M.S. Students | | Ph.D. students | | Postdocs | |
|---|---|---|---|---|---|---|
| | completed | current | completed | current | completed | current |
| 1999-2006 | 8 | 2 | 6 | 2 | 3 | |

W. Kliemann and S. Sethuraman also have acted as outside reviewers of Ph.D. theses in Chile, Germany, India, and Mexico. W. Kliemann currently serves as co-major professor for a Ph.D. student in the Mathematics graduate program at Antofagasta (Chile).

**Future plans**

The area of probability theory and stochastic processes has traditionally been well represented in the Department of Mathematics at Iowa State University. With the recent hiring of Jiyeon Suh the group has added a very promising young researcher, and the Department is currently advertising for an entry level position with emphasis in probability (or in mathematical biology). The strength of this group is essential for collaboration with the excellent Department of Statistics at Iowa State, and with other groups across campus

Together with Statistics, the probability group has developed a proposal for a BS/MS degree in 'Financial Statistics and Mathematics' that will be presented to the College of Liberal Arts and Sciences and the University in early 2007. Adequate staffing for this program and its possible extension to a Ph.D. program will require the addition on one faculty member with research interests in the area.

Besides quantitative analysis of financial models, random graph theory has become a focal point of research, specifically in its applications to networks. Collaborations exist with the graph theory group within the Department of Mathematics, with several faculty in Statistics and the College of Engineering.

The low number of graduate students in the area of probability theory and stochastic processes is partly due to the lack of a graduate level introductory course in probability. The group has proposed such a course and it expects to start teaching the topic as an experimental course in fall 2007.

The ISU tradition in dynamical systems (or qualitative theory of different types of differential equations) has almost disappeared over the last years with the retirement of George Seifert, Richard Miller, A.M. Fink and others. Indeed, the same could be said for other previously active areas of analysis in the department, including topology,

differential geometry, and complex analysis. With J. Murdock entering 'phased retirement' during the next year, the department faces the threat that the area may actually disappear from the list of active research fields at ISU at a time when it enjoys strong international attention. While it is clear that no department of mathematics can maintain a research presence in all fields of research, the loss of such a broad area at the roots of mathematics should be a deliberate decision of the Department and not just the consequence of retirements and short-term hiring decisions. Moving the Department 'into the center of campus' as a unit that can contribute research strength to many of the ongoing priority projects at ISU, may require not only strength in several areas of applied mathematics, but also in basic research in fields of analysis. Dynamical systems and differential geometry seem to be two areas that are particularly well suited for ISU, given its overall strength in complex models in biology, control theory, dynamic and stochastic networks, time series analysis, material sciences and others.

# APPENDICES


A.1 Undergraduate mathematics classes in the 2007-09 catalog .....
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## Appendix 1. Undergraduate Mathematics Classes in the 2007-09 Catalog

Below are the catalog descriptions for each mathematics class. Also given are the 5-year average teaching evaluations for all courses, as rated by the students. In the ratings given below, 3 means "Average" and 5 is "Much above average."

**MATH 010. High School Algebra.** (4-0) Cr. 0. F.S.SS. For students who do not have adequate facility with topics from high school algebra or do not meet the algebra admission requirement. The course is divided into tracks of one- and two-semester lengths. For most students a diagnostic exam will determine which track must be taken. Students will receive a grade in Math 25 or 30 respectively depending on the level of material covered. Satisfactory completion of Math 30 is recommended for students planning to take Math 140 or 151, while Math 25 is sufficient for Math 104, 105, 150, 195, Stat 101 or 105. Students must complete Math 30 to remove a deficiency in the algebra admission requirement. Topics include signed numbers, polynomials, rational and radical expressions, exponential and logarithmic expressions, and equations. Satisfactory Fail Only. Instructor rating 3.88.

**MATH 025. High School Algebra.** (4-0) Cr. 0. F.S.SS. Students should initially enroll in Math 10. See description of Math 10. Satisfactory Fail Only

**MATH 030. High School Algebra.** (4-0) Cr. 0. F.S.SS. Students should initially enroll in Math 10. See description of Math 10. Satisfactory Fail Only

**MATH 101. Orientation in Mathematics.** Cr. R. F. For new majors. Issues to consider in planning a program of study. Sources of general information and perspectives concerning mathematics. Discussion of possible areas of study or careers. Satisfactory Fail Only

**MATH 104. Introduction to Probability and Matrices.** (3-0) Cr. 3. F.S. *Prereq: Satisfactory performance on placement exam, 2 years of high school algebra, 1 year of high school geometry*. Permutations, combinations, probability, binomial and multinomial theorems, matrices, expected value. Instructor rating 3.30

**MATH 105. Introduction to Mathematical Ideas.** (3-0) Cr. 3. F.S. *Prereq: Satisfactory performance on placement exam, 2 years of high school algebra, 1 year of high school geometry*. Topics from mathematics and mathematical applications with emphasis on their nontechnical content. Instructor rating 3.22.

**MATH 140. College Algebra.** (3-1) Cr. 3. F.S.SS. *Prereq: Satisfactory performance on placement exam, 2 years of high school algebra; 1 year of high school geometry*. Coordinate geometry, complex numbers, quadratic and polynomial equations, functions, graphing, polynomial and rational functions, exponential and logarithmic functions, systems of equations. Instructor rating 3.65.

**MATH 141. Trigonometry.** (2-0) Cr. 2. F.S.SS. *Prereq: Satisfactory performance on placement exam, 2 years of high school algebra; 1 year of high school geometry, or enrollment in 140.* May be taken concurrently with 140. Trigonometric functions and their inverses, solving triangles, trigonometric identities and equations, graphing. Instructor rating 3.73.

**MATH 142. Trigonometry and Analytic Geometry.** (2-1) Cr. 3. F.S.SS. *Prereq: Satisfactory performance on placement exam, 2 years of high school algebra, 1 year of high school geometry, or enrollment in 140.* May be taken concurrently with 140. Trigonometric functions and their inverses, solving triangles, trigonometric identities and equations, graphing, polar coordinates, complex numbers, standard equations of lines and conic sections, parametric equations. Instructor rating 3.73.

**MATH 150. Discrete Mathematics for Business and Social Sciences.** (2-1) Cr. 3. F.S.SS. *Prereq: Satisfactory performance on placement exam, 2 years of high school algebra, 1 year of high school geometry*. Linear equations and inequalities, linear programming, matrix algebra, discrete probability. Instructor rating 3.57.

**MATH 151. Calculus for Business and Social Sciences.** (2-1) Cr. 3. F.S.SS. *Prereq: Satisfactory performance on placement exam, 2 years of high school algebra, 1 year of high school geometry*. Differential calculus, applications to max-min problems, integral calculus and applications. Will not serve as prerequisite for 265 or 266. Instructor rating 3.63.

**MATH 165. Calculus I.** (4-0) Cr. 4. F.S.SS. *Prereq: Satisfactory performance on placement exam, 2 years of high school algebra, 1 year of geometry, 1 semester of trigonometry or enrollment in 141 or 142.* Differential calculus, applications of the derivative, introduction to integral calculus. Instructor rating 3.69.

**MATH 166. Calculus II.** (4-0) Cr. 4. F.S.SS. *Prereq: Grade of C- or better in 165, 165H, or high math placement scores.* Integral calculus, applications of the integral, infinite series. Instructor rating 3.84.

**MATH 166H. Honors Calculus II.** (4-0) Cr. 4. F.S. *Prereq: Permission of instructor and 165, 165H, or high math placement scores.* Integral calculus, applications of the integral, infinite series. Additional material of a theoretical, conceptual, computational, or modeling nature. Some of the work may require more ingenuity than is required for Math 166. Preference will be given to students in the University Honors Program.
Only one of Math 151 or 160, the sequence 165-166, or the sequence 181-182 may be counted towards graduation.

**MATH 181. Calculus and Mathematical Modeling for the Life Sciences I.** (4-0) Cr. 4. F.S. *Prereq: Satisfactory performance on placement exam, 2 years of high school algebra, 1 year of high school geometry, 1 semester of trigonometry or enrollment in 141 or 142.* Exponential and logarithm functions, difference equations, derivatives, and applications of the derivative. Examples taken from biology. Only one of Math 151, 160, the sequence

165-166, or the sequence 181-182 may be counted towards graduation. Instructor rating 4.31.

**MATH 182. Calculus and Mathematical Modeling for the Life Sciences II.** (4-0) Cr. 4. S. *Prereq: 181.* Integration, differentiation and integration of transcendental functions, first and second order differential equations, applications of the definite integral. Examples taken from biology.
Only one of 151, 160, the sequence 165-166, or the sequence 181-182 may be counted towards graduation. Instructor rating 4.06.

**MATH 195. Mathematics for Elementary Education I.** (2-2) Cr. 3. F.S. *Prereq: Satisfactory performance on placement exam, 2 years high school algebra, 1 year of high school geometry, enrollment in elementary education or early childhood education.* Language of sets, systems of whole numbers, topics from number theory, geometric shapes, congruence, transformations, linear measurement, problem solving. Instructor rating 3.74.

**MATH 196. Mathematics for Elementary Education II.** (2-2) Cr. 3. F.S. *Prereq: Grade of C- or better in 195 and enrollment in elementary education.* Two-and three-dimensional measurement, probability, data fitting, statistics, operations and algorithms for computing with integers, fractions, and decimals. Instructor rating 3.98.

**MATH 201. Introduction to Proofs.** (3-0) Cr. 3. F.S. *Prereq: 166 or 166H.* Reading and writing simple proofs. Proofs involving the real numbers and the definitions of limit, derivative, and the definite integral. Proofs by mathematical induction. Truth tables. Instructor rating not given since it is highly variable and a major change in credit (to 3 credits as listed instead of 2 credits as currently) is contemplated.

**MATH 265. Calculus III.** (4-0) Cr. 4. F.S.SS. *Prereq: Grade of C- or better in 166 or 166H.* Analytic geometry and vectors, differential calculus of functions of several variables, multiple integrals, vector calculus. Instructor rating 3.87.

**MATH 265H. Honors Calculus III.** (4-0) Cr. 4. F.S. *Prereq: Permission of the instructor; and 166 or 166H.* Analytic geometry and vectors, differential calculus of functions of several variables, multiple integrals, vector calculus. Additional material of a theoretical, conceptual, computational, or modeling nature. Some of the work may require more ingenuity than is required in Math 265. Preference will be given to students in the University Honors Program.

**MATH 266. Elementary Differential Equations.** (3-0) Cr. 3. F.S.SS. *Prereq: Grade of C- or better in 166 or 166H.* Solution methods for ordinary differential equations. First order equations, linear equations, constant coefficient equations. Eigenvalue methods for systems of first order linear equations. Introduction to stability and phase plane analysis. Instructor rating 3.85.

**MATH 267. Elementary Differential Equations and Laplace Transforms.** (4-0) Cr. 4. F.S.SS. *Prereq: Grade of C- or better in 166 or 166H.* Same as 266 but also including Laplace transforms and series solutions to ordinary differential equations. Instructor rating 3.98.

**MATH 268. Laplace Transforms.** (1-0) Cr 1. F. Prereq: 266. Laplace transforms and series solutions to ordinary differential equations. Together, 267 and 268 are the same as 267.

**MATH 290. Independent Study.** Cr. 1-3. Repeatable.
**Topics:** H. Honors

**MATH 297. Intermediate Topics for School Mathematics.** (2-2) Cr. 3. F.S. *Prereq: Enrollment in elementary education and grade of C- or better in 196 or enrollment as mathematics major and admission to teacher education.* Mathematical reasoning, data fitting, and topics in Euclidean and non-Euclidean geometry. Discrete mathematics topics selected from graphs, networks, recurrence relations, probability, Markov chains. Use of technology to learn and teach mathematics. The fall semester is intended primarily for elementary education majors while the spring semester is intended for mathematics majors. Instructor rating 3.88.

**MATH 301. Abstract Algebra I.** (3-0) Cr. 3. F.S. *Prereq: 166 or 166H, 307 or 317, and 201.* Theory of groups. Homomorphisms. Quotient groups. Introduction to rings. Emphasis on writing proofs. Instructor rating 4.01.

**MATH 302. Abstract Algebra II.** (3-0) Cr. 3. S. *Prereq: 301.* Theory of rings and fields. Introduction to Galois theory. Emphasis on writing proofs. Instructor rating 4.31.

**MATH 304. Introductory Combinatorics.** (3-0) Cr. 3. F. *Prereq: 166 or 166H; 201 or experience with proofs.* Permutations, combinations, binomial coefficients, inclusion-exclusion principle, recurrence relations, generating functions. Additional topics selected from probability, random walks, and Markov chains. Instructor rating 3.41.

**MATH 307. Matrices and Linear Algebra.** (3-0) Cr. 3. F.S.SS. *Prereq: 2 semesters of calculus.* Systems of linear equations, determinants, vector spaces, linear transformations, orthogonality, least-squares methods, eigenvalues and eigenvectors. Emphasis on methods and techniques. Instructor rating 3.59.

**MATH 314. Graphs and Networks.** (3-0) Cr. 3. S. *Prereq: 166 or 166H; 201 or experience with proofs.* Structure and extremal properties of graphs. Topics are selected from: trees, networks, colorings, paths and cycles, connectivity, planarity, Ramsey theory, forbidden structures, enumeration, applications. Instructor rating 4.01.

**MATH 317. Theory of Linear Algebra.** (4-0) Cr. 4. F.S. *Prereq: 166; credit or enrollment in 201.* Systems of linear equations, determinants, vector spaces, inner product spaces, linear

transformations, eigenvalues and eigenvectors. Emphasis on writing proofs and results. Instructor rating 3.84.

**MATH 331. Topology.** (3-0) Cr. 3. Alt. S., offered 2009. *Prereq: 307 or 317.* Topological properties of metric spaces, including Euclidean n-space, continuous functions, homeomorphisms, and topological invariants. Examples from surfaces, knots, links, and three-dimensional manifolds. Instructor rating not given since it is rarely taught because of low enrollments.

**MATH 341. Introduction to the Theory of Probability and Statistics I.** (Cross-listed with STAT.) (3-0) Cr. 3. *Prereq: Math 265 (or 265H).* Probability; distribution functions and their properties; classical discrete and continuous distribution functions; moment generating functions, multivariate probability distributions and their properties; transformations of random variables; simulation of random variables and use of the R statistical package. Instructor rating is not given since this is taught by the Statistics Department.

**MATH 342. Introduction to the Theory of Probability and Statistics II.** (Cross-listed with STAT.) (3-0) Cr. 3. *Prereq: Stat 341; Math 307 or 317.* Sampling distributions; confidence intervals and hypothesis testing; theory of estimation and hypothesis tests; linear model theory, enumerative data. Instructor rating is not given since this is taught by the Statistics Department.

**MATH 350. Number Theory.** (Cross-listed with COM S.) (3-0) Cr. 3. S. *Prereq: 307 or 317.* Divisibility, integer representations, primes and divisors, linear diophantine equations, congruences, and multiplicative functions. Applications to cryptography. Instructor rating is not given since it has only recently been taught.

**MATH 365. Complex Variables with Applications.** (3-0) Cr. 3. F.S. *Prereq: 265.* Functions of a complex variable, including differentiation, integration and series expansions, residues, evaluation of integrals, conformal mapping. Instructor rating 3.61.

**MATH 373. Introduction to Scientific Computation.** (3-0) Cr. 3. S. *Prereq: 265.* Vector, matrix and graphics programming in MATLAB for scientific applications. Algorithms for interpolation, systems of linear equations, least squares, nonlinear equations and optimization in one and several variables. Additional topics may include ordinary differential equations, symbolic calculation and the Fast Fourier Transform. Emphasis on effective use of mathematical software, and understanding of its strengths and limitations. Instructor rating not given since the course has frequently failed to run.

**MATH 385. Introduction to Partial Differential Equations.** (3-0) Cr. 3. F.S. *Prereq: 265 and one of 266, 267.* Separation of variables methods for elliptic, parabolic, and hyperbolic partial differential equations. Fourier series, Sturm-Liouville theory, Bessel functions, and spherical harmonics. Instructor rating 3.88.

**MATH 398. Cooperative Education.** Cr. R. Repeatable, maximum of 2 times. F.S.SS. *Prereq: Permission of the department cooperative education coordinator; junior classification.* Required of all cooperative education students. Students must register for this course prior to commencing each work period.

**MATH 414. Analysis I.** (3-0) Cr. 3. F.S.SS. *Prereq: 201; 265; and 307 or 317.* A careful development of calculus of functions of a real variable: limits, continuity, differentiation, integration, series. Instructor rating 4.02.

**MATH 415. Analysis II.** (3-0) Cr. 3. S. *Prereq: 414.* Sequences and series of functions of a real variable, uniform convergence, power series and Taylor series, Fourier series, topology of n-dimensional space, implicit function theorem, calculus of the plane and 3-dimensional space. Additional topics may include metric spaces or Stietjes or Lebesgue integration. Instructor rating 4.41.

**MATH 421. Logic for Mathematics and Computer Science.** (Cross-listed with COM S.) (3-0) Cr. 3. S. *Prereq: Math 301 or 307 or 317 or Com S 330.* Propositional and predicate logic. Topics selected from Horn logic, equational logic, resolution and unification, foundations of logic programming, reasoning about programs, program specification and verification, model checking and binary decision diagrams. Instructor rating not given since it is taught irregularly.

**MATH 426. Mathematical Methods for the Physical Sciences.** (3-0) Cr. 3. F. *Prereq: 266 or 267.* A fast-paced course primarily for first-year graduate students in physics and chemistry. Emphasis on techniques needed for quantum mechanics and electrodynamics. Functions of a complex variable and contour integration, integral transforms and applications, series methods for ordinary differential equations, Green's functions, Sturm-Liouville problems and orthogonal functions, boundary-value problems for partial differential equations. Instructor rating 4.71.

**MATH 435. Geometry I.** (3-0) Cr. 3. F. *Prereq: 307 or 317.* Euclidean geometry. Points, lines, circles, triangles, congruence, similarity, properties invariant under rigid motions. Synthetic, analytic, and axiomatic methods. Instructor rating 4.13.

**MATH 436. Geometry II.** (3-0) Cr. 3. S. *Prereq: 435.* Continuation of Euclidean geometry with topics from elliptic, projective, or hyperbolic geometry. Emphasis on analytic methods. Instructor rating 4.31.

**MATH 439. Mathematics of Fractals and Chaos.** (3-0) Cr. 3. Alt. S., offered 2008. *Prereq: 265.* Topology of metric spaces; iterated function systems; algorithms for generation of fractals; fractal dimension; Julia sets and the Mandelbrot set; applications to chaotic systems. Instructor rating 4.81.

**MATH 465. Advanced Calculus for Applied Mathematics.** (4-0) Cr. 4. S.SS. *Prereq: 265.* Frequently applied concepts from multivariable calculus, presented with enough theory

to promote understanding of applications. Topics may include derivative matrices, Taylor polynomials, curvilinear coordinates, Green's theorem, divergence theorem, Stokes's theorem, uniform convergence, operations on series and integrals, improper integrals. Instructor rating not given since the course frequently fails to run.

**MATH 471. Computational Linear Algebra and Fixed Point Iteration.** (Cross-listed with COM S.) (3-0) Cr. 3. F.S. *Prereq: Math 265 and either Math 266, or 267; knowledge of a programming language.* Computational error, solutions of linear systems, least squares, similarity methods for eigenvalues, solution of nonlinear equations in one and several variables. Instructor rating 3.90.

**MATH 481. Numerical Solution of Differential Equations and Interpolation.** (Cross-listed with COM S.) (3-0) Cr. 3. S.SS. *Prereq: Math 265 and either Math 266 or 267; knowledge of a programming language.* Polynomial and spline interpolation, orthogonal polynomials, least squares, numerical differentiation and integration, numerical solution of ordinary differential equations. Instructor rating 3.83.

**MATH 489. History of Mathematics.** (3-0) Cr. 3. S. *Prereq: 6 credits in mathematics at the 300 level or above. Recommended credit or enrollment in 301 or 414.* History of mathematical ideas found in the undergraduate curriculum. It includes a discussion of the historical and cultural settings in which these ideas arose, and the influence of the culture on the type of mathematical ideas that developed. Some of the particular cultures and their mathematics that are studied include: Babylonian and Ancient Egyptian. Ancient Greek, Arabic, Indian, Western European and Chinese. Instructor rating 3.42.

**MATH 490. Independent Study.** Cr. 1-3. Repeatable, maximum of 9 credits. *Prereq: 301 or 317; 6 credits in mathematics.*

**MATH 491. Undergraduate Thesis.** Cr. 2-3. Writing a formal mathematics paper. Upon approval by the department, the paper will satisfy the departmental advanced English requirement.

**MATH 492. Undergraduate Seminar.** (2-0) Cr. 2. S. *Prereq: Consent of instructor.* Introduction to mathematics research, a participating seminar on advanced topics in mathematics. Mathematical literature search, reading a mathematical article with the guidance of the instructor, mathematical presentation. Seminar content varies.

**MATH 497. Teaching Secondary School Mathematics.** (Cross-listed with C I.) (3-0) Cr. 3. F. *Prereq: 15 credits in college mathematics; if in a teacher licensure program, concurrent enrollment in C I 426 or 526.* Theory and methods for teaching mathematics in grades 7-12. Includes critical examination of instructional strategies, curriculum materials, learning tools, assessment methods, National Standards in Mathematics Education, and equity issues.

**MATH 498. Cooperative Education.** Cr. R. Repeatable, maximum of 2 credits. F.S.SS. *Prereq: Permission of the department cooperative education coordinator; senior classification.* Required of all cooperative education students. Students must register for this course prior to commencing each work period.

## Appendix 2. The student evaluation form

MATHEMATICS DEPARTMENT INSTRUCTOR EVALUATION

Give a rating in response to each of the first thirteen areas described below. As far as possible, your rating should represent your opinion on how the instructor, course, etc. compare with all other instructors or courses that you have had at Iowa State University. Use the following scale:

A – Very Poor (or Strongly Disagree)
B – Poor (or Disagree)
C – Satisfactory (or Neutral/No Opinion)
D – Good (or Agree)
E – Very Good (or Strongly Agree)

1. OVERALL INSTRUCTOR–Your overall rating of this instructor is:
2. OVERALL COURSE–Your overall rating of this course is:
3. PREPARATION–The instructor was sufficiently prepared to present and discuss the course material.
4. SPEAKING–The instructor spoke in a clear and understandable way.
5. WRITING–The instructor wrote clearly and used the blackboard and/or overhead projector effectively.
6. INTEREST–The instructor made the course interesting.
7. QUESTIONS–The instructor encouraged questions and responded well to them.
8. AVAILABILITY–The instructor was available for help outside of class.
9. HOMEWORK/QUIZZES–The instructor used homework and/or quizzes in an appropriate and useful way.
10. TESTING–The instructor gave tests that fairly represented the course material.
11. GRADING–The instructor graded in a prompt and fair way.
12. POLICIES–The instructor was timely, clear, and fair in announcing and administering course policies.
13. TEXTBOOK–The textbook was useful in helping me learn the course material.

The last two questions concern your own work in the course.

14. On average, how many hours each week, outside of class, did you devote to this course?
    A – fewer than 3

B – between 3 and 6
C – between 6 and 9
D – between 9 and 12
E – more than 12

15. What grade do you expect in this course?

A – F
B – D+, D, or D-
C – C+, C, or C-
D – B+, B, or B-
E – A or A-

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COMMENTS: If you wish to make further comments on any of the items listed above, or have other comments about the instructor, the course, the text, the use of technology, etc., please write them in the space below or on the back of this sheet.

## Appendix 3. The senior survey

Mathematics Department Senior Survey

1 How do you rate the quality of your mathematics education at Iowa State University? Poor Adequate Good Excellent

2 I feel that the Iowa State mathematics program met my needs and expectations. Strongly Disagree Disagree Agree Strongly Agree

3 When did you decide to become a mathematics major? While in HS Fr. Yr. So. Yr. Jr. Yr. Sr. Yr.

4 Many of the courses in mathematics are designed to help students learn about an area in depth or to develop mathematical skills. Please rate the effectiveness or quality of any of the listed courses you took in contributing to:

a. Your understanding of calculus and differential equations (relevant courses: 165, 166, 265, 266, 267, 414, 415)
Poor Adequate Good Excellent

b. Your understanding of advanced algebra (relevant courses: 301, 302, 307, 317)
Poor Adequate Good Excellent

c. The development of your problem solving skills (all mathematics courses are relevant)
Poor Adequate Good Excellent

d. Your ability to prove theorems (relevant courses: 201, 301, 302, 304, 314, 317, 331, 350, 414, 415)
Poor Adequate Good Excellent

e. Your ability to communicate mathematics (relevant courses 201, 492, English 314)
Poor Adequate Good Excellent

f. Your breadth of mathematical knowledge (relevant courses: all 300 and 400 level courses)
Poor Adequate Good Excellent

g. Your ability to apply mathematics outside of the classroom (all mathematics courses are relevant)
Poor Adequate Good Excellent

h. (Only for Secondary Education students) Your knowledge of methods for teaching mathematics (relevant courses 297, 497)

## Appendix 4. Survey of instructors of advanced courses taken by many graduating seniors

MATHEMATICS 415
OUTCOMES ASSESSMENT SURVEY FOR FACULTY

As part of the Mathematics Department's Outcome Assessment efforts, the Undergraduate Committee would appreciate it if you would complete the following questionnaire about the Junior and Senior undergraduate majors in your Mathematics 415 class. A list of these students is attached. Please answer all items with only these students in mind.

1. How many of these students are able to read and understand well analysis at the 415 level? (Please mark at an appropriate level below.)
- None 25% 50% 75% All

2. How many of these students are able to write simple analysis proofs well?
- None 25% 50% 75% All

3. How many of these students are able to write moderately complicated analysis proofs well?
- None 25% 50% 75% All

4. How many of these students are able talk intelligibly about the 415 material?
- None 25% 50% 75% All

5. How many of these students occasionally show creativity in their approach to problems?
- None 25% 50% 75% All

6. How many of these students seem to have the skills and con•dence to explore problems di•erent from what they have seen before?
- None 25% 50% 75% All

7. At the beginning of the semester, how many of these students seemed to be well prepared to take this course?
   None 25% 50% 75% All

Below please write any other comments about the performance and/or mathematical abilities of the Math 415 Junior and Senior Mathematics majors.

# Appendix 5. Calculus LAS V05

May 1, 2007

## Maintaining Excellence in Lower Division Mathematics Teaching

### Report of the Calculus Committee of the College of Liberal Arts and Sciences

### A. Summary

The Calculus Committee of the College of Liberal Arts and Sciences analyzed the current strengths and weaknesses of lower division mathematics teaching at Iowa State University, with special emphasis on calculus. The Committee studied reform recommendations from other universities, including the University of Washington, Rutgers University, Virginia Tech, and University of Waterloo. The Committee found that maintaining excellence in lower division mathematics teaching at ISU requires new initiatives in cross-campus collaboration, design of course content, creation of learning environments, and administration of introductory courses.
In summary, the Committee recommends

- Regular campus-wide collaboration on course content issues for lower division courses in mathematics,
- Creation and staffing of calculus learning spaces for undergraduate students according to their majors (Calculus Cafes),
- Creation of a Center for Excellence in Lower Division Mathematics Teaching within the Department of Mathematics to coordinate multi-section course sequences and to train instructors for lower division teaching.

### B. The Calculus Committee of the College of Liberal Arts and Sciences

The Calculus Committee was convened in the Fall of 2006 by Dean Whiteford with the charge to assess the state of calculus education at Iowa State University and to make recommendations for maintaining excellence in lower division mathematics teaching on campus.

**Committee members**

- Roger Alexander, Department of Mathematics
- Amy Froelich, Department of Statistics
- Arne Hallam, Chair, Department of Economics

- Elgin Johnston, Associate Chair, Department of Mathematics
- Wolfgang Kliemann, Department of Mathematics
- David Oliver, Associate Dean, College of Liberal Arts and Sciences, chair of the committee
- Stephen Willson, Department of Mathematics
- Loren Zachary, Assistant Dean, College of Engineering

The Committee met on a biweekly basis during Fall 2006 and Spring 2007. Some of the discussions necessarily extended from instruction of calculus to other areas of lower division mathematics teaching, and some of the recommendations reflect this broader scope.

**C. Background**

The Committee identified several issues that determine the context in which calculus is taught at Iowa State University. These issues include:

For many students, calculus is one of the core college courses (or course sequences) since it is the gateway to a degree in any STEM area, as well as the quantitative social sciences. At ISU, each year about 5,000 students take one of the calculus courses.

The Department of Mathematics currently offers four versions of calculus:

- Math 151 for students in business and social sciences (large lectures)
- Math 160 for students in economics (mid-size sections)
- Math 181, 182 for students in biology (mid-size sections)
- Math 165, 166, 265 for all other students (large lectures and mid-size sections).

Students pick their version of calculus after a placement exam and upon consultation with their advisor(s).

The academic background of students in calculus varies substantially, even within the same version of calculus:

- They may enroll in an ISU calculus course directly after high school (with or without calculus experience), and if they had calculus while attending high school it may have been a high school level course, one of the AP level courses, or a course at a university or community college.
- They may enroll in an ISU calculus course after taking high school level mathematics at ISU (Math 140, 141, 142).
- They may transfer from a community college with some calculus exposure.
- They may transfer from another university with some calculus experience.

Generally, the Department has little information about the quality of student preparation. And students generally do not know if their preparation was adequate for these college

level courses.

Learning communities and study groups allow students to learn calculus in a communicative setting, but learning communities do not cover all students, and study groups, recommended by most instructors, are usually formed (and maintained) in a random way.

Textbooks in calculus usually are written in a fairly comprehensive style, i.e. they contain a wealth of topics related to the main ideas, often covered en passant. While all instructors in any lower division multi-section course follow the same syllabus, they need to pick topic details according to their own experiences and preferences.

Similar issues have been discussed at other universities, including the University of Washington, that have recently proposed models for calculus reform.

**D. Recommendations for an ISU Calculus Model**

The following recommendations target primarily calculus instruction. However, the committee recommends that instruction in other areas of basic college mathematics (capstone courses, differential equations, and possibly linear algebra) be studied in the near future, possibly together with a model for teaching of remedial material although much progress is being made in this area.

**D.1 Cross-Campus Collaboration**

All detail recommendations that follow depend in a crucial way on the collaboration of the Department of Mathematics with the programs and departments on campus whose students are enrolled in the calculus courses, i.e. with downstream programs. This collaboration needs to include issues of course content, learning environments, and feedback about student performance in subsequent courses.

**Recommendations – Cross-Campus collaboration**

1. Create a Calculus Coordination Group for each of the three versions of calculus, staffed by members of the Department of Mathematics and the downstream programs:

    - Math 151, Math 160: College of Business, Department of Economics, Department of Industrial and Manufacturing Systems Engineering, Department of Mathematics
    - Math 181, Math 182: Biology Interdepartmental Undergraduate Program, Department of Mathematics
    - Math 165, 166, 265: College of Engineering, Department of Physics, Department of Statistics, Department of Mathematics.

2. The Coordination Groups make recommendations regarding course content and learning environments to the participating colleges, departments, and programs. The Department of Mathematics is responsible for implementation of course content recommendations. Together, the participating units implement recommendations regarding learning environment. Each group meets at least once per semester.

3. Each down-stream group of programs, departments, and colleges creates a position of calculus liaison as counterpart to the calculus coordinator in the Department of Mathematics. This position is responsible for initiatives and activities as described in the following sections.

**D.2 Course Content**

The selection of calculus content should be coordinated with the students' major program (downstream program). Two philosophies seem to govern course section: One starts from the premise that learning the basic mathematics well will allow students to succeed when models and problems come up in their program courses that require calculus for an adequate solution. This approach seems to work well (under certain conditions, see below), for the one-semester versions of calculus. It leads to substantial 'front-loading' of material in multi-semester versions, hence the preferred approach here is to combine calculus concepts and results with application models and problem solving from the very beginning. Obviously, this requires a calculus syllabus that is specifically designed for a target population. The problem of front-loading is exacerbated in the three semester version of calculus for which textbooks present a long list of physics related ideas without proper introduction and motivation.

The Committee understands that revision of content in all versions of calculus is an ongoing process.

**Recommendations – Course Content**

1. In the one-semester versions of calculus emphasize learning of mathematical tools, using appropriate examples from the social and economical sciences. Coordinate topics and examples with the downstream programs. Since both versions (Math 151 and Math 160) enjoy sufficient enrollment, these versions should be kept separate for now.

2. In the two semester version (Math 181, 182) combine learning of calculus concepts and tools with wet-lab experience or, at least, with lab examples from the biological sciences. Coordinate topics and examples with the downstream programs.

3. The three semester version of calculus (Math 165, 166, 265) requires substantial remodeling, according to the characterization given above:

- Create a non-physics/engineering version that relies less on physics related ideas, but instead emphasizes concepts used in economics, statistics, optimization, mathematics, etc.

- Differentiate the physics/engineering version 'with preference' for certain areas within engineering. This requires careful coordination of topics and examples with the downstream programs.

- Eliminate about 20-25 % of the non-core topics and concentrate on models, conceptual ideas, and problem solving together with tools to help students understand more of calculus. This requires careful coordination with the downstream programs.

- As an alternative to deleting 20-25% of the topics, we could change the sequence from three semester classes (each of 4 credits) to four semester classes (the first three with 4 credits, and the last with 3 credits) without increasing the total course content. This alternative would slow the course and allow a pace with which most students could cope. It would also allow the inclusion of more modeling. There are many schools in which calculus is a four-semester sequence rather than a three-semester sequence, and ISU would join them. A committee involving both College of Engineering faculty and Mathematics Department faculty should decide which alternative is preferable.

- The current (3-1) format for many large lectures in Math 165 and Math 166 allows one recitation meeting per week. Substantial numbers of students in Math 165 have somewhat borderline test scores (in trigonometry or algebra) and would benefit from additional teaching during the week in order to review these other topics. The committee proposes that some of the Math 165 sections be given the (3-2) format, with two recitation meetings per week. The additional time should be in small recitation format, so that the recitation leader can give individual help.

- The College of Engineering will make first recommendations regarding course differentiation and content during Spring 2007.

- The changes in course content and format, together with exploring new approaches to teaching of calculus, should be implemented in some pilot sections for a few semesters, starting Fall 2007. This will allow for assessment of the changes proposed here.

**D.3 Calculus Learning Environments**

While all research regarding student academic success seems to point out that student initiative and participation is a (if not the) key component of learning, few models exist

for specific learning environments that are suitable for groups of hundreds or thousands of students. Universities that have approached this problem, have created extra-course environments that allow students to study mathematics in a supportive way, see e.g. the Math Emporium at VPI, the set-up at the University of Waterloo (Canada), or the organized study activities at many European and Latin American universities. At ISU, learning communities seem to have a positive effect on student performance, but they are not available to all students of calculus.

Student background plays a key role in college success (see, e.g. Adelman, C., *Answers in the Tool Box: Academic Intensity, Attendance Patterns, and Bachelor's Degree Attainment*, Washington, DC: U.S. Department of Education, 1999). Universities generally do not have sufficient information about their students to allow for background-adjusted learning environments. Usually it is recommended that students that did not have adequate high school preparation or that perform poorly on placement exams, take remedial (high school level) courses before proceeding to calculus. According to Adelman and to anecdotal evidence at ISU, very few students that start out in these remedial courses ever graduate from college, graduation in a STEM field is an even rarer event. This points to problems of 'upstream collaboration' (see section E below), and is the reason for Recommendation 2.

The long-standing dispute over the use of large lectures with its well-known pros and cons is difficult to settle without proper data, and these do not (currently) exist at ISU.

**Recommendations – Learning Environments**

1. **Calculus Cafés:** Team Calculus recommends establishing three Calculus Cafés across campus, physical locales that serve students enrolled in or interested in calculus, one café for each of the three versions for calculus. (The Department of Economics currently has a calculus help-room setting for students in Math 160.)

- Each locale should present an inviting environment, hopefully a café-like atmosphere. It should host regular support activities for calculus students (group study, help-room, learning how to learn) and special events related to calculus.

- Each café should be open for at least eight hours per day (noon to 8 pm). It should be staffed jointly be the Department of Mathematics and the downstream programs, departments, and colleges. At least for one hour each day a mathematics instructor should be available for presentations and questions.

2. **Diverse backgrounds**: Calculus courses accommodate students from many different backgrounds, and while students often took courses with similar titles before enrolling in calculus at ISU, their actual knowledge may be quite different. The Committee recommends that an early assessment test be given in each section of calculus with the goal of guiding students to a course or lab that is appropriate for the individual. This assessment should be coordinated with the early warning

system in the College of Engineering.

### D.4 Center for Excellence in Lower Division Mathematics

The Department of Mathematics is aware of the fact that not all instructors (faculty, lecturers, graduate assistants, visitors) are equally prepared and enthusiastic to teach key lower division college courses. In order to make a dramatic improvement in the success rate for students in these mathematics classes, changes may be desirable in class formats, organization, and communication.

**Recommendations – Organization and Personnel**

The Committee recommends the establishment of a "Center for Excellence in Lower Division Mathematics" within the Department of Mathematics. The scope and structure of this Center would include:

1. **Coordinators for courses**

Each course or course series of lower division mathematics should have a "coordinator", who

- is responsible for high quality class offerings and instructors,
- is committed to the course for at least 3 years,
- regularly teaches the course,
- designs and distributes the syllabus for the course,
- is responsible for uniform exams in the course,
- recommends class formats for the course,
- meets regularly with course instructors and teaching assistants of the class,
- is responsible for the selection of textbook and other teaching materials,
- coordinates preparation of additional materials to be used in the courses.

Coordinators are needed for each of the following "packages" of courses

- 165, 166, 265, 266, 267
- 140, 141, 142
- 151, 160
- 150
- 181, 182
- 195, 196, 297
- 104, 105.

The same individual could possibly be coordinator for more than one group. The coordinator for each package should hold that position for several years in order to facilitate uniformity and efficiency. Experienced faculty and/or experienced lecturers could serve as coordinators.

2. **Director**

The director should be a regular faculty member who would work with the Associate Chair in assigning coordinators and instructors to each course, would advocate changes and improvements, would coordinate the coordinators, and would act as departmental liaison to client departments across campus in matters of lower division mathematics courses.

3. **Instructors**

It is desirable that some faculty – lecturers or senior lecturers or tenure-track faculty – teach these courses regularly rather than just occasionally. Such regular commitment should ensure high quality of lower division teaching and improve uniformity over time. This means that some instructors teach the same group of lower division courses repeatedly as part of their teaching load.

4. **Training of graduate students**

A graduate-level course in teaching mathematics will be required of graduate students. The goal of the course will be to help the students become more effective teaching assistants and instructors. In essence the course will help train the students to be teaching assistants. Graduate students would have to complete this course successfully before they could teach their own sections of courses.

**E. Extra-Mural Collaboration and Information System**

The recommendations above are aimed at ISU and can be implemented in a campus-wide effort. However, ongoing improvement in basic college-level mathematics instruction also requires collaboration with institutions that send students to ISU, including high schools and community colleges. Such collaboration becomes more important as university admissions criteria are modified, more high school students take college-level courses while in high school, and articulation agreements with community colleges become more common. This context requires that all institutions and offices in the State of Iowa that are involved in the high school to college transition phase coordinate their efforts to make sure that high school students receive adequate preparation, advice and mentoring at this critical transition point. The Iowa Initiative for College Mathematics and Statistics Education ($I^2$CMASE) was formed to address exactly this issue. $I^2$CMASE is a joint effort of the five departments in the mathematical sciences at the three Regents' institutions: Department of Mathematics at Iowa State University, Department of Statistics at Iowa State University, Department of Mathematics at the University of Iowa, Department of Statistics and Actuarial Science at the University of Iowa, and Department of Mathematics at the University of Northern Iowa.

Sharing of information among the institutions involved in the high school to college

transition is one of the key components of I$^2$CMASE. The Iowa High School – College Information System for Mathematics and Statistics (IHCIS-MS) is the component of this information sharing that is concerned with student achievement during their 9-16 careers. The Committee recommends that calculus initiatives, including the recommendations above, be discussed in the state-wide I$^2$CMASE group. We also recommend IHCIS-MS be set up in such a way that it provides data to better accommodate student from divers backgrounds, as well as data for the assessment of student learning in calculus through performance in downstream courses.

**F. Budgetary Implications for the College of Liberal Arts and Sciences**
The budget for the implementation of the recommendation of the Committee would need to include:

**Calculus Cafés**

These learning spaces would require physical locales with furniture and equipment, supplied by LAS in collaboration with the downstream units.
Staffing for the Calculus Cafés would come from downstream units (TAs) as well as from LAS (6 TAs from Mathematics, 3 faculty buy-outs per semester).

**Early assessment tests**

Early assessment tests would require undergraduate hourly support for grading, estimated at 100 hours per semester.

**Center for Excellence in Lower Division Mathematics**

1. The director should be a faculty member with a course release each year. Since a tenured faculty member teaches 4 courses per year, this amounts to replacement for one course per year.
2. The graduate course in teaching is an additional course, which will displace some other course. This amounts to buyout from one course per year.
3. Faculty are already overextended without adding additional duties of a coordinator, especially for large courses and course sequences. Additional personnel will be needed to handle these coordinator duties. This amounts to buying these coordinators out of teaching for an amount required to cover the extra administrative duties of being coordinator. We estimate that one course every two years for each of these six coordinators would be reasonable, except for the calculus/differential equations sequence that would require buyout every year. Hence this requires buyout of 4 courses per year.
4. In order to obtain high quality lecturers, the Department must be able to offer contracts for at least three years, and it must be able to advertise widely and interview candidates. Achieving this in turn requires a regularized budget so that

hiring can be done long before the beginning of the Fall semester. The timing of the budget approval is crucial for effective instruction.

5. The coordinator for 141 and 142 must have special skills to oversee the web-based formats of these courses. In particular, this coordinator will probably be a new lecturer who can take charge of this course over several years and who will have special computer requirements in the job description (making the appropriate salary higher).
6. The change of some sections of Math 165 from (3-1) format to (3-2) format will require approximately four new teaching assistants.
7. Due to (partial) cancellation of the last Teaching Contract between the College and the Department, the Department has lost three FTE lecturer positions during the last years. These positions were and are essential to maintain excellence in lower division mathematical teaching on campus. The Committee recommends that these positions be reinstated.
8. Flexibility will be needed for hiring in any category (lecturer, grad student, tenure-track faculty) to fill the instructional needs of the Department on different levels. For example, to implement the plan, it may be advisable to hire a tenure-track faculty member in the area of mathematics education to continuously inspire and assess improvements in lower division mathematics teaching. Or it may be more effective to have some current faculty members take a larger role in teaching on the 1xx and 2xx level, while new faculty with exceptional research expectations are being hired.

*Summary of budget implications.*

| | Reinstate FTEs | New FTEs | TAs | Undergraduates |
|---|---|---|---|---|
| **Calculus Cafes** | | **.5** | **6** | |
| **Assessment Tests** | | | | **100 hours** |
| **Center** | **3** | **2** | **4** | |

## Appendix 6. Syllabi for qualifying exams

Syllabi for qualifying exams are posted online at:
*http://www.math.iastate.edu/For/GradExamArchive.html*

Individual exams information is posted online at:

- Algebra - *http://www.math.iastate.edu/For/GQEalgebra.html*
- Analysis - *http://www.math.iastate.edu/For/GQEanalysis.html*
- Applied mathematics - *http://www.math.iastate.edu/For/GQEapplied.html*
- Numerical Analysis - *http://www.math.iastate.edu/For/GQEnumerical.html*

## Appendix 7. Mathematics Graduate Student Handbook

The Mathematics Graduate Student Handbook is posted online at
*http://orion.math.iastate.edu/dept/grad/Handbook.htm*

## Appendix 8. First year graduate student seminars

Fall 2006 Seminar for First Year Mathematics Graduate Students

| Date | Speaker | Topic | Room | Remarks |
|---|---|---|---|---|
| | | | | |
| August 23 | John Hirschman | Disability Resources | 305 | |
| August 30 | Paul Sacks | Degree Requirements | 305 | |
| September 6 | Fritz Keinert | Web Pages | 250 | |
| September 13 | Wolfgang Kliemann | Global behavior of dynamical systems and chaos | 305 | |
| September 20 | Cliff Bergman | TeX | 250 | |
| September 27 | Cliff Bergman | TeX | 250 | |
| October 4 | Cliff Bergman | TeX | 250 | |
| October 11 | Panel | The mathematics job market in the USA | 305 | |
| October 18 | Maria Axenovich & Sung-Yell Song | Unavoidable structures in combinatorics &<br>Codes, designs, and graphs in algebraic combinatorics | 305 | |
| October 25 | Melanie Erickson | More about paperwork | 305 | |
| November 1 | Gary Lieberman | Life outside Carver Hall | 305 | |
| November 8 | Richard Ng | Frobenius-Schur indicators and exponents | 305 | |
| November 15 | Jeremy Alm | Learning to do research in graduate school--one man's story | 305 | |
| November 22 | *Vacation week --- no meeting* | | | |
| November 29 | Alric Rothmayer | Perturbation Methods Applied to Fluid Mechanics | 305 | |
| December 6 | Karen Bovenmyer | The PFF (Preparing Future Faculty) program | 305 | |

# Spring 2007 Seminar for First Year Mathematics Graduate Students

| Date | Speaker | Topic |
|---|---|---|
| | | |
| January 10 | No meeting | |
| January 17 | Teaching panel | |
| January 24 | Leslie Hogben | Minimum rank of symmetric matrices described by a graph |
| January 31 | Roger Maddux | The PNP problem, or, Who wants to be a Millionaire? |
| February 7<br>268 Carver | Jue Yan | Numerical methods for solving partial differential equations |
| February 14 | Fritz Keinert | Tools for Mathematical Calculations |
| February 21 | No meeting | |
| February 28 | Research Panel | |
| March 7 | Mathematics Graduate Student Council | |
| March 14 | Spring Break | |
| March 21 | Justin Peters | Connections between operator algebras and dynamical systems |
| March 28 | Paul Sacks | Mathematics Research Tools |
| April 4 | Graduate Committee | |
| April 11 | Jonathan Smith | Post-Modern Algebra |
| April 18 | Stephen Willson | Some Mathematical Problems in Phylogenetics |
| April 25 | Krishna Athreya | Kolmogorov's model for study of randomness: An introduction to Stochastic Processes |

## Appendix 9a. Applied mathematics graduate student degree count

Applied Math & Math Degree Information -- 1999 through 2006

| Name | Year | Major Professor | Degree | Program | Thesis Title | First Job Information |
|---|---|---|---|---|---|---|
| Becker, Joy | 1999 | Smith, JDH | MS | Math | Collineations of desarguesian projective plans | Further Education, ISU Math, Ames, IA |
| Chun, Changbum | 1999 | Smiley | PhD | AMath | Error estimates for the bifurcation function for semilinear elliptic boundary value problems | Postdoc, Seoul National Univ, Seoul, Korea |
| Chyrsafinos, Kostas | 1999 | Gunzburger | MS | AMath | Lagrange multiplier technique for parabolic with inhomogeneous Dirichlet data | Further Education, ISU Math, Ames, IA |
| Gugat, Brian | 1999 | Hentzel | MS | Math | An analysis of Wari | Statistical Analyst, Rain & Hail Insurance, Johnston, IA |
| Hamilton, Brent | 1999 | Keller | MS | Math | The appropriate use of technology | Math Teacher, NIACC, Mason City, IA |
| Hoover, Amy | 1999 | Bergman | MS | Math | Algorithms for finding primitive roots | None |
| Hourani, Sammy | 1999 | Peters | MS | Math | Presentation on stability of solitary waves in the symmetry, I* | Unknown |
| James, Edna | 1999 | Evans | PhD | AMath | Stochastic models for surface adsorption and reaction processes | Temporary Asst Prof, ISU Math, Ames, IA |
| Johanson, James | 1999 | Cornette | MS | AMath | Predicted twinning rates for north American Holstein sires | Missionary, Riga, Latvia |
| Lu, Ying | 1999 | Peterson | MS | AMath | Global approximation of finite element method | Further Education, ISU Comp Sci, Ames, IA |
| Mills, Mark | 1999 | Cain | PhD | Math | The intersection of some classical equivalence classes of matrices | Asst Professor, Central College, Pella, IA |
| Peterson, Todd | 1999 | Cornette | MS | AMath | Analysis of EST counting | Programming Engr, Lockheed Martin, Syracuse, NY |
| Trangri, Neena | 1999 | Levine | MS | Amath | Performance evaluation of pairwise protein alignment tool | Postdoc Instructor, ISU Math Dept, Ames, IA |
| | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Baccam, Prasith (Sid) | 2000 | Cornette | PhD | Amath | Genetic variation and evolution of equine infectious anemia virus rev quasispecies during long term persistent infection | Postdoc, Los Alamos Natl Lab, Los Alamos, NM |
| Grier, Rebecca | 2000 | Levine | MS | Amath | A model for the onset of tumor angiogenesis | Math Teacher, Central High School, St. Joseph, MO |
| Pamuk, Serdal | 2000 | Levine | PhD | Amath | Two dimensional models of tumor angiogenesis | Kocaeli University, Anitipark Yani, Kocaeli, Turkey |
| Peterson, Brock | 2000 | Hansen | MS | Amath | Modeling of constrained-layer beams | Software Engineer, IBM, Rochester, MN |
| Stellmacher, Anneke | 2000 | Bergman | MS | AMath | Internet Voting | Further education, Germany |
| Thompson, Heather | 2000 | Keller | PhD | Math | Investigating and representing inquiry in college Mathematics course | Lecturer, ISU Math Dept, Ames, IA |
| | | | | | | |
| Calhoun-Lopez, Marcus | 2001 | Gunzburger/ Peterson | MS | AMath | Numerical solutions of hyperbolic conservation laws: Incorporating multi-resolution viscosity methods into the finite element framework | Further Education, ISU Math Dept, Ames, IA |
| Dai, Jack Jie | 2001 | Athreya | PhD | Math | Some results in probability and theoretical computer science | Postdoc, McGill University, Montreal, Canada |
| Flemisch, Bernd | 2001 | Pigozzi | MS | Math | The Alternating Schwarz Method: Mathematical Foundation and Parallel Implementation | Further Education, Stuttgart, Germany |
| Lee, Jeehyun | 2001 | Gunzburger | PhD | AMath | Optimization-based domain decomposition methods for multidisciplinary simulation | Post Doc, Carnegie Mellon Univ, Pittsburgh, PA |
| Calhoun-Lopez, Marcus | 2001 | Gunzburger | MS | AMath | Numerical simulation of superconducting rings using a Ginzburg-Landau model | Further Education, ISU Math Dept, Ames, IA |
| Majumdar, Ruchira | 2001 | Kliemann | PhD | AMath | On relationships between the Lypanov spectrum and the Morse spectrum | Unknown |

| | | | | | | |
|---|---|---|---|---|---|---|
| Rajan, Dileep | 2001 | Pigozzi | MS | Math | Not Available | Math Teacher, Roosevelt Senior High School, Washington, DC |
| Vojtechovsky, Petr | 2001 | Smith, JDH | PhD | Math | Finite sample moufang loops | Temp Asst Prof, ISU Math Dept, Ames, IA |
| Wu, Shiquan | 2001 | Wu, Z. | MS | AMath | Algorithms for optimal recombination problems | Further Education, ISU BCB Program, Ames, IA |
| | | | | | | |
| Becker, Joy | 2002 | Bergman | PhD | Math | Computational complexity of digraph decomposition and the congruence extension property of algebras | Asst Professor, Univ of Wisconsin-Stout, Menomonie, WI |
| Choi, Ji Young | 2002 | Smith, JDH | PhD | Math | Multi-restricted numbers and powers of permutation representations | Asst Professor, Shippensburg Univ, Shippensburg, VA |
| Chrysafinos, Konstantinos | 2002 | Gunzburger | PhD | Amath | Analysis and finite element approximation of parabolic saddle point problems and applications to control | Postdoc, Carnegie Mellon Univ, Pittsburg, PA |
| Gross, Gregory | 2002 | Bergman | MS | Math | Truncated polynomials in the NTRU cryptosystem | Math Teacher, Blair High School, Blair, NE |
| Hammon, Kerstin | 2002 | Weerasinghe | MS | Amath | Some results in the theory of dynamic storage allocation with policy | Further Education, Germany |
| Ju, Lili | 2002 | Gunzburger | PhD | Amath | Probabilistic and parallel algorithms for centroidal Voroni tessalations with application to meshless computing and analysis on surfaces | Postdoc, IMA, Minneapolis, MN |
| McClure, Chris | 2002 | Hou, S. | MS | Amath | How Damping affects Newton's basins | U.S. Military, Fort Sill, OK |
| Nordstrom, Sandra | 2002 | Hogben | MS | Math | The nonnegative P-O-matrix completion problem: classification of patterns for 4 by 4 matrices | Actuarial Analyst, American Express, Minneapolis, MN |

| | | | | | | |
|---|---|---|---|---|---|---|
| Rothbauer, Stefan | 2002 | Bergman | MS | AMath | Enriching representable functors | Further Education, Augsburg Univ, Augsburg, Germany |
| Rubenstein, Kenneth N. | 2002 | D'Alessandro | MS | Math | Generator theory of classical Lie algebra of type | Adjunct Instructor, Portland Comm College, Porland, OR |
| Volfovicz-Leon, Roberto | 2002 | Smith, JDH | MS | AMath | Analysis of a Mathematical model in forest sciences | Asst Prof, Univ of the Republic, Montevideo, Uruguay |
| Zhu, Wenxiang | 2002 | Gunzburger/Hou | PhD | AMath | Modelling, analysis, numerical approximations of the forced Fisher's equation and related control problems | Postdoc, York Univ, Toronto, Ontario, Canada |
| | | | | | | |
| Bibi, Tauqir | 2003 | Wu, Z. | MS | AMath | MTMM: A Matlab Toolbox for Macromolecular Modeling | Lecturer, ISU Math Dept, Ames, IA |
| Campbell Lenarz, Jessie | 2003 | Ashlock | MS | Math | Sphere packing bounds for edit metric codes | Further Education, ISU Math Dept, Ames, IA |
| Calhoun-Lopez, Marcus | 2003 | Gunzburger | PhD | AMath | Numerical solutions of hyperbolic conservation laws: incorporating multi-resolution viscosity methods into finite element framework | VIGRE Postdoc, Univ of Maryland, College Park, MD |
| Candan, Tuncay | 2003 | Dahiya | PhD | AMath | Oscillatory Behavior of Higher Order Functional Differential Equations with Distributed Deviating Arguments | Asst Professor, Nigde Univ, Nigde, Turkey |
| Kwon, Hee-Dae | 2003 | Hou/Gunzburger | PhD | AMath | Analysis and Approximation of Terminal-State Tracking Optimal Control Problems and Controllability Problems Constrained by Linear and Nonlinear Parabolic Partial Differential Equations | Postdoc Research Assoc, North Carolina State Univ, Raleigh, NC |
| Leeds, Daniel | 2003 | Hansen | MS | AMath | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Malonza, David | 2003 | Murdock | PhD | AMath | Normal Forms for Couples Takens-Bogdanov Systems | Lecturer, ISU Math Dept, Ames, IA |
| Njue, John Njeru | 2003 | Sethuraman/ Sacks | MA | Math | Nodel point data for inverse Sturm-Liouville problems | Kenya |
| Rajaram, Rajeev | 2003 | Hansen | MS | AMath | Moment Method in Distributed Control Theory | Further Education, ISU Math Dept, Ames, IA |
| Sargsyan, Seyran Samveli | 2003 | Smith, JDH | MS | Math | Entropy maximization problems | Instructor, Comm College, Washington, DC |
| Tucker, Anna | 2003 | Levine/Nilsen-Hamilton | MS | AMath | A Mathematical model for the onset of avasculaar tumor growth response to the loss of p53 function | Biotech Firm, St Lous, MO |
| Zerr, Ryan | 2003 | Peters | PhD | Math | Partial dynamical systems and AF C*-algebras | Asst Professor, North Dakota State University, Grand Forks, ND |
| | | | | | | |
| Alm, Jeremy | 2004 | Maddux | MS | Math | On sets of first-order formulas axiomatizing representable relation algebras | Further Education, ISU Math Dept, Ames, IA |
| Alturk, Ahmet | 2004 | Keinert | MS | AMath | Matrix-valued wavelets | Further Education, ISU Math Dept, Ames, IA |
| Babyonyshev, Sergei | 2004 | Pigozzi/Bergman | PhD | Math | Metatheories of Deductive Systems | Krasnoyarsk State University, Krasnoyarsk, Russia |
| Bhatt, Gyan Shyam | 2004 | Keinert | PhD | AMath | Nonseparable multivariate wavelets | Temporary Asst Professor, Rose-Hulman Institute, Terre Haute, IN |
| Crabtree, David | 2004 | Smith, JDH | MS | Math | An Equivalence of Categories | Further Education, Univ of Iowa, Iowa City, IA |
| Dagli, Mehmet | 2004 | D'Alessandro/ Smith, JDH | MS | Math | Levi Decomposition of Lie Algebras: Algorithms for its Computation | Further Education, ISU Math Dept, Ames, IA |

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|---|---|---|---|---|---|---|
| Drignei, Michaela Christina | 2004 | Sacks | MS | AMath | Regularization strategies for linear operator equations | Further Education, ISU Math Dept, Ames, IA |
| Kivunge, Benard Muthiani | 2004 | Smith, JHD | PhD | Math | Sedenion Extension Loops and Frames of Hypercomplex 2n-ons | Asst Prof, Huron College, Huron, SD |
| Meng, Qiang | 2004 | Weerasinghe | MS | AMath | Optimal Investment Strategies with Transaction Costs | Further Education, ISU Math Dept, Ames, IA |
| Mutungi, Patrick Mugo | 2004 | Smith, JHD | PhD | Math | Simple Ternary Complex Grassmann Algebras | Asst Prof, Benedict College, Columbia, SC |
| Oftelie, Jessica | 2004 | Ashlock | MS | Math | Simulation of Floral Specialization in Bees | Further Education, Univ of Iowa, Iowa City, IA |
| Ray, Douglas Wayne, Jr. | 2004 | Ashlock | MS | Math | A greedy algorithm enhancing cage search | Further Education, ISU Math Dept, Ames, IA |
| Rice, Theodore A. | 2004 | Smith, JDH | MS | Math | Greedy Quasigroups & Combinatorial Games | Further Education, ISU Math Dept, Ames, IA |
| Shuster, Christie Marie | 2004 | Bergman/Daniels | MS | INFAS & AMath | Identity Based Encryption Using Multiple Trust Authorities in Ad Hoc Networks | Tech Security Spec, Dept of Defense, Baltimore, MD |
| Yang, Sung-Dae | 2004 | Hou | PhD | AMath | Shooting Methods for Numerical Solutions of Control Problems Constrained by Linear and Nonlinear Hyperbolic PDE's | Postdoc, Florida State Univ, Tallahasee, FL |
| | | | | | | |
| Ahmed, Haseena Sulthana-Ameer | 2005 | D'Alessandro | MS | AMath | A feedback control strategy using the Lyapunov method for quantum systems | Further Education, ISU Math Dept, Ames, IA |
| Aydinyan, Ruben | 2005 | Smith, JDH | PhD | Math | Loop transversal codes over finite rings | Temp Asst Professor, Central Michigan Univ, Mount Pleasant, MI |
| Blabac, Eric Michael | 2005 | Bergman | MS | Math | Iterating Analytic Complex Maps | Data Analyst, Scottsdale, AZ |

| | | | | | | |
|---|---|---|---|---|---|---|
| Campbell, Jessie | 2005 | Ashlock | PhD | Math | Enumeration and symmetry of edit spaces | Adjunct Asst Professor, Concordia College, Moorhead, MN |
| Kim, Eun-Youn | 2005 | Ashlock | PhD | Math | Analysis of Game Playing Agents with Fingerprints | Korea |
| Kim, Joohyung | 2005 | Song/Long | PhD | Math | Classification of small class association schemes coming from certain combinatorial objects | Postdoc, Univ of Wisconsin-Madison, Madison, WI |
| Kleiman, Elizabeth | 2005 | Bergman | MS | Math | The XL and XSL Attacks on Baby Rijndael | Further Education, ISU Math Dept, Ames, IA |
| Maxwell, Mandi | 2005 | Song/Bergman | PhD | AMath | Almost perfect nonlinear functions and related combinatorial structures | Asst Professor, Trinity College, Chicago, IL |
| Mukhopadhyay, Kriti | 2005 | Wu, Z. | MS | AMath | NMR refinement of under-determined loop regions of the E200K variant of the human prion protein using database-driven distance constraints | Analyst, 24X7 ESI, Jersey City, NJ |
| Rajaram, Rajeev | 2005 | Hansen | PhD | AMath | Exact boundary controllability results for sandwich beam systems | Asst Professor, Shepherd University, Shepherdstown, WV |
| Rodriguez-Pedraza, Ricardo | 2005 | Weerasinghe | MS | AMath | Optimal portfolio allocatiaon for long-term growth in the presence of transaction costs | Further Education, ISU Statistics Dept, Ames, IA |
| Stanley, Christy Ann | 2005 | Bergman | MS | INFAS | Pairs of values and the chi-squared attack | Price Waterhouse Coopers, St. Louis, MO |
| Wangsness, Amy | 2005 | Hogben | PhD | Math | The matrix completion problem regarding various classes of PO,1-matrices | Asst Professor, Fitchburg State College, Fitchburg, MA |
| | | | | | | |

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|---|---|---|---|---|---|---|
| Alm, Jeremy | 2006 | Maddux | PhD | Math | Weak representation theory in the calculus of relations | Lecturer, ISU Math & Philosophy Depts, Ames, IA |
| Gillen, Tyler | 2006 | Smiley | MS | AMath | A survey of modern methods of biological modeling | Programmer, Citibank, Sioux Falls, SD |
| Go, Jin-Young | 2006 | Athreya/Liu, H. | MS | AMath | Not Available | Unknown |
| Gunaratne, Ajith | 2006 | Wu, Z. | PhD | AMath | A penalty function method for constrained molecular dynamics | Asst Professor, Florida A&M Univ, Tallahasee, FL |
| Liu, Kunlun | 2006 | Weber | MS | AMath | Existence of strong solution for a class of nonlinear parabolic systems | Postdoc, Biomedical Eng Dept, Univ of Minnesota, Minneapolis, MN |
| Meyer, Kristen Ann | 2006 | Bergman | PhD | Math | A new message authentication code based on the non-associativity of quasigroups | Asst Professor, Wisconsin Lutheran College, Milwaukee, WI |
| Murphy, Shane | 2006 | Maddux | MS | Math | A discussion of the application of fuzzy sets to game theory | Graduate Student, Cornell Univ, Ithaca, NY |
| O'Leary, Alison Jo | 2006 | Johnston, E./ Lieberman | MS | AMath | The hyperbolic metric and two-point distortion theorems for univalent functions | Instructor, Iowa Central Comm College, Fort Dodge, IA |
| Smith, Matthew Christian | 2006 | Weerasinghe | MS | AMath | A model of the short rate with regime shifts and reflecting barriers | Des Moines, IA |
| Wimmer, Maximilian B. | 2006 | Sethuraman | MS | Math | A law of large numbers and central limit theorem for the leaves in a random graph model | Graduate Students, Augsburg University, Augsburg, Germany |
| Wu, Di | 2006 | Wu, Z./Jernigan | PhD | AMath/BCB | Distance-based protein structure modeling | Asst Professor, Univ of Kentucky, Bowling Green, KY |

## Appendix 9b. School mathematics graduate student degree count

### MSM Paper/First Job Information

| Name | Year | Major Professor | Major | Thesis Title | First Job |
|---|---|---|---|---|---|
| Peterson, John | 1999 | Sharp | SMath | Not Available | Math Teacher, Ankeny High School, Ankeny, IA |
| Poole, Steven | 1999 | Tondra | SMath | Technology lessons for Mathematics | Lecturer, Math Dept, Cal-State, Stanislaus, CA |
| Testroet, Teresa | 1999 | Rudolph | SMath | Writing effective assessments when graphing calculators are used: testing conceptual knowledge | Math Teacher, Ames High School, Ames, IA |
| Luscombe, Clint | 2000 | Ashlock | SMath | The natural, not magical e | Math Teacher, Des Moines Christian School, Des Moines, IA |
| Petrak, Dan | 2000 | Sharp | SMath | Block scheduling: a look at student retention and teacher p | Math Teacher, Johnston High School, Johnston, IA |
| Reedy, Heather | 2000 | Sharp | SMath | Developing meaningful relationships with students to enhance behavioral (or academic) change: a study in trust psychology | Math Teacher, North Scott High School, Eldridge, IA |
| Sieren, Angela K. Brinkman | 2000 | Sharp | SMath | A computer based learning option for at risk students | Math Teacher, Sigourney High School, Sigourney, IA |
| Trulin, Kimberlee Ann | 2000 | Tondra | SMath | What is Mathematics and importance in society | Math Teacher, Lee Summit North High School, Kansas City, MO |
| Turnis, Shirley | 2000 | Tondra | SMath | Math assessment placement at Northeastern Iowa Community College | Math Teacher, Northeast Iowa Comm College, Peosta, IA |
| | | | | | |
| Bratcher, Doris | 2001 | Ashlock | SMath | Improving instruction on the metric system | Math Teacher, Northwest Iowa Comm College, Sheldon, IA |

| | | | | | |
|---|---|---|---|---|---|
| Cox, Rhonda | 2001 | Sharp | SMath | A unit to improve the ability of students to write and understand | Math Teacher, Orion High School, Orion, IL |
| Felt, Natalie | 2001 | Sharp | Smath | Mozart in the classroom | Math Teacher, Indianola High School, Indianola, IA |
| Hill, Troy | 2001 | Tondra/Andreotti | Smath | Real world Mathematics problems | Math Teacher, Ames High School, Ames, IA |
| Huisinga, Maureen | 2001 | Sharp | Smath | Analysis of achievement level test in the Baxter Smath District | Math Teacher, Baxter High School, Baxter, IA |
| | | | | | |
| Aalbers, Dan | 2002 | Tondra | Smath | Learning Mathematics with the aid of journaling | Math Teacher, Hampton-Dumont High School, Hampton, IA |
| Borich, Vickie | 2002 | Sharp/Andreotti | Smath | How does a philosophy of Mathematics impact the Christian educator | Math Teacher, Grandview Park Baptist High School, Des Moines, IA |
| Christensen, Scott | 2002 | Sharp | Smath | NA | |
| Cuttell, Terri | 2002 | Tondra | Smath | Distance education programs and high Smath students | Math Teacher, Albert City-Truesdale High School, Albert City, IA |
| Firch, Dion | 2002 | Sharp | Smath | An experiment with teaching through problem solving | Math Teacher, Moline High School, Moline, IL |
| Funke, Michele | 2002 | Hogben | Smath | A Mathematical critique of Paulos'' innumeracy | Math Teacher, Moline High School, Moline, IL |
| Jurgenson, Mark | 2002 | Tondra | Smath | A geometry unit of construction using TI92 | Math Teacher, Ames High School, Ames, IA |
| Koops, Michelle | 2002 | Sharp | Smath | Teaching conceptual knowledge of fractions in the remedial Smath classroom | Math Teacher, Moline High School, Moline, IL |
| | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Grebasch, Laura Lynn | 2003 | Tondra | SMath | Not Available | Math Instructor, Heelan High School, Sioux City, IA |
| Moeller, Jill Marie | 2003 | Hentzel | SMath | Fractions and the Transference to Rational Expressions | Math Instructor, Eastern Iowa Comm College, Clinton, IA |
| Roberts, Deborah Jean | 2003 | Tondra | SMath | Problem-Solving Strategies in the Applied Mathematics Classroom | Math Instructor, Corning High School, Corning, IA |
| Robertson, Michelle | 2003 | Tondra | SMath | Teaching styles and learning styles in a Mathematics classroom. | Math Teacher, Winfield Mount Union High School, Winfield, IA |
| | | | | | |
| Breckler-Whitson, Joan K. | 2004 | Tondra | SMath | Not Available | Unknown |
| Brill, Brooke | 2004 | Thompson/ Hentzel | SMath | Discrete Geometry and Calculus: Oh My, What Can We Learn! | Math Instructor, Ottumwa High School, Ottumwa, IA |
| Brooks, Richard | 2004 | Thompson/ Hentzel | SMath | Multiple-Choice v. Constructed Response Questions in High School Mathematics | Math Instructor, Johnston Community Schools, Johnston, IA |
| Lamphier, Lesley | 2004 | Hogben | SMath | Geometric Constructions | Math Teacher, Moline High School, Moline, IL |
| Roberts, Deborah Jean | 2004 | Tondra | SMath | Teaching Problem-Solving Skills in the AMath Classroom | Math Instructor, Corning High School, Corning, IA |
| Stuckwisch, Kevin | 2004 | Hentzel | SMath | Fundamental Calculus: A Reform Alternative | Math Instructor, Warsaw High School, East Moline, IL |
| | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Atherton, Rebecca J. | 2005 | Hogben | SMath | A Look at Markov chains and Their Use in Google | High School Math Teacher, Moline School District, Moline, IL |
| Brincks, Laura | 2005 | Thompson/ Johnston, E. | SMath | Fractals and Chaos | Math Teacher, Earlham High School, Earlham, IA |
| Donald, Christi | 2005 | Thompson/ Johnston, E. | SMath | Hyperbolic Geometry in the High School Geometry Classroom | Math Teacher, Valley Southwoods High School, West Des Moines, IA |
| | | | | | |
| Ehr, Diane | 2006 | Thompson/ Hentzel | SMath | Voting Methods | Math Teacher, McGregor ISD #4, MN |
| Eveland, Joyce | 2006 | Thompson/ Hogben | SMath | Theoretical and Experimental Agorithms Concerning the Dimensions of Fractals in the Secondary Classroom | Math Teacher, Oskaloosa High School, Oskaloosa, IA |
| Parker, Jennifer | 2006 | Hogben | SMath | Distance Geometry Problem | Math Teacher, St. Paul Public Schools, St. Paul, MN |
| Reece, Brian | 2006 | Thompson/ Hentzel | SMath | Estimating Pi Through Monte Carlo Methods in n-dimensions | Math Teacher, Johnston High School, Johnston, IA |

# Appendix 10. Faculty member vitae